# Design and implementation of "Planning One Map" system for comprehensive transport based on Microservice architecture

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**Abstract.** A technical framework, including Microservice architecture, open-source databases GreenPlum and PostGIS, SuperMap iServer engine, and open-source WebGIS client OpenLayer, is proposed to meet business requirements for the "planning one map" system concerning comprehensive transport. This solution addresses practical issues such as complex data interaction, limited planning flexibility, frequent requirement iterations, restricted function expansion, and low multi-user concurrency efficiency. It improves the practicality and scalability of a comprehensive transport "planning one map".

**Keywords:** Microservice architecture; comprehensive transport planning; composite technology; spatio-temporal characteristic data

## 1 Introduction

The "planning one map" system for comprehensive transport includes the basic data from various transportation fields, such as highways, water transportation, railways, civil aviation, land use, and ecological environment. The data organization and management technology is challenging due to differences in data storage format, statistical caliber, attribute characteristics, spatio-temporal granularity, and spatial coordinates. Therefore, exchanging and sharing with "One Base Map" is somewhat restricted. "planning one map" needs to meet functional requirements for different scales and time series, including macro layout, meso-network, and micro structure, to serve various purposes and stages of planning. Practical requirements, including hierarchical data collection and updating, function extension and application, and multi-user remote concurrency, must meet various user roles.

In order to address the issue of inadequate overall planning for the information-based development of the transport industry, the Ministry of Transport has launched


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the construction of the "One Map" platform for comprehensive transport in 2021. This platform will rely on the national comprehensive transport Information Platform and integrate the current geographic information resources of comprehensive transport infrastructure. The platform will have a B/S architecture as the main structure and a C/S architecture as the auxiliary structure. Functions such as online map browsing, map applications, map analysis, and access to external applications have been realized [1]. Lu et al. studied the architecture design and application of a traffic map in Jiangsu Province. The authors utilized the Service- Oriented Architecture (SOA) and Java 2 Enterprise Edition (J2EE) system as the primary framework for their study. They employed a combination of Oracle and MongoDB databases, as well as the SuperMap iServer service framework, to analyze the existing highway, waterway, and road transportation data resources of the province. The Jiangsu Traffic Spatial Geographic Cloud has been developed with the aim of facilitating the sharing of traffic-related geographic information resources [2]. The aforementioned traffic map's construction primarily addresses the integration and standardization of geographic information pertaining to current transportation infrastructure in the domains of highway, waterway, and road transportation. However, it fails to incorporate spatial geographic data concerning line position, point position, and territorial spatial planning elements of the planning scheme. Additionally, it does not encompass existing fundamental geographic information data in the areas of civil aviation, railway, land use, and ecological environment. With the advancement of territorial spatial planning reform, Beijing, Guangdong, and Wuhan have each established a "One Map" platform for territorial spatial planning within their respective regions. Pei Jian has suggested the development of a territorial spatial planning system, known as the "One Map," in Liaoning province. This proposal involves the utilization of ArcGIS Engine and Visual Studio technology. The development of fundamental functionalities, including map browsing, inquiry, mapping, positioning, and statistics, has enabled the integration of supervision and service of territorial space resource data [3]. Yao Zhiwu et al. proposed to adopt Microservice architecture and GIS geographic information technology to develop a map service platform for land and resources in Guangshui City, effectively solving the problems existing in the traditional architecture, such as easy service collapse, unbalanced load and insecure service call, chaotic spatial data management and lack of macro analysis of basic business information [4]. The technical architecture and implementation approach of GIS technology utilized in the development of the "One Map" for territorial space planning can serve as a valuable point of reference. However, when compared to the scene requirements of "One Map" in comprehensive transport planning, the complexity of data, scope, and depth of business requirements are relatively simpler. The focus is more on standardization and regulatory approval of spatial resource information, and less on optimization, evaluation, and analysis of planning schemes. The characteristics of spatio-temporal data and business categories are relatively straightforward.

In consideration of the practical requirements of comprehensive transport planning, this study employs a multi-technology approach with a Microservice architecture as the central framework to develop and design the "planning one map" system for comprehensive transport. The transportation planning resources offer a range of functions, including comprehensive search, planning drawing, spatio-temporal data analysis, and comprehensive three-dimensional transportation network evaluation analysis. These functions are designed to handle large quantities of data, accommodate multiple types of users, and support concurrent usage. The resources enable the exchange and sharing of “One Map” with territorial spatial planning.

