The Technical Design Concept of the New Accelerator Control System for PETRAIV

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DESY.

PETRAIV: The Ultimate 3D X-ray Microscope

PETRA III:

- 2300-metre-long storage ring feeding 24 user beamlines
- Operated either in brightness mode (480 equally distributed bunches, 120 mA stored beam) or in timing mode (40 equally distributed bunches, 100 mA stored beam)
- Research groups from all over the world use the particularly brilliant, intense X-ray light for a variety of experiments - from medical to materials research

From PETRA III to PETRA IV:

- Preparatory phase: 2020 – mid 2023 → Technical Design Report
- Construction / Dark time: Expected to begin in early 2027
- Commissioning: In 2029

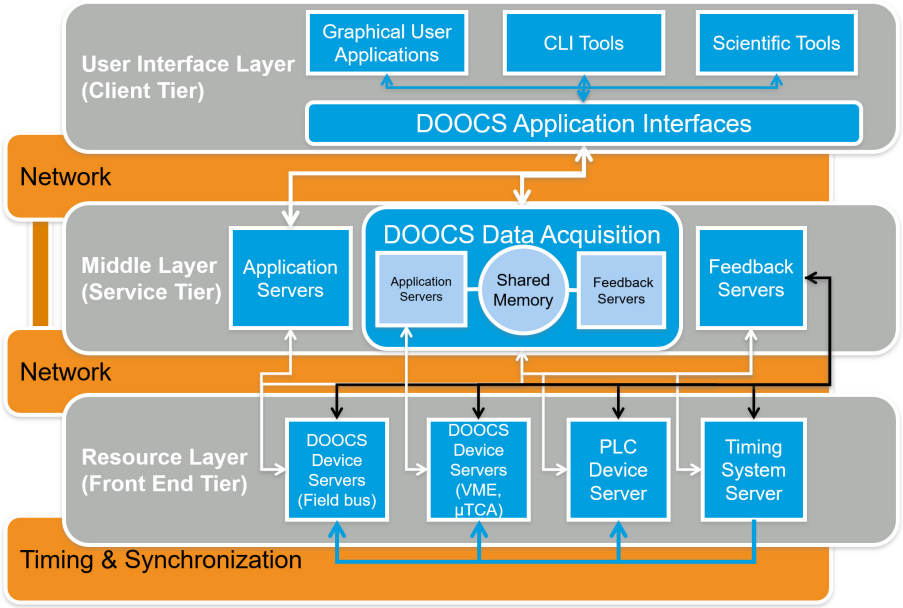
PETRA IV:

- High-resolution 3D X-ray microscope for chemical and physical processes
- Will extend the X-ray view to all length scales, from the atom size to millimetres
- Offers outstanding possibilities and optimal experimental conditions for industry
- Will replace PETRA III, but keeping the existing experimental halls
- An additional experimental hall will provide space for additional 18 user beamlines
- New booster synchrotron DESY IV
- Option: 6 GeV Laser plasma injector

Control System Framework

Distributed Object-Oriented Control System (DOOCS)

- Leading accelerator control system at DESY (EuXFEL, FLASH, special accelerator (conventional, plasma wakefield) projects)
- Architecture:
  - Object-oriented design
  - Distributed client-server approach
  - Device-oriented view
- Transportation layer:
  - Standardized, industrial RPC protocol
  - In progress: Integration of 0MQ protocol
- Implementation:
  - Server: C++
  - Client: C++, Java, Python or MATLAB
- Device interface:
  - Variety of fieldbus and hardware interfaces via device classes
- Development history:
  - Started in 1993
  - Constantly updated to meet the needs of users and keep pace with developments in IT technologies
- Interoperability: Client API provides access to e.g.
  - EPICS (facility control system at DESY)
  - TANGO (beamline control system at PETRA)



DOOCS Control System Layout

Graphical User Interface

Java DOOCS Data Display (JDDD):

- Tool of choice for the standard beam operation as well as operating technical accelerator devices and systems
- Thin-client approach with a functional and rich set of widgets
- Individual UI components can be easily created through a versatile editor IDE without the knowledge of any programming language

Python / MATLAB:

- Tool of choice for rapid prototyping and visualization of scientific procedures and data

Progressive Web Apps (PWA):

- Multi-platform, browser-based applications with a look-and-feel of versatile classical desktop applications
- Based on React JavaScript framework and D3 data visualization library

→ **THP22**

- Under development

Sample JDDD Application (PETRAIII)

