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OVERVIEW OF THE GANIL CONTROL SYSTEMS FOR THE DIFFERENT PROJECTS AROUND THE FACILITY

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Abstract

The Ganil facility is drastically extending its possibilities with new projects, so increasing its capabilities in nuclear physics. The most significant one is the Spiral2 installation based on a linear accelerator, then to be associated with the S3, NFS and DESIR new experimental rooms. Beside of the legacy homemade control system handling the original installation, Epics was chosen as the basic framework for these projects. First, some control system components were used during preliminary beam tests. In parallel, the whole architecture was designed while the organization for future operation started to be considered; also, more structured and sophisticated tools were developed and the first high level applications for the whole machine tuning started to be tested, jointly with the current onsite beam commissioning.

Progression of the control system development is presented, from the first beam tests up to the whole Spiral2 commissioning. Then, according to the new projects to cope with, some highlights are given concerning the related organization as well as specific items and developments to be considered, taking benefit from the Spiral2 control system feedback experience.

OVERVIEW OF THE GANIL FACILITY...

The Ganil ("Grand Accélérateur National d'Ions Lourds") facility has quite yet a long history as the first beam was delivered to physicists in January 1983. It's a heavy ions accelerator complex devoted to nuclear and atomic physics, astrophysics, material science and radiobiology. The original installation consisted of several cyclotrons in cascade for accelerating the beam and, in 2001, was enhanced by the Spiral ("Système de production d'Ions Radioactifs Accélérés en Ligne") extension so that both stable and radioactive beams were able to be produced (see Figure 1).

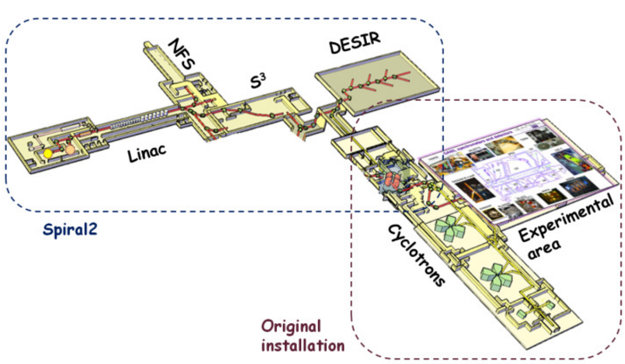

Figure 1: The Ganil facility.

In order to extend to increase the range and quality of exotic nuclei to be delivered, the Spiral2 project was approved in May 2005 [1] and is presently within the commissioning phase [2]. It is based on a superconducting linac delivering up to 5 mA proton or deuteron beams or 1 mA q/a>1/3 ions beams. The project also includes the experimental rooms named S3 ("Super Separator Spectrometer") and NFS ("Neutrons For Science") and, as a continuation, the low energy RIB experimental hall DESIR ("Desintegration, Excitation and Storage of Radioactive Ions").

... AND ITS CONTROL SYSTEMS

As well as the machine itself, control systems strongly evaluate according with time and emerging technologies but always having to take into account the existing solutions.

The initial control system was based on Camac serial loops and parallel branches handled by a minicomputer (specific language for programming) and local microprocessors (assembly language). In 1993, a major evolution replaced the Camac serial controllers by RTVAX/VaxELN CPUs linked through an Ethernet network integrating Vax/VMS machines. The Ada programming was used at every control system layer so all the software had to be rewritten while most of the hardware interfaces remained unchanged. In 1996, was introduced the VME standard with RTVAX/VaxELN CPUs then from 1998 by PowerPC/VxWorks CPUs, both still programmed in Ada. The last important evolution of the original Ganil installation control system was the migration from VMS servers to Linux ones in 2003. After two generations for the hardware servers organised as a cluster group, the last migration consisted this year of setting the servers into virtualized machines (Proxmox solution).

When the Spiral2 project started, many reflexions were carried out for the solution to be considered for the control system to be provided, so provoking many and strong debates. Even if the Ganil control system was functioning pretty well in a robust way, it was decided in 2006 to base the future control system upon a solution widely used among many laboratories, so allowing sharing developments and solutions and being within an opened environment. Epics was therefore chosen to be the basic framework for the control system. Is was decided nevertheless that the future Spiral2 control system would share the same central servers as the original installation control one; the VME standard was kept both for having the same hardware solution and minimizing human resources for implementation. At the same time, the aim was to ease the

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possibilities for collaborations with other laboratories for providing the control system: so, collaborations with CEA/Irfu at Saclay and CNRS/IPHC at Strasbourg were established within this framework.

