ESRF'S NEW BEAM POSITION SYSTEM FOR THE STORAGE RING USING LIBERA BRILLIANCE DEVICES

F. Epaud, ESRF, Grenoble, France

Abstract

The ESRF has entirely refurbished the control of the Storage Ring Beam Position Monitors. 224 intelligent controllers (Libera Brilliance) have replaced the former system working for 17 years. The orbit feedback software reads the orbit parameters from these devices via a set of hierarchical TANGO device servers.

This challenging upgrade has been done progressively over 3 months without interrupting the operation of the ESRF [1]. This paper describes the architecture of both Slow and Fast Orbit Feedback control systems with a particular focus on the challenges linked to data flow generated by this high number of devices. It makes a point on the tools developed for installation and maintenance.

This fast and efficient result was possible thanks to a collaborative development at several levels. The Synchrotron SOLEIL developed the TANGO device server for the Libera which was then re-used and improved by the other Institutes within the collaboration: ELETTRA, ALBA and the ESRF. The FPGA firmware for the Communication Controller of the Fast Orbit Feedback was initially developed at the DIAMOND Light Source and also used by SOLEIL and the ESRF and is now become a standard option of the Libera.

MOTIVATION

The Council of the ESRF, which includes 19 countries, decided in 2008 to launch an ambitious Upgrade Programme, spread over ten years, from 2009-2018. It will build on 20 years of experience and know-how serving a community of more than 10,000 scientists.

The Upgrade will deliver beamlines with remarkable new capabilities and associated environments that will greatly enhance the ESRF's scientific impact.

Improvement of beam positioning is a main issue to achieve the required beam specifications, therefore it has been decided to refurbish the old BPM system conceived 20 years ago. At that time the Slow and Fast orbit corrections was two separated systems but now it has been demonstrated at other light sources (DIAMOND, SLS, ...) that both functionalities can be achieved by the same equipment [2].

One constraint was to upgrade the system gradually during the normal operation and only a few shifts of 8 hours can have been dedicated for the commissioning.

SYSTEM ARCHITECTURE

After market investigations, the Libera Electron from Instrumentation Technologies Company [3] has been selected at that time and used for the first feasibility studies. Later the Libera Brilliance has been used for the upgrade of the 224 BPMs stations of the Storage Ring.

Hardware Device (Libera Brilliance)

Seen from the computing point of view, the Libera Brilliance is a device which calculated the beam positions with four 16 bits ADC inputs connected to the four Radio Frequency signals coming from the Electrodes of the BPM head and thanks to the help of performing treatment algorithms within a FPGA. This device can provides up to 5 data streams which have to be handled by the control system over an Ethernet connection:

- SA (Slow Acquisition): Data coming at 10 Hz: X and Z positions, 4 electrodes values, sum of the Electrodes.
- Turn by Turn: Data buffer of up to 55,5 kilo samples and coming at the Machine Trigger Frequency (Up to 10 Hz at the ESRF).
- ADC: Data buffer of 1024 samples and triggered also by the Machine Trigger.
- Post Mortem: Data buffer of up to 16 kilo samples, triggered by external hardware signal coming from the Machine Interlock system.
- FA (Fast Acquisition): Continuous X and Z positions data stream at 10 KHz but using a dedicated 1Gbits/sec Ethernet Link.

The given data flow given above for one Libera device had to be multiplied by 224 devices to dimension the network and computing infrastructure (figure 1).

The Libera embed an ARM microprocessor running Linux which allows to control the internal resources and to transmit the data using a TCP/IP socket based Ethernet connection hidden by a library named CSPI (Control System Programming Interface).

BPMLibera Device Server

The TANGO device server has been first developed by SOLEIL [5] for the first generation of the Libera, the Electron. It is used also at ELETTRA and in the near future at ALBA as well. We have greatly benefited from this server which was totally debugged by SOLEIL because it was in use since at least two years and have been improved at the time as the several versions of Libera firmware. Thanks to it, it has been very rapidly possible for us to acquire SA positions (at 10 Hz) and also to make Turn by Turn measurement.

A BPMLibera TANGO device server handles one Libera, therefore we have 224 device servers to handle the Storage Ring BPM system.

Nevertheless, we have had to modify this server because the way of using this device at some points is not the same in all the Institutes. The mains ESRF's modifications have been:

- Adding of X and Z global offsets: In new Institutes like SOLEIL and ALBA the offsets and Gains of the BPMs head and also of the Libera front-end Electronics are measured in Laboratory and set as TANGO properties, but for already commissioned Storage Ring as the ESRF, these offsets can be directly measured with beam. Therefore we have added two TANGO properties.
- Also we have reused from the previous BPM system an ESRF's algorithm using arctan() which better calculates the beam position at low current.
- We added also the calculation of electrodes drift. We have observed since years that electrodes can smoothly but also sometime rapidly drift and therefore can suddenly involve huge error in the position calculation. Therefore the device server checks this parameter and possibly reports error to allow automatic disabling of the faulty station.
- Others little modifications required by our Accelerators Physicists have been added: RMS on whole SA history buffer (3 minutes at the ESRF), RMS on DD buffer,...

