Intercontinental Multi-Domain Monitoring for the LHC Community

Domenico Vicinanza
perfSONAR MDM Product Manager
DANTE – Cambridge (UK)
domenico.vicinanza@dante.net

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The need of LHCOPN

The situation:
- CERN Large Hadron Collider (LHC) has really special networking and computing needs
- Computing Model is organised in tiers
  - CERN is the Tier0 (data producer)
  - 11 Tier1s (international big laboratories)
  - ~120 Tier2s (university research centres and labs)
- Data generated: 15 Petabytes/year (22 Petabytes last year)

The solution:
- A special network have been built for CERN to connect it to the 11 Tier1s around the world:
  - The LHC Optical Private Network (LHCOPN)
The situation:

- Tier2 are and will be playing a crucial role
  - *Most of the analysis will be done in Tier2 research centres and labs*
- Network is becoming an increasingly reliable resource
  - Since beginning 2011 a new network started to be designed
- Network is becoming an increasingly reliable resource
  "Data should be able to be pulled [...] from any Tier-2 or even, if possible, from several Tier-2s simultaneously in order to minimize the time to have the data locally to run the analysis task."

The answer:

- LHC Open Network Environment
  - L3VPN based multipoint network architecture
The monitoring challenge

- Robust and reliable operation requires an effective monitoring of LHCOPN and LHCONE
- Monitoring solution needs to be:
  - Scalable
  - Interoperable at international level
  - Easy to deploy and manage
  - Easy to use for network engineers

- The solution chosen is based on perfSONAR for both LHCOPN and LHCONE
perfSONAR

- **Performance focused Service Oriented Network monitoring Architecture**
- International collaboration for network monitoring
- Contributors are GÉANT, Internet2, ESnet, and RNP
- Two main implementations committed to interoperate:
  - perfSONAR MDM within GÉANT: [http://perfsonar.geant.net](http://perfsonar.geant.net)
  - perfSONAR PS within I2/ESnet: [http://psps.perfsonar.net/](http://psps.perfsonar.net/)
- Open OGF protocol to exchange data
- Web-service based
- Design goals: flexibility, extensibility, openness, and decentralization.
Used worldwide to display network performances

- Easy to integrate into other visualisation tools
- Increasing number of organisations/events using perfSONAR to display network topology, utilisation, performances

(from the NICT booth at Supercomputing 2011, Seattle – Collaboration between GEANT and NICT)
Growing number of EU networks adopting perfSONAR MDM
perfSONAR MDM now officially supported by the GÉANT MDSD

MDSD is operational from 08:00 to 17:00 UK time, Monday to Friday.

Reachable by email mdsd@geant.net or telephone +44 1480 484697
LHCOPN sites are all using perfSONAR since the beginning.
- Initially only perfSONAR MDM
- Currently both perfSONAR MDM and perfSONAR PS
LHCONE sites are gradually installing either perfSONAR MDM or perfSONAR PS
perfSONAR MDM deployment at LHC enables:
- Tier1-Tier0 monitoring
- Tier1-Tier1 monitoring
- Tier1-Tier2 monitoring
- Tier2-Tier2 monitoring
→ From the same user interface
New perfSONAR User Interface
Comprehensive monitoring

- perfSONAR MDM has a new web interface:
  
  http://orval.grid.aau.dk:8080/perfsonar-ui-lhcopn/

- **Comprehensive:**
  - Link utilisation, with possibility to compare two links
  - One-way delay
  - One-way delay variation
  - Packet loss
  - Hopcount (traceroute monitoring) with route comparison
  - Regularly scheduled bandwidth measurement
  - On-demand bandwidth measurement

→ All accessible from one URL
New perfSONAR UI: User-driven design

- Built according to real user needs:
  - Used by Network Operation Centre (NOC) engineers
  - Gradually adopted by European NOCs
  - Professionally reviewed
  - Hosted as an independent website which accesses perfSONAR data
    - Customisable (in terms of security, access, ...)
    - Easy to manage
  - Debian and Redhat packages are being prepared
Metrics at a glance: the new web-based weathermap

- Weather map reading live perfSONAR MDM data
- Customisable coloured map
  - 19 metrics implemented
    - The actual availability depends on what it is deployed on each site
  - Colour-coded according to the metric chosen
- Wide variety of metrics to choose, including
  - OWD
  - Jitter
  - Packet Loss
  - Bandwidth
  - Link Utilisation / Input errors / Discarded packets
What’s new about the weathermap (cont.)

