THE CODAC SOFTWARE DISTRIBUTION FOR THE ITER PLANT SYSTEMS

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Abstract

Most of the systems that constitutes the ITER plant will be built and supplied by the seven ITER domestic agencies. These plant systems will require their own Instrumentation and Control (I&C) that will be procured by the various suppliers.

For improving the homogeneity of these plant system I&C, the CODAC group, that is in charge of the ITER control system, is promoting standardized solutions at project level and makes available, as a support for these standards, the software for the development and tests of the plant system I&C.

The CODAC Core System is built by the ITER Organization and distributed to all ITER partners. It includes the ITER standard operating system, RHEL, and the ITER standard control framework, EPICS, as well as some ITER specific tools, mostly for configuration management, and ITER specific software modules, such as drivers for standard I/O boards.

A process for the distribution and support is in place since the first release, in February 2010, and has been continuously improved to support the development and distribution of the following versions[1].

THE CODAC CORE SYSTEM DISTRIBUTION

Plant System I&C Components

The architecture of the Instrumentation and Control (I&C) for the ITER plant systems is illustrated in Figure 1.

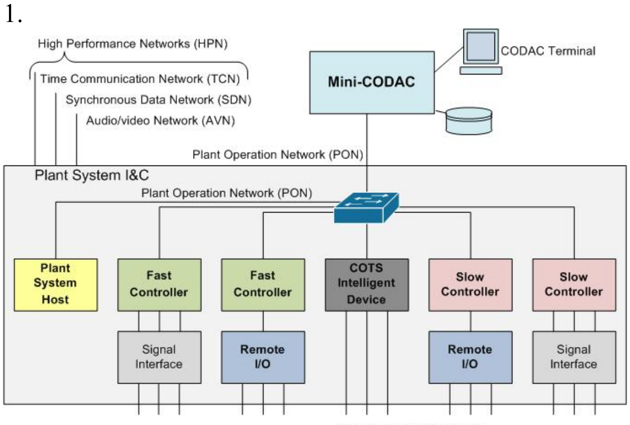

Figure 1: I&C Architecture before integration.

The components are:

- Siemens PLC for "slow" conventional control (up to 10 ms loops) and for "slow" interlock controls (up to 100 ms loops).
- Fast controllers, which currently are PICMG compliant industrial computers controlling a PXI/PXIe/cPCI remote I/O chassis over a PCIe link.
  The operating system is Red Hat Enterprise Linux (RHEL) that can be enhanced with real-time extensions for applications requiring high predictability.
- A system named Plant System Host (PSH) to implement the standard services, such as operating state management or health monitoring.
  The PSH is similar to a fast controller except that it includes no specific I/O. The PSH is also a gateway to communicate with the Siemens PLCs.

Fast interlock controllers as well as high range xTCA I/O for fast controllers are under development and will be within scope of future distributions.

Mini-CODAC

The CODAC acronym means "Control Data Access and Communications" and also designates the central control infrastructure at ITER. During the development phase of a Plant System, the central CODAC services are replaced by a Mini-CODAC system (see Fig. 1). It is both a system development and a runtime platform while providing a subset of CODAC central services, such as alarm handling and archiving facilities.

The operator software on Mini-CODAC is built with Control System Studio (CSS).

The Software Distribution Variants

The CODAC Core System distribution includes the software required for the Mini-CODAC, the fast controllers, the PSH and for additional operator consoles. The distribution covers both the development of the plant system I&C and its operation, during tests. Two set of packages are made available: "development" and "production". The packages that will be installed on a particular system are determined according to the role that the user assigns to the system when installing the CODAC Core System distribution.

For each platform, the distribution bundles, as a common base, the operating system and the EPICS framework.

PLC Support

The development for PLC is based on the Siemens Step-7 software and is not within scope of the CODAC Core System distribution. The CODAC Core System includes however the standard templates for Siemens Step-7 software that shall be used for developing the PLC software and the communication software for the integration of the PLCs into the ITER controls are included.

The development software for Mini-CODAC and PSH includes the tools to declare variables on PLCs and to generate the communication software to exchange data between EPICS variables and the PLC ones. The generated variable declarations shall be included in the PLC application software by the developer.

Fast Controllers Support

The ITER Organization issues some hardware catalogues for the supported I&C components covering the recommended hardware modules for the PLC and the fast controllers.

A set of PXI/PXIe boards is defined in the fast controller catalogue, which is regularly extended. The software for supporting these selected boards will be added in the distribution in an incremental manner

The current distribution includes the software for the following boards:

- NI PXI-6259: a multi-function data acquisition board (16 analog input, 4 analog output, 32 digital I/O).
- NI PXI-6682: a synchronization and timing board (IEEE-1588)

The software for the following boards is under development and will be included in the 2012 versions:

- NI PXIe-6368: a higher performance multi-function data acquisition board (16 simultaneous analog inputs at 2 MS/s)
- NI PXI-6528: a digital I/O board (24 input, 24 output, optically isolated)
- NI FlexRIO boards (FPGA) with adapter boards. In particular PXI-7951R with 6581 (digital) and 5781 (analog) adapters. The software shall be compliant with other FlexRIO hardware and also with cRIO I/O boards connected over PCIe interconnect link.

