Design and Implementation of Software Architecture for Automotive Green Supply Chain Based on Microservices

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Abstract. In order to realize effective control of green procurement, manufacturing and recycling in the green supply chain of automobiles, an automotive green supply chain software architecture based on micro-service architecture is proposed. This architecture contains data acquisition technology, environmental compliance evaluation technology, hazardous materials and collectible materials collection and analysis technology. The system architecture splits the overall application of automotive green supply chain management into multiple services, and APIs are used for communication and collaboration between services. It has been proved by experiments that the micro-service-based automotive green supply chain software architecture can control, track, analyze and record information on automotive materials and components in real time, and give corresponding evaluation of environmental compliance, and label hazardous substances and recyclable materials. It solves the problems of material data information flow lag, low management efficiency, and inability to flexibly expand the system architecture in the green supply chain of automobiles, and provides an effective vehicle green supply chain management and analysis platform for automobile manufacturers.

1. INTRODUCTION

With the continuous increase of the number of automobiles, the pollution caused by automobile-related industries has become increasingly serious. The environmental resource problems caused by it have attracted great attention from all over the world. Especially in the automobile industry, there are widespread waste of resources and environmental pollution in the production and sales processes. Therefore, the design, production, use and recycling of automotive products with the concept of green development, and promotion of the construction of green supply chain in the automotive field are actually our responsibility for the survival of all mankind. Automobile companies need to take the lead in transferring the concept of environmental protection to suppliers, promoting upstream and downstream linkages, and completing the green transformation and upgrading of the industrial chain.

However, in the face of the increasingly complex and diversified automotive green supply chain ecosystem, the original single-frame application development cannot meet the application requirements for scalability and maintainability, and will lead to a significant increase in demand communication costs during the demand research phase and on-line maintenance, causing problems such as poor maintainability of the stage. Starting from the pain point of developing and implementing
business logic, this paper analyzes and constructs the core system model of automobile green supply chain, designs the micro-service component structure model of automobile green supply chain, and gives RESTFUL API and micro-service register calling method between components based on Spring Cloud micro-service development framework. It also describes the CRUD mode data operation and other programs.

| Enterprise Environmental Violation Record Query (EENVQ) Service | Supply chain Environmental risk Management and Analysis (SCERMCA) Service | Supplier Environmental Information Management and Analysis (SEIMAA) Service | Green Procurement (GP) Service | Energy Efficiency Management And Assessment (EEMAA) Service |
|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|

Pic 1 Car green supply chain demand division

2. System Requirements Analysis
The automotive green supply chain system should include the following subsystems:

(1) Enterprise environmental violation record inquiry subsystem: Due to the complicated structure of the automobile and the relatively long industrial chain, the suppliers and risk information are released on the local government supervision platform, and it is difficult for the automobile manufacturing industry to quickly obtain timely suppliers and the quality risks of its products often cause huge economic losses to the car companies indirectly or directly. Vehicle companies can use a single enterprise search and multiple enterprise batch search methods to query certain corporate violation records. The contents of the inquiry include the name of the enterprise, the reason for the violation of the law, the punishment measures, the amount of punishment, the time of punishment, the source of the data, the feedback of the enterprise, etc, and the safety of the vehicle enterprise is escorted from production.

(2) Supply chain environmental risk management and control subsystem: The enterprise can import the supplier's enterprise list, obtain the supplier's environmental compliance status, and export the supplier's environmental risk assessment report, including the number of suppliers, the number of enterprises involved in environmental violations, and the environmental management certification. In this way, car companies can ask Tier 1 suppliers to investigate the environmental monitoring records or pollutant emissions of secondary suppliers through the platform. By comparison, the purpose of circumventing the environmental risks of the entire industrial chain is achieved.

(3) Supplier Environmental Information Management and Analysis Subsystem: The platform ranks the suppliers according to indicators such as supplier information disclosure level, environmental pollution emission level and environmental related certification status, helping enterprises to assess suppliers' green development level and green procurement.

