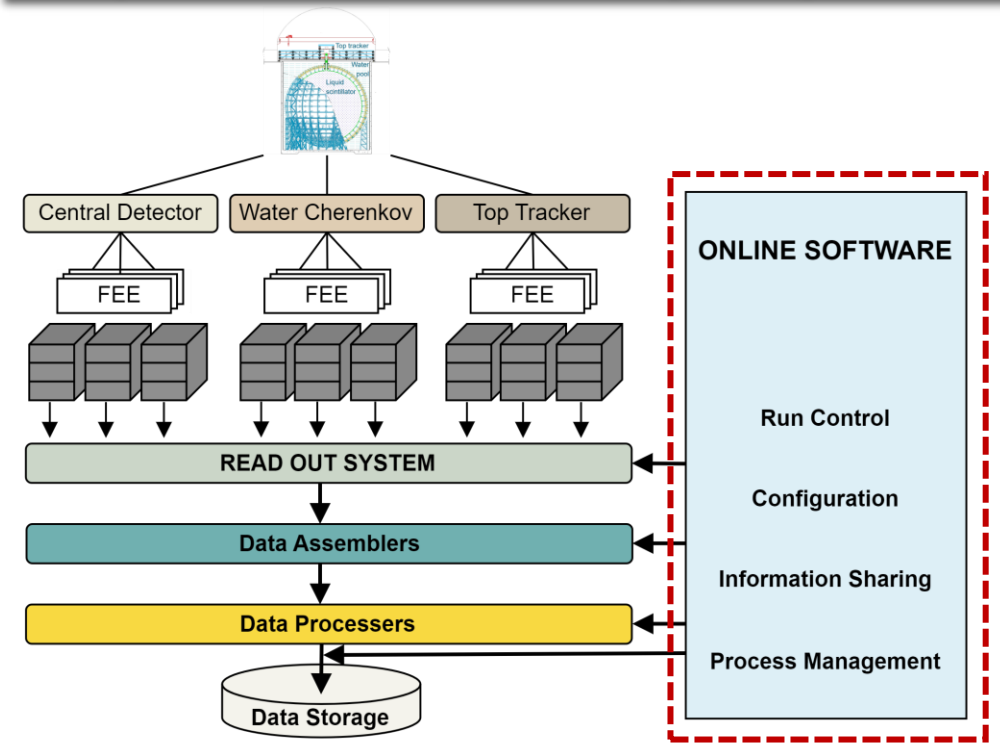
Implementation of the JUNO DAQ Online Software

Yinhui Wu, Zezhong Yu, Shuihan Zhang, Chao Chen, Fei Li, Minhao Gu, Kejun Zhu

The Jiangmen Underground Neutrino Observatory (JUNO)

- Located about 53 kilometers from the Yangjiang and Taishan Nuclear Power Plants
- Accurate measurement of neutrino mass ordering and neutrino mixing parameters

Supernovae in the Milky Way occur only once every few decades



JUNO Data Acquisition (DAQ) System

Objective:

- Read out a large amount of raw data, about **40GB/s**
- Minimize downtime to the maximum extent

Divided into data flow software and **online software**

Online software:

- managing the DAQ system
- providing **high availability** support for the data flow software