THE ORIGINAL INSTALLATION CONTROL SYSTEM

Brief Overview

The original installation (~4000 equipment) control system is a homemade one entirely developed in Ada at every layer of the control system, within a three level architecture: central servers, PCs as operator consoles, VME crates for equipment interfaces (cross-compilation).

The central servers and operator consoles are running different Linux flavours (RHEL, Debian, CentOs) while the VME chassis are under the VxWorks real time operating system [3].

The communication between the central servers, the operator consoles and the VME crates is achieved within a homemade protocol directly programming the TCP-IP sockets. Pieces of equipment are handled either directly from the VME boards or using a serial line as a field bus, through the Modbus/RTU protocol (architecture Figure 2).

GUIs are so programmed in Ada, with the Motif suite and using commercial XRT widgets.

Ingres RDBMS is used for control databases: equipment configuration, machine modelization and beam parameters management.

The archiving system is implemented using XRT proprietary widgets and files format.

The system interfaces Siemens S5 PLCs through a homemade Profibus gateway.

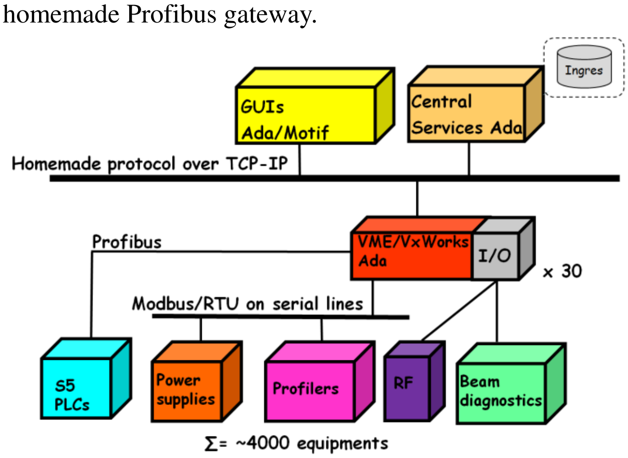

Figure 2: The original installation control system layout.

Evolution Perspectives

As the original installation control system is aging, an important issue is to maintain the system and let it evolve by bringing progressively some upgrades, taking into account the specificities and solutions which were adopted. The whole system is entirely Ada based from up to bottom, which is a significant strength for the system coherency and development environment but turned to be quite isolated as other solutions used in the accelerator community are different, so with very few solutions able to be shared.

Some bottlenecks have still being identified for evolving. First is the graphical environment using Motif and XRT widgets (proprietary solution now no more supported and maintained by the editor). The Ada/SQL integration consists of a specific Ada/SQL preprocessor provided within the Ingres suite but now used by a very few number of users worldwide.

There is still one Camac crate which will be able to be replaced only when equipment driven from this chassis will be changed, which would be quite expensive and is a problem largely coming out from the strictly control system scope.

Introducing other standards than the VME would be a way to start an evolution but would require quite huge human resources.

Lastly, the integration of Siemens PLCs should be renewed by replacing the Profibus gateway by a direct Ethernet communication.

THE SPIRAL2 CONTROL SYSTEM

Introducing Epics for Spiral2

The Epics based Spiral2 control system adopts the same layers as the original installation one [4], [5]. The solutions which were retained aim to constitute a compromise between the introduction of Epics into the laboratory with new concepts and the wish to share, when reasonably possible, some of the existing technologies already in use for the former control system.

Therefore, beside the soft IOCs, VME/VxWorks IOCs are used to interface equipment. Most of them are reached through a field bus (Modbus-TCP protocol) in a larger proportion than for the original installation, except some diagnostics being directly interfaced by VME boards.

Epics tools are used as much as possible such as CSS/BOY for defining GUIs and the archive engines solution for providing the archiving system (Figure 3).

In order to better fit the Spiral2 environment and prepare the future operation, several enhancements have been added to the standard distribution, as described in the following paragraph.

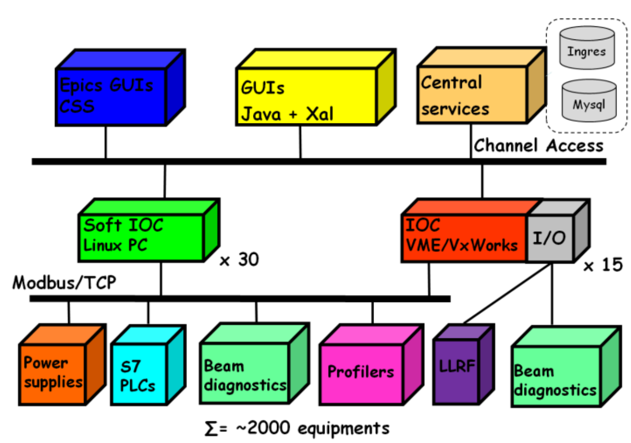

Figure 3: The Spiral2 control system layout.

