The upgrade of the ATLAS High Level Trigger and Data Acquisition systems and their integration
Ricardo Abreu on behalf of the ATLAS TDAQ Collaboration

Abstract

The Data Acquisition (DAQ) and High Level Trigger (HLT) systems that served the ATLAS experiment during LHC’s first run are being upgraded in the first long LHC shutdown period, from 2013 to 2015. This contribution describes the elements that are vital for the new interaction between the two systems. The central architectural enhancement is the fusion of the once separate Level 2, Event Building (EB), and Event Filter steps. Through the factorization of previously disperse functionality and better exploitation of caching mechanisms, the inherent simplification carries with it an increase in performance. Flexibility to different running conditions is improved by an automatic balance of formerly separate tasks. Incremental EB is the principle of the new Data Collection, whereby the HLT farm avoids duplicate requests to the detector Read-Out System (ROS) by preserving and reusing previously obtained data. Moreover, requests are packed and fetched together to avoid redundant trips to the ROS. Anticipated EB is activated when a large enough portion of the event is requested, reinforcing this effect. A new HLT Processing Unit exploits current architecture trends with a multiprocessing approach that is based on process forking, thereby bypassing thread-safety concerns, while containing total memory usage through the OS’s Copy-On-Write feature. HLT and DAQ releases are decoupled by a flexible interface that allows quick updates of the communication between both sides, thus providing increased operational maneuverability. Finally, additional data are recorded through Data Scouting. A method of previewing properties of events whose frequency would otherwise exclude them, this new feature will provide key intelligence for subsequent trigger adjustments.

Upgrade approach

In Run 2, the ATLAS TDAQ system will deal with stricter conditions not so much by scaling computing resources as through the improvement of the systems that are involved. Here we present 5 improvements with high impact on the integration of the DAQ and HLT systems.

HLT merger

Before:

- Detector
- L1
- L2
- HLT
- Offline

After:

- Detector
- L1
- L2
- HLT
- Offline

Benefits:

- Simplified architecture: reduces component dependencies and communication complexity
- releases computing resources
- optimal balance of computing power: Automatically and dynamically

ATLAS DAQ

The Data Acquisition (DAQ) subsystem includes all the infrastructure that drives the data flow from the ATLAS detector to offline storage. This includes, among other things:

- the detector readout system
- HLT hosting infrastructure
- data collection components
- data recording components
- control and management infrastructure
- monitoring infrastructure

Incremental Event Building (EB)

The new HLT selection is a continuous procedure that moves progressively from coarse algorithms to thorough ones. Each algorithm requests data explicitly. With each individual data request from the HLT, a bit more of the event data is retrieved and added to the partially held event, until the EB step retrieves remaining data. For all purposes, the event is built in an incremental fashion.

Data Scouting

The HLT discards about 1000 events for every full event it lets through. The new HLT will however record additional data with the new data scouting feature. Smaller events with only the result of HLT processing (no detector data) can be accepted at otherwise deterent rates. They can be used for both calibration and new physics searches.


Preparing for full throttle

<table>
<thead>
<tr>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminosity (cm⁻²s⁻¹)</td>
<td>8 x 10³³</td>
</tr>
<tr>
<td>Center-of-mass energy (TeV)</td>
<td>8</td>
</tr>
<tr>
<td>Bunch spacing (ns)</td>
<td>50</td>
</tr>
<tr>
<td>Bunch crossing rate (MHz)</td>
<td>20 up to 40</td>
</tr>
<tr>
<td>▶ up to 50 interactions per bunch crossing</td>
<td></td>
</tr>
<tr>
<td>▶ L1 rates increase by about a factor of five</td>
<td></td>
</tr>
<tr>
<td>▶ HLT will have to tighten filtering requirements</td>
<td></td>
</tr>
</tbody>
</table>

Multiprocessing HLT Processing Unit

- Modern CPU evolution rewards parallel over sequential processing
- Each machine in the HLT farm executes several selection processes concurrently
- we bypass thread-safety constraints
- Total memory usage is contained by copy-on-write mechanism
- We initially start only one HLTPU instance in each node. Only after it has completed all initialization, shortly before the first event is processed, is the HLTPU forked into multiple trigger processes

Flexible DAQ/HLT communication

The new HLT receives external information from the DAQ through general parameters, leaving room for updates that are not bound to project releases. This gives us more operational flexibility, allowing fast reactions to maximize efficiency.

Ricardo Abreu is with CERN, PH/ADT Department, CH-1211 Geneva, Switzerland (e-mail: ricardo.abreu@cern.ch)