ESS Controls Infrastructure

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ESS facility

How are we doing at ESS?

Lund C - ESS tramway approved - Late last year Lund City Council gave the final approval for the tramway from Lund C to ESS. Procurement for a contractor is now under way and the plan is to open for traffic in 2019 - the same year as ESS is scheduled to open for scientists!

The Integrated Control System (ICS)

- Integrated Control System Division (ICS) Scope
  - Conventional facilities control integration
    - Site infrastructure: cooling water, power distribution, etc.
  - the accelerator control system
  - the neutron target control system
  - EPICS layer for the neutron instruments (in cooperation with the colleagues from science directorate)
  - Global systems (next slide)
- Combination of
  - On-site developments
  - in-kind contributions (up to 50% of total value)

    e.g., proton source and LEBT controls by CEA, Saclay (France)

ICS Global Systems

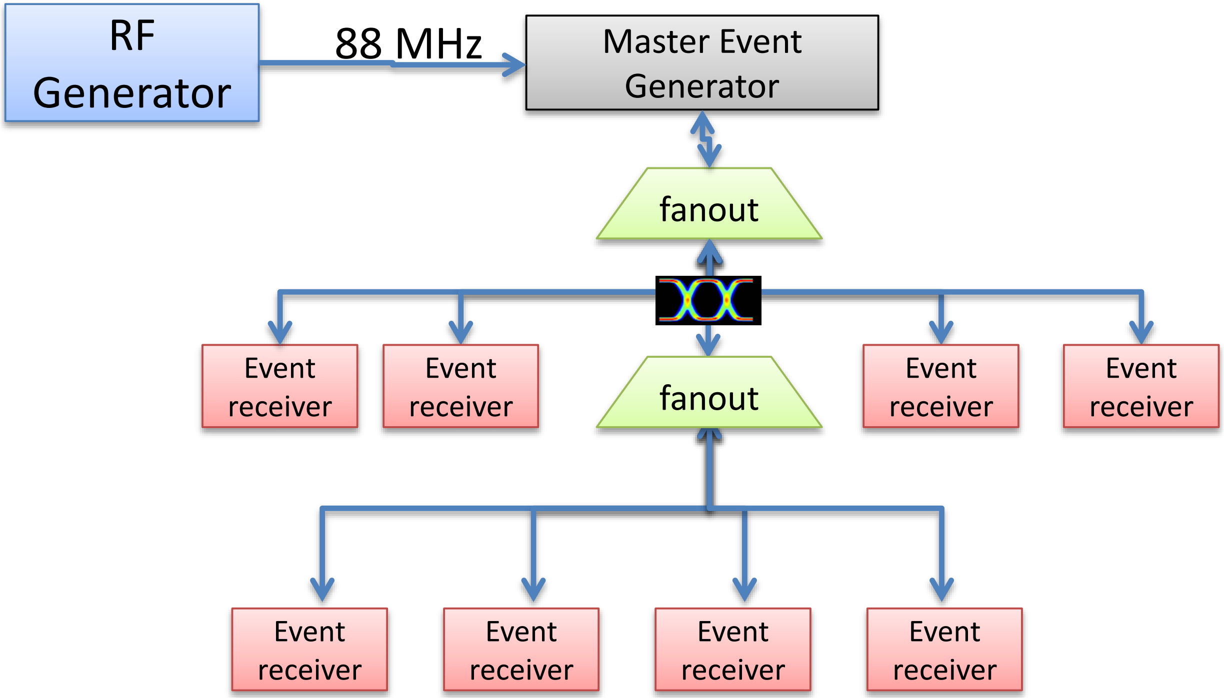
- **Control system networks and servers**
- **Global timing system for site-wide synchronization**
  - Synchronization of devices
  - Distribution of time, time stamping
  - Operation sequencing
  - Using MRF event system, latest generation (see next slides)
- **Protection and Safety systems**
  - Machine protectio - High demands for reliability and speed
  - Personnel Safety
    - Designed according to IEC61508 standard, safety-credited

