DEVELOPMENT OF THE ITER CODAC CORE SYSTEMS

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Abstract

The duration of the construction period for ITER is ten years, from 2008. The procurement model is such that the ITER Plant Systems will mostly be provided 'in kind' to be integrated into the ITER control infrastructure. In the coming three years, the earliest plant systems will be built and some test facilities will also be required. As a result, the CODAC group (Controls, Data Access & Communications) is already preparing the systems that implement the core functions such as operator interface, alarms handling, communications or data storage, reduced and tailored for the development and tests of the plant systems before integration. The work is executed in partnership with labs and industries from the ITER parties and has to be organized as a continuous process to match the consecutive integration and commissioning phases of the ITER project. This paper reports on these tasks, including schedules and decisions.

INTRODUCTION

The construction of ITER has started in 2008 with the objective of having the plant ready for first plasma in 2018. Afterward, during the first years of operations, many more systems will be upgraded or added to the plant until the final DT (Deuterium-Tritium) operation. The very first systems shall be installed in 2013. The procurement period will then be longer than ten years.

On the other hand, the procurement scheme for ITER implies that the plant will be built by many partners distributed among all the ITER parties. For each plant system, Instrumentation and Control (I&C) is a part of the procurement and shall be available for system tests, both at production site and at ITER site. Homogeneity between the plant systems has to be enhanced by means of technical specifications to be injected into the procurement process very early and by standardized tools provided by the ITER Organization (IO) to all partners.

Hardware and software components allowing the development, the tests and the integration of the plant systems shall be prepared and distributed to the partners in the very early phases.

ARCHITECTURE

The Control System Architecture

The Control System architecture is illustrated in Fig. 1. The lower level of the architecture, close to the equipment, is structured into plant systems. The breakdown of ITER into plant systems is made according to the initial breakdown of ITER into major systems subdivided into parts, according to procurement and operation constraints. The current number of plant systems is 161, final number could be up to 200.

