THE NEW CONTROL SYSTEM FOR THE FUTUTRE LOW-EMITTANCE LIGHT SOURCE PETRA 3 AT DESY

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Abstract

At DESY, the existing high-energy physics booster synchrotron PETRA 2 will be transformed into a 3rd-generation light source (PETRA 3) after the final shutdown of HERA operation mid 2007. In addition, the technical systems and components of the pre-accelerators LINAC 2 and DESY 2 will be improved. Within the scope of this project, the control system and the front-end electronics will be upgraded. Key elements of the conceptual design are TINE (Threefold Integrated Network Environment) as integrating software bus to provide efficient data communication mechanisms and support services, control room applications based on the thick-client model for optimum visualization and performance and Java as programming language to ensure platform independence, server-side control APIs in various languages to allow choice of the language that is best suited for the control task to be done, a common device interface for generic access to various field buses, and CANopen as interface standard for device electronics to ensure long-term maintenance. The complete conceptual design and the current project status will be presented.

INTRODUCTION

For more than two years, DESY has been changing its scientific profile from a predominantly high-energy physics laboratory to a unique synchrotron light research centre. This change has been manifest in several decisions, namely (1) to switch off the proton-lepton collider HERA 2 and to transform its booster PETRA 2 into a synchrotron light source (PETRA 3), (2) to upgrade the former Tesla Test Facility (TTF) into a user facility (FLASH), and (3) to participate in the European project of a linear-accelerator-driven hard X-ray free electron laser (XFEL) located at the DESY site. In addition to these facilities, DESY also operates the 2^{nd}-generation synchrotron light source DORIS 3.

The future facility PETRA 3 will be a high-brilliance 3^{rd}-generation light source [1]. The design values for the new storage ring will be 6 GeV for the particle energy and 100 mA for the current. The transverse particle beam emittance ist expected to be 1 nmrad. More than ten undulator beam lines operated by HASYLAB (Hamburger Synchrotronstrahlungslabor) will provide photons for various experiments (X-ray diffraction and imaging, high-energy resolution spectroscopy, material science, X-ray absorption and resonant scattering as well as structural biology).

At the end of July 2007, operation of HERA 2 will be terminated and all other proton facilities at DESY will be shut down. In the following year, PETRA 3 will be upgraded while the electron or positron pre-accelerators LINAC 2 and DESY 2 continue supplying DORIS III with particles. In order to improve the technical systems and components of LINAC 2 and DESY 2 the pre-accelerators will interrupt service for 6 months beginning 2008, as the re-commissioning of LINAC II and DESY II is scheduled for summer 2008 and the initial commissioning of PETRA 3 for autumn 2008. User beam operation is expected to start in January 2009.

Within the scope of the PETRA 3 project, the control systems and the front-end electronics of LINAC 2, DESY 2 and PETRA 2 will be upgraded almost simultaneously. Therefore, a reasonable balance between continued use of proven concepts or technologies and upgrades using new technologies and ideas has to be found.

CONTROL SYSTEM ARCHITECTURE

The new control system uses a multi-layer architecture linked by the integrating middleware or software bus TINE (Threefold Integrated Network Environment), a set of communication protocols and services developed over the past years as the core of the HERA 1/2 control system [2]. TINE is now in a mature state. Figure 1 illustrates the control system architecture.

Software Bus

TINE is a multi-platform system, running on such legacy systems as MS-DOS, Win16, and Vax VMS as well as Win32, Linux, most Unix machines, MACOS, VxWorks and NIOS. TINE is also a multi-protocol system to the extent that IP and IPX are both supported as data exchange protocols. Finally, TINE is a multi-control system architecture system, allowing client-server, publisher-subscriber, broadcast and multicast data exchange.

TINE provides application programmer interfaces (APIs) for Java, VisualBasic, C/C++, LabView, MatLab and a command line interface for scripting tools.

The TINE client/server implementation in C is widely used while the corresponding JAVA implementation has been recently finished.

Name services are provided with plug-and-play automated server registration.

Besides user access control, TINE offers a repeater and redirection mechanisms. The repeater mechanism is suitable for relieving delicate servers such as orbit feedback servers of undue communication burden or data archiving duties. Redirection allows for instance redirecting of locally registered devices (or even 'local' hardware access) to a remote server.

