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Development and Application of Shanghai Big Data Platform for Transportation Planning

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Abstract: With the digital transformation in cities, the development and application of big data platform for transportation planning can empower the data use in planning services. Introducing the technical framework and main functions of the big data platform for transportation planning of Shanghai, this paper elaborates on the design features of the platform from the perspectives of data application, maintenance and management, security coordination, etc. Based on relevant modeling technologies of Shanghai's transportation planning and taking planners as the application object, the platform has gathered multi-dimensional and multi-channel data to provide common theme diagrams and shared data resources. The platform supports superposed analytical application of various data resources and customized drawing functions. Finally, the paper presents case studies to demonstrate a typical application of the platform in planning. With the premise of ensured data security, the platform can realize high-degree sharing and effective utilization of data resources. The platform effectively supports planners' routine work and also provides communication venues for relevant business personnel.**DOI:** 10.13813/j.cn11-5141/u.2023.0102-en

Keywords: transportation planning; transportation model; big data platform; data sharing; Shanghai

1 Research and development background of Shanghai big data platform for transportation planning

Digital transformation in cities is an important driving force for people's city construction, a key move to shape the core competitiveness of cities in the future, and an inevitable requirement for the modernization of the governance system and governance capacity of megacities. At the end of 2020, the Shanghai Municipal Party Committee and the Municipal Government announced the “Opinions on Comprehensively Promoting Shanghai's Digital Transformation”. The opinions require a profound understanding of the significance of Shanghai's entry into a new stage of development and comprehensive promotion of urban digital transformation and clarify related overall requirements. In 2021, the Planning and Natural Resources Administration of Shanghai Municipality formulated the “Key Work Plan for Informatization of the Planning and Natural Resources Administration of Shanghai Municipality in 2021”. Additionally, the goal and specific path of digital transformation in planning resources were put forward to play a fundamental and leading role in urban fine management.

In recent years, big data technology has made great progress, thus exerting a profound influence on the production and business modes of all walks of life. The transportation planning industry is one of the earliest industries involved in big data mining, and increasingly abundant big data resources have greatly improved the accuracy and breadth of the analysis [1]. However, there are also a series of problems in the application of big data technology. For example, diverse data sources, different statistical calibers, and different applicability result in insufficient standardization of data application. High thresholds of data processing and institutional restrictions on data confidentiality lead to a limited application range of data. Meanwhile, the application of transportation model software cannot be popularized to general transportation planners, and different understandings of data analysts and planning analysts on data result in low communication efficiency [2]. In this context, relying on the construction of a new comprehensive transportation planning model in Shanghai, combined with the big data computing cloud platform (TransPaaS) for transportation of Shenzhen Urban Transportation Planning and Design Research Center Co., Ltd., multi-dimensional and multi-channel data are gathered to develop a web-based Shanghai big data platform for transportation planning (hereinafter referred to as the “web platform”) orientated to planning business personnel. Against the backdrop of digital transformation, the big data platform is employed as a venue for timely information transmission and communication [3].

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2 Technical framework and main functions of the platform

2.1 Platform positioning

Compared with the professional platform of the transportation planning model (hereinafter referred to as “professional software platform”), the web platform should have an appropriate functional positioning.

1) The web platform is designed and positioned to serve planners. It can not only be adopted for a simple query or display but also help planners realize convenient access to various data resources and obtain the required planning materials through secondary processing of simple operations. Therefore, it is very necessary to strengthen the superposed and combined application of various data resources and add human-computer interactive drawing functions such as drawing style adjustment.

2) Clear division of labor between the web platform and the professional software platform is conducted well. The platform can not solve all the professional analysis problems of planners but can realize the most commonly employed and relatively simple data analysis and display functions through simple human-machine interactions. Since planners are not professional data model analysts and human-machine interactions also have a limited range of applications, higher requirements are proposed for the platform development. For quantitative analysis functions of complex human-computer interactions, such as transportation model analysis, although the industry has tried to launch some simple modules such as the transportation impact assessment module, the development of the platform and the utilization by users are still very difficult.

3) The integrated construction of the transportation model database of the desktop transportation planning model software TransCAD and the web platform TransPaaS is emphasized. The development of the platform realizes the data sharing and functional complementarity between the web platform and the professional software platform, Meanwhile, the professional software is adopted as the 'background' to realize the database maintenance of the platform, complex transportation analysis, and result output, and then interactions are achieved with the planners through the relatively simple web platform.