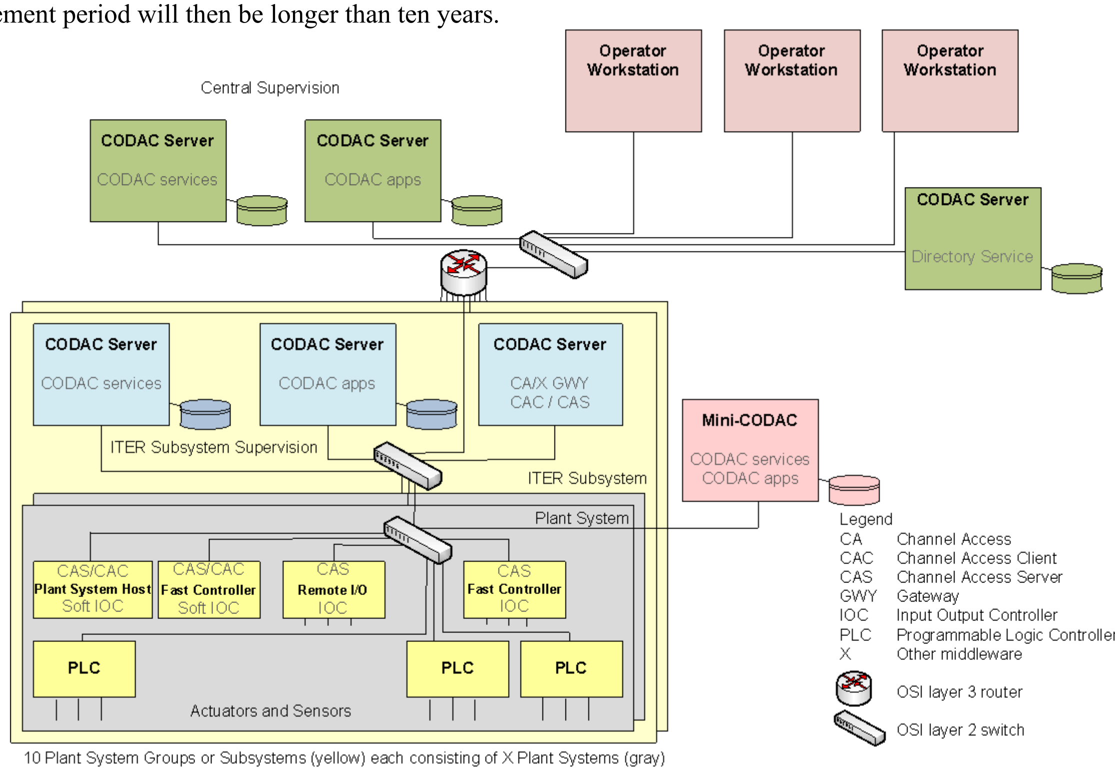

Figure 1: CODAC physical architecture.

Although providing a clear responsibility boundary for procurement and integrity boundary for operation, the plant systems aren't independent units with respect to operation. Therefore, an intermediate subsystem level shall provide both generic CODAC services and plant system specific supervision.

A set of central servers and operator workstations shall implement central supervision services and operator's HMI.

Plant System Instrumentation & Control

To enhance integration, operation and maintenance, the plant system I&C shall comply with a common set of technical specifications issued by the CODAC group in a document titled Plant Control Design Handbook [3]. This document will be re-issued on a regular base in order to cope with the procurement schedule and with the technology evolution.

EPICS has been selected as the software platform for the "fast controllers", which means all controllers except PLCs. The hardware platform for these fast controllers shall be specified at the beginning of 2010. The operating system shall be Linux. No real-time operating system is currently selected.

Siemens Simatic S7 systems have been selected as the PLC to be used for the slow controls. An ITER catalogue is composed in order to list the supported components

Plant System Host

The Plant System Host (PSH) is a component that is part of the plant system I&C but that will be supplied by ITER Organization. The role of this system is to allow the implementation of common services in a platform that is supplied and maintained by the CODAC group. A PSH shall be integrated in each a plant system I&C configuration and it shall be the case also for system tests.

Mini-CODAC

A variant of the ITER control architecture is required for development and tests of the plant systems at production site and before the plant systems are integrated within the CODAC infrastructure. The architecture for local developments and tests is based on a system named Mini-CODAC that shall implement a reduced set of the control system's services. The connection of a Mini-CODAC system is shown in Fig. 1.

Mini-CODAC systems will also be used on site for maintenance and tests.

CODAC CORE SYSTEMS

Core Systems Definition

A set of core services need to be specified and implemented at the very beginning of the project lifecycle.

These are:

- Configuration management
- Communications
- Human Machine Interface (HMI) builder
- Alarms handling
- Errors & Trace logging
- Data archiving
- Supervision
- Tests tools

CODAC core systems designate the hardware platforms and the software components that shall implement such core services, in an incremental manner to cope with the phases of the project (integration, commissioning…).

The short term objective is to provide the end users with preliminary versions of the control system components that should allow them to develop and test the plant system with their controls. We intend to distribute a major release every year.

To comply with the procurement schedule, the 1st version shall be made available in February 2010. The first 3 versions, targeted for users at production site, will be using the Mini-CODAC architecture.

Core Systems Roadmap

Table 1: Core Systems Roadmap

2010/Q1	Version 1	Pure EPICS distribution Integration of slow controllers Self-description editor vs1.
2011/Q1	Version 2	Integration of fast controllers Stable APIs for developers
2012/Q1	Version 3	New tools Stable version for system tests

The roadmap for the first versions is summarized in Table 1.

The main objective for the Version 1 is the integration of industrial controls built with S7 PLCs This version is fully based on EPICS 3.14.10 (maybe .11) and on EPICS tools or extensions.

