Optimization Simulation Analysis of Civil Aviation Meteorological Cluster Information Integrated Service System Based on Load Balancing

Xiaoling Ji*, Liang Zhao

Meteorological Department, East China Air Traffic Management Bureau. CAAC, Shanghai 200335, China

*Corresponding Author email: 782419887@qq.com

Keywords: Load balancing; Meteorological cluster; Integrated service system

Abstract: With the continuous expansion of the scale of civil aviation passenger service information system and the increase of business volume, the amount of information and access carried by servers increases rapidly. How to effectively utilize server resources to handle massive access requests has become an important issue. Effective load balancing strategy is the key to allocate users' service requests to these server resources reasonably. In this paper, the data is synchronized to multiple database servers in real time. Through the load balancing device, multiple database servers are grouped into database clusters to realize load balanced access of the user to the database cluster. Thereby, the access to the user is diverted to the node server of the database cluster, the access pressure to the single database server is slowed down, and the effectiveness and stability of the real-time meteorological data in the flood season are guaranteed. Therefore, the user is more intuitive, so this system has been approved and used by some civil aviation meteorological centers in China.

1. Introduction

With the rapid development of civil aviation passenger information service system, the rapid growth of civil aviation business volume has challenged the new generation system of China's civil aviation information network [1]. The key issue is that the system needs to provide 24/7 uninterrupted operation guarantee, and it is characterized by security, reliability, efficiency and real-time, and requires the system to respond quickly to the request service in time [2]. As a result, more and more public access to information through the meteorological business platform of the website, so for a business platform providing public services, the stability and security of the website on which the business platform relies is very important [3-4]. With the continuous development of economy and society, the harm of extreme weather events to social wealth and the safety of people's lives and property is increasing, and the requirement for the accuracy of weather forecast is also increasing. Meteorological data is the basis of making weather forecast. Only when meteorological data are provided to forecasters in time, can weather forecast be made and released in time and accurately [5].

In recent years, China's civil aviation industry has developed rapidly. At the same time, China's meteorology and related meteorological observation technology are also developing rapidly. With the progress and improvement of observation means, the requirements for traditional meteorological parameters data acquisition are also increasing. For example, more and more monitoring departments require real-time tracking and response of meteorological data [6]. Therefore, how to solve the timeliness problem of meteorological data in large-capacity concurrent environment is the key problem that data collection and distribution system must solve, and the direct and effective way to solve this problem is to adopt multi-machine cluster mechanism [7]. In 2013, an enhanced integrated vision system based on Civil Aviation Integrated Modular Avionics was proposed [8]. In the following 2018, researchers conducted research on model-based systems and civil aviation interoperability projects [9]. In addition to aircraft position monitoring and ground and ground communication, the controller's command and decision requires a large amount of auxiliary information, including aeronautical meteorology, aeronautical information, AFTN telegraph, air force activities, special planes/important missions, General aviation flight, school flight/test flight

  DOI: 10.25236/eeems.2018.011

activity, flow control scheme, etc [10]. The integrated information display system is a customized information integration system for the effective management of information flow and business processes.

In response to the above problems, a plurality of servers are connected by a local area network to form a cluster, and the overall performance of the server is improved by parallel processing and mutual information exchange [11]. Since the impact of different types of requests on the load is different, the adoption of a suitable load balancing algorithm is the key to solving this problem [12]. The cluster mechanism can realize the task of sending and receiving data together by multiple machines, thus solving the processing bottleneck caused by one machine, greatly improving the throughput of task processing and meeting the real-time processing requirements of massive data [13-14]. It is convenient for controllers to obtain all kinds of information, reduce the workload of controllers, improve work efficiency and ensure air traffic safety [15]. Load balancing device is used to distribute database access users to the node database in the database cluster through load balancing strategy, which realizes the diversion of access users, alleviates the pressure of single server database access, and improves the stability and efficiency of the database [16].

