

LHCOPN and LHCONE: Status and Future Evolution

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2015 J. Phys.: Conf. Ser. 664 052025

(<http://iopscience.iop.org/1742-6596/664/5/052025>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 188.184.3.56

This content was downloaded on 24/02/2016 at 12:02

Please note that [terms and conditions apply](#).

LHCOPN and LHCONE: Status and Future Evolution

E Martelli, S Stancu

CERN, 1211 Geneva 23 , Switzerland

E-mail: edoardo.martelli@cern.ch, stefan.stancu@cern.ch

Abstract. The LHC Optical Private Network (LHCOPN), linking CERN and the Tier 1s, and the LHC Open Network Environment (LHCONE) which links these to the Tier 2 community both successfully supported the data transfer needs of the LHC community during Run 1 and have now evolved to serve the networking requirements of the new computing models for Run 2. We present here the current status and the key changes, notably the delivered and planned bandwidth increases, the ongoing work to better address the needs of the Asia-Pacific region, developments to improve redundancy and progress made for provisioning point-to-point links.

1. Introduction

The Worldwide LHC Computing Grid (WLCG) [1] is a global collaboration of almost 200 interconnected computing centres that provide global computing resources to store, distribute and analyse the massive volume of physics data generated by the Large Hadron Collider (LHC) experiments at CERN.

The WLCG has a three tier structure with CERN as the Tier 0, thirteen Tier 1 sites and approximately 170 Tier 2 sites distributed all over the globe. When the WLCG was initially designed, wide area network link speed and quality were considered a possible bottleneck and hence a hierarchical computing model was envisaged, as illustrated in Figure 1. In fact, the network proved to be one of the most robust components of the WLCG architecture and, thanks to constant progress in the networking industry, link capacity has grown well beyond the initial expectations with price/capacity falling rapidly. Consequently, the computing model has been updated to distribute the different processing tasks more flexibly [2], relying on direct transfers between any Tier 1 and/or Tier 2 sites as depicted in Figure 2.

To support the original hierarchical computing model, the LHC Optical Private Network (LHCOPN) was deployed to enable distribution of pre-processed experiment data from Tier-0 to Tier-1 sites, and accessorially support processed data movement between Tier-1 sites. As the computing models developed into a more mesh-like configuration, support for data movement between Tier-2 sites and between Tier-2 sites and the ensemble of Tier-1s became increasingly important and the LHC Open Network Environment (LHCONE) was developed to deliver the necessary network support.

After a quick introduction to the LHCOPN and LHCONE networks, this paper presents their recent updates, upgrades and extensions (higher speed links, extended reach, developing new services and IPv6 support progress) and subsequently provides an overview of improvements in the area of governance and monitoring. The authors would like to point out that this paper



is intended to give an overview of the status and prospects of the LHCOPN and LHCONE networks, which are the result of a huge collaborative effort of the many WLCG sites and the supporting Research and Education (R&E) network providers.

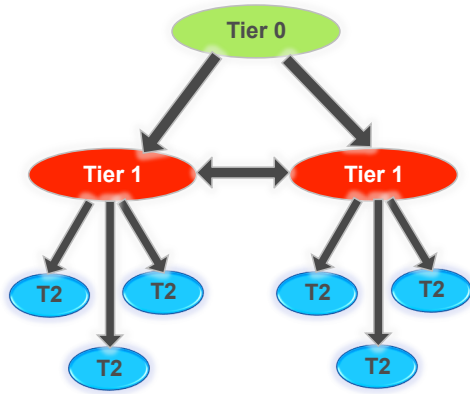


Figure 1. Original WLCG computing model (hierarchic).

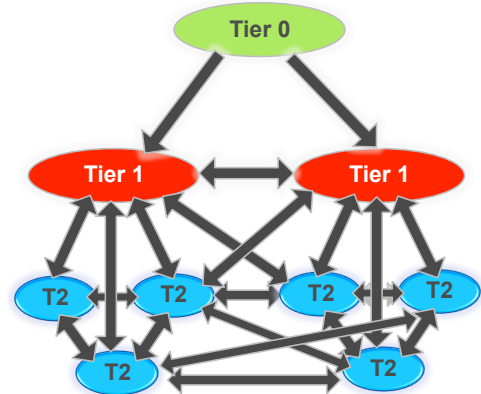


Figure 2. Updated WLCG computing model (distributed).

