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APPLICATION OF MULTI-OBJECTIVE WEIGHING WORK SCHEDULING ALGORITHM INTO STORAGE NETWORK

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ABSTRACT

The resource request task of transmission of large number of servers, wide-band resources in the enterprise storage gridding, the business distribution and download service are limited by scheduling length, time span, load balance, service quality, economic principles, security performance and many other factors, so it is difficult to use definite feature to define it. Given the above, the paper analyzed the enterprise storage gridding storage model and designed the compromised work scheduling algorithm based on multi-objective weighing. Through the massive measurements of randomly generated images, it proved the generosity of the algorithm. According to the result, the algorithm shows good performance on comprehensive indexes such as scheduling length, scheduling cost, average energy consumption, etc.
Keywords: *Enterprise Storage Gridding, Multi-Objective Weighing, Work Scheduling, Comprehensive Evaluation Model.*

1. INTRODUCTION

Storage grid is to learn the theory and technology of the grid so as to more efficiently coordinate the work of a combination of organic intelligent units. Its objective is to establish dynamic virtual storage on distributive, heterogeneous, autonomous network storage resources and environment, and internally realize the resource sharing and coordination cross the autonomous domains [1]. Enterprise data storage technology has undergone a shift from direct storage to network storage. During the period, there has the birth of a subsidiary in the server's disk array (RAID), centralized disk array server, network-attached storage (NAS) and storage area network (SAN), clustered storage, grid storage, cloud storage and many other solutions. The storage grid virtualizes various storage system and devices distributed physically in a certain area into a single storage system, providing uniformed, transparent and safe visiting and management mechanism [2]. In enterprise storage grid system, once physical server topology network is formed, there would need no other change; every computer in the topology is called a node [3].

Scheduling algorithm refers to the resource distribution algorithm according to the system of resource allocation strategies. As nodes joining keep growing, storage grid system work scheduling has become more complex. A short period of time may witness requests tasks coming from multiple applications node resources, and different tasks have different requirements on the size and service real-timeness of the required resource. So resource allocation task scheduling in a multi-node environment is a key problem needed study. Traditional work scheduling algorithms often only take into account the unilateral properties of the task, for example, first-come, first-serve (FCFS) scheduling algorithms only takes into account the time for submission. In this paper, the author considers the space required for storage space (the size of the user data storage space required), expected degree of urgency (refers to the requirements of the user on the server response time) and task submission time, and designed work scheduling model based on the multi-objective (MTB) to meet the large-scale enterprise storage grid work scheduling needs.

2. WORK SCHEDULING MODEL BASED ON MULTI-OBJECTIVE

2.1 Enterprise Storage Grid Model

The enterprise cloud grid storage model basic network structure is shown in Figure 1. Basic machine roles are divided into three categories: ① resource node, the nodes are both the beneficiary and the contributor of resources; ②branch nodes, such nodes will turn static, passive resource node (local guest host) into active actors and is mainly responsible for extracting metadata (Metadata), conversion and reporting to the central node. It is

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distributed in the tree structure, and sub-layer expansion can be carried out in accordance with the enterprise-scale; the metadata Centre service node; the node as important centralized center divides the meta data into a support meta-data (such as loading data, conversion rule metadata) and the driving element data (mapping mode, the migration patterns of element data, etc.), which carry out real-time loading and view organization on the obtained metadata [4]. In addition, there are backup and monitoring such as backup and witness server metadata extraction process.

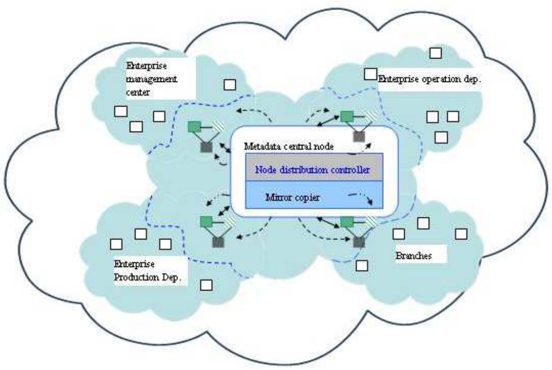

Fig 1: Typical Enterprise Storage Grid Model

2.2 Basic Thoughts

Taking into account multiple users sending service request to the meta-data center services node for resource in a short period of time, the paper draws from the layer analysis method and established the work scheduling model based on multi-objective weighing in order to ensure that each user be able to get the services and service fairness within the acceptable waiting time. In this model, the set of a plurality of ready queues is established,

