CONFIGURATION AND SEQUENCING TOOLS FOR THE LMJ CONTROL SYSTEM

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Abstract

Configuration and Shot Sequencing Tools are the two major components used by operators to reconfigure and adapt the behavior of the Laser Megajoule (LMJ) Control System software during operation.

- Configuration Tools: the configuration manager allows creating a model of the system under control, and makes it available to the different parts of the Control System software. The system is described as a hierarchy of objects linked by different types of relationships, which are used by the supervisory software to propagate events, alarms, states and actions. The model acts also as a centralized repository for all the parameters and characterization data needed to control the process.
- Shot Sequencing tools: specialized software tools were designed to develop and execute the programs that schedule the hundreds of actions needed to perform a laser shot. Sequence programs are described as state machines and VB Scripts. A sequencer embedded into the LMJ SCADA executes them in a distributed manner. Objects, properties and functions of the SCADA applications are made available from within the scripts through specialized API.

CONFIGURATION TOOLS

In order to configure the LMJ control system, the facility is first described using a Persistent Data Model stored in a centralized database called the Configuration Manager.

The Persistent Data Model allows the description of different kinds of objects:

- Resources representing equipments ,
- Functions representing actions on equipments,
- Default settings loaded into equipments during shot operations,
- Equipment characteristics that are used to compute settings before shots, or experimental results after shots.

The relationships existing between resources or functions are also described in the Persistent Data Model:

- Composition relationships (equipment1 is composed of equipement2 and equipement3),
- Utilization relationships (equipment1 uses equipement2),
- Incompatibility relationships (function1 is incompatible of function2).

Composition relationships organize resources in hierarchical trees, also called views. Multiple views can be created, typically one for the system (laser bays, laser bundles and beams, beam sections, and so on) and one for each subsystem (master oscillator, power conditioning alignment, laser diagnostics, target diagnostics).

The Configuration Manager provides synchronization with the Computerized Maintenance Management System Software, so that characteristics associated with resources are automatically updated when a maintenance operator moves a device from one location to another.

As explained below, the main goal dedicated to the Configuration Manager is to act as a centralized repository for configuring SCADA applications and computing shot settings or data results.

SCADA Configuration

An industrial SCADA (PANORAMA E^2 from CODRA) is used either at subsystems level or at central controls level to supervise operations.

The Persistent Data Model of the Configuration Manager database is reloaded into the real time database of PANORAMA E^2 applications at every start. During operation, property value changes are automatically notified to PANORAMA E^2.

The PANORAMA E^2 Data Model describes the system under control as a hierarchy of resources having the following properties:

- Control Points,
- Alarms,
- Functions,
- Current Operational State (OK, Minor Default or Critical Default)
- Current Operational Mode (e.g. Stopped, Standby, Running).

Operational modes transitions are described with state machines. Modes can have sub-modes: for example in the Running mode the system can be Waiting, Charging, or Ready for Shot.

In order to execute functions on a resource, a client has to reserve it. A reserved function or resource is available only to the client that has reserved it.

The PANORAMA E^2 Resource Manager uses the relationships loaded from the persistent data model of the Configuration Manager to propagate reservations, operational states and modes into the system:

- Reservations propagate from parents to children on composition, utilization and incompatibility relationships.
- Operational states propagate from children to parents on composition an utilization relationships, according to state value and resource priority.
- Operational mode values are ordered (Running > Standby > Stopped). A child cannot have an operational mode whose value is greater than those of his parent.

These mechanisms allow the operators to be informed instantaneously of the availability of high level resources or functions and are used to know if a particular sequence can be executed or not.

By changing relationships in the Configuration Manager, the user can also easily reconfigure or tune the behavior of the control system without reprogramming the SCADA applications.

Shot Settings and Data Results Computation

As explained in the next chapter, shot settings are automatically computed according to shot requirements, laser components numerical models and components characteristics that are stored in the Configuration Manager.

After shot, equipment characteristics are also necessary to compute experimental results from raw data acquired by laser and target diagnostics.

SHOT SEQUENCING TOOLS

A sequence is a set of actions executed according to a specific logic. A typical sequence on the LMJ is the set of actions that has to be done for preparing the laser for shot and shooting. A lot of other tasks involve sequences in LMJ operation: fault diagnostics, dry runs, equipment calibration.

Sequence development tools are designed to be used by end users and allow the operation team to develop new sequences by themselves, independently from SCADA application developers.

Sequence development and utilization involve a three stages process:

- Sequence program development
- Sequence settings calculation
- Sequence execution

Sequence Program Development

Sequence program development combines the advantages of two different techniques: GRAFCET and VB Script.

- First the programmer describes the sequence logic with a GRAFCET editor.
- Then he expresses the details of what has to be done in each step of the GRAFCET using VB scripts.
- Inside VB scripts, he is able to access the objects of PANORAMA E^2 applications, and in particular all properties and methods of resources and functions.

Sequence Settings Computation

Settings are computed independently from the sequence program:

- The physicist responsible for the experiment fills in shot requirements: beams and diagnostics used, beams energy and pulse shape.
- Equipments settings are automatically computed from shot requirements using laser components numerical models and the components characteristics that are stored in the Configuration Manager.

Sequence Execution

Before shot, the sequence program and settings are injected into the control system:

- This one verifies if the sequence is compatible with the operational state of the laser.
- Resources involved in the sequence are reserved in the different subsystems they belong to.
- Settings are loaded into subsystems.

Then the sequencer executes the GRAFCET diagrams and scripts of the sequence:

- Resources functions or sub-sequences called by scripts are executed in a distributed manner, inside the subsystems they belong to.
- The sequence is suspended if an alarm is encountered on a resource contributing to it.
- During suspension, the shot director has the ability to solve the problem or abandon the default resource, before going on. He can also choose to abandon the sequence itself.

The sequencer debugging mode allows executing the sequence GRAFCET step by step, monitoring its execution, debugging the VB scripts and inspecting SCADA object properties.

REFERENCES

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