# Exploration on Quasi-Steady-State Real-Time Data Access for EAST Tokamak

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**ABSTRACT :**The EAST (Experimental Advanced Superconducting Tokamak) facility is designed to achieve high-performance steady-state operation. Its data acquisition(DAQ) system provides unified data acquisition and long-term data storage for various diagnostic systems, primarily supporting offline data analysis. With the advancement of long-pulse operation on EAST, researchers require access to real-time data during the long-pulse operation, for the live monitoring of key signals and even for performing simple real-time data processing. To address this, an exploration aiming at quasi-steady-state real-time data transmission within the data acquisition framework has been started, and a prototype system has been developed for tests. The prototype consists of DAQ console, DAQ unit and data service, utilizing ZeroMQ for communication. The DAQ console manages acquisition configurations and control the workflow. Each DAQ unit acquires diagnostic data in real-time and transmits it, formatted in a time-sliced format, to the data service module using a request/reply pattern. Upon receipt, the data service immediately publishes the data via a publish/subscribe pattern while simultaneously storing it for long-term archival. Clients can subscribe to specific signals to receive real-time streams for visualization or basic analysis, they can retrieve complete datasets through the offline data service. Feasibility is validated via 1000-second test, and further evaluation with the prototype system are currently in progress.

## Introduction

EAST (Experimental Advanced Superconducting Tokamak) is the world's first fully superconducting Tokamak experimental device, and has been developed further in support of high-performance steady-state operation [1]-[3]. In January 2025, it successfully achieved a steady-state long pulse high confinement mode plasma operation of over 100 million degrees for 1066 seconds [4]. EAST has established a DAQ system which can provide unified pulse-based DAQ and long-term data storage [5]. There are up to 65 DAQ units with about 4000 channels in EAST DAQ system [5], and the number of DAQ units will continue to increase. As of August 2025, the EAST DAQ system has run more than 159000 shots, ensuring stable acquiring diagnostic data and providing data to physicists.

The steady-state long-pulse operation stimulates to explore the way of providing quasi-real-time data publishing which will help physicists to know the current state of the facility and diagnostics during the pulse operation. The current EAST DAQ system doesn't support the quasi-real-time data publishing. Therefore, a test system is built to explore long-pulse quasi-real-time data publishing for EAST DAQ system.

Fig.1 illustrates the overview of the EAST DAQ system, consisting of DAQ console, DAQ units, and data server. The DAQ console is to control the DAQ workflow and manage the static configuration of DAQ units. DAQ units acquire diagnostic signals, and the data server will store all data. All communication is through DAQ Network.

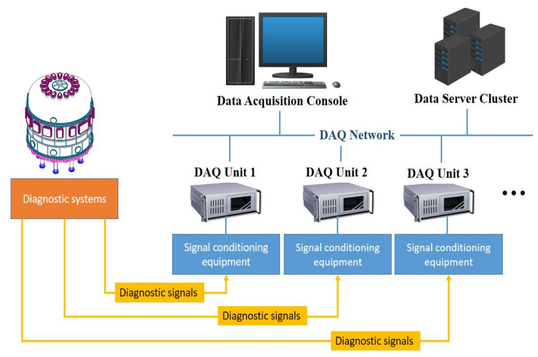



Fig.1 Overview of EAST data acquisition system

## System Architecture

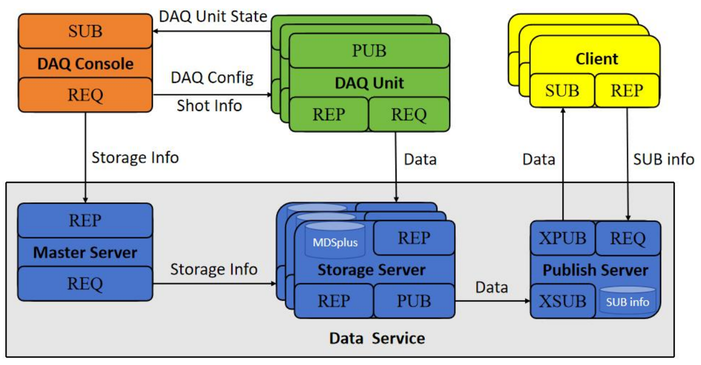



Fig.2 The prototype system architecture

Fig.2 shows the prototype system architecture which is based on EAST DAQ system. The prototype system adopts ZeroMQ to realize the real-time data transmission. For the purpose, the following five types of information need to be transferred with different patterns in the prototype system: DAQ config, shot info, storage info, DAQ unit state, and SUB info.