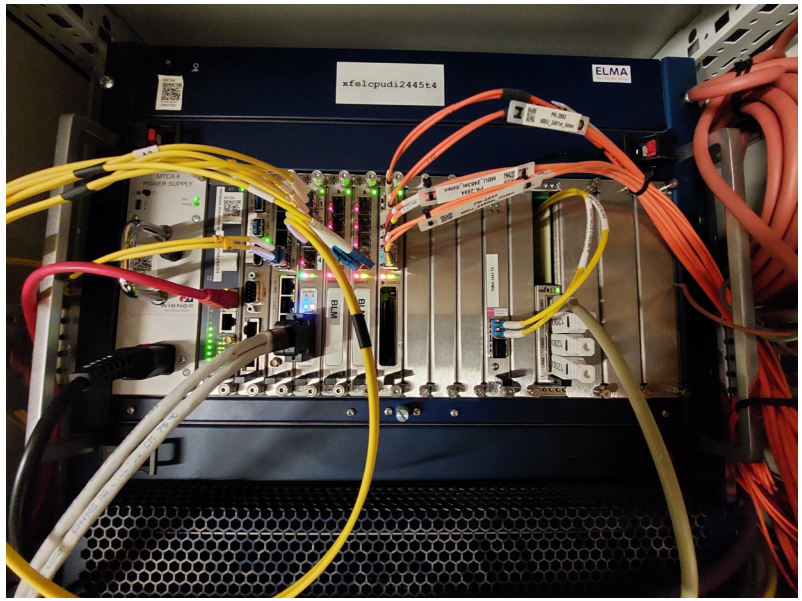
Hardware Interfaces

Interfaces for Triggered, High-Performance Applications:

- Compliant with MTCA.4 technology
- Linux
- Remotely manageable
- Specific modules, e.g.
  - Timing:
    - Beamline experiments can make use of the same timing system hardware
  - Digital I/O:
    - e.g. for beam diagnostics / control
  - ADC:
    - e.g. for pulse form recording / monitoring

Interfaces for Conventional Slow-Control Applications:

- Compliant with industrial process control standards, e.g.
  - OPC UA, Profibus, EtherCAT, CANopen, USB, RS232/485
- Generic bridge server available for, e.g.:
  - OPC UA servers
  - Beckhoff controller
  - Classical PLC



MTCA-Based Device Control Hardware (EuXFEL)

Data Acquisition and Archiving

Data:

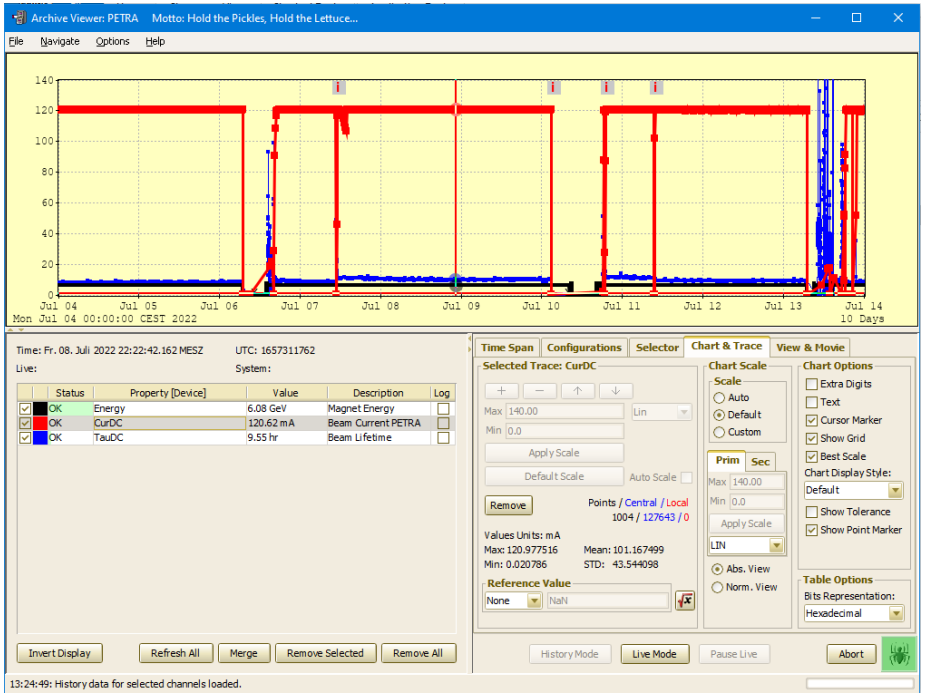
- Time series data:
  - Fast data streams in synchronism with the beam revolution frequency (130 kHz)
    - In most cases pre-processed and aggregated by front-end device electronics
    - Further processing of raw data in special cases only
  - Slow data stream updated asynchronously with less than 100 Hz
- Snapshot data:
  - Data acquisition triggered by e.g. value changes, specific events, operator requests, …

Archiving:

- Commonly-used domain-specific technologies:
  - Multi-purpose relational databases (e.g. PostgreSQL)
  - Time series relational databases (e.g. TimescaleDB, InfluxDB)
- DOOCS DAQ

Versatile visualization and analysis tools:

