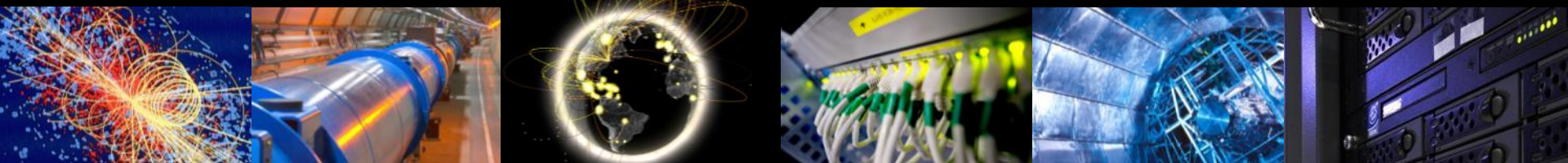# WLCG Network Throughput WG

Shawn McKee, Marian Babik for the Working Group

HEPiX Budapest
25 April 2017

Working Group

- WLCG Network Throughput WG formed in the fall of 2014 within the scope of WLCG operations with the following objectives:
  - Ensure sites and experiments can better understand and fix networking issues
  - Measure end-to-end network performance and use the measurements to single out on complex data transfer issues
  - Improve overall transfer efficiency and help us determine the current status of our networks
- Core activities include:
  - Deployment and operations of perfSONAR infrastructure
    - Gain visibility into how our networks operate and perform
  - Network analytics
    - Improve our ability to fully utilize the existing network capacity
  - Network performance incidents response team
    - Provide support to help debug and fix network performance issues

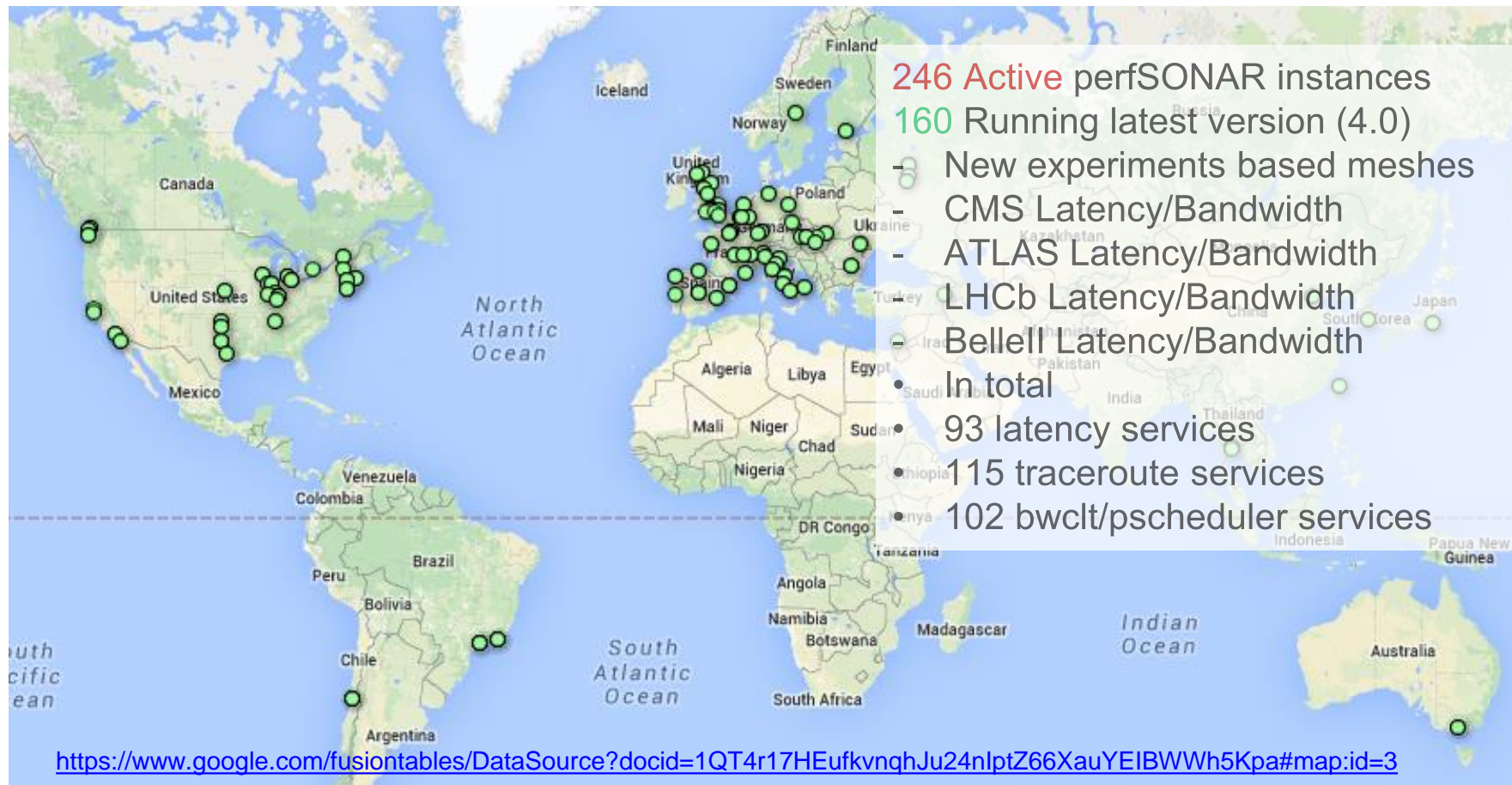## https://twiki.cern.ch/twiki/bin/view/LCG/NetworkTransferMetrics

