ISSN 2616-5767 Vol.6, Issue 6: 1-4, DOI: 10.25236/AJETS.2023.060601

Design and Implementation of IP Address Management System for Universities

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Abstract: *This article aims to explore the problems of IP address management in universities and propose a feasible solution. IP address management in modern universities has attracted much attention in network construction, especially as the scale of universities continues to expand and the number of network devices on campus increases, making the allocation, management, and use of IP addresses complex and difficult. At the same time, security issues such as malicious attacks and illegal use also pose a serious threat to the stable operation of university networks. Taking China University of Geosciences (Beijing) as an example, this paper proposes a B/S-based IP address management system solution. Through the implementation of this system, the automation of IP address resource management is achieved, the efficiency of IP address allocation, management, and use is improved, and the stable operation of campus networks is ensured.*

Keywords: *IP address, Campus network, Management system*

1. Introduction

With the continuous development and popularization of Internet technology, universities have become one of the important areas of information construction [1]. In the digital era, computer networks have become an indispensable part of universities. However, with the continuous expansion of the scale of universities and the increase of network equipment, the IP address management of universities has become increasingly complex and difficult. The vast majority of higher education institutions in China are connected to the China Education and Research Computer Network, and IP address resources are relatively abundant. Many universities have dozens of Class C address segments. However, with the continuous expansion of the scale of universities and the increase of network equipment, IP address allocation, management, and usage have become increasingly complex and difficult [2]. In addition, due to the aggravation of network security issues such as malicious attacks and illegal usage, the stability and reliability of university networks have been seriously threatened [3]. Therefore, establishing a scientifically reasonable, efficient and convenient IP address management system to achieve automated management of computer network system IP address resources has become an urgent problem in the information construction of universities and a development trend of IP address management under new circumstances.

2. Current Situation and Problems

China University of Geosciences (Beijing) is a key comprehensive university. With the continuous expansion of the school size and the increasing number of network devices, IP address allocation, management, and usage have become increasingly complex and difficult. Currently, the university has 80 Class C Internet IP address segments, and while the IP address resources are relatively abundant, there are still some prominent issues in their actual usage and management.

2.1. In Terms of IP Address Allocation

Firstly, there are a series of laws and regulations in China regarding the allocation and management of IP addresses, such as the "Administrative Measures for Internet Information Services" and the "Administrative Measures for Internet Network Address Resources Management", which have made clear requirements for the reasonable allocation, management, and supervision of IP addresses. Therefore,

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the campus network management agency needs to register relevant information when allocating IP addresses. To this end, our university has established its own rules for the management of internal addresses, and users are required to fill in corresponding information forms when applying for addresses. However, due to the large number of addresses allocated in the campus network, it has become increasingly inconvenient to manually record the information and document the campus network IP resource information, which has resulted in a low utilization rate of IP address resources and low query efficiency.

Secondly, in the allocation of IP addresses in the university, some departments and laboratories often apply for a large number of IP addresses, but the actual usage is insufficient, leading to serious waste of IP address resources. At the same time, some important departments and laboratories do not receive enough IP addresses, which can affect the good support of their networks.

2.2. In Terms of IP Address Security

IP addresses represent the identity of a computer on a network and are a necessary condition for its normal use on the network. Therefore, the security of IP addresses cannot be ignored. Manually managing IP addresses can lead to address duplication, which can cause conflicts in the network and affect normal network operation. Traditional IP address management involves network administrators manually assigning and maintaining IP addresses, but due to human interference, problems such as unreasonable allocation, conflicts, and abuse of IP addresses are easily encountered, which have a huge negative impact on network billing, security, and operation [4].

3. System Design

To address the series of issues in the management of campus network IP addresses, and make full use of campus network resources to improve work efficiency, an IP address management system based on the B/S (Browser/Server) mode has been developed.

3.1. Technical Roadmap

As shown in Figure 1, the system adopts a front-end and back-end separation architecture. The front-end uses Vue.js as the main development framework and Element-UI and other component libraries for interface design and development, and uses Webpack to package and compress front-end resources. The back-end uses the Spring Boot framework to build RESTful API services, uses MyBatis for persistence operations, and introduces the Spring Security framework for security assurance. The system's database uses MySQL for data storage and management, and uses Redis as a caching service to speed up system access. For identity authentication, the system uses JWT (Json Web Token) for user authentication and authorization, which improves system security and user experience, and has good maintainability and scalability.

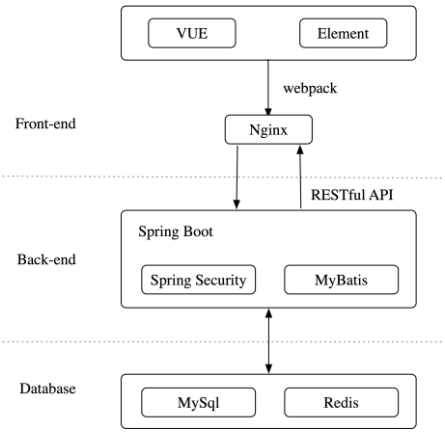

Figure 1: Technology Architecture

3.2. System Functions

The functional module diagram of the IP address management system, as shown in Figure 2, mainly

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includes eight basic modules: IP address registration application, system management, MAC address management, etc.