2. Methodology

Load balancing system is generally composed of multiple node equipment servers and a load balancer responsible for scheduling. When the client sends service requests to the cluster system, the load balancer receives the requests, and according to the scheduling algorithm in the cluster system [17]. Select the most suitable node server from the server cluster and forward the service request to the server, so that the real node device server can process the new customer request [18]. Considering the special nature of service-oriented business platform and the stability and security of network construction, it is better to implement and realize load balancing by hardware, and the server adopts service cluster technology. Connected through a high-performance network to form a virtual, single database logical image, by providing a virtual IP address, at the user level, the user accesses the database cluster by accessing the virtual IP address. The meteorological information integrated service system introduced in this paper applies the current popular browser/server architecture, and on the basis of this, it combines other server programs to support the use and browsing of multiple users.

In order to better analyze the advantages of the algorithm in load balancing, the experimental selection cluster compares the real-time response delay and system throughput of the algorithm under mild load, moderate load and heavy load. Table 1 and Figure 1 are a set of performance parameters selected by the cluster during light load.

Table 1 Light load server performance parameter table

Data one	Network usage(%)	Memory usage(%)
Server 1	23.5	14.1
Server 2	18.6	16.7

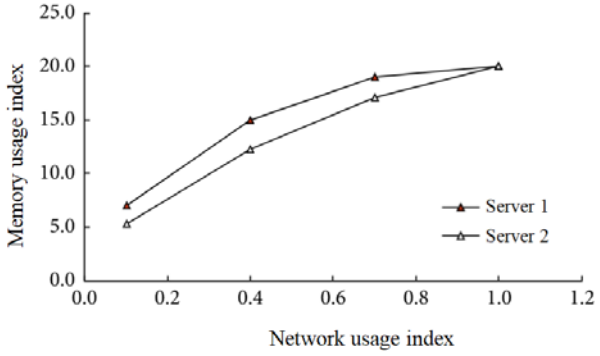

Figure 1 Light load server performance parameter map

To sum up, in light load, load balancing can be well done, whether from response delay or system throughput. Because of its large overhead, it does not have a special advantage in load balancing. Table 2 and Figure 2 below are a set of performance parameters selected by the cluster under moderate load. In the case of moderate load, the processing capacity of the server is not particularly large, even without load balancing, each server can fully respond to client requests. Load balancing requires a certain amount of resource consumption.

Table 2 Moderate load server performance parameter table

Data two	Network usage(%)	Memory usage(%)
Server 1	45.3	20.1
Server 2	38.4	18.6

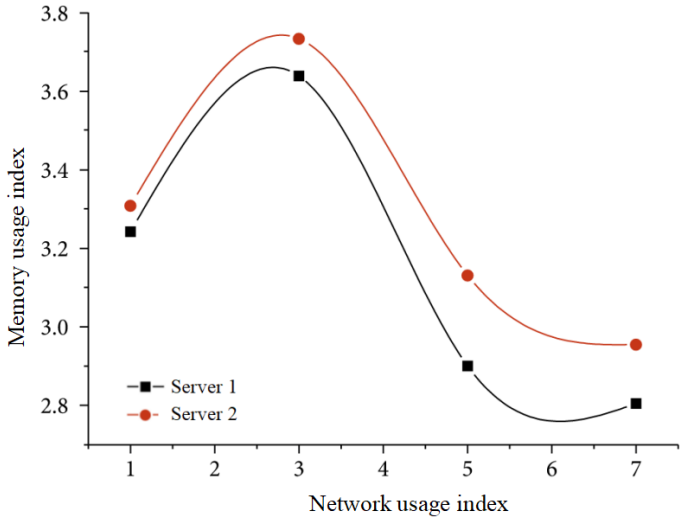

Figure 2 Moderate load server performance parameter map

Load balancing is a collection of servers in a symmetric manner by multiple servers. Each server has an equivalent status and can be served separately without the assistance of other servers. The job scheduling process is mainly responsible for the job scheduling of the data collection and distribution system. The scheduled job types include local collection, remote collection of jobs, scheduled/arrival distribution jobs, scheduled editing jobs, lack of notifications, data replenishment jobs, and metadata synchronization. Jobs, data customization jobs, and program list generation jobs. Among them, static load balancing algorithm mainly includes polling algorithm, weighted polling algorithm, and dynamic load balancing algorithm mainly includes weighted least number of connections algorithm, dynamic weighted polling algorithm and so on. Among them, polling algorithm and weighted polling algorithm require all servers to have the same hardware and software configuration and relatively balanced service requests. The other servers in the group will automatically take over the visits and data processing of the failed servers, thus realizing the functions of multi-machine hot backup and multi-machine load balancing.

