

Research on AIS Data Processing and Visualization Technology

Yujuan Zou^{1,*}, Taizhi Lv²

¹College of Information Technology, Jiangsu Maritime Institute, Jiangsu Nanjing, 211170, China

²Nanjing Longyuan Microelectronic Company Limited, Jiangsu Nanjing, 211106, China

*54552046@qq.com

Abstract

Compared with highway transportation, the research on intelligent water transportation started late, and the complexity of ship transportation itself leads to the difficulty of intelligent shipping research. AIS (automatic identification system) is an important cornerstone of intelligent shipping research, covering the core elements of ship navigation. Tens of billions of AIs are produced every day in the world. How to efficiently store, real-time analysis and data visualization has become a key problem to be solved. Aiming at the problem of AIS data processing and visualization, based on Hadoop, Flink and other big data platforms, this paper constructs a scheme from AIS data acquisition, real-time analysis, mass storage to data visualization, which realizes the effective processing and analysis of AIS, which is of practical significance for effectively tracking ship trajectory, counting traffic flow, and improving the efficiency of ship supervision and maritime management.

Keywords

Automatic identification system(AIS); Big data technology; Hbase; WebGIS, GeoServer; OpenLayer.

1. Introduction

Automatic identification system (AIS) is a digital navigation aid system composed of shore based and ship borne equipment, which realizes the navigation status and ship information interaction between ships and ships, ships and shore based [1]. AIS data includes ship type, name, maritime mobile service identification (MMSI), arrival time, navigation speed, transit area and other information, which can be applied to ship identification, ship tracking, ship collision avoidance, maritime management, channel calculation, etc. With the continuous development of shipping industry, ship activities are becoming more and more frequent. Tracking ship trajectory information through visualization technology has important theoretical and practical significance for ship management, maritime supervision and trade analysis. As an important cornerstone of water transportation research, the data, storage, analysis and visualization of AIS data are of great significance for statistics of traffic flow, tracking ship trajectory and analyzing ship navigation. It has become the focus and hotspot of water transportation research. Intelligent maritime management has always been the key direction of local maritime departments, and the intelligent analysis and processing of AIS is one of the important foundations for the realization of intelligent maritime [2-3].

2. AIS Original Message

2.1. AIS Message Type

As shown in Table 1, AIS contains 13 message types. Among them, type 1, 3 and 5 are the main objects processed by AIS system. Types 1 and 3 are ship position messages, mainly including Maritime Mobile Service Identify (MMSI) number, latitude and longitude, bow direction, ground speed, steering rate and other information [4]. Type 5 is the static information of the ship, which is divided into 2 parts. The first part mainly includes the ship name, MMSI number, IMO number, call sign, equipment type, Captain, ship width, ship type and other unchanged information. The other part is the information that changes with the voyage, such as the port of destination, estimated arrival time, etc.

Table 1. AIS message types

Message Type	Message Name	Message Description
1	Ship position report	Regular position report
2	Ship position report	Ship position report for allocation schedule
3	Ship position report	Special ship position report for replying to inquiry
4	Base station report	Location of base station, UTC date and slot number
5	Static and range related data	Regular static data and ship related ship data report
9	rescue aircraft location report	Location report for use only for aeronautical stations operating in SAR
10	UTC date query	Query UTC time and date
11	UTC date response	Current UTC time
12	Addressing security information	Security information for addressable communication
13	Security information confirmation	Acknowledge the received addressing security information

2.2. AIS Message Format

AIS original message is digitized or compressed coded. To obtain the original information contained in it, it needs to be decoded according to the specified format. The original message form of AIS is shown in Figure 1.

