# IMPROVING THE SAFETY AND PROTECTIVE AUTOMATIC ACTIONS

## OF THE CMS ELECTROMAGNETIC CALORIMETER DETECTOR CONTROL SYSTEM

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# CURRENT AUTOMATIC ACTIONS IMPLEMENTED IN THE CMS ECAL DETECTOR CONTROL SYSTEM

## Automatic actions in the CMS ECAL Preshower detector using control Scripts

The Preshower detector (ES) is organized in partitions known as Control Rings (CR). The ES detector control system (DCS) implements automatic actions, using control scripts to power off individual CRs. The control scripts monitor the detector environment and powering systems and react to potential problems. The ES automatic actions target individual power channels, boards and converters to protect the detector and the electrical equipment against possible damages.

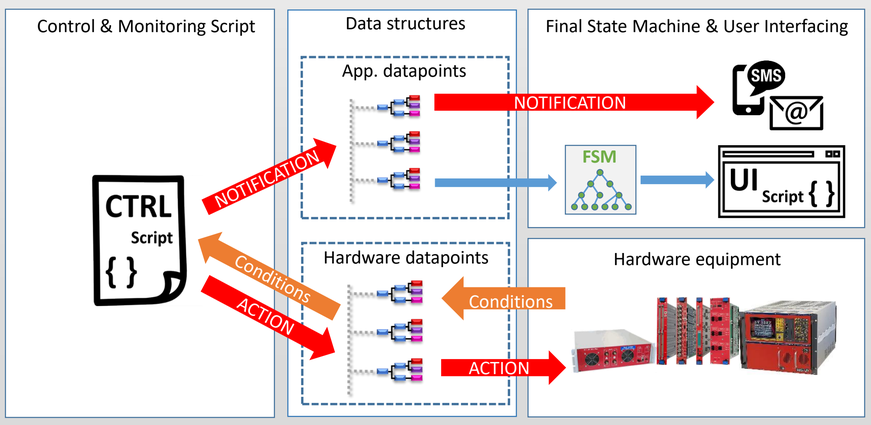


Figure 1: Simplification of the Preshower DCS architecture

## Automatic actions in the CMS ECAL Barrel and Endcaps using the Finite State Machine (FSM)

The CMS ECAL FSM is organized in 40 partitions following the detector physical layout (36 super modules and 4 Dees [half endcap]).

The FSM partitions are sub-divided in the following components: low voltage node (LV), high voltage node (HV), cooling node (C), Safety node (S) and a support mechanism known as distinguisher (D). The distinguisher mechanism allows the FSM to break down complex commands into specific sequences of hardware instructions (see Figure 2). Each of these FSM partitions is able to detect hardware failures and execute automatic actions to power off part of the detector.

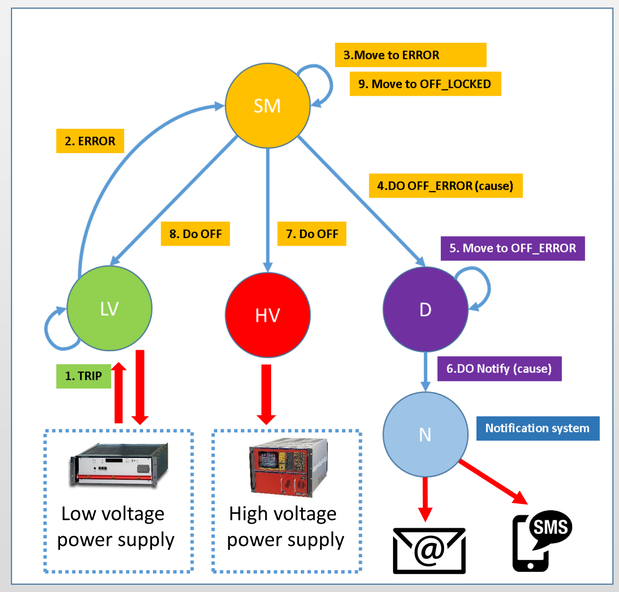


Figure 2: Internal FSM representation for a CMS ECAL supermodule (SM)

# DATA FILTERING FOR AUTOMATIC ACTIONS

## Data filtering in CTRL Scripts

The data used to trigger DCS automatic actions can be degraded for multiple reasons. A transient problem during a sensor readout or the unavailability of a network resource can lead into a wrong execution of the automatic action. A filtering process is introduced to solve some of the problems presented by the acquisition process. However, in certain applications, where the polling time can not be adjusted, the control scripts can miss values that would have been decisive for the execution of the automatic actions.

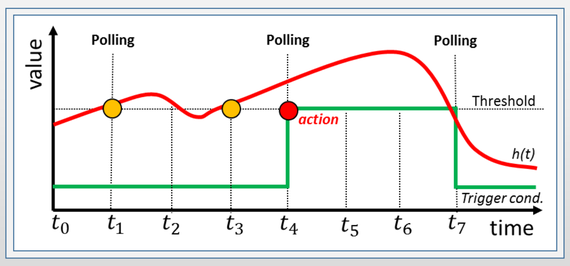


Figure 3: Data processing on script with 3 seconds polling time

## Data filtering using WinCC OA statistical functions

WinCC OA statistical functions can be used to analyse sensors data for a given period of time. The built-in statistical functions are synchronized with the acquisition process and can be used to implement an accurate filtering mechanism. A certain delay in the automatic actions allows for sufficient time to absorb any transient error during the acquisition process.

