Research on an Adaptive Heterogeneous Database Middleware and Visualization Technology

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Abstract. In order to improve the efficiency of MIS development based on heterogeneous data sources, an adaptive heterogeneous database middleware and key visualization technology are proposed to realize the automatic creation of data access layers through visualization operations on the basis of heterogeneous databases. This research focused on the general access mode of various data sources in middleware, the interface of data and operation mapping between entity classes and object-oriented virtual heterogeneous databases, the associated interface technology between associated entity classes and corresponding data tables, the interface technology of cross-table and cross-database operation, the algorithm model for optimizing data access, the visualized operation interface, with the purpose is to provide a universal, powerful and easy-to-use middleware for the development of WEB-based MIS software. It will enable program developers to complete the development of data access layers (library building, entity class creation, data access operation method establishment, etc.) through simple visualized operations, and generate program code for the data access layer, which will greatly reduce the development workload and time of the MIS software in this procedure and improve the efficiency of software development.

Keywords: heterogeneous data sources; middleware; object-oriented; virtual database; management information system

1. Introduction
With the increasing complexity of modern WEB-based management information system (MIS) software, the development model of such software using a three-tier architecture is rapidly popularized, to achieve the purpose of “high cohesion and low coupling” in software development. This mode divides MIS software into presentation layer, service logic layer and data access layer to develop separately. The presentation layer is located at the top layer, used to display and receive data that the user inputs. It provides users with an interactive operation interface, and hand over user requests to the service logic layer for processing. The service logic layer is located between the data access layer and the presentation layer, and plays the role of linking up and down in data exchange. It is mainly used to implement combined operations on the data access layer according to specific logic. The data access layer mainly realizes the access and operation of databases and various data files, providing data...
access support for the service logic layer [1-10].

The current MIS software is developed with a three-tier architecture, and the program developers need to write the program code of each layer. Among them, the presentation layer and service logic layer need to be developed flexibly according to the software interface and logic requirements, while the development mode of the data access layer is relatively fixed. Program developers usually build databases and entity classes first, and then write program codes that connect and access databases on this basis, so as to provide data access support for the service logic layer. The development of the data access layer usually takes developers a lot of time and energy. Therefore, if this part of the development work can be simplified on the premise of meeting the needs, it will undoubtedly be of great benefit to improving the efficiency of software development.

A self-adaptive heterogeneous database middleware and key visualization technology is proposed in this paper to realize the automatic creation of a data access layer through visualized operations on the basis of heterogeneous databases. This research focused on the general access mode of various data sources in middleware, the interface of data and operation mapping between entity classes and object-oriented virtual heterogeneous databases, the associated interface technology between associated entity classes and corresponding data tables, the interface technology of cross-table and cross-database operation, the algorithm model for optimizing data access, the visualized operation interface, with the purpose is to provide a universal, powerful and easy-to-use middleware for the development of WEB-based MIS software. It will enable program developers to complete the development of data access layers (library building, entity class creation, data access operation method establishment, etc.) through simple visualized operations, and generate program code for the data access layer, which will greatly reduce the development workload and time of the MIS software in this procedure and improve the efficiency of software development.

2. Proposal of adaptive heterogeneous database middleware

Relevant analysis will be given to the operating mechanism, development characteristics and code structure of the data access layer in the current MIS software -- the code structure is the final code form generated by the middleware. With this as the goal, the author will study the structure of each kind of basic information generated inside the middleware, and then explore the overall structure and operation process required to generate the basic information. On this basis, the author will research the operations that the visualized human-computer interaction interface needs to include, the structure of the internal information generated by the operations, and the creation and mapping of object-oriented virtual heterogeneous data sources. By analyzing the interaction characteristics between the data access layer and the current mainstream relational databases, the interaction and mapping mechanism between object-oriented virtual heterogeneous data sources and entity relational databases can be understood. Finally, the code of the data access layer can be generated according to the internal information of the middleware.

2.1 Adaptive heterogeneous database middleware

Based on the development and operation mode of the data access layer in an object-oriented environment, an adaptive heterogeneous database middleware is proposed in this paper. The middleware is divided into four parts: the underlying database, the internal virtual database, the internal information processing part and the visualized operation part. The basic idea and architecture are shown in Figure 1.

The underlying database is composed of several current mainstream relational databases. It is the physical data foundation of middleware and used to physically store data. On this basis, a virtual object-oriented heterogeneous database is established for internal access by middleware. The virtual heterogeneous database is used to logically store the upper-layer object data, and then establishes a corresponding mapping processing mechanism between the interface and the underlying entity database to realize the data exchange between the virtual database and the entity class database. The underlying entity database provides support for its upper-layer virtual database, and the virtual
database provides support for the upper-layer object-oriented data access.