1.1. LHCOPN

The LHCOPN [3] connects the Tier 0 and Tier 1 sites, as illustrated in Figure 3. It is reserved for LHC data transfers and analysis, has a highly resilient architecture and relies on dedicated long distance 10G and 100G Ethernet links, deployed either individually or as bundles. LHCOPN's routing relies on BGP peerings directly managed by the connected sites which ensure that only declared IP prefixes can exchange traffic.

With the development of LHCONE (see Section 1.2), most of the traffic between Tier 1 sites has moved from LHCOPN to LHCONE. Furthermore, the LHCOPN links are backed-up by LHCONE, as CERN is connected itself to LHCONE.

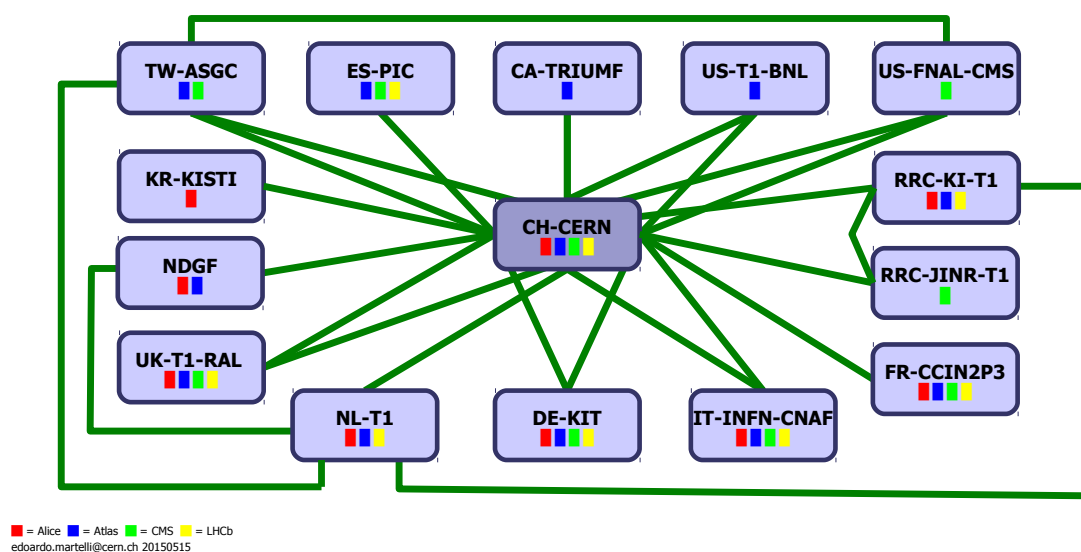


Figure 3. LHCOPN topology.

1.2. LHCONE

The LHCONE [4] has naturally emerged from the computing model update towards fully distributed processing, requiring transfers between any pair of Tier 1 and Tier 2 sites. It allows sharing the cost of expensive resources and enables HEP (High Energy Physics) traffic separation from regular Internet traffic. LHCONE is a collaborative effort of R&E Network Providers, notably ESnet, GEANT, Internet2, SURFnet and NORDUnet. LHCONE's core service is a Layer 3 VPN (Virtual Private Network), and work is ongoing for a point-to-point (P2P) service providing on demand links with guaranteed bandwidth.

The L3VPN service provides any-to-any connectivity between Tier 1 and Tier 2 sites. It relies on a routed VPN, implemented using VRF (Virtual Routing and Forwarding) for providing a dedicated worldwide backbone reserved for HEP data transfers and analysis. As illustrated in Figure 4:

- Tier X sites connect to national VRFs or continental VRFs.
- National VRFs are interconnected via continental VRFs.
- Continental VRFs are interconnected by trans-continental/trans-oceanic links.