# 2 Technical Architecture Selection Analysis

## 2.1 Microservice architecture selection analysis

The architecture of platform software is typically categorized into four types based on the application evolution process: monolithic architecture, vertical unit architecture, SOA, and Microservices architecture [5]. One approach to deploying business applications involves utilizing a monolithic architecture that centralizes all applications within a web service center. This approach offered benefits such as rapid development and implementation, and enhanced code consistency. However, it also presents challenges such as high maintenance costs and a significant workload for updates. Vertical architecture refers to the process of breaking down a monolithic architecture into multiple smaller systems based on business logic, resulting in an evolutionary approach to architecture. Each system implements the application of business logic through network interactions, thereby addressing the challenges of concurrency pressure and independent iterative optimization of various modules to a certain extent. The interaction between subsystem services and cluster load balancing is relatively complex. The SOA facilitates the integration of various subsystems within a vertical architecture by utilizing Enterprise Service Bus (ESB) and Web Services. This approach offers a convenient means for software development[6]. In the context of frequently iterated application requirements, subsystem splitting tends to have a coarser granularity, resulting in central dependencies among different services. As a consequence, the iterative development process becomes relatively complex. The Microservice architecture is a novel service architecture that has evolved from the SOA. It involves the division of complex business applications into smaller, more manageable services based on the principles of high cohesion and low coupling. Inter-service invocation is achieved by means of the service registration mechanism, while load balancing is performed directly on the client side. Additionally, fault-tolerant control is implemented to ensure system reliability [7-9]. The system exhibits characteristics such as ease of maintenance and expansion, low technical requirements for maintenance and development, and enhanced software robustness. In conclusion, the interdependence of monolithic architecture, vertical architecture, and SOA makes them suitable for the top-down waterfall development pattern. On the other hand, Microservice architecture is better suited for the bottom-up agile development pattern, which is based on frequent iterative requirements.

The “planning one map” transportation system is a novel business application that offers comprehensive transport planning capabilities. The demand for planning is influenced by practical factors, including the uncertainty of planning methods and objects, the need for frequent iteration and function expansion, the requirement for service agility, complex data organization, and the pressure of remote and concurrent calls from multi-stage users. Therefore, it is recommended that the "planning one map" comprehensive transport system should adopt Microservice architecture as its primary framework, owing to its practicality, stability, scalability, and cost-effectiveness.

## 2.2 Analysis of the selection of Geographic Information System (GIS) composite technical architecture

GIS technology plays a crucial role in the comprehensive transport "planning one map" system, facilitating the unification and integration of spatial data resources related to traffic planning. This includes the organization and management of traffic spatial data resources, service release, browsing and inquiry, as well as the visualization, optimization, evaluation, and analysis of planning schemes. The technical architecture of GIS is typically categorized into two main groups: open-source GIS architecture and established GIS products. The utilization of commercial GIS products for both application and development purposes incurs significant costs, and the iterative expansion process is often inflexible, thereby impeding the digital transformation and development of small and medium-sized enterprises [10]. In recent years, open-source GIS technology has been further applied. The difficulty of development is gradually reduced, and the advantages of openness, flexibility, economy, and strong expansibility are more prominent [11]. In practical implementation, it has been observed that both the front-end and underlying data services of GIS technology utilize open-source frameworks, which entail significant development workload and complexity. Particularly in the context of multi-business spatial data applications that involve large-scale and complex organizational structures, the technical demands placed on maintainers are relatively high, and the potential for instability is significantly elevated. OpenLayers is an open source, completely free javascript library developed by MetaCarta. It is widely used in the development of dynamic maps in web pages, with rich and scalable interfaces and high performance. It can meet the diverse map requirements in "planning one map". Firstly supports loading and browsing of WMS (web Mapping Service) and WFS (web Feature Service) and other standard map services. Secondly supports common operations such as symbolic display, pan, zoom-in or zoom-out, etc. , Thirdly supports selection, marking, layer overlay on the map and other interactive operations. Finally it works well in querying spatial data from the spatial database or calling the spatial analysis service for making thematic map. Therefore, the system typically employs the GIS combined technical framework, which involves utilizing the open-source OpenLayer for developing the WebGIS environment on the front end and leveraging the mature SuperMap iServe products on the back end to facilitate data service release. This approach helps to avoid deep binding with GIS commodity platforms and enables the expansion and upgrading of personalized requirements. In order to achieve sustainable and stable development in transportation, it is necessary to establish a comprehensive "planning one map" system.