In summary, with the increase of the number of requests sent by clients and the network load, the pressure on the cluster increases gradually, and the situation of load imbalance begins to appear. When the deviation of the load of each server increases gradually to a certain extent, the load balancer starts to implement the balancing algorithm. Comparatively speaking, it has certain advantages in the case of increasing load. Table 3 below is a set of performance parameters selected by the cluster under heavy load. Figure 3 is a comparison chart of system response delay in the case of Table 3.

Table 3 Heavy load server performance parameter table

Data three	CPU usage(%)	Net flow(%)
Server 1	80.14	75.66
Server 2	75.38	87.93

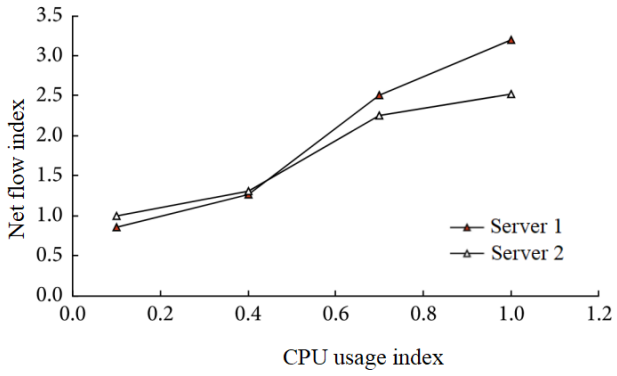

Figure 3 Comparison of algorithm response delays under severe load

After the access users are offloaded to the node machines of the database cluster, the data on each node machine must be synchronized in a timely and fast manner to ensure that users access real-time data. And each customer is assigned an independent service unit; for the data processing module is mainly responsible for the extraction and interpretation of several large categories of data; projection transformation module is responsible for the conversion of meteorological data in the latitude and longitude, cylindrical projection, etc. . As the software system directly used by the end user, the core is to realize the display of various information and business flow through human-computer interaction. For different user identities, the system will automatically load different functional modules to achieve the reasonable protection of information. In addition, the use of system login records statistics attendance, scheduling support and improved system logs are part of the terminal software. By categorizing the types of service requests, matching the types of requests with the corresponding server groups in the background can reduce the duplicate caching of the same content in multiple servers, thus improving the cache hit rate of servers and improving the system throughput.

3. Result Analysis and Discussion

The database server carrying meteorological data always bears the pressure of a large number of data inputting into the database and many users accessing queries. Especially in the flood season, users pay close attention to the real-time data of national and regional automatic weather stations, and the amount of visits increases, which puts great pressure on the database server. This system skillfully applies the prevailing B/S architecture, which makes it easy for the experiencer to get the comprehensive information provided by the system through the Web browser. The system has a humanized human-computer interaction interface, which not only enables participants to visualize meteorological data, but also can combine different standard domestic meteorological data. For this system, it has a vector format, so it can display pictures and other data. Perform any shrinkage and enlargement without losing the authenticity. Since the core business of the data collection and distribution system is data collection and data distribution, the data collection and distribution of data collection and distribution systems in a cluster environment focuses on data collection and distribution.

Aiming at the phenomenon of load imbalance in the network, this paper draws on the load migration algorithm based on air pressure principle in physics, so that the load of the heavy load node shifts the load to the light load node and the load is balanced, and finally the load balance of the whole system is achieved. Among them, the load migration changes are shown in Table 4 and Figure 4 below.

