Distributed Cloud Platform Access Collaborative Selection Algorithm based on Multi-objective Optimization

Wei Zhao*, Huiqin Li, Chenfei Wang, Yajuan Wang, Liyang Xu and Juan Liu
State Grid Customer Service Center, Tianjin 300000, China

*Corresponding author

Abstract. Decentralization is the mainstream trend of large-scale center construction. Based on the requirements of mass service access, big data processing and high reliability of State Grid 95598 cloud platform, a distributed cloud platform access collaboration selection algorithm based on multi-objective optimization is proposed. The algorithm considers load balance of distributed cloud platform and average user experience quality. In addition, it measures the comprehensive performance of the cloud platform from users and load balance of distributed cloud platform based on the synergy degree in the selection process in order to avoid "cask effect". The simulation results show that the algorithm can adjust the access cloud centers of users in real time and balance loads of cloud centers, which can provide technical support for cloud platform construction in the era of big data.

Keywords: Multi-objective optimization; Distributed cloud platform; State Grid 95598; Cloud center selection.

1. Introduction

With the advent of the era of big data, power data information is developing in a diversified and sea-quantified direction. In order to adapt to this trend, the 95598 cloud platform must be upgraded to improve its security, reliability and service quality in order to meet the growing needs of power customers [1].

The traditional cloud platform adopts the single-center mode. It can meet the customer's needs by multi-level protection while ensuring the security of the platform itself. However, this single-center mode has limited reliability and is difficult to ensure the stability of the system in earthquakes, heavy rains and other irresistible natures [2]. In addition, the cloud platform’s load continues to rise and the user distribution area is increasing. Traditional single-center mode is prone to business accumulation and difficult to guarantee the service quality. Hence, a more reasonable solution is urgently needed [3]. In order to break the bottleneck of traditional single-center construction mode, distributed construction strategy is gradually being widely used in various fields. Distributed strategy refers to serving all customers by multiple centers at the same time. This mode can avoid the system crash caused by single center failure [4]. However, the user's service quality must be considered while considering the load level of each cloud center in the distributed mode. Excellent balance can ensure the rational use of system resources.

To this end, we propose a distributed cloud platform access collaborative algorithm (MOOAA) based on multi-objective optimization in this paper. The algorithm first evaluates the experience quality for each user by MOS quality model. In addition, in order to measure load balance of multiple centers, the cloud center load balance indicator is proposed. Finally, we consider these two optimization goals of maximum service quality and load balance to provide the best access scheme for all users.
Simulation results show that the MOOAA can guarantee service quality and load balance of distributed cloud platform as much as possible, which can optimize the system performance of the distributed cloud platform to the greatest extent.

2. Related Work
The traditional cloud platform adopts the single-center mode, which meet the customer's needs by multi-level protection while ensuring the security of the platform itself. Pawar in [5] established an algorithm based on preemptable task execution and multiple Service Level Agreements parameters. The algorithm in [6] performs resource preemption from low-priority tasks to high-priority tasks, and considers multiple SLA parameters for deploying services to perform high-level replacement of resources. Jokhio in [7] proposed a dynamic resource allocation algorithm based on prediction, which provides a mechanism for horizontally allocating and releasing virtual machines (VMs) to a cluster of video transcoding servers. Chang in [8] proposed a fuzzy-based dynamic resource allocation scheme for load balancing (FDLB) in cloud computing to improve the growth of service types and the number of users in mobile networks, requiring higher performance in terms of service provision and throughput. However, traditional single-center mode is prone to business accumulation and difficult to guarantee the service quality. In this paper, we propose a distributed cloud platform access collaborative algorithm, which can guarantee the service quality efficiently.

3. System Model
In this paper, we defines a topological network with a directed graph $G(U, S, E)$, where $u_n \in U$ represents a user with requirement, $s_m \in S$ represents a cloud center and $e_{um} \in E$ represents the link between user $u_n$ and its cloud center $s_m$. $N$ and $M$ respectively represent the number of users and cloud centers in the network. The figure 1 shows the distributed cloud platform access network.

![Figure 1. Distributed cloud platform access network.](image)

It is assumed that each user submits a service request to the cloud platform in the initial stage of each round. The cloud platform allocates the cloud center to each user according to the algorithm reasonably. The system processes the services at the end of the round and restarts the task acceptance in the next round.
4. Access Collaborative Selection Algorithm Based on Multi-objective Optimization

4.1. Optimization Objective

4.1.1 Maximum user experience quality. The locations of cloud centers are different in cloud platform and the response delays of cloud centers for single user are different due to different link distances. Users have subjective experience differences for services provided by system. Compared with the traditional objective quality evaluation of network performance, the user experience quality is introduced to quantize subjective feelings. We select the average opinion score model (Mean opinion score, MOS) commonly used by international standards organizations in table 1 as the subjective evaluation indicator[9]. It can divide the user's subjective feeling into 4 levels.

| MOS value | User experience quality |
|-----------|-------------------------|
| [1,2)     | Very dissatisfied       |
| [2,3)     | Dissatisfied            |
| [3,4)     | Satisfied               |
| [4,5)     | Very satisfied          |

