Research on multi-dimensional analysis model of drilling operations safety evaluation system

Xu Ji Lin1*, Shen Jian Kun1, Qin Liu1, Tang Zhi Jie1, Ju Yueqing2, Li Jian2*

1CCDC Safety Environment Quality Supervision & Testing Research Institute, Guanghui City, Sichuan Province, 618300, China
2School of Computer Science, Southwest Petroleum University, Chengdu City, Sichuan Province, 610500, China

*Xu Ji Lin’s e-mail: 264597145@qq.com, *Li Jian’s e-mail: 909717181@qq.com

Abstract. Oil and gas drilling operation has the characteristics of large investment and high risk, so the effective identification and analysis of potential accidents is an important problem that needs to be solved urgently. In order to meet the requirements of complex analysis of drilling safety evaluation system, a multidimensional data analysis model based on data warehouse is constructed in view of the shortcomings of traditional database technology in information analysis ability, which transforms the application-oriented data structure into the analysis of multi-dimensional data structure, and provides a good environment and analysis method for drilling safety analysis and evaluation. According to the human, material, environmental and management factors of oil and gas drilling accidents, the relevant modelling topics were determined, and a multidimensional data model for analysing the potential accidents was constructed. This paper introduces the construction method of multidimensional data model with the theme of “analysis of potential accidents of drilling operation” as an example.

1. Introduction

As the beginning of oil exploration and development, drilling operations are faced with a variety of unsafe factors, such as staffs illegal operation, wrong operation of command signals, defects of safety management mechanism, environmental impact. These unsafe factors have caused various accidents during the drilling operation, which caused both property damage and threat to personal safety [1]. Hidden dangers of production safety accidents (hereinafter referred to as "potential accidents"), refer to violations of the production safety law and regulations, regulations, standards, procedures and the regulation of safety production management system, or other factors that in the production and business operation activities may lead to accidents of the dangerous state, people's unsafe behaviours and defects of administration. The relevant departments of work safety also formulated the management system, operation rules and regulations for the identification and treatment of potential accidents, but the drilling accidents have not been effectively contained [2]. The reason is that the potential accidents of human, machine, ring, pipe and other aspects in drilling operations cannot be timely investigated and treated, which leads to frequent accidents. To control the occurrence of accidents, it is necessary to identify and control all kinds of potential accidents in drilling operation. Therefore, the effective identification and analysis of potential accidents in drilling operation is the core problem that urgently needs to be solved.

At present, the safety evaluation of oil and gas drilling operation is mostly in the stage of theoretical exploration among the relevant research results in China, and there is no research on the multi-
dimensional data analysis model of the potential accident of oil and gas drilling operation and the literature reviews on the relevant application system. Research on potential accident identification and management mainly focuses on the construction of potential accidents management system, improvement of long-term mechanism, and optimization of investigation and control measures [3-5]. There are two main reasons for this situation: first, the research on the safety of oil and gas drilling operations is not long, and it started late; Secondly, the safety of drilling operation is a complicated systematic engineering. It is difficult to effectively identify and analyse the hidden trouble of drilling operation by using the traditional method to establish the identification and analysis model of the hidden trouble of drilling operation. During the research, it was also found that the domestic existing safety evaluation systems are almost all of the information system based on database, the database system can only support for the daily operational application of the original data, and provide a simple query and statistics. It is hard to meet the oil and gas drilling operation safety evaluation and early warning analysis of the complex requirements, is also very difficult for managers to provide effective and scientific decision-making basis.

2. Design of multidimensional data model of drilling operation safety evaluation system

The data in the data warehouse is organized subject-oriented. The themes are criteria for categorizing data at a higher level and generally reflect the issues of greatest concern to decision makers. In the following, the theme of "drilling operation accident analysis" is used as an example to explain the multi-dimensional model design process.

2.1 Subject demand analysis

In order to conduct a complete and standardized analysis of relevant data, a user information requirement table is used to describe the user's information requirement status. The user information requirement table lists the analysis problems of the multidimensional data model and the required level of detail and level of information, aiming at topic of "analysis of potential accidents in drilling operations" is shown in Table 1.

| Analysis of potential drilling accident trend. |
|-----------------------------------------------|
| time | region | human behaviour | condition of things | environmental factors | management factors |
| years | countries | illegal operation | equipment defect | Poor natural environment | safety management defect |
| quarter | oil field | illegal command | safety defect | Poor workplace | Production management defect |
| month | block | violation of labour discipline | | | |
| weeks | well | unsafe attire | | | |
| day | illegal driving | | | | |

