A Ship-borne Trajectory Real-time Processing System Based on Service Bus

Shangcheng Hu\textsuperscript{1,2,*}, Yonggang Li\textsuperscript{2} and Yawei Hou\textsuperscript{2}

\textsuperscript{1}National University of Defense Technology, Changsha 410073, China
\textsuperscript{2}China Satelite Maritime Tracking and Control Department, Jiangyin 214431, China

*Corresponding author e-mail: shallow2006@sina.com

Abstract. Currently, ship-borne trajectory real-time processing system adopt centrality soft-model, it existed obvious shortcoming, such as strong coupling, weak adaptable and difficult to upgrade. Based on analyzing the real-time processing flow and requirement of the ship-borne trajectory real-time processing, together with the advantage of service bus have been used in other scene, this article designed a soft-model based on service bus. It has the advantage with less coupling and more adaptable. The research results have been directly applied to the maritime tracking and control software, effectively enhance the real-time processing system of task adaptability and maintainability of efficiency and improve the ability to carry out the task.

1. Introduction
In our country, spacecraft tracking telemetering and control ship (TT&C ship) is flexible and plays an important role in China's space tracking telemetering and control tasks. Different from the land-based fixed station, the sea-based measurement platform has dynamic characteristics, and the ship-borne trajectory measurement data needs to correction errors such as ship shake, deformation, not-horizontal and ship position [1], forming a unified geocentric solid contact measurement data. In the process of multiple input but single output, the timing relationship of the data is strict. Therefore, the real-time processing of the ship-borne trajectory measurement data generally adopts a centralized processing architecture. In the centralized processing, the time synchronization is completed by artificially preset data delay smoothing, data processing priority, data-double-buffer matching and interrupt mechanism. With the rapid development of space monitoring and control tasks, the coverage frequency band is wider and wider, the measurement and control system is becoming more and more innovation, and the types and quantities of ship-borne radar equipment have undergone tremendous changes. The centralized processing architecture has the characteristics of insufficient performance and poor scalability is more and more obvious. This article analyzes the real-time processing requirements and service bus technology for the ship-borne trajectory data processing, designed a parallel processing architecture based on service bus.

2. Real-time processing requirements of the ship-borne trajectory data
The measurement of sea-based measurement data mainly adopts the single station positioning system. The original measurement data of the radar is the measurement spherical coordinate, and the
measurement data reference is the three-axis intersection of the radar mechanical axis. Compared to the land-based fixed measuring station, the TT&C ship's radar base is directly fixed on the hull deck. During the sea tracking and telemetering, the data reference has been changing with the hull's shaking and swinging. In order to correct the dynamic error of the hull deck, the platform inertial guidance and deformation equipment are equipped in the TT&C ship to record the swaying of the hull and the deformation between the radar and the inertial navigation device. The real-time processing of ship-borne trajectory tracking data includes pre-processing, correction of the ship shake, deformation and ship position [2]. The real-time processing flow of ship-borne trajectory measurement data under the centralized architecture is shown in Figure 1.

![Fig.1 Centralized ship tracking data processing flow chart](image)

The data storage buffer in the figure includes sampling data of radar trajectory, inertial navigation, deformation and other equipment. With different sampling mechanism, the centralized real-time processing used double buffering and interrupt waiting mechanism. Waiting for all data collected, it processes the inertial navigation and deformation, and then processes the trajectory measurement data. With the changes in the number of ship-borne trajectory measuring equipment, measurement and control system and real-time processing requirements, the real-time processing of the centralized architecture presents the following shortcomings: 1) The number of trajectory radars and tracking targets increase, and the real-time processing volume in one sampling period double growth, insufficient performance will become the bottleneck of tracking capability expansion; 2) When adding new system measurement and control, the new real-time processing module of trajectory measurement data will have an impact on mature software code, and the workload of analysis and test verification is large; 3) processing priority of different radar is fixed, the calculation state and parameter intercommunication of the inter-radar trajectory measurement data cannot be realized.

