

Research on AIS Signal Frequency Statistics based on SpringBoot+Vue

Xuejun You^{1,*}, Yingying Chen¹, Taizhi Lv²

¹ School of Information Engineering, Jiangsu Maritime Institute, Nanjing 211170, China

² R&D Department, Nanjing Huihai Transportation Technology Company Limited, 210019, Nanjing, China

* Corresponding author: Xuejun You (Email: 99026743@qq.com)

Abstract: With the rapid development of global industry, AIS (automatic identification system) has become an important tool for ship management and safety monitoring. In order to better display the frequency distribution of AIS signals, this paper graphically displays the data in the AIS signals, allowing users to fully understand the data in the AIS signals, including ship type distribution, speed range, and signal frequencies in different areas. It uses Kafka and Flink technology to receive, clean and analyze the sent data, and finally stores it in MySQL and Redis data. It reads the data through Spring Boot + MyBatis, and uses Vue + Echarts chart tool and AutoNavi Map API for display and analysis. To gain an in-depth understanding of its importance and application prospects in the field of epidemics.

Keywords: AIS (automatic identification system); Flink; Spring Boot; Vue; AutoNavi Map; Signal frequency analysis.

1. Introduction

The Automatic Identification System (AIS) is a new type of digital navigation system and equipment that integrates network technology, modern communication technology, computer technology, and electronic information, consisting of shore based (base station) facilities and onboard equipment [1-2]. The AIS system, in conjunction with the Global Positioning System (GPS), dynamically combines ship information such as position, speed, change of course rate, and heading with ship information such as ship name, call sign, draft, and dangerous cargo. With the increase in the number of ships and the complexity of shipping activities, the analysis of AIS ship signal frequency has become a focus of attention for researchers. By analyzing the frequency characteristics of AIS ship signals, the frequency distribution and abnormal situations of the signals can be revealed.

This paper aims to obtain ship related information by analyzing AIS message signals, and use this information to analyze ships. AIS message signals are data transmitted in the ship automatic identification system, including information such as the position, speed, heading, and name of the ship. By comparing and analyzing the information of multiple ships, it is possible to understand their traffic conditions, congested areas, and channel utilization rates.

2. System architecture

As shown in the figure 1, this system consists of five layers: data acquisition layer, data aggregation layer, data computing layer, data storage layer, and data visualization layer. AIS data is sent by the ship's base station and collected through Kafka. Next, use the streaming framework Flink to interface with Kafka and perform data cleaning operations, such as deduplication and abnormal data processing. The cleaned data is stored in MySQL and Redis clusters. The backend uses Spring Boot technology to read and convert data into JSON format, and then transmit it to the front-end. The front-end uses the Vue framework and utilizes Ajax technology to obtain the transmitted data from the back-end. At the same

time, use the AutoNavi Map API technology to visualize the positioning of AIS ship maps, and use Echarts for chart visualization analysis.

3. Data visualization based on spring boot and vue

3.1. Real time data transmission based on Kafka

Kafka is a distributed publish/subscribe based message queue designed specifically for distributed high throughput systems [3]. Kafka has better throughput, built-in partitioning, replication, and inherent fault tolerance, making it very suitable for large-scale message processing applications. Therefore, this system adopts the Kafka framework, where Kafka producers convert data from ship base stations into messages and send them to designated Kafka topics. Consumers use Flink as a streaming framework, reading data from Kafka topics by subscribing to them, and receiving and processing data sent by producers. Through this combination of Kafka and Flink, the system can achieve efficient data transmission and processing.

3.2. Real time data calculation based on Flink

Apache Flink is powerful and supports the development and operation of various types of applications. Its main features include batch flow integration, precise state management, event time support, and precise one-time state consistency guarantee [4]. Based on this feature, this system fully utilizes Flink's real-time processing capabilities and receives AIS data streams in real-time through connectors integrated with Kafka.

The received data is parsed and transformed to meet subsequent processing needs. Clean and filter the converted data using Flink's operators to eliminate errors and abnormal data. Finally, the cleaned data is stored in the database, providing a convenient and accurate data foundation for subsequent analysis and use. This architecture design can achieve real-time data processing and cleaning, ensure data quality and consistency, and provide stable and reliable

support for system functions.

3.3. Data storage based on Redis and MySQL

Redis is an open-source database written in ANSI C language, using the BSD protocol, supporting network operations, and capable of storing data in memory or persisting [5]. By integrating Spring Boot with Redis and utilizing the fast data reading feature of Redis, the system's

access speed and response performance can be significantly improved.

MySQL is a popular open-source relational database management system (RDBMS) widely used in web application and other types of software development [6]. This system chooses to use MySQL as the database for storing the cleaned complete AIS data for future use and processing.

