The LHCb Experiment Control System: On the path to full automation

Clara Gaspar, October 2011
The Experiment Control System

- Is in charge of the Control and Monitoring of all areas of the experiment

Experiment Control System

DCS Devices (HV, LV, GAS, Cooling, etc.)

Detector Channels

Front End Electronics

Readout Network

HLT Farm

Storage

Monitoring Farm

External Systems (LHC, Technical Services, Safety, etc)

DAQ

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Homogeneity

- Same architecture and same tools used throughout the Control System.
- **Generic Architecture:**

![Diagram of the Control System with different blocks and connections highlighting the architecture and tools used.]
The Control Framework

The JCOP* Framework is based on:

- SCADA System - PVSSII for:
  - Device Description (Run-time Database)
  - Device Access (OPC, Profibus, drivers) +DIM
  - Alarm Handling (Generation, Filtering, Masking, etc)
  - Archiving, Logging, Scripting, Trending
  - User Interface Builder
  - Alarm Display, Access Control, etc.

- SMI++ providing:
  - Abstract behavior modeling (Finite State Machines)
  - Automation & Error Recovery (Rule based system)

* - The Joint COntrols Project (between the 4 LHC exp. and the CERN Control Group)

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Device Units

Provide access to “real” devices:

- The FW provides interfaces to all necessary types of devices:
  - LHCb devices: HV channels, Read Out boards, Trigger processes running in the HLT farm or Monitoring tasks for data quality, etc.
  - External devices: the LHC, a gas system, etc.

- Each device is modeled as a Finite State Machine:
  - It’s main interface to the outside world is a “State” and a (small) set of “Actions”.

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Hierarchical control

- Each Control Unit:
  - Is defined as one or more Finite State Machines
    - It’s interface to outside is also a state and actions
  - Can implement rules based on its children’s states
  - In general it is able to:
    - Include/Exclude children (Partitioning)
    - Excluded nodes can run in stand-alone
    - Implement specific behaviour & Take local decisions
    - Sequence & Automate operations
    - Recover errors
    - User Interfacing
      - Present information and receive commands
FW - Graphical Editor

SMI++
Objects
States &
Actions

Parallelism, Synchronization
Asynchronous Rules

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Operation Domains

- **DCS Domain**
  Equipment operation related to a running period (Ex: GAS, Cooling)

- **HV Domain**
  Equipment operation related to the LHC State (Ex: High Voltages)

- **DAQ Domain**
  Equipment operation related to a “RUN” (Ex: RO board, HLT process)

- **FSM templates distributed to all Sub-detectors**

- **All Devices and Sub-Systems have been implemented using one of these templates**

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Some Examples:

- **HLT Control (~1500 PCs)**
  - Automatically excludes misbehaving PCs (within limits)
  - Can (re)include PCs at run-time (they get automatically configured and started)

- **RunControl**
  - Automatically detects and recovers SubDetector desynchronizations
  - Can Reset SDs when problems detected by monitoring

- **AutoPilot**
  - Knows how to start and keep a run going from any state.

- **BigBrother**
  - Based on the LHC state:
    - Controls SD Voltages
    - VELO Closure
    - RunControl
Run Control

Matrix Domain
Sub-Detector

Activity
Used for Configuring all Sub-Systems
Two operators on shift:
- Data Manager
- Shift Leader

Shift Leader has 2 views of the System:
- Run Control
- Big Brother

Big Brother
- Manages LHC dependencies:
  - SubDetector Voltages
  - VELO Closing
  - Run Control
Size of the Control Tree:
- Distributed over ~150 PCs
  - ~100 Linux
    (50 for the HLT)
  - ~50 Windows
- >2000 Control Units
- >50000 Device Units

Run Control Timing
- Cold Start to Running: 4 minutes
  - Configure all Sub-detectors, Start & Configure ~40000 HLT processes (always done well before PHYSICS)
- Stop/Start Run: 6 seconds
Conclusions

- LHCb has designed and implemented a coherent and homogeneous control system

- The Experiment Control System allows to:
  - Configure, Monitor and Operate the Full Experiment
  - Run any combination of sub-detectors in parallel in standalone

- Some of its main features:
  - Partitioning, Sequencing, Error recovery, Automation
  - Come from the usage of SMI++ (integrated with PVSS)

- LHCb operations now almost completely automated
  - Operator task is easier (basically only confirmations)
  - DAQ Efficiency improved to ~98%