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The ATLAS Detector Control System

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Abstract

The ATLAS experiment is one of the multi-purpose experiments at the Large Hadron Collider (LHC) at CERN, constructed to study elementary particle interactions in collisions of high-energy proton beams. Twelve different sub detectors as well as the common experimental infrastructure are controlled and monitored by the Detector Control System (DCS) using a highly distributed system of 140 server machines running the industrial SCADA product PVSS. Higher level control system layers based on the CERN JCOP framework allow for automatic control procedures, efficient error recognition and handling, manage the communication with external control systems such as LHC controls, and provide a synchronization mechanism with the ATLAS data acquisition system. Different databases are used to store the online parameters of the experiment, replicate a subset used for physics reconstruction, and store the configuration parameters of the systems. This contribution describes the computing architecture and software tools to handle this complex and highly interconnected control system.

Architecture

The ATLAS Detector

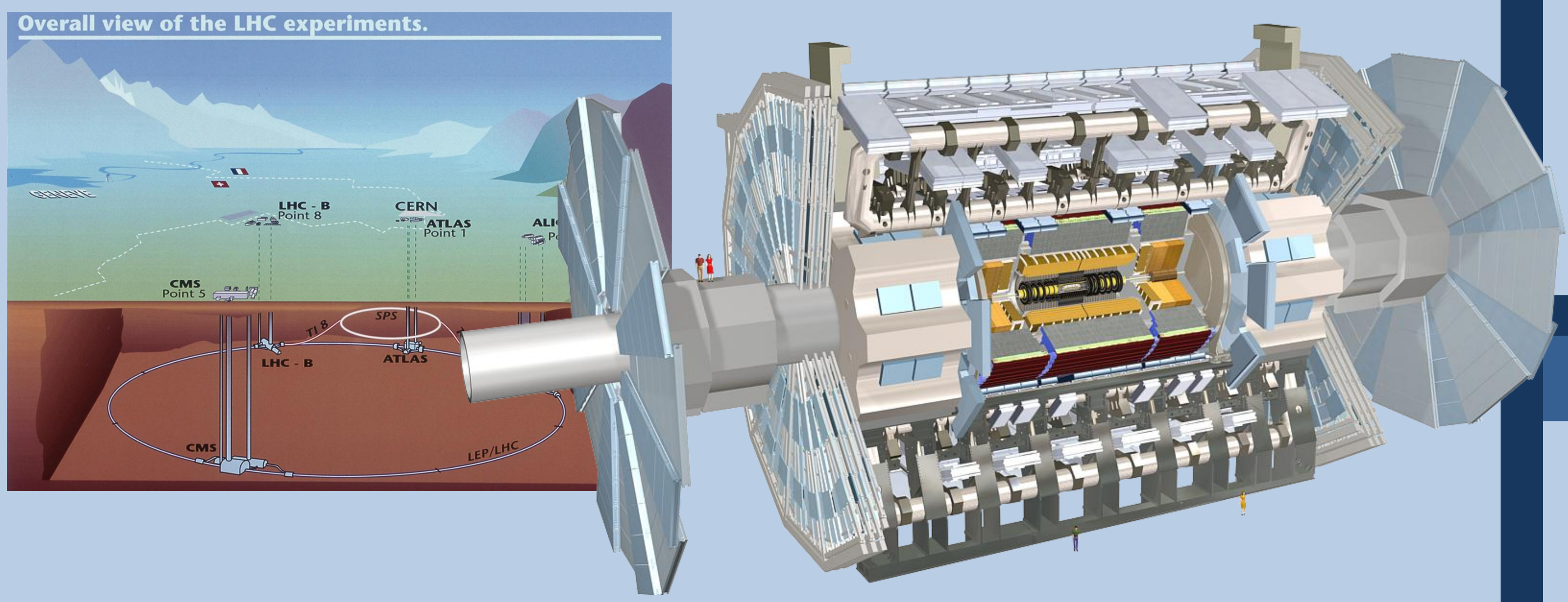
ATLAS:

▷ Largest of the four LHC experiments at CERN, general purpose detector

▷ Length: 44 m, Ø 25 m, weight: 7000 t → 100.000.000 readout channels

▷ 12 sub detectors

▷ Operation with proton-proton collisions since end of 2009



DCS Front End

Control and Monitoring, Hardware:

▷ Industrial power supply crates, readout and control via CAN/Ethernet.

