THE EMBL BEAMLINE CONTROL FRAMEWORK BICFROCK

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Abstract

The EMBL hosts three beamlines at the Petra Synchrotron at DESY. The control of the beamlines is based on a LabVIEW TINE Framework. Working examples of the layered structure of the control software and the signal transport with the Fieldbus based control electronic using EtherCAT will be presented as well as the layout of the synchronization implementation of all beamline elements.

INTRODUCTION

Three EMBL beamlines for structural biology are in user operation at PETRA III synchrotron on the DESY site in Hamburg, Germany. A layered control software architecture and industrial control electronics [1] is implemented and operational on all three beamlines. Key elements are the TINE control system [2], EtherCAT fieldbus electronics [3] and the LabVIEW software package [4]. The control of all backbone instruments of the beamlines is being integrated in one framework called BICFROK (BeamlIneControlFRamewOrK). The framework should provide a graphical representation of the entire beamline to the beamline operator. It should give him access to all instrument control applications in a well arranged manner and should display monitor values of the principal parameters relevant for the synchrotron beamline operation.

CONTROL ELECTRONIC

The control of nearly all instruments is achieved by standardized electronic units. An example of such a unit, the device control for an X-ray focusing mirror set at EMBL beamline P13 for macromolecular crystallography, is shown in Figure 1. The center piece of the units is a Beckhoff CX1030 embedded PC which communicates via an EtherCAT protocol with the Beckhoff EtherCAT hardware modules that are connected to the single devices of the complex X-ray optical instrument. For the sake of standardization, the selection of EtherCAT modules in different control units varies only a little. At present, there are 30 control units distributed in vicinity of the instruments. The local installation reduces the length of the cables from the instrument to the control unit and the problems associated with this. As the units are installed in radiation controlled areas they have to be protected against background X-ray scattering. Radiation

Control Computer and Ethercat Master

All control units are equipped with a Beckhoff CX1030 PC where all control software components are installed. The TINE control system is installed embedded on all of the control electronic masters. Part of the TINE Toolkit installation are the TINE common device interface CDI and the TINE Motor and Scan server. CDI acts as the low level device server which acts on one side as common interface to devices using bus plugs Figure 4 and on the other hand export the devie functionality as TINE properties.

The low level CDI TINE server communicated then with the generic TINE motor and scan server which exports motor control and scan features. It is a component of the TINE toolkit. The PLC runs on the same computer and offers a ADS communications.

Ethercat Installation

The soft real time fieldbus system EtherCat is Ethernet based. EtherCAT allows clock synchronisation of 1µs (+/-20ns). The cycle frequency for PLC's varies between 1 kHz and 10 kHz. Every installation is logically represented as a master installation. The Beckhoff EL-6692 acts for time synchronization between master units. With this concept the whole beamline signals like motor and encoder positions, intensities, vacuum pressure and temperatures monitors are synchronized with respect to each other.

Motor Controller

Currently 150 axis Beckhoff EtherCAT Modules EL7041 for stepper motor control are in operation at the beamline. 150 EL-5101counter acts as motor encoder readout. In operation are 2 servo motor axis controlled by Ax5125 synchron asynchron motor drivers, 24 Attocube ANC350 piezo translations and 12 PI axis piezo motor controller are controlled via Ethercat.

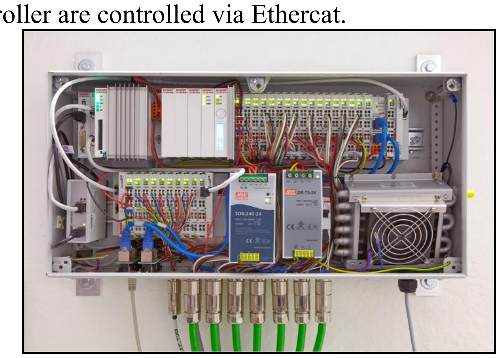

Figure 1: KB mirror control unit of the EMBL Beamline P13.

DAQ

DIO and AIO as well as counters and profibus fieldbus communications are integrated into the system. Time stamp and oversampling modules are working in parallel according to the needs.

Configuration of the system and parameters of the controlled objects are defined in the configuration file. External communications are implemented via the chain: PLC code TwinCAT - ADS protocol [3] – CDI server – TINE [2] protocol. The CDI (Common Device Interface) server is used as an interface between ADS and TINE protocols. It is a component of the TINE toolkit. The server runs in the same PC as the PLC which simplifies the ADS communications. It sends data to TINE clients in Connections with CAT6 Ethernet cables. Communications. It sends data to TINE clients in asynchronous mode. The correspondence between TINE properties and the TwinCAT.

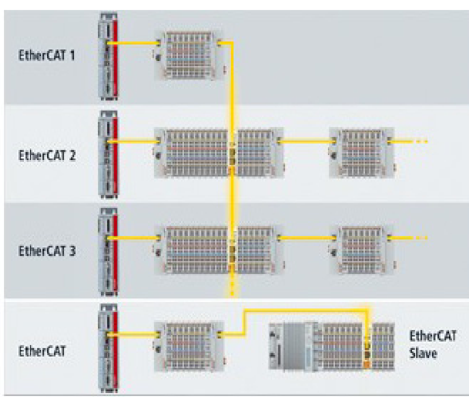

Figure 2: Master to Master Synchronization example [3].

The Master to Master communication is illustrated in Figure 2. Every Master has a EL6692 Beckhoff module installed which allows the exchange of data with other beamline masters.