fact: number of potential accidents

2.2 Dimension and granularity design

Dimension is the abstraction of factors related to an event in a relational model. For example, the analysis of potential risks of drilling operation involves factors such as time, location, people, materials, environment and management. In addition to above factors, the hierarchy of the data, or granularity should be considered. Granularity reflects the data of detail degree, for example, analysing data by year, quarter, month, week, and day. For the factors involved, dimension tables can be established for them, and their characteristics can be reflected by the attributes or hierarchical information recorded in the dimension tables, and the granularity can be reflected by the division of each dimension level. For the relational database, several dimensions and their granularity commonly used in the analysis of the potential accidents of drilling operation are designed. The logical model: time dimensional table (time
ID, year, quarter, month, week, day), region dimensional table (region ID, country, oil field, block, well) human behaviour dimensional table (human behaviour ID, illegal operation, illegal command, violation of labour discipline, unsafe attire, illegal driving), condition of things dimensional table (item status ID, equipment and facility defects, safety protection defects), environmental factors dimensional table (environmental factor ID, bad natural environment, bad workplace), management factors dimensional table (management factor ID, safety management defect, production management defect), fact table (Time ID, Region ID, human behaviour ID, state ID, environmental factor ID, management factor ID, number of potential accidents)

2.3 Design of a multidimensional data model for analyzing the potential accidents of drilling

The fact table and dimension table are the foundation of the whole multidimensional data model, so both of them must be reasonable. The attributes in the dimension table describe the attributes of the dimension itself, while the fact table contains the numerical metrics that the user wants to know about, which should be numeric and additive. The dimension tables determined by logical model design are: time dimension table, region dimension table, human behaviour dimension table, condition of things dimensional table, environment factors dimension table and management factors dimension table. The fact table is a potential accidents table, in which each tuple stores only some pointers to various dimension tables, namely foreign keys, while the corresponding primary keys are stored in different dimension tables. The metric is the central value of the analysed cube and the data that the end user needs to focus on when browsing the cube. So far, the multi-dimensional model for analysing the potential accidents of drilling operation is designed, as shown in Figure 1.

![Multi-dimensional data model for analysis of drilling operation accident risks](image)

Figure 1. Multi-dimensional data model for analysis of drilling operation accident risks.

3. Architecture of data warehouse of drilling safety evaluation system and OLAP architecture

3.1 Architecture of data warehouse of drilling safety evaluation system

The data warehouse structure of the drilling safety evaluation system designed in this paper uses a three-tier B/S architecture. Compared with the C/S architecture, the advantages of the B/S system architecture are very obvious. It provides a data exchange method based on Web channels, the system data and application can be acquired by any computers connected to the Web. The architecture of the drilling safety evaluation system data warehouse is shown in Figure 2.
3.2 OLAP architecture of drilling safety evaluation system

The drilling safety evaluation system uses the OLAP architecture based on B/S, which not only enables end users to access the data warehouse efficiently and conveniently through a browser, but also has a unified interface and the same type of pages. Users can access the WEB server through TCP/IP protocol at any time and place to use data warehouse or OLTP database, thus realizing the requirements of cross-region and cross-platform [6-7].

3.2.1 OLAP multidimensional analysis engine

Located between the data warehouse layer and the user interaction layer, the OLAP analysis engine analyses user input, converts it into SQL statements, performs various operation on the multidimensional views in the data warehouse, and then returns the results to the user interaction layer. OLAP engine working process is as follows: first, the user input commands into various parameters, and then the parameter input to the multidimensional processing module, multidimensional processing module receives the parameters, to analyse it, and then generate the corresponding SQL statements, obtain the required data from a data mart, get the cube, again according to the user to select the cube way for processing, including the generated form and images in two ways, finally returned to the user interaction layer. The working flow chart of OLAP multidimensional analysis engine is shown in Figure 3:

![Diagram of OLAP architecture of drilling safety evaluation system](image1)

![Diagram of OLAP multidimensional analysis engine](image2)

3.2.2 the way to access the database through the WEB

The following is a brief overview of common methods for accessing databases through the WEB. In addition to returning static HTML pages to the customer, the WEB server can also perform data query processing based on the customer's data query request, and then return dynamically generated HTML pages to the customer. At present, there are mainly the following methods.

- The traditional CGL approach.
- Dedicated API provided by the web server.
- ASP + ActiveX Components.

This system adopts the third method. The method is to use on the Web page insert office Web Components (OWC, office Web Components, OWC is with Microsoft office issued a set of Components,
for use in a Web browser and traditional development environment to build solutions, data Analysis and data report OWC provides a control the PivotTable tools, it can from the Analysis Services cube display data. For the first approach, in the process of implementation the limitation of susceptible to execute the script in the ASP technology, and it is difficult for graphical display results, compared with using Office Web components can make full use of the powerful features of the pivot table and perspectives in the OWC, in view of this, this article chooses the inserted in the Web page Office Web components to achieve access the data cube through the Web page.

4. Conclusion
The multi-dimensional data analysis model based on data warehouse is built, and the data is transformed from application oriented structure to analysis oriented multi-dimensional data structure, providing a good analysis environment and means for the safety analysis and evaluation of drilling operation. This research provides a new research direction for the identification and analysis model of oil and gas drilling operation. It is of great significance to establish and effectively operate the safety management system, enrich the safety science theory and application technology, and improve the safety management level of drilling companies from the perspective of the urgency, practicality and importance of its practical needs.

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