Table 4 Load migration table

Time	Node	Threshold
T_1	23	0.68
T_2	18	0.19

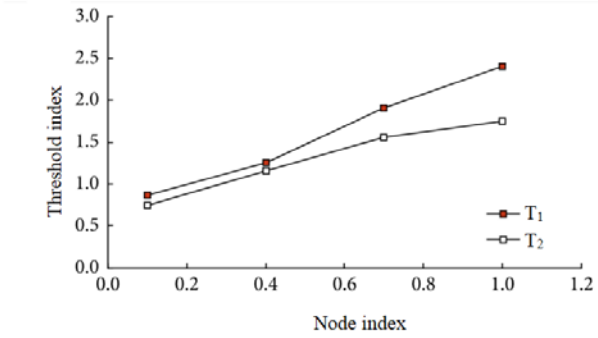

Figure 4 Load migration change diagram

Some relevant definitions of the load balancing algorithm are given: the load vector e of server i is:

$$e_j = -k\sum_{i=1}^{n} f_{ij} \ln f_{ij} \tag{1}$$

The node processing capability of server e is Wj:

$$W_j = 1 + k\sum_{i=1}^{n} f_{ij} \ln f_{ij} \Big/ \sum_{j=1}^{m}(1 + k\sum_{i=1}^{n} f_{ij} \ln f_{ij}) \tag{2}$$

In order to calculate the node processing capability of the server, the weight vector dj is defined as:

$$W_j = d_j \Big/ \sum_{j=1}^{m} d_j \tag{3}$$

Assuming the service request type is j, the load impact on the server node and the processing power of the server are as follows:

$$y_i = \frac{\max(y) - y_i}{\max(y) - \min(y)} \tag{4}$$

The load weight ratio of the server is determined by the load vector k of the server and the processing capability vector Wj:

$$a_k = \begin{cases} 1, & s_k > s_j, \forall j, k \neq j \\ 0, & \text{Other} \end{cases} \tag{5}$$

Then, the task request is probabilistically forwarded based on the distribution weight, wherein the calculation of wij is as follows:

$$w_{ij} = w_{ij} + a(\frac{X_i}{m} - w_{ij}) \tag{6}$$

Wj requests of 300 bits in length are programmed, which consume the CPU resources of the server. The constructed request data is sent at certain intervals, and the system throughput of the statistical algorithm is shown in Figure 5 below.

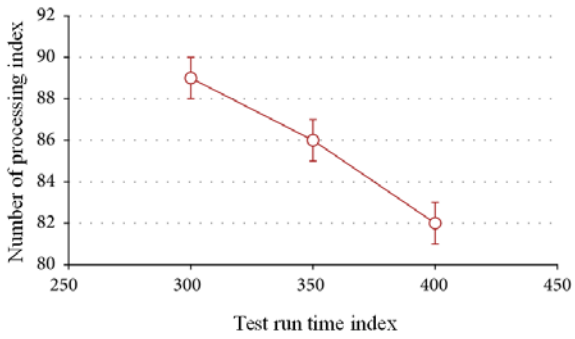

Figure 5 The number of requests processed by the system

A hash mapping table is established on the distributed service invocation platform, and the service request category, the server group corresponding to the background, the working state of the nodes in the server cluster, and the load weighting ratio value are associated. Application load balancing has two purposes: first, a large number of concurrent access or data traffic sharing is processed separately on multiple node devices to reduce the time for users to wait for response; secondly, the operation of a single heavy load is shared to multiple node devices. Parallel processing, after the processing of each node device is finished, the results are summarized and returned to the user, and the system processing capability is greatly improved. If an exception occurs to a single database or server in a database cluster, user access will be allocated to other nodes without being affected by the failure of a single node in the database cluster. At the same time, the failure of a single node machine will not have a great impact on the database cluster, the database cluster can still work normally, access, query and other operations will not be interrupted.