2.2 Technical framework

The technical framework adopts a four-layer architecture of data layer, support layer, application layer, and display layer, and employs some of the latest technologies in the fields of database and GIS (Fig. 1). 1) In the data layer, the

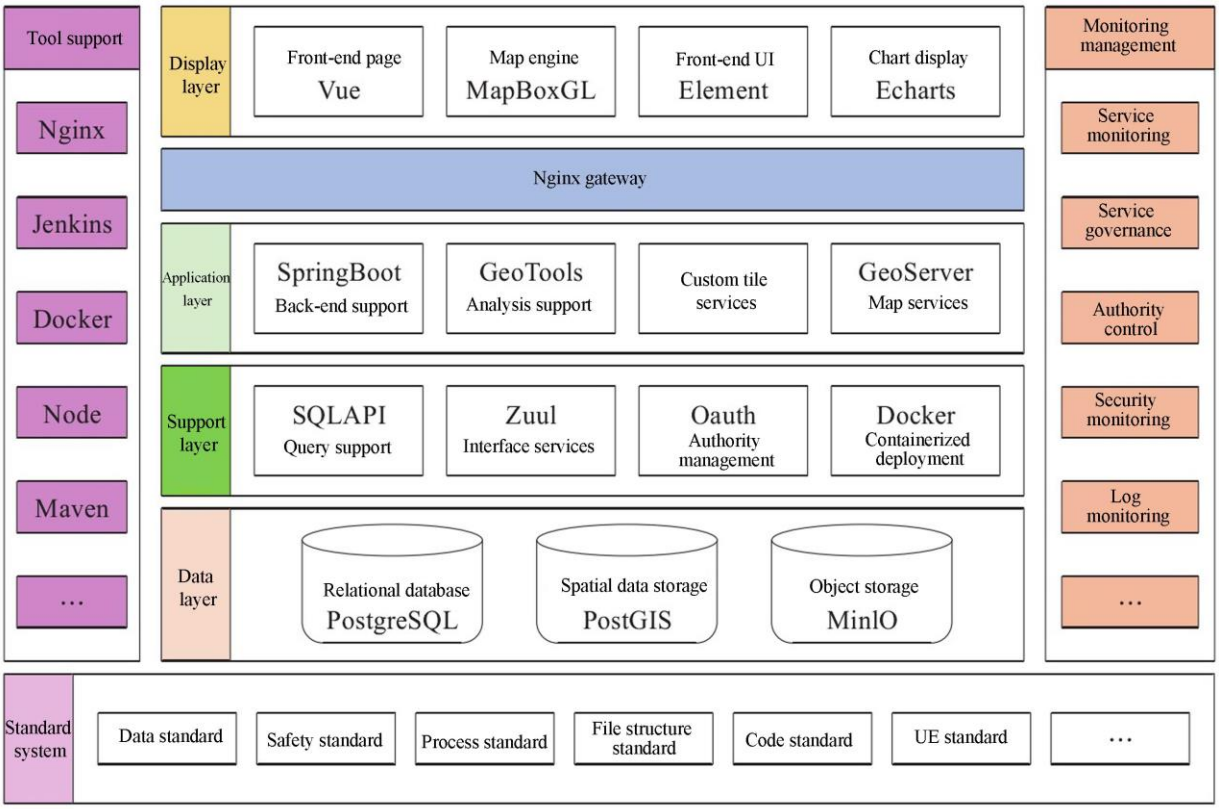


Fig. 1 Technical framework of the Shanghai big data platform for transportation planning

Data source: Reference [4].

PostgreSQL database is leveraged as the relational database to store the structured index table, and the PostGIS extension module to store the spatial data. The MinIO object storage tool is utilized to store the user-defined uploaded files and maps. 2) The support layer supports the platform layer. SQLAPI and the Zuul gateway provide support for the SQL query and interface services respectively, Oauth performs authority management, and Docker is for containerized deployment to facilitate deployment and maintenance. 3) In the application layer, the application back-end support is provided based on the SpringBoot framework, the GIS analysis is supported through GeoTools, and a custom tile service is built, with the employment of GeoServer to release the Web Map Service (WMS). 4) The display layer is for end users. The front-end page is developed based on the Vue framework, the front-end map engine utilizes the MapBoxGL framework, and the front-end UI is developed by the Element framework, with the realization of chart display by the Echarts framework [4].