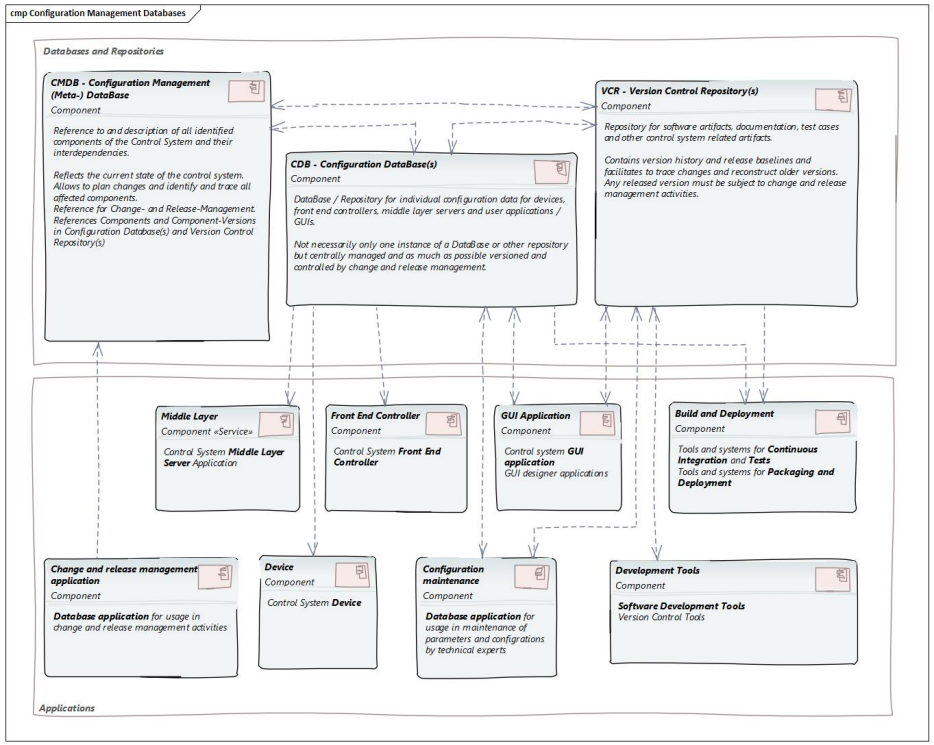
- Further development of applications used at PETRAIII and EuXFEL/FLASH



Archive Data Viewer (PETRAIII)

Configuration Management System

- Under development
- Includes all software and hardware components
- Applies to all phases of the life cycle of PETRA IV
- Implementation includes
  - Configuration data base(s)
  - Repositories
  - Workflows and management applications



Design Sketch

High-Level Control Applications

HLC Team:

- Controls experts and accelerator physicists
- Interfaces specific needs of beam commissioning and operations and implements corresponding tools and applications

→ **FRO11**

MATLAB Middle Layer Library Suite:

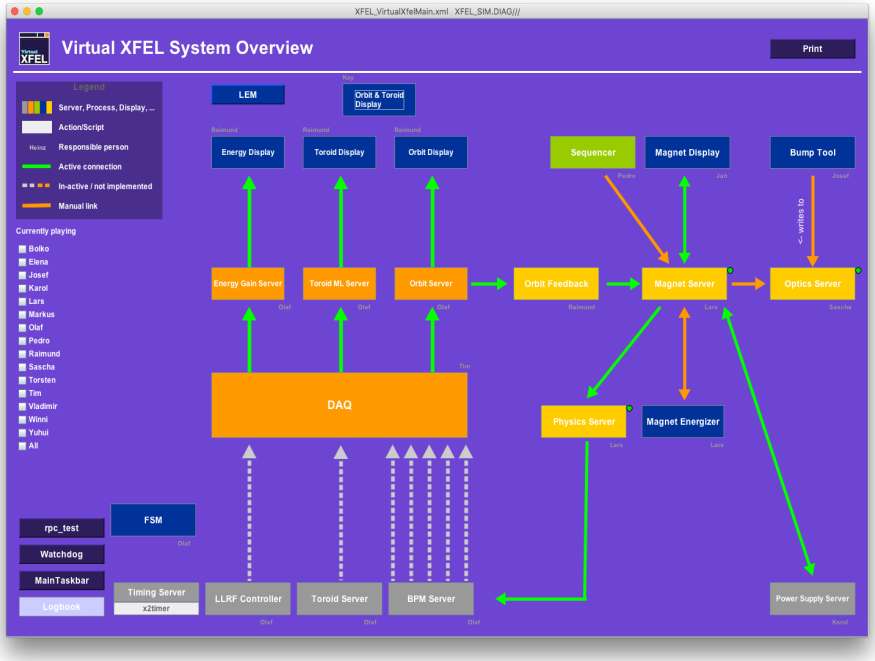
- Supplemented by special procedures developed for PETRAIII operation
- Will be adapted for further use at PETRA IV

Machine Learning:

- Novel control concepts for automation of PETRA IV operation are being developed and tested at PETRA III

Virtual PETRA Accelerator:

- Similar to Virtual European XFEL Accelerator
- Will be used to test new concepts, enhancements or just modified and improved applications before they will be put into the field



Virtual Accelerator (EuXFEL)

Thank you

Contact

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