▷ PLCs read out via Modbus (managed by CERN infrastructure)

▷ Custom built low-cost I/O concentrator: Embedded Local Monitoring Board (ELMB)

- ✓ Usage e.g. readout of temperature sensors, control of power supply channels
- ✓ 64 analog inputs (16-bit ADC) and 24 digital I/O channels
- ✓ ATmega128 microcontroller (8 bits, 4 MHz)
- ✓ CAN controller for communication over field-bus
- ✓ Powered by custom power supply via CAN bus (or hosting board)
- ✓ Modular, remotely upgradable firmware
- ✓ CANopen OPC server for communication with back-end
- ✓ Radiation hard up to 50 Gy, tolerant to magnetic field >1.4T
- ✓ More than 5000 ELMBs in use in ATLAS

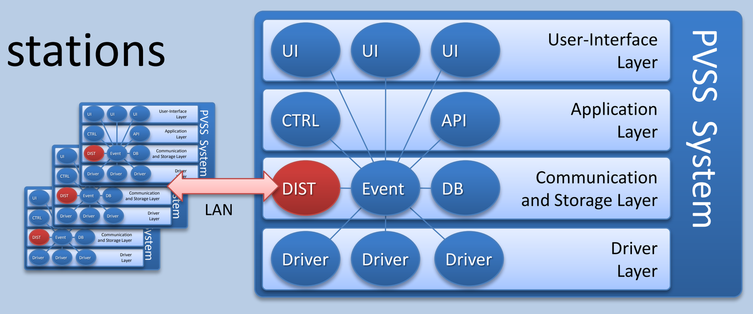
DCS Back End

Back End:

▷ Front end interfaced to individual control stations

▷ SCADA software PVSS II (Siemens) used:

- ✓ Allows distribution of applications
- ✓ Scalability
- ✓ Support for Windows/Unix platforms



▷ Data exchanged via OPC, Modbus (PLCs), DIM , custom drivers

▷ Conditions data can be streamed to relational database (Oracle)

▷ Low level alarm system for individual parameters crossing thresholds

DCS Architecture

Controls Hierarchy:

▷ Standard building blocks

- ✓ Joint COntrols Project (JCOP)

▷ Global Back End:

- ✓ Interfaces to operators, storage and external facilities

▷ Sub-detector Back End:

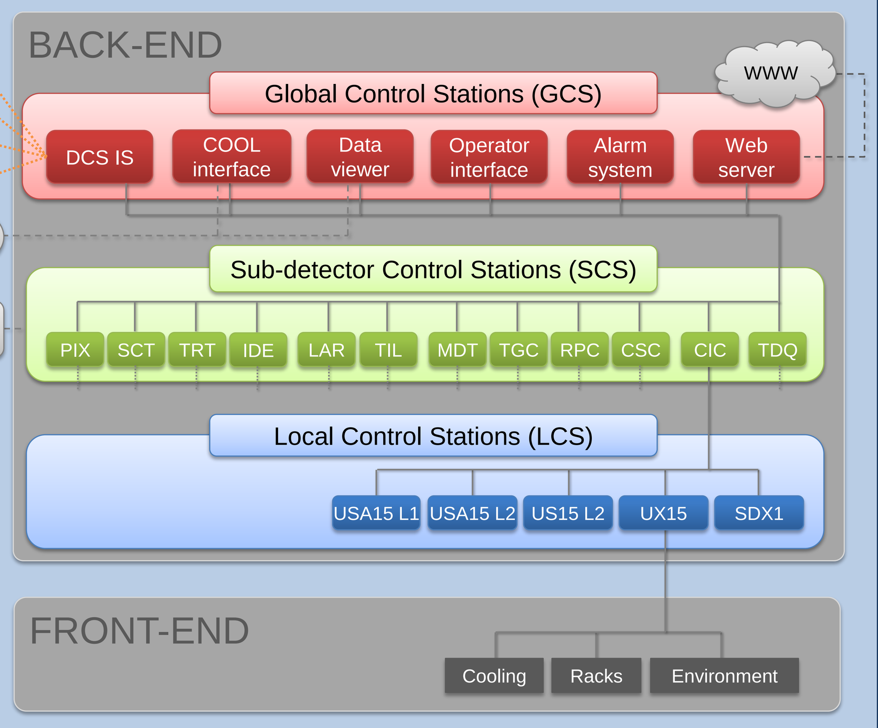
- ✓ Standalone operation

▷ Local Back End (BE):

- ✓ FE connection,
- ✓ readout,
- ✓ processing

▷ Front End (FE):

- ✓ Detector interface



Integration:

▷ Distributed System of > 100 stations in private network

▷ Control applications developed by different sub system developers based on event driven processing of > 10^7 data elements

Data Storage

Data Handling:

