Construction of Cloud Platform for Mining Group Operation

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Abstract. The operation important for mining group management. The traditional operation is complicated and inefficient for many reasons. Information technologies such as cloud computing, big data, and business intelligence, are inevitable requirements for the quality and efficiency of the mining group. In this study, a cloud platform structure for mining group operation was established with virtualization resource layer, cloud computing platform layer, and service access layer. Then the business logic on cloud platform was designed by using business model, computing logic, business intelligence tools, mathematical model and analysis method, which consists of distributed data acquisition, multidimensional data processing and storage, and business intelligence oriented analysis and decision-making. Finally, a case study was taken out at a large mining group which significantly increases the efficiency of management. The study suggests that Cloud Platform for Mining Group Operation can greatly improve the efficiency of information circulation and provide reliable decision support.

1. Introduction

Mineral resources are essential for economic and social development. The distribution of mineral resources is extremely uneven regardless of variety, quantity, and quality [1]. Mining industry is gradually showing a trend of regionalization and globalization. Mining group is an important outcome of mining globalization, which includes transnational exploration and development of mineral resources, transnational processing and marketing of mineral products, transnational flow of mining funds, transnational sharing of mining information, transnational joint implementation of large-scale mineral projects, etc. [2].

The operation of mining group is facing a new situation with the rapid development of enterprises, the transformation of management mode, the diversification of industries, and the cross-region of management, etc. These changes put higher requirements for the degree of management refinement, and also increase the difficulty of operation at the group level. The cloud platform is a new business computing model for sharing basic resources with the rapid development of computing, storage and communication technologies, which can provide securely, reliable, and efficient services of data acquisition, processing, and storage [3].

A new application mode of management for mining group has been developed by using cloud platform to establish a wide-covered, comprehensive utilized, and access unified data sharing solution. The Cloud Platform for Mining Group Operation establishes a centralized cloud computing service center at the group headquarters, providing comprehensive cloud computing services for the group headquarters and the subsidiaries all over the country. The cloud platform provides unified, automated deployed, and flexible extension of application component services to all levels of the group, and realizes the logical integration of the group's business management.
Mineral resources data and operational data of all subsidiaries in the mining group can be gathered by establishing cloud database, and business development and future trends can be grasped by cloud computing. At the same time, the cloud platform collects mineral resources and related data from countries and regions around the world with internet API. Combined with the data of national social development, political and economic environment, and natural resource distribution, the global resource pattern can be analyzed to determine the demand and development trend of mineral resources, which can provide analysis and decision-making basis for the group to determine the development priority. With the features above, a big data platform covering the whole mining industry chain is formed, which can not only meet the needs of operation for all subsidiaries in mining group, but also provide relevant analytical services for partners and think-tank support for national mineral resources strategy [4, 5].

2. Construction of Cloud Platform

2.1. Management Characteristics of Mining Group
Integrated control is the common management mode for mining group. Although this mode improves the intensive management and subsidiary synergy, it also increases the difficulty of operation at the group level [6]. At the same time, due to the particularity of the industry, most of the mining group's subsidiaries are mining enterprises. The main management content is the process of transforming geological resources into mineral products, which has great management diversity and geological resources uncertainty [7, 8, 9]. So there are higher requirements for operation, the details are as follows:
(1) Multi-level organizational structure: operation information needs multi-level and hierarchical summary;
(2) Cross-regional and diversified management: There’s a need for diversified analysis, multi-path queries, multi-dimensional integration, and personalized data aggregation and analysis;
(3) Numerous management contents: The scope of management and control is wide, which involves not only general business of enterprises but also the special business of mining management, including geology, production, operation, finance, energy, etc.;
(4) Individuation of production process of different mining enterprises: The index system of mining enterprises is closely related to its mining methods, types of mineral products, production processes, etc. When determining the index and algorithm, it’s necessary to refine the common indexes while not to lose the particularity of different mining enterprises;
(5) The remoteness of mining enterprises: Most mines are located far away from group headquarters, where are remote and network unstable.