BPMLiberaAll Device Server

On top of the 224 BPMLibera device servers, another device server BPMLiberaAll is in charge of regrouping the data and to make them available to the clients. Except for debug and maintenance, the Applications used in the Control room never access directly the 224 BPMLibera device servers but always the BPMLiberaAll. This speeds up the data collection but also avoids having incoherent setting. Accessing the 224 BPMLibera device servers is made by TANGO attributes Group call (same attribute read/write command sent to all the Liberas). The reading of one scalar (e.g. double, long ...) on all of the 224 device servers requires only ~15 milli-seconds.

This server has also much other functionality:

- Enable/disable stations, checks electrodes incoherencies, detects frozen Libera (this occurred sometime with Libera firmware release 1.82)
- Can manage several versions of BPMLibera device servers. This has been necessary during the smooth upgrade when we have had up to 3 different versions of Libera Brilliance firmware at the same time.
- Make positions corrections according to the Storage Ring current.
- Checks coherencies of vital parameters and rises a warning if incoherencies are detected.
- Checks parameters which can involve huge network traffic when they are enabled.
- Archives the positions and RMS on positions into our History Database and also some maintenance parameters.
- Manages the Fast Orbit Feedback synchronisation and starting-up.

Computing and Network Infrastructure

The Libera Brilliance hosts an ARM microprocessor with a Linux operating system, therefore a try to embed the TANGO device server has been made by Nicolas Leclercq from SOLEIL with the help of Michael Abbott of DIAMOND Light Source for floating point emulation optimisation.

Table 1: Computing Needs Measured on One PCI Linux Crate for One Libera (Left Number) and Estimated for the 224 Liberas (Right Number)

Mode	CPU	Memory
SA (10Hz)	0.07 / 16 %	1.2 / 268 MB
SA + DD@1Hz (50 samples)	0.18 / 40 %	1.2 / 268 MB
SA + DD @1Hz (5.5 K samples)	1.8 / **403 %**	1.2 / 268 MB

This architecture can be used when collecting SA data at 10Hz (as at ELETTRA) but provides huge limitation when using Turn by Turn data. Therefore, at the ESRF we decided to not use the embedded version of the server but to run it on dedicated PCI computers running Linux. Unfortunately this architecture has draw back to the network architecture because the data should be transmitted over the Ethernet TCP/IP socket connection from the Libera to the host running the TANGO device server.

Table 2: Network Bandwidth Measured at Several Points of the Network (Figure 1). Points 1: On the Libera Ethernet Connection; 2: Between the Cells Switch and the Central Switch; 3: Between the Central Switch and a PCI Crate Handling ¼ of the SR (56 Libera Devices); 4: Between the 2 Networks Switches (Estimated)

Mode	Network points 1, 2,3,4
SA (10Hz)	0.1 / 0.1 / 1.5 / 0.1 %
SA + DD@1Hz (50 samples)	0.2 / 0.1 / 1.5 / 0.1 %
SA + DD@1Hz (5.5 K samples)	1.8 / 0.6 / **11** / 0.9 %
SA + DD@10Hz (5.5 K samples)	9 / 2.5 / **48** / 4 %

Some computing resources and network bandwidth measurements (tables 1 and 2) demonstrated that there will be no problem for SA data, but that Turn by Turn measurement will have to be carefully used if using the actual network infrastructure shared with the rest of the control system. Nevertheless we decided to use the current network infrastructure and 4 last generation PCI crates (PCI Express, Pentium 4 Core Duo / 2 GHz – 3MB RAM) to run the 224 BPMLibera device servers (56 per crate) and a 5th one to run the BPMLiberaAll (figure 1).

Upgrade Tools

The Libera Brilliance was not fully adapted for our needs and we have requested some modifications or improvements to I-Tech and had therefore to suffer of the

several firmwares and TANGO device server releases to install, therefore some tools for the smooth upgrade from the old system to the new system, but also from one release to another had to be developed.

All the units were delivered in November 2008 with 1.82 release and in January 2009 we started to test the 2.00 release. During that time and according to our request, I-Tech has integrated the DCC (Diamond Communication Controller) and then delivered the 2.02 release. Since then, we have had also the 2.03, 2.04 and recently the 2.05.1. For most of these releases, the TANGO device server had to be at least relinked and sometime modified.

