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Key Technology on Middleware-based Dynamic Traffic Information Platform

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Abstract

According to traffic information of multi-source heterogeneity and complexity of information processing, the architecture of the dynamic traffic information platform based on middleware is proposed, which enhanced the system stability, generality, and efficiency depending on the high integration and scalability of middleware. This middleware-based platform unifies and encodes the data from all sorts of detectors, and integrates the multi-mode transmission, data preprocessing, and data fusion. On the publishing stage, this platform realizes the interactions between different publishing devices and traffic database through an independent traffic information publishing middleware. The proposed platform overcomes the data loss and data noise, decreases the data redundancy due to the heterogeneous multi-source data, and ensures the data accuracy with better security and expandability. The performance is efficient, reliable with cross-platform information transmission.

Keywords: *middleware, information collection, information publishing, traffic information platform, intelligent transportation system*

1. Introduction

Along with the economical development and the urbanized advancement, the vehicle quantity increased sharply. It brought a series of traffic problems such as traffic congestions, environmental pollution, and the increased traffic accidents, and simultaneously created huge energy waste and economic loss. The traffic conditions became the bottleneck of economy restriction and the social sustainable development.

With the advanced information technology applied unceasingly in the transportation, the informatization becomes one of the important solutions to transportation problems. The integration of advanced technologies such as computer, information, communication, sensor, electronic, and artificial intelligence, forms a comprehensive, real-time, accurate, and efficient dynamic traffic information system. This system can adjust the time and spatial distribution of traffic flow effectively, advance the road network traffic capacity, realize the information resource sharing, enhance the transportation efficiency, and improve urban environment [1]. In recent years, Public Security Ministry has implemented the national public security traffic information system construction on a national scale, such as the vehicle and the driver query system, the road traffic accident information system, the imported vehicle verification system, and the motor vehicle registration management system [2-6]. When these systems collect and process the traffic information, they only serve their own related traffic management modules. However, the information could not be shared or fully used by the other government administration or the social public. This kind of barriers between different management departments cause the “isolated island” problem in traffic information systems, which makes the information dispersion and the equipment independence with the low use ratio. This phenomenon becomes the important restraints to the development of Intelligence Transportation System (ITS).

Following the further development of concomitance transportation intellectualization, the independent traffic management system can not meet the needs of the flourished transportation. Therefore, resource sharing among all sorts of ITS subsystems appears more urgent [7, 8]. Establishing dynamic traffic information platform by using advanced information technology realizes the integration, sharing and cooperation of all the transportation data and

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resources in a wide range [9, 10]. The dynamic traffic information platform can also combine the resources of each system organically, so as to perform its biggest potency and form a new integrated intelligent transportation system to solve the above problems. The coexistence of all kinds of traffic information detectors with multiple communication modes, together with the heterogeneous multi-source characteristic of collected information and the complexity of information processing [2], brings lots of inconveniences to the traffic information processing and comprehensive utilization. Meanwhile, there are sorts of information publishing modes in the traffic information publishing terminal. Each publishing mode is developed respectively and accesses the database directly. From the perspective of security, it increases the risk of accessing the database. In the aspect of development cost, the software reusability is low with long development cycle and huge cost.

Consequently, an intelligent dynamic traffic information platform based on middleware is proposed to simplify the traffic information system structure and uniform the traffic information communication protocol in order to latter information processing and comprehensive utilization. This platform overcomes the data missing, the data noise, and especially the heterogeneous multi-source which affects the entire traffic information system, reduces the data redundancy, guarantees the data accuracy, and enhances the data transmission reliability. Moreover, the middleware-based traffic information publishing system in the platform realizes efficient, credible, and cross-platform data transmission [11-13].

2. Middleware-based Platform Architecture

The dynamic traffic information platform collects the traffic information from different detectors equipped in the road network firstly. Then, it transforms, processes, stores the collected information, and analyzes the data for comprehensive utilization. Moreover, in order to meet the requirements of different users, the platform will also provide useful audio and video data for inquiry and selection. Therefore, a complete dynamic traffic information platform should include at least four basic functions. The first is information collection, such as fixed detectors (e.g. coil detector, microwave detector, video detector, etc.) and movable floating car. The second is data processing and analysis, including data preprocessing, data fusion, data mining, optimal route decision making, and diagram information statistics. The third is traffic information publishing, including internal information publishing system and external information publishing system. The last is the data storage and backup. The logic architecture of general dynamic traffic information platform can be described as Figure 1.