2.2. Limitations Analysis of Traditional Platform
There are extensive and intensive information exchange issues in the operation of mining group. The traditional operation platform mainly adopts the sub-theme construction mode, which means self-building software and hardware platforms, reporting data at multi-levels, and giving instructions at multi-levels. This mode has certain limitations, which are as follows:
(1) Loading problem of hardware resources
The subsidiaries deployed massive independent hardware devices in accordance with the software system in the early stage of informationization. There is a lack of unified Information Resource Planning(IRP) at the group level. With the increasing volume of business data processing, the capacity of servers has reached the limit, and the locally deployed devices cannot be load balanced.
(2) Intractable sharing and integration of software and data resources
The management services of mining enterprises are different, so the application scope of various professional software developed by each subsidiary is limited to itself. The unavailability of these information resources reduces their utilization and limits the horizontal information exchange between subsidiaries.
(3) Duplicate definition of metadata
Different types of hardware and software resources are introduced to subsidiaries according to their respective characteristics, while plenty of information elements have the same meaning and usage, which can be abstracted as master data. The disunity of metadata criteria results in the "information island" and system maintenance pressure.

(4) Information response deficiency
The business process of the mining group is lengthy and complicated, so the information response capability is poor.

There are complicated reporting and filtering process for original data between production site and decision-making level. Employees who are in close contact with the ore production business are unable to feedback the fastest and most accurate data to the group headquarters for the fastest decision response. So it’s not conducive to the analysis of international mining situation and group management strategy. Referring to the general architecture of the cloud platform design, the structure of cloud platform for mining group operation is divided into three layers: virtualization resource layer, cloud computing platform layer and service access layer.

2.3. Structure Design of Cloud Platform
By using cloud computing technology, a dynamically expandable resource pool can be formed, and the software, platform, storage, and computing capabilities are provided to the distributed users through the network to realize centralized deployment of numerous applications.

Resource utilization can be maximized since multi-application shared, and the usage of virtualization and cloud storage can improve equipment utilization and reduce the cost effectively. At the same time, unified storage of data and centralized deployment can deeply mine the data of operation and provide more effective decision support.

The main design goals and principles of the mining group cloud platform are practicality, scalability, resource conservation, data compatibility, and security. Referring to the general architecture of the cloud platform design, the Cloud Platform for Mining Group Operation is divided into three layers: virtualization resource layer, cloud computing platform layer, and service access layer (As shown in Figure 1) [10, 11, 12].
The virtualization resource layer mainly includes 1. Computing resources, storage resources, network resources, and other necessary hardware infrastructure; 2. Virtualization technology is used to virtualize computers into numerous virtual machines to realize abstraction and virtualization of computing resources, storage resources and other resources.

The cloud computing platform layer is the bridge between the physical device and the software application. By deploying the Hadoop cloud computing platform in the virtual cluster, the HDFS file system is used for file management, and the MapReduce is used to process system business related data.

The service access layer provides API for all kinds of applications, facilitating access to the group headquarters and subsidiaries, and providing strategies for the production, operation, supervision, analysis, and decision-making of the whole group.

Based on this structure, personnel of the mining group shares the same cloud platform, access applications in the same service, which achieves synchronous of management and information. In the cloud platform, each subsidiary is an independent individual and does not interfere with each other to realize the internal affairs management. With the cloud platform, the public information of each subsidiary can be shared, while the private information is protected, to realize the effective utilization of resources.

