Status of ITER and CODAC

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Disclaimer: The views and opinions expressed herein do not necessarily reflect those of the ITER Organization
The Final Goal: Integrated Operation

B71 Control building
Step 1: Prepare the operation schedule off-line
Step 2 : Execute
Step 3 : Analyze the data
Data Flow Model

1. Preparation
2. Execution
3. Analysis

To reach the goal all systems need to communicate
Many different networks for different purposes

All, except nuclear safety and quench loop, based on Ethernet

**Plant Operation Network (PON)**
- General purpose command, status, archive,… (Gbps Ethernet)

**Synchronous Databus Network (SDN)**
- Distributed feedback control (10 Gbps UDP multi-cast)

**Time Communication Network (TCN)**
- Absolute time synchronization (IEEE 1588 2008)

**Data Archiving Network (DAN)**
- High volume data archiving (10 Gbps Ethernet)

**Central Interlock Network (CIN)**
- Industrial Ethernet, Hardwired

**Central Safety Networks (CSN)**
- Industrial Ethernet, Hardwired

Mainstream industrial standards
## CODAC Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of computers</td>
<td>1.000</td>
</tr>
<tr>
<td>Total number of signals (wires)</td>
<td>100.000</td>
</tr>
<tr>
<td>Total number of process variables</td>
<td>1.000.000</td>
</tr>
<tr>
<td>Maximum sustained data flow on PON</td>
<td>50 MB/s</td>
</tr>
<tr>
<td>Total PON archive rate</td>
<td>25 MB/s</td>
</tr>
<tr>
<td>Total DAN archive rate (initial)</td>
<td>2 GB/s</td>
</tr>
<tr>
<td>Total DAN archive rate (final)</td>
<td>50 GB/s</td>
</tr>
<tr>
<td>Total archive capacity</td>
<td>90-2200 TB/day</td>
</tr>
<tr>
<td>Accuracy of time synchronization</td>
<td>50 ns RMS</td>
</tr>
<tr>
<td>Number of nodes on SDN</td>
<td>100</td>
</tr>
<tr>
<td>Maximum latency asynchronous events</td>
<td>1 ms</td>
</tr>
<tr>
<td>Maximum latency application to application (SDN)</td>
<td>50 μs</td>
</tr>
<tr>
<td>Maximum sustained data flow on SDN</td>
<td>25 MB/s</td>
</tr>
</tbody>
</table>

Achievable with today’s COTS technology
Architecture

Central supervision & automation, monitoring and data handling

CODAC Server
CODAC services
CODAC Server
Applications
CODAC Server
Archiving
CODAC Terminal
Interlock Desk
Safety Desk

Human Machine Interface

Legend
PON = Plant Operation Network
TCN = Time Communication Network
SDN = Synchronous Databus Network
DAN = Data Archive Network
CIN = Central Interlock Network
CSN = Central Safety Network

Central

CODAC Server
CODAC services and applications
CODAC Server
Channel Access Gateway

Central Interlock System
Central Safety System

CODAC CIS Interface
CODAC CSS Interface

CODAC Control Group (x 18)

ITER Control Group

Local

Sensors / Actuators

IO DA Interfaces

Plant System I&C (x ~ 207)

Signal Interface
Remote I/O
Remote I/O
Signal Interface

Signal Interface
Remote I/O
Remote I/O
Signal Interface

Slow Controller
Slow Controller
COTS Intelligent Device

Slow Controller
Plant System Host
Architecture
ITER control system is broken down in 18 ITER control groups (CBS level 1)
An ITER control group contains many Plant System I&C (CBS level 2)
A Plant System I&C is a deliverable from a procurement arrangement (IN-KIND)
A procurement arrangement delivers a part, one or many Plant System I&C
Integration

The main challenge for ITER Control System is **INTEGRATION**

**MITIGATION**

- Define *standards, specifications and interfaces* applicable to all plant systems instrumentation and control (PCDH)
- Develop and distribute a *control system framework* that implements standards defined in PCDH and guarantees that the local control system can be integrated into the central system (CODAC Core System)
- Provide *user support*
- Organize *training*; PCDH campaign, CODAC Core System hands-on workshops
- Provide *I&C Integration Kit* free of charge (PSH, Mini-CODAC, switch)
- Demonstrate system on *pilot projects*
I&C standards – catalogue products

**Slow control**
- Siemens S7-300 and S7-400 products
- ET200M and ET200S for remote I/O
- Covering standard industrial signals

**Cubicles**
- Schneider Electric products
- Address floor standing and wall mounted cubicles
- Address Standard and EMC protected.

**Fast control**
- PCI Express. CPU and I/O segregated
- Mainly National Instruments products
- Covering acquisition and control > 50 Hz
CODAC Core System: based on Open Source

• The selected operating system is **Red Hat Enterprise Linux** for the x86-64 architecture (RHEL x86_64)

• The infrastructure layer is **EPICS**, used in hundreds of projects world-wide: light sources, high energy physics, fusion (KSTAR, NSTX), telescopes

• The CODAC services layer is **Control System Studio** used at many EPICS and other sites and including HMI, alarming, archiving etc.

• **ITER specific software** such as configuration (system description), state handling, drivers, networking, etc.

• 6 month release cycle (major + minor release every year), extensive testing procedures
MRR = Manufacture Readiness Review
RFE = Building Ready For Equipment
IRR = Installation Readiness Review
TRR = Test Readiness Review
Current Activities

• CODAC Core System release: 5.0 (2015)
  – RHEL 6.5
  – EPICS Base 3.15
  – EPICS V4 (evaluation only)

• IO takes EPICS Support development responsibility
• New S7 communication drivers
• Design of real-time framework for plasma control
• Design of pulse configuration system
• Preparing tools to be used in FAT tests
What’s Next?

- Continue development and support of CODAC Core System
- Continue design of high level operation applications
- Continue design of Interlock and Safety
- Start implementing network infrastructure
- Engage with users (plant system I&C developers)
- Detail interfaces with plant system I&C
- Develop integration schedule and procedures
Thank you