For each board, the software support includes the Linux device driver and the EPICS device support.

The configuration tools (SDD, see below) are also extended to allow generating the configuration files for these boards from the controller's configuration.

CODAC Core System Versions

The CODAC Core system distribution is produced with a major release every year, very few (1-2) intermediate minor in between and maintenance releases for distributing bug fixes or minor extensions whenever required[2].

The CODAC Core System versions are defined as: *major_id.minor_id.maintenance_id*. Examples: 3.0.0 is the base release for the version 3 and 2.1.1 is the 1st maintenance release for the 2.1 version.

The installation of a maintenance release will update an installed version so, by default, the application software does not require being re-built. A minor release shall be backward compatible with another minor release within the same major version so, in principle, the application software requires being re-built but not being modified. Major release may include a new version of the operating system or of EPICS and, up to now, require a full installation.

Preliminary versions are also produced before any official release with alpha/beta identifiers replacing the maintenance release number (ex: 3.0b1 for the 1st beta version of 3.0).

Self-Description Data (SDD) Tools

The promoted approach for ITER controls is to have the configuration data for the plant system I&C structured with a common schema defined at project level [3].

This is implemented in the CODAC Core System with a set of configuration management tools that maintain the plant system I&C definition in relational databases

This definition includes:

- The functions
- The variables (EPICS PVs, PLC variables)
- The signals
- The controllers with their I/O boards
- The links between variables, signals and I/O boards
- The configuration for alarms
- The configuration for archiving

When the CODAC core system distribution is installed on a Mini-CODAC system, a local database is configured in order to store/retrieve the plant system I&C definitions. In IO, a central repository is also maintained. The local databases are initialized with data copied from the central database and can be synchronized with the central ones in order to update local copies with the central one or to commit new definitions (see [4] for details).

An editor (SDD editor) allows the creation/edition of the plant system I&C into the local database. A web application (SDD browser) is also provided to allow accessing the plant system I&C definitions from web browsers.

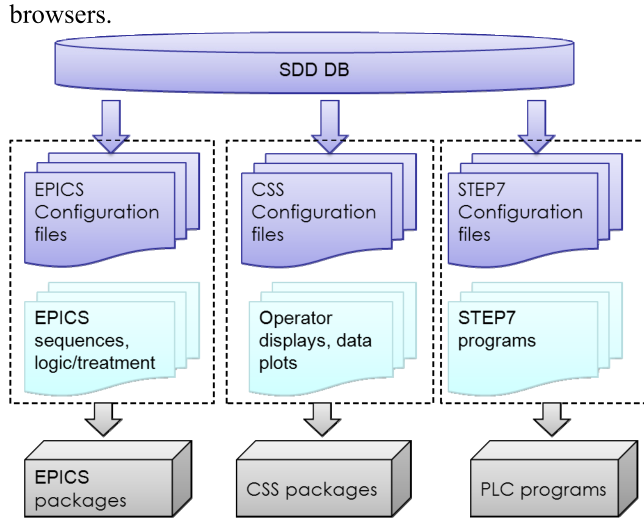

Figure 2: SDD generated configuration files.

As illustrated in Figure 2, the SDD toolkit includes translators for generating all specific files:

- the build files (makefile, scripts…),
- the EPICS configuration files (record databases, IOC scripts…),

– the Control System Studio (CSS) configuration files for alarms and archiving,
– the variables declaration for the PLCs.

The EPICS database files, which define the set of EPICS records implementing the application, are usually edited with text editor or graphical "database configuration tool" such as VDCT. In the ITER environment, these files are generated by the SDD tools but, it will also be possible, in the 2012 version, to use EPICS tools to edit these files and have any resulting change or addition retrofitted into the SDD database.

The SDD tools also include validation functions, which allow verifying the completeness of the definition during the development and the compliance with ITER standards, such as the naming convention, before delivery.

BUILD OF THE CODAC CORE SYSTEM DISTRIBUTION

Different software distributions are built for the different "system roles": Mini-CODAC/development, Mni-CODAC/Operation, PSH/Operation, etc.

