INTEGRATION OF NEW POWER SUPPLY CONTROLLERS IN THE EXISTING ELETTRA CONTROL SYSTEM

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Abstract

The Elettra control system has been running since 1993. The controllers of the storage ring power supplies, still the original ones, have become obsolete and are no more under service. A renewal to overcome these limitations is foreseen. A prototype of the new controllers based on the BeagleBone embedded board and an in-house designed ADC/DAC carrier board, has been installed and tested in Elettra. A TANGO device server running in the BeagleBone is in charge of controlling the power supply. In order to transparently integrate the new TANGO controlled power supplies with the existing Remote Procedure Call (RPC) based control system, a number of software tools have been developed, mostly in the form of TANGO devices and protocol bridges. This approach allows us to keep using legacy machine physics programs when integrating the new TANGO based controllers and to carry out the upgrade gradually with less impact on the machine operation schedule.

RENEWAL OF POWER SUPPLY CONTROLLERS

The Elettra synchrotron light source has been running since October 1993. Many of its subsystems have been replaced or refurbished since then, but some of the core systems, such as the magnet power supplies controllers [1], are still operating with the original components. Unfortunately their VME boards are no longer serviced by the manufacturer and their electronic components are no more available on the market. Although we have acquired the capability to repair some of the most common failures, we cannot guarantee the full working of this vital part of the control system in future, considering that the failure rate of the components may rise as they grow older. In order to prevent this potential crisis, we have started a project to renew this part of the control system, starting with the big magnets: bending, quadrupoles, sextupoles.

Requirements and Constraints

The new power supply controller (NewPSC) that replaces the old VME-based system must satisfy several requirements:

- extend the power supply (PS) control system lifetime for at least 10 years;
- use the existing PS electrical interface to the controller with no change on the power electronics side;
- use open design components;
- simplify the present two level architecture using a single controller connected to the PS hardware and to the Ethernet control network;
- extend diagnostics capabilities and functionalities;

The new PS controller must also respect some constraints:

- have equal or better performance and stability compared to the existing PS controller;
- easy installation and replacement;
- the integration of the new PS controller with the existing software of the control system must be transparent;
- run the machine with a mix of new and old PS controllers for testing or upgrading in batches;

The "NewPSC" BeagleBone Based Controller

The NewPSC is based on a BeagleBone board [2, 3], powered by an AM3358 or AM3359 system-on-chip running at 720 MHz; it has a 100 Mb/s Ethernet interface, expansion connectors for I/O pins, open source approach for both hardware and software and runs several flavors of Linux. This powerful and inexpensive board is used as "smart node" in several applications at Elettra [4–6].

The BeagleBone provides the computing power, Ethernet connectivity for the NewPSC to the rest of the control systems and interfaces to the power supply local electronics via a dedicated carrier board developed in house [7]. The carrier board provides analog to digital conversion (ADC), digital to analog conversion (DAC) and several digital input and output channels, replacing the functions formerly carried out by several VME boards (see Fig. 1). The electrical performance has been optimized and characterized [8] in order to guarantee the performance of the NewPSC is equal or better than that of the old system.

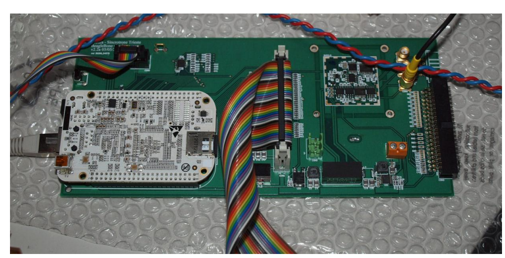

Figure 1: The NewPSC prototype.

INTEGRATION WITH THE EXISTING CONTROL SYSTEM

The control of the NewPSC is implemented as an embedded TANGO device server running on the BeagleBone. TANGO has been adopted at Elettra in 2004 and all new developments since then have been based on TANGO. Many parts of the control system and high level programs are however still running with the old CERN nc/rpc [9] based services, including the controllers of the magnet power supplies. We had to provide some means to integrate the NewPSC TANGO devices with the legacy nc/rpc based programs in

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order to guarantee uninterrupted and smooth operations of the accelerator; moreover we wanted to test the eventual impact of the NewPSC on the performance of the accelerator without introducing unneeded changes to the operating environment. This was accomplished by developing a protocol bridge, known as lpc2tango.

Lpc2tango Protocol Bridge

The old Elettra control system is based on 3 levels of computers. The middle level computers, named Local Process Computers (LPC) handle the data exchange from top level computers and applications to the rest of the system; applications interact with LPCs via the so called lpc service. This service, based on CERN nc/rpc protocol, allows to read and write (get / set) control system variables identified by names (in the form of C strings) and to issue simple commands (no data associated) also identified by names. The control system variables can be of different types: double, integer, string, boolean and their arrays. The lpc service implements the minimum set of features needed by a control system. The lpc service is supported by an auxiliary library implementing a static database used for associating a named variable to an host name and port number for address resolution.

Named control system variables are easily mapped to TANGO *device/attributes*, while simple commands are mapped to TANGO *command_inout* primitives in the special case without input and output parameters. In other words, the functionalities of the lpc service are a proper subset of those of TANGO. We have exploited this fact for developing a dedicated rpc server which does the actual mapping from lpc protocol (read or write of named variable) to the appropriate TANGO primitive (read or write of device/attribute, command_inout). The server is configured by means of a configuration file. TANGO exceptions are transformed into the appropriate error codes and messages too. The behavior of the lpc2tango server, from the client point of view, is identical to that of the native lpc server.

