CMS Data Transfer operations after the first years of LHC collisions

Outline

• Data Transfers Operations
  o introduction to operations;
  o monitoring and problems
  o troubleshooting

• Improving transfers quality
  o LHCONE

• Data Consistency
  o operations;
  o challenges;
Distributed computing infrastructure

up to 1.8GB/s

7 Tier-1s; 54 Tier-2s; over 60 Tier-3s

over 2550 active links

Rapolas Kaselis
PhEDEx

- Physics Experiment Data Export is at the core of all CMS data transfers.
- Distributed database-centric architecture.
- Keeps track of data stored at sites.
- Central agents, which are calculating routes, harvest historical data, etc., are running at CERN.
- Each CMS site runs a set of site software agents.
- Web based monitoring and control
  - helps to observe failing transfers, debug issues;
  - data subscriptions and approvals managed by responsible site administrators.
- Web service providing machine readable information.

Rapolas Kaselis
2012-05-21
Quantities

• In data taking mode:
  o 25-30 TB are being exported from Tier-0 daily during protons’ runs.
  o 60 TB on avg. exported daily during heavy-ions’ runs (with record 120 TB/day, ~1.4 GB/s) from Tier-0.
  o 30-35 TB are being exported from Tier-1s to Tier-2s daily.
  o 15 TB daily Tier-2s to Tier-2s.
  o ~1400 TB transferred in one week
Preparation for 2012

- During the most recent test (Tier-0 ➔ Tier-1s), 1.2GB/s export rate has been achieved (export planned for 2012)
  - furthermore, available infrastructure can keep up to 1.8GB/s (retained for 12h)
- Regular transfer tests are going on all the time
- Commissioning links
  - Export from Tier-1 at 20MB/s for 24h
  - Export from Tier-2 at 5MB/s for 24h
Monitoring transfers

• Mostly looking at PhEDEx web page:
  o transfers quality plots.
  o transfers rate table.

• More than 2550 active links.

• 4 central operators.

• Basic checks are being done by computing shifters*, who monitor 24/7 and are very helpful detecting stuck transfers or dead PhEDEx agents at sites.

* see “Towards higher reliability of CMS Computing Facilities” poster by José Flix

Rapolas Kaselis
Monitoring transfers 2

Quality plot

Rate table

e.g. FNAL → all sites
Transfer problems

- Storage issues
  - corrupted tape
  - crashed storage node
  - data loss

- Network issues
  - cable cut
  - misbehaving router on the path
  - timeouts

- Authorization issues
  - expired certificate/proxy
  - certificate/proxy doesn’t have appropriate roles/extensions

- Configuration issues
  - Improper PhEDEx agents’ configuration
  - FTS channels configuration
Troubleshooting

• Check if there is a link between hosting file site and receiving site?
  o additional inspections why path can not be calculated.

• Check what status file is in?
  o might be a problem staging from tape.
  o might not report properly as staged on disk.

• Check if there are errors on that link?
  o errors might immediately tell what the problem is and where is it.

• Open a ticket to a site. Give some hints what might be causing problems, ask to solve the them.
  o ~1300 tickets were opened during the last year.
  o On avg. 3.5 tickets per day (5 tickets/day excl. weekends).
  o 15-20 tickets on average are open at any given moment.
LHCONE

- LHC Open Network Environment.
- CMS transfers must rely on a stable and reliable network behind, but should be ready to face any changes in the underlying network infrastructure.
- The objective of LHCONE is to provide a collection of access locations that are effectively entry points into a network that is private to the LHC T1/2/3 sites.
  - LHCONE is not intended to replace the LHCOPN but rather to complement it;
  - it addresses Tier-2/3 levels, on GPN infrastructures in different nations so far;
  - LHCONE is intended to grow as a robust and scalable solution for a global system serving LHC Tiers’ needs and to fit in less-hierarchical computing models.
Transfer tests in LHCONE

• The T2-T2 commissioning work in CMS was done in 2010.
  o connections need to be tested BEFORE and AFTER any change to the network

• CMS decided to adopt a strategy consisting of two complementary approaches
  o one based on PhEDEx LoadTest infrastructure;
  o one based on FTS/FTM;
  o the first approach is CMS specific, the second is general;
  o the first approach allows to map the performances of the T2-T2 connections and monitor them over time
    • in terms of transfer rates, transfer quality, transfer latency to transfer a few TBs sample

• The first round of such test activities is done. We are now in the process of testing connections from/to sites which enter the LHCONE prototype, one by one
A snapshot of test results

E.g. rates *→ T2_IT_Pisa

E.g. rates T2_IT_Pisa→ *

Max rate in 1 hr [MiB/s]