Timing System (I)
Functions

- **Distribute synchronous triggers to a (very) large number of devices**
  - Triggers can be **pulses**, electrical or optical, with different configurable properties
  - Triggers can also be software, **triggering some action** in the IOC by "processing" EPICS channels (e.g. read out data, write values, calculate).
- **Distribute (limited amounts of) data to many receivers synchronously**
  - This happens in parallel to the trigger distribution, no effect on accuracy.
  - Limited amount (2 kilobytes per transmission, up to 125 MB/sec.
- **Distribute synchronous timestamps**
- **Generate (programmable) sequences of triggers (events)**
- **Accept asynchronous inputs to generate events**
- **Synchronize to an external input trigger with optional phase adjustmen**
- **And other things…(distribute clock signals, take in interlock inputs,…)**

Timing System (II)

Structure of the system



- The (accelerator) synchronization frequency (of 88 MHz) will be fed into the master event generator and used as the system clock. Downstream will be synchronized to that.
- The 14 Hz operating frequency will be generated at the Master Event Generator.
- Events and (limited amounts of) data can also flow upstream (optionally)
- Fan-out system can (and will) have many levels in the latest version of the fanout system

Timing System (III)
Integration

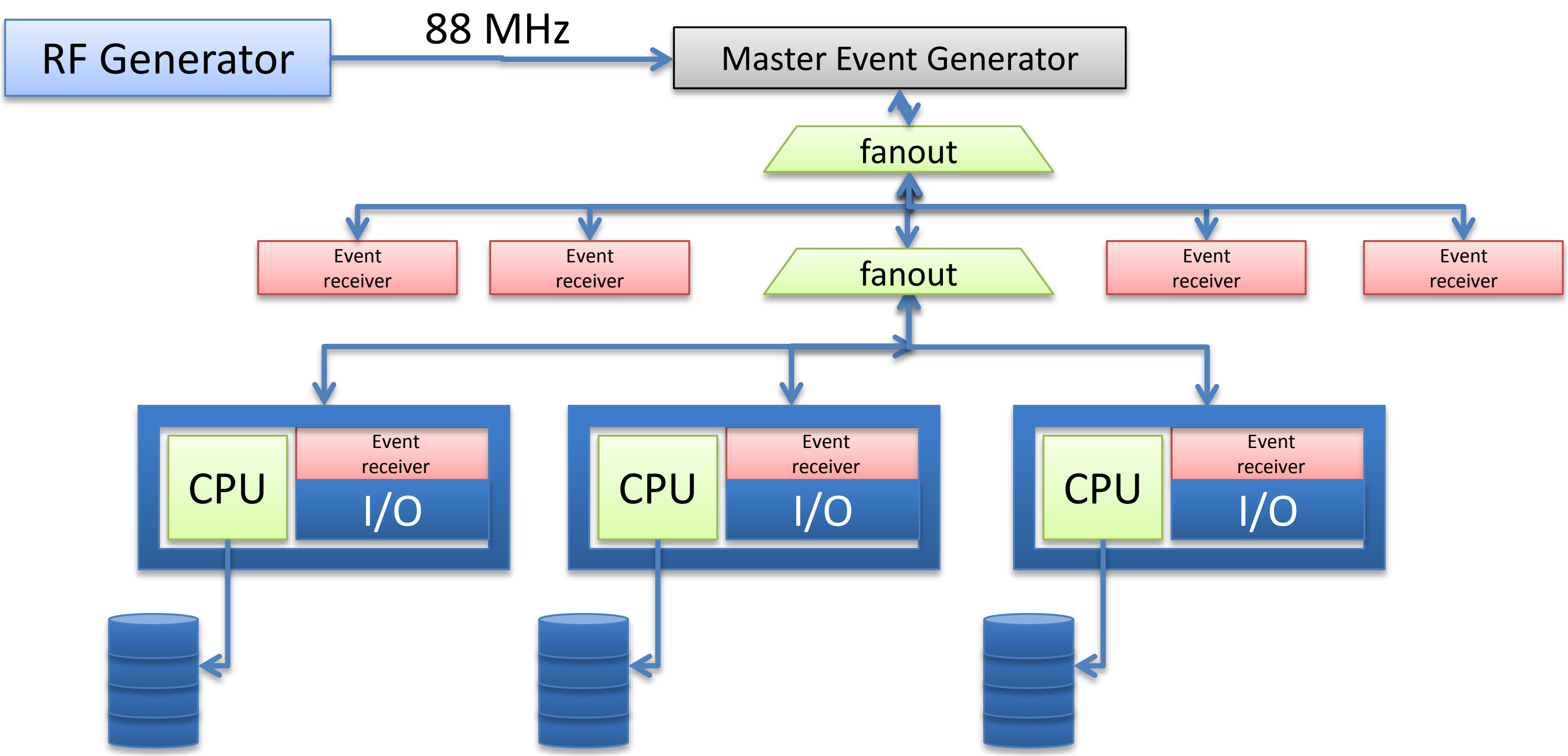
- **Event receivers will be fully supported in the EPICS framework**
  - On ESS platforms: MTCA, on PC hardware (Linux) if required
  - We try to provide solutions for other platforms like PLCs

