THE CONCEPT OF EMBL BEAMLINE CONTROL AT PETRA III

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Abstract

The EMBL-Hamburg is the first institution where the TINE [1], [2] Control system is used for Beamline and experiment control. Beamline control is based on other hardware and control software than accelerators. Typical Beamline hardware elements are the detector, the Monochromator and the Goniometer etc. Here we present our concept for Beamline control with TINE at the Petra III Beamlines.

The control electronic is the Ethernet based real time software PLC TwinCAT [3]. The field bus is EtherCAT. The PLCs will be used for motor control and data acquisition. Only fast data acquisition will be performed with National Instruments [7] PXI/FPGA electronic.

INTRODUCTION

The European Molecular Biology Laboratory EMBL-Hamburg is located at the DESY campus in Hamburg/Germany. The EMBL operates 6 Beamlines at the DORISIII synchrotron. Additional there are three new Beamlines at the PETRAIII synchrotron facility under construction. Figure 1 shows the experimental hall of Petra III. The new Beamlines will be two Protein Crystallographic Beamlines MX1 and MX2 The third beamline is a the BIOSAXS Beamline. The first Beamline in operation will be the BIOSAXS Beamline which will start first user experiments in April 2010.

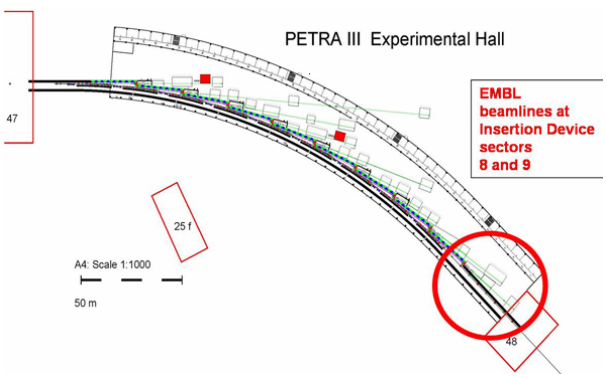

Figure 1: Sketch of the Petra experimental hall.

Since the last upgrade of the existing EMBL Beamlines at the DESY/DORIS III synchrotron there have been major requirement changes for Beamline operation and Beamline control. These changes are based on the improvement of the synchrotron technology in terms of brilliance and beam stability and beam size. This has reduced the time needed for data collection at the experiment from several hours down to minutes.

The detector readout time has been decreased by new detector technologies. The data processing is more and more involved into the data collection itself. The detectors like the PILATUS produce experimental data up to 60 MB/s. This data have to be displayed, stored and processed. The transport of videos and experimental data requires network technologies with high bandwidth. Smaller sample sizes require precision mechanic and improved beam stability. The control electronic has handle fast feedbacks and data synchronization in micro second range.

THE BEAMLINE CONTROL SYSTEM

Control System Requirements

Main requirements for the Beamline control system are the reliability, the efficiency of the data through put. Important features are the scalability and flexibility of the system. The control system has to offer tools for data archiving, alarming, sequencing and data logging. The control systems should support common operating systems and programming languages. The data transport protocol should be flexible to support new data types. The installation and usage should be straight forward.

These points are necessary to ensure that the control system will handle also in future the new hardware and new software developments.

TINE Features

Tine as control system for Petra III was chosen because of its key features. TINE is multi-platform, where platforms Windows, MAC/OS and Linux can be integral parts of the control system. TINE is also multi-architecture, where data transfer can follow a client-server, publish-subscribe, producer-consumer, or publisher-consumer strategy.

The user can chose between the UDP transport protocol which allows multicast communication for reduced network traffic and the TCP/IP protocol for handshake safe data transport within TINE.

The TINE hardware access suite CDI common device interface [6] is the TINE tool for automatic device server generation. CDI offers various bus plugs for different types of field bus systems. Supported field bus systems are Profibus, CANOpen, TwinCAT, Sedac. The EMBL uses the CDI bus plug of TwinCAT. The bus plug connects to the field bus TwinCAT via the Beckhoff ADS communication protocol to TINE and generates device servers.

