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Optimization of Resource Scheduling for Multi Tenant Advertising Systems

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Abstract: We are developing an advertising system on SaaS platforms for the entertainment industry, with a focus on solving the problem of multi tenant resource scheduling. From 2017 to 2019, the global entertainment industry grew rapidly, and SaaS became a key support for digital transformation due to its low cost, high security, and flexible customization. But the old system has many flaws - single functionality, insufficient reputation evaluation models, and inability to keep up with resource scheduling. We used the fuzzy analytic hierarchy process to establish a tenant reputation evaluation system, scoring each tenant. Then, by combining Min2 dynamic adjustment and cyclic queue strategies, resource allocation can be optimized. The system integrates modules such as finance, data statistics, and tenant information management. The third mode of data isolation is MySQL read-write separation combined with Redis caching, which ensures security and improves access speed. The test results are okay. All functional modules can run smoothly, and performance tests show an average response time between 158 and 258 milliseconds. The throughput is 329 to 471 times per second, and the error rate does not exceed 0.52% for 1000 to 3000 concurrent threads. The resource scheduling strategy has increased the overall hit rate, reduced operating costs, and basically met SLA constraints.This mechanism can adapt to the dynamic changes of tenants and provide some practical reference for advertising resource scheduling on SaaS platforms in the entertainment industry.

1. Introduction

In the digital age, the entertainment industry presents significant characteristics of networking and digital development. In 2017, the global output value of the pan entertainment industry was about 560 billion yuan and maintained a year-on-year growth rate of 32%. By 2019, the industry's average annual compound growth rate reached 6%, ranking among the top in the global media and entertainment industry growth rate. The SaaS model[1], with its low cost, high security, and flexible customization features, gradually replaces traditional management systems and becomes the core support for the digital transformation of the entertainment industry; Its key application - multi

tenant management system[2], achieves efficient allocation of tenant resources, data security isolation, and reduced operation and maintenance costs through shared infrastructure and on-demand customization capabilities, which is of great value in promoting tenant digital transformation and healthy industry development. However, although existing research has made progress in SaaS access control (such as RBAC extension model), system module customization (such as HTTP service automation deployment), and multi tenant architecture (such as Google Borg, AWS EC2 isolation mechanism), there are still challenges such as single functionality of traditional management systems, insufficient research on tenant reputation evaluation models, and lack of resource scheduling optimization mechanisms in multi tenant scenarios. To this end, this article focuses on the optimization problem of resource scheduling for multi tenant advertising systems on SaaS platforms in the entertainment industry. The aim is to improve overall hit rates, reduce operating costs, and strengthen SLA constraint satisfaction capabilities through system design (integrating financial management, data statistics, tenant reputation evaluation, and other functions), reputation evaluation model construction (using fuzzy analytic hierarchy process and verifying its effectiveness through empirical verification), and innovative resource allocation strategies (such as min_2 dynamic adjustment and cyclic queue redundant resource management). Its contribution lies in proposing a resource scheduling mechanism that adapts to the dynamic changing scenarios of tenants, improving the performance and cost-effectiveness of multi tenant advertising systems, and providing theoretical support and practical reference for optimizing SaaS platform resources in the entertainment industry.

2. Correlation theory

2.1 Analysis of SaaS Technology Characteristics and Maturity Model

SaaS (Software as a Service) is an architecture technology that provides software services based on the network. Its core features include Internet, multi-user and service. Internet is reflected in that users access the applications deployed in the service provider's cloud server through the Internet, and the network environment, speed and security directly affect the use experience; Multi user support allows multiple tenants to share a software system, and service providers only need to maintain a single application instance, reducing development and operation costs. At the same time, customized functionality can be used to meet specific needs of tenants; Serviceability involves aspects that are not covered by traditional software, such as billing and fee collection, service contract signing, and online service guarantee. The SaaS maturity model is divided into four levels: the first level is customized development, where each tenant corresponds to an independent database and server, physically isolated to ensure high security but with high development costs; The second level introduces configurable attributes to meet the personalized needs of tenants through metadata and other methods, reducing the burden of backend maintenance; The third level adopts a multi tenant architecture, where multiple tenants share software applications. The key is to achieve spatial independence of data resources among tenants; The fourth level is a scalable architecture that improves system scalability through load balancing layers and multi instance deployment. It supports horizontal scaling to cope with large-scale user access, but needs to address the technical challenges of horizontal splitting of database server data. The model gradually strengthens its configurable, high-performance, and scalable capabilities as the level increases, ultimately reducing long-term costs through economies of scale.