- New updated topology being implemented.
  - [http://tinyurl.com/lhcopn-weathermap](http://tinyurl.com/lhcopn-weathermap)
  - Username and password created for the LHC community:
    - User: webcnm_lhcopn
    - Password: Txc5,Mb5

- Please contact the perfSONAR MDM team if you would like your site to be included in the map!
Screenshots from the LHCOPN/LHCONE perfSONAR MDM web interface
Link utilisation, input errors, output drops (RRD-MA)
RRD-MA

Comparing two interfaces

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Description</th>
<th>Address</th>
<th>Domain</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Te2/3</td>
<td>E5net SDN3 LHCPN</td>
<td>192.16.166.6</td>
<td></td>
<td>10,000,000,000 bps</td>
</tr>
<tr>
<td>2</td>
<td>Te3/1</td>
<td>E5net SDN1 LHCPN</td>
<td>192.16.166.26</td>
<td></td>
<td>10,000,000,000 bps</td>
</tr>
<tr>
<td>3</td>
<td>Te4/4</td>
<td>DON/CMS E2E</td>
<td>198.151.133.170</td>
<td></td>
<td>10,000,000,000 bps</td>
</tr>
<tr>
<td>4</td>
<td>Te7/4</td>
<td>E5net Te7/Te8</td>
<td>192.16.166.30</td>
<td></td>
<td>10,000,000,000 bps</td>
</tr>
<tr>
<td>5</td>
<td>Te7/4</td>
<td>E5net Te7/Te8</td>
<td>198.151.133.142</td>
<td></td>
<td>10,000,000,000 bps</td>
</tr>
</tbody>
</table>

Comparing Te2/3 and Te4/4

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Address</th>
<th>Domain</th>
<th>Status</th>
<th>Max inbound utilization</th>
<th>Max outbound utilization</th>
<th>Avg inbound utilization</th>
<th>Avg outbound utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Te2/3</td>
<td>E5net SDN3 LHCPN</td>
<td>192.16.166.6</td>
<td></td>
<td>OK</td>
<td>3624.4 Mbps</td>
<td>1028.5 Mbps</td>
<td>360.41 Mbps</td>
<td>1986.69 Mbps</td>
</tr>
<tr>
<td>Te4/4</td>
<td>DON/CMS E2E</td>
<td>198.151.133.170</td>
<td></td>
<td>OK</td>
<td>1808.84 Mbps</td>
<td>1028.5 Mbps</td>
<td>309.33 Mbps</td>
<td>254.67 Mbps</td>
</tr>
</tbody>
</table>
1Way Delay, Jitter, Packet Loss and Traceroute
As usual you can select and magnify...
1Way Delay, Jitter, Packet Loss and Traceroute

Clicking on the hop counts graph you can get the traceroutes and compare them.
Each dot is a measurement run. Clicking on the dot a window displays the details.
Making an on-demand BWCTL measurement...
...and getting the results in two clicks from the web interface

![Graph showing network performance measurements](image-url)
T1-T1, T1-T2 and T2-T2 monitoring from the same interface

<table>
<thead>
<tr>
<th>Tier 1 -</th>
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<th>Tier 1 -</th>
<th>Tier 1 -</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT-INFN-CNAF</td>
<td>NDGF</td>
<td>NL-T1</td>
<td>TW-ASGC</td>
<td>UK-T1-RAL</td>
</tr>
<tr>
<td>BWCTL_MP</td>
<td>BWCTL_MP</td>
<td>BWCTL_MP</td>
<td>BWCTL</td>
<td>BWCTL_MP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tier 1 -</th>
<th>Tier 1 -</th>
<th>Tier 2 -</th>
<th>Tier 2 -</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-FNAL-CMS</td>
<td>US-T1-BNL</td>
<td>ES-CIEMAT</td>
<td>IT-INFN-CT</td>
</tr>
<tr>
<td>BWCTL_MP</td>
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</tr>
</tbody>
</table>
### T1-T2 Measurements