When a new resource request task arrives, put it into the rear of the queue equal to its priority (or approximately equal). In the beginning, the first queue is scheduled according to the FCFS principle. When it turns to perform the task, if it can be completed within a time slice, the grid server can delete this task from the ready queue; Otherwise, they transfer the task to the tail of next queue, and then apply FCFS principle of scheduling; so on and so forth, after a long task is degraded to n queue, the operation in the n queue will be in line with the time lice operation. Only when 1 degraded to (i-1) queue is empty, the grid server would schedule the task execution of tasks in the i-th queue. If the server is serving in the i queue for a task and then the new task enters into the high priority queue, the grid puts the task being performed in the grid servers back to the tail of the queue and serves for the high-priority task.

Determining the user node resource request task priority is a key step in this method. The paper is based on the required storage space by the user's data, the urgency extent of the expected service, the user resource request task submission time and other objectives [5], draws on the analytic hierarchy process to establish a multi-objective scheduling model to assess user resources requested tasks priority. Assume the assessed object was as follows: x_1 (scheduling execution of the user 1 resource request tasks), x_2 (scheduling resource request of the user 2 is executed task), ..., x_n (scheduling execution of user n resource request tasks); Evaluation:, f_1, f_2, $\cdots f_n$ (resource requests tasks by scheduling length, time span, load balancing, quality of service, economic principles and safety performance); index weight: w_1, w_2, $\cdots w_n$,among them $0 \le w_i \le 1$, $\sum_{i=1}^{3} w_i = 1$, $i = 1,2,3$. The following evaluation matrix A could be obtained:

$$A = \begin{matrix} & f_1 & f_2 & \cdots f_n \\ x_1 & a_{11} & a_{21} & \ldots a_{31} \\ x_2 & a_{21} & a_{22} & \ldots a_{31} \\ \cdots & \cdots & \cdots & \cdots \\ x_n & a_{n1} & a_{n2} & \ldots a_{n3} \end{matrix},$$

Here a_{ij} indicates the value of index f_j on scheme, x_i, $i = 1,\ldots, n$; $j = 1,2,3$. Priority function value y decreases with increase of the required storage space. With the increase of the degree of urgency of expected service, the submission time becomes sooner, the priority function value greater. In order to facilitate the modeling, one could convert the submission time into waiting service time (waiting for service time = scheduling time of the moment - submission moment of time). The basic process is as follows:

It begins by standardizing of index values. Deploy the 1～9 scale [6] proposed by people such as Salty to quantify the urgent degree of the expected services of qualitative description, just as table 1 show:

Table 1 Quantification Of Qualitative Indexes

Class	Not urgent at all	Not urgent	So-so	Urgent	Very urgent
Score	1	3	5	7	9

As the dimension of factor varies from each other, we can not directly adopt the method of

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summation or method of linear weighted summation. Instead, it should be first standardized. Here vector normalization is adopted to conduct standardization.

For the j index f_j, we have:

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{n} a_{ij}^2}} (i = 1, \ldots, n; \quad j = 1,2,3)$$

(1)

After standardization on x_{ij} in formula (1), the value of x_{ij} under f_j becomes right the value of the resource requirement of the application node i under index f_j.

$$h_{ij} = \begin{cases} 1, & \text{If } f_i > f_j \\ 0.5, & \text{If } f_i = f_j \\ 0, & \text{If } f_i < f_j \end{cases}$$

$(i = 1, \cdots, n; \quad j = 1,2,3)$ (2)

Assume $H = (h_{ij})_{3\times 3}$, $i, j = 1,2,3$, then we can have

$$\begin{cases} h_{ii} = 0.5 \\ h_{ij} + h_{ji} = 1 \end{cases} \quad i, j = 1,2,3 \qquad (3)$$