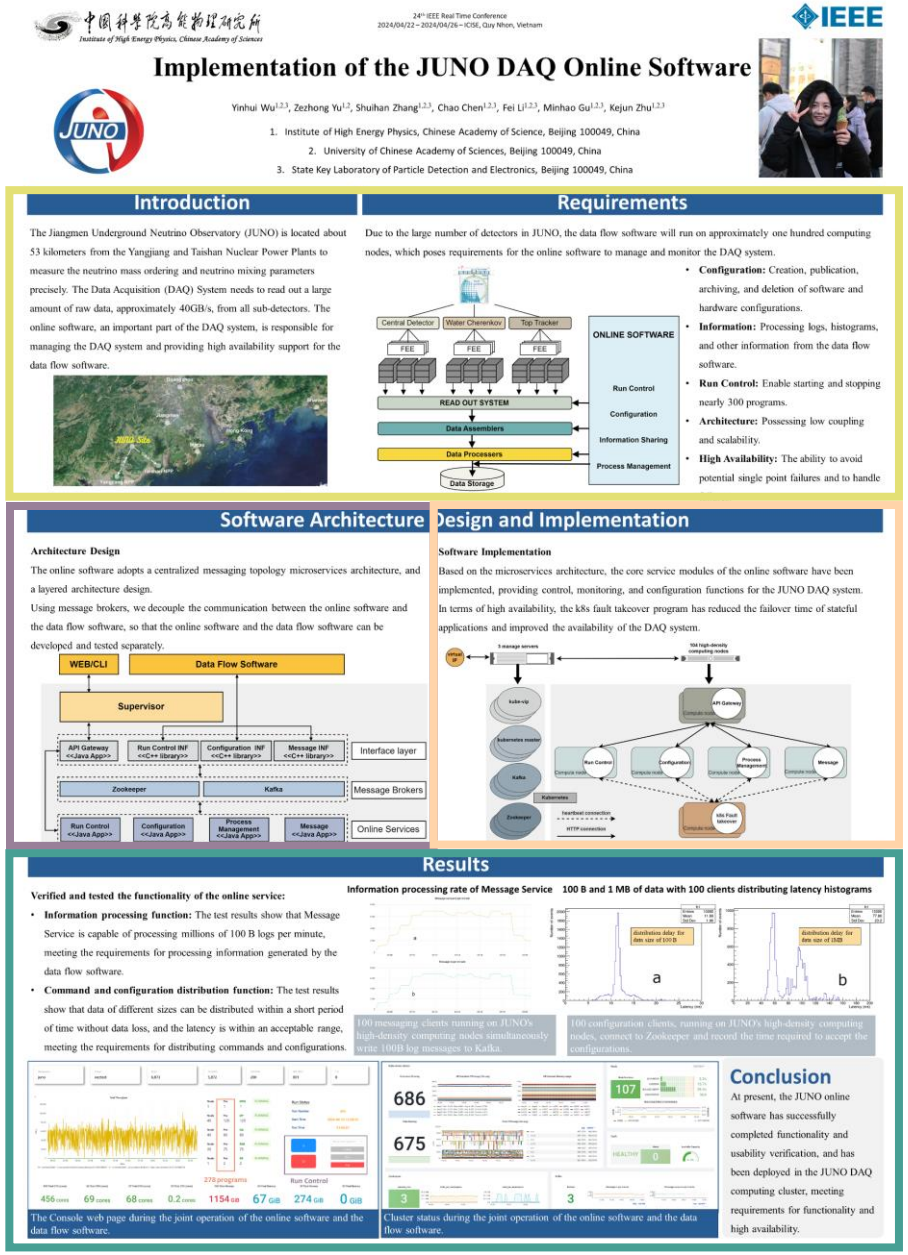
Introduction and Motivation

Online Software Architecture Design

- Ensure that each service does not interfere with one another
- Isolate data flow software and online software

Achieved Results

The JUNO Online Software has successfully completed functionality and usability verification and has deployed in the JUNO DAQ computing cluster.



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Introduction

The Jiangmen Underground Neutrino Observatory (JUNO) is located about 53 kilometers from the Yangjiang and Taishan Nuclear Power Plants to measure the neutrino mass ordering and neutrino mixing parameters precisely. The Data Acquisition (DAQ) System needs to read out a large amount of raw data, approximately 40GB/s, from all sub-detectors. The online software, an important part of the DAQ system, is responsible for managing the DAQ system and providing high availability support for the data flow software.

Requirements

Due to the large number of detectors in JUNO, the data flow software will run on approximately one hundred computing nodes, which poses requirements for the online software to manage and monitor the DAQ system.

- **Configuration:** Creation, publication, archiving, and deletion of software and hardware configurations.
- **Information:** Processing logs, histograms, and other information from the data flow software.
- **Run Control:** Enable starting and stopping nearly 300 programs.
- **Architecture:** Possessing low coupling and scalability.
- **High Availability:** The ability to avoid potential single point failures and to handle

Software Architecture

Architecture Design

The online software adopts a centralized messaging topology microservices architecture, and a layered architecture design.

Using message brokers, we decouple the communication between the online software and the data flow software, so that the online software and the data flow software can be developed and tested separately.

Design and Implementation

Software Implementation

Based on the microservices architecture, the core service modules of the online software have been implemented, providing control, monitoring, and configuration functions for the JUNO DAQ system. In terms of high availability, the k8s fault takeover program has reduced the failover time of stateful applications and improved the availability of the DAQ system.

Results

Verified and tested the functionality of the online service:

- **Information processing function:** The test results show that Message Service is capable of processing millions of 100 B logs per minute, meeting the requirements for processing information generated by the data flow software.
- **Command and configuration distribution function:** The test results show that data of different sizes can be distributed within a short period of time without data loss, and the latency is within an acceptable range, meeting the requirements for distributing commands and configurations.

Information processing rate of Message Service 100 B and 1 MB of data with 100 clients distributing latency histograms

100 messaging clients running on JUNO's high-density computing nodes simultaneously write 100B log messages to Kafka.

100 configuration clients, running on JUNO's high-density computing nodes, connect to Zookeeper and record the time required to accept the configurations.

The Console web page during the joint operation of the online software and the data flow software.

Cluster status during the joint operation of the online software and the data flow software.

Conclusion

At present, the JUNO online software has successfully completed functionality and usability verification, and has been deployed in the JUNO DAQ computing cluster, meeting requirements for functionality and high availability.

Implementation

- Providing control, monitoring, and configuration functions for the JUNO DAQ system.
- Optimizing software deployment and failover based on k8s container management mechanisms.

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