STATUS OF SOLEIL CONTROL SYSTEMS

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Abstract

The SOLEIL light source is a 2.75 GeV third generation synchrotron radiation facility under construction near Paris. Storage ring commissioning began in May 2006 and 10 beamlines will start operation for the end of 2006. This paper will describe, from the electronics and software point of view, the technical choices and architectures of the control systems of accelerators and beamlines, and will give the current status of the deployment.

OUR VISION AND DESIGN GUIDELINES

Industrial Approach

The control system of a synchrotron shares many similarities with other large scientific facilities (*LHC, W7X, LMJ…*), and some elements are not very different to the control system of a factory or a power station. As a consequence, solutions to most of the control needs have already been found in the industry.

We can quickly summarize the control requirements to:

• Analog input or output – *fast or slow, with large or small accuracy, synchronous or asynchronous*

• Digital input or output - with different levels (*TTL, PECL…)*

• Data exchange mediums (*serial link, GPIB*)

In order to meet these requirements, we have divided the electronics of the control system into three categories:

• **Programmable Logic Controllers** (PLC) for slow and well known processes,

• **Compact PCI** systems for fast or synchronous control,

• **Standalone crates** to control motors.

Each piece of hardware control is interconnected via Ethernet so as to exchange data and commands. Locally, a simple, industrial and widespread fieldbus (**PROFIBUS**) is used to connect equipment to the control system.

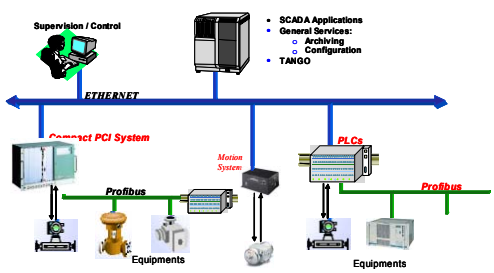

Figure 1: Hardware Architecture of SOLEIL's Control System.

The "LEGO®"Model

Small blocks of hardware and software have been identified and made, then assembled to build the Machine and Experiments control systems, like bricks of a LEGO [3] set. For instance, to generate a synchronous 16 bits analog signal, a commercial product has been standardized and the corresponding software component (*a TANGO Device Server*) has been developed.

The object oriented approach of our software framework, the TANGO one, allowed us to have such a modular approach and obtain this software and hardware project breakdown.

TANGO has been designed to be "control system middleware" and has proved to be a very good "integration system" allowing us to integrate easily all these various pieces in a coherent and effective manner.

Large Use of Subcontractors and Commercial Products

Because the size of the team is designed for the exploitation and not for the construction of SOLEIL, mass-market technologies and products have been extensively used. Moreover, using the mass market in control allows saving money. Calls for tender have been made to select products that fit our requirements at the best price: PLC, CPU, Motion controllers…

Many subcontractors have been employed to carry out well identified, known and standalone projects which in turn have required additional staff with specific skills: this is the case for PLC integration, PCB design, Software Device Server development, java applications.

ELECTRONIC ARCHITECTURES ON ACCELERATORS

Programmable Logic Controllers

Siemens S7-300 PLC's are dedicated to slow and safe applications like vacuum, temperature, interlock, etc. Digital and analog inputs/outputs can be connected directly or via the Profibus fieldbus to the PLC and of course a generic TANGO Device Server has been developed to exchange data with higher software layers.

After a training period, the Machine groups have developed their own PLC applications with the help of the control staff and of Siemens support.

About **100 PLC's** needed for the control of the Machine are installed and in production on the transfert

lines, Booster and Storage Ring . Verification, integration, and cabling folder were done by subcontractors. About 40 PLC needed for front-ends control are being currently installed.

Motion Systems

A ready-to-use solution, based on the 8-axis Galil DMC-2182 controller, the Midi-Ingénierie and Phytron power boards, is available to control standard motors:*(i.e 4-phases bipolar stepper motors, absolute SSI or incremental TTL encoders)*. SOLEIL has developed three crates called ControlBox, DriverBox and VacuumBox to supply standard packaging and connectors, and provides a kit of software utility and TANGO Device Server. If necessary, the standard solution can be adapted to control non standard motors like brushless or ceramic ones.

About 15 motion controllers needed for the control of the Machine are installed and in production on the transfer lines, Booster and Storage Ring. About 25 motion controllers will be installed during the next months for front end controls.

Compact PCI Crates

Compact PCI are dedicated for fast, communication bus, and high performance applications. A 6U crate customized contains 2 distinct Compact PCI buses which can receive 3U or 6U boards: Inova CPU with Pentium-M processor, I/O boards provided by ADLink and National Instruments. External patch panels developed by SOLEIL give standard connectors for standardized boards.

All CPCI crates run Win2000, which allows us to use mass market products (National Instrument for instance) with widely used and debugged drivers. The REMBO [10] software has been selected to manage the software images deployment and automate installation of these "remote" computers.

80% of the Compact PCI systems are now in production on the Accelerators. This represents about 60 double-buses crates hosting about 100 CPUs and 150 I/O boards with the associated patch-panels. The missing 20% for front end controls will be installed during the next months.

Timing System

The timing system, which is needed to trigger equipments synchronously to the beam, is based on a solution developed for the synchronization of the CEA's MegaJoule Laser: a central system provides clocks and data events and broadcasts them to local systems through an optical fiber network. Located in Compact PCI crates close to the equipments, these local systems generate delayed signals to trigger them.