2.3 Functional architecture

The functional architecture includes four functional pages of data indicator, intelligent planning, working platform, and personal space. 1) The data indicator is a data management page, which integrates the data view, data application, data audit (available to administrators), and indicator management. 2) Intelligent planning is a standardized intelligent query and analysis tool for transportation data resources to analyze and display all kinds of big data for transportation by customizing areas or setting query conditions. 3) The working platform is the main user interface, with the functions of graphics and data calls, online drawing, query, analysis, etc. 4) The personal space stores user-defined theme diagrams and self-uploaded data, and provides the functions of personal folder management and fast link to the pages of the theme diagrams.

2.4 Functional overview of working platform

With the working platform as the core interactive interface, functions such as browsing and query, index monitoring, graphic data calls, and modification and sharing of theme diagrams are provided. The page of the platform is divided into theme diagrams, public databases, data table operations, customized drawings, personal space, and other functional modules (Fig. 2). Theme diagrams, data table operations, and public databases provide users with the most commonly employed theme diagrams and public data resources and implement superposed applications of any combination. Additionally, the customized drawing can provide support for users to modify theme diagrams and related data tables and perform user-defined preservation and shared publishing. The personal space supports users to upload data and call and superpose the layers of public databases online.

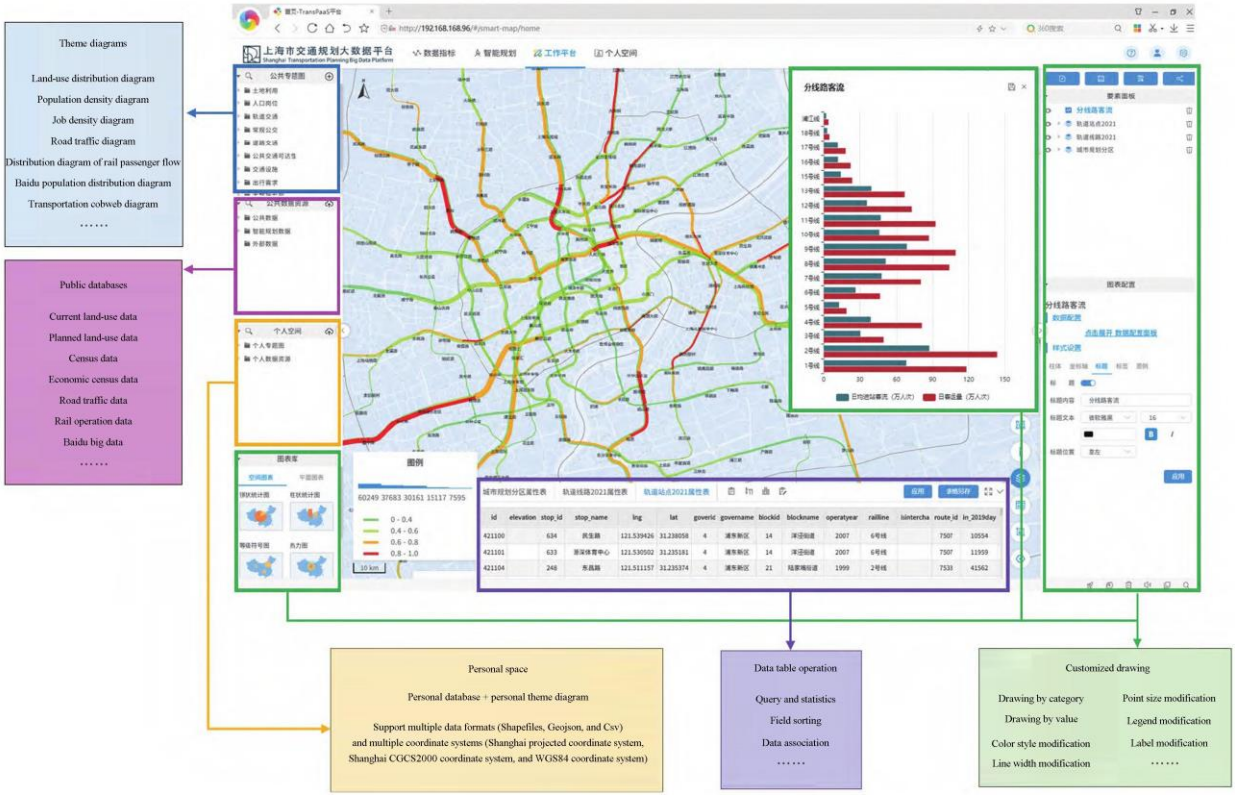


Fig. 2 Main functional modules of the working platform

3 Platform design features

3.1 Rich data applications

The working platform supports users to superimpose layers and data of different spatial dimensions such as points, lines, and surfaces onto the map interface. Finally, the free combination of spatial data is quickly completed to transform from data indicators to custom planning theme diagrams. The administrator of the platform can easily define various types of public theme diagrams for release, which can be called directly by users. For common business scenarios, about 50 public theme diagrams in 11 categories have been released (Fig. 3). The categories contain the planned land-use distribution, the current daily passenger flow of urban rail transit stations, the density distribution of permanent residents, the density distribution of employees, the flow distribution of highways, and the passenger volume of railway stations in the Yangtze River Delta. According to the requirements of the planning business, public theme diagrams can be continuously increased through management pages.

