ITER Operation Application Systems for Plant System Integration and Commissioning

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ITER Organization

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Daejeon, Republic of KOREA
• Overview of ITER CODAC (Control, Data Access and Communication)
• Progresses of CODAC Operation Application System
• CODAC for 1st Plant System Commissioning
• Future Plan
Is the central control system in charge to monitor/control all ITER plant systems and to orchestrate ITER operation and shall deliver:

1. Control Software toolkits/suites for
   - Plant Control System: CODAC Core System (CCS)
   - Operation Support: Operation Application System (OP App)

2. Data Handling (Access/Service) (ITERDB)

3. Control Infrastructure
   - Network Infrastructures
   - Main/Back-up Control Rooms and Main/Back-up Server Rooms
   - Temporary Services (for early plant systems): TCR, T-MCR, T-MSR

4. Supports for Plant System I&Cs
   - Mini-CODAC and I&C Integration Kits (for Plant I&C developments)
   - Control environment for software development and distributions
   - Control System Simulator
• The base software on all CODAC computers for developments of plant control systems
  – 154 distributed to 63 organizations (excl. IO-CT)
  – Statistics of CODAC software as of Feb-2018

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Number of software units | 196
Total number of Software Line of Codes (SLOC) | 3,770,910
Total time to develop (year) | 7.77
Total cost of development (in 2000’s USD) | 153,783,627
The software suite for supporting plant system commissioning, tokamak operation and plasma experiments by delivering the following tools:

- Support of plant I&C test & commissioning, ‘Configuration Editor’
- Pulse configuration, validation & verification, ‘PSPS’
- Supervision & Automation, ‘SUP & AUTO’
- Real-time Feedback Control, ‘PCS’ on ‘RTF’
- Data Access and Services, ‘UDA’ 1st implementation of UDA in service for plant commissioning
- Remote participation, ‘ORG/ODG’
Localization in the Production System

**CODAC Tools for Diagnostic I&C**

* NDS: Driver framework for data acquisition devices
ITER Real-Time Framework

All core features have been implemented and supporting functions are under developments:
- 2018: alpha version with limited functionality
- 2019: fully functional version
- 2020: additional release with extensions
  - NDS v3 interface
  - Function Block (FB) for additional DAQ
  - PXI-6259, PXIE-6368 FB to support massive data transport
  - FlexRIO FB
  - Built-in monitoring and profiling service
  - FB for use of Simulink S-functions

Evaluation and demonstration with real use cases:
- Plasma density control system on RTF evaluated at KSTAR in Nov. 2018
- ETS, DNFM diagnostics systems being implemented on RTF

Decision propagation
Remote Participation (RP)

- Plant Operation Zone (POZ) - a collection of computer or hardwired networks, and of plant system equipment connected to those networks, required for integrated plant operation
- Control system parts which are not connected to POZ are then called XPOZ ("eXternal to POZ")
- IT general purpose networks (no control system specific) are neither POZ nor XPOZ
- Operation Request Gatekeeper (ORG): incoming requests
- Outgoing Data Gateway (ODG): outgoing data (mirroring)
- 1st version of ORG tested for pulse scheduling of Demo at KSTAR

Diagram:
- LDAP Infrastructure
- XPOZ
  - Requester
  - XPOZ Database
  - Submitted File area Master
  - Submitted File area Replica
  - ODG-EXT
- POZ
  - POZ Database
  - Submitted File area Replica
  - BEAUTY Archive Master
  - BEAUTY Archive Replica
  - ODG-INT
  - Operator applying pulse schedule
  - Operator applying software update

Legend:
- Interlocks
- Safety
- Supervision
- Schedule
- Data display
- In-pulse plasma simulation
- ITER site
- Remote sites
- Plasma simulation

12th IAEA Technical Meeting on Control, Data Acquisition and Remote Participation for Fusion Research / 13-17 May 2019 / Daejeon, KOREA
ITER Data Types

- **PON Data**: EPICS traffic, conventional control/monitoring data, 25-50MB/s, archiving in RDB
- **DAN Data**: data with high throughput (scientific data), a few MB/s to 50GB/s, archiving to HDF5 file

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Data Access Workflow – POZ (“small POZ”)

- **Data access shall be transparent and independent of data source and data type**
  - Unified data access for DAN, SDN and PON data
  - User can access the different data transparently
  - Very modular – plugins based

- **UDA APIs** in C/C++/Python/Java/Matlab
  - Retrieve the list of variables (wildcard supported)
  - Retrieve structure of a given variable (case for DAN and SDN)
  - Retrieve values of a variable for a given shot number, a given time range
  - Support for basic mathematical operation and basic filtering

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Plugins to various existing visualization tools: CSS databrowser (for continuous data), MDS+ Jscope, Matlab, Uda-itude (Python/Matplotlib), ThermaVip

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ITER Data System
• Implementing Data Service for Plant System Commissioning
  • Complete 1st implementation of UDA (Unified Data Access) at IT for plant data service, 1st client is UTIL connected to B36 TCR. Plant commissioning data backed up in a storage at IT
  • Working on the design of ITER Data System alongside Remote Participation in terms of infrastructure (with IT): data evolution, data center & disaster center, security, etc
TCR (Temporary Control Room)

- To allow integration of plant I&Cs before the availability of B71N
  - Temporary central services and temporary control rooms in strategic buildings
  - Included plant configuration, data archiving, alarm handling, logging, HMI, gateway and data access together with operator terminals
  - 1st TCR B36 delivered in May-2018 for UTIL-HV and B36 BMS SAT and commissioning

T-MCR (Temporary Main Control Room)

- Functions
  - Supervision and monitoring: at least, 6 plant systems in operation until 2023
  - Plant commissioning and testing
    - Individual and/or multiple plant systems commissioning
  - Remote Participation
    - Tests with multiple DAs on-going and under planning (RF-DA,QST in JA, GA, others)
  - Operator Training
  - Plant simulator

- Construction complete by end of May 2019
Architecture of TCR

Data Access Layer

CODAC Central Services

Operator Terminal

ITER I&C Architecture
B36 and SSEN SAT/Commissioning

Energization as seen from central data archive

- Successfully integrated UTIL-HV plant I&C with CODAC (B36 TCR)
- Complete SAT and commissioning of UTIL-HV
- Energization and switch-over from CEA on Jan. 26 2019

B36 and SSEN SAT/Commissioning

Data flow

Command flow
*Scientific Data Center (SDC), Disaster Recovery Backup, High-Performance Computing under design*