3. Business Design Based on Cloud Platform
The Cloud Platform for Mining Group Operation includes distributed data acquisition, multidimensional data processing and storage, and business intelligence oriented analysis and decision-making, as shown in Figure 2.
3.1. Distributed Data Acquisition
The data sources for subsidiaries collected by mining group include geographic information system (GIS), operation data of fixed equipment (hoist, crushing station, etc.), operation data of mobile devices (trucks, scraper, etc.), sensor (video system, safety monitoring system, etc.) and manual data (manual report to management information systems). Faced with complex and diverse data sources, the big data of subsidiaries is aggregated into the Cloud Platform for Mining Group Operation based on the enterprise data integration bus, the distributed data acquisition method, and the network environment combining the private network and the Internet.

In addition, the complicated business and inconsistent informatization of subsidiaries increase the difficulty of data acquisition. According to different types and status of subsidiaries, four data acquisition modes are designed: real-time acquisition, timing acquisition, manual filling, and file import. The application scenarios are shown in Table 1.

Table 1. The application scenarios of data acquisition modes.

| Acquisition method | Real-time Acquisition | Timing Acquisition | Manual Filling | File Import |
|--------------------|-----------------------|--------------------|----------------|-------------|
| Acquisition cycle  | Direct access to database | Direct access to database | Interface filling | File upload |
| Active/passive acquisition | Real-time | Timing | Timing | Timing |
| Informationization of subsidiaries | Active | Active | Passive | passive |
| Network of subsidiaries | High level | High level | Low level | Low level |

3.2. Multidimensional Data Processing and Storage
The traditional data storage is distributed in the local database of each system. It is difficult to construct a fast and effective data model in the face of cross-service data interaction and data auditing. Data management in cloud platform deploys data processing and storage to the cloud, breaks business boundaries and system boundaries, and builds data warehouse for different themes, which improves information flow efficiency and data accuracy effectively.

ETL establishes the mapping relationship between the theme data warehouse and the source. According to the type of data source, different extraction components are used to extract and store the data into the theme data warehouse.

First, the original data is extracted and cleaned to check data validity and filter error data. Then, the data is temporarily stored in cloud computing memory, combined with data dictionary, metadata and algorithm library, the data is transformed into different theme data and finally loaded into the theme data warehouse, as shown in Figure 3.
3.3. Business Intelligence Oriented Analysis and Decision-making

Business intelligence refers to the use of modern data warehouse technology, online analytical processing technology, data mining technology, and data visualization technology for data analysis to achieve business value, which plays an important role in modern enterprise management. Business intelligence requires the support of big data storage and high-performance computing, and the cloud platform can be used as the physical entity for business intelligence.

The business of mining group covers geological exploration, mining, smelting, transportation, and sales, which generate massive data. Business intelligence provides an intelligent means for mining group analysis, whose functions rely on models and algorithms encapsulated in data mining method libraries and big data in data warehouses. Business Intelligence Oriented Analysis and Decision-making mainly include the following modes:

1. Routine analysis: product output, mining volume, excavation volume, cost and expense analysis, plan completion rate analysis, etc.
2. Relevance analysis and factor analysis: warning and key analysis for units in poor condition; warning and key factors analysis for underperforming subsidiaries;
3. Big data analysis: Using comprehensive statistical analysis method to complete the performance rank of subsidiaries. Using the system evaluation method to analyze the operation dynamically. Using the outlier method for abnormal state analysis and early warning. Using clustering analysis, data mining and system prediction models for forecasting and decision support.

3.4. Advantages of Cloud Platform for Mining Group

The traditional data analysis process of the mining group is: Each system administrator exports business data to Excel document and submits it to the competent department through OA or email. The data is finally gathered to the data analysis department and analyzed by professional data analysts to form analysis reports and proposals, which are submitted to the group decision-making level to support decision-making. This process has great limitations. First of all, the data flow process is complex and multiple times, which can easily lead to long data analysis period and inaccurate data. Secondly, due to the influence of individual data analysts, decision support is inaccurate with the changes of data analysts. Finally, due to the complexity of mine production management, data analysts are required to have both solid data analysis ability and familiarity with mine operation.