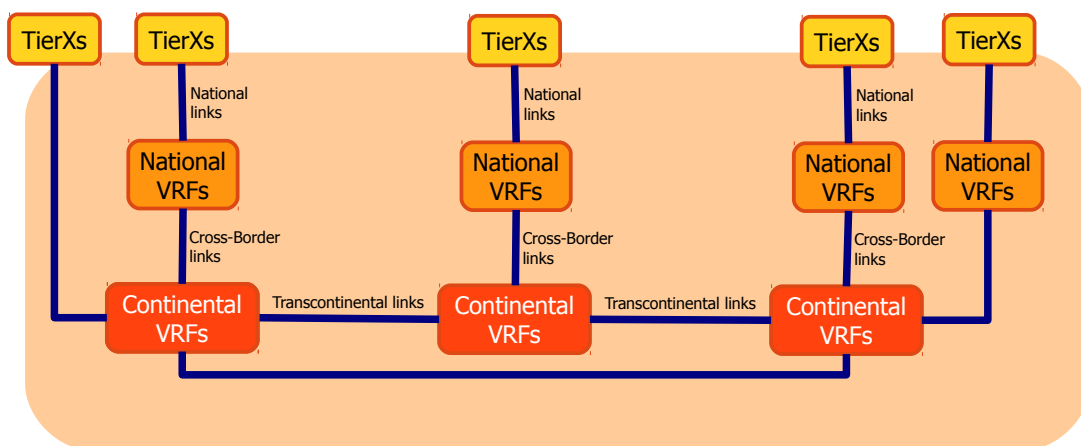


Figure 4. LHCONE Layer-3 VPN architecture.

2. Updates, Upgrades and Extensions

This section describes the improvements and extensions to the LHCOPN and LHCONE infrastructure as well as the ongoing work for developing the LHCONE P2P service and for introducing IPv6.

2.1. Network Upgrades

CERN's connectivity to LHCONE/LHCOPN and Internet has been upgraded to make use of multiple 100G links:

- CERN's connection to ESnet (transatlantic link provider) has been upgraded to two 100G links for LHCOPN/LHCONE and four 10G links for general IP connectivity.
- CERN's connection to GEANT was upgraded to one 100G link for LHCONE, and general IP connectivity will soon be upgraded to one 100G link with an additional 100G backup link to SWITCH.

ESnet (US Energy Science network) – one of the LHCONE R&E Network Providers – has extended to Europe and is now the largest provider of LHCOPN/LHCONE trans-Atlantic services, at least in terms of bandwidth. ESnet operates four transatlantic links (three 100G and one 40G) with three European PoPs (Points of Presence) at London, Amsterdam and Geneva (CERN). At the latter two sites, ESNET and GEANT have a direct interconnection.

To support the current and foreseen enlargement of the LHC collaboration and to provide access to LHC data to physics institutes worldwide, work is ongoing for establishing two new LHCONE VRFs: one in Asia in collaboration with TEIN and APAN and one in South America in collaboration with CBPF (Brazilian Center for Physics Research) as the Tier 2 site and RPN Brazil as the R&E network provider.

2.2. Expansion to support the Belle-II collaboration

Belle-II is the international collaboration at the SuperKEKB [5] accelerator in Tsukuba, Japan, an upgrade of the KEKB accelerator designed to increase the instantaneous and integrated luminosity by two orders of magnitude.

Although most of the Belle-II member sites were already participating in the WLCG collaboration, the two main sites, the host laboratory (KEK in Japan) and the Pacific Northwest National Laboratory (PNNL) in the US, were not. The community saw the wisdom of including these sites and updated the AUP (Acceptable Use Policy, see Section 3.1) to allow it. With PNNL now fully connected and the imminent integration of KEK, the productivity of the Belle-II collaboration members will soon be increased thanks to full access to the resources of LHCONE.

2.3. LHCONE P2P Service

The LHCONE P2P service aims to provide on demand dedicated point-to-point links between any pair of WLCG sites, with guaranteed bandwidth (i.e. protected from any other traffic) over a multi-domain network. To be effective, the P2P service must be accessible and configurable via software APIs.