The TINE Video system has a key function for the Beamline control of the EMBL Beamlines. The video system is the only tool transporting videos by the control system in UDP multicast mode. The multicast is the only possibility to connect more than one client to a video server without blowing up the network. TINE offers a fast archive, an event database, event alarm handlers and tools for comfortable server and client generation. The main new tools are all coded in Java and are platform independent. At the end the Beamline user benefits from all this features of TINE.

TINE At The EMBL DORIS III Beamlines

The EMBL-Hamburg has started the usage of TINE for Beamline control in 2006. Tine was integrated into the existing DORIS III Beamline control software [4]. Up to then Beamline control was more or less single computer based.

The first implementation with TINE for Beamline control was at the DORIS III Beamline BW7B. The sample changer [5] as well as the experiment control including detector and Beamline control was implemented. This has been presented at the PCAPAC 2006. Now TINE is integrated at the Doris Beamline X33 a small angle scattering Beamline and at the MX Beamline BW7A and at BW7B. Since the beginning of 2008 BW7A and BW7B became test Beamlines for the new Petra III Beamlines. At the moment the first applications with the later presented Petra III control concept are implemented at this Beamlines.

CONTROL SOFTWARE CONCEPT FOR PETRA III

Figure 2 shows a sketch of the control server layer concept which will be implemented at Petra III. Starting at lowest the hardware level are servers like CDI and others device server. The properties exported by this server are not foreseen for the client user. But the servers guarantee hardware access and export the whole device functionality.

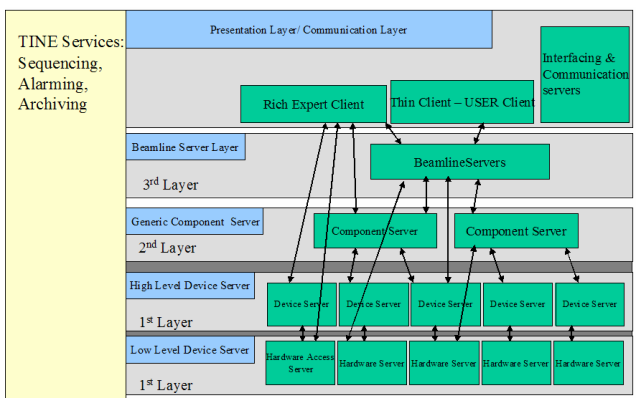

Figure 2: Beam line control layer concept

The high level device server exports the device functionality which is relevant for further usage in the component or Beamline server layer.

The component server layer exports Beamline component functionality and can consist of various device servers of lower or higher level. The Beamline components are the Monochromator, mirrors, beam position monitors, sample changer, collimator or the Goniometer.

The highest level is the Experiment or Beamline layer. This layer level maps the functionality of the experiment or other functionality like Beamline alignment, Beamline feedback or the data processing. The graphical user interface represents the presentation layer. In case of thin clients only the results of the underlying layers are presented. In difference to that rich clients are able to access pure data/information and process them. Rich clients either get their data form underlying layers of every level or they access properties of underlying layers. All Layer servers starting at the device server layer are servers to the higher levels and clients to the lower levels.

SOFTWARE DEVELOPMENT TOOLS

- The main languages for server development are C/C++ and LabView. For both languages most device driver for hardware access are available by vendors of hardware.
- High level servers starting at layer 2 are optional written in Java.
- For Scripting t-commands + COMA will be available. This is still in discussion.

PLC BASED CONTROL ELECTRONIC

PLC based field bus systems are used since a long time for Beamline control at synchrotrons. Usually PLC based systems are used for slow controls like vacuum control.