3. Processing system based on Service bus
The service bus is the foundation platform of the service-oriented architecture. The message processing through the service connects the service requester and the server, allowing the software and services to communicate with each other in a modular and flexible deployment regardless of the programming mode, the deployment hardware and the running software environment. The important key is: 1) transforming the service into a business build interface through abstraction; 2) communicating the messages between the services through routing; and 3) parsing the message between the service requester and the server through a preset format specification. At present,
enterprise service bus has been widely used and promoted in the fields of electric power gov, finance, telecommunications and e-government.

The existing commercial service bus software has a wide range of applications, integrates technologies such as Web and XML, supports services, messages and event-based interactions in heterogeneous environments, and has bridging and conversion based on message communication protocols. In terms of the field, the processing flow is complex, the function is redundant, and the application cost is high [3].

For the business field and application scenarios of maritime monitoring and control, and drawing on the advantages of enterprise service bus, designing a dedicated service bus for maritime measurement and control software, which has the advantages of scalable, flexible deployment and high security of traditional service bus, and meets the high real-time nature of maritime measurement and control. Demand for low resource consumption. The real-time processing architecture model of ship-borne trajectory measurement data based on service bus is shown in Figure 2.

In the figure, the provider of each service separates from the entire application system, hides the business logic from the outside world, and communicates between different services through a preset standardized service interface. The main design elements of the real-time processing architecture of ship-borne trajectory measurement data based on service bus include service interface abstraction, message routing, message format specification, etc.

3.1. Service interface abstraction
Each component module based on the service bus has loose coupling and modular features, and the connection between the modules presents a mesh structure [4]. The service interface granularity is too thick. Although the number of interfaces is small and the association is simple, each component module has many internal functions, the function coupling is large, and the independence is poor. It is difficult to achieve the loose coupling effect; if the service interface granularity is too fine, the number of interfaces Too much, the connection is complicated, the development is difficult, and the modification and maintenance will be very difficult. When abstracting the service interface, choose the appropriate service interface granularity. It is generally abstracted and divided for the purpose of reuse of business logic functions that the service is responsible for [5].According to the input and output of real-time processing of ship-borne trajectory measurement data, the service interface is abstracted according to functions. The main service interfaces include network data transmission and reception service, ship attitude correction service, deformation correction service, ship position correction service, radio wave refraction correction service, etc.

3.2. Message routing mechanism
Message routing is the step of analyzing the delivery of services, establishing the process of transmitting lines and rules, and gradually delivering messages.

The content is passed from the provider to the recipient [6]. Message processing is the key to the implementation of the entire architecture and the implementation of a loosely coupled structure. Message routing mainly includes two parts: routing lines and routing rules. According to the actual
situation of the application scenario, a lightweight message routing mechanism is designed, only the message routing route in the same level LAN is considered, and the external expansion interface is appropriately reserved.

A control mode with a central node will cause the entire network to crash when attacked or abnormally crashed. In order to improve the invulnerability and reliability of the central node, an autonomous collaborative model and service negotiation mechanism for the central node subnet can be constructed [7], but the implementation process is complex, affecting system efficiency and cost. In the dedicated service bus, due to the speciality and internal controllability of the service customization, the mechanism of using the service bus as the central node and the distributed node proxy can be adopted by distributing the configuration. A message management platform is deployed on each distributed node, which is responsible for message receiving, parsing, and intra-node forwarding processing between nodes. The node internally uses a unified pipeline data flow mode and conditional wait mechanism to complete the service request and response processing between component modules.

3.3. Message format specification

Messages are the only way to call a service between functional modules. The efficiency of message delivery and parsing directly affects the performance of the entire system. In order to simplify the parsing of messages and isolate the system complexity caused by changes in the external environment, a unified internal message format (IXP) based on the TCP transport protocol is established within the system. In the interaction layer of the internal and external systems, the protocol converter is added to complete the format interchange. The IXP header contains the source address, destination address, and message classification of the message. The service bus quickly completes the message distribution and parsing processing according to the content of the message header.

