OVERVIEW OF THE SPIRAL2 CONTROL SYSTEM PROGRESS

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Abstract

Spiral2 whose construction physically started by the beginning of this year at Ganil (Caen, France) will be a new Radioactive Ion Beams facility to extend scientific knowledge in nuclear physics, astrophysics and interdisciplinary researches. The project consists of a high intensity multi-ion accelerator driver delivering beams to a high power production system to generate the Radioactive Ion Beams being then post-accelerated and used within the existing Ganil complex. Resulting from the collaboration between several laboratories, Epics has been adopted as the standard framework for the control command system. At the lower level, pieces of equipment are handled through VME/VxWorks chassis or directly interfaced using the Modbus/TCP protocol; also, Siemens programmable logic controllers are tightly coupled to the control system, being in charge of specific devices or hardware safety systems. The graphical user interface layer integrates both some standard Epics client tools (EDM, CSS under evaluation, etc …) and specific high level applications written in Java, also deriving developments from the Xal framework. Relational databases are involved into the control system for equipment configuration (foreseen), machine representation and configuration, CSS archivers (under evaluation) and Irmis (mainly for process variable description). The first components of the Spiral2 control system are now used in operation within the context of the ion and deuteron sources test platforms. The paper also describes how software development and sharing is managed within the collaboration.

THE SPIRAL2 PROJECT

Ganil is one of the major facilities producing stable or rare ions beams (RIB) for nuclear physics, astrophysics and interdisciplinary research. In order to extend both the range and mass of exotic nuclei able to be provided, the Spiral2 project [1] at Ganil will deliver RIB at intensities never reached before and is built within two phases:

- The first one is the primary beam acceleration process consisting of deuterons and heavy ions sources, a warm RFQ and a superconducting linac. It also includes the S3 (Super Separator Spectrometer) and NFS (Neutrons for Science) stable experimental areas. Construction of the buildings is under way so that the installation should start in fall 2012 with the first beams expected in 2013. To anticipate the commissioning phases, the deuteron and heavy ions sources with their associated low energy beam lines are already in test respectively at CEA-IRFU (Saclay) and CNRS-LPSC (Grenoble).

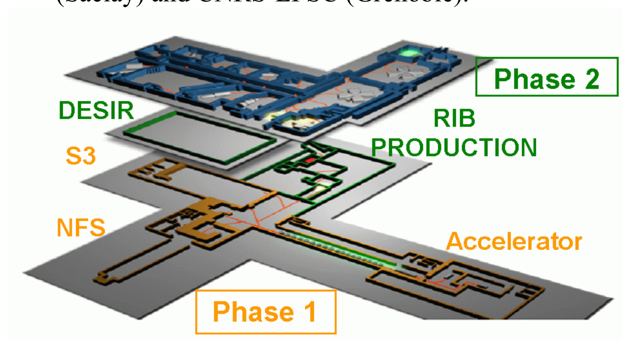

Figure 1: The Spiral2 general layout.

- Phase two concerns the RIB production complex, a new DESIR experimental room and the link to the existing Ganil facility for post acceleration and reuse of the experimental switchyard.

CONTROL SYSTEM CONTEXT

Software Development Around Epics

Since the preliminary design phase study, it has been decided to build the Spiral2 control system upon the Epics framework.

For the phase 1 control system, a collaboration between CEA-IRFU (Saclay), CNRS-IPHC (Strasbourg) and Ganil (Caen) has been set within a specific organisation so that these three laboratories share their developments [2] according to the work packages they are in charge of.

The phase 2 control system will be also based within the same Epics technical pattern, being still under design for its detailed conception. Nevertheless, it is clear that a specific point will have to be addressed as this part of the facility as it will be the recovery domain of the new Spiral2 and the legacy Ganil control systems, this last one resulting of an home-made Ada design formerly defined in the beginning of the 90's.

