Pakistan-UK LHC Data Movement Issues Summary
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The National Center for Physics (NCP) at the Quaid-i-Azam University Campus in Islamabad, Pakistan, is a Tier 2 Large Hadron Collector (LHC) Site. NCP contacted EPOC in September, 2018, for assistance with an ongoing performance issue when moving data to and from the GridPP (www.gridpp.ac.uk) Tier 1 site at the Queen Mary University in London. As a Tier 2 LHC site, NCP is responsible for downloading data sets from the Tier 1 site to share with LHC researchers in the region in a timely manner. NCP has a 1Gbps connection to their national R&E network, Pakistan Education and Research Network (PERN), however, they were seeing transfer rates as low as 40Mbps to some Tier 1 LHC sites. These performance problems were intermittent, and have been ongoing for at least a year prior to contacting us. Our engagement with NCP started in October 2018 and ended in January 2019. We identified five main issues during that time, which resulted in performance improvement to ~480Mbps. This rate is not consistently achievable due to a congested link in the path detailed in issue five below.

The performance goal requested by NCP was to achieve file transfer rates to LHC sites in line with transfer rates to other locations. NCP had been able to successfully achieve transfers up to approximately 500Mbps to Aarnet (Australia) and up to 280Mbps to ESnet (es.net) Data Transfer Nodes in the United States. It was believed that an acceptable performance goal would be to achieve at least 160Mbps to the GridPP LHC site at Queen Mary University.

EPOC engineers and engagement specialists worked with engineers and systems administrators from five other institutions during the investigation including TEIN*CC (www.tein.asia), PERN (pern.edu.pk), GEANT (www.geant.org), and INFN (home.infn.it).

During the investigation, a perfSONAR (www.perfsonar.net) mesh and dashboard that included servers spanning the NCP, PERN, TEIN, and GEANT networks was created. This mesh allowed for easier ongoing identification of packet loss and network congestion. perfSONAR experts from the GlobalNOC systems team were able to guide the configuration of these hosts and help alleviate systems issues that arose. Adhoc latency and bandwidth testing were also used on an ongoing basis to see the effect of troubleshooting in real time. The perfSONAR MaDDash was left in place for future testing as well.

Five main issues were identified during the engagement:

1. A traffic shaping misconfiguration on the NCP connection to PERN caused research and education traffic to be limited to 50Mbps. PERN identified the error and fixed the issue. PERN engineers report that R&E (Research and Education) traffic should not have any traffic shaping applied.
2. A top of rack switch was identified as a bottleneck between NCP's file transfer node and their edge router. When the file transfer node was directly attached to the edge router, performance increased from 40Mbps to tests achieving an average of 100Mbps to 500Mbps or better.
3. We also observed in the perfSONAR dashboard small amounts of ongoing packet loss within the campus network supported by NCP. NCP engineers are continuing to track down the cause of this packet loss. NCP moved their data node closer to the edge of their network to alleviate the issue.
4. Packet loss was also identified by the perfSONAR mesh inside the PERN regional network. PERN network engineers worked to resolve the issue, however, they did not report the specific cause of the loss.

5. Additional bottlenecks were observed at the connection between PERN and TEIN networks. This connection currently only supports 1Gbps, and therefore experiences congestion which causes packet loss and that prevents NCP's file transfer speeds from increasing. This was verified by temporarily changing the routing to a commercial path, at which time NCP achieved expected transfer rates. TEIN and PERN are currently discussing an interconnect upgrade to 10Gbps, which would likely alleviate the congestion and allow for greater transfer speeds. It was suggested that in the meanwhile, NCP could work with PERN to have their LHC traffic follow the commercial path while they wait for the interconnection upgrade.

The final result of this engagement was an overall increase in data transfers between NCP and Queen Mary University to ~480Mbps. As identified above, this performance is based on a test during a uncongested time. Additional areas for performance improvements have been identified, but require longer term changes in infrastructure to be achieved. EPOC will stay engaged with all parties and help NCP test when needed.