The weight of factors (namely, evaluation indexes f_1, f_2, f_n) influencing rational distribution and utilization of resources can assign weights for f_1, f_2, f_n with flexibility and decide the order of the weights of f_1, f_2, f_n in accordance with the specific goals of the system. For example, the weight of f_1 (the urgent degree of service expected from users)> the weight of f_2 (required storage space)>the weight of f_3 (submitting time), then we have:

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} = \begin{bmatrix} 0.5 & 0 & 1 \\ 1 & 0.5 & 1 \\ 0 & 0 & 0.5 \end{bmatrix}$$

(4)

The weight of f_i can be obtained through the weight calculation formula, which can be demonstrated as follows:

$$w_i = \frac{\sum_{j=1}^{3} h_{ij}}{\sum_{i=1}^{3}(\sum_{j=1}^{3} h_{ij})} \quad (i = 1, 2, 3)$$

(5)

In this way, we can transform the weight of qualitative description to a quantitative one.

Knowing the weights of all indexes and values of a random scheme under random indexes, we can get the priority function with two methods. The priority functions of y obtained through the method of linear weighted summation and the method of nonlinear weighted summation are respectively as follows:

$$y_i = w_1 x_{i1} + w_2 x_{i2} + w_3 x_{i3} \quad (i=1,\ldots,n) \qquad (6)$$

$$y_i = \prod_{i=1}^{n} x_{ij}^{w} (i = 1, \ldots, n; \quad j = 1,2,3) \qquad (7)$$

2.3 Resources Allocation Model

Once the priority of tasks is targeted, the order of scheduling is also decided. Then, the storage task shall be assigned to the online resource nodes of the network. In light of the size of required storage space for tasks and the idea of buddy algorithm, we adopt a relatively appropriate adaptation algorithm to identify the target resource nodes [7-9].The allocation of online nodes can be showed as Figure 2:

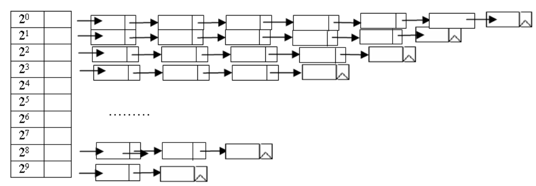

Figure 2:.Distributions Of Online Nodes

This model distributes the storage space of all online nodes in the storage network system to arrays [10] .Here each element has a corresponding group of nodes close in space. The available space for corresponding node satisfies the following formulas:

$$\begin{cases} 2^i \le S_{group}^i < 2^{i+1}, 0 < i < 9 \\ 0 < S_{group}^i < 2^{i+1}, \quad i = 0 \\ S_{group}^i \ge 2^i, \quad i = 9 \end{cases} \qquad (8)$$

In the above formula, S_{group}^i stands for the available storage space for nodes in group i . From the formula, we can see that the array element in diagram 3 is increasing geometrically.

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$$DR_i = \frac{AS_i - NS_i}{AS_i} \le \frac{AS_i - 2^k}{AS_i} < \frac{2^{k+1} - 2^k}{2^{k+1}} = \frac{1}{2} \quad (9)$$

For a random required storage space $NeedSpace(NeedSpace > 0)$, there exists a natural number i that satisfies the following condition:

$$2^i \ge NeedSpace \text{ namely } i \ge \log_2 NeedSpace \quad (10)$$

Then, we can get the range of the weight of i. After taking an integer (round down), we can obtain the smallest natural number which satisfies formula (10)

$$i = \lfloor \log_2 NeedSpace \rfloor \quad (11)$$

As we have known that $i \ge 9$ with the help of formula (11), we can find all target resource nodes and conduct allocation.

2.4 Algorithm Description

Above all, metadata center service node is responsible for distributing multiple storage tasks into the corresponding resource nodes. The concrete algorithm is as follows:

Step1: define an index. According to various applicative nodes demand, it identifies multiple indexes and in line with it, it records the schedule tasks' order and times.

Step2: as for single task distribution algorithm, it carries out calculation according to 2.3 models. If there were nodes needed for available spaces, it distributes the ST to the node; otherwise, divide the storage task to two sub-tasks ST_{i_1}, ST_{i_2};

Step3: recursion completed step2. Distribute sub-task to corresponding resource node till all users' request task become empty.

