Integration of the ATLAS Tag Database with Data Management and Analysis Components

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Overview

• Introduction
• ATLAS event-level metadata
• The ATLAS Tag Database
• Distributed Data Management & Analysis
• The ATLAS Tag Navigator Tool
• Some performance measurements
• Conclusions & further work
• ATLAS raw data rate after triggers: 200 Hz
• Raw event size: 1.6 MB
• Processed to ESD (1 MB), AOD (100 kB)
• $2 \times 10^9$ events/year
• Selectivity for Higgs event: $\sim 1$ in $10^{13}$
ATLAS Event-level Metadata

- "Tags" - summary physics data for events
- Allows:
  - efficient selection of interesting events
  - direct navigation to these events
- 2 formats
  - ROOT files: useful as indices to event
  - Relational Database: useful for querying
- 1 kB/event, 6 types of attribute stored
  - Includes pointers to AOD, ESD and RAW data files
The Tag Database

- Generated from file-based tags which are produced at reconstruction
- Global Oracle database at CERN
- Replication to other sites (Oracle / MySQL) under investigation
- Series of test databases deployed
  - Largest: 1 TB
  - Most realistic: 2 GB (+ indices)
- Prototype Web Query Browser

Talk #161 - “Building a Scalable Event-Level Metadata System for ATLAS” - has details of performance tests
A Physicist Use Case

Query Tag Database
Get list of events
Find correct files on grid
Run distributed analysis
Get output!
3 grids used by ATLAS: LCG, OSG, NDGF
Data movement and cataloging by Distributed Data Management system: DQ2
Uses *dataset* as unit of data handling
Dataset = group of files + metadata
See talk #64: “Managing ATLAS data on a petabyte-scale with DQ2”

**Challenge: Tag Database ignorant of datasets**
ATLAS Distributed Analysis

- Use grid computing for analysis, hide complexity from users
- Tools developed include
  - PanDA (Talk # 167)
  - GANGA (Talks #146, 287)
- Tag Database initially integrated with GANGA

**Challenge:** GANGA supported file-based tags, not relational tags
The Tag Navigator Tool

- Developed to meet these challenges
- Standalone version: Python wrapper around existing grid tools
  - Limited to LCG
- GangaTnt: plugin for GANGA
  - Modular GANGA design gave easy integration
  - Allows access to GANGA job handling
  - Allows access to other GANGA plugins
Some Performance Measurements

• Simple tests to give initial understanding of performance
  - Much more work needed!

• Example \( Z \rightarrow e,e \) analysis
  - Reads electron objects from persistent storage and reconstructs invariant mass to get Z peak

• Comparison of analysis without tags, with file-based tags, with relational tags

• AOD cut (~10%) :
  2 electrons, electron \( p_T > 20 \text{ GeV}, \ |\eta| < 2.5 \)
Local Tests: single file

- AOD and Tag files on local disk (CERN lxplus)
- 5000 events
- Run Athena on whole file
  - Without tags
  - With varying percentage of events pre-selected with tag file
Local Tests: single file results
Local Tests: increasing input events

- Increasing number of input files, 4-5000 events each
- All on local disk
- Run Athena on events
  - Without tags
  - With ~10% pre-selection on file-based tags
  - With ~10% pre-selection on Tag Database
    - Query done within Athena, included in analysis time
Local Tests: increasing events results

![Graph showing the relationship between total real time and number of events for different tagging methods.

- **No tags**
- **File-based tags**
- **Relational tags**

As the number of events increases, the total real time for processing also increases. The graph illustrates the performance differences among the three tagging methods, with **No tags** showing the highest total real time and **Relational tags** showing the lowest.
Local Tests: increasing events results

The graph shows the total CPU time (s) against the number of events for three different tagging methods: No tags, File-based tags, and Relational tags. The CPU time increases linearly with the number of events for all three methods, with Relational tags having the highest CPU time and File-based tags having the lowest. The error bars indicate the variability in the CPU time for different runs.
Local Tests: increasing events results

![Graph showing the ratio of No tags : File-based tags vs Number of AOD files. The graph includes two lines: one for Real time (blue squares) and one for CPU time (green triangles). The ratio increases as the number of AOD files increases.](image-url)
Local Test Summary

- Using tags gives significant improvement in time for tight selections
  - Using tags faster for selectivities < 60%
- As number of input events increases, performance gain from tags increases
- Little difference seen between file-based and relational tags
Distributed Analysis Tests

- Same analysis, run on LCG through GANGA
- 2 files from 1 AOD dataset as input
- Jobs sent to sites with the dataset
- No job splitting
- Measured on worker node:
  - Time for setup, including any data fetching \((\text{setup time})\)
  - Time for analysis to run \((\text{analysis time})\)
• Run Athena as GANGLA application with
  - No tags used: AOD dataset name given to GANGLA, job goes to that site
  - File-based tags: AOD and Tag dataset names given to GANGLA, job goes to site with AOD
    • *Should* also have Tag dataset there.. but not yet always the case
  - Tag Database: GangaTnt used to run query and find correct dataset
Distributed Analysis Tests: results

Long setup time because tag files not at sites.
Distributed Analysis Test Summary

• Setup times similar with and without tags
  - Delay with file-based tags should not be present in future
• Analysis ~ twice as fast with tags
• Little difference between file-based and relational tags
  - GangaTnt query time (few seconds) not included here
• Consistent with local analysis results
  - With larger analyses, impact of using tags will be higher
• GangaTnt and standard GANGA tag use complementary
Conclusions & Future Work

- TNT and GangaTnt enable integration of ATLAS Tag Database with Distributed Data Management and Analysis components
- Initial tests show:
  - 50% cut in analysis time for 10% selection on single file
  - Tags improve performance for selectivity up to 60%
  - Increasing performance gain for tags as input events increase
- Further work needed to understand:
  - Tag use with larger numbers of events
  - Effects of file I/O
  - Differences between file-based and relational tags
- Tag Database will continue to grow and GangaTnt will continue to develop
Backup Slides
• **Budget**: 1 kB / event

• **6 groups of attributes**:
  - **Event quantities**: run number, event number, luminosity...
  - **Data quality**: detector status, “good for physics”...
  - **Physics objects**: e, μ, τ, jets
  - **Physics/Performance Group attributes**
  - **Trigger information**
  - **Pointers to event data**: AOD, ESD & RAW refs, software version...