

# Research on the Development Strategies of Real-time Data Analysis and Decision-support Systems

Wei Tang\*

Sichuan Provincial Architectural Design and Research Institute Co., Ltd., Chengdu 610000, Sichuan, China

\*Corresponding author: Wei Tang, 13980526616@163.com

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the advent of the big data era, real-time data analysis and decision-support systems have been recognized as essential tools for enhancing enterprise competitiveness and optimizing the decision-making process. This study aims to explore the development strategies of real-time data analysis and decision-support systems, and analyze their application status and future development trends in various industries. The article first reviews the basic concepts and importance of real-time data analysis and decision-support systems, and then discusses in detail the key technical aspects such as system architecture, data collection and processing, analysis methods, and visualization techniques.

**Keywords:** Real-time data analysis; Decision-support system; Big data; System architecture; Data processing; Visualization technology

**Online publication:** April 3, 2025

## 1. Introduction

In the current era of rapid development of information technology, data has become an indispensable and important asset for enterprises and organizations. The application of real-time data analysis and decision-support systems enables enterprises to make informed decisions quickly in a volatile market environment, thereby enhancing their competitiveness and improving operational efficiency<sup>[1]</sup>. Decision-support systems can not only integrate a large amount of real-time data but also provide solid decision-making support through complex data analysis models. However, building an efficient real-time data analysis and decision-support system is no easy task. It requires careful planning and design in many aspects, including system architecture, data collection and processing, analysis methods, and visualization techniques.

## 2. Basic principles and concepts of real-time data analysis and decision-support systems

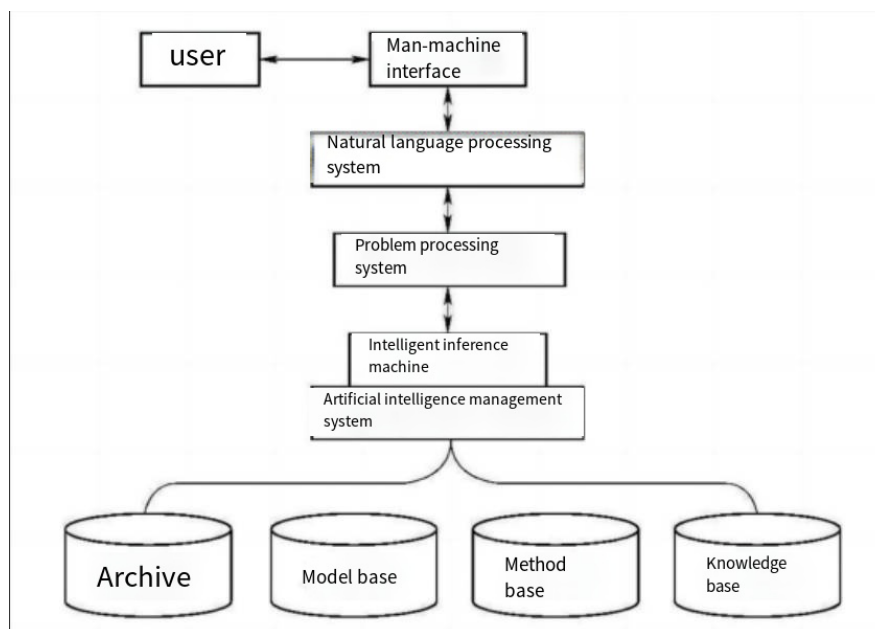
The real-time data analysis and decision-support system (DSS) is an important application of modern

information technology in the field of enterprise decision-making. The basic working principle of this system covers a series of continuous processes, including data collection, transmission, processing, analysis, and presentation.

Real-time data analysis involves collecting data from various sources, such as sensors, network logs, and social media. The operation of the data collection system depends on strong high-concurrency processing capabilities and stable and reliable transmission channels, which are the keys to ensuring the timeliness and integrity of the collected data. Data transmission usually relies on high-speed networks and message queue systems, such as Kafka, to ensure that data can quickly reach the central processing system<sup>[2]</sup>.