Also because the upgrade needed to be done in a limited time during MDT (Machine Dedicated Time: 1 day per week to be shared with other Accelerators Physics Experiments) all the releases needed to be carefully tested and installed first on one Libera then on the 7 Liberas of a Cell. Finally when the release had been fully tested on a cell, it could be installed in one shoot on the 217 remaining Liberas.

Also the V1.82 to V2.00 was a major upgrade with a change of the Linux distribution with was not without risk to break the Libera, therefore we have preferred to make this upgrade one Libera per one Libera. Finally we have broken 3 devices during their upgrades, but they can be recovered with the help of the I-Tech company.

Fast Orbit Feedback

The 224 Liberas are now operational since March and used for the Slow Orbit Feedback. In parallel to many improvements we are working on, we also are currently developing the Fast Orbit Feedback [2,4,6]. We have chosen to use the DCC (Diamond Communication Controller) to transfer data at 10 KHz from the 224 Liberas to 8 corrections stations plus one diagnostics station and asked I-Tech to integrate it as an option of the Libera Brilliance.

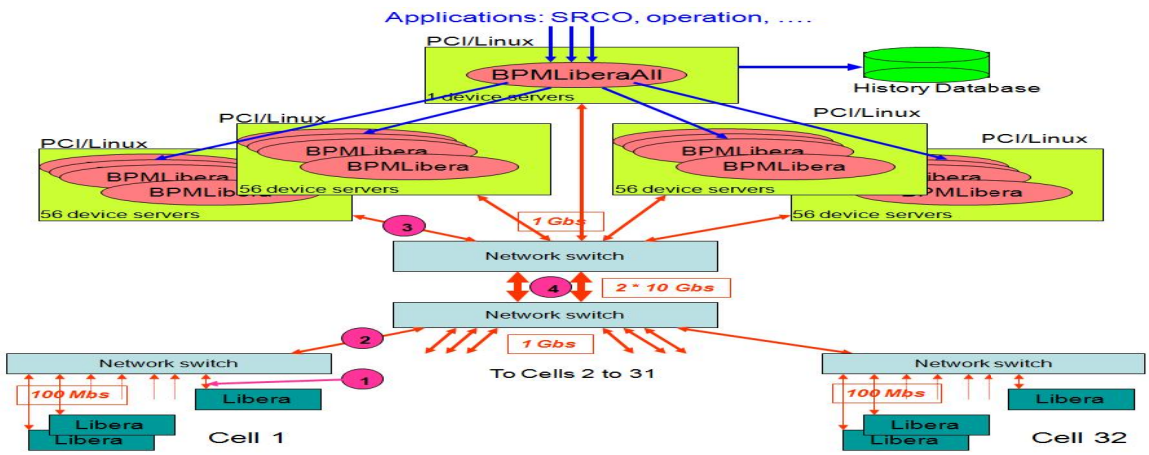

Figure 1: Network and software architecture of the new ESRF's BPM system for the storage ring using Libera devices.

Results

Presently, mainly the SA mode at 10Hz is daily use for the Slow Orbit correction and the performance of this system has been drastically improved (Figure 2).

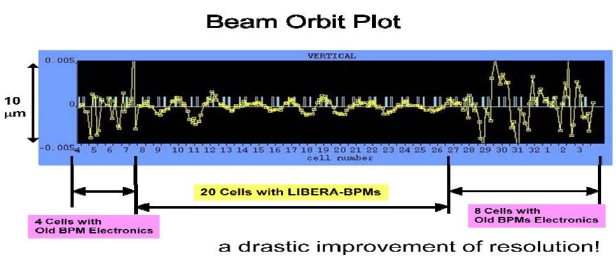

Figure 2: Improvement of the BPM system resolution.

We are currently working on the commissioning of the Turn by Turn mode and the development of the Fast Orbit Feedback, but already some new ideas as the calculation of the transfer Efficiencies, the Lifetime and the Tune measurements are in mind for future improvement of the Accelerators diagnostics.

REFERENCES

[1] K.B.Scheidt, F. Epaud, ESRF, "Installation and Commissioning of a complete upgrade of the BPM system for the ESRF Storage Ring," MOPD05, DIPAC-09, Basel.

[2] G.Rehm, "Digital eBPMs at Diamond : Operational Experience and Integration into a Fast Global Orbit Feedback" , mod1a01, DIPAC-07, Venice.

[3] Instrumentation Technologies, http://www.i-tech.si.

[4] N. Hubert et al., "The SOLEIL BPM and Orbit Feedback systems", TUPC020, DIPAC-07, Venice.

[5] N.Leclercq, Synchrotron SOLEIL. BPMLibera TANGO device server Users'guide.

[6] E. Plouviez, J. M. Koch, ESRF, "New Fast Orbit Feedback Architecture Based on Libera Brilliance Devices for the ESRF Storage Ring," THB004, ICALEPCS-09.