News

- perfSONAR 4.0 released on April 17
  - Major release bringing many new features
  - Default installations should auto-update
  - Some LHCONE/LHCOPN instances may require manual intervention.
- OSG Network Measurement Service updates coming along with perfSONAR 4.0
  - New Mesh-configuration Agent (MCA)
    - Now part of perfSONAR 4.0; available as new central component
  - Updated WLCG perfSONAR monitoring based on ETF
  - New analytics capabilities using ELK + Jupyter and new data available via messaging/streaming API

Current perfSONAR Deployment

http://grid-monitoring.cern.ch/perfsonar_report.txt for stats

246 Active perfSONAR instances
160 Running latest version (4.0)
- New experiments based meshes
- CMS Latency/Bandwidth
- ATLAS Latency/Bandwidth
- LHCb Latency/Bandwidth
- BelleII Latency/Bandwidth
• In total
• 93 latency services
• 115 traceroute services
• 102 bwclt/pscheduler services

https://www.google.com/fusiontables/DataSource?docid=1QT4r17HEufkvnqhJu24nIptZ66XauYEIBWWh5Kpa#map:id=3
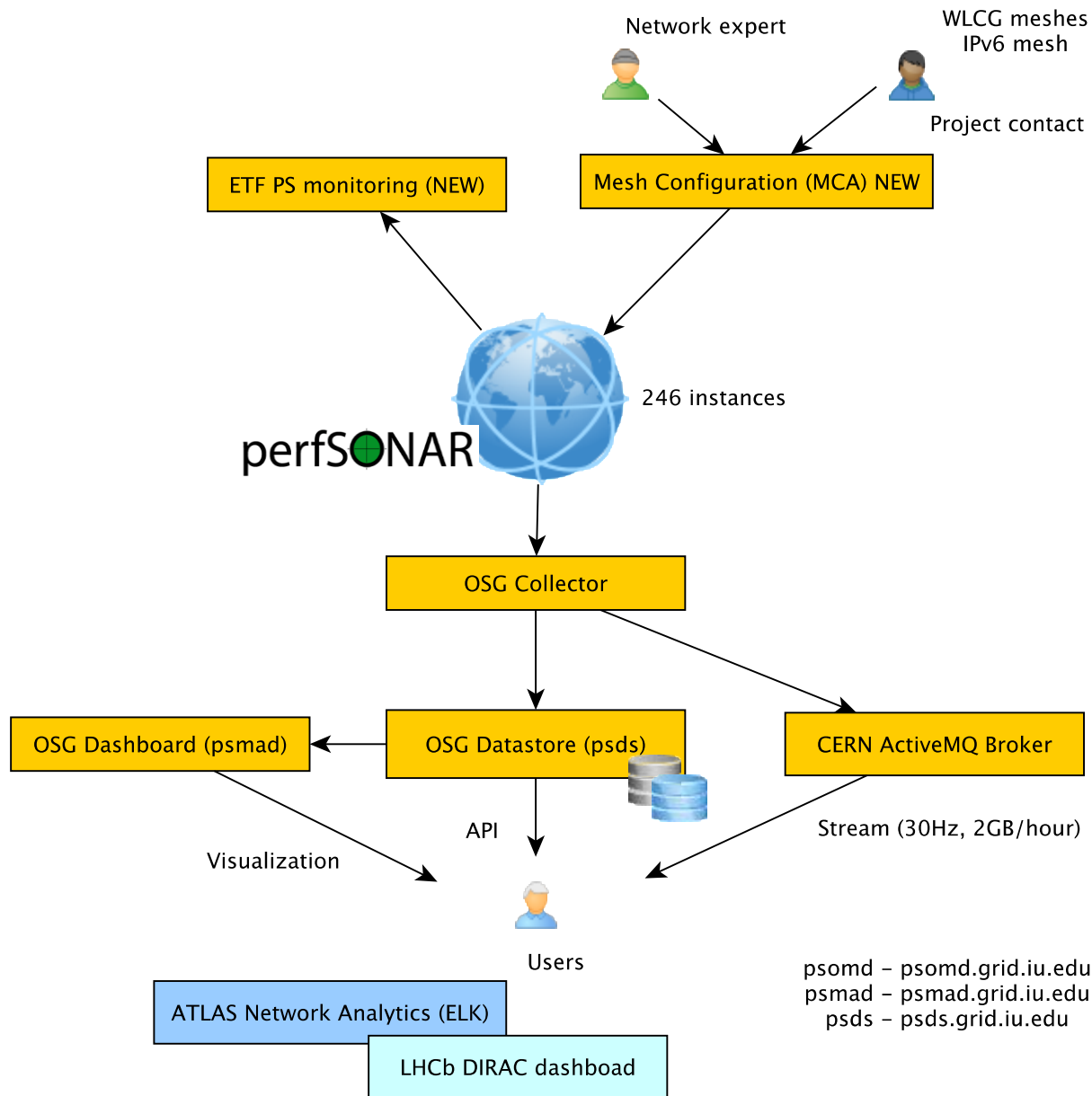
- Initial deployment coordinated by WLCG perfSONAR TF
- Commissioning of the network followed by WLCG Network and Transfer Metrics WG

