Overcoming obstacles to IPv6 on WLCG

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(on behalf of the HEPiX IPv6 Working Group)

CHEP2023, Norfolk VA, USA, 11 May 2023
On behalf of all members of the HEPiX IPv6 working group - (many thanks all!)

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(underlined authors are attending CHEP2023)

• Many more in the past, and members join/leave from time to time

• many thanks also to WLCG operations, WLCG sites, LHC experiments, networking teams, monitoring groups, storage developers…
Outline

• IPv6 traffic growth
• The HEPiX IPv6 working group
• Drivers for IPv6
• Deployment of IPv6/IPv4 dual-stack storage
• The good news - Tier-1/Tier-2 storage, LHCOPN & LHCONE
• Plans for IPv6-only WLCG
• Obstacles to IPv6 on WLCG
  • and overcoming those obstacles
• Summary
IPv6 traffic continues to grow

Google

WLCG Data Transfers
The HEPiX IPv6 Working Group

- In 2010-11
  - some HEPiX sites running out of IPv4 addresses
  - IANA projecting imminent IPv4 address exhaustion
  - Moving to support IPv6 would not be fast - better start now!
- **Phase 1** - 2011-2016 - full analysis, investigations, ran a testbed
  - lots of work by storage developers to be IPv6-capable
- **Phase 2** - 2017-2023 - deploy dual-stack storage on WLCG
  - in production
- **Phase 3** - 2019-onwards - plan for IPv6-only
  - investigate and fix reasons for obstacles to deployment of IPv6

https://www.hepix.org/e10227/e10327/e10326/
https://indico.cern.ch/category/3538/ (meetings)
Drivers for use of IPv6

• Sites running out of routable IPv4 addresses (avoid NAT)
  • Use IPv6 addresses for external public networking
• To be ready to support use of IPv6-only CPU clients
• There are other drivers for IPv6:
  • scitags.org – packet marking (in header of IPv6 packets)
    • Research Networking Technical Working Group (RNTWG)
  • USA Federal Government – directive on “IPv6-only” (Nov 2020)
  • multiONE (several LHCONE’s for different communities)
    • either, the services must be in different IP LANs (suggests use of IPv6)
    • or use the scitags in IPv6 header flow label for policy based routing
IPv6/IPv4 deployment at WLCG Tier-1/2 sites

- Tier-1 complete
- Tier-2 deployment from Nov17
- *(status)* shows >91% T2 sites
  - 93% of Tier-2 storage is dual stack

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Fraction of T2 storage accessible via IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALICE</td>
<td>90%</td>
</tr>
<tr>
<td>ATLAS</td>
<td>90%</td>
</tr>
<tr>
<td>CMS</td>
<td>96%</td>
</tr>
<tr>
<td>LHCb</td>
<td>100%</td>
</tr>
<tr>
<td>Overall</td>
<td>93%</td>
</tr>
</tbody>
</table>
Importance of monitoring

• We must monitor
  • deployment of IPv6-capable services
  • fraction of data transfers taking place over IPv6
• Monitoring implementations used for IPv6
  • perfSONAR
  • ETF - experiment test framework
  • FTS (File Transfer Service)
  • Network utilisation and traffic plots
    • e.g. IPv6 versus IPv4 on LHCOPN/LHCONE
• But in recent years some existing monitoring stopped working
  • FTS over WebDAV not tracking IPv6 (GSIFTP and SRM was instrumented)
  • work is ongoing to fix this problem
Good news (IPv6 on WLCG) after removing several “obstacles” during the last year

LHCOPN network (at CERN) ~95% IPv6 last 30 days

Storage - Tier-1 (100%) and Tier-2 (93%)

LHCONE network at CESNET (CZ)
- last 30 days
  Ingress ~93% IPv6
  Egress ~90% IPv6
Good news (2) - %IPv6 on LHCONE (Imperial College London)

dCache storage preference set to IPv6

Since Feb 2022
~90% IPv6
IPv6-only on WLCG (CHEP2019)
https://doi.org/10.1051/epjconf/202024507045

- The end point of the transition from IPv4 is an IPv6-only WLCG core network
- To simplify operations
  - Dual-stack infrastructure is the most complex
  - Dual-stack has more security threat vectors
- Large infrastructures (e.g. Facebook, Microsoft,...) use IPv6-only internally
- The goal we are still working towards
  - “IPv6-only” for the majority of WLCG services and clients
  - With ongoing support for IPv4-only clients where needed/possible
- Timetable to be defined
“Obstacles” to IPv6

There are many reasons stopping the full use of IPv6/IPv4

• Dual stack is an essential step on the journey to IPv6-only

The Obstacles that we have been addressing:

1. **WLCG Sites not yet deployed IPv6 networking** ~done
2. **Sites have IPv6 but Tier-2 has no dual-stack storage** ~done
3. **IPv6 monitoring not available or broken** see next slide
4. **Service is dual-stack but IPv4 being used** see next slide
   • no time to describe all the obstacles we found and fixed
Some obstacles fixed (#3 and #4)

Data transfers into USA/ATLAS Great Lakes Tier 2 (AGTL2)
Found to use IPv4 even when both ends dual-stack (dCache/WebDAV)
java.net.preferIPv6Addresses (default: false) - Now set to “true”
Fixed at 17:00 on 14 Feb 2022 (confirmed in the plot!)
This fix is essential for all dCache instances - fixed in v7.2.11

Some FTS monitoring now able to distinguish IPv6 from IPv4
ATLAS & CMS HTTP transfers into CERN (last year)
– IPv6 showing from August 2022 onwards
Obstacles to IPv6 - to be addressed

5. Non-storage services not yet dual-stack
   a. ~60% of all WLCG services are dual-stack today

6. WLCG client CPU (worker nodes, VMs, containers) some IPv4-only

7. Services/clients outside of WLCG Tier-1/Tier-2 not yet considered
   a. Tier-3, Public/Commercial Clouds, Analysis facilities, Experiment portals…

8. Use of new or evolving technologies not yet tested or tracked
   a. New CPU architectures (GPU, non-x86, …), container orchestration, …

9. “People” can be the obstacle
   a. they do not consider use of IPv6 or refuse to deploy!

All of these will be addressed by the working group
Summary

• WLCG is ready to support use of IPv6-only clients
• Tier-1s: all have production storage accessible over IPv6
• Tier-2s: 93% storage is IPv6 capable
• Monitoring data transfers is essential - was broken and being fixed
  • Traffic on LHCOPN and LHCONE is 90-95% IPv6 (after obstacles removed)
• We continue to address more obstacles to IPv6 in WLCG
  • To enable move to IPv6-only services

• Message to WLCG sites and LHC experiments:
  • Deploy dual-stack on all services & CPU clients and prefer IPv6
• Message to new research communities - build on IPv6 from start
Questions, Discussion?