![perfSONAR web user interface](image)

**Access**
- Access RRD measurements
- Access HADES measurements
- Access BWCTL measurements
- Make BWCTL measurement

#### Interval measurements

<table>
<thead>
<tr>
<th>Interval</th>
<th>Transferred</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>0s - 6s</td>
<td>6.9 MB (6,185,312 B)</td>
<td>8.2 Mbps (8,224,418 bps)</td>
</tr>
<tr>
<td>6s - 12s</td>
<td>3.6 MB (3,700,440 B)</td>
<td>4.9 Mbps (4,933,920 bps)</td>
</tr>
<tr>
<td>12s - 18s</td>
<td>4.5 MB (4,757,904 B)</td>
<td>6.3 Mbps (6,343,672 bps)</td>
</tr>
<tr>
<td>18s - 24s</td>
<td>4.5 MB (4,962,240 B)</td>
<td>6.3 Mbps (6,256,320 bps)</td>
</tr>
<tr>
<td>24s - 30s</td>
<td>6.0 MB (5,963,644 B)</td>
<td>9.3 Mbps (9,271,392 bps)</td>
</tr>
<tr>
<td>Average</td>
<td>25.6 MB (25,869,760 B)</td>
<td>7 Mbps (6,969,855 bps)</td>
</tr>
</tbody>
</table>
T2-T2 Measurements

**Graph:**
- **X-axis:** Time [seconds]
- **Y-axis:** Throughput [Mbps]
- Data points indicate increasing throughput over time, starting from 5 Mbps and peaking at 9.3 Mbps.

**Table:**

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<th>Transferred</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>0s - 5s</td>
<td>5.9 MB (6,189,312 B)</td>
<td>8.2 Mbps (6,224,416 bps)</td>
</tr>
<tr>
<td>5s - 10s</td>
<td>6.6 MB (7,069,240 B)</td>
<td>8.8 Mbps (6,767,920 bps)</td>
</tr>
<tr>
<td>10s - 15s</td>
<td>7.3 MB (8,050,336 B)</td>
<td>9.1 Mbps (7,248,608 bps)</td>
</tr>
<tr>
<td>15s - 20s</td>
<td>8.0 MB (9,034,576 B)</td>
<td>9.3 Mbps (7,927,192 bps)</td>
</tr>
<tr>
<td>20s - 25s</td>
<td>8.7 MB (10,018,816 B)</td>
<td>9.5 Mbps (8,603,200 bps)</td>
</tr>
<tr>
<td>25s - 30s</td>
<td>9.4 MB (11,003,056 B)</td>
<td>9.7 Mbps (9,280,896 bps)</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>26.6 MB (30,272,864 B)</td>
<td><strong>7 Mbps</strong> (5,888,896 bps)</td>
</tr>
</tbody>
</table>
New developments:
Interface accessible from mobile devices
Interface accessible from mobile devices (with on-demand capabilities)

The interface on a smartphone (Apple iPhone)
Interface accessible from mobile devices (iPad)

The interface on an Apple iPad
Troubleshooting on the move

The result of an on-demand Bandwidth test run from an iPhone
New developments:
Integration of the new weather map
New weather map integration
19 perfSONAR parameters available
Weather map examples
(Packet loss)
Weather map examples
(One-way delay)
Another example: access to interface statistics
Another example: Interface input errors
Example: Selecting one-way delay metric and clicking on a link
It is possible to select an area to magnify for further inspection.
The OWD results after having magnified the area
Site-specific star display shown when clicking on each site
perfSONAR MDM website: http://perfsonar.geant.net

Goals:
- Single point of access for perfSONAR
- Contact points, FAQs, resources & downloads, and support
- Host news and success stories from Users
perfSONAR Twitter: @perfSONARMDM

Weekly tweets
Messages re-tweeted by other sister networks and organisations
Growing community of followers around the world
@perfSONARMDM
Question?

Follow perfSONAR at: http://twitter.com/#!/perfSONARMDM

- Website: http://perfsonar.geant.net
- Twitter: @perfSONARMDM
- Info: domenico.vicinanza@dante.net