EMBL Beamline control at Petra III

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Petra III Instrumentation EMBL-Hamburg
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Introduction

• The European Molecular Biology Laboratory EMBL-Hamburg will build and operate 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).

• The EMBL operates currently 6 Beamlines at the DORISIII/DESY synchrotron.
The image contains a diagram of a beamline setup, labeled as BIOSAXS Beamline. The setup includes a sample at the beginning, followed by horizontal and vertical focusing mirrors, a multilayer monochromator (DCM), an undulator, and various positions marked in meters from the source. The first experiment on this beamline took place in April 2010.
TINE @ EMBL

• TINE was first installed at the DESY/DORIS III Beamline BW7B in 2006. Since then the Beamline control module BCM, the experiment control and a robotic sample changer are controlled by TINE. Presented at the PCAPAC 2006.

• Now TINE is integrated at the Doris Beamline for small angle scattering X33 and at the MX Beamlines BW7A and BW7B.

• Since the beginning of 2008 BW7A and BW7B became test Beamlines for the new Petra III project of the EMBL. At the moment the first applications with the Petra III control concept are implemented at this Beamlines.
Why TINE

- Very good support of MCS
- TINE unique features:
  - Different transport protocols: UDP, TCP/IP, ...
  - Multicast Video server in UDP
  - Labview server API
  - WinCE support
  - Data types like <str,dbl,dbl>
  - ....
TINE additional tools

- **TINE Instant Client**
- **TINE Video** (Multicasting + Scheduling)
- **TINE JAVA COMA TOOL**
- **RUNTIME Client generation!**
- **Secure Web access**
- **Common device interface**

**TINE command-line tools**
- tservers (queries the ENS for registered servers)
- tdevlist (queries a server for its devices)
- tproplist (queries a server for its properties)
- tinfo (queries a server for property information)
- tget (synchronous read-only call to server)
- tsend (synchronous write/read call to server)
- tmonitor (asynchronous read-only poll to server)
- thistory (queries the archive server)

With tget in tcl scripts PLEASE use a tvisRepeater!
Platforms for PetraIII

- WIN
- Linux
- MAC
- WinCE

Talk by Andres Pazos

Server Programming tools

- C++ for server integration
- LabView device server
- CDI Tine Common device interface for hardware access
- Java hardware independent servers

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Client Programming tools

- TINE COMA-> client generation in runtime!
- Labview TINE API for Win/Linux/MAC
- TINE ACOP Java Win/Linux/MAC
- Web2C /Web service/Ajax

POSTER robotic sample changer control
LabView and standard devices

- Device control software for many standard devices like oscilloscopes (Tektronics, HP, LeCryo, etc..), function generators, multimeter (Fluke, Agilent, Keithley, …)

Spectrum analyzer are available for LabView as download at [www.ni.com](http://www.ni.com).

It is quick to create a TINE device server device driver is available.
Interconnectivity

- TINE - TANGO Gateway
- TANGO - TINE Gateway
- by Cosylab / EMBL DESY MCS
- Single server translation
- Will be used for fast Tango server startup. Not permanently!

MD2 server (TANGO) translation
MD2 server (TINE)
TINE Client
EMBL Control Software Concept

TINE Services:
Sequencing, Alarming, Archiving

Presentation Layer/Communication Layer

Web2C
Rich Expert Client
Thin Client – USER Client

Interfacing & Communication servers

Beamline Server Layer

3rd Layer

Generic Component Server

2nd Layer

Component Server

BeamlineServers

High Level Device Server

1st Layer

Device Server

Device Server

Device Server

Device Server

Device Server

Low Level Device Server

1st Layer

Hardware Access Server

Hardware Server

Hardware Server

Hardware Server

Hardware Server

Hardware Server

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Example Server Hierarchy

- **User GUI**
- **Web GUI**
- **Client PC**
- **Rich Clients**
- **Expert GUI**

**Network**

**UDP**

**Translators**
- Tango
- Epics
- Doocs

**High Level Generic Server** for user operation i.e.
- Monochromator (Motor, Diagnostic, Vacuum, Cameras)

**Control system**
- Network Bus / Alarms / Events / Database / Storage

**Low level Hardware Server-CDI** (common device interface)
- Sync Move, Scan, PseudoM, etc...

**Device driver**
- example: Motor

**Control-PC**
- Example Beckhoff PLC computer

Motor
Beamline Software

- **Beamline Server**
  - Feedback
  - Alignment
  - User Database
  - Data processing
  - ....

- **Component Server**
  - Monochromator
  - Mirror
  - Collimator
  - Sample Changer
  - Diffractometer
  - ....

- **Device Server**
  - Beckhoff
  - Goniometer
  - Centering
  - Video

- **Generic Detector server**
  - MAR 333
  - Pilatus
  - MAR 555
  - MAR 165
  - ....