In the field of real-time data analysis, data processing plays a crucial role. For example, stream processing frameworks like Apache Flink and Apache Storm are characterized by their ability to process data immediately when it arrives, rather than using the traditional batch-processing method. This link includes steps such as data cleaning, format conversion, data aggregation, and in-depth analysis, aiming to ensure the accuracy of the data and meet the requirements of subsequent analysis.

In this process, techniques from statistics, machine learning, and data mining are used to conduct in-depth analysis of real-time generated data. Models are built to predict future trends, revealing potential valuable information and patterns. The analysis results are usually presented to decision-makers through visualization tools, such as Tableau and Power BI, to provide an intuitive understanding and application of the data. The DSS uses the results of real-time data analysis to assist decision-makers in making appropriate decisions when facing semi-structured or unstructured decision-making situations<sup>[3]</sup>. The DSS consists of components such as a database, a model base, a knowledge base, and a user interface, and its functions cover aspects such as data management, model management, and user interaction. **Figure 1** shows the structure of an intelligent command decision-support system using artificial intelligence.



**Figure 1.** Structure of the intelligent command decision-support system using artificial intelligence

### **3. Development strategies of real-time data analysis and decision-support systems**

#### **3.1. System architecture design**

##### **3.1.1. Data collection layer**

The data collection layer is responsible for collecting data in real-time from multiple sources. To ensure that the data remains up-to-date within a specific period and covers all the necessary content, an efficient information collection strategy must be established. Common data collection techniques include various methods, such as using sensor networks, log collectors, API interfaces, and data stream platforms (such as Apache Kafka).

##### **3.1.2. Data transmission layer**

The data transmission layer undertakes the crucial task of ensuring that the collected data can be quickly and accurately delivered to the central processing system. In the field of computer network communication, common protocols include TCP/IP, HTTP, etc. In addition, message queue technology, such as RabbitMQ, is also widely used in data transmission<sup>[4]</sup>. To improve the efficiency of data transmission, data compression methods and batch-transmission techniques can be adopted.

##### **3.1.3. Data processing layer**

The data processing layer is responsible for performing real-time processing and operations on the data transmitted to this layer. For example, Apache Flink and Apache Storm are both stream-processing frameworks that play a vital role in realizing real-time data processing. Data processing includes several links, such as data cleaning, format conversion, aggregation, and analysis.

##### **3.1.4. Data storage layer**

In the process of real-time data processing, both temporary and persistent storage technologies must be used. As a medium for temporarily storing data during the data-processing stage, in-memory databases (such as Redis) and NoSQL databases (such as MongoDB) are usually used. These tools and technologies aim to improve data access speed and ensure data consistency<sup>[5]</sup>. For the long-term storage and analysis of historical data, distributed file systems (such as HDFS) and relational databases (such as MySQL) are usually adopted.

##### **3.1.5. Analysis layer**

In the field of data analysis, it is crucial to conduct in-depth analysis and model building on the processed data by applying various algorithms and models. The range of analysis tools includes machine-learning libraries (e.g., TensorFlow, Scikit-learn) and statistical analysis tools (e.g., R, SAS), which are commonly used in this field.

#### **3.2. Data collection and processing strategies**

##### **3.2.1. Data collection strategy**

During the data collection process, it is particularly important to select appropriate data sources and collection methods. When choosing data sources, factors such as data real-time update, accuracy, and relevance to the research objectives must be considered. Data collected from sensor networks, Internet of Things devices, as well as information recorded by log systems and API interfaces, are common data sources. To ensure the efficiency of the data collection process, parallel processing, and distributed collection strategies can be implemented<sup>[6]</sup>.

### **3.2.2. Data processing strategy**

In the data-processing strategy, ensuring the real-time update and accuracy of the data is of great significance. Data cleaning is a key operation carried out at the initial stage of the data-processing flow. Its purpose is to eliminate irrelevant information in the data set and correct incorrect data. In the data pre-processing process, common processing methods include filling in missing data, detecting and identifying outliers, and identifying and removing duplicate records. Data in different formats are adjusted to the same format for subsequent processing.

