PETAL CONTROL SYSTEM STATUS REPORT

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Abstract

The PETAL laser is a high energy multi-Petawatt laser beam being installed in the building of the Laser MegaJoule facility at the CEA/CESTA near Bordeaux (France). The control system commissioning has started with the amplifier section alignment in 2013.

The presentation gives an overview of the general control system architecture, and focuses on the use of the TANGO framework in some of the subsystems software.

INTRODUCTION

The PETAL project consists in the addition of one short-pulse (500 fs to 10 ps) ultra-high-power, high-energy beam (few kJ compressed energy) to the LMJ facility [1]. The Laser MegaJoule facility (LMJ) is presently under construction at the CEA/CESTA site near Bordeaux (France). LMJ is an up to 240-beam laser system designed to study inertial confinement fusion (ICF) and physics of extreme energy densities and pressures [2].

PETAL will offer a combination of a very high intensity multi-Petawatt beam, synchronized with the nanosecond beams of the LMJ. PETAL will be used for High Energy Density Physics and research on Fast Ignition.

PETAL is dedicated to academic research: designed and constructed by the CEA/CESTA for the Aquitaine Region which receives a financial support from the French Ministry of Research and of the European Union.

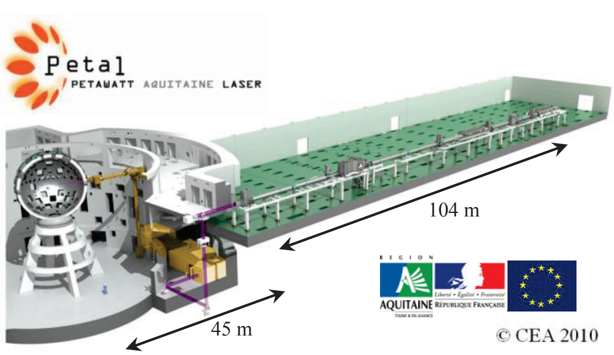

Figure 1: PETAL in the LMJ building.

PETAL'S PHASING STAGES

The PETAL project is divided in 5 phases. The 1st one, finished in 2008, concerned the feasibility of key issues (front end and compression). The 2nd, finished in 2012, was the construction of the amplifier section infrastructures. The current 3rd and 4th phases are constructing notably the front end, the laser diagnostics, the energy bank, the compression stage area, and the transport-focusing stage in the target bay.

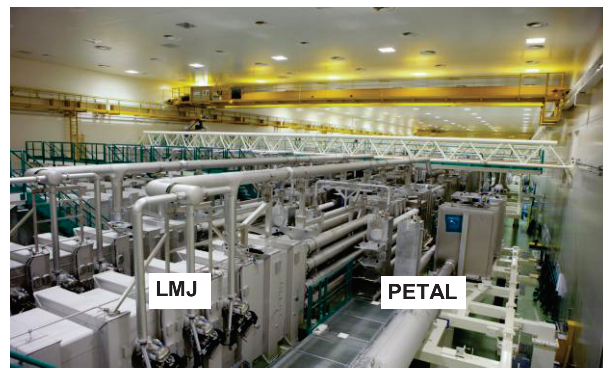

Figure 2: LMJ and PETAL amplifier sections.

The 5th phase will be the coupling of PETAL and one LMJ's bundle especially the synchronisation subsystems.

PETAL'S CONTROL SYSTEM

Overview

PETAL's control system is distributed on a pyramid of 4 layers:

- Facility's management on the N3 layer provides tools for the laser specialists to prepare and post treat the shots.
- Central supervisory control on the N2 layer allows PETAL shot director to lead to the shot.
- Low level supervisory control on the N1 layer provides applications for the exploiters to gather detailed information of each subsystem.
- Equipment microcontrollers and PLC's on the N0 layer command and control the beam equipments

Subsystem Architecture

PETAL is divided into 10 major subsystems, corresponding to the main functions of the beam's control system. The Shot Sequence Execution controls the states of each subsystem to lead to the shot.