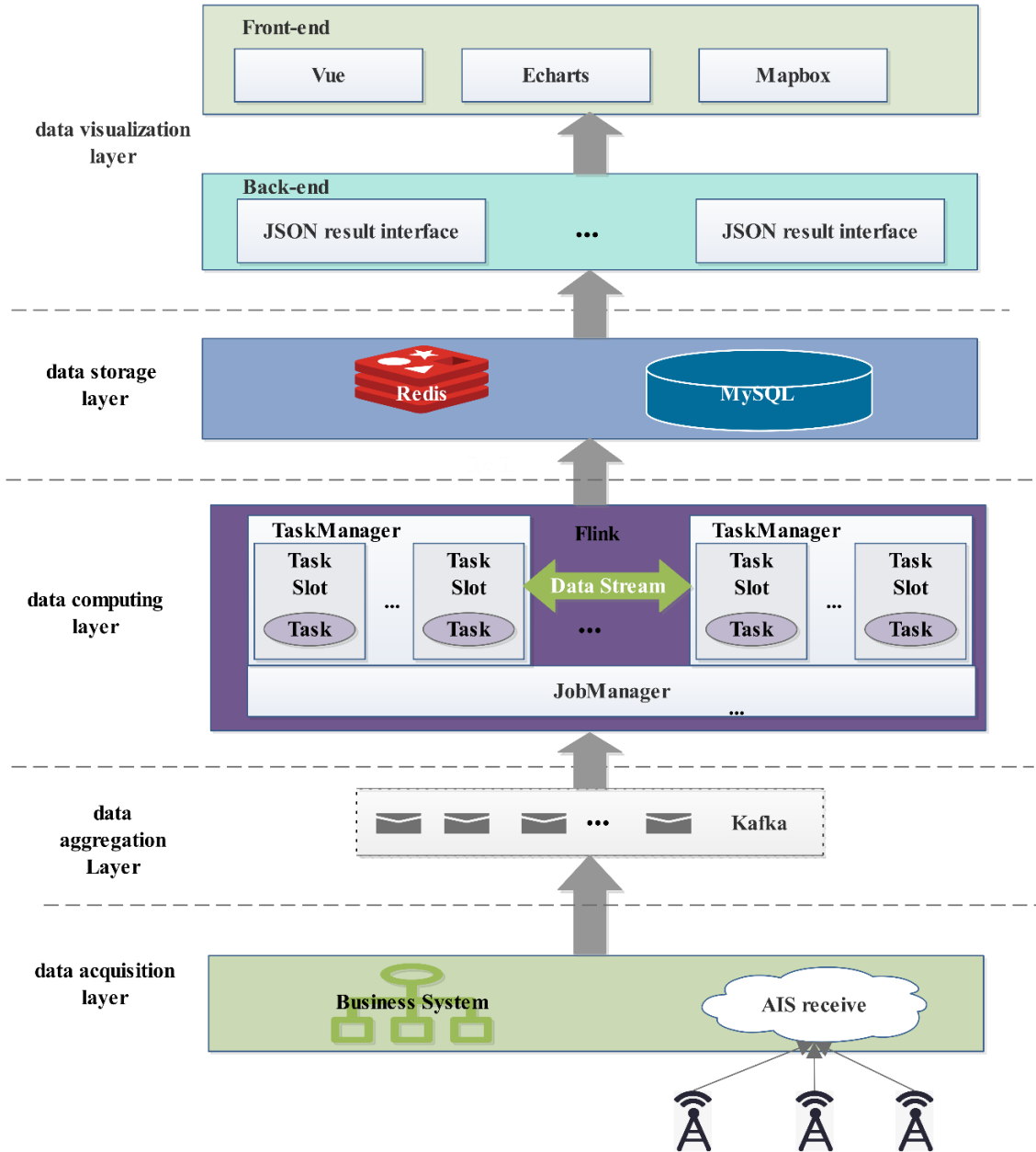


Fig. 1 The system architecture

3.4. Data visualization based on front-end and back-end separation

This module adopts a front-end and back-end separation architecture to achieve data visualization. This model is a software architecture pattern that separates the development and deployment of the front-end and back-end of an application [7]. The backend of the visualization module adopts the Spring Boot framework. Spring Boot is an open-source framework aimed at simplifying the development of Java applications [8]. The visualization module integrates MyBatis and JedisTemplate to read the database through Spring Boot. The Spring controller receives front-end

requests, processes them, and then returns data to the front-end. The front-end of the visualization module adopts the Vue framework and adjusts the style in conjunction with the Element UI. Vue is a progressive framework for building user interfaces, applied from the bottom up [9]. Vue's core library only focuses on view layers and can be integrated with third-party libraries or existing projects.

