Construction of Decision Support System (DSS) for Equipment Support Based on Big Data

Xuguang Tian*, Hongwei Zhao, Kun Wang, Chengming Zhang, Xiaotao Tian
Chemical Defense Institute of Academy of Military Sciences, Beijing, China

*Corresponding author e-mail: tiancug@163.com

Abstract. To build a Decision Support System (DSS) for equipment support based on big data analysis, the connotation and structure of DSS in big data environment are studied, and the data elements and decision scenario of big data decision for equipment support are analyzed. The basic framework of big data decision system for equipment support is preliminarily constructed. The purpose of this paper is to provide guidance and reference for the application of big data technology in the field of equipment support.

1. Introduction

With the booming of mobile internet, Internet of Things and cloud computing technology, people find that the traditional data processing methods are unable to meet a big data number of real-time data processing needs. So, the Big Data is proposed. Big data is generally understood as “a huge data set that ordinary computer software cannot capture, manage and process in an acceptable time range” [1]. Nature launched a special issue on big data in 2008, and Science released a special issue on "Dealing with Data" in 2011 to study the importance of big data for scientific research. The GFS file system developed by Google in 2003 and the MapReduce programming model developed in 2004 lay the technical foundation for big data processing.

Some researchers have carried out exploratory research on big data in the military field. He You [2] summarized and refined the characteristics of national defense big data, analyzed the challenges faced by national defense big data, and put forward the scientific problems and key technologies needed to be solved in the research and application of national defense big data. Zhang Wenhao [3] and Cao Huizhi [4] have studied the application of big data in equipment support theoretically. In the process of equipment support, decision-making is an important part. With the help of big data analysis and decision-making, it is of great significance to realize big data decision-making of equipment support for optimizing the support resources, improving the support efficiency, and realizing accurate and immediate support.

2. Decision analysis of big data for equipment support

2.1. Data elements for equipment support

Equipment support data can be considered to contain all data information related to equipment support activities. Generally speaking, equipment support data includes not only the information directly related to equipment support, but also the geographic environment, meteorological climate, social and civil conditions, national and international environment, as well as the situation of the enemy and ourselves which can be called background information. Narrowly, the information related
to equipment support are equipment type, fault information, quantity and quality, regulations and standards. Data elements for equipment support are as shown in Table 1.

| Data Name                      | Data content                                                                                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Natural environment           | The natural environment information related to the equipment support task, such as geographical environment (topography, geomorphology, etc.), meteorology (wind, rain, cloud, air, etc.), ocean (sea condition, water temperature, etc.). |
| Cultural environment          | Information on public opinion, building facilities, road network and road conditions related to equipment support tasks.                         |
| Enemy information             | In the course of carrying out the operational support mission, the enemy's force composition, equipment, fire range and all other related information. |
| information of equipment      | The description information of the equipment itself, such as the model, type, use, category, technical parameters, scope of use, etc.              |
| Historical information        | Historical information on equipment maintenance history, fault information, maintenance process and equipment consumption.                      |
| of equipment support          | Real-time or non-real-time acquisition of equipment status information, including pre-defined technical parameters of the numerical value, equipment position parameters, operation track and other information. Mainly includes equipment support scheme, operation capability, operation equipment, application scenario (environmental requirements) information, tactical requirements information, system information, personnel information, operation rules, deployment information and so on. |
| Equipment status information  |                                                                                                                                 |
| Equipment usage rule information |                                                                                                                                 |
| Support unit information      | Describe the personnel support, task and capability description of equipment support unit.                                                     |
| Equipment materials information | The types and quantities of materials needed in the process of preparation and support, as well as the information of the amount of materials configuration data, configuration region, support scope, support mode and so on. |
| Equipment facilities information | Information such as facility name, responsibility task, capability scope, geographical location and personnel allocation for carrying out equipment support tasks. |

The data elements of some equipment support are listed above, which have the following characteristics:

- **Volume**: with the development of equipment informatization and intellectualization, a big number of data will be produced in the process of equipment operation and support, such as: equipment operation environment information, equipment real-time monitoring information, and materials configuration and consumption in the process of equipment support. From the perspective of the whole army, it will be a huge data set.

