CONTROL SYSTEM INTEGRATION OF THE PETRA III BPM SYSTEM BASED ON LIBERA BRILLIANCE

Piotr Karol Bartkiewicz, Igor Krouptchenkov, Gero Kube, Frank Schmidt-Foehre, Josef Wilgen, Franziska Wedtstein and Honggong Wu, DESY MCS, Hamburg, Germany

Abstract

The PETRA III Storage Ring has recently successfully commissioned the new BPM System based on ~230 Libera Brilliance [1] modules. This is at present the largest full installation of these modules. This paper presents the complete BPM system from the control aspect. The distributed Libera Brilliance modules are connected via the control system internet. A dedicated middle-layer Linux PC running in a multithreaded environment communicates with all modules using the CSPI package provided by the vendor of the Libera Brilliance modules. This middle layer processes runs in the framework of the TINE [2] control system and services requests from the user applications. In this case, the middle layer server is heavily multithreaded and deals with hundreds of Brilliance modules and is therefore unique, as all the other Libera installations run in a one-process-to-one-Libera mode. Several well designed user applications written in Java and MATLAB® are used for commissioning, testing and operating the BPM system. An automation procedure has also been developed for remote installing and updating software packages, as well as restarting and rebooting the CSPI server running on the Libera modules.

INTRODUCTION

PETRA III [3] is a new high-brilliance synchrotron radiation source. The complete BPM system has been renewed to meet the resolution and stability requirements of PETRA III. The Libera Brilliance modules were chosen for BPM signal processing, and software development began in the autumn of 2008. The vendor-provided “generic server” (based on the remote CSPI software package) was used as the interface to the middle layer server program running on a single Linux PC. A dedicated MATLAB® program interfacing to this middle layer was developed and used during machine commissioning. Console applications were in place when the commissioning started on the beginning of April 2009.

BPM AND LIBERA BRILLIANCE

PETRA III is equipped with 227 BPMs for the orbit measurement. There are eight different types of electrostatic button pickup-stations because the vacuum system of PETRA III has various types of vacuum chamber cross sections. Commercial RF button feedthroughs from PMB and Meggitt are used as pickups for the BPM blocks. The 227 Libera Brilliance modules are housed in 24 racks, placed in the halls around the ring. An air conditioning system is used to provide temperature stabilization.

There are five main data paths of the Libera Brilliance: raw ADC data, TbT (“Turn by Turn”) data, decimated TbT data (factor 64) for a long time tracking interval, around 10 Hz slow acquisition (SA) data for monitoring and slow feedback calculation, and fast acquisition data (FA).

The raw ADC data sampling with 117MHz can be retrieved with 1024 samples with an event trigger. The TbT data with a revolution frequency of 131KHz is stored in a ring buffer and can be collected with or without trigger.

As a Single board Computer based on Linux kernel 2.6, the Libera Brilliance provides a C library called Control System Programming Interface (CSPI), which allows user applications to access the data of the Libera family in a consistent way. The Libera generic server is based on TCP sockets and the CSPI enables the data access remotely. The connection to the generic server is based on a “one thread per client” model.

LIBERA DATA COLLECTION SERVER

The Libera Brilliance modules are already used at other light sources, such as Diamond and ESRF. In all previous cases the control software have been intentionally embedded in the Libera Brilliance modules (either EPICS or TANGO). Each Libera Brilliance module itself becomes a “native” device server in the control environment. This represents the case of one device server to one module. A middle layer BPM server has to be developed to collect the data from individual Libera Brilliance and bring them together as an orbit server.

On the other hand, the generic server provided by vendor itself is already a BPM device server. The source code and Libera utility provide a good example of how to implement a user program accessing the Libera generic server remotely. There is no need to embed a TINE device server on each Libera Brilliance module. Developing one middle layer BPM server by using the CSPI generic server in the context of the TINE control environment was chosen for the integration of the Libera Brilliance modules into PETRA III. In this case there is a single TINE middle layer server accessing all 227 Libera modules via the CSPI generic server. This is then a model of a single node (one TINE device server) accessing many Libera modules, in contrast to the one-node-per-module model of the embedded solution. A major advantage of this model is that there is no need to deploy any control relevant software into the Libera Brilliance modules themselves, obviating any future need for control-system specific updates, etc. Vendor software upgrading would be decoupled with the control software.