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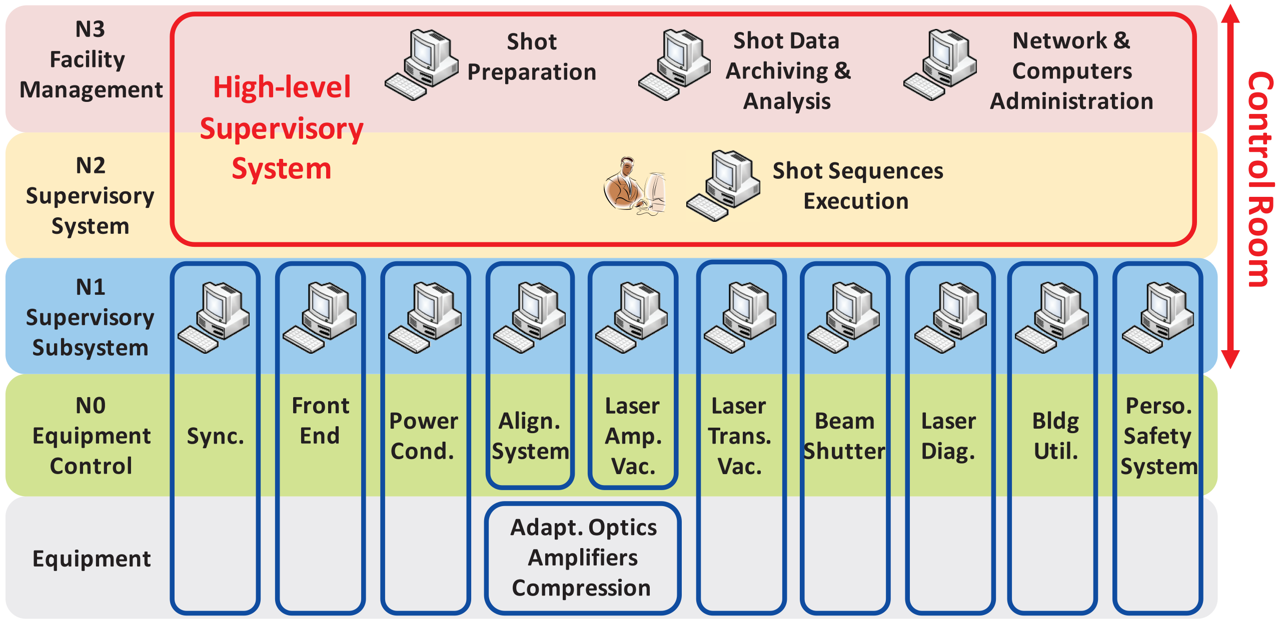

Figure 3: Subsystem architecture.

Software Architecture

The N1 and N2 are based on the PANORAMA SCADA software.

The N3 software is developed in C# and based on the WCF and WPF language from the .Net Framework. Communication in between the N3 and the rest of the command-control is done through the use of XML files complying to specific XML schemas.

The N1 and N2 layer communicate with the N0 layer using the OPC communication protocol.

Hardware Architecture

All the N1, N2 and N3 layers are virtualized using VMware and DataCore solutions. N3, N2 layers and each subsystem (N1, N0) are localized on a VLAN linked to the central backbone.

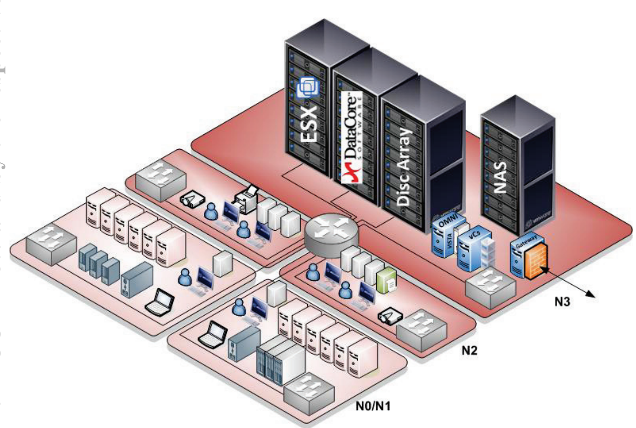

Figure 4: Hardware architecture.