# 3 Architecture Design of Comprehensive Transport "planning one map" System

The technical architecture of the comprehensive transport system "planning one map" follows the system design principles of preferring Microservice architecture, utilizing open-source technology, and being economical, practical, and easy to expand. This architecture is divided into five layers: infrastructure, data service, backend service, security protection, and front-end application, as illustrated in Figure 1.

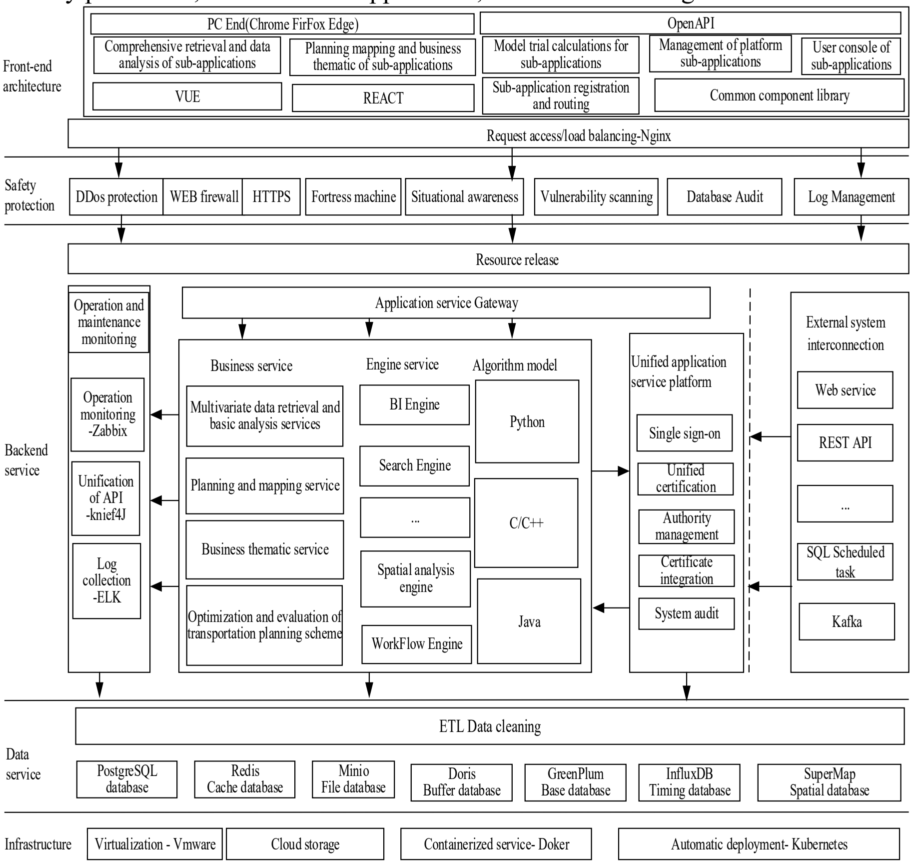


**Fig. 1.** Technical architecture of the comprehensive transport "planing one map" system.

The infrastructure layer offers fundamental support by means of host virtualization, cloud storage, containerized services, and automated deployment.

The data service layer includes the structured application database, cache database, file database, high-frequency buffer database, sequential database and spatial database, which provides integrated data service support. The structured application database uses GreenPlum, an open-source distributed database based on Postgre for storage management. The high-frequency data is processed by Apache Doris, a relatively new big data architecture, which can obtain better computing performance and stability.

The backend service layer is founded on the Microservice Spring Cloud technology architecture, which encompasses operation and maintenance monitoring, log collection, unified external interface management, service gateway, service registry, and other essential functions. The backend Microservice employs the Feign interface for load balancing and fault circuit breaker implementation. The utilization of BI Engines, Search Engines, and other engine service technologies is prevalent in providing backend application support for the construction of algorithm models. The present study focuses on the development and implementation of a multi-source data retrieval system, along with basic analysis techniques, planning drawing, traffic planning scheme optimization, and evaluation. Additionally, the study explores the application of four business Microservices related to the business topic.

The security protection layer is implemented through a range of measures, including DDOS defense, web firewall, encryption certificate, fortress computer, situation awareness, vulnerability scanning, database audit, and log management. These integrated security protection measures work together to ensure the safety and security of the system.

The front-end application layer primarily engages with PC applications and open APIs. The Qiankun micro front-end architecture serves as the basis for constructing both the main and sub-applications of the micro front-end. The primary software application incorporates publicly accessible functions, including registration, routing, communication, and display control of sub-applications.