![Figure 1 The basic idea and architecture of middleware](image.png)

The visualized operation part and the internal information processing part of the middleware are built on the virtual database, which is responsible for managing the database and generating the data access layer. In the visual operation part, the underlying database information is generated by creating and managing the underlying database, laying the foundation for creating an object-oriented virtual database. By creating a virtual database and establishing the mapping relationship between it and the underlying database, virtual database information is generated, which lays the foundation for the mapping between entity classes and virtual databases as well as the storage of objects. The entity class information is generated by creating and managing the entity class, and then the entity class is mapped to the object-oriented virtual database and the corresponding mapping information is generated, realizing the storage of the entity class object in the virtual database. Based on the entity class information and its mapping information with the virtual database, the CRUD operation for the entity class object is mapped to the corresponding operation in the virtual database, and the corresponding mapping information is generated. In the same way, the mapping of the association relationship between the entity class objects in the virtual database can be realized, and the corresponding mapping information can be generated.

Based on the various settings and mapping information generated inside the above middleware, a data access layer is further generated.

### 2.2 Key points of design
The design of middleware has the following three key points:
(1) Generic access model of heterogeneous data sources based on virtual database technology

On the basis of the access methods of current mainstream relational databases in an object-oriented environment, a generic data access model is constructed to encapsulate the way of storing and retrieving data in relational databases. It supports a user to build various underlying databases in middleware through a visual interface in a default or customized way, and the middleware can encapsulate various database access programs. According to the underlying database type selected by the user, a corresponding database access program is generated. The middleware automatically creates the library in the underlying database software of the corresponding type and establishes a connection with the database. On this basis, an object-oriented virtual heterogeneous database is established to lay the foundation for the upper-layer object-oriented access method. In view of the fact that the SQL language for accessing relational databases is not a cross-database standard, users are based on the SQL language to study the common access language of virtual heterogeneous databases in the platform. And then the platform translates the language into the SQL language corresponding to the entity database according to the type of entity database currently accessed, and then executes the operation on the database. A user can build a virtual object-oriented heterogeneous database through this model. The middleware hides the underlying entity database architecture from the user and provides complete object-oriented CRUD operations. The user only needs to access the virtual data source without paying attention to the operation of the underlying entity database.

(2) Adaptive access interface for heterogeneous databases

By studying the development model of the object-oriented software and the transfer mode of objects between various layers, various mapping processing mechanisms between entity classes and object-oriented virtual heterogeneous data sources are established, and the application object is finally persisted in the table of the underlying relational database through the interface between the virtual heterogeneous data source and the entity database. In addition to realizing that the attributes in the entity class correspond to the fields in the underlying entity data table and that the association relationship between the entity classes corresponds to the association relationship of the corresponding data table in the underlying entity database, it can correspond to the CRUD operations on the underlying entity database for adding, deleting, modifying, and querying objects, and also support one object corresponding to multiple underlying entity data tables or data tables in multiple entity databases.

(3) Automatic code generator of middleware and the visual operation

The research on the visualized operation interface based on the internal structure and operation mechanism of the middleware enables users to construct the data access layer only by simple operations through the visualized operation interface. A user can create and manage the underlying entity database, create the object-oriented virtual heterogeneous database and establish the interface between it and the entity database, create and manage entity classes, and establish various interfaces between entity classes and virtual data sources. Then the corresponding internal information of the middleware can be generated. The middleware generates the corresponding program code of data access layer according to the internal information, thereby eliminating the user's work of writing this part of the code and improving the development efficiency.

3. Conclusion

Serious exploration was given to the general access mode of common data sources in MIS software development, the data and operation mapping interface between entity classes and object-oriented virtual heterogeneous databases, and the associated interface technology between related entity classes and corresponding data tables, the interface technology for cross-table and cross-database operations, algorithm model for optimizing data access, visual operation interface, etc. The construction of MIS software development of web-based adaptive heterogeneous database middleware enables program developers to complete many data access layer development tasks only through simple visual operations, such as database building, entity class creation, establishment of data access operation methods, and so on, and generate the program code of the data access layer, which can effectively
reduce the development workload and time in this procedure of the MIS software and improves the efficiency of software development.

This middleware has been used in the software development of management information system. In the development and maintenance of MIS software, it can help users to quickly build object-oriented virtual heterogeneous databases through visual operations. When the underlying distributed actual database changes, they can easily reconstruct the virtual heterogeneous database, so as to better deal with the frequent changes of MIS software database structure. This middleware allows programmers to focus on the design of software architecture, flow and logic when developing MIS software, greatly reducing the development workload at the data access layer and effectively improving the efficiency of software development and maintenance.

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