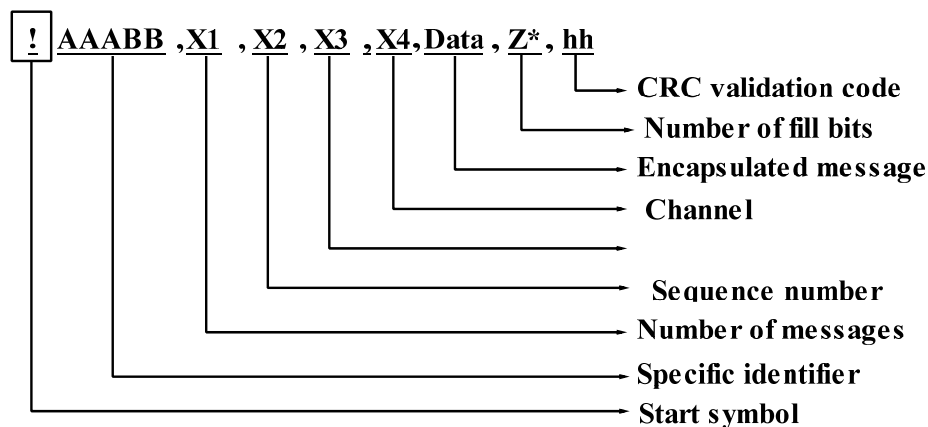


Figure 1. Message diagram of ship AIS data

XX: AI is the shipboard mark and BS is the base station mark.

YYY: statement type. VDM indicates that the information of other ship is encapsulated, and VDO indicates that the information of this ship is encapsulated.

X1: the length of one AIS data may be very long, and multiple messages are required to send. This field specifies the number of messages required to send this AIS message, and the value range is bits 1 to 9

X2: sequence number of this message in an AIS message;

X3: identification code (0-9) of continuous message. Each new multi statement AIS message is assigned a number according to sequence. Different messages of the same AIS message contain message numbers of the same sequence, which is used to identify each message containing the same AIS message.

X4: AIS channel indication, indicating whether the message is received from channel "a" or "B".

Data: the data part of the package. The maximum length of the package is limited to the total number of characters of the statement not exceeding 82. For messages transmitted with multiple statements, this field supports up to 62 valid characters. For a single message, the maximum is 63 valid characters;

V*: Filling bits (number of bits). This field must be a multiple of 6. If not, add 1-5 filling bits. This field indicates the number of bits added to the last 6-bit encoded character. When the padding bit is not added, the padding value is 0. This field cannot be empty.

HH: inspection field. AIS data adopts 8-bit CRC. Take the high four bits of its 8-bit CRC check code and convert it into hexadecimal number to form the first bit of AIS check code. Take the low four bits of its 8-bit CRC check code and convert it into hexadecimal number to form the second bit of check code [5].

3. AIS Data Storage Method

AIS data is the ship trajectory information, which conforms to the characteristics of large-scale, high-speed and low value density of big data. The massive data and high concurrent access of AIS lead a great challenge to the traditional storage method based on relational database [6]. Some scholars propose solutions based on relational database sub database or sub table storage. Although it alleviates the defect of load to a certain extent, it also leads to the complexity of capacity expansion, and cross table query also increases the complexity of query. With the advent of the big data era, the development of distributed storage and non-relational (NoSQL) database technology provides an opportunity to solve massive data storage and query. Hadoop, a highly reliable, efficient and scalable distributed processing platform, and non-relational databases with fast storage and query such as HBase and Redis have been widely used in many fields such as medical treatment, transportation, intelligence and so on.

This paper constructs AIS massive data storage based on HBase platform. AIS data is stored on a distributed HBase cluster. The HBase cluster is built on the Hadoop cluster. The Hadoop cluster adopts the high available(HA) mode to realize hot switching through two master-slave Namenode servers. The data node server stores data. At present, it provides four data node servers. In the future, it can be expanded freely with the increase of business demand [7].