## **3.3. Analysis methods and algorithms**

### **3.3.1. Statistical analysis methods**

As a key means of real-time data analysis, statistical analysis plays an indispensable role in in-depth data research. In the field of data analysis, common analysis methods include basic data summarization (descriptive statistics), inferring the population from samples (inferential statistics), exploring the relationships between variables (regression analysis), and studying the patterns of data changes over time (time-series analysis). These methods form the basic framework for researching data and information and provide a scientific basis for decision-making<sup>[7]</sup>.

### **3.3.2. Machine-learning algorithms**

Machine-learning technology is the core of dealing with real-time data analysis problems. Supervised learning algorithms, such as linear regression, decision trees, and support vector machines; unsupervised learning algorithms, such as cluster analysis and principal component analysis; and reinforcement learning, which is a learning method that trains models through reward and punishment mechanisms. Machine-learning algorithms can automatically obtain models from data and make predictions and classifications based on them<sup>[8]</sup>.

### **3.3.3. Data mining techniques**

Data mining involves the in-depth exploration of massive data to discover valuable information and patterns. In the field of data mining, common techniques include discovering association rules, data classification, data clustering, and extracting frequent patterns. Through data-mining techniques, hidden potential patterns and relationships in the data can be discovered, providing data support for the decision-making process<sup>[9]</sup>.

### **3.3.4. Real-time analysis techniques**

Real-time analysis techniques are the core elements for realizing real-time data analysis and play a crucial role. For example, stream-processing frameworks such as Apache Flink and Apache Storm, as well as real-time analysis platforms like Spark Streaming, can perform immediate processing and in-depth analysis on continuous data streams. Real-time analysis techniques require high-concurrency processing and low-latency response from the system.

## **3.4. Visualization techniques**

Visualization techniques are key tools that present the results of data analysis and processing in a graphical way, making it more intuitive to explore and understand information. Through graphical representation, geographical mapping, and interface display, data and analysis conclusions can be more clearly perceived and grasped by users<sup>[10]</sup>.



### **3.4.1. Selection of visualization tools**

When presenting data, choosing the appropriate visualization method is a decisive factor in determining the information presentation effect and efficiency. In the field of data visualization, FineBI, Tableau, Power BI, and D3.js are common and widely used tools. These tools have excellent data processing and visualization capabilities and can adapt to diverse application scenarios.

### **3.4.2. Principles of visualization design**

When conducting visualization design, simplicity, intuitiveness, and understandability must be emphasized. When choosing a chart, the characteristics of the data and the display objectives should be considered. For example, for time-series data, a line chart is a suitable display method. For categorical data, bar charts or pie charts can effectively visualize the data. During the page design process, appropriate attention should be paid to color matching and layout structure to avoid visual confusion caused by too many graphical elements and to ensure that the information presentation does not exceed the audience's reception capacity<sup>[11]</sup>.

## **3.5. System integration and testing**

### **3.5.1. System integration strategy**

System integration involves integrating multiple independent modules into a unified whole. During the system integration process, the interaction interfaces between modules should be closely monitored, and seamless data flow should be ensured. In the practice of system integration, common methods include hierarchical integration, phased incremental integration, and continuous integration strategies<sup>[12]</sup>.

### **3.5.2. Testing strategy**

Ensuring system quality depends on the key step of testing. The testing strategy covers multiple levels, including unit testing, integration testing, system testing, and acceptance testing, aiming to comprehensively evaluate software quality. Unit testing is the process of testing individual modules to verify the accuracy of their functions. Integration testing is to comprehensively test the integrated modules to ensure that the interfaces and data flow meet the expected standards. System testing is to comprehensively test a complete system to ensure that all functions operate normally and meet the established performance standards<sup>[13]</sup>.

### **3.5.3. Performance testing**

In the field of real-time data analysis and the development of DSS, performance testing plays a key role. The inspection of system performance mainly covers the evaluation of the system's load, stress, and stability. Load testing is a method for evaluating the performance of a system under various expected load conditions. Stress testing is to apply pressure to the system to evaluate its stability under extreme conditions. Stability testing aims to evaluate the performance of the system during long-term continuous operation<sup>[14]</sup>.