3.2 Customized drawing based on Web-GIS

The public theme diagrams are stored in the public theme diagram area and stored in folders according to the display content, which can be directly called by users on the working platform. The web platform supports users to modify or make theme diagrams and has the functions of making theme diagrams commonly adopted by users. The functions include layer control (opening, closing, adding, and adjusting the order), point-line-surface style (color, symbol, width, fill, and transparency) and other preference settings, theme diagram settings (color theme, size symbol theme, and chart theme), label setting (adding and deleting labels, selecting label fields, font styles, etc.), and legend setting (addition, closing, font content, style adjustment, etc.). Meanwhile, data can be screened according to the attributes and masks (with the only display of a certain area, such as the administrative area) can be created. The theme diagrams modified or made by users can be saved in their personal space and shared with other users.

The working platform provides a variety of spatial charts and planar charts to support the diversified presentation of data resources. 1) Spatial charts include the pie chart, column

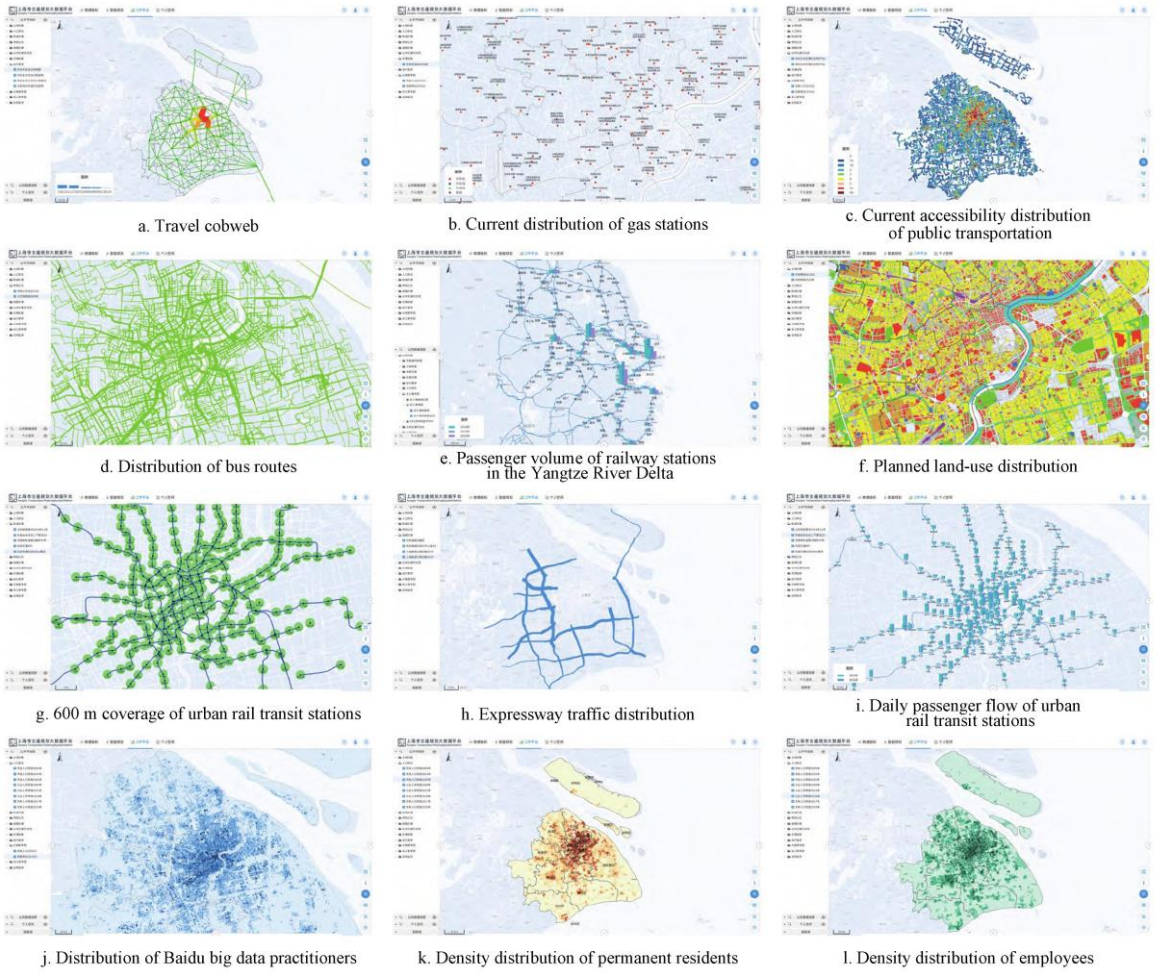


Fig. 3 Examples of public theme diagrams of the Shanghai big data platform for transportation planning

chart, grade symbol chart and heat map, expected line chart, and cobweb chart, which are employed for the spatial display of various data. For example, the column chart is to make a passenger traffic map of railway stations, and the grade symbol chart is to make the passenger flow distribution map of urban rail transit stations. 2) Planar charts include line charts, histograms, pie charts, radar charts, rectangular charts, and relationship charts. They are suspended in the spatial layer and mainly adopted for supplementary descriptions or summaries of the spatial layer, such as increasing the passenger volume histogram over the years in the line distribution map of urban rail transits. Meanwhile, the planar charts can also be utilized to make a display panel of core monitoring indicators for monitoring and querying. During the development, considering that GIS-T is different from the general GIS and the bidirectional characteristics of the traffic flow, special development is carried out for bidirectional labels, bidirectional color themes, and bidirectional size symbol themes (Fig. 4) to meet the display requirements of the GIS system for traffic data.