- **Variety**: Including not only traditional structured data, such as equipment regulations, standards and other information, but also unstructured information, such as equipment operation scene, battlefield environment, fault information, war damage information, which can be recorded in pictures, audio and video formats and is vital to equipment support process.

- **Complexity**: In the process of equipment support, the data types and structures are various, the relationships are complex, and the data sources are diverse, heterogeneous, and the real-time requirements are high. It is difficult to find the intrinsic relationship by using traditional data analysis methods.

- **Dynamics**: Informationized battlefield environment requires the whole process of equipment support to be visible, transparent and controllable, the whole process of equipment support needs to be perceived and monitored, and the data is mainly acquired in real time, which has a strong
Therefore, the equipment support data, in a sense, has already possessed the general characteristics of big data [2]: Volume, Variety, Velocity and Value and so on. At the same time, it also has the unique characteristics of super complexity, super secrecy, high mobility, high security, strong antagonism and strong real-time. The thinking and method of big data must be used to deal with it.

2.2. Decision Scenario of Equipment Support for Big Data

One of the important changes brought by big data to information warfare is the transformation of decision thinking mode and method. In the US big data development plan: “from data to decision”, by collecting a big data number of military intelligence data and constructing an algorithm model for fast and accurate analysis of data, the massive data are correlated, integrated and recognized in real time and independently, and important information about target threat, track tracking and Firepower Strike is mined. Task-oriented comprehensible decision-making is provided to enable commanders to understand and grasp the battlefield situation at a very high speed, so that data (information) advantages can be quickly converted into decision-making advantages. The decision scenario of big data for equipment support mainly includes the following aspects.

1. Accurate Delivery of Resources
   The precise delivery of support resources is the inevitable requirement of the full-dimension controllable and full-capital visual development of equipment support, and is also the inevitable result of the development of information technology. Depending on the analysis of big data of support, it can optimize the delivery direction and route of support resources and improve the efficiency of support. For example, according to the real-time state of equipment to predict its health status, so as to pre-reserve equipment and materials, pre-planning support personnel, to meet the real-time needs of equipment maintenance, but also according to the support needs of support content customization, support mode selection and accurate push content of support.

2. Optimization of Support Scheme
   The evaluation and optimization of the support scheme is to evaluate the feasibility and rationality of the support scheme under the specific combat scenario. The traditional method of scheme evaluation is often limited to the static evaluation such as AHP, ADC and Expert Scoring. It relies on historical experience. Under the background of big data, through fully mining historical data and predicting future trend, it establishes the correlation between equipment support needs and battlefield situation, so as to we can accurately forecast the support needs, optimize the security plan, and improve the accuracy and effectiveness of the support scheme.

3. Support Situation Prediction
   The core of big data is prediction. The era of big data has changed from traditional "causality" to "correlation". In the process of equipment support activities, equipment, personnel, equipment, distribution process and command relations are intertwined, and the correlation is very complex. Using big data analysis, the correlation between various activities can be excavated, and the decision-making factors such as material consumption, staffing, inventory location can be predicted, and the overall security state can be established. Potential diagram helps support commanders to establish decision-making, making relying on experience and intuition to rely on big data analysis.

