Architecture Design of Resource Support System for the Rail-Water Intermodal Transportation Cloud Platform

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Abstract. Due to the unbalanced development of intermodal information development in different regions of China, the rigid structure of resource system and the low degree of information sharing, the development of intermodal transportation informationization is restricted to a large extent. According to the architecture design of the rail-water intermodal transportation cloud platform, this paper reconstructs the traditional IaaS and PaaS architectures, and establishes a multi-area redundant architecture, so that these virtual resources can form an organic whole in the cloud and interact with the intermodal organizations. At the same time, the direct coupling between the hardware infrastructure and software of the "chimneys" system architecture are eliminated by using the layered structure based on the virtualization technology. The resource support system can reduce the use cost of information, strengthen the management efficiency of software and hardware resources of cloud platform and a large number of heterogeneous business applications.

1. Introduction

With the proposal of The Belt And Road Initiative in China, the role of rail-water intermodal transportation in the field of logistics is becoming more and more important. Although the current rail-water intermodal cloud platform has realized the common facility virtualization and application management architecture, it does not consider the dispatch of server resources on demand allocation, resulting in a large amount of waste of resources, which makes poor overall performance of the server. Therefore, many scholars focus on how to design an overall structure of the rail-water intermodal transportation cloud platform correctly. As the basic service layer, the resource support system plays an important role in the architecture design of the cloud platform of rail-water combined transport.

Therefore, through infrastructure virtualization technology, we improve the overall utilization of IT resources. Based on the mechanism of on-demand allocation of computing resources and the core concept of "maximum utilization of resources" of cloud computing, the traditional IaaS and PaaS architectures are reconstructed with container cloud being as the center. A three-tier system including infrastructure layer, core layer and operation and maintenance management layer is designed. The hardware resources and software applications are virtualized by infrastructure layer and core layer respectively. We propose a redundant mechanism which bring the offsite disaster tolerance center in the rail-water intermodal transportation cloud platform and isolate the different types of intermodal transportation applications logically, so as to form a unified cloud information interaction mode. The establishment of a flat operation and maintenance system which adapted to the horizontal division of virtual resource management model improves the degree of automation, effectively improves the operational efficiency of intermodal transportation applications and provides intermodal transportation...
application and data infrastructure services for the business layer so as to solve the problems in the process of rail-water intermodal informatization by using single virtualization method, improve the management efficiency of business applications and adapt to the environment of heterogeneous seriously intermodal transportation applications.\cite{1,2}

2. The architecture design of the resource support system

Since most of the current cloud platforms only provide users with a single virtualization medium, the management efficiency of IaaS service based on virtual machine is relatively low. Besides, PaaS service, which is completely encapsulated in the development and deployment environment, can only support a limited software architecture and cannot adapt to the heterogeneous multimodal application environment. Resource support system, as the basic service layer, needs to manage hardware resources such as servers and network facilities for the lower service layer and heterogeneous combined transport applications for the upper service layer.\cite{3,4}

2.1. Resource support system

We propose to reconstruct the traditional IaaS and PaaS architectures with using cloud container as the center. Firstly, IaaS virtualization technology is adopted to integrate the physical nodes scattered in multiple data centers into a huge virtual resource pool, and build a virtual cluster environment based on that. Then, hybrid resource virtualization is adopted to standardize and package resources, and a unified resource management environment is established on it. It can provide cross-regional continuous integration and automatic operation and maintenance for a large number of heterogeneous multimodal transport business applications, and provide multimodal transport applications and data infrastructure services for the business layer. The architecture is designed as Figure 1:

![Resource Support System Framework of Intermodal Cloud Platform](image)

Figure 1. Resource Support System Framework of Intermodal Cloud Platform.

2.2 Layers of resource support system

As shown in the figure 1, the resource support system is mainly divided into three layers, including the infrastructure layer, the core layer and the operation and maintenance management layer, which are described in detail below.

1) Infrastructure Layer (IL): Provides virtual machine services. Hardware facilities of cloud room are abstracted to form a virtual resource pool, providing shared resources allocated according to requirements such as computing, storage, network and security.
(2) Core Layer (CL): Provides unified application virtualization services for the business layer, adopts standard image to encapsulate the intermodal application and dependencies, and hides the complexity of hardware and software virtualization by shielding the application heterogeneity through the Abstract Runtime Environment (ARE). The CL layer provides general IaaS/CaaS services upward encapsulating the IL layer.

(3) Operation and Management Layer (OML): Provides application management services and integrated PaaS services with IaaS and CaaS to the business layer through service interfaces such as unified authentication, resource allocation, system continuous integration, capacity scalability and mirroring management.

From the perspective of component composition, the IL layer adopts mature OpenStack to build IaaS services, and virtualizes server hardware into virtual machines to realize infrastructure sharing and on-demand distribution. By further abstracting and standardizing IaaS computing resources, computing resources at the CL layer ARE divided into virtual machine (VM) and Container (Container) to manage three kinds of combined applications: application service system, data processing system and legacy business system. Among them, Kubernetes realizes the arrangement management of the application service system, Chronos realizes the scheduling management of the data processing system, and Mesos completes the related resource allocation and distributed task scheduling. For legacy business systems that cannot be containerized, we adopt virtual machine encapsulation. These three kinds of system by the Consul framework for service registration and discovery and consumption. Through the intermodal application management environment, continuous integration, monitoring and authentication components, the PaaS management environment in OML is formed to meet the requirements of the intermodal application.