**(1) DAQ config:** static configuration of DAQ units, such as DAQ board information, signal name, the signal conversion coefficients, etc.

**(2) shot info:** shot information of the new shot, such as shot number, data acquisition duration, start or stop the discharge, etc.

**(3) storage info:** information about MDSplus trees, such as signal name, signal conversion coefficients, etc.

**(4) DAQ unit state:** online state and DAQ state of the DAQ unit.

**(5) SUB info:** the signal subscribed/unsubscribe by clients.

The prototype system comprises DAQ console, DAQ unit, data service, and client. The data service is divided into 3 parts: master server, storage server and publish server. The storage servers are scalable to cope with the increasing DAQ units. The storage server stores the data from DAQ units and publishes it to the publish server. The publish server stores all SUB info and publishes subscribed data.

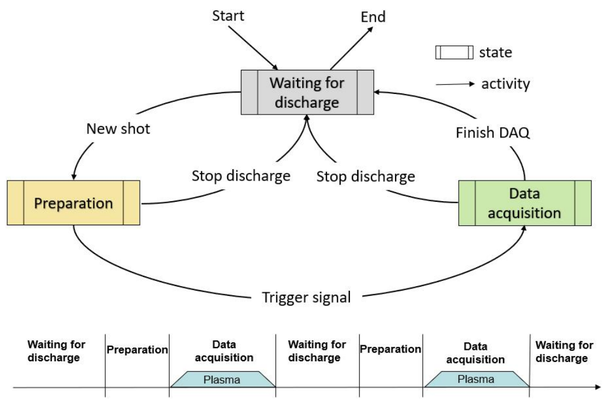
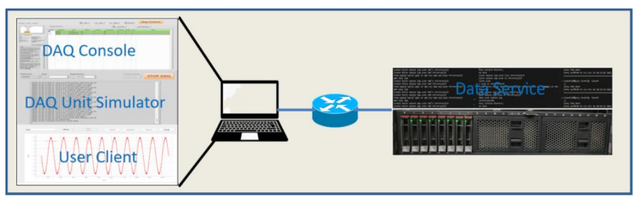


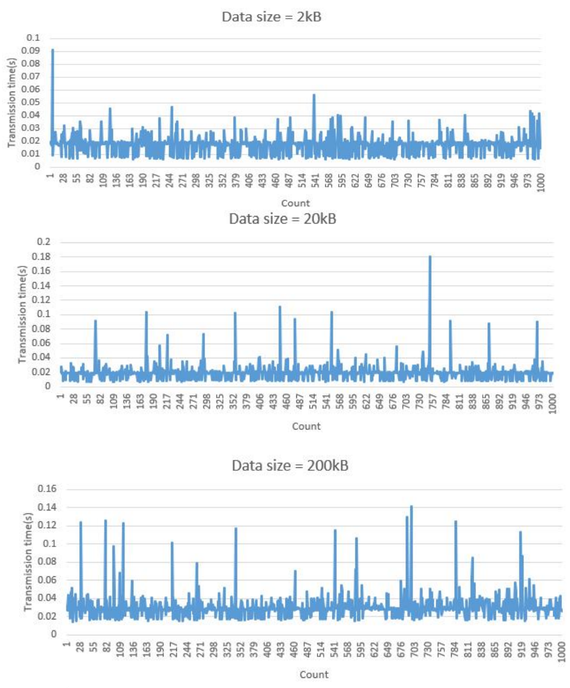

Fig.3 State machine

Fig.3 shows the state machine. The system should keep running during the EAST campaign, which usually continue several months. DAQ config and storage info can be update in the <waiting for discharge> state, while the shot info will be update in the <preparation> state for every shot. It keeps publishing the DAQ unit state and clients can request the SUB info in any time.