2.2 Overview of Multi tenant Storage Architecture and System Development Technology

The core of multi tenant technology is to achieve data non-interference between tenants, mainly

using three storage architectures: independent database mode [3] to configure independent databases for each tenant, which has the best security but high development costs; Shared database - Isolation data architecture isolates tenant data through schema logic [4], supporting multi tenant sharing but complex fault recovery; Shared database - The shared data architecture distinguishes data based on tenant IDs, with the lowest hardware cost and highest degree of sharing, making it suitable for scenarios that require cost savings in development. In terms of system development technology, the SpringBoot framework [5] serves as a backend development tool that simplifies configuration, supports rapid development, and maintains stable performance. It combines annotations and component libraries to improve development efficiency; Redis in memory database, with its high-speed read and write capabilities, is often used as a caching middleware to store hot data, reduce database burden, support multiple data types such as String and List, and optimize system operating efficiency. This chapter summarizes the relevant concepts and technologies involved in the multi tenant management system of SaaS platforms in the entertainment industry, covering SaaS characteristics, maturity models, storage architecture, and development techniques, providing comprehensive technical support for system design and implementation.

3. Research method

3.1 Requirement Analysis of Multi Tenant Management System for Saas Platform in the Entertainment Industry

The entertainment industry SaaS platform multi tenant management system aims to provide tenants with integrated services of informatization, sharing, efficiency, and intelligence. The main participating roles of the system include platform administrators, tenant administrators, financial administrators, and artists. The platform administrator is responsible for permission distribution, the tenant administrator manages enterprise business (such as user and role management), the financial administrator manages platform funds uniformly, and the artist, as the credit evaluation subject, can comment on the tenant. The system functional requirements are refined into five modules through use case diagrams. Tenant information management supports adding, deleting, modifying, querying, searching, password resetting, multi criteria querying, and data backup. Role permission management supports adding, deleting, granting, and revoking roles and permissions, achieving user operation isolation. Financial management includes tenant exit review, delayed exit setting, parameter configuration, reward amount viewing, consumption warning, and account maintenance. Tenant reputation evaluation management supports dimension setting, warning monitoring, evaluation deletion, one click rating update, and score sorting. The data statistics module can view revenue, accounts receivable balance, data overview, export revenue records, and display tenant revenue and operational status through bar charts, line charts, and pie charts. The use case diagram and activity diagram provide a detailed explanation of the operational requirements for each role, forming a complete requirement model and providing a basis for system design and implementation.

3.2 Design of Multi Tenant Management System for SaaS Platform in Entertainment Industry

There are four principles in system design. Function development is guided by customer needs. Modular business decomposition reduces dependencies and facilitates scalability and maintenance. Strictly divide roles and permissions in terms of security, and ensure data backup, transmission encryption, and SQL injection protection. The layered architecture is divided into display layer, control layer, service layer, and storage layer, with each layer having independent responsibilities.The overall architecture of the system adopts a third-party server cluster deployment, and tenants access service instances through browsers or mobile devices to ensure high availability

and security stability. The display layer is built based on the Vue framework to create a user interface; The control layer remotely calls the service layer interface through RPC, relies on the Zookeeper registry to achieve service registration and discovery, and combines with the Spring container to manage object lifecycle; The service layer handles business logic and data interaction, and provides unified configuration and naming services based on Zookeeper; The storage layer adopts MySQL relational database to achieve read-write separation, with the master database responsible for data writing and the slave database responsible for data reading. Redis in memory database[6]is introduced as a caching middleware to store hotspot data to improve query efficiency, while ensuring data storage security through regular disk writes and log records. This architecture achieves efficient operation and flexible scalability of the system through layered collaboration and technology integration.

