

Research on the Construction of a National Coal Mine Gas Basic Information Database

Jun Liang^{1,2}

¹ State Key Laboratory of Coal Mine Disaster Prevention and Control, Chongqing 400037, China

² China Coal Technology and Engineering Group Chongqing Research Institute, Chongqing 400037, China

Abstract

With the rapid development of China's coal industry, coal mine safety issues have become increasingly prominent, particularly frequent gas accidents, posing severe threats to lives and property. Based on the construction project of the National Coal Mine Gas Basic Information Database, this paper explores in depth the application value and technical implementation of this database in coal mine safety management. By analyzing the database's construction objectives, overall design, and functional implementation, the study aims to provide a scientific reference for coal mine safety management and informatization development.

Keywords

Coal Mine Safety; Gas Basic Information Database; Informatization Management; Data Mining; Gas Prevention and Control.

1. Introduction

China is the world's largest producer and consumer of coal, with coal occupying a dominant position in the energy structure [1]. However, coal mine safety issues have always been a bottleneck restricting the healthy development of the coal industry [2-3]. Gas accidents, as one of the main types of coal mine accidents, have the characteristics of strong suddenness and great destructive power, bringing huge challenges to coal mine safety production [4-5]. To effectively curb the occurrence of gas accidents and improve the level of coal mine safety management, it is particularly important to establish a national coal mine gas basic information database.

The construction of the national coal mine gas basic information database is of great significance for improving the level of coal mine safety management and promoting the sustainable development of the coal industry. On the one hand, by centralizing and sharing basic gas information, it can provide a basis for the government to formulate industrial policies, industry regulation, and scientific research. On the other hand, the application of databases helps to realize the intelligence and precision of coal mine gas prevention and control technology, and improve the prevention and emergency response capabilities of gas accidents. In recent years, the country has attached great importance to coal mine safety production work and taken a series of measures to strengthen coal mine safety supervision [6-7]. However, due to the large and scattered amount of basic information on coal mine gas, the difficulty of information collection and organization, and the lack of a comprehensive, dynamic, and authoritative information database and management system, it has brought many inconveniences to coal mine safety management. Therefore, the construction of a national coal mine gas basic information database has become an urgent need.

2. Overall Database Design

2.1. System Construction Objectives

The construction goals of the national coal mine gas basic information database mainly include the following aspects: (1) Regularly collecting and updating gas information: regularly organizing the collection of gas update data from various coal mines or mining areas, collecting gas accident data in real time, and inputting it into the computer system. (2) Classification management of gas basic data: Each mining area, coal production base, and county-level, municipal, and provincial-level management departments can classify and manage their gas basic data. (3) Query and statistical analysis: based on time series, query and statistical analysis of national coal resources, gas resources, coal production enterprises and mines, coal mining and coalbed methane development and utilization, different levels of gas (outburst) hazardous areas, gas prevention and control technology, gas accidents, gas drainage status, etc. (4) Establish a standard database: Establish a standard gas basic information database, in addition to electronic files stored on servers, regularly produce CDs and paper files. (5) Establishing standards for data collection, storage, statistics, management, and service: preparing for the establishment of a national coal mine basic information database. (6) System stability and compatibility: The system has good stability, compatibility, portability, and is easy for the server to respond promptly and quickly to client browsing and queries.

2.2. Overall Architecture

The national coal mining area gas basic information database is established using a client/server (C/S) model, based on MapObjects client and ArcIMS file based GIS data center server. It interacts with business databases and gas basic information databases through XML messages and ADO.NET technology. The entire software system platform is based on the main products of ESRI ArcGIS series, with Windows system as the unified network operating system and Microsoft SQL SERVER 2000 as the database management system.