The EPICS tools that will be packaged as Version 1 are EDM, ALH, SNL/Sequencer, CAJ, Channel Archiver, VDCT and autoSaveRestore.

This version shall also include a package for the integration of the S7 PLCs and a self-description editor to manage the PSH/PLC interface. We are working with the SLS S7plc driver.

Version 2 shall extend the support for the EPICS IOC based controllers and shall freeze all the APIs the plant system developers depends on.

Some networks dedicated for real-time feedback, precise time distribution and inter plant synchronization shall also be interfaced at that point.

Version 3 shall be a stable release that can be included for acceptance tests. New tools shall also be made available at this point.

The current plan includes a major release in February every year with one or more minor releases until June.

Linux is the selected operating system for core systems, RHEL is the reference distribution.

MAIN FEATURES

Plant System Self-Description

An objective is to be able to configure in an automatic manner the CODAC core systems for the operation of a given Plant System from metadata describing the Plant System characteristics

Self-description is a key ITER concept that has been defined in the CODAC Conceptual design [4]. The approach is that the component shall disclose all the necessary data about its interfaces and internal structure for enabling treatment by external programs.

All data shall be expressed using XML in conformance with a schema specified at project level.

This approach results in having the configuration data required to integrate a plant system as part of the deliverable. It implies that IO shall provide the support for this data management from the very beginning.

Quality

To cope with the ITER procurement scheme, we need to improve the autonomy and efficiency of the plant system developers. To use an open software "SCADA" is a strategic decision but we have to reduce the gap with respect to commercial software in this domain.

Starting from version 1, we intend to provide as the ITER distribution all the required EPICS components as well as any ITER extension as RPMs. Support for end-users shall be set-up at the same time the Version 1 will be made available.

For all first versions, we will invest efforts into packaging, documentation, procedures and new tools.

New Tools

In parallel with the distribution of the EDM/ALH/SNL… combination from version 1, it is planned to deliver new tools with version 3 and some. preliminary releases with the version 2.

Java and Eclipse are the selected platforms for any new tools. Control System Studio (CSS) is very attractive in this context.

States and Sequences

States, state transitions, sequences are important paradigms for Tokamaks and have been strongly emphasized in the CODAC Conceptual design [3]. Pulse schedules are also variants of complex sequences with timed commands and conditions.

The interface schema and the frameworks made for ITER will have strong support of such paradigms.

Gateway

For the operational installation, we can expect 500-1000 fast controllers distributed among the different plant systems. Gateway services implemented with CA-GW will be required at an intermediate level, not only for scalability perspectives but also for additional services, such as access control or abstract names mapping.

RESOURCES

Teams

The tasks for the Vs 1-3 are carried out by 3 partners: an ITER team composed of members of the CODAC group working part-time on core systems, a design and development team, from the Indian Institute for Plasma Research (IPR) and from Tata Consultancy Services (TCS), and a support team from Cosylab.

Collaborations

Some preparation tasks have been executed in partnership with fusion facilities.

KSTAR, the Korean fusion facility is a very strong reference using EPICS. KSTAR is providing us with their experience on "EPICS for Tokamak" and has significantly contributed to our engineering design this way.

An R&D task for fast controllers is executed by ASIPP, the Chinese Institute of Plasma Physics. Some prototypes using ATCA and PXIe are developed.

We will collaborate with RFX, the fusion facility in Padova for testing the core systems on the Neutral Beam facility for ITER.

As a new member of the EPICS community, we already benefited a lot from the help of EPICS experts from Europe (BESSY, DESY) and US (ORNL, ANL, BNL…)

CONCLUSION

ITER is a big facility with a long construction/ integration/commissioning period and a complex procurement scheme.

To cope with these constraints, we are now prescribing what controllers can be used. EPICS and Siemens PLC have been selected in this context. We are preparing an early version of the CODAC core systems to provide the first users with a standard solution for development and tests. We will improve these in an incremental manner every year according to the project schedule. The first version shall be on line in February.

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