In conclusion, the comprehensive transport system known as “planning one map” typically utilizes a technical architecture that combines Microservices as the framework, open-source databases and front-end as the foundation, and SuperMap iServer service as the engine. This approach effectively addresses various challenges, including accommodating flexible planning requirements, overcoming limitations in product and service expansion, and reducing high development and maintenance costs.

# 4 Research and Applications of The Key Technologies

## 4.1 Microservice architecture application and implementations

The development and implementation of the “planning one map” system for comprehensive transport utilize the Microservice architecture of Qiankun micro front-end and SpringCloud micro backend, as illustrated in Figure 2.

The concept of micro front-end applications encompasses a set of five sub-applications that can be deployed and executed independently. These sub-applications include a comprehensive search and data analysis tool, a planning and drawing application, a business topics module, a model trial calculation tool, and a management platform. To enhance the visual display of planning space, the React front-end framework is utilized for constructing business sub-applications, while the Vue front-end framework is employed for constructing other sub-applications. We have developed shared components that facilitate Excel editing, data uploading, map rendering, chart presentation, and other functionalities. These components can be readily reused and loaded for various sub-applications.

The micro-backend applications are comprised of several micro-services, including the rights management service, data search and analysis service, planning and drawing service, business topic service, model trial calculation service, management platform service, log service, and other related services. The micro-services are registered, configured, and receive front-end requests in a unified manner. They also perform permission verification and log registration, while obtaining corresponding service calls from each other through the registry center. The Microservice interface employs the Feign mode to achieve load balancing and fault circuit control management, thereby enhancing the system application's robustness and usability.

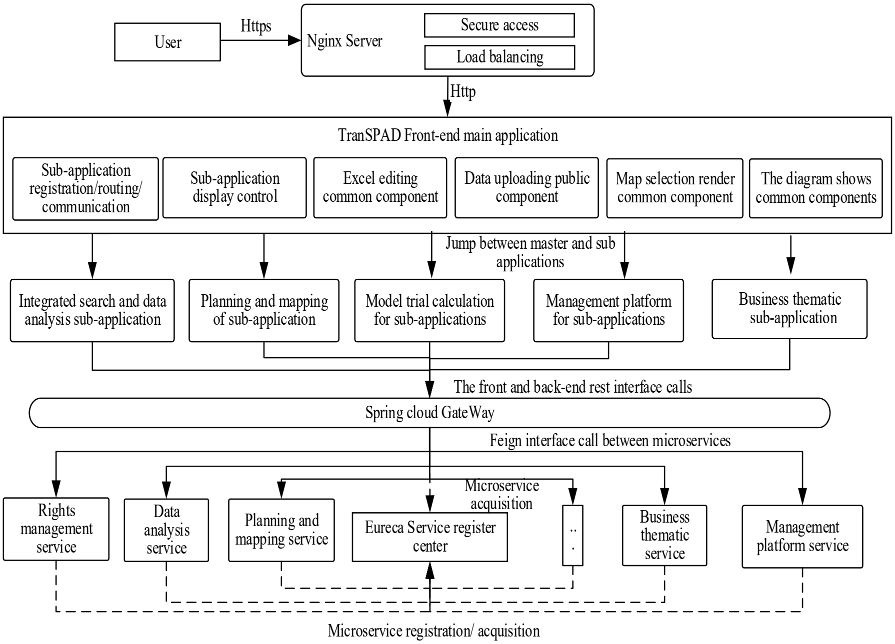


**Fig. 2.** Microservice architecture of the Comprehensive transport "planing one map" system.

## 4.2 Application and implementation of open-source database technology for spatial-temporal characteristic data

The transportation "planning one map" is a comprehensive tool that contains data on the current state and planned positions of transportation infrastructure, including roads, waterways, hubs, ports, airports, and ship locks. It also includes spatial attribute data related to environmental protection, such as territorial and ecological protection red lines, nature reserves, drinking water sources, wetlands, and parks. Additionally, the map provides geographic spatial basic data, such as boundaries and administrative centers of provinces, cities, and counties. The map also incorporates dynamic data from traffic flow survey stations, toll stations, traffic control stations, maritime vessels, waterway vessels, and other traffic operation monitoring sources, as well as open-source data such as Internet POI and navigation tracks. The map accumulates more than one hundred different business data sets. The classification of data into distinct categories. comprehensive transport planning necessitates meticulous attention to the attributes of spatio-temporal characteristic data. The processing, organization, and fusion analysis of planning spatial data from various transportation modes, spatial scales, and sequential units are complex and demanding.