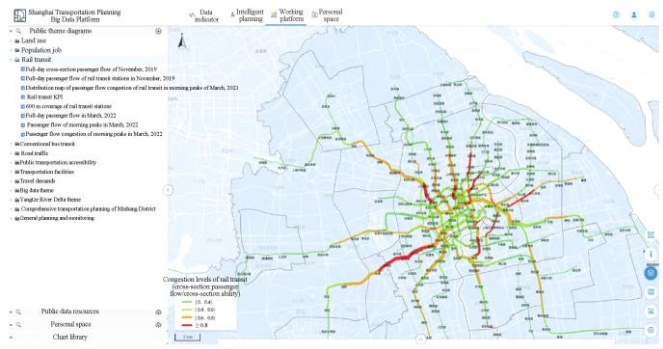


Fig. 4 Theme diagram of bi-directional passenger volume and congestion levels of urban rail transit

3.3 Efficient data maintenance and management

The web platform collects massive data, and the standardized, convenient, and efficient planning management has laid a sound data foundation for the application.

1) Simple browsing and query functions of data resources are provided. Each user can quickly understand the overall situation of data resources and the detailed attribute structure of each data, and the directory of data resources is consistent with that of the working platform data to make sure what you see is what you use (Fig. 5).

2) Convenient data management functions are provided, including a custom data directory, data import, and data update. Meanwhile, the platform supports user-defined data upload and data of multiple coordinate systems such as the Shanghai projected coordinate system, Shanghai CGCS2000 coordinate system, and WGS84 coordinate system to realize the automatic conversion of different coordinate systems in the background. Additionally, the channel between the professional database of the transportation model and the database of the web platform is opened up, and the model data is imported into the database of the web platform directly to greatly improve work efficiency.

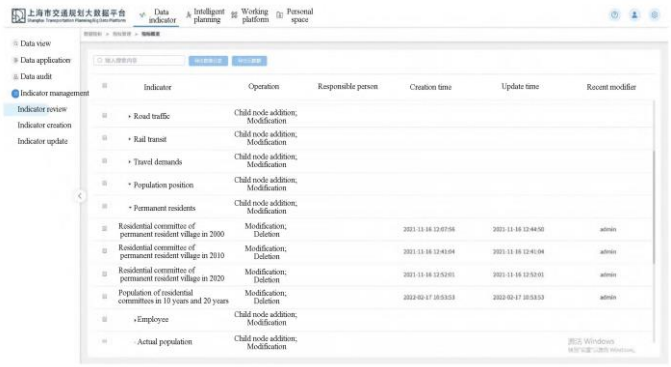


Fig. 5 Data directory management interface of the Shanghai big data platform for transportation planning

3.4 High-degree data sharing

The web platform integrates all kinds of statistical data, traffic operation data, traffic survey data, and network big data for planning, and arranges them by the three spatial dimensions of point, line, and surface. This provides a simple and intuitive visual query interface to quickly obtain planning data indicators and achieve maximum data sharing. Finally, the problems of data dispersion, different caliber, and repeated check processing can be solved to improve data accuracy and promote data sharing.