(4) Green procurement subsystem: Based on the results of green supplier star rating, it provides decision support for enterprise green procurement. At the same time, the procurement process can be carried out online. The purchaser publishes the purchase product information and purchase order information on the platform, and the supplier can add the intention to the interested purchaser and register the purchase order of interest.

(5) Energy efficiency management and evaluation subsystem: The platform provides two functions of energy efficiency assessment and carbon emission calculation. Enterprises can report energy efficiency assessment calculations by reporting energy structure and usage, purchased electricity and steam, and economic indicator data, and generate energy efficiency assessment reports. They can compare the same type of enterprises in the same industry to understand their energy efficiency levels and clear the space for energy efficiency improvement. At the same time, companies can report carbon
emissions by reporting data and generate carbon emission calculation reports for green products and green factories.

3. Microservice Architecture
In the traditional software, application architecture is often a single architecture, as the module and scale of the business continue to expand, the single application architecture will have the following problems.

Code compilation and deployment time is getting longer and longer: Due to the iteration of the version and the improvement of the requirements, the code volume of the single application continues to increase, resulting in a code size of tens of thousands or even hundreds of thousands of lines for a large and medium-sized system. Compiling once takes a few minutes or even ten minutes, and the downtime is also getting longer and longer, greatly reduce the user experience.

Debugging is becoming more and more complicated: the continuous increase in the amount of single-architecture code leads to a lot of redundancy in the code. Debugging a small bug often requires tracking the execution results of many lines of code, and developers are simply unable to start with unfamiliar codes.

The cost of team development collaboration is getting higher and higher: the continuous increase in the amount of code will inevitably lead to more code coupling. The dependencies between the code are more and more complicated. Frequently repairing a line of code leads to problems in many functions. The entire development team has to stop the ongoing developments but work overtime to solve new problems which may cause other problems. Such a vicious cycle will not only increase the cost of collaboration, but also reduce the development efficiency.

System availability is getting weaker: more and more problems with code memory leaks may arise, making companies have to use expensive servers and put more operational costs into operation.

The springcloud microservice architecture used in this system uses the following microservice technologies and components:

1. Registration Discovery Center: All services register themselves in the registration discovery center, so that all callers of the service can pass the correct IP and port of the callee found by the registration discovery center.

2. Configuration Center: All services will request the configuration center to find their own configuration items during initialization.

3. Gateway service: All requests are routed through the gateway, and the destination service found by discovering the service registration list is processed.

4. Monitoring service: The monitoring service can conveniently display the status of the entire microservice cluster, such as cpu, memory usage, and so on.

Adopting a microservice architecture has the following advantages:

1. Development efficiency advantage: The business module can be divided into independent service development, which does not affect each other's development progress.

2. Deployment and high availability advantages: Each service module is deployed independently, combined with the current popular docker virtualization technology, can achieve environmental isolation between services, and can achieve distributed deployment, greatly improves application availability.

3. Independent upgrade maintenance: In the maintenance of traditional single service, when a module needs to be upgraded and maintained, it is often necessary to stop the entire software service and affect the user experience. With the micro-service architecture, it is only necessary to stop the current service micro-service module to upgrade and maintain the current module.

4. Performance advantages: The micro-service architecture has the advantage of distributed cluster deployment, which can divert huge access traffic pressure to multiple servers through load balancing strategy, improving system throughput and robustness.
4. Functional Module Design
The automotive green supply chain system can release and display the latest government regulations and publicity information of parts suppliers, performance indicators, environmental parameters, regulatory records, and certification status of parts and components. And the government department can conduct star rating assessment for parts suppliers according to quarterly or annual review.