3.5. Data visualization interface

As shown in Figure 2, the visualization module includes six buttons, including AIS speed frequency at different time periods, frequency statistics for different types of ships, frequency statistics for different speeds, daily AIS signal

quantity statistics for ships, AIS signal area statistics, and ship thermal map. The green arrow on the map represents the ship

and displays its latest location.

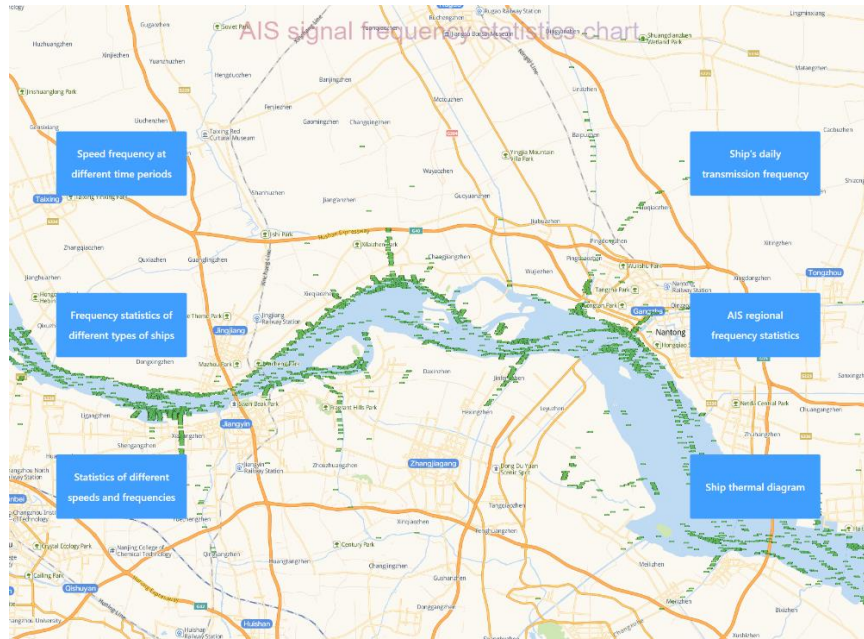


Fig. 2 The AIS signal frequency statistics

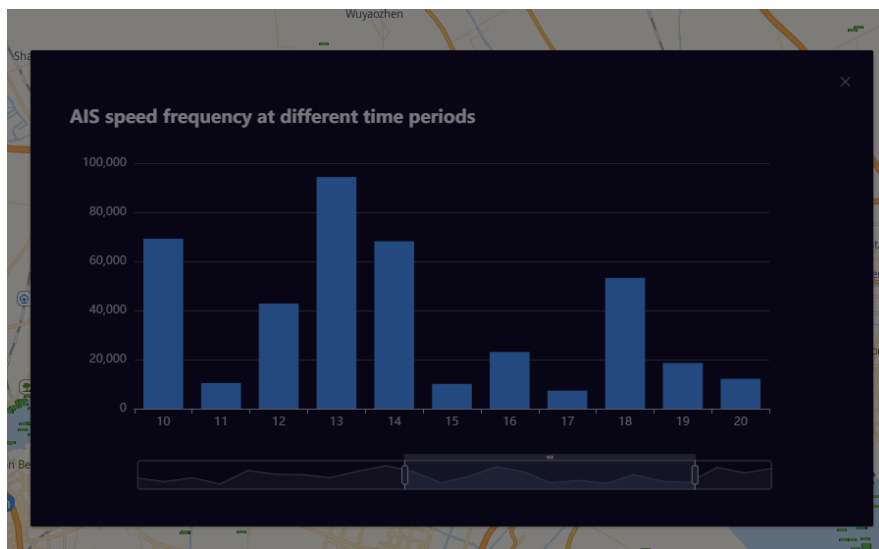


Fig. 3 The AIS speed frequency statistics at different time periods

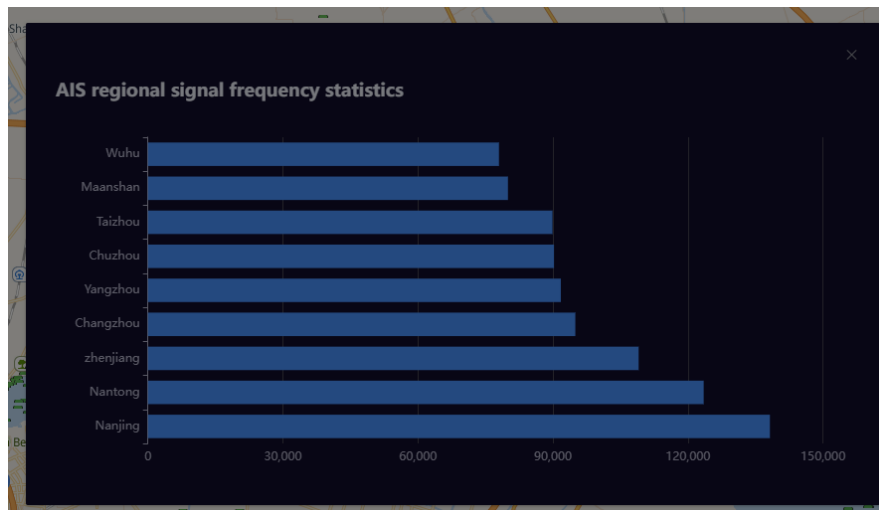


Fig. 4 The AIS frequency statistics at different region

When the corresponding button is clicked, a chart will appear. For example, by clicking the button Statistics of

different speeds and frequency and AIS regional frequency statistics, the interface shown in Figures 3 and 4. They display AIS signal frequency statistics for different time periods and AIS signal frequency statistics in different regions, respectively.

4. Conclusion

This paper studies the frequency analysis of AIS ship signals and discusses its research background and significance in the shipping field. By analyzing the characteristics of AIS ships, the AIS data signal frequency is revealed. Although this paper has achieved certain research results in the frequency analysis of AIS ship signals, there are still some problems that need to be solved and expanded as follows.

1) In-depth study of the frequency characteristics of different types of ship signals: Different ship types may lead to differences in signal frequency characteristics. Further research on the frequency characteristics of different types of ship signals can improve the ability to accurately classify and identify ships.

2) Anomaly detection and fault diagnosis: Combining AIS ship signal frequency analysis and anomaly detection technology to conduct research on ship signal anomalies. By monitoring and analyzing abnormal signals, potential faults or safety risks can be discovered in time, providing a more comprehensive guarantee for shipping safety.

3) Apply AIS ship signal frequency analysis to a wider range of fields, such as navigation route optimization, ship collision risk assessment and environmental protection. Through integration and analysis with other data sources, the intelligent level of shipping management can be further improved.

