Design and Implementation of School Ticket Ticketing Service Platform Based on Kubernetes Container Self-Scalable Technology

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Abstract. The current system of line colonel tickets booking in colleges and universities is not able to predict the high and low peak of student booking flow in time, which leads to the unreasonable allocation of computer resources. In order to optimize the online booking experience of campus students, this paper proposes a design scheme of the school bus ticket booking service platform based on Kubernetes container self-expanding technology. The experiment shows that the platform can monitor and predict the booking situation of students, timely respond to the high and low peak period of student booking on campus, ensure the smooth experience of students booking online, which reflects the advantages of the platform.

1. Introduction
On the one hand, with the development of Internet technology, the mainstream way of buying college tickets has also changed from offline to online. However, due to the continuous expansion of the scale of college students, the problem of high and low peaks of student travel has gradually become prominent[1], which has attracted extensive attention from researchers. The php-based campus shuttle bus management system proposed by Zhao ChenFei [2] and the BP neural network passenger flow prediction model proposed by Zhang GuoSheng [3] still fail to solve the problem of high and low peak of school ticket reservation.

On the other hand, compared with the traditional virtual machine technology, the cloud computing technology based on docker virtualization technology[4] is more lightweight and more flexible. As an open source advanced container engine, docker is more simple and convenient in the development, release and deployment of applications. Kubernetes[5], as an open source Docker container scheduling engine, supports automatic deployment, large-scale scalability, application containerization, service self-inspection and recovery and other container management functions, which can improve the utilization rate of computer resources and elastic expansion ability.

Based on these two considerations, this paper proposes a design scheme that combines the application system of school ticket booking service with container technology and kubernetes, and turns the application originally deployed on the server end into the cloud, so as to improve the adaptability of the platform to drastic business fluctuations and the intelligent booking experience of students.
2. Platform Design

2.1. Platform Architecture Design

The school bus ticket booking service platform is a design idea that combines the school bus ticket booking service application system with container technology and Kubernetes. It is based on the server and network equipment based on the Linux kernel, and is supported by the docker as the underlying foundation. The Kubernetes container management platform is used as the base. The foundation is redeveloped to achieve system application load balancing, elastic scaling, error handling and other functions. At the same time, Jenkins is used to manage the platform continually and automatically, Prometheus is used to monitor and control the server in real time, to provide monitoring statistics for the server, pay attention to the running state of the cluster in real time, and visualize the monitoring state through Grafana. Web UI provides a complete business development and platform operation and maintenance function experience, which is applied to the school ticket booking service system. Finally, through the display of mobile phones, computers, tablets and other terminals, it can quickly launch business and improve the information service level of campus tickets.

The overall structure is shown in Figure 1.

![Figure 1. Overall architecture of the platform](image-url)
2.2. Platform Function Design
Through the analysis of the demand of the school ticket platform, it is concluded that the platform is mainly composed of two functions: student booking module and ticket management.

The functional analysis of the platform is shown in Figure 2.

![Figure 2. Platform function analysis](image)

2.2.1. Student Booking Function.
The student booking module is for students to log in and use, including four sub-functions of user information, train inquiry, ticket processing and my order.

- **User information**
  Students log in to the school bus ticket booking platform by logging in the school number and password of the educational system to view the personal data imported by the school student database, including student name, student number, college, professional class, mobile phone number, ID number, etc. No need to fill in personal information, if the personal information is wrong, they can authorize the change after making an application to the relevant department of the school. In order to further protect the information security of students, students can directly modify the login password.

- **Train inquiry**
  After the students enter the platform, they can view the schedule of the trains today and the next four days through the announcement information of the platform. At the same time, they can also query the trains with the time and place as keywords according to individual needs.

- **Ticket processing**
  Ticket processing is the main function of the platform, including the operation of the logged-in user to make reservations, unsubscribe, change and online application.

- **My order**
  My order function enables users to query past orders and unpaid orders, as well as timely payment or cancellation of unpaid orders.

2.2.2. Ticket Management Function.
The ticket management function is available for administrators to log in, including two sub-functions: management function and statistical analysis.

- **Management function**
  After logging in to the platform with an administrator account, the platform administrator has the right to add, delete, change, and check all the train information in the platform.

- **Statistical analysis**
  The administrator can inquire the ticket amount and total amount of the train.