Main Technical Options

Most of the technical options result from the Epics environment (currently 3.14.12) which was adopted and the main choices were presented previously [3], [4].

IOC servers will be either VME crates running VxWorks (currently 6.8 release) or Linux PCs. Equipment will be addressed either directly from VME chassis or through field buses (mainly Modbus/TCP). Also Siemens S7 PLCs will be used, being in charge of specific devices or handling safety processes.

On the client side, GUIs will be, depending on the context and needs, either standard Epics tools or Java applications being developed within an adaptation to our project of the Xal framework [5].

Basic Infrastructure

In order to integrate the future needs brought by Spiral2 and to cope with the needs of the existing Ganil facility, a consequent upgrade of the Ganil central servers was performed during the yearly Ganil winter shutdown by the beginning of this year.

The new environment consists of two Dell Power Edge servers equipped with Intel Xeon E5620 processors at 2.4 GHz. SAN disks are configured as Raid10 (3 Tb) and Raid 5 (4 Tb) within iSCSI storage units. The operating system is the Red Hat Linux 6 distribution with the high availability features provided by the cluster suite package.

Shared by both the Ganil and Spiral2 control systems, this set of replicated servers is in charge of all the basic system services as well as the relational database management servers (Ingres for Ganil and Spiral2, in addition MySql envisioned for Spiral2).

Beside of these infrastructure servers, application program servers dedicated to each of the Ganil and Spiral2 machines run on specific applicative servers.

EQUIPMENT LAYER

First, linked to the equipment management (fig. 2), a development is in parallel under way for providing an environment to integrate the equipment into the control system by the end users themselves, even not Epics aware people [6]. It relies on the standard Epics template database files, the substitution mechanisms and the so-called "generation" consists of generating the starting boot file, the Epics substitutions files and (if required) the sequencer scripting files. This has been prototyped up to now within the context of quite simple equipment such as beam slits or power supplies; to be compliant with this process, developments have to respect configuration, programming rules and codification recommendations.

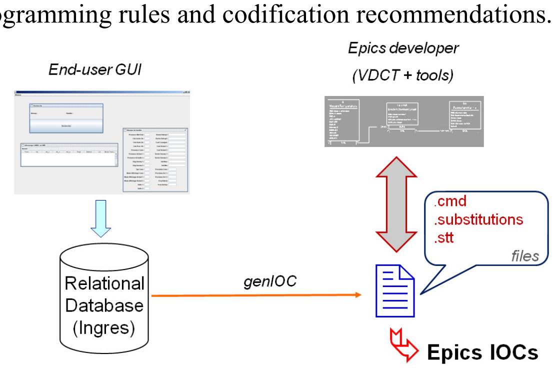

Figure 2: Equipment management work flow.

Table 1 summarizes most of the equipment to be integrated within the accelerator control system; according to the current status development, items are highlighted from green (tested during the first beam tests at Saclay and Grenoble), orange (work in progress) or red (standby).