4. Optimal Configuration of Support Resources
   In the past, the allocation of support resources, such as the location of the equipment warehouse, the establishment of support institutions, the ordering of maintenance equipment and the formulation of funds, relied on historical experience, natural environment and human factors. By using big data analysis technology, the historical demand of support resources is counted up and the status of support power is analyzed through multidimensional and multi angle analysis. And define the support needs of each time domain, each region and the various support requirements. It can optimize the allocation and timely adjustment of support resources (personnel settings, inventory, and transportation) and improve the support capacity.
3. Architecture design of equipment support decision support system

3.1. Decision making and decision support system

Decision-making is a process in which information is collected, processed and concluded based on certain information and experience. During the process, information is the key factor that can directly affect the decision-making results. Decision-making information mainly comes from the integrated analysis and judgment of the collected data. Decision makers can screen valuable information for decision-making.

In decision-making process, people generally rely on past experience or decision support systems. Decision Support System (DSS) was first proposed by Scott Morton[5] and others in the 1970s.

In traditional decision-making process, people sample or filter the data set, then analyse the data samples to find the characteristics and laws, and obtain as much information as possible from the limited sample space through complex algorithms. With the increase of data volume and real-time, traditional decision-making system and decision-making process cannot meet the needs of efficient decision-making. So big data analysis is used to deal with massive, real-time data to find out the relevance between them, extract valuable information for decision makers. The arrival of the era of big data has brought a series of challenges to traditional DSS, mainly in the following aspects:

- From sample data to complete data. Everything is quantifiable in big data. DSS generally infers from causality, whereas big data mainly pursues correlation rather than causality. And the object is the whole data, rather than the small sample data. This requires DSS to change its decision support process and methods, so that it can rely on massive data for analysis.
- From post decision making to real-time decision making. At present, most DSS is mainly used for post decision making. However, under the background of big data, memory computing and streaming data processing are becoming mainstream ways. The main reason is that the growth rate of data is very fast, and the effective period of data value is shortened, which requires that decision support ability can be provided in real-time in the process of big data decision-making.
- From structured data to multi-source and heterogeneous data. In the context of big data, information sources are more complex, not only relying on traditional structured data storage, but also more unstructured and semi-structured data. But DSS has been relying on data warehouse for decision support.

3.2. Architecture design of equipment support decision support system

Because of the challenges brought by big data, traditional decision support system must be adapting to changes and show new structural characteristics. There is no authoritative structure for decision-making systems based on big data at present, but people have begun to study this problem. Liang Roxi[5] studied the real-time decision support system based on big data, and proposed a structure of big data real-time decision support system; Wang Chuanqi[6] studied the development of decision support system in big data environment, and proposed a structure model of decision support system and big data synergy; Li Chongdong[7] constructed a big data military decision-making system composed of data acquisition layer, data processing layer and data application layer.

According to the overall structure of big data and the function composition of decision support system, this paper proposes a framework of equipment support DDS which applies big data analysis technology to DDS. The most typical feature of this structure is that it combines the flow computing function of big data and distributed computing function with DSS to provide the processing ability of real-time and massive equipment support data under the background of big data.

- Data acquisition: The bottom of the framework is data acquisition layer. The main function is to complete the work of original data (such as natural environment, equipment data, battlefield situation data, etc.) conversion, cleaning and monitoring. Data conversion is used to transform data from original type into models needed by decision system. The function of data cleaning is to keep data consistency and reduce data duplication and uselessness in decision-making process. Monitoring is the monitoring of data changes in data sources. When data has been change, data extraction and transmission are carried out to update data. The data acquisition layer mainly relies on Flume, Sqoop/Canal, Kafka and other technologies.
Data resources: The data resources include models, knowledge and methods, which are used to store the common knowledge, heuristic knowledge, decision analysis and processing model and method of equipment support decision problem solving. And the real-time equipment support data (equipment state, battlefield environment) needed by the flow calculation. In order to meet the storage requirements of massive data, data resources adopt distributed data storage mode, which is compatible with structured data, semi-structured data and unstructured data. Data value discovery mainly adopts the knowledge, model and method of support decision-making which is needed to discover, mine and extract from the stored historical data. The model base, knowledge base and method library are constructed by means of metadata and knowledge ontology. The layer relies on HBase, MySQL, Text, HDFS and other technologies.

