ISBN: 978-3-95450-237-0 ISSN: 2673-5512 doi:10.18429/JACoW-PCaPAC2022-TH014

HOW GANIL PLAN TO USE WEB TECHNOLOGIES TO UPDATE THE CONTROL SYSTEM USER INTERFACE

C.H. Haquin†, O. Delahaye, C.H. Patard, F. Pillon, J. Pivard, G. Senecal, GANIL, Caen, France

Abstract

The Grand Accelerateur National d'Ions Lourds (GANIL) Control System was developed in the first half of the nineties with ADA language. The user interfaces use MOTIF and XRT widgets. User interfaces have become more and more difficult to modify and there is a risk of obsolescence. GANIL plan to replace these old technologies and web technologies are anticipated. This paper will present the strategy defined to make the switch.

CURRENT SYSTEM

The control system of the original GANIL accelerator (2 ions sources, 5 cyclotrons), called GANICIEL, relies on several software (about 65), entirely developed in ADA language specifically for this machine thirty years ago, by the developers who were present at that time.

There are two main software layers (see Fig. 1), the first one, the human machine interfaces layer (about 45 software), corresponds to all the software required to tune the accelerator by operators from the control room. The other, the equipment control layer, comprehends all the real-time servers (about 10 software multi instantiated on 31 VME) interacting with equipment to handle Human Machine Interface's (HMI) requests and ensure parameters setting and data monitoring.

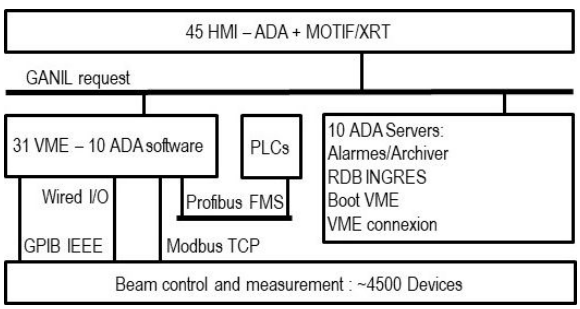

Figure 1: Current GANIL control system architecture.

To operate, both layers rely on relational databases (INGRES technology), at HMI layer level, widget are powered by MOTIF/XRT technology, at the equipment control layer level, VxWorks 6.9 operating system is required to run VME software.

In between the two layers, there is a batch (about 10) of software servers providing services for data bases access, alarm monitoring, data archiving and minimization of the Transmission Control Protocol/Internet Protocol (TCP/IP) connection between HMI and Versa Module Europa (VME).

GANICIEL Request Concept

The communication between the HMI layer and the equipment control layer is achieved over TCP/IP with a homemade request system providing simple and complex order services. Simple order offer the possibility to interact quickly with an equipment by sending unitary order with no reply, complex order gives the possibility to execute a sequence of order on an equipment and receive a report with only one transaction between a HMI and a VME.

Technical Threats and Opportunities

ADA Language The ADA language appeared in the early eighteen with ADA83 and was enhanced with revision ADA95, ADA2005 and ADA2012. Software developed in ADA are renowned to be robust, its attractiveness increased with the needs for security for payment systems, ADA is a technology we can rely on for the future. However, it is not widespread, the lack of skilled people and the weak attraction of the young developers for it are the main drawback that pushes us to reduce its use. Currently there are almost 3 MLoC in ADA for the whole control system (see Table 1).

Table 1: ADA Source Code Distribution

	Million Lines of Code
HMI, graphical rendering	1,0
HMI, command/algorithm	0,5
Total for HMI layer	1,5
VME ADA software	0,3
ADA servers	0,4
Total	2,7

HMI Layer There are two kind of HMI, one dedicated to equipment command and one to the so-called algorithmic command, equipment commands correspond the simplest HMI dedicated to a single equipment like basic Input/Output (I/O), driving a power supply, insertions. Algorithmic command HMI implement complex sequences like cycling a cyclotron or optimizing the beam transmission, they can involve several equipment potentially spread-out on several crates.

There are 1.5 Million Lines of Code (MLoC) for the HMI layer, 1 MLoC for the graphical rendering, the remaining half MLoC for the commands and algorithm. The widgets used for the graphical rendering are issued from the MOTIF/XRT libraries which are not commercialised and maintained since 2016, workmate that are now retired managed to keep these libraries up and running at each hosts renewal (every five years). We do not have the MOTIF/XRT skills anymore, there is a risk that we don't manage to repeat the performance for the next host renewal (2026) and we may face a blocking software or hardware incompatibility.

Equipment Control Layer The equipment control layer has a typical early nineteen architecture based on 31 VME crates allowing the control of the 4500 devices of

† christophe.haquin@ganil.fr

ISBN: 978-3-95450-237-0 ISSN: 2673-5512 doi:10.18429/JACoW-PCaPAC2022-TH014

the accelerator. Each crate consists of a Central Processing Unit (CPU) card plus a set of I/O cards, there are 230 digital I/O, analog I/O and protocol card, some of the I/O cards were homemade, some are off the shelf products, protocol cards are off the shelf but execute a closed source software. Each crates executes one instance of the 10 VME software application, at boot time, each instance retrieves from a data base sever its configuration describing the set of I/O cards installed in the crate, the I/O mapping of each card and the names of the equipment to be controlled by that crate.