<table>
<thead>
<tr>
<th>to</th>
<th>BE</th>
<th>DE</th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
<th>IN</th>
<th>IT</th>
<th>IT</th>
<th>RU</th>
<th>UK</th>
<th>US</th>
<th>US</th>
<th>US</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE</td>
<td>IIHE</td>
<td>DESY</td>
<td>RWTH</td>
<td>IFCA</td>
<td>GRIF_LLRR</td>
<td>TIFR</td>
<td>Legnaro</td>
<td>Pisa</td>
<td>RRC_KI</td>
<td>London_IC</td>
<td>MIT</td>
<td>Purdue</td>
<td>Wisconsin</td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>105</td>
<td>105</td>
<td>518</td>
<td>85</td>
<td>62</td>
<td>61</td>
<td>148</td>
<td>126</td>
<td>65</td>
<td>182</td>
<td>209</td>
<td>260</td>
<td>109</td>
<td>256</td>
</tr>
<tr>
<td>ES</td>
<td>97</td>
<td>144</td>
<td>86</td>
<td>108</td>
<td>61</td>
<td>76</td>
<td>87</td>
<td>113</td>
<td>66</td>
<td>122</td>
<td>72</td>
<td>136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td>77</td>
<td>85</td>
<td>97</td>
<td>61</td>
<td>77</td>
<td>145</td>
<td>96</td>
<td>57</td>
<td>320</td>
<td>279</td>
<td>133</td>
<td>368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>107</td>
<td>132</td>
<td>449</td>
<td>76</td>
<td>88</td>
<td>148</td>
<td>126</td>
<td>65</td>
<td>182</td>
<td>209</td>
<td>260</td>
<td>109</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>IT</td>
<td>87</td>
<td>109</td>
<td>196</td>
<td>64</td>
<td>57</td>
<td>47</td>
<td>105</td>
<td>62</td>
<td>79</td>
<td>171</td>
<td>114</td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RU</td>
<td>105</td>
<td>135</td>
<td>217</td>
<td>81</td>
<td>59</td>
<td>61</td>
<td>137</td>
<td>74</td>
<td>180</td>
<td>197</td>
<td>141</td>
<td>126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>42</td>
<td>68</td>
<td>119</td>
<td>28</td>
<td>n/a</td>
<td>42</td>
<td>51</td>
<td>49</td>
<td>74</td>
<td>99</td>
<td>77</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>64</td>
<td>110</td>
<td>414</td>
<td>93</td>
<td>88</td>
<td>87</td>
<td>139</td>
<td>132</td>
<td>63</td>
<td>305</td>
<td>116</td>
<td>287</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIT</td>
<td>108</td>
<td>89</td>
<td>422</td>
<td>84</td>
<td>68</td>
<td>65</td>
<td>133</td>
<td>133</td>
<td>59</td>
<td>39</td>
<td>72</td>
<td>428</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purdue</td>
<td>101</td>
<td>55</td>
<td>314</td>
<td>55</td>
<td>48</td>
<td>75</td>
<td>75</td>
<td>138</td>
<td>48</td>
<td>427</td>
<td>320</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td>102</td>
<td>105</td>
<td>365</td>
<td>81</td>
<td>43</td>
<td>86</td>
<td>139</td>
<td>108</td>
<td>62</td>
<td>100</td>
<td>330</td>
<td>85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data consistency

• Meta-data about all CMS production data is being stored separately (in databases) from the real data (on disks, tapes) and should stay consistent.
• Inconsistency can appear due to hardware failure.
• Several different points to check:
  o all files stored in the database should actually exist on the storage elements
  o files, stored on the storage elements, are complete
  o should be no dark data – files, that we don’t know about
• Monthly consistency check are being done at all Tier-1s.
• Being extended to Tier-2s.
How checks are being done?

• Storage consistency check (SCC):
  o List of all files older than one month are being gathered from the site.
  o List is checked against internal databases.
  o Present files not found in databases are called orphans.
  o Orphans have to be double checked:
    • If they are ‘real’ orphans, they get deleted.
    • If they are ‘fake’ – they get registered in databases properly.

• Block download verify (BDV):
  o Done centrally, if PhEDEx BDV agent is running at site.
  o Agent checks file and its size with information stored on transfers database.
  o Failures either get deleted completely, or scheduled for a re-transfer to site, if it is available somewhere else.
Consistency challenges

• Big number of sites (there are >50 Tier-2s).
• ~20 millions (~50PB) of files stored across T0, T1s and T2s.
• Big variation of storage technologies (CASTOR, dCache, DPM, Lustre, Hadoop…).
• Aiming for a full consistency is operationally challenging:
  o Not all sites are running PhEDEx BDV agent or running some old version not compatible with central DB or BDV agent is not properly configured, therefore either reporting many failures or not reporting at all.
  o Can not be fully automated (failures in some steps might cause data loss), but some things can be done to ease the process.
Average data transfer volume

Terabytes per day

- Debug
- Production
- CCRC08
- CSA06
- Load test
- SC4
- SC3
- SC2
Summary

• Transfers are running, and stand up for CMS needs.
• Monitoring takes a lot of effort in both – time and manpower to ensure smooth data transfer.
• Transfer operations can and will be partially automated
  o main issue to fully automatize - error messages from various components of the system are not unified on the same problem
    • e.g. different storage systems report different error messages
• Operators are fully prepared to meet this year transfers’ challenges.
Questions?

Thank you 😊