3 SIMULATION EXPERIMENT AND ANALYSIS

We use Grid platform to verify the effectiveness of the proposed algorithm. With a graph with weight FIG G = (V, E), here the vertex is constituted by the server and the user. User node is divided into the resource nodes and the application node. Its QoS requirements are not identical, which respectively define different data packet length, the generation rate, and respective information-source produces data stream obeying the Mandelbrot Zip Poisson distribution. Assume that the experimental parameters are shown in Table 2, the randomly generated is shown in Figure3. Algorithm test code is written by Java and proved by Eclipse3.6 encoding. Assume the required weighing objectives reach N, then the worst calculation time complexity of the multi-objective weighing algorithm is $O(3^{N/3})$.

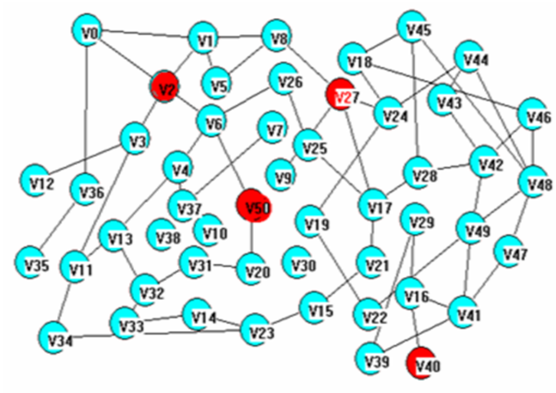

Figure 3: The Randomly Generated

Table2 Experimental Parameter Setting

Parameter name	Set Value
Target area	400×400m2
Bandwidth	400Kb/s
Server	10 个
Resource node	50 个
Applicative node	90 个
Task	300
Task arrival rate	0.1～1.0
Itinerates	300
Generation rate of cyling data stream	1Packet/s

Furthermore, given the unit time and the same size, MTB, compared to FCFS and SJF, the work scheduling length, the average energy consumption (cost), have obvious advantages, as shown in Figure 4, Figure5. Therefore, when the proposed scheduling algorithm

Operating in a large-scale map-like data processing, it can effectively reduce the resource leasing costs; maximize flexibility to meet the mission requirements of a variety of real-time requirements of resource allocation.

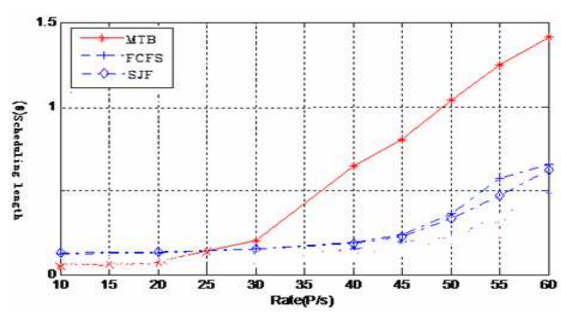

Figure 4: Work Scheduling Length

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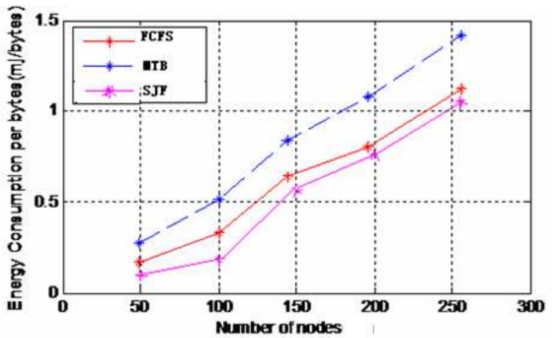

Figure 5: Average Energy Consumption (Cost)

4. CONCLUSION

The resource request task of transmission of large number of servers, wide-band resources in the enterprise storage gridding, the business distribution and download service are limited by scheduling length, time span, load balance, service quality, economic principles, security performance and many other factors, so it is difficult to use definite feature to define it. Given the above, the paper analyzed the enterprise storage gridding storage model and designed the compromised work scheduling algorithm based on multi-objective weighing. Through the massive measurements of randomly generated images, it proved the generosity of the algorithm. According to the result, the algorithm shows good performance on comprehensive indexes such as scheduling length, scheduling cost, average energy consumption, etc.

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