3. Virtual resource pool of resource support system
Virtual resource pool is the abstraction of the resource support system for the management resources. We use the infrastructure layer and the core layer to virtualize the hardware resources and software applications respectively and finally forms a hybrid resource pool environment combining virtual machines and containers to meet the differentiated demand of heterogeneous applications for resources, as shown in figure 2:

![Virtual Resource Pool Design for Resource Support System](image-url)

**Figure 2. Virtual Resource Pool Design for Resource Support System.**
As shown in figure 2, virtual resource pool is divided into six parts, including storage resource pool, security resource pool and mirror resource pool, which are described respectively as follows:

1. Calculating resource pool
The computing resource pool is not only responsible for the allocation and sharing of computing resources, but also provides facility protection for the migration of legacy intermodal business applications. Its core is Nova component of OpenStack and key technology is based on server virtualization. Through the establishment of virtual hardware environment, it can be distinguished from physical hardware, and achieve the compatibility of multiple operating system instances in unified hardware.

2. Container resource pool
Based on Docker, container resource pool provides packaging standard and operating environment for packaging intermodal information system, stores and uses the business system in the standard container image mode. These images form the container cloud environment under the scheduling of scheduling system, provide lightweight cloud service which is more suitable for service system than VM.

3. Storage Resource Pool
With the help of the storage resource pool, the physical storage medium can be reasonably controlled and data block scheduling can be carried out under the condition of equipment abstraction. The logical attributes of the equipment are preserved, while the physical attributes no longer exist, which finally enables the storage system to achieve unified and centralized management.

4. Network Resource Pool
Network resource pool is a software-defined network exchange architecture formed by using virtualization technology, including virtual machine network layer and container network. The construction of the virtual network is divided into two kinds of patterns which are vertical cutting and horizontal network integration. Separation of business, data, storage network and isolation among tenants belong to the vertical network cutting pattern, while the communication between application systems belongs to the horizontal network integration mode. The network resource pool adopts the Neutron VxLAN network mode to realize the separation of IaaS functional networks, and adopts the Overlay network of Mesos and Kubernetes to realize the tenant network separation and data communication between application systems.

5. Secure Resource Pool
It needs to meet the three requirements of network communication security, computing resource security and access control at the same time. In the aspect of network communication security, the category of virtual firewall is defined, so that the physical firewall device can realize the transformation of logical firewall. In the aspect of computing resource security, Docker uses CGroup namespace to achieve resource isolation between containers on the same virtual machine. In the aspect of access control, we adopt the existing cloud facility access control scheme.

6. Image resource pool
An image pool is a repository of virtual machines, components, and applications. According to the requirements on the environment of heterogeneous applications, it is divided into two parts: virtual machine image pool and container image pool. The virtual machine image is managed by Glance and stored by Cinder. Container image can be divided into public image and private image. The public image repository provides the basic image of operating system and public service components, and the private one manages all application images.

4. Redundant architecture of the resource support system
With the increasing complexity of software system and the extensive deployment of distributed applications, the operating environment of software becomes more and more complex, and the reliability of operating environment must be achieved through the redundancy of resources. Whether application cannot be accessed due to software and hardware failure, or due to a large number of concurrent business resulting in slow response, will affect the normal intermodal business. [56]
Most of the current "chimney" architecture adopts the hardware-based redundancy architecture of primary and standby servers. In case of failure, the availability of the system can be solved to some extent through routing switch. However, the hardware-based redundancy method not only consumes a lot of resources, but also cannot solve the problem of service unavailability when the equipment fails in the machine room. In addition, when the server performance bottleneck occurs, the hardware facilities must be extended. The performance bottleneck cannot be handled in a short time, leading to the decline of service quality [7,8]. Even in the distributed environment, the redundancy of hardware facilities in a single computer room or even a single area of multi-room hardware cannot guarantee the reliability of application services under the force majeure.

In order to ensure high availability of applications, it is necessary to establish a multiregional redundant architecture. We put forward introducing Remote Center that allows disaster to occur into redundant mechanism of rail-water transportation cloud platform, in order to make full use of the flexibility of virtual resource management, and improve the reliability of application service and fault tolerance. Therefore, the redundant architecture of the resource support system needs to simultaneously manage the virtual pool resources built by the physical server cluster based on multiple cloud computer rooms and the disaster recovery resources of the remote disaster tolerance cloud. The design is shown in figure 3:

![Figure 3. Redundant architecture of the resource support system.](image-url)

The redundant structure of the resource support system can be divided into two logic zones: primary and backup. The primary zone manages multi-room mutual master backup mode. The Remote Center, are generally commercial cloud platforms with high reliability. When the main area fails or the service pressure is too high, resulting in the unavailability of the service or the request response time is too long, the resource support system can be rapidly configured in different places, start or add service nodes, and...
at the same time, the requests in the main area will be shunted and redirected to the standby area, so as to ensure the high availability of the service.

5. Conclusions
Based on the analysis of current existing problems in the architecture of the resource support system for the rail-water intermodal cloud platform, this paper proposes the new idea of resource support system architecture. Combining the core technologies and concepts of virtualization technology and multi-area redundant architecture, the resource support system is optimized by using container cloud technology. The reconstructed resource support system can improve the application environment of intermodal transportation with serious heterogeneity, solve the problem of service unavailability, and effectively improve the application efficiency of intermodal transportation.

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