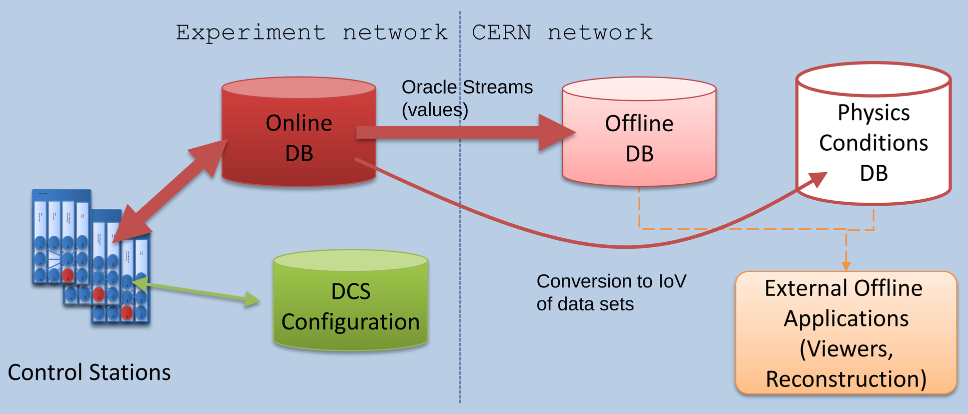
▷ Use of Oracle databases

- ✓ CERN IT services

▷ Configuration DB: 1.6 GB

▷ Conditions DB: 7 GB/day

- ✓ Replicated for offline use: 0.2 GB/d



Data Access:

▷ Directly from PVSS (trends, script based) via online DB

▷ Dedicated web based DCS Data Viewer (DDV)

- ✓ World wide DCS data access, can be embedded in any web page
- ✓ Generic approach allows use in other experiments (COMPASS)

Operations

FSM

State Machine Hierarchy:

▷ Reduce complexity!

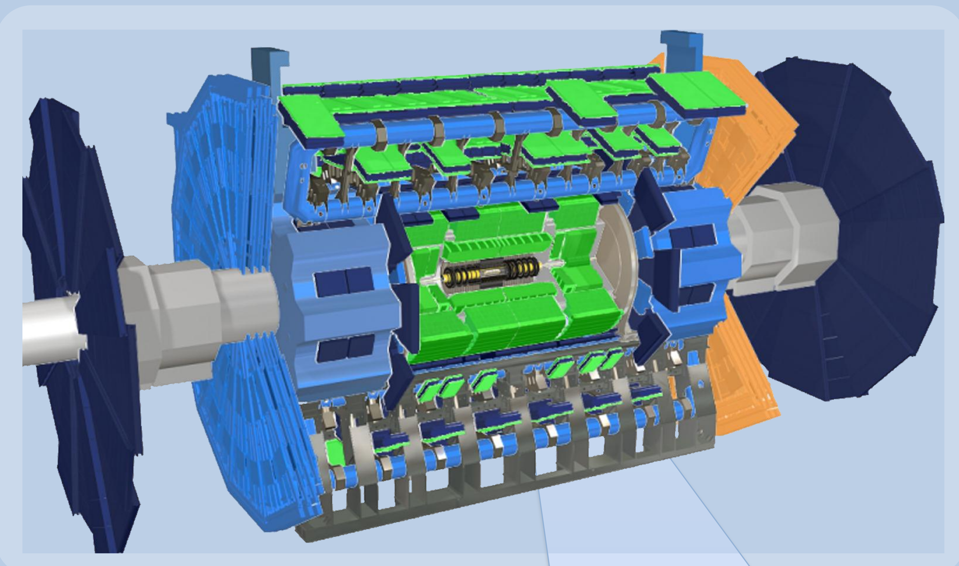
▷ Detector control mapped to state machine hierarchy above SCADA layer

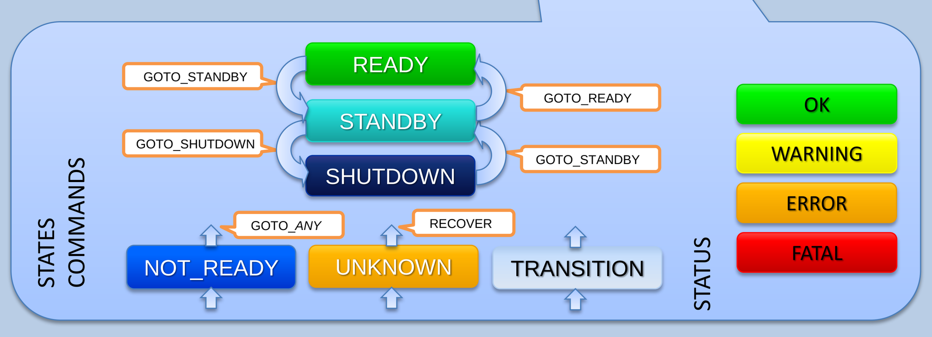
▷ Using JCOP FSM software framework *(C. Gaspar et al. 2006)*

▷ Node ***States*** are propagated upwards using state rules, ***Commands*** are propagated downwards