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When GUIs need to introduce algorithms, need to interface databases or become quite complex to be written under CSS/BOY, development is performed using Java programming [6] within an environment derived from openXal originally developed at SNS and now used by several institutes. In fact, the frontier between the two technologies able to be used CSS/BOY and Java is sometimes not so obvious...

As for the original installation, Ingres RDBMS is used for an equipment database (upstream the so-called Epics database) and for describing the machine lattice (in a coherent architecture to be Xal compliant). MySql is devoted to the archiving storage functionality.

PLCs are from the Siemens S7 series and reached as other devices using again the Modbus-TCP protocol.

SPIRAL2 Control System Specificities

Beside of the standard use of the Epics framework for Spiral2, several significant enhancements were brought to the common distributions used within the community.

- To ease equipment handling and their user interfaces, a specific model has been adopted for defining the default and status words as well as command specifications. It consists of a set of database records having to be inserted in each equipment module [7].
- CSS/BOY is widely used either by the equipment specialists or the future operating teams. The standard distribution was adapted within several axes. First two distributions CSSdev (for developers) and CSSop (for operators) have been generated from the standard SNS one, so limiting the actions able to be reached at the operation level. Also specific widgets devoted to Spiral2 were designed (quadrupoles, slits, Faraday cups ...) having pre-defined properties both for behaviour and graphical representation (PV name, value, default and status appearance, alignment ...). Lastly, in respect to a graphical convention, predefined areas are specified on the screen for locating the application launcher, the beam title, the main display and an optional one with two tabs, one for commands and the other one for status and default details (example shown in Figure 4).

Figure 4: CSSop standard display.

- Considering the feedback got from the Ganil operation, it was decided to create an equipment configuration database upstream the standard Epics "database" flat files (.db, .cmd and . snl ones). This database allows each user, even not Epics aware, to define their equipment belonging to classes previously defined by the controls group, in a friendly way, having only to define equipment characteristics such as maximum and minimum bounds, conversion factors, range, alarm thresholds, network addresses ... Then, a generation process allows to generate the Epics files complying with the standard Epics mechanisms (macros ...). For equipment driven by PLCs unit, this process (the so-called "genIOC" software in Figure 5) goes further as it generates not only the Epics files but also the Epics modules themselves with the appropriate Modbus-TCP commands and data blocks interfaces.

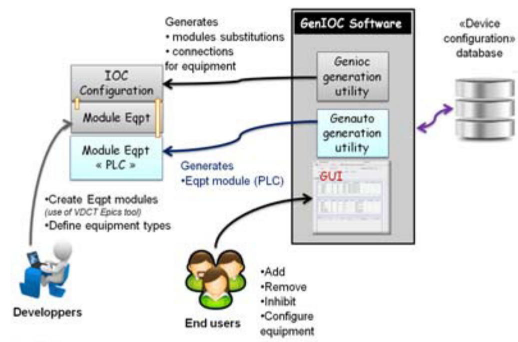

Figure 5: Spiral2 equipment configuration workflow.

- For high level applications and tuning algorithms, a framework derived from the openXal suite developed at SNS is in use. It includes the standard openXal tree structure of the machine with some new classes having to be added, having previously described the machine modelization. As Spiral2 is able to produce many types of particles, a key issue is to manage the different sets of parameters and this is achieved using also this database (workflow shown on Figure 6):

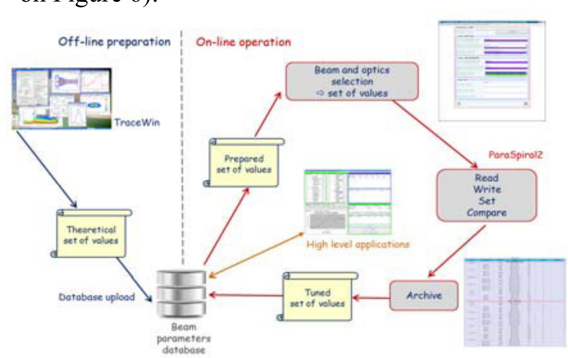

Figure 6: Spiral2 beam parameters dataflow.

The CEA off line Tracewin software is used to perform calculation providing theoretical sets of values which are uploaded into the database. People in charge of preparing the beam parameters to be applied then constitute sets of values resulting from the combination between these theoretical sets and previous archives. .xdxf Xal compliant files are generated from the database and tuning appli-

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cations can access either these files or the database itself. Snapshots of the whole machine can be taken and inserted into the database for off-line analysis or future use as archives. Lastly comparisons can be done between sets of values (theoretical, archives, in-use).