3.3 Database Design for Multi Tenant Management System

The system adopts MySQL relational database for data storage, strictly following the requirements of database paradigm. The logical structure design clarifies the entity associations such as tenants, roles, and permissions through E-R diagrams, supporting the functions of the five core modules. The core data table of the physical layer constructed includes tenant information (ID, status, contact person), performing arts personnel (type, account, encrypted password), evaluation records (size, weight, timestamp), role permission associations, and financial details (withdrawal records, account balance, income details). Tables are associated through primary and foreign keys. The storage layer uses Redis to cache hotspot data to improve query performance, while also ensuring data security through regular disk writes and logging. The design takes into account query efficiency, storage security, and scalability.

4. Results and discussion

4.1 Tenant Credit Evaluation System and Application of Fuzzy Analytic Hierarchy Process

The reputation of tenants directly affects what kind of artists you can hire, whether customers are willing to spend money, and how people in the industry perceive you. Simply put, a good reputation can make money. We tried to quantify this matter and rate it from the perspectives of "tenants" and "artists". Tenants have four things to consider: whether the venue is clean, whether the artists are satisfied, whether the money is worth it, and whether the service attitude is good; From the artist's perspective, there are two hard indicators: the type of identity authentication (such as regular authentication or yellow V) and the number of tenants who have worked with them in history. These two dimensions can basically reflect credibility and objectivity. The fuzzy analytic hierarchy process is used for reputation evaluation. This method constructs a judgment matrix by comparing indicators pairwise, determines the hierarchical weights through normalization and feature vector calculation, verifies consistency, synthesizes combined weights, and finally combines fuzzy mathematical principles to comprehensively evaluate the reputation score. It effectively handles uncertain factors in the evaluation, achieves systematic and comprehensive quantitative analysis, and provides scientific basis for tenant reputation management.

4.2 Model experiment

The tenant reputation evaluation model is constructed using a combination of Analytic Hierarchy Process and Fuzzy Comprehensive Evaluation Method, with tenant reputation evaluation as the target layer, and a criterion layer (tenant and artist dimensions) as the sub layer. The indicator layer

includes environment, artist satisfaction, cost-effectiveness, service attitude (tenant dimension), certification type, and number of employed tenants (artist dimension). Construct a judgment matrix by pairwise comparing indicators: criterion layer matrix M1 (tenant to artist weight ratio of 0.7520:1), tenant dimension matrix M2 (environment, satisfaction, cost-effectiveness, service attitude weight ratio of 0.9455:1.4650:0.5432:1.5230), and artist dimension matrix M3 (certification type to employment weight ratio of 0.9372:1.0423). The specific data is shown in Table 1.

Table 1 Tenant Dimension Secondary Indicator Weight Judgment Matrix M2

Row\Column	B1 (Environment)	B2 (Artist Satisfaction)	B3 (Cost Performance)	B4 (Service Attitude)
B1	1.0000	0.9455	0.9580	0.9435
B2	0.9344	1.0000	1.4650	1.5230
B3	4.0355	1.6564	1.0000	0.5432
B4	3.0352	0.5560	1.4563	1.0000

The weight calculation adopts the root square method, and the formula is as follows: normalization matrix element [7] $a_{ij} = b_{ij} / \sum_{k-1}^{n} b_{kj}$, eigenvector $w_i = \sum_{j-1}^{n} a_{ij}$, maximum eigenvalue $\lambda_{max} = \frac{1}{n} \sum_{i-1}^{n} \frac{(AW)_i}{w_i}$. The consistency test was validated by CI and CR values, and passed when CR $\leqslant$ 0.1 (e.g. CR=0.056 for M1, CR=0.0442 for M2, and CR=0.0919 for M3 all meet the requirements). The fuzzy comprehensive evaluation process is shown in Figure 1,