The equipment control layer works fine, unlike the HMI layer, there is no urgent risk related to obsolescence. However, according to the number of devices that are now accessible over TCP/IP network and the performances of the hypervisors, the CPU/protocol cards association could be replaced by a virtual server, a VME crate with its CPU card and batch of I/O cards could, in many cases, advantageously be replaced by connected I/O systems. In other words, the innovations of the last decades give us the opportunity to reduce the cost related to spare and repair, ease interventions and maintenance with remote access and improve service monitoring.

THE RENOVATION PROJECT

In 2023 the GANIL will celebrate the 40th anniversary of the first beam, and the demand from the physicist remain high, the GANIL must consider its exploitation for at least the next two decades. Consequently, an ambitious renovation project is currently being defined in which we plan to solve the obsolescence risk and modernize the architecture of the control system with latest technologies.

Staff and Skills Considerations

The main objective for the control system renovation is to eliminate the obsolescence risk, but, skills and human resources availability have also been taken into account to design the renovation plan.

The current system is the second-generation control system, it was designed and developed by eight people from GANIL between 1990 and 1992, the commissioning occurred in 1993, it has been enhanced during the next two decades by its creators, there were up to 10 people working on it. Things started to become more complicated in the last decade when people retired and not all of them were replaced, currently only 4 young permanent people helped by 3 non-permanent people and they have to work not only on the legacy machine but also on the Experimental Physics and Industrial Control System (EPICS) control system for the Systeme de Production d'Ions Radioactifs Accelere en Ligne2 (SPIRAL2) Linear Accelerator (LINAC), Super Seperateur Spectrometre (S3), Désintégration, Excitation et Stockage d'Ions Radioactifs (DESIR) and New GANIL Injector (NewGain). So, the challenge we are facing is how can we do more with less people?

Though the current control system works fine it still need to evolve constantly, modifications take too much time because the tools are basic, it is difficult to find ADA developers (student or a temporary contract or a software service company) or to motivate young developers with this language.

Consequently, the renovation plan aims at solving this obsolescence risk with XRT/MOTIF technology but also to reduce the human resources needs for maintenance and open wide outsourcing alternative.

HMI Layer Modification

The HMI layer was developed at a time where software quality consideration like specification, maintainability, scalability, testability were not as obvious and rooted as today, the architecture of each HMI is not really layered, the view and the control are completely interleaved.

We thought about the possibility to redevelop all the HMI but we came to the conclusion that though the actual code is far from being perfect, the code in which there are algorithms and intelligent control, state machines or sequences still has a lot of value because of its 30 years of maturity. We defined a two steps strategy aiming at preserving and building on this value.

The first step: the refactoring of the code prior removing the XRT/MOTIF stack, is an unavoidable prerequisite in order to start from a sound basis with two well-defined view/control layers interacting with a well-defined interface. This step gives us the possibility to validate that the refactored HMI work like the non-refactored ones and if not, the guarantee that the root cause is in the refactored code and not related to the introduction of the new technology.

The second step aims at minimising the impact on the valuable code by replacing only the view layer with theoretically no impact on the control layer or at least minimize the modification and avoid that each HMI has its own set of specificity and workaround.

The Web Technology Introduction The most straight forward strategy would have been to replace XRT/MOTIF by gtkADA but, according to the staff & skills consideration, we decided that we should choose a more widespread technology, that's how we started to think about using web technology.

Though no framework is chosen yet, we redefined the control system architecture by introducing the web concepts (see Fig. 2).

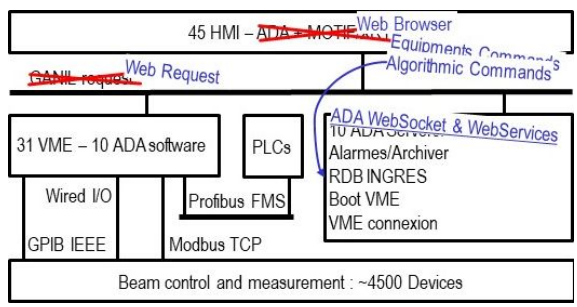

Figure 2: HMI Modification.

The strictly speaking user interfaces will be accessible with a web browser, the GANIL request system will be replaced by WebSocket [1] for commands that require full-duplex communication and Web-Services for the other.

ISBN: 978-3-95450-237-0 ISSN: 2673-5512 doi:10.18429/JACoW-PCaPAC2022-TH014

Those web communications will provide access to the View/Control interface defined during the refactoring in order to make available for the user interface the ADA most valuable services. Finally, the ADA code corresponding to the control layer and all the other server will migrate to web server.

