Evolution of the Trigger and Data Acquisition System in the ATLAS experiment

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²<https://cdsweb.cern.ch/record/1386334>

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Existing Trigger and DAQ system

- Three level design

- Level 1 built with custom h/w ($< 2.5 \mu\text{s}$ latency)
- Level 2 and Event Filter form High Level Trigger(HLT) and are s/w triggers running on commodity PCs

Existing Trigger and DAQ system

- On L1 accept
 - Data pushed to ReadOut System(ROS) PCs
 - Information on detector Regions with Interesting activity (RoI) passed to Level 2

Existing Trigger and DAQ system

- Level 2 has a latency $\sim 40\text{ms}$
 - Reads only partial event data (RoI) from ROS
 - L2 Accept triggers event building

Existing Trigger and DAQ system

Event Builder

- Event data pulled from ROS to Event Builder
- Collects full event data
- Feed assembled event data to Event Filter through BackEnd network

Existing Trigger and DAQ system

- Data logger
 - Store events in different files (streams) depending on trigger results
 - Send files to Tier 0 asynchronously

Existing Trigger and DAQ system

- Event level parallelism
 - Each Processing Unit(PU) process works on single event
 - Multiple processes in each node
- Operating beyond design capacity

Performance in 2011-2012

- Delivered luminosity
 - 5.32 fb^{-1} @ 7 TeV in 2011
 - $\sim 16.4 \text{ fb}^{-1}$ @ 8 TeV in 2012
- 93.8% efficiency in ~ 2900 hours of beam time
- Bunch crossing is 50ns
- Average number of interactions per bunch crossing (pileup) in a run
 - 9.1 in 2011
 - 20.0 in 2012
- Peak pileup already exceeded 35 interactions per bunch-crossing

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Pileup Dependency

- Event size
 - Largely linear but might deviate in the future
- For pileup rate of 35
 - Recorded event size ~1.6 MB
- CPU also depends on pileup
 - Older nodes are approaching to their limit
 - Under control until the Long Shutdown at the beginning of next year

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LHC Long Shutdown

- Good opportunity to upgrade S/W and H/W
 - Improve design with experience acquired during 2010-2012
 - Create a better, more scalable platform for 2014 and beyond
 - Utilize modern tools, compilers, libraries
 - Take H/W developments into account
 - Many-Core systems
 - GPGPUs
 - Accelerator cards

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- Expected parameters after shutdown
 - 100 kHz L1 Rate
 - 1 kHz EF output
 - 25 ns bunch-crossing rate

Changes in Design

- Merge L2, EB and EF into one system
 - Simplify farm structure
 - Simplify network topology
 - All event processing in single node

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Changes in Design

- Each HLT node contains
 - One Data Collection Manager (DCM)
 - One or more HLT Processing Units (HLTPU)

Changes in Design

- HLT Processing units

- Does event selection
- Fork multiple children

- Minimize memory utilization using Copy-on-Write feature of Linux kernel
- ~300 MB/child instead of ~1.2 GB/process for 32bit application

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- Data Collection Manager

- In charge of data collection, caching and integrity
- Assigns events to available Processing Units (HLTPU)
- Sends accepted events to Data Logger
- IPC through shared memory and unix sockets

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Changes in Design

- **HLT SuperVisor (HLTSV) supervises HLTPU Nodes**
 - Gets the L1 Result from Level 1 trigger
 - Assigns it to an available Data Collection Manager
 - Provides load balancing of non-uniform nodes
 - Single application seems enough for event rates up to 100kHz

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Changes in Event Selection

Current event selection

• L2PU

- Receives partial event data
- Produces a selection result
- Sends result to L2ResultHandler node

• EFPU

- Receives full event data (containing the L2Result)
- Processes the event using the L2Result as seed
- Produces final decision

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- Serialization-Deserialization between processes
- Network latency
- L2 data unpacked twice

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New event selection

- Execute L2 and EF algorithms in same process
 - No latency or duplication of work
 - HLT Result serialization only on accept
 - Data accessed and unpacked only once
- Optimize algorithm order of execution to minimize decision time
 - Execute the set of algorithms that are most likely to accept the event first
 - Less load on event buffers (ROS)

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Prototyping

Prototyping efforts are ongoing

- HLTSV
 - Multiple prototypes using different technologies are developed
 - All exceeded 100kHz
- DCM
 - A demonstration implementation is available
- HLTPU
 - Prototyping implementation is ready
 - Can be used in data flow tests
- First implementations will be available at the beginning of next year
- To be tested and finalized during 2013 in test beds and at HLT farms

Summary

- ATLAS Trigger and DAQ system has shown great performance during 2010-2012
- Current system went well beyond its design and all parameters are under control
- Evolution design will be an improvement of current system and leave the door open for future developments
- Trigger and DAQ will be ready for collecting new data after the long shutdown

Backup

HLTSV Scalability