- **Generic Motor server**
  - Beckhoff
  - Delta Tau

- **DAQ**
  - TwinCAT EterCAT
  - NI PXI/FPGA
  - Tektronix Scope
Software Modules for the PETRA3 Beamline control

- **Generic motor server**
  - Beckhoff/TwinCAT motor control and DAQ
  - Delta Tau PMAC
  - Aerotech
  - Attocube
  - PXI/NI

- **Generic Detector server**
  - Pilatus
  - MAR333, MAR555
  - MAR 345, MAR165

- **Endstation software**
  - SC3 Tine device server
  - MD2 Tine device server
  - Goniometer server

- **General Beamline tools**
  - Scope
  - Function generator
  - ...

- **Oracle data base connectivity**
  - User/Experiment info

- **Data processing**
  - eDNA connectivity
  - …..

- **Experiment Web access**
  - ISPY_B connectivity

- **GUI Framework**
  - Bliss Framework/ MX-Cube
  - BLUE ICE
  - EMBL-HH LabView Framework

- **To be created**
- **Existing**

In evaluation

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TwinCAT/EterCAT specifications

- Ethernet based real time software PLC with cycle times down to 50 us
- Clock synchronization of connected I/O hardware by 1 us precision.
- Connected via CAT5 Ethernet cable and ordinary network switches
- Industrial standard, high reliability, Computer without rotating parts (fans, hard disks, etc)
- Cheap, fast delivery, long live products supported for many years
- Easy interfacing to other Fieldbus systems (CAN, S5, SerCos, Profinet Gateways available)
- Counter, DIO, AIO, Stepper motor controller, DC-motor control all in one system available
- 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)
- 24 bit AI available- Prototyp Beckhoff – in test at the EMBL
- EterCAT open protocol EMBL-Hamburg member www.EterCAT.org

K-Bus only

www.Beckhoff.com

Ethernet based real time software PLC -> TwinCAT
There is a bunch of hardware of 3rd parity vendors for EtherCAT available.
The synchronization problem

Precise Synchronization (<< 1 µs!) by exact adjustment of distributed clocks

EterCAT is redundant
If a ring topology is applied

DC-Motors
Motor controller

Intensity diode Input
LVDT input
POTI
Renishaw encoder

DIO – valve control, Trigger, shutter, Counter

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TwinCAT system manager

- Manages the hardware connected
- Links hardware inputs and outputs with the PLC variables
- Updates cyclic the variables offered by the hardware connected to TwinCAT

Hardware connected:
- K-Bus
- EterCAT

Features:
- Disable hardware for test option
- Simulate hardware option

Online display of hardware inputs and outputs
The TwinCAT PLC runs cyclic. During a PLC cycle by EterCAT or K-bus, connected variables are read or set. Additional, the PLC user program or function blocks are executed. The shortest cycle times are 50us for EterCAT and 10ms for the K-bus.

Advantage of PLC programming: STRUCTURED TEXT.

Up to 4 tasks per PLC
Up to 3 PLC’s per TwinCAT installation

Monitoring of cycle times etc.

Communication with CDI via the ADS protocol

Direct monitoring of variables which are linked in the System Manager to hardware inputs and outputs.

Cycle time X100ns.
EMBL/DESY CDI/TwinCAT PLC library features

- Synchronous move of n-motors
- Continuous motor scans
- Motor step scan
- Initialization of the connected hardware (server)

The start of a ‘On The Fly’ scan is proceeded by selection of the axis to scan and performing a move.
Multilayer project @ BW7A (S.Fiedler)

POSTER BY A.PAZOS

Beam on 1st Layer

Motors Counter AIO, DIO VIDEO

Vessel, motor, encoder (Renishaw, LVDT), substrates etc.

Beckhoff CX-1020

WIN-CE 2GHz, 1GB Computer TINE, MotorServer, CDI

backside

Normalised diode signal

Normalised angle (deg)
ELECTRONIC DISTRIBUTION

Commissioning: all in one!

• PLC COMPUTERS ARE THE Beckhoff CX-1020, CX-1030 or BC9010
  • Operating system is WinCE or WinXP embedded
  • TINE
  • CDI common device interface
  • Component server
  • Client
  • Video server and other servers can run here
MULTICAST for large file transport with TINE

TINE UDP Multicast @ EMBL

- DORISIII Parameter (current, status of Beamline etc) all EMBL user can start this client.
- Robotic sample changer 3 click centering min 2 Video Clients

ESRF Detector data streams max. 200MB/s Pilatus 6 M pixel detector 60MB/sec
Experimental data transported by the control system

*SLS&GKSS: display and redundant storage of experiment data acquired by the Pilatus pixel detector
-> 10 GBE network and TINE UDP Multicast??

- Storage intermediate
- Storage permanent
- Monitor
- Web access
- Detector data
- Online Processing software1
- Online Processing software2
- DNA
- BCM, SC
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