- **Different electrical standards (LVTTL, PECL, CML, (slow) optical….**

- **Frequently asked question: can I embed and EVR in my FPGA?**
  - .

Timing System (IV)

Synchronous data collection

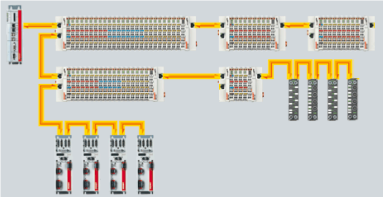


- Each IOC (control box) receives the same events
- Event triggers reading out a piece of data (detector, AD converter, status bit/word)
- Data is time stamped and put into a “silo”
- Data can be streamed out (continuous recording) or read out as chunks (finite length)

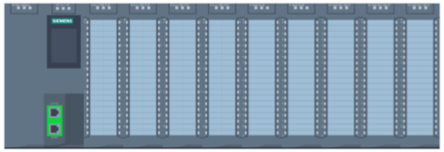
Hardware Strategy. Threefold structure for generic I/O

- **Fast real-time processing, FPGAs**
  - MTCA.4
  - Use only where needed (high cost, specialization)
  - Extensively use FMC (Vita-57) mezzanine cards

- **Real-time industrial-type I/O**
  - EtherCAT, on IOC
  - Low cost, distributed, good real-time performance
  - Moderate speed (e.g. up to 100 kSPS A/D conversion)



- **Process I/O with no tight syncronisation requirements**
  - PLCs (Siemens)



- **In addition, prepare integration of off-the-shelf devices**
  - Serial and LAN interfaces

Hardware Strategy. I/O Controller variants

- **MTCA.4 based digital front-end platform**
- **Industrial PCs where appropriate**
- **Virtualized IOCs running on server infrastructure**
  - No tight real-time requirements or pulse-to-pulse data
  - Site infrastructure systems, cryogenics, vacuum
  - Redundant fail-over clusters
  - Typically interfacing PLC-based systems
- **possible mini-IOC**
  - Concept study ongoing
  - Integrated timing and processing unit

Software Technologies

- **EPICS as the system backbone, for all controls I/O**
  – Use **exclusively** EPICS 4
  – Model for distributed development (next slide)
- **Services based on Web/RESTful interfaces**
  – Configuration data management
    - Controls Configuration Database (CCDB)
  – Cable Database
  – Naming service
- **IOC Factory for IOC management**
  – Create, maintain, audit IOCs

