The ALICE DAQ, current status and future evolution

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Abstract. ALICE (A Large Ion Collider Experiment) is the heavy-ion detector designed to study the physics of strongly interacting matter and the Quark-Gluon Plasma at the CERN Large Hadron Collider (LHC). A large bandwidth and flexible Data Acquisition System (DAQ) has been designed and deployed to collect sufficient statistics in the short running time available per year for heavy ions and to accommodate very different requirements originating from the 18 sub-detectors. After several months of data taking with beam, lots of experience has been accumulated and some important developments have been initiated in order to evolve towards a more automated and reliable experiment. We will present the experience accumulated so far and the new developments. Several upgrades of existing ALICE detectors or addition of new ones have also been proposed with a significant impact on the DAQ. We will review these proposals, their implication for the DAQ and the way they will be addressed.

1. The ALICE experiment

ALICE (A Large Ion Collider Experiment) is the heavy-ion detector designed to study the physics of strongly interacting matter and the Quark-Gluon Plasma in nucleus-nucleus collisions at the CERN Large Hadron Collider (LHC) [1]. It primarily targets heavy-ion lead-lead collisions (Pb-Pb), but it also has a substantial physics program with proton-proton (pp) and proton-ion (pA) collisions. The experiment has been designed to cope with the highest particle multiplicities anticipated for Pb-Pb reactions.

ALICE currently comprises eighteen sub-detectors: high resolution tracking (silicon detectors, time-projection chamber), particle identification, calorimetry, and triggering elements. Ten of the ALICE detectors contribute to the trigger decisions. The sub-detectors are able to take data independently (standalone operation) or in global partitions (set of sub-detectors running together).

1.1. The online systems

ALICE also includes 5 online systems [2]:

- The Central Trigger Processor (CTP) delivers the trigger decisions to readout the sub-detectors based on their busy status and the input from the trigger sub-detectors.
- The High-Level Trigger (HLT) permits a firmware and software filtering mechanism to select interesting events in order to optimize use of the recording bandwidth available.
- The Data Acquisition system (DAQ) handles the data flow from the detector to the permanent data storage in the CERN computing center.
The Detector Control Systems (DCS) controls the sub-detectors and their services. The Experiment Control System (ECS) controls the whole experiment and provides to the shift crew a simplified view of this complex experiment. This function is realized through the control and the synchronization of the other four online systems.

The dataflow of the online systems is shown in figure 1.

The DATE software is the distributed system managing the DAQ data flow between the DAQ nodes: the Local Data Concentrators (LDCs) receiving data fragments sent by the detector electronics over several Detector Data Links (DDL) and the Global Data Collectors (GDC) building the full events. DATE consists of several processes executed on every node, depending of its role in the data acquisition.

### 1.2. The local data storage

One peculiarity of the ALICE DAQ system is its large bandwidth local data storage located at the experimental area and which provides a data storage autonomy of several hours. It is organized around a storage network based on a Fibre Channel Storage Area Network used to interconnect the servers (90 GDCs) and the storage (75 Transient Data Storage System or TDS). This SAN has evolved since the initial installation and is now constituted by 2 enterprises switches and 4 satellite switches (see figure 2). The switches are interconnected by Fibre Channel 10 Gbit/s while the servers and the storage equipment are connected to the switches by Fibre Channel 4 Gbit/s.

![Figure 1. Hardware architecture of the ALICE online systems.](image1)

![Figure 2. The ALICE local data storage.](image2)
A commercial cluster file system (Quantum StorNext) is used to provide a coherent access from all servers to all storage devices. A feature of this file system is used to establish an *affinity* between a node of the file system and a peculiar storage device. One can therefore avoid concurrent data traffic to the same data volume which is essential to keep good performances.

It was originally estimated that a bandwidth of 1.25 GB/s to the data archiving would provide adequate physics statistics. During the 2010 heavy ion run, the archival bandwidth was often superior to 2.0 GB/s. The total data recording performance of the storage system has been measured during the preparation. The aggregate performance is 7 GB/s: 4.5 GB/s for writing and 2.5 GB/s for reading.

2. The ALICE experiment commissioning and operation

2.1. The experiment commissioning and first year of data taking

The ALICE detectors have been installed and commissioned during several years. Three periods have been dedicated to the systematic commissioning of every detector with the online systems followed by a global commissioning of the experiment: 10th to 21st December 2007, 4th February to 9th March 2008, and 5th May to 20th October 2008. During these periods, the time was shared between the standalone commissioning of each detector and the global runs performed with the detectors ready to participate. The number of detectors participating to these runs is an indication of the readiness of the ALICE experiment. Figure 3 shows the duration of global data taking as a function of the number of detectors participating to these global runs for the commissioning periods and also for the 2010 pp run. One can clearly see the evolution of the experiment readiness by the increase of the number of detectors participating to global runs.

![Graph showing duration of global data taking as a function of the number of detectors participating to these global runs.](image)

*Figure 3.* Duration of the global data taking as a function of the number of detectors participating to these global runs.

The 2010 physics data taking lasted from April till early December. The total numbers of physics trigger with proton and lead ion beams are shown in figures 4 and 5 respectively for the main physics triggers used.
2.2. Experiment operation
The experiment has been initially operated by a team of 24 persons. A large effort has been done to reduce this heavy load by combining shifts and training the shifters. A better support has also been provided to the shift crew by improving the existing software tools such as the Data Quality Monitoring (DQM) [3] or by adding new tools such as the ALICE Configuration Tool (ACT) [4] in charge of configuring the whole experiment.

3. The experiment upgrade

3.1. ALICE upgrade

Different upgrades are considered for the ALICE detector: modification or construction of a new Inner Tracking System (ITS), addition of a Forward Calorimeter (FOCAL), or addition of a Very High Momentum Particle Identification (VHMPID). There is no decision yet on any of them but it is already clear that new readout solutions will have to be proposed. The DAQ has therefore already started an R&D in view of proposing new readout solutions and for the upgrade of the DAQ system itself. The R&D is performed in different areas presented hereafter.

3.2. Detector readout upgrade

Figure 1 shows the ALICE dataflow from the detectors to the DAQ and HLT systems implemented as a set of parallel point-to-point optical links: the DDLs with a bandwidth of 2 Gb/s in both directions. New options are being investigated as cheaper (1 Gb/s Ethernet) or faster (the CERN PH-ESE versatile link, the 6 Gb/s link used for the common DAQ and HLT RORC, and 10 Gb Ethernet) alternatives to the DDL. Figure 6 shows the performance of the Internet Protocol (IP) based DATE readout using a 10 Gb/s Ethernet link. The performance has been done with a software data source which has a maximum throughput of 500 MB/s. The work has started to build a hardware data source in order to test the connection at wire speed.
3.3. DAQ input/output

Some modifications of the DAQ are also required to adapt to the PC’s evolution such as the transition from PCI-X to PCI-e. This is in particular needed for the readout of the Detector Data Links (DDL) used to transfer the data from the detectors to the DAQ PCs. The adapter used are called DAQ Read-Out Receiver Cards (D-RORC) and are plugged in PCI-X slots. A PCI-e version of the D-RORC has been designed. The bandwidth of both versions is shown in figure 7.

![Figure 7. Bandwidth of the PCI-X and PCI-e D-RORCs as a function of the transfer size.](image)

4. Conclusion

The ALICE DAQ system has been used in production at nominal performance for a complete year. It has delivered 2000 hours of global physics data taking, read out $5 \times 10^9$ events, and recorded 1.8 PB of data recorded at a bandwidth of up to 2.8 GB/s. The DAQ team has started the R&D required for the ALICE upgrade.

References

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