Several load indicators, such as resource, memory resource, current process number and response time, are used to synthesize the load information of nodes. Therefore, any node dynamic load value formula can be described as follows:

$$E_{RME} = \sqrt{\frac{1}{P}\sum_{p=1}^{P}(E_P)^2} \tag{7}$$

The average load imbalance is m. If the number of server nodes in the cluster is I, the load imbalance of the server node i is j within a certain period of time p, then the average imbalance of the cluster can be calculated by the formula:

$$I_i = \left[\sum_{j=1}^{p}\omega_j^m y_{ij}^m\right]^{1/m} \tag{8}$$

Assuming that the load deviation of server b is n, the load value of server W is A, and the number of servers is i, the load balance can be calculated by:

$$\mathrm{F}_c = \frac{2b}{\left(n+l\right)K^{\frac{1}{n}}}\left(\frac{W}{A}\right)^{\frac{n+1}{n}} \tag{9}$$

Assuming that in a certain time, the number of requests sent by the client is x, the time when the request arrives at the system is b, the time when the system starts processing the request is d, and the time when the request is completed is n, then the average response time of the system can be calculated by the formula.

$$\mathrm{dF}_r = 2b\int_0^L \tau dx \tag{10}$$

A large number of read and write requests are written by the program. The specific construction process of the request is: writing a file (file size is 2MB) → reading the file → deleting the file. The request is disk-intensive and mainly related to the disk I/O rate. The system throughput of the statistical algorithm is shown in Figure 6 below.

The security policy server controls the access rights of the user according to the check result. The security linkage device provides network services to users who have passed the security status; isolates the unqualified users in the security state to the quarantine area, and performs system repair and patch and virus database upgrade until The safety status is qualified; after the user upgrade is completed, the safety certification can be re-executed. The number of requests processed per second by the system increases with the test run time and eventually stabilizes near the saturation value. When the test run time is less than 30 seconds, the number of requests per second processed by the algorithm is the lowest, which is due to less resource consumption when computing requests. If one

or more servers in network load balancing are unavailable, the service will not be interrupted. When network load balancing automatically detects that the server is unavailable, it can quickly reassign client communication in the remaining servers. This protection can help you provide uninterrupted services to key business processes. The number of network load balancing servers can be increased according to the increase of network access.

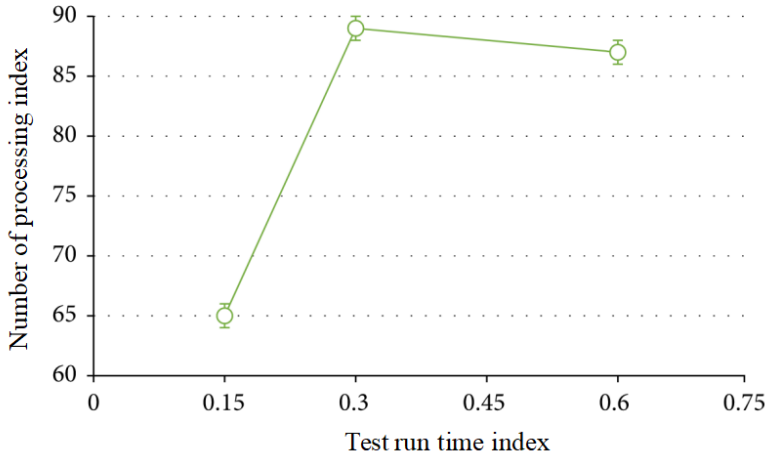

Figure 6 Number of system processing requests for read and write request types

4. Conclusions

The construction of network plays an important role in the construction of business platform. Poor network framework or inadequate application technology can easily lead to overload of network equipment and bottleneck of network, which can easily lead to instability of website operation and low network access ability. Therefore, it is easy to paralyse in the case of large amount of visits. The application of load balancing technology to build network solves this problem. Through the browser to provide users with a variety of civil aviation meteorological graphical services. The improved dynamic load balancing algorithm proposed in this paper considers the service request type, the processing power of the server node and the current load of the server. Through periodic feedback, the real-time and validity of the load information is guaranteed, thus improving the system. Throughput. It can not only integrate meteorological elements of various observations into the same GIS, but also enable human-computer interaction, which can provide more personalized services for different users.

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