Distributed development

- Issue: support of off-site developers

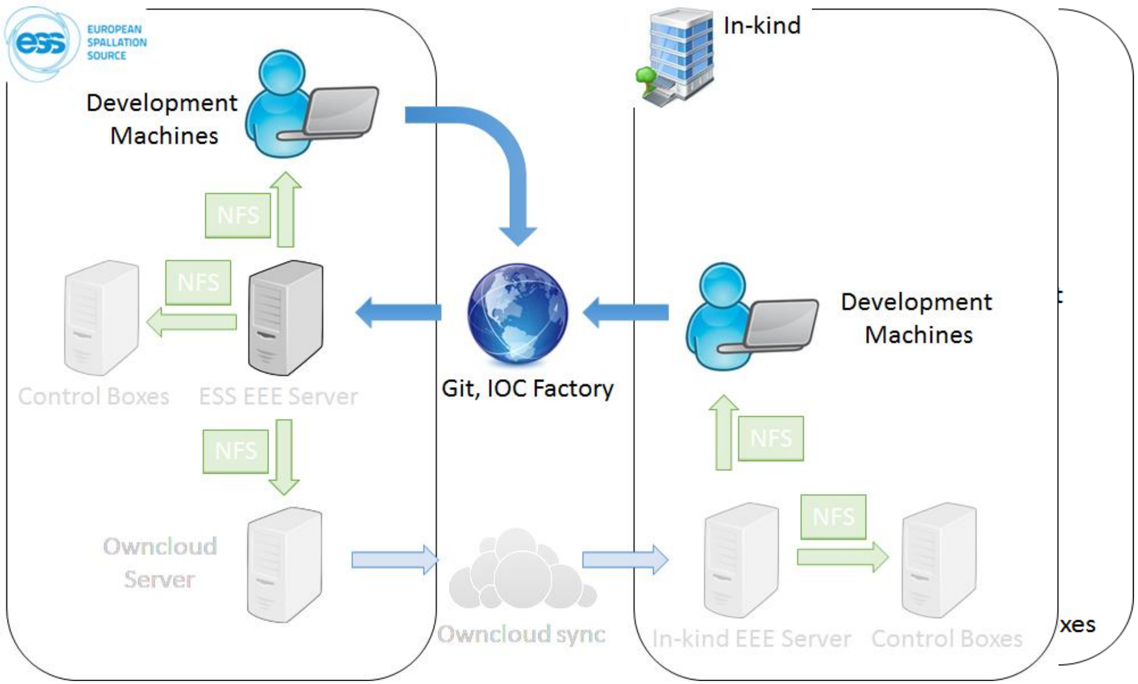
- An (incomplete) map of collaborating institutes
- Potentially any/all of these could be developing or integrating control system components for ESS
- Development and testing happens at the institutes
- Finally all of this has to be integrated into ESS in Lund
- How to manage that?
- We cannot afford long release cycles