Figure 1 shows the various scenarios of how to integrate the Libera Brilliance into the accelerator control system.

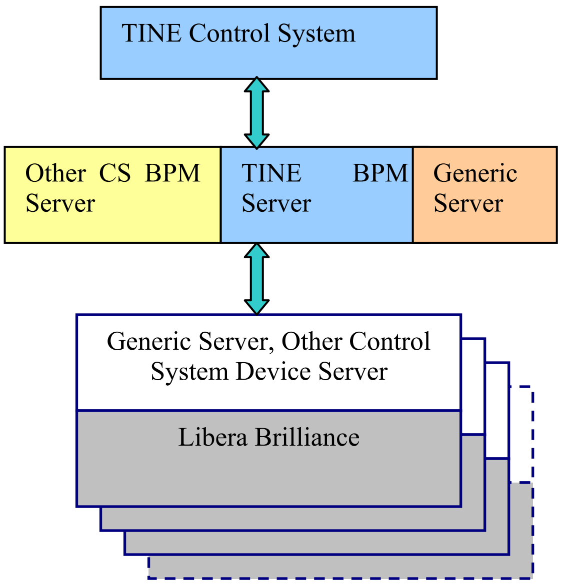

Figure 1: Integration to Control System.

The middle layer server is of course a multithreaded program. As the CSPI generic server is based on a one-thread-per-client model, accessing different data sources in parallel requires numerous simultaneous threads. Each Libera module requires five independent threads for data acquisition and environment data monitoring. The data sources are environment parameters, slow acquisition, raw ADC, TbT and post mortem data. The event handling mechanism for multicast is used to catch the injection trigger, Post mortem trigger and various interlock events, to propagate to the data accessing threads.

There are about 460 threads running continuously. The environment data, including temperature and fan speed, interlock information update at one Hertz, and associated parameters can be changed upon user request. The slow acquisition data are collected at a frequency of 10 Hz without data lost. The other threads are created when user application requests or some trigger events, e.g. Post Mortem trigger, are coming. In the case when all data are requested simultaneously, there would be more than 1100 threads running parallel. Besides the data collection the server has to provide information to user applications and central services such as alarm and data logging. The 100Mbit/s Ethernet connected to the middle layer Linux PC is capable of sampling slow acquisition data from all Libera Brilliance modules and supplying them to user applications at ten Hertz. In spite of all of these demands, the Middle-layer server has so far been working flawlessly over the initial half year period of operation.

The TbT and raw ADC data have been an integral part of tuning the beam during the commissioning phase. These data can be collected after the single injection trigger happens. With the injection event triggers at 6Hz the "first turn" data can be displayed continuously as well. In this case all Libera Brilliance modules results a Multicast to the Linux PC with a frequency of 1.36 KHz, the amount of data to read have to be reduced to a mere dozens of turns from each Libera in order to collect the data with the trigger frequency.

The Post Mortem data collection is similar to the TbT data collection. Upon the post mortem trigger, a thread for the Libera module is created to retrieve the 16K PM data through the generic server, saved in the local memory for application access.

BPM USER APPLICATIONS

MatLab Application for Commissioning

MATLAB has been an indispensable tool during the commissioning period, as it was used to handle the bulk of the analysis of the raw ADC, TbT and orbit data coming from the Libera system. Further details can be found in Ref. [4].

Libera Configurator

The large number of installed Libera Brilliance modules requires a specialized software tool in order to allow experts to perform the initial setup as well as any general maintenance tasks. Such an application was written as a Java client application, giving access to all relevant parameters by addressing corresponding properties of the BPM server. The client-server connection makes use of various TINE data transfer modes, offering continuous status polling of all BPMs, and read-write methods of selected parameters. Due to importance of some settings all possible users were categorized as 'experts', 'operators' and 'watchers'. The Libera Configurator application offers three different running modes (mode selection protected by passwords) limiting write access to certain parameters.