The P2P service is currently under development. Work has been carried out to prototype and understand the two important functionalities of the service:

- provisioning of P2P circuits over multi-hop networks which has been demonstrated [6] using the GLIF AutoGOLE [7] infrastructure; and
- use of software APIs for provisioning circuits on demand, demonstrated through enhancements to the CMS experiment data management transfer tool, PhEDEx, to use ANSE (Advanced Network Services for Experiments) to dynamically request circuits [8].

Some challenges remain to be addressed for providing the P2P service, notably:

- *routing traffic into P2P links at the end sites*: Several proposals have been made [9] but no final solution has been chosen to date. Regardless of the chosen solution, the implementation of this feature is laborious as it requires automating the provisioning process over heterogeneous network equipment, managed autonomously by end sites.
- *resource arbitration*: Since the LHCONE resources are shared by multiple sites, a mechanism has to be put in place in order to handle conflicting resource reservation requests.
- *charging for premium services*: To offer premium services billing support for on-demand temporary circuits needs to be implemented.

2.4. IPv6

With the ongoing depletion of IPv4 addresses, WLCG sites are experiencing difficulties to acquire the necessary IPv4 addresses and it is easy to foresee a case in which a new site will only be accessible over IPv6. To integrate such sites it becomes important to have full IPv6 support in

the WLCG. Unfortunately, whilst the HEPiX IPv6 working group is actively testing the IPv6 compliance of WLCG applications [10], improvements in IPv6 interconnectivity are still needed: although more than 50% of LHCOPN sites have implemented IPv6 connectivity, the goal was to have reached 100% by the end of April 2015, and the fraction of LHCONE sites with IPv6 connectivity is much lower, although no target for full interconnectivity has been set. We expect delivering improvements in IPv6 interconnectivity to be a focus for the coming months.

3. Governance and Monitoring

LHCONE started as an informal collaboration, but the lack of any governance infrastructure became a concern with the growth that came with success. On this account an Acceptable Use Policy was established and had the side effect of helping the community to diversify and encompass non-LHC related HEP collaborations. Another issue that arose with the LHCONE growth was the need to establish a framework for monitoring the usage and performance of its resources.

3.1. New Acceptable Use Policy

To restrict access to authorized sources and also enlarge the scope of LHCONE to non WLCG MoU (Memorandum of Understanding) signatories a new AUP (Acceptable Use Policy) [11] has been recently defined and agreed. The AUP covers the following aspects:

- announcement of IP Prefixes for LHCONE traffic – traffic inside LHCONE must originate from and be addressed to addresses belonging to LHCONE prefixes;
- authorised source and destinations nodes – these must be limited to nodes used for physics data storage, distribution and processing, together with network infrastructure equipment (including perfSONAR monitoring probes, see Section 3.2);
- eligibility for becoming an LHCONE site;
- security incident response – sites receiving malicious traffic can disconnect themselves without notice, and should report the offending site;
- roles and responsibilities; and finally
- consequences of non-compliance with the AUP.

3.2. PerfSONAR deployment

Following the endorsement of the perfSONAR network measurement toolkit [12] as a standard WLCG service, guidelines have been provided for deploying perfSONAR in WLCG [13]. Currently there are approximately 250 active instances deployed at WLCG sites and VRF interconnection points, of which more than 70% are running the latest perfSONAR version (version 3.4.2).

To ensure that all relevant metrics are identified, collected and published by the perfSONAR infrastructure, a Network and Transfer Metrics Working Group [14] was established. A sample summary dashboard with the latency metrics collected by the LHCOPN perfSONAR instances is depicted in Figure 5.

4. Conclusion

We have presented the current status and future prospects for LHCOPN and LHCONE, the networks that are at the heart of the WLCG, the worldwide collaboration of sites responsible for providing the computing resources that are essential to the delivery of physics results from the huge volume of data generated by the LHC experiments at CERN. Several throughput upgrades and geographical extensions have been performed and the scope of the collaboration was enlarged to enable the inclusion of sites that, whilst full members of the High Energy Physics