4. Application of the service bus

According to the real-time processing requirements of the ship-borne trajectory measurement data, the software implementation structure based on the service bus is shown in Figure 3.
According to the marine monitoring and control application scenario, the message manager of the dedicated service bus adopts a preset parameter mode to reduce message routing and resolution. The functions completed by each service module in the figure are as follows:

1) Protocol converter: completes the transmission and reception of various trajectory data and protocol conversion, and provides the adaptation of the "data transceiver service" to the external environment;

2) Data transcribing service: completes the transmission and reception of communication data, communicates with each functional module through the service bus, and the main data content includes standardized ship-borne measurement data and processing results;

3) Inertial navigation processing service: acquires inertial measurement data by requesting a subscription service of "data transcribing service", and the processing result is used as a service provider for inertial correction and deformation correction;

4) Atmospheric correction service: provide meteorological correction service;

5) Smoothing service: providing services such as smoothing, filtering, and predicting data;

6) Radar trajectory measurement processing service: obtain the ship-borne trajectory test data by requesting the subscription service of "data transcribing service", and after the pre-processing, calculate the final service by requesting services such as "inertial navigation correction, deformation correction, meteorological correction, smoothing". The result data, and the processing result is sent through the publishing service network of the "data receiving and dispatching service";

7) Control service: Check the input parameters of human-computer interaction, and modify the legal function parameters through the service interface (some service function modules have control service response interface) to modify each service function parameter.

The ship-borne trajectory measurement data real-time processing software realized by the architecture runs stably in the sea measurement and control tasks, and the real-time curves between nodes and nodes are shown in Fig. 4.

As can be seen from the above figure, the time delay of the service call is 0.17 milliseconds, the maximum value is less than 0.4 milliseconds, the real-time performance is high, which satisfies the requirements of the system index.

Take the function extension of the atmospheric service as an example. The software maintenance content is shown in Table 1.
Table 1. Content comparison of Software architecture

| Project                              | The centralized architecture | Architecture based on the service bus |
|--------------------------------------|------------------------------|--------------------------------------|
| Atmospheric correction core code maintenance | Maintenance of model interface and call interface | Consistent core maintenance code |
| Interface maintenance                | Only need to maintain the model interface | Consistent core maintenance code |
| Influence domain analysis            | Need to analyze the impact of the core code, function calls, real-time processing flowed. | Only need to analyze the core code |
| Test verification                    | Test verification of the impact more domain | Test verification of the impact less domain |
| Configuration management             | Management and upgrade of a single code may affect other core modules, and management is difficult. | Only need to manage and upgrade the atmospheric correction service module code, easy to configure and manage |

As can be seen from the above table, the real-time processing software based on the service bus architecture is more scalable than the centralized architecture.

5. Conclusions

The ship-borne trajectory real-time processing software architecture based on service bus has the characteristics of loose coupling, modularization and easy to expand. It encapsulates the internal complex mathematical model processing according to the functional granularity, and communicates with other modules through the specification-based service interface, which has good scalability. In the situation the sea-based tracking and control presents high density, increasingly demanding of the data real-time processing, the architecture can effectively improve the software maintenance and test verification efficiency. The design idea based on service bus provides a reference for the construction of cloud platform for marine measurement and control software [8]. According to the flexible deployment and high availability requirements of the cloud platform, the message management mode of the service bus needs to be further optimized.

References

[1] Jiang Wenda, The Spacecraft tracking telemetering and control ship. Beijing, 2002.
[2] Li Huifen, et. Accuracy Estimation Methods Applied in Mobile Maritime Tracking Stations, J. Journal of Spacecraft TT&C Technology, 2011.10.
[3] Li Zi, et. Application of enterprise service bus (ESB) technology in large enterprises, Information Technology, 2013(2).
[4] Guo Junfeng. Optimized Service Interfaces Based on SOA, J. Journal of Chengdu University, 2008, 27(4).
[5] Su Yanbin. Research on soft bus and message transmission in SOA open control platform. South China University of Technology, 2011.
[6] Sun Xin. Ship-bore Command and Control System Integration Method Based on Service Bus, J. Ship Electronic Engineering, 2014, 34(1).
[7] Li Peipei. Research on service negotiation mechanism of complex network centric node. Nanjing University of Science and Technology, 2013.
[8] Deng Weiling. Research on the overall framework of the regional primary medical cloud based on the shared exchange cloud platform, J. Internet of things technologies, 2015(03).