Distributed Data Analysis in LHCb

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On behalf of the LHCb Distributed Analysis Team
Outline

- Distributed Analysis for LHCb
- Job preparation via Ganga
- DIRAC API as an interface to the WMS
- Performance
LHCb distributed data analysis will occur at the Tier-1 sites
  - CERN (Tier-0) also acts as a Tier-1 site

Jobs are sent where replicas of the data are
  - No on-demand data replication
Distributed Analysis for LHCb

- Stripping is a centrally managed analysis run as a production
  - Reduces analysis datasets to a size of $10^6$ to $10^7$ events per year
- User analysis performed on stripped data throughout the year
  - All stripped data will be disk resident and replicated to all Tier-1 sites
- No direct LCG submission for LHCb Distributed Analysis jobs
  - Instead submit via DIRAC
Job Preparation and Submission via Ganga

- Ganga provides LHCb users with a transparent mechanism for submitting jobs to available backends
  - Local
  - LSF and other batch systems
  - DIRAC
- Jobs can be persisted via a remote job repository
- Client-side splitting allows input data to be sorted by site
  - The LHCb Computing Model dictates that jobs should be sent where the data resides
- For LHCb Grid jobs, the default mode of submission is via DIRAC
  - Ganga utilizes the DIRAC API for distributed analysis tasks

See talk [146] - A.Maier et al.
DIRAC is the LHCb Workload and Data Management system (WMS)
- Realizes the PULL scheduling paradigm
- DIRAC WMS can be viewed as a very large batch system
  - Accounting
  - Priority
  - Fairshare

The DIRAC WMS provides several key benefits for a community of users
- Central Task Queue allows workload optimizations at the level of the VO
- VO policy can be applied in one central location

See poster [189] A.Tsaregorodtsev et al.
The DIRAC API provides a transparent and secure means for users to submit jobs to the WMS.

- Also exposes the functionality of the production system to users
  - Can construct DAGs
- Serves as the interface for Ganga

The heterogeneity of underlying resources is masked from users.

- Little or no Grid knowledge is required to submit jobs via Ganga to DIRAC
- LCG jobs are Pilot jobs for the DIRAC WMS
  - Actual workload management performed by DIRAC
Additional Benefits of the DIRAC WMS

- Input data is checked in LFC prior to sending Pilot Agents to the Grid
  - If no eligible destination sites are found jobs can be failed meaningfully
- Central Grid site ‘mask’ ensures jobs run on fully operational sites
  - Prevents common problems affecting jobs such as
    - ‘Black-holes’
    - Incorrectly configured sites
    - Non-transparent downtime, etc.
- Data access for LHCb is via available protocols
  - DIRAC Job Wrapper resolves input data into best replica TURLs for site local SEs
- DIRAC Stager provides a mechanism to recall files from tape in advance of job execution
  - Can otherwise consume large amounts of wall-clock time on WNs
  - Mainly a production activity, also made available to users

See talk [174] - S.Paterson et al.
The DIRAC Sandbox mechanism ensures input and output files are delivered to and returned from the Grid WNs:

- Small files are stored in the WMS MySQL DB.
- Larger files may be uploaded to Grid storage and specified by LFN.

Output sandbox files exceeding 10MB are automatically uploaded to Grid storage:

- Prevents population of MSSs with small files.
Treatment of Output Data

- Specified output data is automatically transferred and registered in the LFC by the DIRAC Job Wrapper
  - Notification is sent to users in output sandbox
- Users are free to use the resulting replica (LFN) as input data for subsequent jobs
- Job management functionality will soon be exposed via the web interface
  - Job reschedule, delete etc.
**LHCb DIRAC Monitoring**

- Job management functionality will soon be exposed via the web interface
  - Job reschedule, delete etc.

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**Diagram:**

- JDL (Job Definition Language) details
- Job status and parameters

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S.K.Paterson, CHEP 2007, Victoria
The LHCb distributed analysis framework has been stable for 2 years

- During LHCb DC06 data processing phase up to 1.2K concurrent data analysis jobs were running through DIRAC
- The sample being considered here are real LHCb user jobs submitted from January to August 2007
  - Over 70 distinct users
  - More than 100 Grid sites involved

Submission of user distributed analysis tasks can be considered chaotic

- User jobs are of the highest priority
- Must have a responsive system in place
Job Start Times

- Job start time is defined here as the difference between time of submission to the WMS and the job starting on the Grid WN
  - 15K real user distributed analysis tasks considered

- 3K jobs of >24hrs duration were ignored
  - These correspond to ‘rescheduled’ jobs
The Grid environment is inherently unpredictable
- Studies over short periods of time yield high job efficiencies
- Performance over extended periods of time can highlight sources of error

Results breakdown of 25K LHCb user job sample

- 56% Successful
- 20% Failed to upload output data
- 15% Application failure
- 7% Stalled
- 1% Data access failure
- 1% DIRAC success
- 1% Unknown
Job Completion Efficiency

- **Successful (56%)**
  - Jobs completing with no errors

- **DIRAC Success (20%)**
  - Represent jobs identified by DIRAC WMS that could not be successfully executed, e.g.
    - Input data not available in LFC or not correctly specified
    - User proxy too short for job
    - Illegal Job JDL
  - No resources are expended on these jobs

- **Data Access Failure (15%)**
  - SRM instability can result in unresolved TURLs
  - Inconsistencies in the data
    - E.g. impossible to obtain TURL for zero size replicas in LFC
    - Rescheduling jobs has no effect in this case

*See talk [174] - M.Bargiotti et al.*
Job Completion Efficiency

- **Stalled (7%)**
  - DIRAC jobs send regular ‘heartbeats’ during execution
  - Jobs are stalled when these heartbeats are not received, e.g.
    - Jobs running out of CPU time / Wall-clock time
    - Expired proxies
    - Loss of open data connections at sites, etc.

- **Failed to Upload Output Data (1%)**
  - The DIRAC site mask ensures that problematic SEs can be banned from use as soon as issues are discovered
    - Small effect for user jobs

- **Application Failure (1%)**
  - Can also account for some of the stalled jobs above
    - E.g. users running their own compiled code
  - Application failure can also be related to corruptions in site shared-areas
The DIRAC WMS provides a stable platform for running LHCb central production and distributed analysis tasks

- Agents check the local environment to ensure a resource is capable of successfully running a job
- The DIRAC site mask prevents jobs failing due to temporary instabilities

Issues such as data integrity are becoming increasingly significant

- Efforts are ongoing to correct this

Identifying problems before submission to the Grid can conserve resources

- Issues with 20% of the sample of user jobs were found
The LHCb distributed analysis framework has been stable for 2 years
- No direct LCG submission, all LHCb distributed analysis tasks go through DIRAC
- Users require little or no knowledge of the Grid to proceed
- Issues affecting performance over extended periods of time have been identified
  - Inconsistencies in available data