These distributions are built from:

1. The operating system.
   RHEL 6.1 will be provided with the CODAC Core System vs3 in 2012 (today: 5.5). RHEL-MRG-R (6.1 with real-time extensions) can also be provided with the fast controller distributions.
2. EPICS components.
   It includes the EPICS base and EPICS modules, such as the SNL sequencer, CAJ/JCA (Java client library) and VDCT.
3. Control System Studio (CSS) and CSS applications: BOY, BEAST, BEAUTY and SNL editor, in the Mini-CODAC distributions.
4. ITER specific development tools.
   Self-description data (SDD) tools and maven-based build process are included in the "development" distributions.
5. Software support for the standard I/O modules in the fast controller distributions.

Changes made by ITER in the EPICS components, such as extensions for 64 bits or support for the PostgreSQL database are, as far as possible, retrofitted in the shared EPICS sources but the ITER distributions are only built from the ITER source repository (SVN).

ITER Build Tools

The steps for building software components from the source code in repository to the packages in installation servers are supported by commands implemented with the Apache maven (mvn) tools.

The system packages as well as the application ones are built with standardized mvn commands:

- mvn checkout - extract a software unit from the source repository (using versions' branch or tag)
- mvn compile – build all object files
- mvn test – run the tests of the unit
- mvn package – build the RPMs for deploying the unit to target hosts.

These commands are executed by the developers during development and, when a unit is included in the distribution, by the build servers for producing the different software releases. Build servers are configured with the Jenkins continuous integration tool.

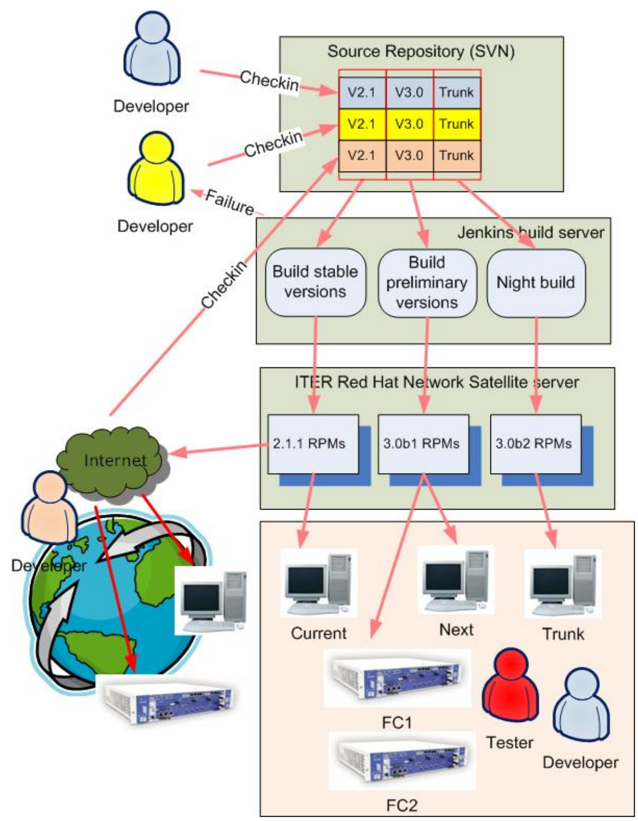

Figure 3: Build and distribution process.

The next actions executed by the build servers are the following:

- Sign the RPMS and copy them to network shared directories.
- Copy the official releases RPM, tagged with a version id, to the distribution servers at release time.
- Copy the RPMs that are generated for continuous integration, tagged with a branch id and a SVN id, to distribution servers every night.

Test computers are thereafter updated with new releases, automatically for the nightly built ones.

Whenever a compilation or a test executed by a build server fails, the package owner is informed by mail. Build logs can be consulted with the Jenkins tools.

Verification of the Java code with static code analysis tools, such as CheckStyle, will be added in order to also provide the developers with reports on the quality weaknesses detected in their code.

Installation of the ITER Distribution

The ITER distribution servers are configured with the Red Hat Network Satellite management system. The operating system distribution, the ITER packages distribution and the subscription management are centralized on these servers.

Users are grouped into organizations that can be remotely administrated by authorized users for allocating RHEL subscriptions and configuring the local systems.

For any installation, the user shall have access to the distribution servers. However, once configured, the local systems do not require permanent access to the ITER servers, except for delivering software in the ITER repositories or for accessing support information.

Installing a local system is an automated procedure using the IO supplied installation disk images. They provide a selection of the CODAC Core System, bundled with the RHEL operating system and a suitable role for the target system.

CONCLUSION

The integrated process for building and distributing the CODAC software allows automating the compilation, testing and packaging of software components from different sources. It also allows maintaining a unique distribution system for the systems in Cadarache and the ones used by the suppliers and partners that are very widely distributed.

It requires constant resources for the maintenance but the automated processes reduce a lot the time and cost for the integration and tests of the software releases. This is very valuable to cope with the increase of the test and maintenance releases that will be required during the development phase of the plant system I&C.

REFERENCES

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The views and opinions expressed herein do not necessarily reflect those of the ITER Organization