TINE includes interfaces to several associated services. Data filtering and archiving, event handling, alarm filtering and archiving are already supported. Interfaces for central message processing and archiving as well as to

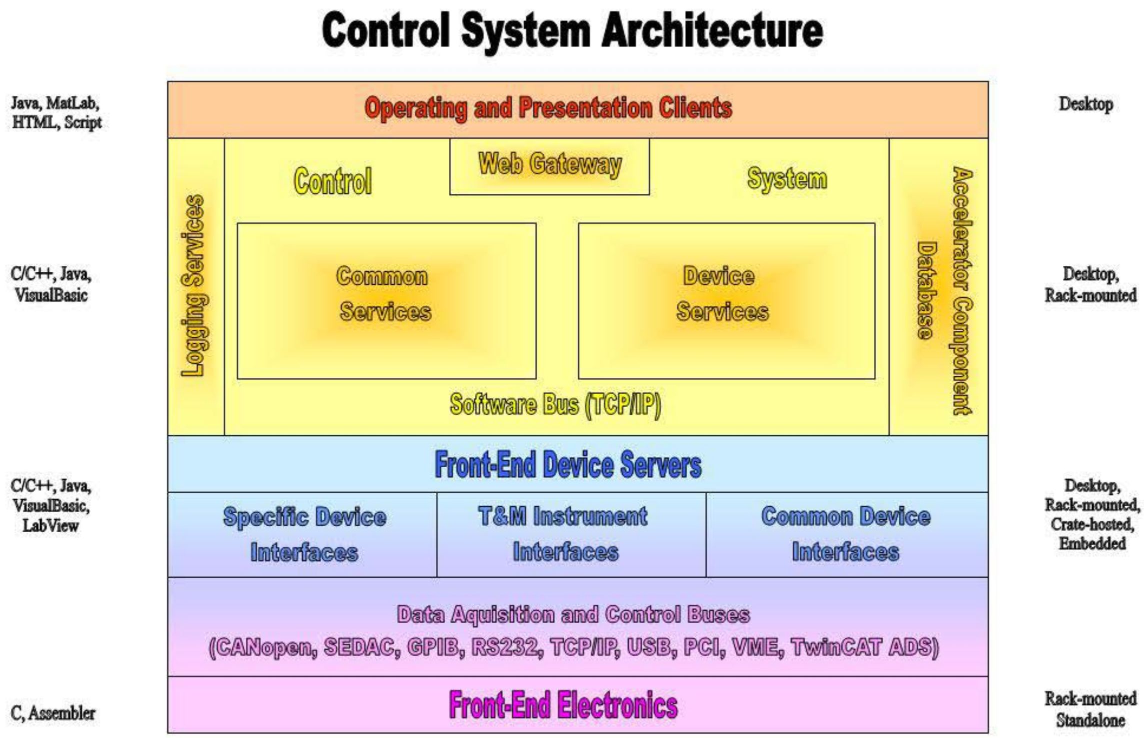

Figure 1: Architecture of the control system for the future light source PETRA 3

the common accelerator component database will be developed.

Access to the photon beam line equipment of HASYLAB will mostly be performed directly via the TINE protocol and APIs. An EPICS-to-TINE translator, routinely used to access process data of the HERA Helium refrigerator plant, will be used to integrate seamlessly EPICS IOCs controlling mains power, water-cooling and ventilation facilities. In addition, a prototype implementation of a read-only TINE Web gateway has been completed which is located in the so-called “Demilitarized Zone” between Internet and Intranet. Data are returned in response to an http-GET request from the corresponding web server.

Operating and Presentation Clients

According to our experience, control room applications based on the rich-client model are best suited for providing optimum visualization and performance. For instance, the integrated operation of LINAC 2 and DESY 2 in conjunction with the complex synchronisation controls requires very specific operator display and operating features.

To ensure platform independence, Java is preferred and recommended as the programming language. Swing lightweight components are the basis for the graphical applications. Common Java class libraries have been prepared to ensure design conformity, to handle initialization data and to reduce the final coding work. In addition, the ACOP (Accelerator Component Oriented Programming) toolbox [3] is used for simple data access and rendition. The widely used ACOP chart component is presently being extended to a suite of different ACOP components offering a powerful graphical user interface for rapid development of simple applications.

In order to promote accelerator physicists to develop complex tuning and measurement algorithms a MatLab interface and a simple command line interface for scripting languages is provided.

Less complex overview displays based on HTML will supply users outside of the firewall protected control system network with information about the current accelerator or photon beam line status.

