Configuring and Automating an LHC Experiment

For faster and better Physics Output

Clara Gaspar, October 2017
LHCb’s New Online Dataflow in Run II

- Introduced Prompt Calibration and Alignment
- Aims:
  - Better Trigger Efficiency
  - Full offline-quality data directly out of the Online System
    - straight to Physics Analyses
  - By Making better use of online farm resources
    - Take advantage of LHC’s duty cycle and shutdown periods

- Represented a challenge for the control system
Experiment Control System

Scope:

- Experiment Control System
- Detector Channels
- Front End Electronics
- Readout Boards
- High Level Trigger Farm
- Storage
- Monitoring
- Infrastructure & Detector Control System
- External Systems (LHC, Technical Services, Safety, etc.)
Control Units are logical entities:

- Behave as a Finite State Machine / Rule Based system:
  - Capable of Partitioning: Exclude/Include children
  - Can take local decisions: Sequence & Automate Operations or Recover Errors

Device Units

- Provide the interface to the device (hardware or software)

Implementation:

- (JCOP project)
  - WinCC-OA
  - SMI++

Deployment:

- Runs distributed over ~160 PCs (Virtual Machines)
The High Level Trigger

- Selects interesting events for Physics
- Runs distributed on the HLT Farm

Farm Hardware
- ~1600 nodes, ~50000 cores, heterogeneous
- Organized in 62 sub-farms, 24 to 32 nodes each

Farm Software
- Dataflow Pattern
  - Buffer Manager Concept
- Dataflow Tasks
  - Based on Gaudi Online
  - Integrated in Control System like any other Device via FSM states&actions
**Resource Optimization in 2012 -> Deferred HLT**

- Idea: Buffer data to disk when HLT busy / Process in inter-fill gap
- Reconfigure the whole farm at start/end of Physics

**Standard HLT**

**Deferred HLT**

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Even better Resource Optimization in 2015 -> Split HLT

- Idea: Buffer ALL data to disk after HLT1 / Perform Calibration & Alignment / Run HLT2 permanently in background
- Each node has 3 concurrent/independent dataflow slices
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**HLT Farm Now**

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Control Tree
- From 1 to 3 Independent Trees (actions, states and partitioning)

Dataflow Tasks:
- In the past were Hardwired in the Control Tree
- Now Dynamic via a Controller which receives an “Architecture”

62 Subfarms
28/32 Nodes per Subfarm
“Architecture” Concept

- Defines the dataflow / task layout on each (farm) node

- Graphic Editor:
  - Examples:
    - Old-style HLT
    - HLT1
    - HLT2
    - Calibration, Alignment, etc.

- Graphic Used at Run Time

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“Scenario” Concept

- Defines number of HLT1 & HLT2 tasks for load balancing (initially hardwired in the Architecture)
  - Depending on the LHC/LHCb State and type of node
  - Can be applied at RunTime and takes effect within a second

![Dataflow Scenario](image-url)
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### “Activity” Concept

#### Run Control driven by an Activity:
- Defines the set of parameters (“recipe”) which is applied by each sub-system.
  - Example: “PHYSICS|LEAD”
  - Contains, for example, the “Architecture”

#### Three Farm Slices -> Three Run Control(s):
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“Scheduler” Concept

Big Brother automates operations based on the LHC State, driven by Scheduler(s):

- Define sequences of Activities/Scenarios
- Complete Automation of each Run Control with very few lines
- 3 lines to automate main Run Control
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LHCb’s New Online Dataflow represented an Operational challenge, but due to:

- The modular architecture and flexibility of the original design
- Some new concepts (architectures, scenarios, schedulers)

It is now:

- Seamlessly Integrated
- Completely automated

And the farm is kept as busy as possible

- Also offline simulation (concurrently) when still free resources.

Conclusions