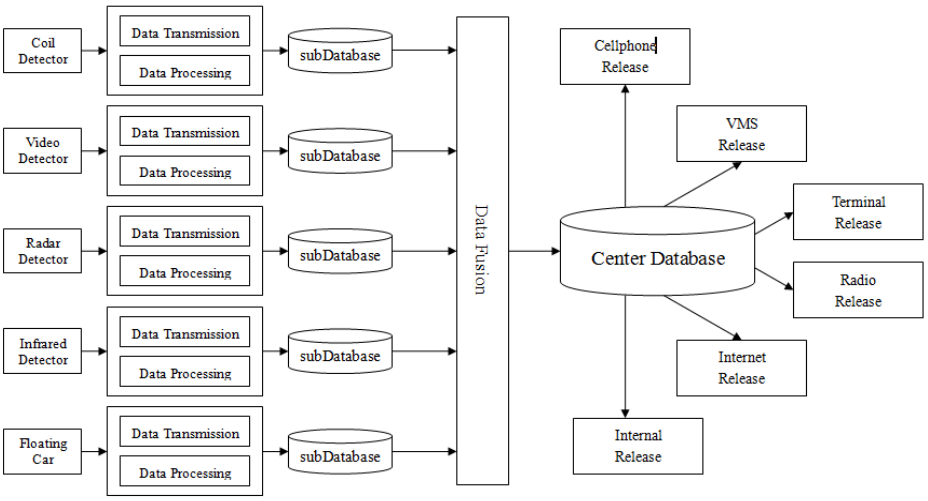

Figure 1. Traditional Logic Architecture of Dynamic Traffic Information Platform

Figure 1 shows that the data collected from different kinds of detectors have the characteristics of multi-source, heterogeneity, hierarchy, imperfection, and inconsistency. Moreover, the data also have the temporal and spatial characteristics. Hence, they need advanced data processing technology such as data preprocessing and data fusion to enhance

the reliability and accuracy. Special sub-databases, which possess huge data space, must be designed for data storage. The increased data redundancy goes against to data processing. Meanwhile, the traffic information publishing terminals access the database directly. It not only increases the throughput, but also increases the risk of data accessing. However, the middleware-based traffic information platform can overcome the above disadvantages so as to provide a safe, reliable, efficient, and accurate dynamic information platform. Figure 2 shows the logic architecture of middleware-based dynamic traffic information platform.

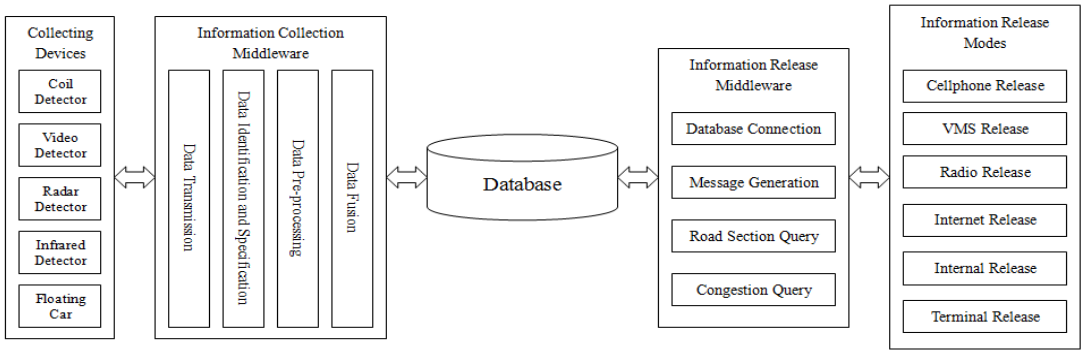

Figure 2. Logic Architecture of Middleware-based Dynamic Traffic Information Platform

The logic architecture of dynamic traffic information platform based on the middleware in Figure 2 is divided into three layers, namely, the traffic collection and processing layer, the data storage layer, and the information publishing layer. Each layer is well arranged and easy to developed and implemented.