Pic 3 Automotive Green Supply Chain Functional Module Design
The modules of the system are designed as follows:

Enterprise Environmental Violation Record Query Subsystem: This subsystem contains functions such as filling, modifying, retrieving, and publicizing the parts supplier's regulatory information.
Supply Chain Environmental Risk Management Subsystem: This subsystem should be able to predict or judge the current supplier's environmental risk level through a certain algorithm based on the regulatory information of each component supplier.

Supplier Environmental Information Management and Analysis Subsystem: This subsystem can report the environmental protection information of each supplier's parts and the collection of environmental monitoring data, including the pollutant discharge permit, environmental assessment information, administrative penalty information, and environmental monitoring data, environmental performance report and green certification, etc. It aims to help car companies analyze the relevant advantages and disadvantages of each component supplier horizontally or vertically.

Green Procurement Subsystem: The system includes the release of procurement information, the recommendation of supplier parts, the matching of transactions, and bidding.

Energy efficiency management and evaluation subsystem: This subsystem can upload data such as the output value and energy consumption of the supplier. The system has the functions of visualizing the energy efficiency data of all component suppliers and ranking the energy efficiency of the same parts.

5. System Implementation

5.1. Microservice Architecture Implementation
The vehicle green supply chain system divides the business modules including system management, registration discovery service, configuration service, and monitoring service into service clusters composed of 9 microservices. Any microservice can be single or clustered on the same or separate servers. Word deployment.

5.2. Storage and Cache Implementation
Due to the large number of subsystems of the green supply chain system of the automobile, the volume of business and data is large. In order to reduce the pressure of reading and writing database, the hot data read and written by the high frequency will be placed in the REDIS cache.

In ensuring the consistency between the REDIS cache data and the ORACLE storage data, the cache data should be deleted in the cache each time the data is added, deleted, or changed. In the next
query operation, the data is written to the cache. In the persistent storage, the strategy of splitting the table and separating the reading and writing will be adopted, as shown in the following figure.

5.3. Implementation Of Microservice Individual
All services of the automotive green supply chain system use the framework of springboot, springmvc, and mybatis to implement the restful service. The architecture can easily realize the calling function between services, as shown in the following figure.

5.4. Implementation Of Distributed Transaction Locks
In the automotive green supply chain system, we use REDIS as a distributed lock. Since REDIS is based on single-threaded multiplexing technology, only one request can be processed at the same time. Using this principle, before the thread modifies the data, it will request REDIS to obtain the distributed transaction lock. When the request is successful, the data can be modified. Otherwise, it will wait for the distributed transaction lock to be modified, ensuring that a piece of data does not cause data inconsistency due to being modified by multiple threads at the same time.
5.5. Implementation Of Version Management
In the development cycle, the system uses gitLab private service as the source code management tool of the system to ensure the security of source code and the flexibility of version switching.

6. CONCLUSION
This paper discusses the design and implementation of automotive green supply chain software system based on micro-service architecture. The whole system adopts mature springcloud micro-service architecture, adopts distributed deployment and automatic construction, which greatly improves the efficiency of development and deployment. At the same time, the storage layer design of separating table and reading and writing separation is adopted, which greatly improves the throughput and availability of data storage.

The system utilizes distributed software technology to solve the problem that the company's environmental violation records are scattered among the local governments and local environmental protection bureaus. It is difficult to investigate the environmental violations of suppliers one by one, and the suppliers have a large workload. The huge number of suppliers is hard to count completely. And the supply chain is too long, it is difficult to check the environmental protection problems of suppliers below the third level, which makes it difficult for auto companies to avoid the pain of environmental risks in the supply chain.

However, the system also has some shortcomings. When extreme access peaks occur, the system may lose some requests due to database pressure. In the future, the message queue will be used to timely cut the peak of the access request according to the degree of access growth. In terms of distributed transactions, although REDIS can support hundreds of thousands of concurrent accesses, it does not adopt high-availability clusters. This may lead to the problem of service unavailability and distributed transaction lock service downtime in the condition of power failure or host failure, so it needs to consider enhancing the robustness and usability of the system in the future.

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