## Result

### Scenario 1




The Laptop:

- Windows 11
- CPU@2.30 GHz
- RAM 32GB
- LabVIEW / Python
- Gigabit Network

The data server:

- CentOS 7
- CPU@2.40GHz
- RAM 64GB
- C/C++
- Gigabit Network

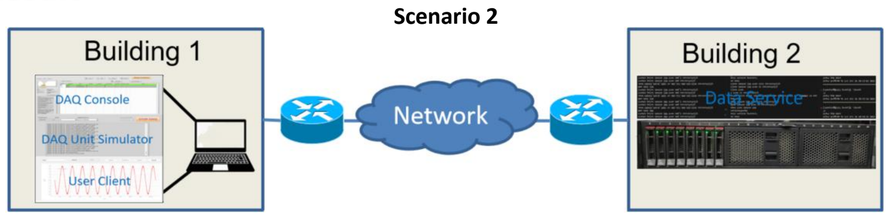
**Scenario 1**

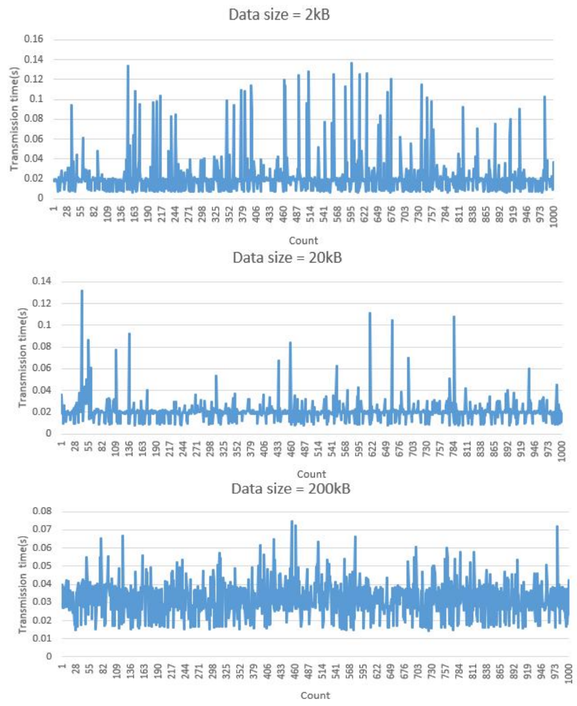
| Data size | Average(s) | Max(s) | Min(s) |
|---|---|---|---|
| 2kB | 0.0176 | 0.0915 | 0.0060 |
| 20kB | 0.0194 | 0.1810 | 0.0070 |
| 200kB | 0.0303 | 0.1414 | 0.0142 |

**Scenario 2**

| Data size | Average(s) | Max(s) | Min(s) |
|---|---|---|---|
| 2kB | 0.0216 | 0.1360 | 0.0064 |
| 20kB | 0.0209 | 0.1315 | 0.0079 |
| 200kB | 0.0319 | 0.0747 | 0.0142 |

### Scenario 2




- ✓ Multiple 1000 seconds and 3600 seconds tests were conducted, with stable data publishing.
- ✓ The transmission with different data size in different network was tested, and the average transmission delay is less than 35 ms.
- ✓ Basically meets the requirements for viewing data during the discharge.

## Conclusion

The quasi-steady-state real-time data publishing system is taking shape, and a prototype system based on ZeroMQ is established and tested. The prototype system comprises DAQ console, DAQ unit, data service, and client. On the basis of the state machine, the data structure and data transmission mode have been designed to meet the needs of real-time data publishing, which can basically meet the requirements of viewing data during the pulse. The data transmission is based on ZeroMQ REQ/REP and PUB/SUB patterns. User can get real-time data during the pulse via the publish server, and also can get offline data with the MDSplus service. From 1000-second and 3600-second tests in two scenarios, the system has the ability of long-pulse data storage and real-time data publishing.

Looking forward, future improvements include, such as testing with real DAQ hardware, distinguishing real shots and test shots, improving status monitoring, improve the management of signal subscription, endurance testing, etc.

## References

[1] B.N. Wan, Y. Liang, X.Z. Gong, et al.， Recent advances in EAST physics experiments in support of steady-state operation for ITER and CFETR, Nucl. Fusion 59 (2019) 112003.

[2] Jiansheng Hu, Weibin Xi, Jian Zhang, Liansheng Huang，et al.， All superconducting tokamak: EAST, AAPPS Bulletin，(2023) 33:8.

[3]X. Gong,Yuntao Song, Baonian Wan, Jiangang Li, Yuanxi Wan, et al., Overview of recent experimental results on the EAST Tokamak, Nucl. Fusion 64 (2024) 112013.

[4]X. Gong, J. Huang, B. Zhang,X.Zhang, et al.,Overview of recent experimental Results on EAST in Support of ITER New Research Plan, 30th IAEA Fusion Energy Conference,Chengdu,China, October 13-18, 2025.

[5]Ying Chen, Shi Li, Feng Wang, Yong Wang, Upgrade of EAST data acquisition system, Fusion Eng. Des., 195(2023) 113942.