Experience qualities of users are consistent with their subjective feelings. The experience quality is improved when the response delay is low, but it doesn’t increase when the response delay reaches minimum threshold. Similarly, the experience quality will reach a minimum value when the response delay reaches to maximum threshold, which means very dissatisfied with the service provided by the cloud platform. The response delay is positively related to the distance between cloud center and user. According to link distance, experience qualities of users can be calculated as follows:

$$MOS_n(d_n) = \begin{cases} 
1 & d_n \geq d_{\text{max}} \\
\frac{\alpha}{d_n + \beta} & d_{\text{min}} \leq d_n \leq d_{\text{max}} \\
4.5 & d_n \leq d_{\text{min}} 
\end{cases}$$

(1)

where $d_n$ is the link distance of user $n$, $d_{\text{min}}$ and $d_{\text{max}}$ are respectively minimum and maximum distance threshold. $\alpha$ and $\beta$ can be calculated by $MOS_n(d_{\text{max}}) = 1$ and $MOS_n(d_{\text{min}}) = 4.5$, where $d_{\text{min}}$ and $d_{\text{max}}$ can be set according to actual requirements. Hence, average experience quality can be calculated by formulate (2), where $MOS_{\text{max}}^n$ is the highest user experience quality of user $n$ under the current cloud center distribution.

$$u_n = \frac{1}{N} \sum_{n=1}^{N} \frac{MOS_n(d_n)}{MOS_{\text{max}}^n}$$

(2)

4.1.2 Maximum load balance of cloud centers. In order to ensure the load balance of cloud centers in the distributed cloud platform access collaborative selection scheme, we use formulate (3) to quantize the cloud load balance.
where \( I_m = \sum_{n=1}^{M} l_n | n \in U, e_{mn} \neq \phi \) and \( l_n \) is the traffic of user \( n \).

4.2. Access Collaborative Selection Based on Multi-Objective Optimization

Based on these two goals of maximizing average user experience quality and balancing cloud load, the comprehensive benefit of cloud platform when users choose different cloud center can be calculated as follows:

\[
B_{nm} = \xi u_1 + (1 - \xi) u_2
\]

(4)

where \( B_{nm} \) is comprehensive benefit of cloud platform when user \( n \) choose cloud center \( m \). \( u_1 \) and \( u_2 \) are respectively average user experience quality and cloud load balance of cloud centers when user \( n \) choose cloud center \( m \). \( \xi \) is the synergy degree between these two goals and can be calculated as follows:

\[
\xi = \frac{e(U_1)}{e(U_1) + e(U_2)}
\]

(5)

where \( e(U_1) \) and \( e(U_2) \) are respectively the entropy of the experience quality and cloud center load of all networked users when user \( n \) choose cloud center. We quantize the cooperative state of network performance through Shannon entropy. The access collaborative selection based on synergy degree can measure the comprehensive performance of the network from users and the cloud platform side in order to avoid "cask effect" [10].

5. Simulation and Results

The algorithm is simulated by MATLAB in this paper. The simulation parameters are shown in table 2. The users are randomly distributed in the simulation area. Three fixed cloud centers are responsible for processing all services. All users in each round make business requests to the system. The average user experience quality and cloud center load variance are used as performance indicators to evaluate the effect of the algorithm. The simulation results are as follows:

**Table 2. Simulation parameters.**

| Simulation parameters | Value |
|-----------------------|-------|
| Simulation area       | 200m×200m |
| \( Sink_1 \)          | (100,175) |
| \( Sink_2 \)          | (50,50) |
| \( Sink_3 \)          | (150,50) |
| User number           | 100   |
| \( d_{min} \)         | 20 m  |
| \( d_{max} \)         | 80 m  |
Figure 2. Cloud load variance comparison.

Figure 3. Average user experience quality comparison.

MOOAA is compared with the RAA algorithm on the above two indicators. In the RAA (Random Access Algorithm), the system randomly assigns cloud centers to all users. It can be seen from figure 2 and figure 3 that the cloud load variance of the MOOAA algorithm is lower than the RAA algorithm, but its average user experience quality is higher than the RAA and is very stable. This is because each user randomly selects a cloud center without considering user experience quality and cloud load balance. However, MOOAA algorithm considers the average user experience quality and cloud load balance when selecting the cloud center. Using multi-objective optimization, it can ensure service quality while balancing cloud centers' load. Hence, MOOAA can effectively balance load of distributed cloud platform while providing reliable services and optimize system performance.

6. Conclusion

This paper establishes a distributed cloud platform model based on the actual construction and application background of the State Grid 95588. In addition, we proposed a distributed cloud platform collaborative access algorithm based on key factors affecting the performance of the distributed cloud platform. Considering the service quality and the load balance, the optimal access scheme is obtained through MOOAA. Distributed cloud platforms have become the mainstream trend of large-scale cloud construction and multi-center load balancing and user service quality assurance are particularly critical. The overall experimental results are reasonable and have certain practical value.

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