3. Key Technology

3.1. Information Collection and Processing

Multi-sensor detection with complementary advantages becomes the main direction in traffic information collection system. The real-time information accessed to the traffic information platform is collected from sorts of detectors and artificial collection sources located in the urban road network. Automatic detectors include fixed detectors, such as coil detectors, microwave detectors, video detectors, and movable floating car detectors. The collection location of fixed detectors is fixed with a small coverage. However, the accuracy of the collected data is high. In the contrary, the floating car detectors can collect mass of data with a large range, which have already been one of the most important information collection modes. However, the data accuracy collected by the floating car is less lower due to interferences of GPS localization signal by the shelter from urban expressways and high-rise buildings and the internal affects.

As each kind of traffic information detector has the good and bad points respectively, the collected traffic parameter type and form as well as the data format are possibly various. Hence, the traffic data have the characteristics such as multi-source, isomerism, hierarchy, imperfection and inconsistency, and they also have the time and spatial characteristic. Data processing techniques like information fusion can enhance the traffic information reliability and accuracy, and it is also able to transform the imprecise, incomplete, inconsistent and unreliable traffic information to uniform explanation and description to the goal or the phenomenon.

Considering the coexistence of sorts of communication pattern, the heterogeneous multi-source traffic information terminals provided by all kinds of traffic information detectors, and the complex traffic information processing, the middleware-based dynamic traffic information collection system construction is proposed to simplify the traffic information collection system structure and regulate traffic data format. This construction will use the middleware technology to uniform and code the data from different traffic information detectors so as to well perform the data preprocessing and fusion. The middleware-based system can overcome the disadvantages such as data missing, data noise, and multi-source heterogeneous isomerism, as well as reducing the data redundancy, guaranteeing the data accuracy, and enhancing the data transmission reliability.

The logic construction of middleware-based dynamic traffic information collection system integrates the system into three layers: traffic information detector layer (Detecting layer), information collection and the processing layer (Middleware layer), and traffic information storage layer (Traffic Database layer). Each layer is clearly distinct and easy to develop and realize. The main characteristic of the information collection middleware is to effectively manage the connection and accessing to the database so as to improve multi-user accessing database performance, optimize network transmission, and support with many kinds of database accessing. The information collection middleware mainly consists of the following four parts. Firstly, it contains the traffic information transmission by serial port of network communication. Secondly, it uses the Interface Definition Language (IDL) in CORBA middleware technology to customize the information collection port, which can match with all kinds of traffic information detectors. It can also identify and specify the data from these detectors, and realize the real-time collection of traffic flow, vehicle speed, lane occupancy, and so on. Thirdly, it preprocesses all the collected heterogeneous multi-source data and matches the Floating Car Data (FCD) into the electronic map by road network matching algorithm based on the network topology relation. In the end, the middleware fuses the preprocessed data and moves them into the Database.

3.2. Information Publishing

Along with the development of the intelligence transportation system, the dynamic traffic information publishing system presents the unification of the diversity and information accuracy. The general traffic information publishing modes include Short Message Service (SMS), Variable Message Sign (VMS), traffic radio, vehicle terminal, and Internet.

Each publishing mode is developed respectively and accesses the database directly. From the perspective of security, it increases the risk of accessing the database. In the aspect of development cost, the reusability is low with long development cycle and huge cost. The information publishing middleware is a module consisting of a message transmission mechanism or message queue mode. It provides a general and credible method for establishing, sending, and receiving information so as to realize effective, reliable, cross-platform information transmission by utilizing efficient credible information transmission mechanism for data exchange among different platforms. The publishing middleware integrates the commonness of different publishing modes, and it is independent of all these publishing modes. The publishing middleware can be suitable for current publishing modes by secondary development. It locates between the database and each publishing terminal so as to simplify the database call, provide public port for accessing database access authority for enhancing database security.

The logic architecture of the dynamic traffic information publishing system is divided into three layers, including data store layer, information publishing middleware layer, and multi-mode information publishing layer. Each layer is well arranged and easy to developed and implemented. The information publishing middleware development package document contains four parts, which are com.traffic.dbconn package, com.traffic.roadinfo package, com.traffic.message package, and com.traffic.example package. From the function aspect, the information publishing middleware includes data connection module, SMS module, road section inquiry module, congestion degree inquiry module, and so on.