Cloud platform uses visualized ETL process, OLAP technology, advanced data processing mode of cloud computing, and captures analysis topics based on business data packages, drilling, scrolling, slicing, dicing, and rotating data to build the data cube. It has greatly accelerated the speed of data processing and analysis and is more flexible, and closer to the operational needs of modern mining group. Supported by the powerful data mining engine of cloud platform, the theme data in the warehouse is processed to form information with guiding value for production and displayed through the Web and mobile phone. Traditional data analysis and cloud analysis are shown in Table 2:

| Table 2. The contrast between traditional data analysis and cloud analysis. |
|---------------------------------|-----------------|-----------------|
| Traditional data analysis     | Cloud analysis  |
| Platform                       | Local platform  | Cloud platform  |
| Data source                    | Each information system | Data warehouse |
| Data Accuracy                  | Low             | High            |
| Analysis tools                 | Professional data analysis software | Cloud analysis model |
| Operator                       | Professional data analyst | Personnel |
| Limitation of results          | Analysts' individual differences | Almost none |
| Presentation form              | Analysis report | Self-help query and analysis |
| Analysis duration              | Long            | Cloud Real-time Computing |
4. Results and Discussion

4.1. Case Study

A large mining group in China has 19 gold mines, 5 non-ferrous mines, 2 iron ore mines, and 1 non-metallic mine. They are distributed both at home and abroad, whose products are diverse, with a variety of products, management modes, and management levels. This mining group has set up a cloud computing center at its headquarters and private networks to communicate with the mines to build the cloud platform. The platform implements data mining and analysis (Figure 4), operational management dashboard (Figure 5) and real-time analysis of the mobile terminal (Figure 6).

Figure 4. Data Mining and Analysis Interface.

Figure 5. Operational Management Dashboard.

Figure 6. Real-time Analysis of Mobile Terminal.
4.2. Applying Effects

Compared with the traditional mode, the Cloud Platform for Mining Operation Group has many improvements, mainly reflected in the following three aspects:

(1) Unification of standards and norms.
Unified planning and design at the group level and centralized construction can ensure the unification of platform structure, business systems, data interfaces, and other standards and norms, and effectively avoid the deviation of platform construction standards and norms.

(2) Data interchange and business collaboration.
The cloud platform uniformly deploys the operation services to realize the flat management of the business and efficient use of information resources. Interoperability, business collaboration, and information sharing are implemented on the unified cloud platform to avoid difficulties and obstacles in the interconnection and interoperability of platforms at all levels under the traditional construction mode.

(3) Low construction and operation costs.
The Cloud Platform for Mining Group Operation can give full play to the cost advantages of the cloud platform and the advantages of unified operation management, avoiding duplication of investment and waste of resources caused by decentralized construction of each subsidiary, and reducing platform construction cost, manpower cost, and platform maintenance cost.

The Cloud Platform for Mining Group Operation meets the needs of the mining group for the decentralized and detailed collection of operation information. The system integrates distributed data acquisition, multidimensional data processing and storage, and business intelligence oriented analysis and decision-making, which greatly increases the efficiency of data cross-regional management, ensures the accuracy and timing of operations, greatly improves the effectiveness and accuracy of management, and reduces the cost of management.

Then the traditional fixed time, fixed location, fixed report forms, and fixed scenarios mode is upgraded to a big data integration, agile, intelligent and efficient business mode.

5. Conclusion

The construction of the Cloud Platform for Mining Group Operation has realized information sharing, data knowledge discovery, and operational decision support. By constructing the cloud platform, the original scattered and isolated information can be scientifically integrated to realize real-time query and analysis of multi-path, multi-combination and interactive operation information within the authorized scope. It breaks through the limitations of region and time in traditional management and greatly improves the efficiency of information circulation. Cloud data mining is realized by using the efficient computing power of the cloud. Decision support can be provided for group managers to quickly discover problems in operation, timely control strategic planning, and quickly adjust production layout.

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7. References

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