The sharing data resources include public data resources and personal data resources, among which public data resources are divided into land use, road traffic, urban rail transit, travel demand, population and jobs, transportation facilities, and common boundaries according to content and source. The web platform has released about 100 public data in 12 categories. Personal resources are the data uploaded by users for personal use only. The working platform provides functions such as arbitrary calls, browsing, query, and drawing of data resources.

3.5 Secure data collaboration

While ensuring the convenient utilization of various data by planners, the confidentiality and security of data should also be paid attention to. The data is visible and available to users but does not mean that the planners can obtain the original data at will. Generally, data sharing and security are a pair of contradictions. One solution is to encrypt the data through a closed computer environment, and the output data should be manually reviewed or decrypted. The advantage of this solution is that it can employ a variety of professional software data, but this is time-consuming and laborious. Data encryption and decryption are restricted by data types to affect computational efficiency. Shanghai big data platform for transportation planning manages the data operation

authority through the background (Fig. 6). This not only improves the management efficiency but also realizes the convenient utilization of various data by planners, thus solving the above contradictions to a great extent.

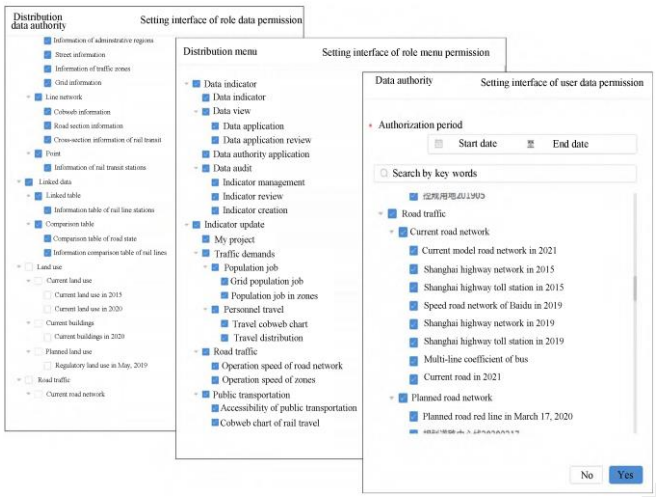


Fig. 6 Data application permission management of the Shanghai big data platform for transportation planning

Each user has personal space to ensure the data security of individual users. The structure of personal space is consistent with that of public space, which is employed to store personal data and personal theme diagrams. The superposed analysis of the theme diagrams of personal space and public data, and the one-click sharing of theme diagrams in personal space to other users are both supported.

3.6 Dynamic interaction between the professional software platform and the web platform

The basic database of the platform takes the database of information work as the basis to achieve unified standards and data interaction. The professional software platform is oriented to the professionals of data and models and focuses on the model professional analysis and the editing and maintenance of geographic information and database. This has high operation requirements for professional software, known as technical “background”. The web platform for general planners concentrates on the results of the release, query, display, drawing, and data overlay, known as the application “foreground”. The professional software platform uploads various geographic information data (including model output results) edited and maintained to the PostgreSQL database of the web platform, and can also call the database in the web platform to achieve interaction (Fig. 7).

3.7 Simple background management

The background provides three functions of user management, role management, and system log. User management is employed for each user's account management and authority management. Authority management includes data usage permission and menu permission. Role management is divided into developers, ordinary users, and super administrators. The system log is to count the usage of theme diagrams and data by users, which is convenient for updating the most commonly utilized data by planners.

4 Typical applications

4.1 Data query and browsing

On the working platform, public theme diagrams and public data are directly invoked by clicking or dragging, and detailed data is filtered by clicking the 'query' button in the map area or by conditional query to achieve convenient data query and browsing (Fig. 8).