We took great care to design the software interface and behavior of the NewPSC TANGO device to be compatible with that of the old power supplies. This was a fundamental constrain to be satisfied, otherwise it would have been impossible to smoothly integrate programs written more than twenty years ago with servers written and deployed at the beginning of 2014. Accurate analysis and modeling are two keys of the success of the NewPSC integration.

TANGO Proxies for the Old Control System

The old Elettra control system uses a specialized nc/rpc based service for getting and setting the current of all the machine power supplies as a single operation. This service, named SARE , is used for performing the so called SAve/REstore operations. All the magnet power supplies settings are read form the equipment and saved as a single entity in a database table; the saved data is identified by a unique key. This key is used later to recover the settings and restore all the magnet power supplies settings. Save/restore is one of the most important control room tools and is essential for accelerator operations.

We estimated that writing a protocol bridge for the SARE service would have been technically difficult and not worth the effort for two main reasons:

- need to modify some old code running on 68030 CPUs, with the need to recommission a system that has been running since 1993;
- save/restore is accessed by a single dedicated operator graphic panel;

The TANGO based snapshot database [10] and its companion tools provide the same functions of the old SARE system and its graphic panel. They are already extensively used at Elettra for the booster and FERMI operations, so we decided to use them also for the storage ring power supplies. In order to do this we wrote a set of TANGO devices which act as proxies to the old control system, calling the appropriate rpc functions of the lpc service for getting and setting all the power supply variables from TANGO. Also in this case we took great care to perform the correct analysis and implementation of the interface and behavior of the TANGO device so that it is compatible with the NewPSC. The programming effort was relatively light since we had to develop only two device servers for handling the differences between the power supplies of the big magnets and those of the steerer magnets. We also exploited inheritance features of TANGO in C++ for sharing about 50% of the code of the two devices.

A desired effect of the implementation and deployment of the TANGO proxies for the power supplies is the possibility to use the old control system with many different tools developed with TANGO and not only with the snapshot database. For example we have recently deployed the Matlab Middle Layer [11] using the Soleil developed TANGO interface.

In the end, legacy and new applications work in a hybrid environment (see Fig. 2).

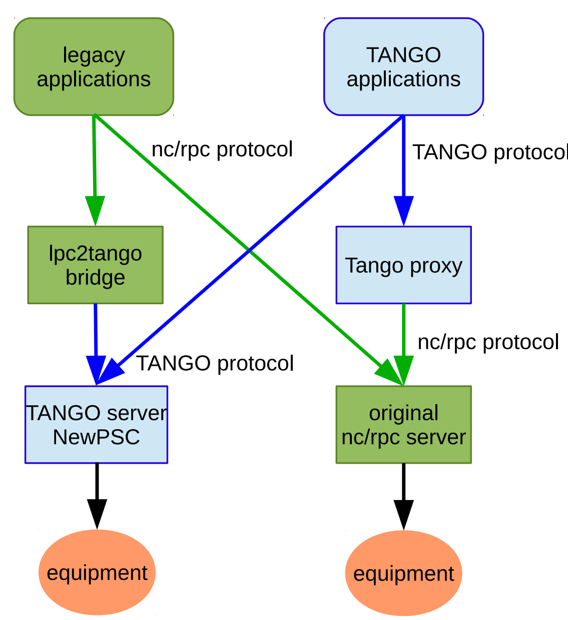

Figure 2: Bridges and proxies in hybrid environment.

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STATUS AND FUTURE DEVELOPMENTS

Status

Three power supplies of the Elettra storage ring have been under full control of the NewPSC since march 2014 (see Fig. 3). The performance of the storage ring and that of the power supplies [12] have been completely satisfactory and no problems have been detected. The integration of the NewPSC has been almost transparent for operators and physicists and no additional downtime or impairment of operations have been experienced.

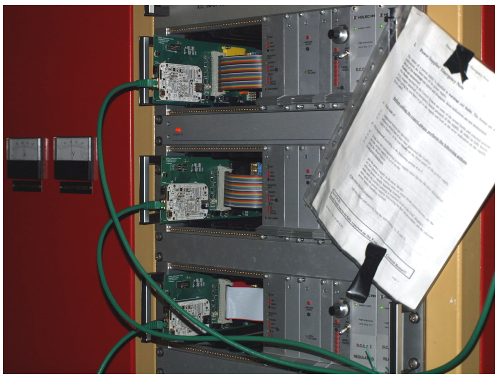

Figure 3: NewPSC installed in Elettra.

Following the positive results of the tests, the renewal of the controllers of the power supplies of the main Elettra magnets has been approved. We began the procurement procedure for building the required number of NewPSC controllers (42 plus spare parts) and planned their installation.

The NewPSC assemblies will be equipped with an LCD touch screen providing local control and diagnostics during maintenance activities.

Future Developments

We are designing the prototype of a new BeagleBone based controller for the Elettra steerer power supplies. The new design may also be used to upgrade the power electronics of the power supplies, moving from the present analog linear design to a digitally controlled PWM power module.

CONCLUSION

The integration of the NewPSC in the Elettra control system has been successful. During the more than six months long test of the first three pre-production controllers no disruptions or delay to machine operations due to the new system occurred. We are able to run both legacy and new high level applications transparently using a mix of new and old power supplies controllers. We will thus be able to manage the transition to the new controllers with ease and flexibility: we can decide to upgrade all the power supplies in one go or in different batches.

A careful analysis and design of the NewPSC interface and behavior, which focused also on the backward compatibility with the old system, has been one of the keys of the project success.

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