The Large Scale European XFEL Control System

Overview and Status of the Commissioning

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on behalf of the controls groups

The European XFEL

Hamburg City Center (7 km)
XFEL Control Systems

2700 bunches with 10 Hz, 17.5 GeV
100 cryo modules w/ 8 sc. Cavities, 1.3 GHz

- **DOOCS**: all beam based fast controls
- **TINE**: magnets, vacuum
- **EPICS**: cryogenics, water, power
- **KARABO**: photon beam lines and experiments

Tight interconnection
Multi Control System Interface

- **DOOCS**
  - Java e.g. jddd
  - Get(adr, dataIn, dataOut)

- **Native libraries of the control systems**
  - TINE Server
  - DOOCS Server
  - DAQ
  - KARABO Server
  - EPICS Server

- **Standard Application Programming Interface API**
  - Name Server ENS
  - Data transformation to uniform format
The KARABO System

> Fast point-to-point communication
  - A single Mpixel detector reaches up to 10 GB of image data every second
  - A broker negotiates the connections
  - Includes PC farm layer, online data cache and offline data archiving with computing clusters

> Basic device communication via a message-oriented middleware
  - Used for pumps, motors, PLCs, Protection systems, …

> Detectors are synchronized with the accelerator by a MTCA.4 Timing Receiver
  - Pulse frequency up to 4.5 MHz
  - Provides: Unique train IDs, clocks, triggers, …
Karabo: Control System of the Photon Experiments

User interface(s)

DAQ Equipment
- e.g. 2D-detectors (AGIPD, LPD, DSSC)

Equipment Control
- e.g. motor, pump, valve, sensor

Service Device
- e.g. calibrationManager, configurationManager

DAQ Equipment

Data Storage Node
- e.g. storage of data from runs

Analysis Node
- e.g. calibrationManager, projectManager, GUI server

Composite Device
- e.g. complex detector motion control

Message Broker

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Poster: MOM301 WEPGF050 WEPGF153
Cryogenic Controls

2 Kelvin Helium Plant and Distribution

Control system features:

> Process control system running 24/7, uninterrupted > 1 year!
  - *Reliability and availability is an important issue*

> Closed loop controls and state notation programs are implemented in EPICS IOCs (Input Output Controller)
  Only machine protection runs on PLCs

> Redundant process controllers, networks and power supplies on UPS

> Archiving ~21,000 channel (700 values/sec (total) sustained rate)

> Profibus is used for the redundant field bus on single mode fiber:
  - 13 Profibus lines
  - Cryogenic plant: 210 Profibus nodes with 6,400 EPICS records.
  - Helium distribution system: 330 nodes and 6,300 records.

> Control System Studio (CSS) is an Eclipse application comprising operator applications diagnostic tools and a framework to configure cryogenic control systems (from sensor to graphic)
Cryogenic Controls

Cold Boxes
CB41  CB43  DB54  CB44

Helium Distribution
XLVB  XIVB

Injector
XI1FB

XFEL Tunnel
XTL

12X

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Integration of the Undulator Controls

DOOCS Undulator Server

ZeroMQ Messaging

GAP TAPER MOVE R ...

GAP TAPER MOVE R ...

DOOCS Undulator Server

ZeroMQ Adapter

Beckhoff Controller (PLC)

LINUX server

Windows PC with turnkey system
Beckhoff software and ZeroMQ interface

3 sections with 35 Undulators each
~600 m total
XFEL Tunnel: One out of 25 Klystron Sections

4 Accelerating modules, 32 cavities and one klystron = 50 m

> 200 MicroTCA crates:
  - 58 LLRF
  - 53 Coupler Interlocks
  - 50 Diagnostics
  - 21 Special Diagnostics
  - 20 Vacuum, Magnets
  - + Experiments
Management, Controls and Development Interfaces

**Management**
- DOOCS IPMI-Server

**Controls**
- jddd Panels

**Development**
- FPGA
- MMC Firmware
- Firmware
- LINUX Driver
- DOOCS x2timer-Server
- RPC
- MAP file

**MicroTCA Crate**
- IPMI
- Hot-plug support
- Transmitter Firmware
- FPGA Firmware
- MCH
- PCIe

**> 2500 FPGA Firmware**
Fast Data Processing from MicroTCA to DAQ Server

1.3 GB/s continuous data flow from > 13 000 channels to ≥ 4 DAQ servers in parallel
Conclusions

- Most parts of the hardware and software are in successful operation:
  - **FLASH**: 20 crates installed, 6 RF stations are controlled 24/7 by MicroTCA
    - Multibeamline operation with timing and machine protection
  - **XFEL**: One RF section with 32 cavities is commissioned inside the tunnel
    - VirtualXFEL: software simulation installed
  - Cryogenic plant runs since half a year
  - Undulator controls are demonstrated in a mock-up
  - Experiment controls operate e.g. a large pump-probe laser

- Next steps
  - Operation of the XFEL Injector end 2015
  - 2016: full operation of XFEL
**XFEL MicroTCA Crates**

**Common modules**

- **MCH**
- **CPU**
- **Timing**
- **Machine Protection System**

**Application modules**

- **ADC**
- Digi. IO
- Controller

From central timing

From central MPS

MTCA.4 Backplane

Ethernet

Clock Cross-Point-Switch

PCIe, Ethernet Cross-Point-Switch

Clock

Trigger

Interlock
MicroTCA Remote Management Software

Graphical representations:
- Is-inserted, fault, …
- Temperatures, voltages
- Reset, power on/off
- Act. Power consumption

Display by standard controls tool jddd

Remote upgrade of Firmware
Remove/insert of modules in a running system

> 2500 FPGA Firmwares