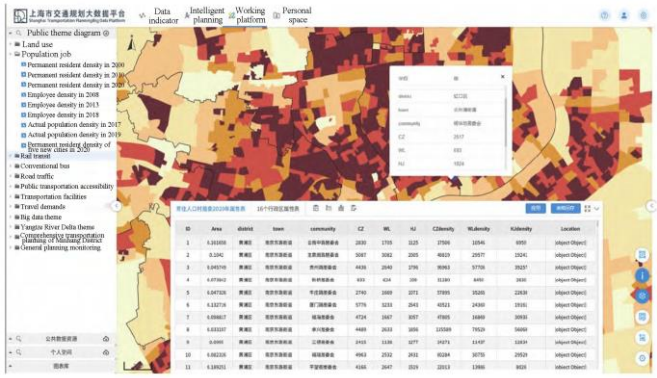
4.2 Indicator query and monitoring

The indicator display panel is made through the platform to realize dynamic monitoring and convenient query of core indicators. Fig. 9 is a theme diagram of monitoring the core indicators of the existing urban rail transit.It shows the core indicators such as the average daily passenger volume of the urban rail transit network over the years, the length of operating lines, and the average daily passenger volume of each line in recent years. Detailed data can be directly queried by clicking the plane icon.

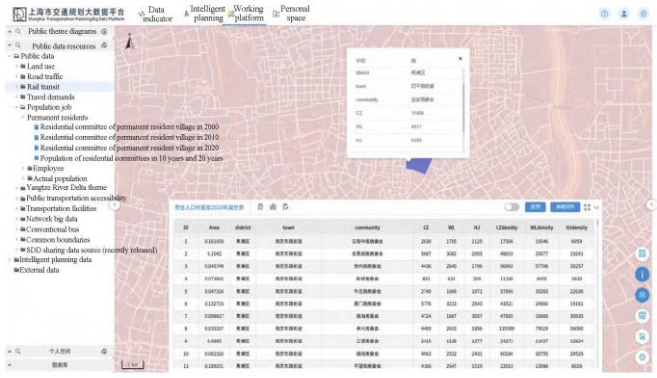
a. Professional platform for transportation planning models (professional software version)

b. Big data platform for transportation planning (web version)

Fig. 7 Interaction of professional software version platform and web version platform



a. Query and browsing through theme diagrams



b. Query and browsing by calling public data

Fig. 8 Data query and data browsing function

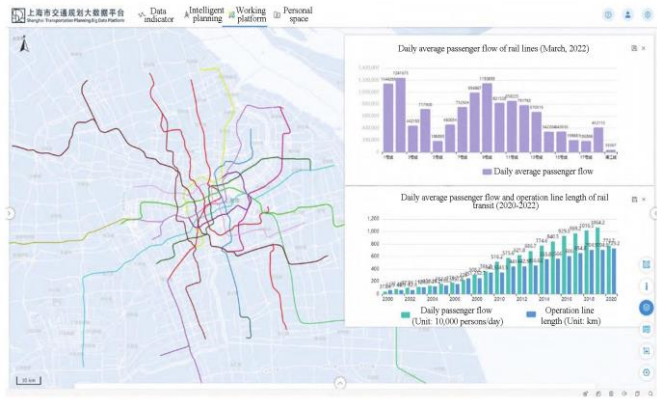


Fig. 9 Theme diagram of monitoring on core indicators of the existing urban rail transit

4.3 Online drawing and sharing

The online interactive drawing function is the core function of the web platform. By employing the data and drawing functions, various theme diagrams can be produced to support daily project applications. Fig. 10 is a thematic analysis diagram produced by the web platform in the comprehensive transportation planning of Minhang District, Shanghai.

The web platform supports the sharing of theme diagrams and data with other users. On the working platform, a sharing link of any theme diagram can be generated, and other users can view the data by clicking the link without logging in.

5 Conclusions

Relying on the construction of a new comprehensive transportation planning model in Shanghai, the web platform not only provides a medium for the application and display of a comprehensive transportation planning model but also a helpful attempt for informatization planning. Based on the functions of visualization and query analysis commonly adopted in the urban and transportation planning information platform, the application function is further improved. Based on the different advantages of the web platform for more ordinary users and the professional software platform for professional function applications, the two platforms realize data interaction and communication, and the exchanges between transportation modelers, data analysts, information engineers, transportation planners, and urban planners. The design concept of the web platform is to provide common theme diagrams and publicly shared data resources for planners. Through the superposed analysis and application of various data resources and customized drawing functions, the data use can be empowered in planning services. The web platform can make the planners easily view and employ various data resources, and ensure data security. The background management of the system can easily realize the management of various data rights and roles. According to the data use frequency of the background statistics, the maintenance personnel can rely on the professional software platform to edit, maintain, and transmit the data, and dynamically release the theme diagrams with large business needs to realize the close combination of the web platform and the planning work.