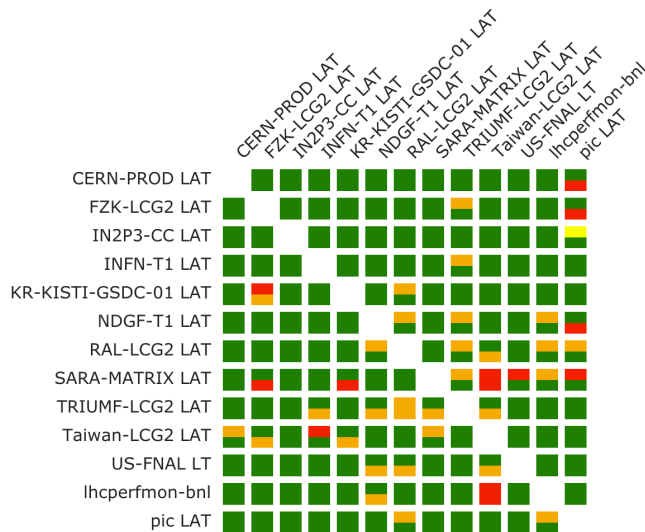


Figure 5. LHCOPN perfSONAR latency dashboard.

community, were not participating in the LHC programme – notably KEK in Japan and PNNL in the US which are key to the success of the Belle II experiment. Work is ongoing for developing a P2P on-demand service over LHCONE, and also for enabling IPv6 connectivity throughout LHCOPN and LHCONE. Last but not least, significant improvements have been brought to the governance and monitoring of these networks by establishing an acceptable use policy for LHCONE and by deploying the perfSONAR measurement toolkit and making sure it collects the relevant metrics.

Since LHCOPN and especially LHCONE are fairly dynamic, following the LHCOPN–LHCONE meetings [15] is a good way to stay up to date with the most recent developments. Should an institute become interested in joining LHCOPN or LHCONE, it can express interest or request additional information at lhcopn-interest@cern.ch and lhcopn-operations@cern.ch, or lhcone-operations@cern.ch, lhcone-architecture@cern.ch and lhcone-asia-pacific@cern.ch respectively.

Acknowledgments

The authors would like to thank the WLCG collaboration and the R&E Network Providers (ESnet, GEANT, Internet2, SURFnet, NORDUnet, and many others) for their continued effort in operating maintaining and extending the LHCOPN and LHCONE.

References

- [1] The Worldwide LHC Computing Grid URL <http://wlcg.web.cern.ch>
- [2] Bird I *et al.* Update of the Computing Models of the WLCG and the LHC Experiments URL <https://cds.cern.ch/record/1695401>
- [3] LHCOPN – Large Hadron Collider Optical Private Network URL <http://lhcopn.web.cern.ch/lhcopn>
- [4] LHCONE – LHC Open Network Environment URL <http://lhcone.net>
- [5] SuperKEKB Project URL <http://www-superkekb.kek.jp>
- [6] Van Malenstein G 2015 Point2Point service – Status update LHCOPN-LHCONE meeting – Cambridge (UK) URL <https://indico.cern.ch/event/342059/contribution/18>
- [7] GLIF Automated GOLE Pilot Project URL <http://www.glif.is/meetings/2011/winter/poster/AutoGOLE-handout-20110217-v5.pdf>
- [8] Wildish T Virtual Circuits in PhEDEx, an update from the ANSE project CHEP2015 URL <http://indico.cern.ch/event/304944/session/4/contribution/191>
- [9] Coulouarn T 2015 Middleware integration LHCOPN-LHCONE meeting – Cambridge (UK) URL <https://indico.cern.ch/event/342059/contribution/21>

- [10] HEPiX IPv6 Working Group IPv6 compliance of WLCG applications URL <http://hepix-ipv6.web.cern.ch/wlcg-applications>
- [11] LHCONE Acceptable Use Policy URL <https://twiki.cern.ch/twiki/bin/view/LHCONE/LhcOneAup>
- [12] perfSONAR URL <http://www.perfsonar.net>
- [13] Deploying perfSONAR for WLCG/OSG URL <https://twiki.opensciencegrid.org/bin/view/Documentation/DeployperfSONAR>
- [14] Network and Transfer Metrics WG URL <https://twiki.cern.ch/twiki/bin/view/LCG/NetworkTransferMetrics>
- [15] WLCG Networking URL <https://indico.cern.ch/category/5793>