Progress Status for the EMBL Petra3 Beamlines
Uwe Ristau
Overview

- Introduction
- Beamline control with TINE
- Software Architecture
- Control Electronic Architecture
- Example
- Outlook
Introduction

• The European Molecular Biology Laboratory EMBL-Hamburg currently constructs an integrated infrastructure for life science applications at PETRA III / DESY.

• Beside others the centre comprises two Beamlines for Macromolecular X-ray crystallography (MX1, MX2) and one for Small Angle X-ray Scattering (BioSAXS).

• Two DORISIII/DESY wiggler beamlines are available as Test beamlines for hardware and software equipment
PETRA3 Beamlines

- Energy: 6 GeV
- Current: 100 mA (200 mA) – top-up
- Emittance: 1.0 nm rad
- Coupling: ≈ 1%
- Bunching: 960 or 40 bunches
- Brilliance: $10^{21}$ 1/s mm$^2$ mrad$^2$ 0.1%BW
- Circumference: 2.3 Km

Operated in top-up mode
EMBL@PETRA III beamlines for structural biology

- 3 out of 14 PETRA beamlines operated by EMBL.
- One beamline for biological SAXS (P12) and two for macromolecular biology (P13 & P14).
- Standardized layout, optics & controls for all beamlines.
EMBL@PETRA III: Integrated facility for structural biology

- High Throughput Crystalisation Facility
- Wetlab for sample preparation and characterisation
- Computing facility for Data Analysis.
- Workshop, offices and seminar room.
Petra3 Beamlines

EMBL
All Double Crystal Monochromators installed and operational.
- Motion control by fieldbus modules (exception Bragg axis) operational.
- BioSAXS & MX2 DCM: in beam commissioning started.
First beam

BioSAXS beamline

• First beam on frontend (white beam) on 15.7.2010
• First monomchromatic beam on 22.7.2010

MX2 beamline

• First beam on frontend of BioSAXS beamline on 9.9.2010
• First monomchromatic beam on 17.9.2010

MX1 beamline

• Expected in 11/2010
Network Topology

Repeater server for all important Petra data are via the TINE GATEWAY accessible at the EMBL dataflow through the DMZ with communication through defined ports.

TINE DESY 131.169

EMBL Standalone TINE installation 10.150

Experimental area Optics

MX1

MX2

BioSaxs

Hasylab

Frontend

Petra synchrotron

Undulator Beamlines
Data Access Rights with TINE

- DelicateControl system data can easily be protected by:
  - Client Username (PC)
  - Client IP address
  - Server Property (Channel)
Platforms for PetraIII

- Linux
- WinXP/XPE

Programming tools

- C/C++ server programming
- LabView device server, Clients, Rich Clients remote Beamline software access
- TINE Common Device Interface CDI for Device access
- TINE Command line tools
- PyTINE Scripting
- MxCube Graphical Beamline User Interface ESRF
Software Modules

• Generic tine motor server
  – Beckhoff/TwinCAT motor K-Bus
  – Beckhoff/NC EtherCAT Plugin

• Generic Detector server
  – Pilatus
  – Rayonics MX225
  – MAR 345, MAR165

• Endstation software
  – Marvin SC device server
  – MD2 Tine device server

• Data collection server

• Instrument protection system

• Vacuum control

• Experiment server

• General Beamline tools
  – Scope
  – Function generator
  – ...

• Experiment Web access
  – ISPY_B connectivity

• GUI Experiment control MX beamlines
  – Bliss Framwork/ MX-Cube

Scripting tools

PyTine

Slit scanning server

Mirror server
  – Remote Beamline Access
  – TINE Videoserver

Metaserver
GOAL

- Distributed electronic
- All Signals, Monitors, Motor parameter etc synchronized to each other

PLC Electronics

- Distributed-> short signal lines
- New Ethernet based
  - signal synchronization <1ms
  - acquisition cycle <1ms
- Servo and Stepper motor control
- Requirement: AI 16 bit
- Counter : 5MHz
TwinCat/EtherCAT Features

- EtherCAT=CANOpen over Ethernet -> open protocol
- Real time software PLC cycle times 100 us
- Master Master Clock synchronization 1 us.
- Interfacing to (CAN, S5, SerCos, Profibus Gateways available)
- Counter, DIO, AIO
- NC numeric motor control of TwinCAT operates servo motors, stepper motors, dc motors,.
- DIO XFC (extreme fast controls) modules of Beckhoff timing to 100ns. Incremental timing with 10ns steps possible.
- Analog input up to 200kHz (15 bit, 0.5% precision) Overclocking
- 24 bit AI available
- EtherCAT open protocol
- www.EtherCAT.org
EtherCAT PLC Signal Synchronisation