Fig. 1 Decision support system architecture based on big data

Decision calculation: It is the core of the whole framework. The layer not only integrates the functions of conventional data mining, but also includes the functions stream computing and distributed computing, In order to support real-time decision making and massive data decision making. Among them, the distributed computing depends on the implementation of Map Reduce computing engine, and the streaming computing can be implemented by the distributed streaming computing engine such as Storm/Spark.

Man-machine interaction: this layer mainly implements the equipment support decision making functions under specific decision scenario. It mainly includes the four basic application scenarios mentioned above. In this layer, based on the big data processing technology and the development method of assistant decision system, all kinds of application systems can be developed and constructed to meet the needs of support command, equipment repair, equipment management, equipment supply, and support training.

Calculation resource services: Including the basic hardware resources needed for decision-making and computing functions, including CPU, memory, hard disk and network resources. Computing resources provide external computing functions in the form of service to meet the needs of different level of computing resources.

The above framework integrates data acquisition, data analysis and data application process of big data, and integrates the basic function structure of DSS, which reflects the basic requirements of DSS for equipment support in big data environment.
3.3. Workflow of decision framework

The basic workflow of the equipment support decision-making system architecture is shown in Figure 2. The workflow macroscopically describes several core processes of decision support system based on big data: task decomposition, resource allocation, distributed computing, memory computing, decision reasoning and result visualization.

According to the workflow, when a decision-making task is generated, it is necessary to plan the task reasonably and divide it into a series of parallel computations, in order to improve operation efficiency and the ability of decision-making in massive data environment. In the task computing process stage, according to the real-time requirement of the task and the difference of the data types to be processed, the equal-flow computing mode of memory computing or the distributed computing mode will be invoked respectively: for non-real-time decision-making computing, the Map Reduce computing engine is called, and for real-time decision-making computing, the Spark or Storm computing framework is called. When different computing methods are invoked, the resource allocation process is responsible for allocating reasonable computing resources for each step, including hardware resources and data resources. Hardware resource allocation is responsible for the rational planning of hardware computing resources in the running process; data resource collection is responsible for the rational allocation of massive data resources such as historical data, real-time data flow and knowledge base, model base and method base.

![Fig. 2 Basic workflow of decision support system based on big data](image)

4. Conclusion

On the basis of sorting out the data elements and decision scenarios of equipment support, this paper proposes and constructs a basic equipment support decision system architecture combined with the existing problems of decision support system under the big data background, and briefly introduces the composition and workflow of the architecture. The main purpose of this paper is to make a preliminary discussion on the application of large data technology in the field of military equipment support, and put forward the basic ideas. The degree of research is preliminary, and many aspects need to be further deepened. I hope this study can provide some reference for the future application and development of big data technology in the military field.

References

[1] FANG Wei, ZHENG Yu, XIU Jiang. Big Data: Conceptions, key technologies and application[J]. Journal of Nanjing University of Information Science and Technology: Natural Science Edition, 2014, 6(5): 405-419.

[2] HE You. Panorama of national defense big data[J]. Systems Engineering and Electronics, 2016, 38(6): 1300-1307.
[3] ZHANG Wenhao, WANG Xuezhi. Analysis on the necessity of applying big data to equipment support decision[J]. China Management Informationization, 2015, 18(9): 70-71.

[4] CAO Huizhi, LI Pei. Research on construction and development of equipment support in the era of big data[J]. China Management Informationization, 2014, 17(17): 52-54.

[5] LIANG Luoxi. The Research of Big Data Based Real-time Decision Support System[D]. Northwest University, 2016.

[6] WANG Chuanqi. Prospect of Decision Support System Based on Big Data[J]. System simulation technology and Application, 2015, 16: 447-451.

[7] LI Chongdong. Study on the Construction of the Military Decision-Making System Based on Large Data Support[J]. Software Engineering, 2016, 19(3): 21-23.