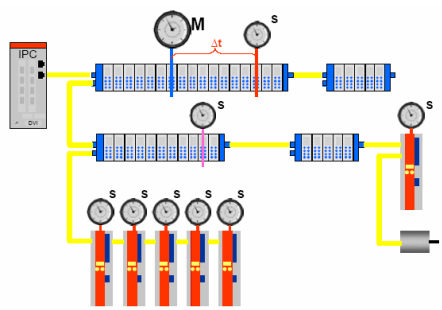

Figure 3: EtherCAT Synchronization

The new generation of real time based PLC systems like Profinet or EtherCAT offer faster cycle times based on improved controller hardware and improved data synchronization. This new technology helps to process more complex tasks via the PLC. The EMBL has chosen

the Ethernet based real time software programmable logic controller PLC TwinCAT of Beckhoff with EtherCAT as field bus protocol.

The EMBL-Hamburg is member of the EterCAT technology group. As a member we are able to develop our own EtherCAT hardware. Ehtercat is an open field bus protocol and there are many companies registered as hardware and software developer for EtherCAT. The range of products available for EtherCAT is fast increasing. Up to now we use Beckhoff hardware and the TwinCAT software PLC for Beamline control. Strong points of Beckhoff are the numeric control software 'NC' for motor control which allows to control almost all motors like dc, stepper and servo motors. There is even a 24 bit analogue input available.

CONTROL ELECTRONIC

At the EMBL TwinCAT is used for motor control Because of the signal synchronization of up to 10 kHz we are able to perform continuous motor scans, were the motor runs from the desired start position until the end position and during the move the motor position and desired intensity readings are stored inside the PLC. Together with DESY PLC libraries for motor control, scanning of motors, synchronous movement and hardware initialisation have been developed.

Fast Signal Control

Because of the performance limit of the EtherCAT field bus all fast signals (>10 kHz) are processed with PXI. The signals will be processed with National Instruments FPGA acquisition cards. The fast acquisition will be necessary for feedbacks running on higher frequencies and for vibration analyses. The FPGA electronic will be programmed with LabView.

Electronic Distribution

The control electronic will be mounted in small units/racks on the girders of the beamline elements inside the optical and experimental hutches. Beamline elements are the Monochromator, the mirror system, the sample changer and the end station. The advantage of this installation is the short cable length for signal and motor cables. This reduces the noise level on the signal cables to a minimum. An electronic unit will consist of a computer / controller where the software PLC is running on and the electronic modules needed for instrument control. We have chosen Beckhoff as supplier and TwinCAT as Software PLC.

One TwinCAT installation can run per PLC up to 4 tasks. Up to 3 PLCs run on one TwinCAT installation. TwinCAT masters are able to communicate between each other via the Beckhoff network variables. This is an important feature for a system hierarchy of the PLCs. A Beamline element consists of the device, the control electronic and the device server software. The device server generation is performed by the TINE tool CDI [6] the common device interface.

The commissioning of such a Beamline elelment will be convenient because the whole element can be commissioned as one unit. The Beamline element can be installed at the Beamline after the commissioning has been finished.

CONTROL SOFTWARE STATUS

First attempt of our Beamline control with TINE has been to ensure compatibility of TINE and TANGO. COSYLAB has developed the T2T Gateways. Gateways from TINE to EPICS and TINE to DOOCS are also available. A TINE server for the control of a MD2 Goniometer is operational and will be tested by summer 2009 as soon as the device will be delivered. The development of a TINE server for the Oxford double crystal Monochromator starts by the end of 2008. A TINE server to read and write to the EMBL Oracle data base exists and has to be tested.

A Client for the display of the diffraction data is developed. The data of a MAR165 CCD detector can be transported by the control system. The protocol is UDP using the multicast mode. A TINE support for the operating system WINCE has been developed. A generic detector server development has been started. By now the Pilatus, the MAR 165 and the MAR Image plate detector are available as TINE device servers. The development of a TINE server for the MAR 555 detector will follow soon.

CONCLUSION

The control system and the control electronic are defined. Many TINE servers which are part of the Beamline control are in operation and have proven the usability of TINE for Beamline control.

The decision on the Graphical presentation layer framework is not taken yet. Options are either to develop a LabView framework or to use the TINE tools COMA in combination with the TINE Scripting tool. A third option is to use existing frameworks like the MXCUBE [5]. It is part of the Bliss frame work[6] developed at the ESRF.

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