2.3. Platform Key Technology Design
The platform's real-time monitoring, dynamic prediction and service are the advantages of the current server-based school ticket system, and it is also the embodiment of the key technology to optimize
students' online booking experience. The implementation process is: The Pod is used to load the booking system application, and the original pod and the pod copy constitute an external service for the entire application system. The service request is distributed to the pod set, and the user's request can be distributed to each pod instance to reduce the waiting time of the service queue. At the same time, the time for requesting the response of the user can be reduced, and the experience of the online booking of the user can be optimized. At the same time, Kubernetes controls the number of copies of the pod set through the Replication Controller, and increases the pod copy when the student booking request peaks to ensure that the server does not crash. The low peak of the booking request is to reduce the number of pods and avoid resource waste, thereby realizing the effective use of resources. The overall key technology module [6] includes monitoring module, state analysis module, prediction module and scaling module. The overall architecture of key technologies is shown in Figure 3.

![Figure 3. Key Technology Overall Architecture](image1)

![Figure 4. performance data diagram of real-time monitoring](image2)

2.3.1. Platform Monitoring Module. The monitoring module is mainly based on the implementation of the Kubernetes monitoring solution "Heapster+influxDB+grafana". Heapster first obtains information about all Nodes in the cluster from the K8S Master, and then obtains useful data through the kubelets on these Nodes, while the data of the kubelet itself is obtained from cAdvisor. All acquired data is pushed to the back-end storage of the Heapster configuration, and data visualization is also supported. Now backend storage and visualization methods like InfluxDB + grafana.

2.3.2. State Analysis Module. The state analysis module is mainly used to determine the prediction time, that is, how long the prediction model needs to predict the load change. The workflow is: first obtain each pod information in the replica set through the label of the state analysis module replica set, and then analyze the state of each pod. For the pod that is initialized in the replica set, calculate its initialization time, and finally calculate the average initialization time of the replica set as the predicted time.

2.3.3. Platform Prediction Module. The prediction module is responsible for predicting future load changes for the pod replica set. The prediction module obtains the load data of pod replica sets from the monitoring module and saves them to form the historical load data. Then, the prediction time is calculated according to the state analysis module. The combination model of grey-exponential smoothing is used to model the historical load data and predict the load change of the replica sets in the next stage.

2.3.4. Platform Expansion Module. The scaling module is responsible for calculating the expected number of copies. Kubernetes' automatic scaling service[6] is to periodically check the load status of
all copies in the pod copy set through the automatic retractor HPA (Horizontal Pod Autoscaler), and automatically adjust the number of copies. If the true value is less than the expected value, the capacity is expanded; if the true value is greater than the expected value, then reducing the capacity of the cluster while improving the quality of the application service. This process does not require human intervention, and is more applicable to scenarios with dynamic load changes.

3. Platform Implementation and Application
The school bus ticket booking platform is mainly composed of two modules: the student ticket booking module and the ticket management module. The system has realized its preconceived function. Due to the limitation of space, the implementation interface of the main functions of the platform is introduced here.

The student registration number and initial password of the school ticket booking system are the same as the way of login to the school educational administration network. The password can be changed after one login. After entering the system, students can browse the school bus shifts and also query the shifts.

In addition, the pod's CPU, memory, network, filesystem, uptime and other related performance data are displayed through visual tools, and the results are shown in figure 4.

4. Superiority Analysis
Combined with the current mainstream school ticket service platform to compare, the system has the following three advantages.

- **Platform management is convenient and more reliable**
  The system utilizes Kubernetes' automatic layout, automatic restart, automatic copying, and automatic scaling to realize application status check and self-repair to realize load balancing and fault self-healing functions, which can avoid service stoppage due to server downtime, physical disk damage, etc. The phenomenon guarantees the reliability and continuity of the service.

- **Real-time monitoring to ensure the accuracy of the service**
  The real-time log monitoring of the school ticket ticketing service platform provides monitoring statistics for the server. In the Kubernetes cluster, node-exporter, Prometheus, and Grafana are used to monitor the cluster, and the cluster's running status is monitored in real time to solve problems that may be encountered in time.

- **Simplified Web UI interface to improve user experience**
  When viewing the data of student booking, the administrator can directly observe the utilization status of computer resources through the intuitive dynamic statistical graph of the Web UI, so as to reduce the learning cost and provide humanized platform operation and maintenance function experience.

5. Summary
In this paper, the platform is a good solution to the current college students booking school tickets peak problem of school bus management information service level and service quality. However, there are some problems such as response delay and capacity enlargement delay in automatic scaling. The school ticket booking service platform developed in this paper has certain reference significance for the school bus management of colleges and universities in China, as well as for the design of road, railway and civil aviation booking systems.

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