An important feature of the web platform construction is the addition of human-machine interaction drawing functions. In the professional software platform, the map will be updated with the data. While in the web platform, the map will not be updated synchronously with the data, and it can only be realized through the sliced image data generated by the front-end rendering, which is relatively complicated. High-efficiency update of maps with the data is a direction that the web version platform needs to improve in the future. For example, theme diagrams released after data update can be automatically updated. Additionally, although the web platform realizes the coordinate transformation of vector data in different coordinate systems, it currently only supports web Mercator projection image data, and the images for local projection coordinates require applying this projection to the vector data for matching. In the future, the setting functions of different projections for vector data should also be added.

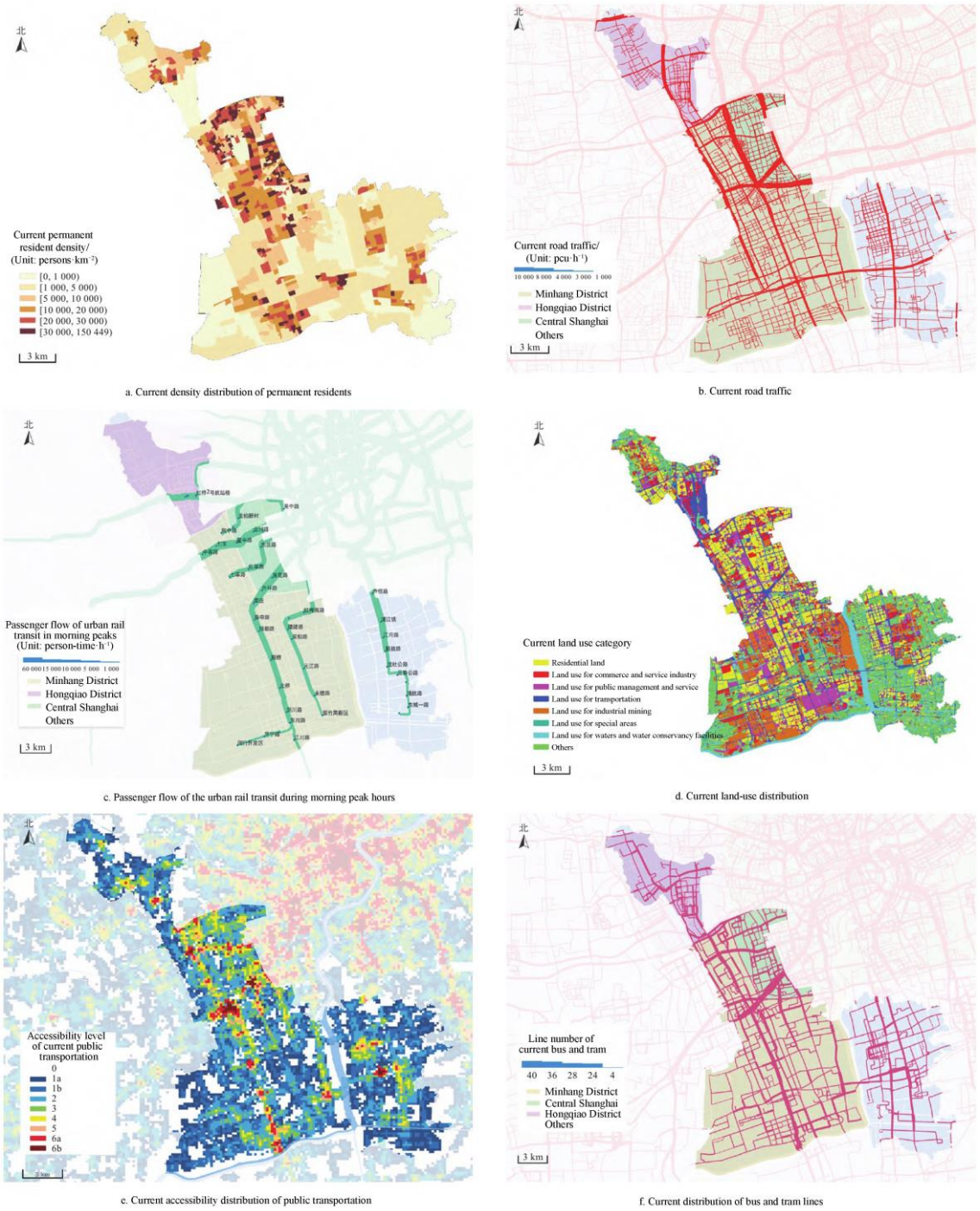


Fig. 10 Thematic analysis diagram produced using the web version platform in the comprehensive transportation planning of Minhang District, Shanghai

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