3.3. Data Management

The database design is one of the main contents in dynamic traffic information platform construction. A good database design is the essential condition of stable operation of dynamic traffic information platform with mass data. Besides the basic functions like guarantee of data storage and backup, the database design must ensure the data security so as to provide the entire information platform safety

The real-time data is saved in distributional database, which improves the reliability, availability, scalability of the traffic information platform. One-minute data and fifteen-minute data are processed and integrated respectively, and then transmitted to the central database for further information analysis, utilization and publishing. This procedure can not only lighten the burden of central database, but also satisfy the real-time demand of information service as well as enhancing platform operating efficiency.

The storage of traffic data includes static information and dynamic information. The static traffic information is time independent with less update, which saves as the map

document or static attribute data in the database. The dynamic traffic information is highly time dependent. The data quantity increases along with time variation, which needs to be saved in the real-time database.

Because of the quick change of dynamic traffic information due to time variation and the short sampling time interval, the data capacity can multiply and cause heavy database burden, which brings the difficulty for data storage. How to design the database reasonably and choose the appropriate storage scheme becomes one of the important issues of dynamic traffic information platform.

The general data storage approach for the traffic management center is to delete the collected data after a certain period preservation. The deletion of original data can result in data loss so as to bring inconvenience to traffic management, analysis, planning, and decision making as well as the history data maintenance and value-added services. In order to solve the above problem, the data must be integrated before the deletion. The specific implementation is to integrate the data in different time interval according to different application demands. For example, the original data collected in the time interval of twenty second are integrated in one-minute data, five-minute data, fifteen-minute data, and one-hour data respectively for further history data analysis and utilization so as to reduce the data storage capacity. The original traffic data should be preserved at least one day as well as a month for the one-minute data and a year for the one-hour data.

4. Middleware-based Platform Realization

According to Jinan road traffic resources and Jinan intelligent transportation development program, we demonstratively established the dynamic traffic information platform based on middleware. This system mainly includes heterogeneous multi-source traffic information collection system, internal traffic information publishing system serving the traffic management department, and external traffic information publishing system serving the general traffic participants.

The Dynamic traffic information collection system based on middleware is shown in Figure 3. After entering the system, the system can implement the functions of data collection, data preprocessing, data fusion, data store, and so on in the background automatically. Moreover, the system also has the functions of data query, road section management, user management so as to provide convenient operation of later data query, data utilization, and fluctuant road and detector information management due to further renewal.

Figure 3. Middleware-based Dynamic Information Collection System

The internal traffic information publishing system serving the traffic control department realizes the following function based on the electronic map.

Basic operation includes map zoom-in, zoom-out, translation, inquiry, and layer management in the Geography Information System (GIS) platform.

Data analysis includes dynamic data inquiry, static data inquiry, data mining, and history trend analysis.

Video management includes regulation of video position, video attribute edition, and video checking.

Authority operation includes intervention function of the internal traffic information publishing system, such as the published information edition and management. The internal traffic information publishing system is as shown in Figure 4.