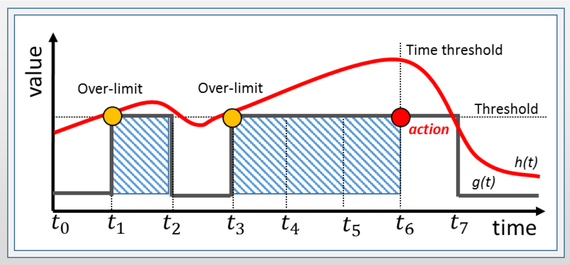


Figure 4: Data processing using built-in statistical functions

# CMS ECAL AUTOMATIC ACTIONS ON REMOTE SYSTEMS

## Using WinCCOA distributed connection

The distribution mechanism enables the access to the internal data structures between two DCS applications. This type of connections are very reliable and widely use in large control systems. On the other hand, distributed connections have a strong impact on the design of the applications due to the transfer of implementation details across DCS applications.

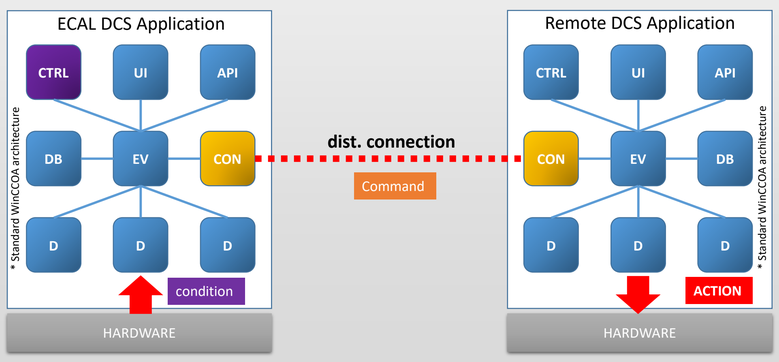


Figure 5: Automatic actions over WinCCOA distributed connection

## Using FSM commands

This mechanism is used as an abstraction layer to communicate between different sub-systems. Commands across FSM trees can be used to execute remote automatic actions. In the current FSM framework [3], commands in ascendant direction are not directly supported. The FSM toolkit permits the creation of links between scattered FSM trees. The usage of this feature impacts the spanning tree design of the FSM. The introduction of cycles in the tree can alter to the original behaviour FSM, resulting in indefinite loops in the status calculation and a possible misleading execution of commands [5].

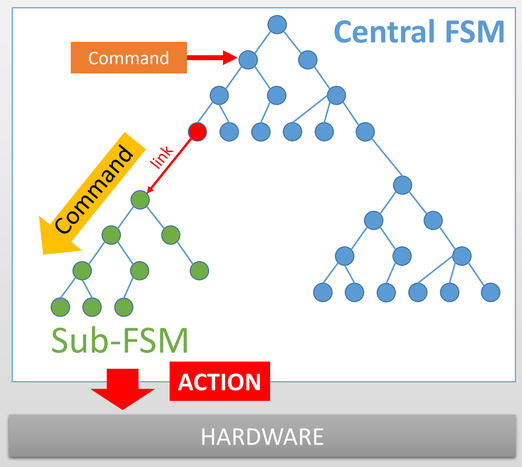


Figure 6: Automatic actions using FSM commands

## Using Remote procedure calls (RPC) over web services

The DCS automatic actions performed out of the sub-detector's context reveal the need for a service-oriented architecture. The CMS DCS features a communication mechanism known as the CMS XML-RPC system. The CMS XML-RPC system is an implementation of the standard Remote Procedure Call (RPC) protocol using the Extensible Mark-up Language (XML) to model, encode and expose a certain set of operations using HTTP as transport mechanism. The CMS XML-RPC permits to organize the DCS software as services and to expose its functionality to other applications using the XML-RPC protocol (see Figure 7). The CMS ECAL DCS team is currently evaluating the usage of this protocol to implement remote automatic actions on some of the CMS DCS centralized resources.

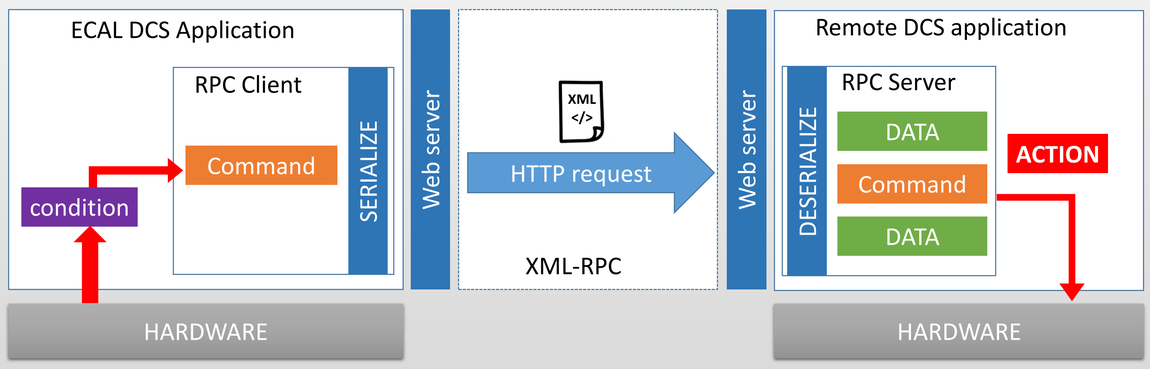


Figure 7: Automatic actions using RPC and web services

**REFERENCES:** [3,5] * References can be found in the proceedings.

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