The comprehensive transport planning data governance concept advocates for the use of comprehensive transport “planning one map” system that utilizes open-source database technology to perform the unified transformation, extraction, and integrated visualization from the three characteristic dimensions of “Traffic Space - Planning Attributes - Timing Process”. The database structure of the “Plan One Map” system is comprised of several components, including the buffer database, basic database, spatial basic database, topic database, and index database. These components are illustrated in Figure 3. The buffer database employs the high-performance Apache Doris to facilitate the storage, querying, and computation of electronic statistical data, AIS data, vehicle trajectory data, traffic flow data, and other high-frequency data. The buffer database utilizes column storage and partitioning techniques based on data characteristics and query conditions, including time, physical and chemical index, to facilitate extensive data querying, cleaning, and statistical analysis. The database can be categorized into two main types: structured basic database and spatial basic database. The structured basic database has been developed utilizing the GreenPlum open-source database, which achieves high availability by using data replication and MPP (Massively Parallel Processing) technology for high performance and it includes base statistical data, highway data, railway Data, port data, channel data, OAG statistics, comprehensive transposition data, traffic survey statistics, AIS statistics, urban traffic data, and environment data etc. The data contained within the buffer database undergoes a series of processes, including data governance, convergence, and dimensionalization, in order to generate the fundamental data utilized in the process of “planning one map”. The spatial basic database stores various data related to traffic status, traffic planning, environmental protection, administrative division, and other attributes in the PostGIS spatial database. This enables the SuperMap iServer to perform spatial analysis, processing, and browsing of the data. The database subject classification system facilitates the organization, storage, and management of data within the basic database, based on business subject categories. The thematic database conducts evaluations, analyses, and predictions of attribute index data from both the basic database and the spatial basic database. The search database offers a data search service that synchronizes search fields from the basic database cluster and application database group to ElasticSearch. It establishes a connection to specific data through the primary key to enable detailed display. To sum up, this system uses open-source database technologies such as Apache Doris, GreenPlum and Postgis to process, organize, manage and apply large-scale complex spatio-temporal feature planning data for complex spatio-temporal feature planning data.

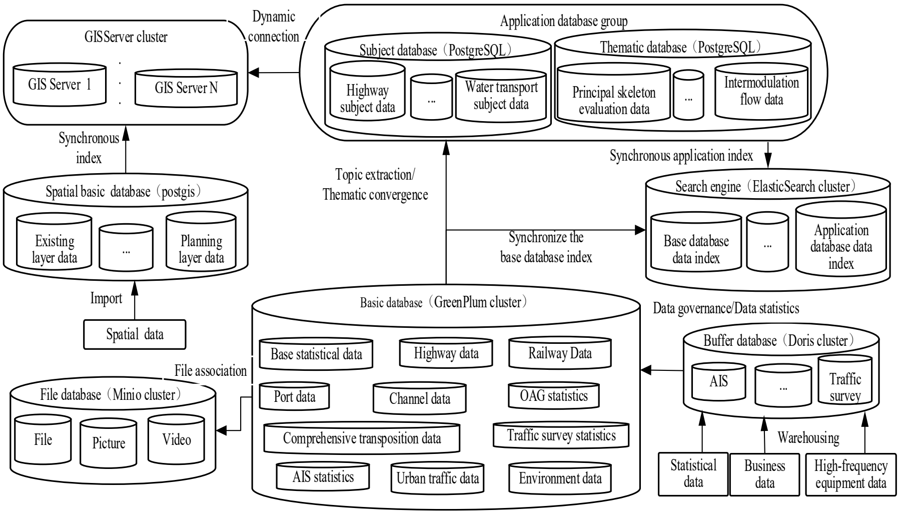


**Fig. 3.** The open-source technical architecture of spatial-temporal characteristic data.

## 5 Conclusions

The "planning one map" system for comprehensive transport is a crucial technical foundation for transportation planning. This paper investigates the design scheme of the system architecture, the utilization of micro-service, the selection of the combined GIS technical framework, and the application of the open-source database for spatio-temporal characteristic planning data. The findings of this study provide valuable guidance for the development of the "planning one map" system and the digital transformation of comprehensive transport planning. In the subsequent phase, the system functionalities, including intelligent mining and analysis of planning data, and flexible visualization of "planning one map," will be enhanced to meet the business requirements, such as transportation planning evaluation and optimization. This will expedite the advancement of digital capabilities of comprehensive transport planning.

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