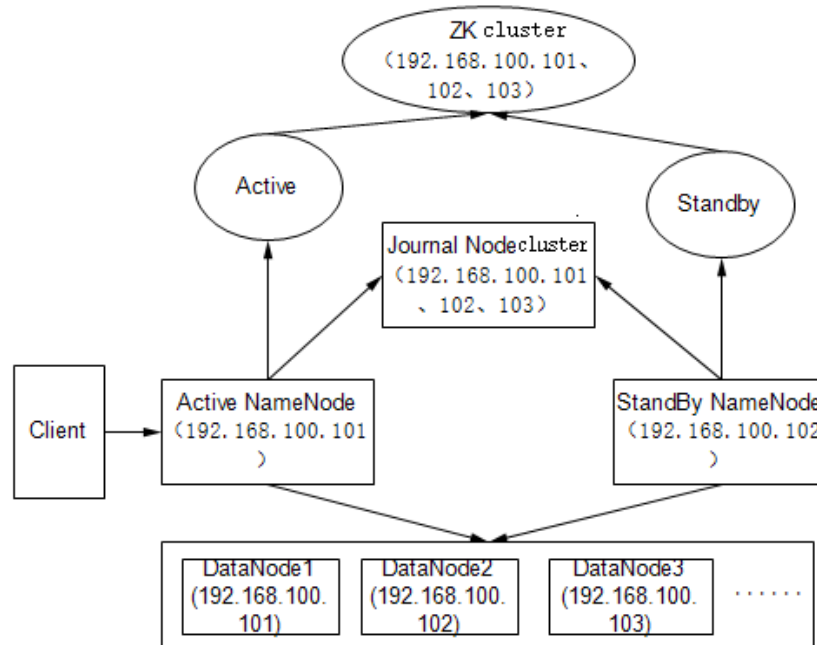


Figure 2. Hadoop system architecture

4. AIS Data Processing Method

Massive AIS data is the data cornerstone of intelligent shipping. If AIS data is processed quickly and efficiently, it has become one of the hotspots of intelligent shipping research. Based on Flink streaming computing technology, this paper constructs an AIS real-time processing technology platform, which can perform the operations of AIS data De duplication, decoding, calculation and statistics.

As shown in Figure 3, AIS data real-time computing platform is built based on Flink, Kafka, redis, HBase and other technologies.

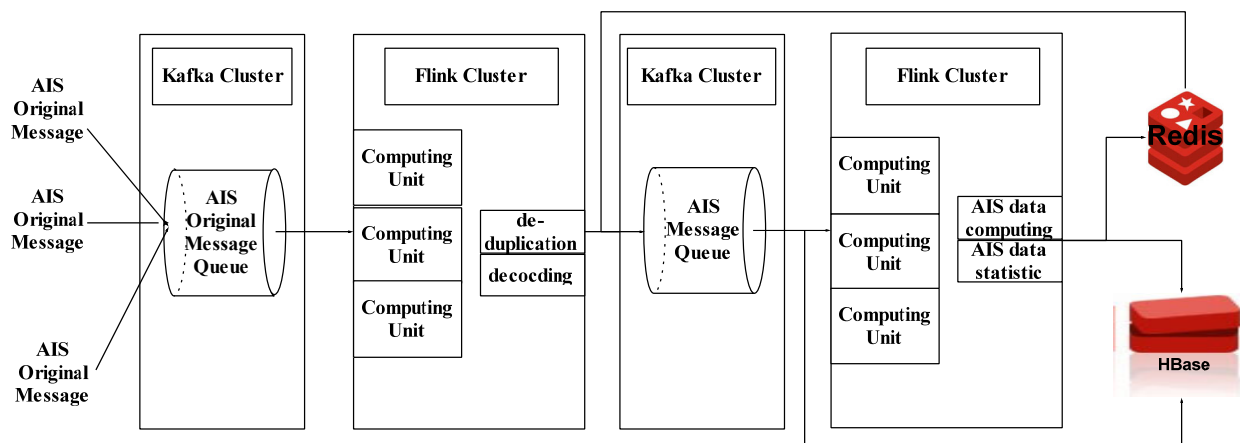


Figure 3. AIS data processing based on Flink platform

Kafka is a fast, scalable, persistent and error tolerant publish subscribe message system [8]. It is often used for the transmission and analysis of real-time stream data structure. At present, three machines are provided to realize Kafka cluster, which can meet the high-performance, safe and reliable transmission of AIS data. As the producer, the program that receives the original AIS message from the base station sends the AIS data to the broker by pushing, and the data is pushed to the Flink cluster for real-time calculation.

Apache Flink is an efficient and distributed general data processing platform, which executes arbitrary stream data programs in parallel and pipelined manner [9]. Flink platform stores the results in real-time data warehouse and database through real-time processing. To ensure the stability of AIS data real-time processing, AIS data basic processing, analysis and statistics are run in two Flink clusters respectively. The first Flink cluster mainly realizes AIS data De duplication and message analysis, and the processing results are pushed to Doris real-time data warehouse and the second Flink cluster through Kafka queue at the same time. The second Flink cluster realizes the real-time statistics of AIS area, anomaly and ship type, and the statistical results are stored in the database.