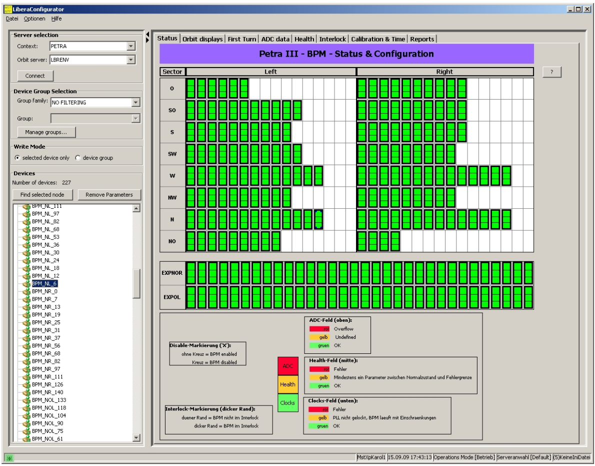

Figure 2: Libera configurator status overview.

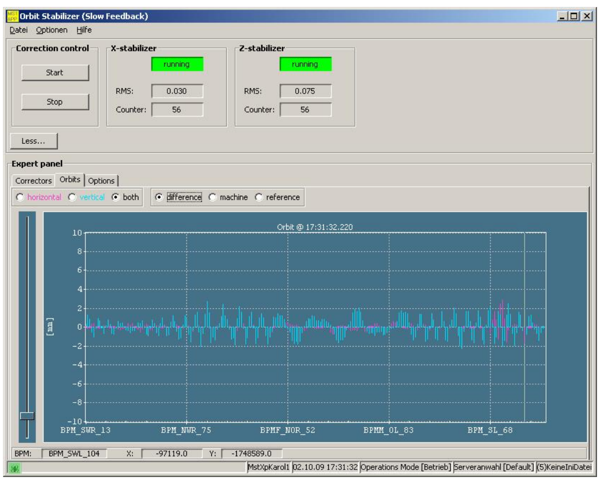

Figure 3: Overview of orbit stabilization client.

Figure 4: Orbit correction overview.

BPM Slow Orbit Feedback and Correction

The aim of a slow orbit feedback system is to cancel slow motions of the beam within time span of a few seconds. The core of the system is a Slow Orbit Stabilizer, a middle-layer server code, running on the Linux PC, getting orbit data from BPM server and sending correction decisions to Central Magnet Control Server. The Slow Orbit Stabilizer uses the SVD algorithm (singular value decomposition) to calculate current changes of corrector magnets. Communication between Slow Orbit Stabilizer and the BPM server as well as the Central Magnet Server is provided by the TINE control system. The Slow Orbit Stabilizer Client application provides operators in control room with an overview of the stabilization process as well as a possibility of stopping the stabilizer or re-starting it with different a parameter set (such as the number of used correctors or period in which the correction is applied). A Java orbit correction application makes use of the local bump method to correct orbits.

CONCLUSION

The BPM system based on 227 Libera Brilliance modules has been successfully integrated into the PETRA III TINE control environment. The vendor provided interface package, the remote CSPI has been working reliably with the Linux heavily multithreaded BPM middle layer server. Numerous user applications have proven invaluable for the commission and orbit measurement. The whole BPM system has been running smoothly since successful commissioning in the beginning of April 2009. Slow and fast orbit feedbacks are still under further development.

REFERENCES

[1] Instrumentation Technologies, Slovenia, http://www.i-tech

[2] http://tine.desy.

[3] Technical Design Report (TDR) "PETRA III: A low Emittance Synchrotron Radiation Source" Ed. K. Balewski et al., DESY 2004-035.

[4] A. Brenger et al., Proceedings of DIPAC09, "Experience with the commsioning of the Libera Brilliance BPM Electronics PETRA III",.