## **3.6. Security and privacy protection**

### **3.6.1. Data security**

In the development of real-time data analysis and DSS, data security is an important aspect that cannot be ignored. During data transmission, encryption technologies such as SSL/TLS should be used to effectively prevent data from being intercepted and modified. During data storage, strict access-control mechanisms must be implemented, and data should be encrypted to resist unauthorized access attempts.

### 3.6.2. Privacy protection

Privacy protection includes maintaining the security of users' personal information to ensure that it is not accessed, used, disclosed, or tampered with without authorization. During software development, relevant laws and regulations, such as the General Data Protection Regulation (GDPR), must be complied with to ensure data security and compliance. To achieve the confidentiality of personal information, protection measures include anonymizing data, applying privacy-protecting algorithms, and setting strict system access permissions<sup>[15]</sup>.

## 4. Conclusion

The development strategies of real-time data analysis and DSS are the keys to ensuring the efficiency, reliability, and scalability of the system in practical applications. By discussing in detail aspects such as system architecture design, data collection, and processing, analysis methods and algorithms, visualization techniques, system integration and testing, security and privacy protection, and user-experience design, this study provides comprehensive guidance and references for the development of high-performance real-time data analysis and DSS. Against the backdrop of the rapid development of big data and the Internet of Things, the demand for real-time data analysis and DSS is constantly increasing. In the future, with the in-depth integration of artificial intelligence and machine-learning technologies, real-time data analysis and DSS will become more intelligent and efficient. The application of edge computing will further reduce the latency of data processing and improve the system response speed. Innovations in data visualization techniques will make data presentation more intuitive and understandable, helping decision-makers understand and utilize data more quickly and effectively.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Yuan L, 2023, The Development of Sports Data Analysis and Sports Decision-Support Systems. *Sports Goods & Science and Technology*, (23): 142–144.
- [2] Tang X, Xu Y, 2023, Research on the Correction Strategy for Calculation Deviations in Decision-support Systems-taking the Recruitment Support System as an Example. *Journal of Intelligence*, 42(6): 87–95.
- [3] Liu S, 2023, Research on Medical Information Management and Decision-Support Systems Based on Big Data Analysis. *Science and Informatization*, (24): 160–162.
- [4] Ai G, 2024, Research on the Maintenance Decision-Support System for Coal Mine Tunneling Equipment Based on Big Data. *China Plant Engineering*, (07): 166–168.
- [5] Chang X, 2024, Communication Data Analysis and Real-Time Decision-support in the Internet of Things Environment. *Telecommunications Power Technology*, 41(1): 142–144.
- [6] Jing H, 2024, Real-time Data Analysis and Decision-Support of Artificial Intelligence in Grid Digitalization. *China Strategic Emerging Industry*, (02): 48–50.
- [7] Wu Z, 2024, The Application of Intelligence in Equipment Management. *Mechanical Engineering & Automation*, (03): 222–223 + 226.
- [8] Du L, Chen D, 2024, Research and Analysis of Water Conservancy Engineering Survey Based on the Smart Big Data Platform. *Stone*, (05): 101–103.

- [9] Yue M, 2025, Construction of the Whole-Process Cost Dynamic Monitoring and Decision-Support System for Enterprises. *Modern Enterprise*, (01): 45–47.
- [10] Wang P, 2025, Design of a Procurement Decision-Support System Based on Big Data Analysis. *Automation Application*, 66(01): 199–201.
- [11] Wu D, 2024, Intelligent Monitoring and Real-Time Data Analysis Methods for Chemical Equipment. *Chemical Engineering & Equipment*, (12): 107–109.
- [12] Wang H, 2024, The Application of Computer Systems in Emergency Rescue Decision-Support Systems. *Applications of IC*, 41(5): 266–267.
- [13] Zhang Q, Gao L, Zhang Y, 2024, Design of Big Data Analysis and Intelligent Decision-support Systems in Power System Communication. *Telecommunications Power Technology*, 41(6): 69–71.
- [14] Wang H, 2024, The Application of Computer Systems in Emergency Rescue Decision-support Systems. *Applications of IC*, 41(5): 266–267.
- [15] Qin Z, 2024, Research on the Assembly Quality Control System for Automobile Engines Based on Big Data Analysis. *Farm Machinery Using & Maintenance*, (6): 24–26.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.