5. AIS Data Visualization Method

Through data visualization, users can quickly digest information and better analyze data. There is a large amount of value information in massive AIS data. It is particularly important to show AIS data in a visual way. AIS visualization is to show AIS data to users in the form of images, including electronic chart, statistical chart and so on.

This paper presents AIS data by means of electronic chart and statistical chart. Ship dynamic map builds AIS data visualization based on GeoServer, spring boot, Openlayers and other technologies. GeoServer is an open source map server conforming to OpenGIS web server specification, which can publish various types of map data and share spatial geographic information. Openlayers is a JavaScript package developed by WebGIS front-end, which is used for access, operation and display of map services.

AIS visualization adopts the traditional B/S architecture, which is composed of data layer, data processing layer, business logic layer and presentation layer. AIS data is stored in the HBase database. The data processing layer realizes the crud operation of AIS ship data through the spring data HBase framework. The business logic layer is mainly responsible for the business logic of the response and returns the data in the corresponding GeoJson format according to the user's request. The presentation layer runs on the front page, takes the sky map and channel map as the base map based on openlayer API, dynamically superimposes and displays the ship dynamic data on it, and realizes the data statistical chart based on Echarts.

6. Conclusion

AIS data is of great significance to realize intelligent shipping. This paper studies the massive AIS data collected through the shore, and puts forward a scheme from AIS collection, storage, analysis to visualization. AIS data forwarding is completed through Kafka message queue to realize efficient and stable message transmission, offline and streaming analysis of data is realized through Flink cluster, real-time query of historical information is realized through HBase, second level query can be realized to provide support for data analysis, and data visualization is realized through Openlayers and Echarts.

Acknowledgments

This work was financially supported by the funding of the shipping big data collaborative innovation center of Jiangsu Maritime Institute, the natural science project for colleges and universities in Jiangsu Province(21KJB580007), the young academic leaders of Jiangsu colleges and universities QingLan project, excellent teaching team of Jiangsu colleges and universities QingLan project (Innovative teaching team of software technology specialty).

References

- [1] Zhou, H. , et al. "Frequency offset insensitive demodulation algorithm for satellite-based automatic identification system." *International Journal of Satellite Communications and Networks* 37.3(2019):213-223.
- [2] Svanberg, M. , et al. "AIS in maritime research." *Marine Policy* 106.AUG.(2019):103520.1-103520.10.
- [3] Skauen, A. N. . "Ship tracking results from state-of-the-art space-based AIS receiver systems for maritime surveillance." *CEAS Space Journal* 11.3(2019):301-316.
- [4] Woo, et al. "Analysis of requirements for Automatic Identification System." *Journal of the Korean Society for Marine Environment & Energy* 3.1(2000):45-51.
- [5] Lin, C. , et al. "AIS Information Decoding and Fuzzy Fusion Processing with Marine Radar." *International Conference on Wireless Communications IEEE*, 2008: 1-5.
- [6] Lv, Taizhi, et al. "Massive AIS data storage and query based on Hadoop platform." *Journal of Physics: Conference Series*. Vol. 1948. No. 1. IOP Publishing, 2021 :1-5.
- [7] Khan, M. A. , Z. A. Memon , and S. Khan . "Highly Available Hadoop NameNode Architecture." *International Conference on Advanced Computer Science Applications and Technologies, ACSAT 2012*:167-172.
- [8] Ba Ng, J. , et al. "Design and implementation of a load shedding engine for solving starvation problems in Apache Kafka." *Noms IEEE/IFIP Network Operations & Management Symposium IEEE*, 2018:1-4.
- [9] Alcalde-Barros, A. , et al. "DPASF: a flink library for streaming data preprocessing." *Big Data Analytics* 4.1(2019):1-17.
- [10] Lv, Taizhi, Zhiyang Song, and Chenyong He. "Research on ship dynamic map based on AIS." *2021 International Symposium on Computer Technology and Information Science (ISCTIS)*. IEEE, 2021:276-279.