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Design of Data Management for New Plasma Control System

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The Plasma Control System (PCS) serves as the central control system responsible for operating the tokamak and controlling the plasma therein.
A new framework of PCS for high-performance steady-state operation is designed.
It is built based on component modularity, providing the operational environment for components, data management model and interfaces to external systems.
A meticulously designed data model can enhance system performance, efficiently utilize data resources, and contribute to achieving plasma control objectives.

The data management model of new PCS is referred to as the Data Engine (DE), which provides standardized organization and communication of data. Its architecture consists of the application layer, logical layer, and physical layer.
The DE application layer consists of the specific application logic and business logic implemented by developers. The application layer utilizes the interfaces and functionalities provided by the DE logical layer to fulfill specific Function Block（FB）requirements.

The logical layer of DE provides a key-value collection (hash map) for storing and managing metadata. Metadata offers a description of the data, encompassing its address, type, and parameters. In DE, generic programming is applied to handle metadata, allowing for the handling of data with unspecified types without requiring specific implementations for each type.
In the logical layer, all data is divided into individual subsets using the key values. Data within the same subset is allocated in a contiguous block of memory called a "Block", which improves the efficiency of data transfer.
By default, Blocks are deployed in heap memory but can also be deployed in other forms, such as shared memory. Different mapping methods of Block is provides depending on the type of memory.

At the physical layer, communication between various components is accomplished through shared memory. Expanding on this, a configurable service is provided to synchronize shared memory Blocks across multiple computer nodes, enabling inter-component data communication across nodes.
The memory for data is reused across different operational cycles to enable the system to effectively handle the large amounts of data generated during long-pulse operation and provide reliable and uninterrupted services. In addition, a real-time service for data archiving is provided to complement this functionality.

DE enables transparent access to data, allowing developers to access all system data in a unified manner. This further facilitates easy system scalability, enhancing system performance.
The new PCS powered by DE was successfully applied in the 2023 EAST summer operation campaign, completing a total of 286 shots without any system failures. Additionally, more than 24 hours continuous running has been tested, demonstrating that DE can effectively serve steady-state operation control.

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