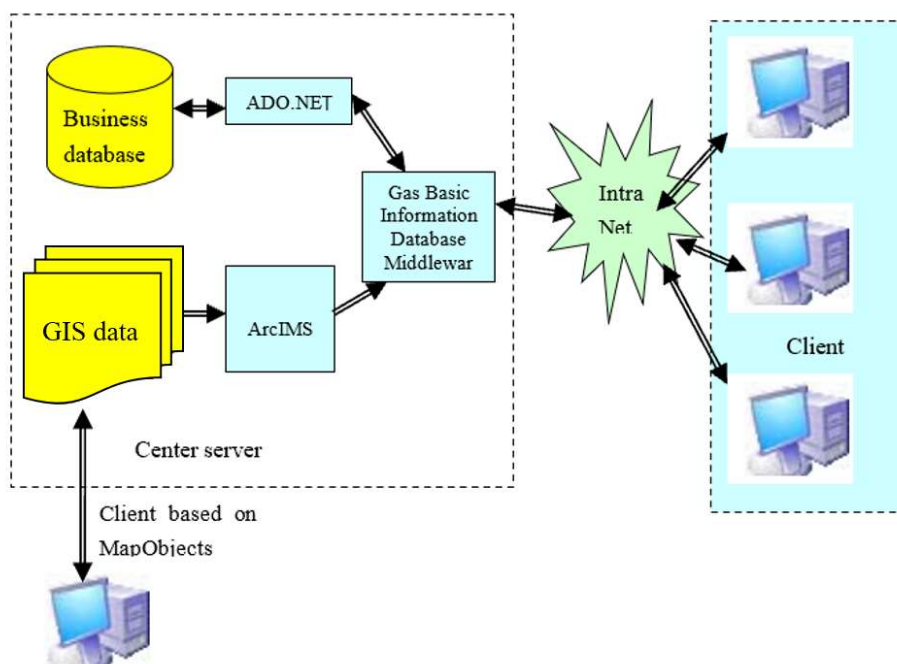


Figure 1. System application framework

2.3. Implementation Technical Description

(1) C/S mode

The C/S model has the advantage of fully utilizing the processing capabilities of the client PC, with fast response times and suitable for handling large amounts of data and complex business logic. In this project, the application of C/S mode enables the system to efficiently handle tasks such as collecting, storing, querying, and statistical analysis of gas basic information.

(2) GIS technology

The application of GIS technology in the coal mine gas basic information database has achieved functions such as visualization of spatial terrain contour features, visualization of terrain thematic attribute information with spatial reference characteristics, spatial orientation, and spatial thinking. Through GIS technology, users can intuitively view information such as coal mine distribution, gas resource distribution, and gas accident locations, providing strong support for coal mine safety management.

(3) Component based GIS technology

The system uses the component-based GIS product MapObjects to develop a spatial data maintenance client, achieving the organic integration of spatial data and business data. Component based GIS technology has the characteristics of strong scalability and scalability, making it easy to expand functions and customize development according to actual needs.

2.4. Functional Design

The national coal mine gas basic information database system is constructed using a mixed mode of browser/server and client/server. The browser extracts, statistics, and analyzes business information, while the client maintains and integrates spatial and business data. Specific functions include: (1) Basic map operations: Complete basic operations such as map scaling, roaming, positioning, querying, and measurement. (2) Mineral point query: Directly query the distribution data of mineral resources from the map using different spatial query methods. The query results can be quickly located on the map and can be statistically analyzed by year and category. (3) Data statistics: Provide statistical methods such as mine data, gas situation, and accident information. Corresponding statistical charts and reports can be created according to needs, and different types of thematic maps can be generated by combining maps. (4) User permission management: Manage user permissions by role to ensure that different users can only access data within their permission range. (5) Spatial data management: Edit and maintain thematic spatial data of coal mines, ensuring consistency and correlation between spatial data and business attribute data through geographic coding. (6) Business data management: Complete tasks such as inputting, modifying, and verifying business data to ensure its accuracy and completeness.

2.5. Database Design

Coal mine information includes two categories: spatial data and business attribute data. Spatial data includes basic spatial data and thematic spatial data, while business attribute data covers multiple aspects such as basic information, production information, gas information, and accident information of coal mines. In order to better maintain data security and facilitate system calls, spatial data and business data are stored separately and their association is maintained through geographic coding. This design approach increases the flexibility of data invocation, allowing for separate invocation of spatial or business data, as well as simultaneous invocation of both types of data.