Distributed development. Development Environmet

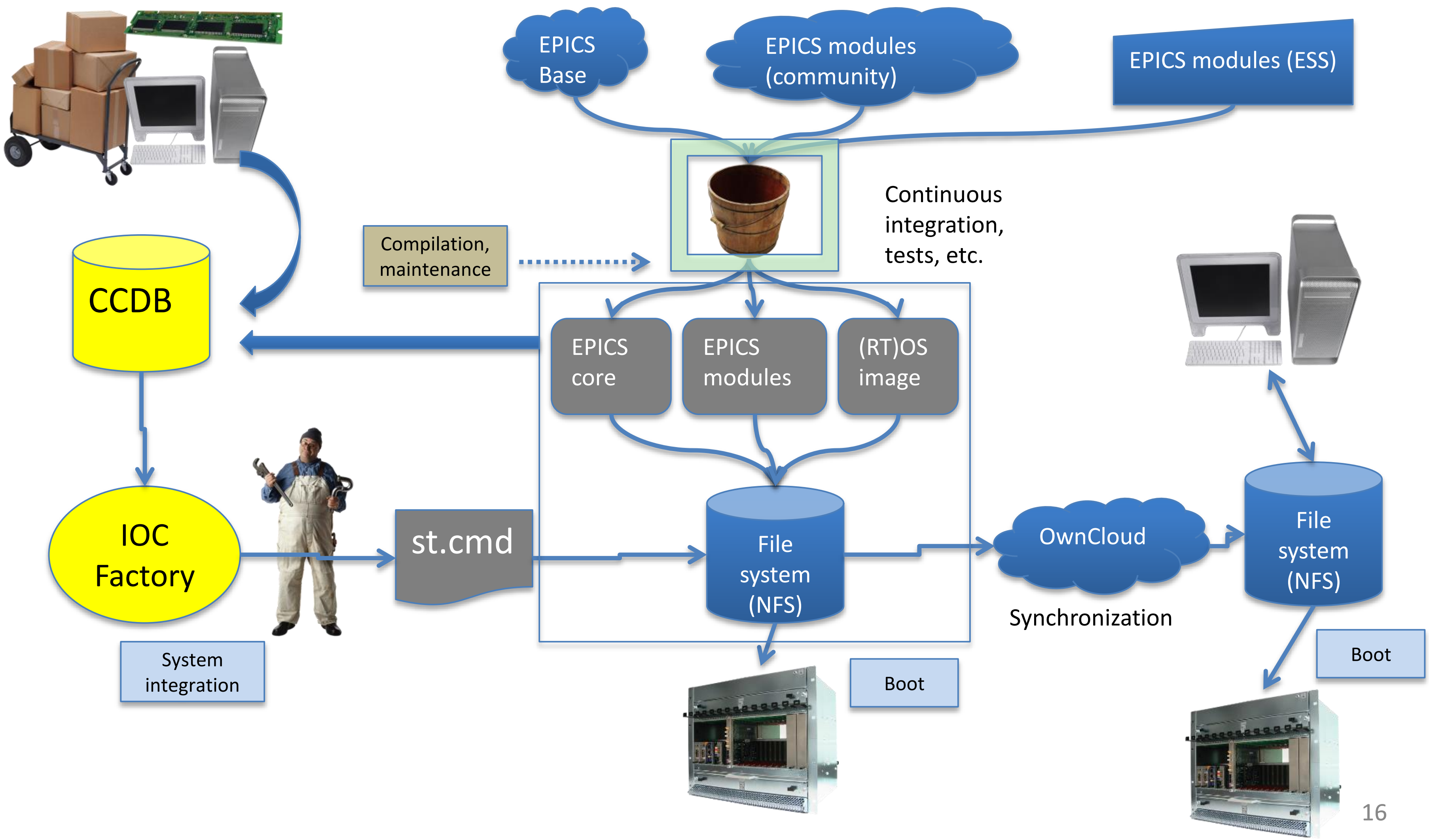
- **Web-based infrastructure tools**
  - Naming, configuration, cabling, IOC configuration
  - Collaborative tools
  - IOC Factory tool to manage IOC configuration (set-up, deployment, audit)
- **Network-synchronized development cycle**
  - Ansible playbooks for development (virtual, real) machine configuration
  - ESS EPICS Environment (EEE). Pre-built, loadable EPICS modules (concept courtesy of Dirk Zimoch, PSI)
  - EPICS tools and libraries on network drives (next slide)

Distributed development (3)

- All software hosted in a central repository
- Full cycle can be reproduced at Lund anytime
- All developers work with exactly the same versions of tools
- Deployed, first user feedback is very positive (still needs work, though)



EPICS Integration Workflow using our Development Environment



Current PLC activities/projects

- Proton Source Control (Local Interlock System)
- Proton Source Vacuum System
- ESS Instrument Integration Project
- Interceptive Device Generic Interlocks Prototype
- Magnet powering interlocks
- Slow beam interlocks system
- Target local protection system
- PSS Development

Machine Operation

- Machine sequencing
  - Repetition rate, beam current, pulse length: power envelope
    - Careful coordination with machine protection
- Measurements
  - Beam-synchronous data acquisition
    - Neutron instruments need pulse-to-pulse beam data
- Machine modeling
  - Online model for beam commissioning applications
- Machine protection
  - Post-mortem analysis an essential tool

Summary

- Construction has started
  - On and off Lund site
  - Controls support needed **now**
- Try to use the best from the community
  - Borrow & contribute
  - Invent ourselves things to cover the special needs
- Project management is a challenge
  - Standardization should help
- More to come – in the next meetings!