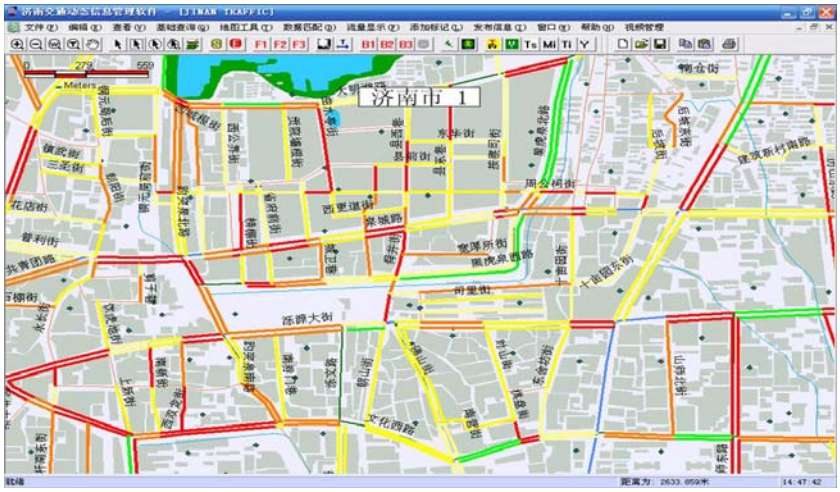

Figure 4. Internal Traffic Information Publishing System

The internal information publishing system enhances the efficiency of the traffic supervising and managing departments, and the external information publishing system manifests its important value. What the platform plays for is no other than serving general traffic participants. The external information publishing system is shown in Figure 5.

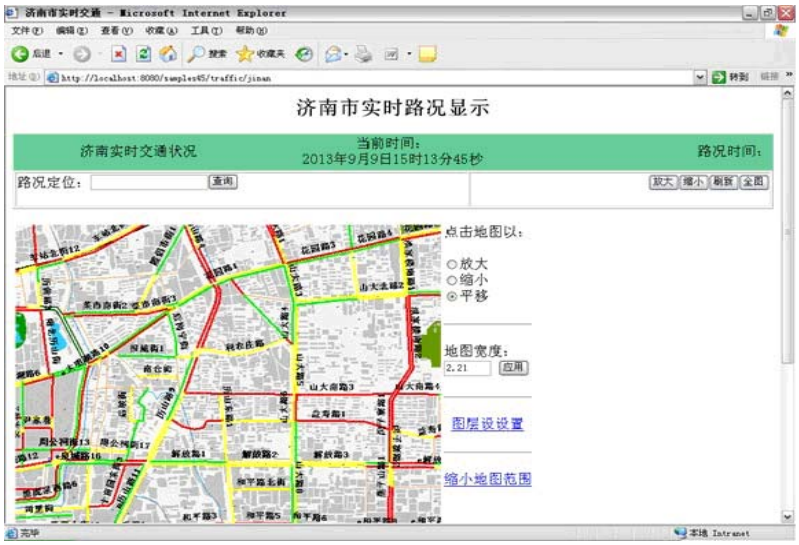

Figure 5. One of the External Traffic Information Publishing System

Compared with traditional traffic information platform, the middleware-based traffic information platform integrates the traffic data collection, traffic information management, and traffic information releasing. The middleware-based traffic platform includes the static geographic map data, real-time traffic information, and traffic control data. The proposed platform can provide a coincident data access interface to manage and control the data so as to overcome the differences among all sorts of traffic data source in various traffic application systems. The introduction of middleware not only can share the traffic data among different subsystems, but also can make the information query and utilization across platforms easier to traffic administrators.

5. Conclusion

The traffic information platform is the hub of the intelligent transportation system, which shares the information from sorts of traffic subsystems. The traffic information platform can provide significant criterions for the relevant departments to implement scientific transportation organization and control schemes. The platform adopts advanced data storage and management technology to integrate and manage all these traffic subsystems efficiently so as to solve the isolated information problem. The middleware-based dynamic traffic information platform brings the middleware technology in the traditional traffic information platform, collects and publishes the dynamic traffic information so as to provide accurate and real-time traffic information to the general traffic travelers.

The coexistence of all kinds of traffic information detectors with multiple communication modes, together with the heterogeneous multi-source characteristic of collected information and the information processing complexity, brings lots of inconveniences to the traffic information processing and comprehensive utilization. Meanwhile, there are sorts of information publishing modes in the traffic information publishing terminal. Each publishing mode is developed respectively and accesses the database directly. From the perspective of security, it increases the risk of accessing the database. In the aspect of development cost, the reusability is low with long development cycle and huge cost. The proposed intelligent dynamic traffic information platform based on middleware is to simplify the traffic information system structure and uniform the traffic information communication protocol in order to latter information processing and comprehensive utilization. This platform overcomes the data missing, the data noise, and especially the heterogeneous multi-source which affects the entire traffic information system, reduces the data redundancy, guarantees the data accuracy, and enhances the data transmission reliability. Moreover, the middleware-based traffic information publishing system in the platform realizes efficient, credible, and cross-platform data transmission.

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