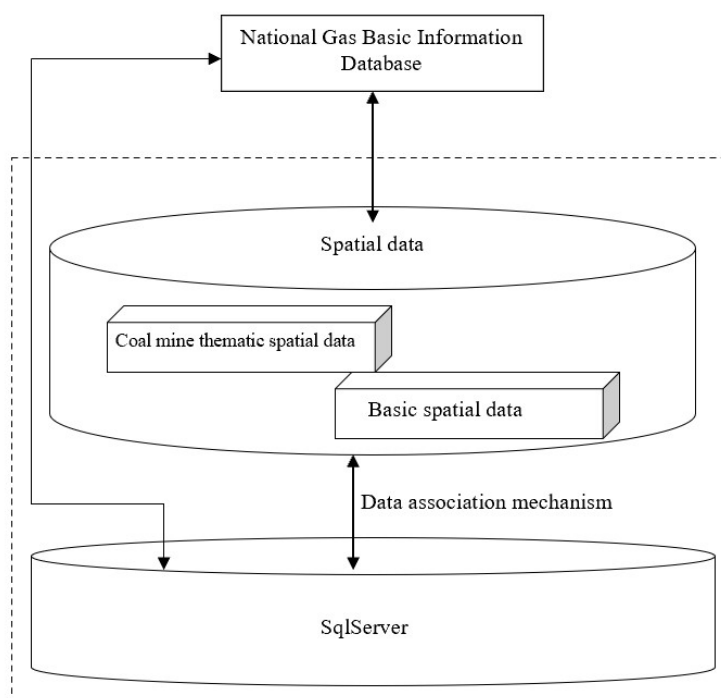


Figure 2. Database structure

3. Construction and Implementation of Data System

3.1. Data Status

The data content of the coal mine gas basic information database is extensive, including macro data information, specific information of coal enterprises, gas control technology and equipment information, coal mine gas accident information, and many other aspects. These data provide comprehensive information support for coal mine safety management.

3.2. Data Feature Analysis

In terms of data feature analysis, the particularity of the construction of the coal industry resource sharing platform has been fully considered. Based on the requirements of distributed collection, processing, storage, and sharing services of gas basic information resources, the technical standards for China's gas basic information sharing system have been proposed. Through in-depth analysis of the national and regional characteristics of the distribution of coalbed methane resources, gas hazard areas, gas extraction and utilization, a technical support system for system construction has been formed.

3.3. Data Structure

To ensure the accuracy and completeness of the data, this project has designed a detailed data structure. Taking the basic information database as an example, it contains multiple data tables, such as the mine information table (OwnerUnit), accident information table (Accideninfo), mining information table (Exploitationinfo), etc. Each data table defines detailed field descriptions, field names, types, lengths, null limit conditions, primary keys, and field descriptions. The design of these data tables provides a solid foundation for data storage, querying, and analysis.

3.4. System Features and Implementation

The National Coal Mining Area Gas Basic Information Database System has the following characteristics:

(1) Centralized data management: By storing relevant information on dedicated large servers and sharing it through a local area network, centralized management and efficient utilization of data are achieved.

(2) Hierarchical management: Each mining area, coal production base, and management department at all levels can manage their gas basic data in a hierarchical manner, improving the flexibility and efficiency of data management.

(3) Visual query and statistical analysis: Based on WebGIS (electronic map) and time series query and statistical analysis functions, users can intuitively view information such as coal mine distribution, gas resource distribution, and gas accident locations, providing strong support for coal mine safety management.

(4) Standardization construction: Established standards for gas basic information data collection, storage, statistics, management, and service, laying the groundwork for the establishment of a national coal mine basic information database.

In terms of system implementation, this project has gone through multiple stages, including preliminary requirement research, data collection and database construction, incremental development, and system development. Through repeated argumentation and modification, a national coal mine gas basic information system that meets business needs, is easy to operate, and stable has been ultimately formed. This system not only meets the practical needs of coal mine safety management, but also provides possibilities for subsequent data mining and intelligent analysis.

4. Conclusion and Prospect

4.1. Conclusion

The construction of the national coal mine gas basic information database is of great significance for improving the level of coal mine safety management. By centralizing and sharing basic information on gas, it can provide a basis for the government to formulate industrial policies, regulate industries, and conduct scientific research; At the same time, the application of databases helps to realize the intelligence and precision of coal mine gas prevention and control technology, and improve the prevention and emergency response capabilities of gas accidents. This article verifies the effectiveness and reliability of the system by analyzing the background, objectives, overall design, functional implementation, and experimental test results of the database construction.

4.2. Prospect

In the future, with the continuous development of the coal industry and the advancement of information technology, the national coal mine gas basic information database will play a more important role in coal mine safety management. On the one hand, we will continue to strengthen the research and application of data mining techniques to improve the efficiency and accuracy of data processing; On the other hand, we will continuously improve the data collection mechanism and data storage and processing procedures to ensure the comprehensiveness and timeliness of the data. At the same time, we will actively explore the potential application of databases in the intelligent construction of coal mines, contributing to the sustainable development of the coal industry.

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