PETAL set up two twin plat-forms. The first one is dedicated to operation process, the second to control system integration process.

FLEXIBLE LOW-LEVEL CONTROL SYSTEM ARCHITECTURE

The N0 layer is composed of 10 different subsystems. While no requirements forces the use of a specific technology, the N0 layer controls a heterogeneous set of equipments, spread along the laser chain. Moreover, software development is dependent on the technologies provided by the manufacturer of these equipments.

In addition, all subsystems have a common set of functionalities: loading configuration, sequencing, communication, producing shot results.

Inevitably, as all research facilities, specifications tend to evolve during the development, thus, a flexible architecture was needed.

In order to fulfil all of these requirements, a shared architecture has been used on the N0 control system of three major subsystems: alignment system, laser diagnostics, then front-end.

Overview

The architecture has been designed based on the following principles:

- Distributed architecture: de-correlate the hardware architecture from the software one and allow on the fly adjustment to the software deployment.
- “On the shelf” components: each component is self-sustained, can run on its own and implements one functionality. Adapting the component is done through configuration.

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The choice has been made to base this architecture on the TANGO framework.

This framework based on the OmniORB CORBA implementation allows the development of distributed application. It is well community supported and already in production of half a dozen synchrotrons in Europe.

Development can be done in C++, Java and Python making it easy to develop addition tools by the scientific community.

Reusable Core Components

The N0 architecture is composed of 4 layers:

- A “SCADA” layer : regroups all the interface, logging and global system state management components
- A “Process” layer : regroups components used implement the specific task of each subsystem (use SCXML for the sequence), plugin base system to implement algorithms
- An “Equipment” layer : regroups all the components that controls a specific equipment (cameras, motors, barrel wheel)
- A “Driver” layer : regroups components that allows access to a shared resource (RS485 modbus gateway, specific control card for AON input and output cards)

Each component can be picked up to build a control system. Once a development has been done to control a specific equipment, it can be reused without additional cost in any project.

Specific behaviour is externalized in configuration files and through the use of a SCXML sequences files.

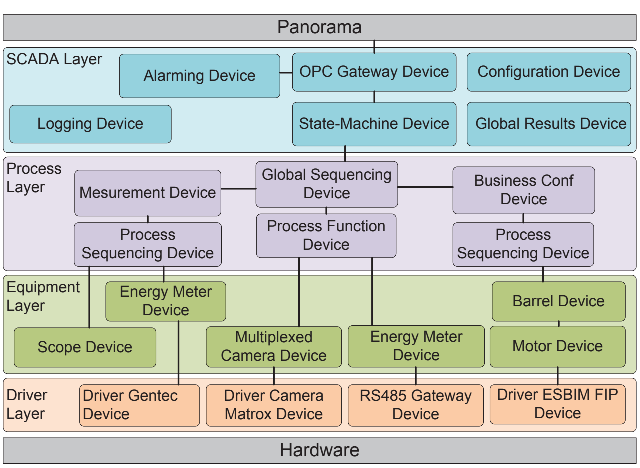

Figure 5: Four layer flexible architecture.

Decrease Development Time/Increase Quality

For the Alignment system and Diagnostics system, the architecture has allowed making gradual changes to specifications without modifying the whole software. The core components once validated at the launch of the project have not been modified since then.

Finally, using this architecture allowed the development time of the front-end control system to be reduced by half.

CONCLUSION

The use of technologies of virtualization and distributed software architecture gave to the PETAL project the necessary flexibility to develop, integrate and evolve the system according to the met constraints.

Thus, PETAL control system is actually ready for the next step coming soon that is amplification of the laser beam.

REFERENCES

[1] N. Blanchot et al., “Overview of PETAL, the multi-Petawatt project in the LMJ facility”, IFSA 2011, European Physical Journal: Web of Knowledge, to be published.

[2] J.P. Arnoult, F. Signol, J. Nicoloso “The Laser Megajoule facility control system status report”, ICALEPS 2011, October 2011.

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