▷ Error handling upwards using parallel tree of ***Status*** objects

▷ **Allows for single operator**





Operator Control

Detector operation by shifters:

▷ Alarm screen → quick recognition and response to problems

- ✓ Filter alarms relevant to subsystem

▷ Homogenous navigation through state machine hierarchy for operator using custom HMI

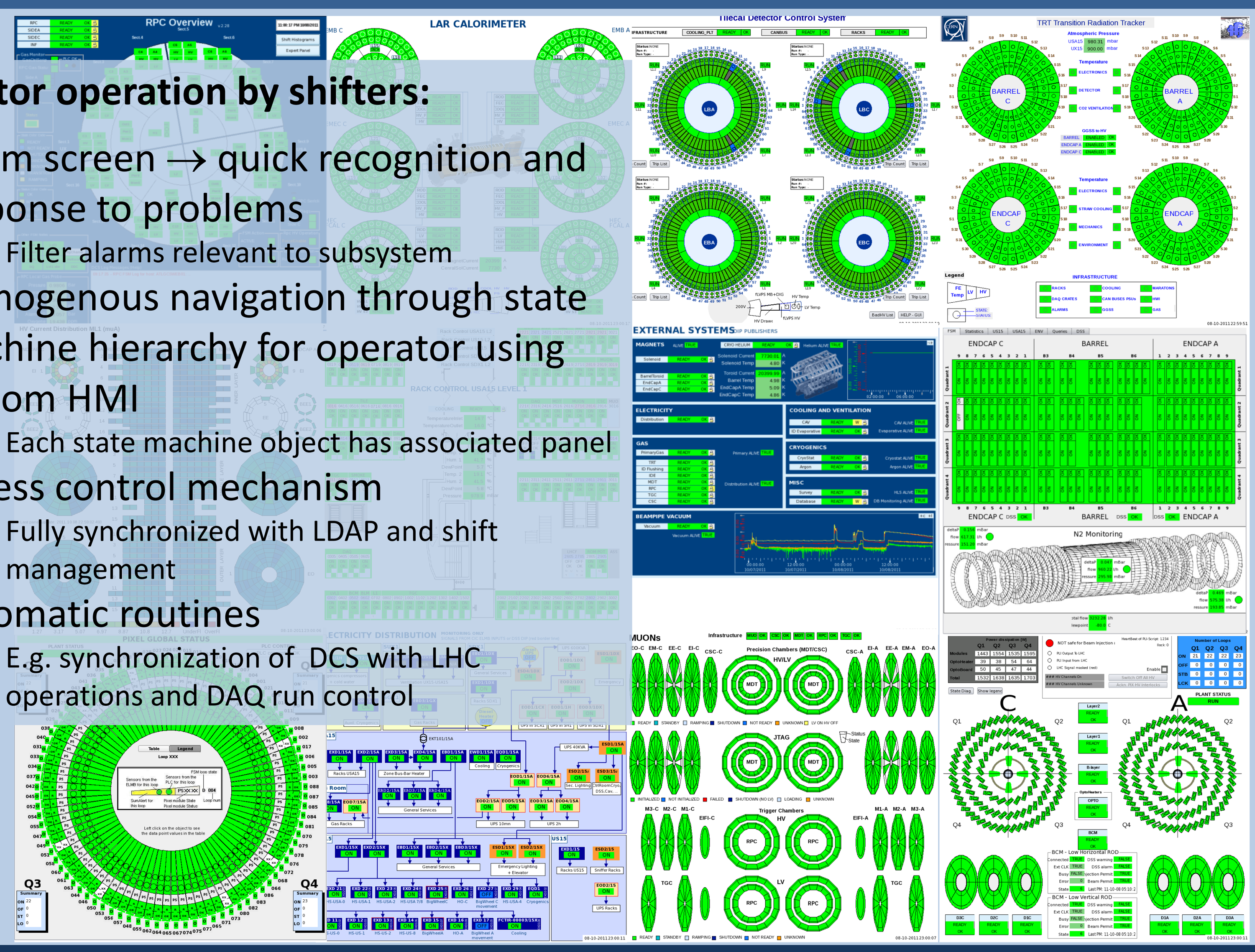
- ✓ Each state machine object has associated panel

▷ Access control mechanism

- ✓ Fully synchronized with LDAP and shift management

▷ Automatic routines

- ✓ E.g. synchronization of DCS with LHC operations and DAQ run control



Outlook

- DCS extremely reliable so far, system proven to handle routine detector operation well.
- Continuous consolidation and automation e.g. of routine maintenance tasks.
- Software/OS Maintenance, replacement of PCI interfaces → Migration to Linux
- Documentation, merging of expertise and responsibilities
- Prepare for future upgrades: accelerator, detectors, control systems

ATLAS EXPERIMENT