To meet our needs, a redesign of this system has been done by GreenField Technology company. A central system with about 20 local systems are currently in production.

COMPUTING AND NETWORK INFRASTRUCTURE

Ethernet Network

The machine control network is based on a "network heart" – a CISCO 6500 switch with redundant critical components – connected to 30 "secondary" CISCO 3750 switches through redundant fiber optic cables.

Up to 900 connections points are installed now. The deployment of a WIFI network is forecast this summer to provide wireless connections in the technical gallery around the storage ring. The aim is to ease maintenance operations on accelerator equipments during Machine shutdowns.

Computers Infrastructure

At the higher level of the hardware architecture, about 30 X terminals are deployed as operators console in the control room. They proved to be a good solution to minimize installation and support workload.

Located in the synchrotron computer room below the control room, about 30 rack mounted Linux bi-processors support all general control services – archiving, configuration databases, general purpose Device Servers, supervision applications, beam dynamics applications, X terminals support – and classical services – filer, etc. –.

SOFTWARE ARCHITECTURES : THE TANGO CONTROL SYSTEM

TANGO : The Software Framework

On the software side, the architecture is based on the TANGO [2] bus, a framework initially developed at ESRF.

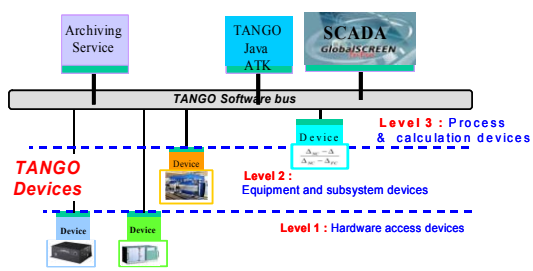

Figure 2: Software Architecture of SOLEIL's Control System.

The collaboration contract signed on March 2002 between the ESRF [4] and SOLEIL definitively boosted the TANGO development. ELETTRA [5] and ALBA [6] joined the collaboration in 2004 and 2005 respectively.

After 4 years of collaborative effort, TANGO has reached the required level of maturity and has proved to be a good performance and easy to use framework for software developers.

Status of Development of Device Servers

100% of low level *(level 1)* devices are now operational. For equipment and subsystems devices, and process or calculation devices *(level 2 and 3)* work is still going on and is completed at about 70%. At the moment, more than 8000 devices coming from more than 150 object classes are running on the SOLEIL site.

SUPERVISION TECHNOLOGIES

On top of these devices, the TANGO system provides services, bindings for scripting or data processing environments, applications and GUI development environments commonly named « high » level applications.

Archiving System

The major functionality delivered as a Tango service is the archiving service. The goal of this service is to maintain the archive history of about 6000 main accelerators control parameters, in order to be able to correlate signals or to get snapshots of the system at different times and to compare them. *(see paper [1] and references therein).*

Bindings with User's Environments

To give to users of LABVIEW, MATLAB data processing tools, the ability to access data acquired from the Tango control system, SOLEIL developed for each of these environments what is called a dedicated binding, that is, a tango shared library acting as a dynamic wrapper for tango requests (command executing, attribute reading and writing) written in the given environment language syntax to the underlying C/C++ tango core method calls.

For example, it allows interfacing the MATLAB beam dynamics applications to TANGO. *(see paper [1] and references therein).*

Sequencing System

To address batch processing and sequencing needs, two kinds of environments are available: the Python scripting environment for which a dedicated Tango binding have been developed and **Passerelle** [7], a graphical environment in which sequences can be modelled by drag dropping component actors (representing elementary tasks) and to use a graphical language syntax to "program" data flow between successive tasks to achieve the wanted process execution.

Supervision Applications

Supervisory and control applications are all Java applications using the Java beans technology and made up on top of the **Application Tango Toolkit** [8]. This toolkit serves as a base to develop generic graphical applications to handle basic issues: configuration, commissioning, etc.

SOLEIL also adopted **GlobalSCREEN** [9], a professional Java SCADA. This environment enables end users to quickly build user-friendly GUIs without writing any java code and by drag-dropping reusable widget components. It also provides many functionalities as access right management, web access and remote administration.

A cooperative work with Machine and Beamlines teams has lead to the definition of a standard "SOLEIL look and feel" for all applications. A SoleilLibrary of widget components required for application developments has already been developed by the control software team. Internal guidelines for a coherent product use have been defined

As a result, the Machine and Beamlines teams are able to build themselves their supervisory applications. Almost 10 applications are routinely used for Machine Controls today *(see paper [1] and references therein).*

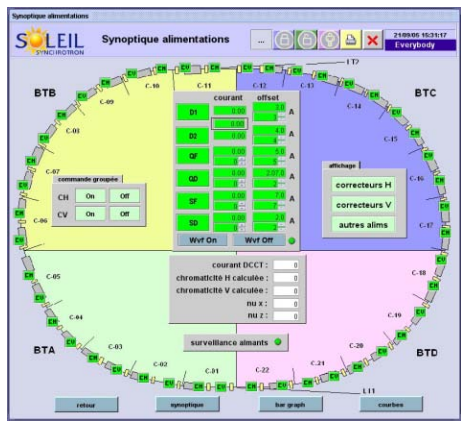

Figure 3: The Booster supervision application

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