GANIL CONTROL SYSTEMS SYNTHESIS

The following table summarizes the main features concerning the Ganil original installation and Spiral2 control systems.

Table 1: The Ganil Control Systems

	Original installation	**Spiral2**
Framework	Homemade	Epics
Servers	Shared with Spiral2 Debian & RHEL6 operating systems on Virtual Machines	Shared with the original installation Debian & RHEL6 operating systems on Virtual Machines
Operator consoles	PCs/CentOs	PCs/CentOs
Equipment interfaces	VME/VxWorks & 1 Camac/VaxELN	VME/VxWorks
GUI software	Ada / Motif + XRT widgets	CSS/BOY & Javascript Java within Xal framework
Real time implementation	Ada	Epics records SNL C
Communication protocol	Homemade	Channel Access
Field bus	Modbus/RTU on serial lines	Modbus/TCP
Safety devices	CFP / Labview	cRIO / Labview

So, the control system group has now two different control systems to support, maintain and evolve. The use of Epics for the Spiral2 extension brought openness to the control systems laboratories and is clearly a promise for future.

Because of the specific solutions used within the original installation control system and human resources, it would require a lot of resources to merge the two control systems into one global Epics one, so the perspective is to adopt progressively solutions for the original installation control system as close as possible to the Spiral2 one. It's already the case when sharing some environment (VME, VxWorks, Ingres, central servers) and the control group will go through this process in the following times when reasonable and feasible.

NEW EXPERIMENTAL AREA CONTROL SYSTEMS

Next to the Spiral2 accelerator itself will be installed the new experimental rooms NFS, S3 and DESIR.

The control system which is under consideration for these rooms will be technically built upon the Spiral2 control system taking also benefit of the feedback from its development and its first use during the commissioning phase.

A first major difference with the Spiral2 control system development is that the controls group has now some experience with Epics, which was not the case at the beginning of the Spîral2 project. Also, some of the enhancements brought to the standard use of Epics in the context of Spiral2 were not available at the beginning of the project and only became mature quite late during the development, so were partially used or had to be mixed with the basic solutions.

But now, we consolidated the use of the Epics tools we are using and do have a good basis for providing an environment suitable for the operation. Typically, this is the case of the use of the CSSdev, CSSop Spiral2 CSS/BOY based distributions as well as the openXal implementation for the accelerator. Also the use of the genIOC suite proved to be highly beneficial not only for describing equipment but also when having to interface Modbus-TCP driven equipment: people does not have to write any piece of code or define Epics database, they define equipment configuration, play the genIOC suite which both generates the Epics modules and the associated databases, that's to say most of the IOC paradigms. Doing that way allows saving a lot of time during this type of development.

We do hope that the development of the NFS, S3 and DESIR rooms would benefit from the use of such environment and add-ons. Some of the corresponding control systems developments will be done under collaborations such as the S3 beam dump (CEA/Irfu) or the High Resolution Spectrometer of DESIR (CNRS/CEN-BG).

A specific consideration concerning the DESIR room is that it would be able to receive either beams coming from Spiral2 through the S3 room but also from the original installation. This particular point will have to be taken into account as the two control systems will have to interact at a level having still to be defined.

CONCLUSION

The Ganil facility has now two control systems having to evolve and to be maintained jointly. Because of human resources and of the technical solutions, replacing the original homemade control system by a Spiral2 style Epics based is not a short term objective.

So the controls group will better try to smoothly evolve the original installation control system to have as most as reasonably possible the more convergence points with the Spiral2 one.

The Spiral2 control system starts now to prove its efficiency as the machine commissioning progresses, with a

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great openness to other laboratories and communities. This is the good result of the technology drastic choice which was adopted for the new project. We expect that, for future, we will take more and more benefit from this strategy, including the new projects to come, with first the new experimental rooms to control.

Also, another objective is to introduce new hardware technologies inside the existing Spiral2 control system, more modern than the quite traditional and old VME standard.

Lastly, investigating Epics V4 would be a good investment for future.

ACKNOWLEDGEMENT

As the Ganil took the opportunity of the Spiral2 project to adopt shared solutions by many laboratories, first acknowledgements are addressed to the Epics, CSS and openXal communities which were of a great help for the control system development.

Also the Spiral2 control system was developed in collaboration with other laboratories [8]. Beside the Spiral2 Epics distribution, Irfu/CEA also provided the controls for the sources [9], the LLRF and some diagnostics controls; CNRS/IPHC developed the control systems for the emittancemeters and beam extension monitors. Many thanks to these institutes for their work and the exchanges we had during this period.

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