COMPUTER ENVRINOMENT

The TINE Control system installation is embedded as Linux installation including the central services installed on two redundant installed HP Rack Pc's with redundant installed Power supplies and Raid1 mirrored hard discs. All Instrumentation Windows PCs are backed up and run with raid1 mirrored hard discs.

The standard operating system of the control computers is Windows 7 Professional. All of the PLC computer run XP embedded. All data of the instrumentation Pc's and PLC's are backed up.

As code repository SVN is in use. With the help of the CVI tool also LabVIEW is part of SVN. As well as the PLC code and related files.

CONTROL SOFTWARE

Each of the control electronic masters has its own CDI TINE Server running. In the Control Architecture sketch this is implemented as the low level device server layer.

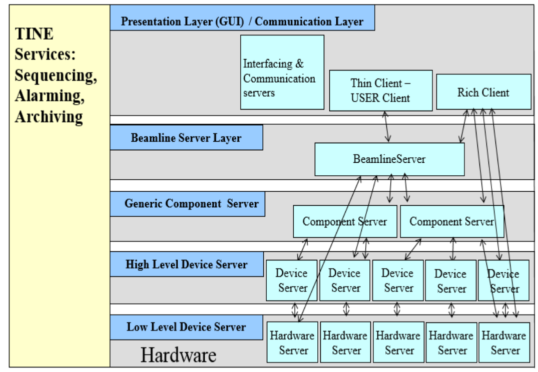

Figure 3: Layered control Software Architecture.

Figure 3 presents the layered structure of the beamline control Architecture which allows to access from all layers information of lower levels. The design has proven to be well fitting the needs of all relevant players at the beamline.

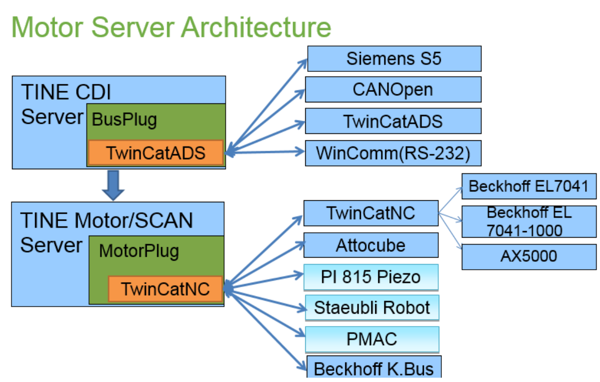

Figure 4: Motor and Scan Server Arichtecture.

The Tine Motor and Scan Server Figure 4. Describes the interaction between CDI TINE server and the TINE Generic motor and scan server which is presently implemented for TwinCat motors, Attocube motors and piezo drives of the company PI. The integration of the Staeubli robot bus plug and the PMAC bus plug are ongoing.

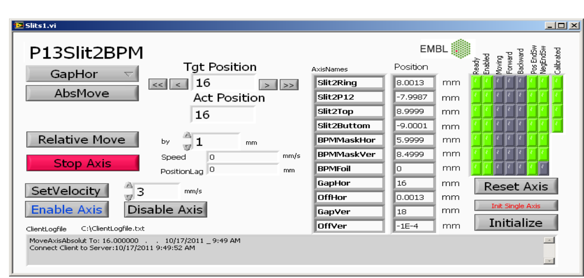

Figure 5: Generic standard motor client.

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The standard motor client Figure 5 is initialized by file csv file and offers initialization of axis, command logging, Error display, axis status and all other needed functionality for control of a motorized axis. It also supports pseudo axis operation.

Framework for data transport, central services as well as the TINE Tools. Servers are written in C/C++ and in G-Code using the LabVIEW framework. All Clients are programmed with LabVIEW.

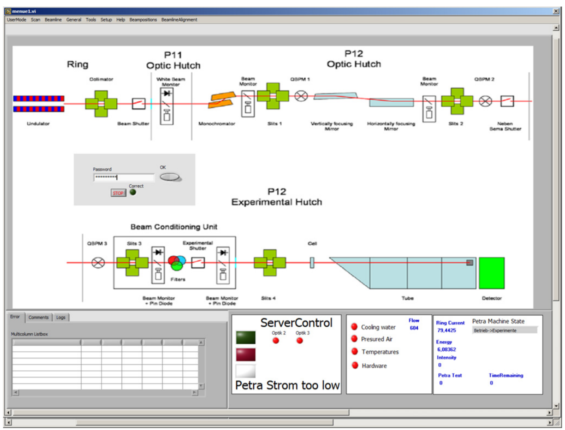

Figure 6: BIGFROC beamline overview Client.

Figure 6 presents the Container which is running all Client application at a single beamline. Client and server status, logging and display of user inputs main machine parameters and error handling is handled by the BICFROC container. Different types of user can login to the system with different rights to guarantee device safety and user comfort.

SUMMARY & OUTLOOK

The three EMBL beamlines at PETRA III are in user service and the beamline control software for them is operational. However, since the beginning of 2014 a revision of the existing software is under way.. The concept of EtherCAT based electronics, TINE as control system, LabVIEW and C/C++ for server/client programming will be continued and complemented by the comprehensive BICFROC framework. The system is still in the development phase and it is planned to put it into operation in 04/2015.

REFERENCES

[1] U. Ristau et al., "The Concept of EMBL beamline Control at PETRA III", MOZ02, Proceedings of PCaPAC08, Ljubljana, Slovenia (2008), p.22-24,

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