Equipment Control Layer Modification

As mentioned before, to ease the maintenance, the number of VME crates could be dramatically reduced, we estimate that 12 crates can be directly virtualized since they are dedicated to beam profiler, power supply and PLCs accessible with Modbus/TCP protocol, 10 more crates with off the shelf I/O cards could be virtualized by introducing connected I/O devices, this requires to develop new drivers. Finally, 9 crates with homemade I/O cards will remain unchanged (Fig. 3). Virtualizing those crates would impact heavily the controlled devices and imply import hardware and software development to finally obtain the same functionalities. This is considered not worth the effort.

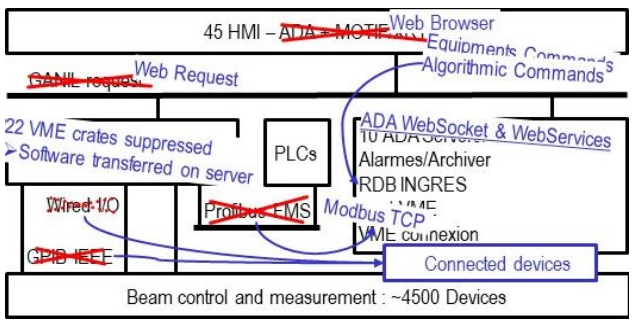

Figure 3: Equipment control layer modification.

As for the HMI control layer ADA code, the code transferred from the VME will integrate the batch of web services and WebSocket services will have to be activated in the 9 remaining VME (Fig. 4).

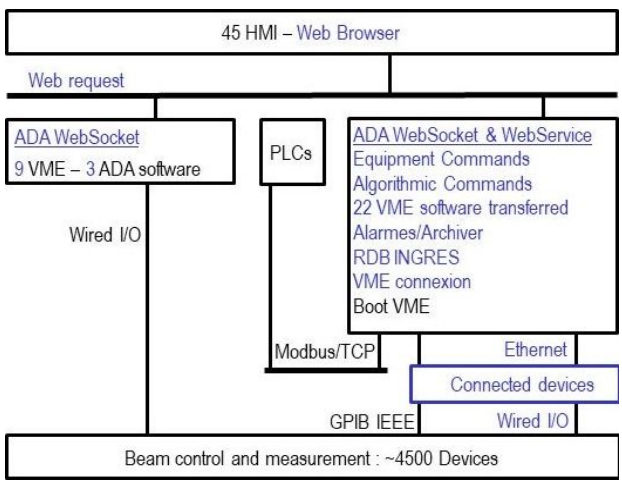

Figure 4: Final GANIL control system architecture.

How PLC Technology Could Also Be Involved

We've also taken into account the technical improvement that are coming from the PLCs. With the current architecture, 3 VME and 10 HMI have no real added value they are just gateway to PLCs, this is legacy from the time where supervision was available only on windows platform and not on Linux platform. Since there is also a renovation plan for PLCs, old Siemens series 5 will be replaced by S7 series, we are also looking closely to WinCC Unified, the new Siemens HMI technology, to replace the 10 ADA HMI and remove the 3 VME crates or their virtualized version.

Human Resources

The effort was first estimated for a well-known and reasonably complex HMI, then we applied the resulting person-years/MLoC ratio to the other HMI, we finally obtained a total of seven person-years for the whole HMI layer modification.

The corresponding method was applied to a VME taking into account the integration of the connected I/O devices, we obtained a total of five person-years.

The GANIL control system renovation is therefore estimated at twelve person-years and we plan to outsource seven person-years.

Planning

We expect the project kick-off at beginning of 2023, the first task will be to establish the outsourcing call for tender and we plan the technical tasks to be executed between 2024 and 2026.

CONCLUSION

How can we replace the old XRT/MOTIF stack has been a discussion topic in the software team since at least fifteen years! Discussions often ended up with the conclusion that it was not possible without rewriting everything and we didn't had time and resources.

The rise of an ambitious renovation project at GANIL scale gives us the opportunity to obtain the resources required by such a complex task and make the change come true.

Moreover, with the outsourcing approach and the will of the young developers to work with state of the art technologies and engineering process, it open the perspective to introduce better test & validation practices and use of continuous integration/deployment (CI/CD) tools.

Finally, lessons need to be learnt from the commissioning of the SPIRAL2 accelerator in order to tackle HMI development not only as a software development task but as a holistic product [2] requiring the engagement of the users. From tuning capabilities point of view, current GANIL HMI are fully satisfying, this will be the functional baseline to be integrated in a user centric process based on regular delivery and demo, taking into account design and user interface/experience (UI/UX) considerations from the start.

REFERENCES

[1] A. Uchiyama *et al.,* "EPICS Channel Access Using WebSocket", in *Proc. PAaPAC'12*, Kolkata, India, 2012, paper WECC02, pp. 7-9.

[2] M. Cagan, *Inspired: How to Create Tech Products Customers Love*, Silicon Valley Product Group, USA: Wiley, 2017.