ATLAS Distributed Computing Operations in the First Two Years of Data Taking

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ATLAS in two years of data taking

The Large Hadron Collider (LHC) at European Organization for Nuclear Research (CERN) has been delivering stable beams colliding at 7 TeV since 2010.03.30

ATLAS has been taking and processing data with a good efficiency
ATLAS Computing Model: T0 Data Flow

- Tier-0: Data Recording to tape, First Pass Processing
- Tier-1: CERN Analysis Facility, Tier-1 (Tier-1 centers, RAW data copy on tape, Analysis data on disk, Reprocessing)
- Tier-2: 38 Tier-2 centers, Analysis data on disk, User Analysis

Event Summary Data (ESD): ~1 MB/evt
Analysis Object Data (AOD): ~100 kB/evt
derived data (dESD, dAOD, NTUP,...) distributed over the Grid

200Hz
RAW: ~1.6MB/evt
Calibration
ATLAS Computing Model: MC Data Flow

- Tier-1: CERN
  - Analysis Facility
  - 10 Tier-1 centers + CERN
  - Aggregation of produced data
  - Source for further distribution

- Tier-2: Job input
  - 38 Tier-2 centers
  - MC Simulation
  - Group/User Analysis

- Tier-1: Tier-2
- Tier-2: Tier-2
- Tier-2: Tier-2
Data Distribution in First Years

Started data distribution following the “ATLAS Computing Model”
- Not necessarily applicable to the “first year”
- Revised the model according to the needs

First year (2010)
- Many analysis jobs using ESD for detector performances
  ‣ extra replicas of ESD

Second year (2011)
- Less reduction by event filtering before recording = higher trigger rate up to 400 Hz
- RAW data on DISK for “discovery mode”
- keeping the disk usage and data export throughput within the limits
  ‣ RAW data compression (factor ~2)
  ‣ ESD on DISK with limited lifetime
Data Distribution Revisited

Strategy

- Introduced the concepts of ‘primary’ (base replicas) and ‘secondary’ (extra replicas)
- Distribute ‘primary’ base replicas according to the model
- Add ‘secondary’ extra replicas of supposedly popular data, using the remaining available disk spaces
- Removing unused ‘extra’ data when need to free some space

Compound

- Pre-defined distribution based on the model (primary+secondary)
  - T1 replicas for redundancy (p)
  - T2 replicas for analysis (p)
  - Extra replicas for larger opportunity for analysis (s)
- Dynamic data placement based on the usage (secondary)
  - Started mid 2010
  - Tuning beginning of 2011
- On-demand replication system
Data Processing Activities

Official Production

- Monte Carlo simulation has been running constantly since before the start of data taking
- Reprocessing of detector data ran several times

End-user Analysis

- End-user physics analysis on the grid started rising since the start of data taking

Group Activities

- Groups of physics analysis produce common data for end-user analysis.
- Started as “end-user analysis” of the responsible people
- Has been formalized as “Group Production”
ATLAS software and database

ATLAS jobs need ATLAS software and detector information

The initial model

• ATLAS jobs install and validate software on a shared file system at each site
• A Database at each Tier-1 site synchronized with Oracle Streams from Tier-0
  ‣ Jobs needing information in database are sent to the Tier-1 sites
• File-based database containing a part of information distributed to all the sites
  ‣ Detector geometry parameters needed for simulation jobs
  ‣ Detector conditions information needed for end-user analysis jobs

Evolution

• CernVM-FS for software distribution – removing bottlenecks with the shared FS
  ‣ CernVM-FS: a network file system based on HTTP
  ‣ ATLAS software and file-based database are installed on the server at CERN
  ‣ Files are downloaded and cached at the sites and on the worker nodes
• Frontier/Squid for database access – removing limits with the database access
  ‣ http-based system to access remote database with caching
  ‣ Any type of jobs can run at any Grid site
Ensuring Smooth Activities

Constant flow of tests to detect problems as soon as possible and react

Data Transfer Functional Tests
- Important especially for Tier-1 sites where data replication from Tier-0 is crucial while Tier-0 export is not a constant flow.
  - to avoid finding a problem only when starting a replication

Automatic control of data transfers
- based on declared site downtime, free space at the destination

Analysis Job Functional Tests and automatic control of queue status
- Problems are usually reported after seeing a large number of failures
  - Production jobs are re-submitted automatically by the system when failed
  - Analysis jobs are not
    - When jobs are failing, it is too late. Users are already suffering.
- Need to detect problems as soon as possible, and close the queues at problematic sites
  - and re-opening the queues only after successful tests

Production Job Functional Tests and automatic control of queue status
- being introduced recently aiming at reducing the load of manual interventions
Monitoring

A “key” for operations
  ▸ A large amount of efforts have been put in to monitoring

ATLAS activities
  ▸ to understand the situation of the various ATLAS activities

Site status – tracking all the sites
  ▸ not only that the services provided by the sites are working
  ▸ but also if the sites are used and are working in ATLAS activities
  ▸ also records declared site downtime information.
    - can be taken into account for availability calculation
    - started using it for automatic control of queues

Network – monitoring the full mesh of O(100 x 100)
  ▸ ATLAS ‘sonar’ – file transfers by the ATLAS system
  ▸ perfSONAR – network performance (throughput, latency, traceroute, ...)
    - recently started with a short list of sites to be extended in future
Network Revisited - Transfer Routing

The original model
- **Dedicated network** between T1s
- **Good network** between associated T1-T2s
- Initial transfer routing between T2s
  - T2-T1-T1-T2
  - except for close sites (direct transfer T2-T2)

Reality
- Some T2s have no problem in data transfers from/to other T2s, or T1s not associated to

Auto-routing
- mesh transfer tests from every site to every site (‘sonar’ tests)
- the transfer system decides the site-to-site routing based on the measurements
Beyond the Original Data Processing Model

The original model

• Each production task is assigned to a T1 where the input data is available
• The jobs of the task are run at the T1 and its associated T2s
  ‣ parts of the input data sent to the T2s
  ‣ the output data aggregated to the T1
• T1 disk capacity and T1+T2 cpu capacity may not be in balance

Multi-association of T2 with T1s

• Some T2s with good network connection can be associated to multiple T1s
• high priority tasks can be done more quickly
• can bring disk-cpu capacities into balance

Even T1s can be associated with other T1s
Data Processing Model Revised

10 Tier-1 centers + CERN
Aggregation of produced data
Source for further distribution

Tier-1

CERN Analysis Facility

Tier-2

job input
Summary

**ATLAS distributed computing system has been running stably with the large amount of data**

- Data distribution from Tier-0
- Production of simulated data and its distribution
- Group and end-user analysis jobs

**The system continues to evolve and improve**

- Data placement with various components
- Group analysis into production system
- Constant flow of Functional Tests (data transfer, analysis, production)
- Monitoring of activities, sites, network
- Beyond the original data processing model

Looking forward to fruitful physics results from the experiment