Data Bridge Beckhoff EL6692

- PLC1
  - Motor
- PLC2
  - Motor2
- PLC3
- PLC4
  - Monitor

PLC clock synchronization Cycle synchron up to 100 kHz
NEW: NI - RIO series
TINE Generic Motor Server EtherCat Plugin

- Support for closed and open loop motor control
- Definition of MotorGroups (Pseudo motor axis in file)
- Motor configuration in file
- 'Step scan' for motors or Motor Groups
- 'OnTheFlyScans' of motors or predefined Motor groups
  WaitTime zero enables the PLC to store Axis position and Monitor Value to PLC array.
- Scan(StartPosition,StopPosition,MoveIncrement,WaitTime,Monitor[])
TwinCAT NC Hardware Management system

Servo axis control closed and open loop servers are automatically generated by the TINE MotorServer and CDI.
EMBL – FMB Oxford Monochromator

FMB Oxford
Bragg axis: PMAC

Fine adjustment:
Piezo motors, PI controller

Crystal stage

Stepper Motor control:
Ethercat motor controller
Renishaw encoder

Motor

Beckhoff EtherCAT control electronic
Beamline Frontend GUI Status

- Petra Monitor
  - Ring Current: 0 mA
  - Energy: 0 GeV
  - Wartung

- ThermoCouple
  - Temperature Logger
    - 1stCrystalSi111: 118.53 K
    - 1stCrystalSi311: 115.73 K
    - 2ndCrystalSi111: 118.63 K
    - 2ndCrystalSi311: 118.93 K

- User Interface:
  - Energy Move/On/Off
  - System Halted
  - Energy Move
  - CmdPosBragg/Deg: 14.332
  - Bragg/deg 14.508
  - pOffset/mm: -1.5
  - Perp/mm: 9.35
The EtherCAT bridge terminal EL6692

- data exchange between EtherCAT strands with different masters.
- synchronization of the distributed clocks
Beckhoff @ the Petra Synchrotron

Ring:  Undulator control
       Positionining of the Petra Dipol magnets

Beamlines Hasylab:
       Vacuum interlock
       Control of the large offset Monochromator

GKSS :
       Detector tube for the BIOSaxs Beamline

EMBL:
       Monochromator
       Mirrors
       Slits
       Tables
Monochromator - Undulator synchronization

Hardware synchronization
With EL6692 Communication
Box PLC cycle synchron timing

Renishaw CounterBragg
Robotic Sample Changer development
PCaPAC2010 Progress status for the EMBL Petra3 Beamlines
Experiment control

PcAPAC2010 Progress status for the EMBL Petra3 Beamlines

Screening

Samples to Process

Process Status

Sample Handling

<table>
<thead>
<tr>
<th>PositionNr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Puck from Load position to Center Position</td>
</tr>
<tr>
<td>Eject Puck From Center Position to Load Position</td>
</tr>
<tr>
<td>Put Puck to Position Nr from Load Position</td>
</tr>
<tr>
<td>Eject Puck From Position Nr to Load Position</td>
</tr>
<tr>
<td>Put Puck From Center Position to Position Nr</td>
</tr>
<tr>
<td>Get Puck From Position Nr to Center Position</td>
</tr>
</tbody>
</table>

| Dry Gripper |
| Open Lid |
| Close Lid |

| Sample Number |
| Mount Sample |
| Dismount Sample |
| Take Data |

| Process Status |
| Sample Handling Progress |

| IC1/[mA] | 0.023 |
| IC2/[mA] | 0.022 |
| Doris Current | 0.85 |

Di, 23. Feb 2010 10:07:52

EMBL

RobotMoving

| File Name Extension |
| Image Decoder |
| Environment of Reference |
| File Name |

CENTRING Sample Mount & Data Collection Barcode Beamline Control
Acknowledgments

• Petra3 Instrumentation Group
• Groupleader Stefan Fiedler
• Andres Pazos
• Mario DiCastro
• Bernd Robrahn
• Lifu Gao

and

• Philip Duval MCS, DESY
Outlook

EMBL is the Pioneer for TINE Beamline control

others should follow - TINE is a excellent choice