COMMISSIONING OF THE NEW CONTROL SYSTEM FOR THE PETRA3 ACCELERATOR COMPLEX AT DESY

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Abstract

At DESY the existing accelerator complex has been upgraded and partially rebuilt to become the high-brilliance 3rd-generation light source PETRA3. The pre-accelerators have been successfully re-commissioned during the second half-year 2008, while PETRA3 has provided stored beam for the first time in April 2009. In the context of the PETRA3 project, the control systems of all accelerators involved have been rebuilt. At all levels radical and significant changes have been introduced. Key elements of the chosen architecture and technologies are among others: TINE as core control system software suite, JAVA as the principal programming language for implementing graphical operator applications as well as many device and middle-layer servers (other device servers making use of C, C++, VB, and LabVIEW), integrated MATLAB and light-weight dynamic web-based applications, generic device access, CANopen as interface for standard process control, more than 200 LIBERA brilliance beam position internet appliances and integrated high-bandwidth video transmission. This paper reports the experiences gained so far during the commissioning of the new control systems.

INTRODUCTION

After having switched off the proton-lepton collider HERA 2, the booster PETRA 2 has been fully remodelled and upgraded between summer 2007 and spring 2009 into the high-brilliance 3rd-generation light source PETRA 3 [1]. The design values for the new storage ring are 6 GeV for the particle energy and 100 mA for the current. The transverse particle beam emittance is expected to be 1 nmrad. Fourteen undulator beam lines operated by HASYLAB (Hamburger Synchrotronstrahlungslabor), EMBL (European Molecular Biology Laboratory) and the GKSS research centre 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).

Within the scope of the PETRA 3 project, the accelerator control systems and large fractions of the front-end electronics of PETRA and the electron/positron pre-accelerators LINAC and DESY 2 were upgraded simultaneously. The re-commissioning of LINAC 2 and DESY 2 was finished in summer 2008 with the successful and stable delivery of positron beam to the light source DORIS, still be in operation at DESY. The commissioning of PETRA 3 was started in spring 2009. Since then the performance of the facility is being gradually improved towards the design values. First positron beam was stored in April 2009 and first x-ray light was observed in July 2009. The start of regular user beam operation is planned for January 2010.

THE CONTROL SYSTEM TASK

Basic Design Decisions

Technical reasons and principal strategic considerations such as platform independence and better system interoperability have driven a radical revision of the control systems of the PETRA 3 accelerator complex. Outdated network technology (SPX/IPX) was replaced by TCP(UDP)/IP. The legacy language VB6 lost its role as the primary programming language for applications in favour of Java, C/C++, MATLAB and LabVIEW. Instead of using the proprietary in-house fieldbus standard SEDAC communication with equipment electronics modules is now preferably based on the CANopen [2] protocol or relies directly on Ethernet and its real-time extension TwinCAT [3]. The outdated Novell 4 computing infrastructure was exchanged by a mixed infrastructure with Windows-based operator consoles and terminal services on the one hand and Linux, Windows and occasionally VxWorks servers on the other. Off-the shelf electronics for signal digitizing based on the industry standard PXI is now integrated seamlessly. Finally, the outdated previous control system protocol with limited scalability and performance was replaced by the highly integrative TINE [4] control system suite developed for and successfully used at the large-scale facility HERA.

Collaborative Responsibilities

The accelerator controls group is responsible for providing the underlying infrastructure and the developer tools as well as the core control system software. It performs most of the coding for the rich-client control room (Java) and the middle-layer applications (Java, C/C++). Equipment servers are provided by either the accelerator controls group or by the experts from the technical equipment groups (Java, C/C++, LabVIEW, VB). Accelerator physicists contribute high-level beam physics applications or off-line analysis tools (MATLAB).

Beam line equipment and experiment control is handled separately by the corresponding beam line control group.

Control System Statistics

In total, more than 200 rich-client control room applications and more than 100 server applications were coded and are now in routine use. Although the initial commissioning phase saw the implementation of the basic operation functionalities today's focus has turned to much more complex supervisory and automation tasks.

The control system TCP/IP network encompasses more than 300 individual nodes covering operator consoles, full-sized and embedded servers, and beam-position internet appliances. Several thousand fieldbus-connected equipment modules of various types were designed, fabricated and commissioned. All modules run stably and reliably. Many tens of thousands of control points are presently accessible via the TINE naming system.

Between 2005 and 2009 the allocated man-power for implementing the new control system and the equipment electronics amounts to approximately 100 man-years. The final investment cost slightly exceeds 1 M€.

Project Management Details

A resource-loaded, web-based work breakdown structure filled with mid-sized tasks was developed serving as the basic planning tool. It had been continuously refined and updated during the whole project lifetime.

Weekly team meetings kept the controls team up-to-date. Quarterly individual meetings with each team member were arranged to assign or reassign and to iterate or review tasks. Problem-oriented meetings completed the communication flow within the team. Customer meetings provided input to generate and communicate lists of user's needs.

Following the best-practice approach, the existing work processes in the team was analyzed and consolidated resulting in standardized and semi-automated procedures for application build and deployment, code generation and interfacing equipment electronics.

SPECIFIC CONTROLS ITEMS

The TINE Software Suite

The Threefold Integrated Network Environment (TINE) is a set of communication protocols and control system services. TINE is stream-lined for efficient network communication and provides optimal flexibility for the control system users. While already mature TINE is being continuously updated following the present technical developments, information technology trends and user's needs.

TINE is a multi-platform system, running on WIN32/64, Linux, most UNIX machines, MACOS, VxWorks and NIOS as well as some legacy systems. It is a multi-control system architecture system, allowing client-server, publisher-subscriber, broadcast and multicast data exchange. The transmission of video frames in multicast mode is routinely used at DESY [5].

