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## Circuit Oriented End-to-End Services for HEP Data Transfers

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Most of today's data networks are a mixture of packet switched and circuit switched technologies, with Ethernet/IP on the campus and in data centers, and SONET/SDH over the wide area infrastructure.

SONET/SDH allows creating dedicated circuits with bandwidth guarantees along the path, suitable for the use of aggressive transport protocols optimised for fast data transfer and without fairness constraints. On the downside, a provisioned, but under-utilised circuit may result in poor overall network utilisation, as the reserved bandwidth cannot be used by another flow. Addressing this issue, Virtual Concatenation (VCAT) and Link Capacity Adjustment Scheme (LCAS) are recent addition to SONET/SDH, and allow dynamic creation and hitless bandwidth adjustment of virtual circuits.

Caltech and CERN have deployed optical multiplexing equipment supporting VCAT/LCAS on their US LHCNet transatlantic network, and agent-based grid and network monitoring software based on Caltech's MonALISA system, to provide on-demand end-to-end bandwidth guarantees for data transfers between Tier-N centres, following the GLIF concept for control plane interaction between the participating networks.

This is being coordinated with the LHC experiments' management software for dataset distribution, and with the circuit segment-provisioning developments of ESnet, Internet2, Fermilab, BNL, GEANT2 and collaborators to form the end-to-end network paths. MonALISA is used to oversee the progress, troubleshoot and mitigate problems associated with dynamic provisioning in response to multiple transfer requests.

We present our experience with operating VCAT/LCAS enabled network for transatlantic connections, along with the details of a first implementation of circuit oriented end-to-end services for data transfers between data centres.

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