Common Services

Many users of the control system will use common services such as data archiving, event processing and alarm handling or central logging. Most of these services have been already developed and successfully implemented at HERA and require only minor modifications.

A major task is the design and set-up of a central accelerator component database. The database will be the unique store from which all initialization, configuration and machine state specific set-up data can be retrieved.

Device Services

Device services are server applications with system-wide responsibilities. Examples are (1) feedback loops combining beam orbit data, beam optics algorithms and magnet current settings, (2) applications representing complete RF or vacuum systems with many different components and dependencies or (3) process automation and supervisor tasks interfering with various technical sub-systems and components.

Device services will in general not have direct local access to fieldbus interfaces or front-end electronics. We plan to use rack-mounted Linux or Windows PCs running with a restricted, well-configured set of system services for safety and reliability reasons. Application programmer interfaces are available for Java, VisualBasic and C/C++. A graphical wizard tool helps to generate code skeletons already fully operational and integrated into the control system to increase programming efficiency and conformity.

Front-End Device Servers and Bus Interfaces

Front-end device servers control specific components or fractions of technical subsystems, including single measurement devices such as digital oscilloscopes or data acquisition modules providing a few ADC channels.

We plan to use rack-mounted, crate-hosted (cPCI, VME) or embedded (PC104) CPUs to ensure reliable operation even in non-office environments. Similar to the device services, a wide set of APIs including laboratory automation environment such as LabView is offered to allow choice of the programming language that is best suited for the control task to be done. Obviously, in the case of a VME CPU running VxWorks or an embedded PC104 system running Linux only the C API can be used.

In general, these systems are directly connected to a data acquisition and control bus. Besides bus specific interfaces a common device interface is provided. This interface runs as a separate TINE equipment module and has been recently developed to offer a generic access to the attached front-end electronics. Plugs will be available for CANopen, the DESY-proprietary field bus SEDAC, GPIB, RS232, USB, PCI, VME. In addition, plugs for interfacing stand-alone PLC systems connected through TCP/IP or TwinCAT ADS [4] will be provided.

Specific stand-alone and off-the-shelf test and measurement instruments such as oscilloscopes or spectrum analysers do not in general fit seamlessly into control system architectures. Proper instrument integration often imposes an undue burden on the application developer. To simplify this task, we plan to use IVI-foundation [5] compliant instrument drivers. The Interchangeable Virtual Instrument (IVI) standard defines interfaces to generic virtual instrument drivers in order to avoid vendor-specific incompatibilities. Prototype-like LabView virtual instrument applications for oscilloscopes and digital multimeters have been recently finished. .

Front-End Electronics

A commonly used front-end hardware standard is mandatory to ensure efficient long-term maintenance of hardware and software. At DESY, hardware standardization was enforced by the DESY-proprietary fieldbus standard SEDAC with decreasing success during the last years. SEDAC is now more than 25 years old and is experiencing strong competition from modern industrial fieldbuses or data links. We plan to establish a new standard based on the industrial 3U-Euro crate standard and the industrial fieldbus standard CANopen to regain the necessary flexibility.

General electronic boards based on the Coldfire and HCS12 microcontroller [6] families have been developed and the corresponding Vector [7] CANopen implementations have been adapted to our needs. In order to communicate with the CANopen stack the developer of the application software registers the user specific variables in the CANopen object dictionary and provides the user specific code for a predefined set of callback functions. In addition, a processor board based on Altera NIOS II is under development.

The general processor boards are connected with user-specific boards implementing the corresponding electrical and mechanical interfaces. Boards to control vacuum equipment, magnet power supplies or trigger distribution etc are in various stages of development or series production.

SUMMARY

Within the scope of the PETRA 3 project at DESY, the control systems and the front-end electronics of PETRA 2 and the pre-accelerators LINAC 2 and DESY 2 will be upgraded. PETRA 3 will start user beam operation in January 2009.

Key elements of the proposed conceptual design are (1) TINE as integrating software bus to provide efficient data communication mechanisms and support services, (2) control room applications based on the rich-client model for optimum visualization and performance and Java / Swing as programming language to ensure platform independence, (3) server-side control system APIs in various languages to allow choice of the language that is best suited for the control task to be done, (4) a common device interface for generic access to various data acquisition and control buses, and (5) CANopen as the preferred future interface standard for modular front-end electronics to ensure efficient long-term maintenance.

REFERENCES

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