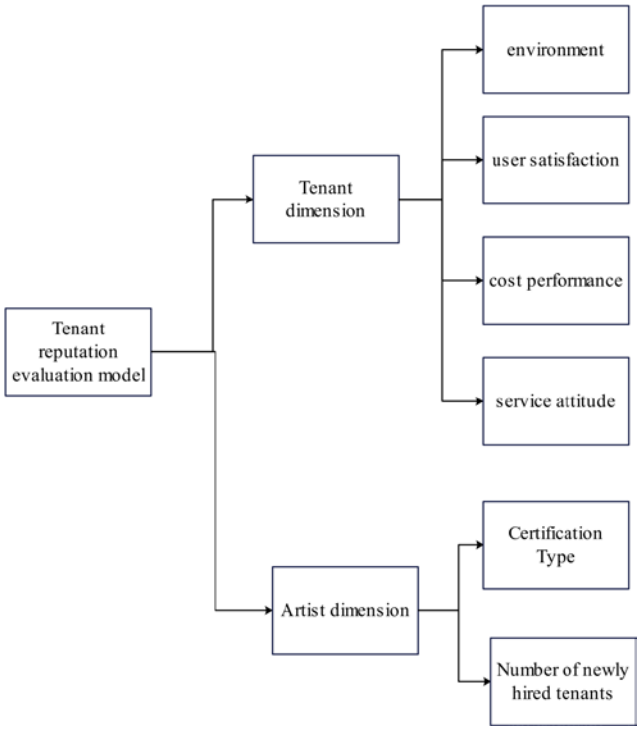

Figure 1 Multi dimensional hierarchical structure model diagram of tenant reputation evaluation

Let the comment set be {excellent, good, average, poor} with corresponding scores [9,7,5,3]. The evaluation result vector B=W • R is synthesized by the fuzzy relationship matrix R and the weight vector W, and the final score Z=B • D^T (D is the score vector).

4.3 Effect analysis

The optimization of resource scheduling for multi tenant advertising systems achieves dual guarantees of functional performance and dynamic resource allocation through system testing, modular design, and efficient development environment. The testing adopts black box technology [8] to cover functional testing and performance testing, verifying the correctness of core modules such as tenant information management, role permission allocation, reputation evaluation, financial audit, and data statistics. The performance testing relies on JMeter to simulate high concurrency scenarios. The login function has a response time of 158-258ms under 1000-3000 threads, a throughput of 329-471 times/second, and an error rate of $\leqslant$ 0.52%. The system uses RoleController and RentUserController to handle role and permission mapping; EvaluateController calculates reputation scores through a fuzzy comprehensive evaluation model; CashAdvanceController manages large/delayed withdrawals and automatically processes when the threshold is reached; Calculate the revenue change rate using IncomeController and SearchController and draw a trend chart. Backend SpringBoot+MyBatis+Redis, frontend Vue, configuration files divided into multiple environments, cache and database are all connected.The tenant management module standardizes the processes of adding, modifying, deleting, searching, and resetting passwords through a sequence diagram, and supports full lifecycle management through interfaces [9]. Combining role permissions and reputation evaluation models, it tilts advertising resources towards high reputation tenants, ultimately achieving optimal allocation and efficient utilization of resources in multi tenant scenarios.

5. Conclusion

The multi tenant advertising system adopts the third data isolation mode, which supports functional collaboration among tenants while ensuring data independence. After comparing the advantages and disadvantages of the three modes, we have determined this solution, which provides a foundation for resource scheduling. The demand phase defines core processes such as tenant information input, password reset, and permission management, and presents business logic through flowcharts to assist in precise allocation of advertising resources. Then, a tenant reputation evaluation index system was constructed, and the weights of the indicators were calculated using the fuzzy analytic hierarchy process. The reputation score was quantified using a fuzzy comprehensive evaluation model to achieve dynamic scheduling tilted towards high reputation tenants. The system architecture design covers the front-end display layer, business service layer, and basic database layer, and improves resource scheduling efficiency through layered collaboration; The database adopts MySQL read-write separation architecture, combined with Redis caching hotspot data, to optimize the speed of advertising data access. In the future, we will optimize the client interface and business logic, improve the collaboration mechanism between system modules [10], enhance concurrent processing capabilities, and ultimately achieve optimal allocation and efficient utilization of advertising resources in multi tenant scenarios.

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