Acknowledgements

This work was financially supported by the Natural Science Foundation of the Jiangsu Higher Education Institutions of China (23KJA580002), the Fundamental Computer Education Teaching Research Project (2022-AFCEC-367) of the Fundamental Computing Education Association of Chinese Universities and Colleges, and the Excellent Teaching Team for QingLan Project of the Jiangsu Higher Education Institutions of China (Big Data Technology Teaching Team with Shipping Characteristic).

References

- [1] Lv, Taizhi, Peiyi Tang, and Juan Zhang. "A Real-Time AIS Data Cleaning and Indicator Analysis Algorithm Based on Stream Computing." *Scientific Programming* 2023 (2023):1-11.
- [2] Zhang, Jinfen, et al. "An interpretable knowledge-based decision support method for ship collision avoidance using AIS data." *Reliability Engineering & System Safety* 230 (2023): 108919.
- [3] Zhang, Jun, et al. "A web log real-time analysis platform based on stream computing." *Third International Conference on Computer Vision and Data Mining (ICCVDM 2022)*. Vol. 12511. SPIE, 2023: 471-476.
- [4] Lv, Taizhi, et al. "Research on Ship AIS Data Analysis Based on Stream Computing and Virtual Fence." *2023 4th International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE)*. IEEE, 2023: 41-44.
- [5] Abu Kausar, M., M. Nasar, and A. Soosaimanickam. "A Study of Performance and Comparison of NoSQL Databases: MongoDB, Cassandra, and Redis Using YCSB." *Indian Journal of Science and Technology* 15.31 (2022): 1532-1540.
- [6] Sotnik, Svitlana, Volodymyr Manakov, and Vyacheslav Lyashenko. "Overview: PHP and MySQL Features for Creating Modern Web Projects." (2023).
- [7] Kang, Xiaolin, et al. "Design of student information management system based on the separation of front and back ends." *2nd International Conference on Internet of Things and Smart City (IoTSC 2022)*. Vol. 12249. SPIE, 2022: 103-109.
- [8] Zou, Yujuan, et al. "Research on ship data analysis based on Spark platform." *2023 5th International Conference on Communications, Information System and Computer Engineering (CISCE)*. IEEE, 2023: 249-252.
- [9] Zhang, Juan, and Taizhi Lv. "Design and implementation of ship data analysis platform." *Frontiers in Computing and Intelligent Systems* 2.1 (2022): 20-22.