The TINE kernel library exists in C and Java. Bindings are provided for Java, C/C++, LabVIEW, MATLAB, Python and .NET as well as legacy VB6. A command line interface for scripting tools is also available.

Name services are provided with plug-and-play automated server registration. Address redirection allows the grouping of existing servers into virtual servers which hide potentially complex topologies from the client user.

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

The connectivity to other control systems is a unique feature of TINE. TINE is embedded in DOOCS and EPICS. A gateway is provided to integrate TANGO servers.

Beam Position System Integration

The diagnostics equipment group at DESY has successfully commissioned a new beam position system based on 228 Libera Brilliance [6] modules.

Communication with the control system is realized via TCP/IP through the generic Libera Control System Programming Interface (CSPI). The N-to-1 client-server controls topology implies that all beam position modules (CSPI server) are supervised by only one heavily multi-threaded middle-layer server [7] (CSPI client) serving as gateway to the TINE control system. Specific procedures have been established for remote software installing and updating as well as restarting and rebooting of the distributed Libera modules.

TINE General Purpose Applications

According to our experience, control room applications based on the rich-client model are best suited for providing optimum visualization and performance. Consequently, a set of generic Java application [8] have been implemented on contract basis by Cosylab [9].

An alarm viewer panel informs the operator about critical device states. All alarms are processed and archived by the central alarm system which is an associated service of the TINE control system. The alarms are sorted by various categories and rated according to a predefined alarm severity scheme. Open as well as already closed alarm tickets can be displayed simultaneously if requested. Detailed metadata complete the pure alarm data.

Similarly, the different archive viewer applications (parameter archive viewer, multi-channel analyzer, event archive viewer, transient recorder viewer) support quick off-line analysis of all types of archived accelerator parameters (Fig. 1). Charts for data sets arranged as time series or event-driven data structures and correlation plots are provided.

The so-called scope trace viewer is a configurable graphical interface application with scope-like look-and feel to all data traces available through the control system.

In addition, an operation statistics application and various applications for administrative purposes complete the set of applications delivered.

Web2c Light-Weight Internet Applications

The Web2cToolkit [10] is a framework for internet control system applications. It provides customer-specific, browser-hosted, interactive and graphical client applications communicating with the Web2c Java servlet. The Web2cToolkit consists of run-time engines for synoptic displays, a graphical synoptic display editor and an archive data viewer.

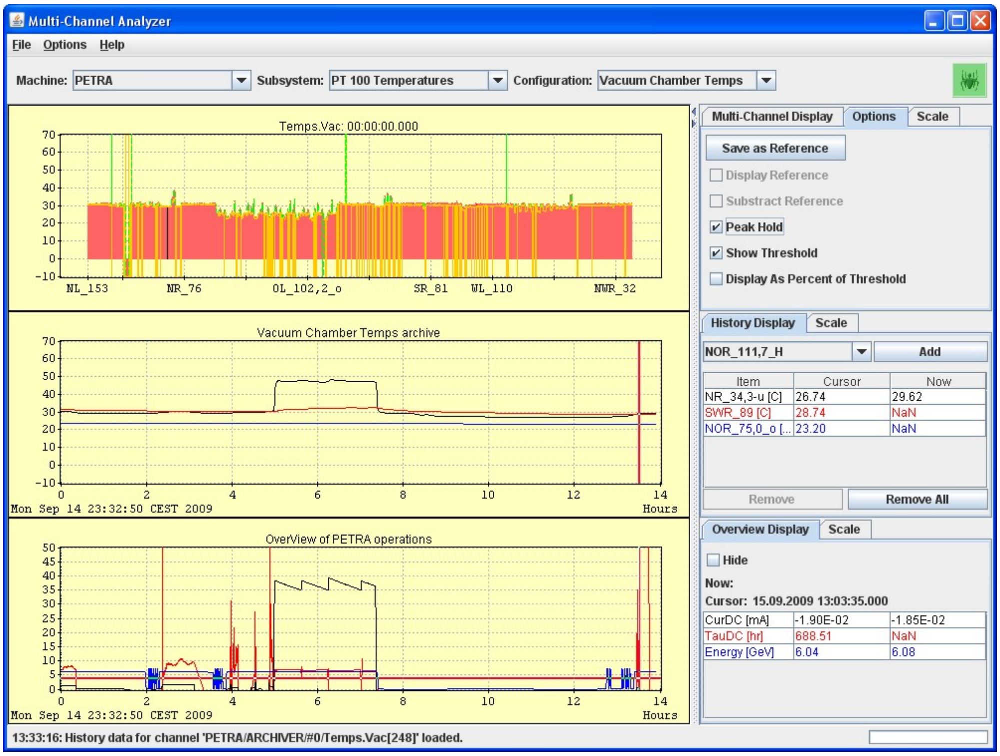

Figure 1: Multi-Channel Analyzer application.

The servlet connects via plugs to all major accelerator control systems (TINE, DOOCS, EPICS and TANGO). In addition it is capable of receiving jpeg-type video streams transmitted through the RTP protocol as well as control system embedded video streams (TINE). The video frames are being redirected to the Web2c client applications at a reduced rate.

Typical use cases for Web2cToolkit-based applications are overview or information live panels, service panels for remote maintenance or summary accelerator operation reports based on archived parameter data.

Console Application Manager

The Console Application Manager (CAM) [11] is a JMX-based management tool. It provides an intuitive to use launching pad for operator's applications by combining applications to task-specific groups. The CAM automates starting and stopping of grouped or single applications and re-applies screen attributes of applications (size and position). It is configurable by the operator and preserves the operator's preferences.

The Console Application Manager is primarily designed to handle Java-based applications. However, support for non-Java applications is integrated.

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