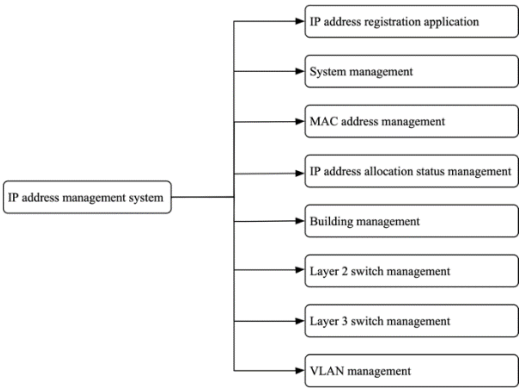

Figure 2: Functional module diagram of IP address management system

IP address registration application: Users can fill out the application form for a fixed IP address online by themselves. They only need to submit the MAC address of the device and the information of the room where it is located. The system will automatically plan and allocate IP addresses. The system can also control the usage period of IP addresses. After the IP address expires, it will be automatically disabled. By integrating with the email system and SMS system, the system can automatically send reminder messages to users before the IP address expires.

System management: This system is used to manage some basic information, mainly including system initial settings, system administrator management, system login logs, and data backup.

MAC address management: includes functions such as IP address planning, binding, unbinding, recovery, MAC address disabling, and enabling. After the user submits an IP address application, the system searches the corresponding IP address range and port information in the database based on the user's room location, and generates an automatic binding command to complete the binding of IP address, MAC address, and port. When a device of a campus network user is infected with a virus or other malicious software, affecting the normal operation of the network, the MAC address disabling function can be used to isolate the infected device, and the user can be notified to perform virus removal through SMS notification. Every year when students graduate, a large number of IP addresses need to be recovered. The system is docked with the school's data center to achieve batch IP address recovery, thereby improving the recovery efficiency and reducing management workload.

IP address allocation status management: Implement the IP status information query function, which is convenient for administrators to check whether the IP address is available.

Building management: mainly used to manage information such as buildings, floors, and rooms.

Layer 2 switch management: mainly used to manage layer 2 switches, establish the relationship between ports, rooms, and VLANs.

Layer 3 switch management: mainly used to manage layer 3 switches, save device locations, corresponding VLANs, and management passwords.

VLAN management: mainly used to manage VLANs, establish relationships with layer 3 switches and assignable IP address segments.

3.3. Prevention of IP Address Hijacking Design

IP address theft is a common problem in the field of network security [5]. When an IP address is stolen, hackers or unauthorized users can use it to access other computers or services on the network, which can lead to confidential information leakage, abuse or destruction of network resources, and even more serious network security issues.

To prevent IP address theft, the system can adopt two methods for management and control. Among them, the IP address and MAC address binding is a common method that can automatically bind a specific IP address with its corresponding MAC address. This method requires devices that support Layer 3 switching functions to implement, such as Huawei, H3C, Cisco, and other brands of Layer 3 switches. This method can to some extent prevent IP address theft, but if the user simultaneously modifies both the

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IP address and MAC address, it cannot be controlled.

Another way is to bind MAC addresses with switch ports, which is commonly used in layer 2 switch devices. By binding a specific MAC address to a designated switch port, this address can be restricted to only communicate through that port. However, this method requires disabling the dynamic learning function of the switch port and only allowing computers with static MAC binding to pass through. Although this method strictly limits MAC addresses, if a user connects to the internet using a computer that has already been authorized with a MAC address, they can still steal someone else's IP address. Therefore, combining IP+MAC binding with MAC+port binding can more thoroughly solve the problem of IP address theft.

By using the above two IP security control methods, not only can IP address theft be prevented, but also unallocated and expired IP addresses can be automatically locked and prevented from being used. In addition, when a computer is infected with a virus or there is a human hacker activity in the network, the IP address control function can be used to directly cut off the network connection of that address, thereby protecting the security of other computers.

3.4. Automatic IP Binding Technology

In order to prevent IP address theft, network administrators often use various binding strategies. However, manually binding each device's IP address is a time-consuming and laborious task, especially when managing a large number of IP addresses, which can lead to confusion and errors in management [6]. To solve this problem, we use an automatic binding technology. The system reads room and port information from the Layer 2 switch module, reads user room and device MAC information from the user application records, and automatically binds the system-planned IP, Layer 2 switch port, and user device. This automated binding method not only greatly reduces the workload of administrators but also enhances the controllability of information. Administrators can fully understand the security control of all IP addresses, make adjustments and modifications at any time, without complex manual operations. The use of this technology can greatly improve management efficiency and accuracy, as well as effectively prevent IP address theft and abuse, thereby ensuring the security and stability of the network.

4. Conclusions

Currently, the IP address management system at China University of Geosciences (Beijing) manages over 20,000 IP addresses. Among them, about 7,000 IP addresses have implemented IP+MAC binding, and about 2,000 have implemented MAC+Port binding. The system has been running stably. By automating the management of IP addresses, the IP address management system reduces human interference, improves the rationality and security of IP address allocation, and increases work efficiency, allowing campus network resources to be more fully utilized. In this article, a university IP address management system was designed and implemented. By analyzing the current situation and problems of IP address management in universities, a B/S architecture-based solution was proposed, which achieved effective management and use of IP addresses while ensuring network security. The system has practical and promotional value, and provides an effective solution for other universities' address management. In future applications, the system's functionality can be further optimized and expanded to improve its applicability and performance, better meeting the needs of campus network IP address management.

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