Table 1: Equipment Integration

Equipment	Interface	Comments
Power supplies [6]	Modbus/TCP	Alarms handling still to be implemented. Various implementations according to providers.
PLCs	Modbus/TCP	Siemens S7 serie.
Faraday Cups & ACCT - DCCT Current transformers [7]	VME	Slow acquisition to get average value and fast acquisition for peak value as well as pulse display.
Slits	Modbus/RTU	Step by step motors. Temperature measurement and beam current acquisition through VME.
Fast Faraday Cup	Digital oscilloscope	Preliminary tests performed using the SCPI protocol (packet length).
Time of flight	Modbus/TCP (phase)	Specific Ganil design.
Fast current transformer	Digital oscilloscope Modbus/TCP (phase)	Preliminary tests performed using the SCPI protocol (packet length).
Transversal emittance	VME	Complex system with HT settings, Brushless motors and Faraday cups. Validated for the Low Energy Beam Transfer Lines.
Profilers	Modbus/RTU	Specific Ganil design.
Beam Position Monitors	VME64x	Specific BARC design.
Beam Losses Monitors	VME	Complex system with NIM chassis, HT modules. Specific IFIN-HH design.
Beam Energy Monitors	?	Detector not yet defined
RF amplifiers [8]	Modbus/TCP	Different for the RFQ and the Linac cavities.
LLRF control	VME64x	Specific IRFU design.
q/a=1/3 ions source [9]	VME	Complex system tested at LPSC Grenoble. Uses LabView &Epics.
Deuterons source	VME	Complex system tested at IRFU Saclay.
Timing system	Modbus/TCP	Handled by a PLC and an electronic system to tune the beam pulse shape by setting the sources, RFQ, and chopper pulsations.
Hall probe magnetic field	Modbus/TCP	Specific Ganil design.
NMR probe magnetic field	?	To be specified according to the system to be used.
Buncher, RFQ and Linac cavities	RF systems	Linked with the LLRF, RF PLCs and a private network.
Machine Protection System	?	GUIs, alarms, thresholds handling to be specified upstream the system.

Conventional facilities, cryogenic distribution and the personal access control system are out of the scope of the control system.

OPERATION INTEGRATION

Operator Interfaces and Tools

First, the EDM standard Epics editor is used for supervision applications, CSS/BOY being presently in evaluation with a specific care for its use in operation.

The archiving system is planned to be implemented with archive engines upstream a MySql database and performance tests started recently (400 values at 10 Hz monitored), jointly with the CSS client operator interface.

The alarm handling system will be a home made one (Java development), being able to process both the alarms coming from the legacy Ganil and new Spiral2 control systems. Alarms are stored in an Ingres relational database up to 330 per second for the global throughput.

Software Organisation and Standardisation

From the very beginning, to cope with the collaboration needs, a dedicated organisation was set to share developments. A Spiral2 repository was adopted both for the Epics and Java developments, including naming rules and conventions for files, directories. Also codification rules were defined for equipment.

Later, it turned out for better interactions to propose a standardized interface between IOCs and the GUI applications by defining a generic way to access equipment [10]. First, deeper codification rules were extended for Process Variable naming to handle settings, readbacks and measurements. Then, a specific database pattern consisting of dedicated records is introduced within IOC developments. It presents to any Channel Access client Process Variables to read the status word, read the default word, provide the list of all available commands to be applied, provide the list of all defaults able to be raised, get the meaning of each status bit …

High Level Applications and Machine Description

After having decided to write high level applications in Java, an investigation was done to adopt or define a framework able to fulfill our needs and requirements. Therefore, the Xal environment was evaluated within our context and, with the help of the Xal collaboration, tests were carried out successfully so that a Spiral2 derived version is now available [11]. It uses all the Xal approach and concepts and integrates some specificities coming from the new machine itself or inheriting from our previous Ganil approach.

According to the Xal schema, the facility is defined along an accelerator tree whose final leaves are the accelerator components. This description is stored in a relational Ingres database from which data are extracted to generate the Xal .xdxf compliant file. A gateway with the simulation CEA TraceWin program was added to generate theoretical values for the beam to be produced.

The first Xal based application was a general one to manage beam parameters; others under development are the beam profiles display, an optimization on-line program (using Xal algorithms), the buncher tuning and a general purpose handling tool. Many others are planned. Also standard Xal applications will be used such as the scanning programs and the magnet cycling one.

NEXT STEPS

Taking benefit of the ions and deuterons test platforms at Grenoble and Saclay, some components of the control system were tested within a quite operational context.

Nevertheless, a lot of work has still to be done with the development of the Linac control system. Also, providing more operational tools and high level applications is an issue. Lastly, the scalability of the system in a more loaded environment has to be checked carefully.

The installation is planned from summer 2012 while, in parallel, the phase 2 control system is under design.

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The basic hardware and software infrastructure and the network architecture are managed and provided by the Ganil Computing Infrastructure group.

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