perfSONAR 4.0

- Focus is on "Control and Stability"
  - New standalone mesh-config (MCA)
  - New test scheduler (pScheduler) replacing BWCTL:
    - Shared by all tests and aware of the resources each uses
    - Containing finer grained controls about who can run tests and what tests they are allowed to run.
    - Increased visibility and control as to when tests will be run
- CentOS 7 and Debian 8 support
  - perfSONAR **4.1** plan drops SL6 support; requires reinstall for SL6 hosts
- New Endpoint selection capabilities
  - Better metadata, topology information will be available
- New Dashboard (MaDDash w/MadAlert) part of this release
- New minimum HW requirements
  - Dual-core (2GHz+) and 4GB RAM
  - Heavily used latency instances would benefit from more memory
  - But new deployment models planned for 4.1: small-factor, VMs, docker
- Toolkit now exposes info via JSON, used in our monitoring:
  - http://psum06.aglt2.org/toolkit/?format=json

Network Measurement Platform

The diagram on the right provides a high-level view of how WLCG/OSG is managing perfSONAR deployments, gathering metrics and making them available for use.

Network expert

WLCG meshes
IPv6 mesh

Project contact

ETF PS monitoring (NEW)

Mesh Configuration (MCA) NEW

perfSONAR

246 instances

OSG Collector

OSG Dashboard (psmad)

OSG Datastore (psds)

CERN ActiveMQ Broker

API

Stream (30Hz, 2GB/hour)

Visualization

Users

ATLAS Network Analytics (ELK)

LHCb DIRAC dashboad

psomd – psomd.grid.iu.edu
psmad – psmad.grid.iu.edu
psds – psds.grid.iu.edu

MCA

- Gathers and organizes information on hosts from a combination of sources
  - Imports from perfSONAR global lookup service entries; we can discover perfSONARs deployed anywhere if the join the right community
  - Able to gather information from grid registration databases like GOCDB / OIM
- Auto-completion / entry of values
- Context dependent user interface (see Testspecs)
- Can be easily installed outside of OSG
- Provides a RESTful interface to allow easy monitoring and software-controlled config
  - https://meshconfig-itb.grid.iu.edu/apidoc/
- Supports filtering and dynamic host groups
  - Can now build dynamic meshes, e.g., all CentOS6 hosts who are members of the ATLAS community
- Becomes part of perfSONAR software stack – major upstream contribution from OSG/WLCG

MCA

Config-view of **M**esh **C**onfig **A**dministrator shown below.   We now have the ability to do much finer-grained control and can setup as many mesh-config 'admins' as needed.

New production instance being activated in OSG in the next week or two.

ETF PS

- New monitoring based on WLCG ETF
  - We have an etf_ps version in docker: mbabik/etf:1.2.8p20
  - See https://etf.aglt2.org/etf/check_mk/ for a running example
- Goal is to replace the OSG psomd.grid.iu.edu and perfsonar-itb.grid.iu.edu check_mk instances with this

Network Analytics

- Ilija Vukotic/U Chicago has been leading an effort within ATLAS to get network metrics into an analytics platform
- This analytics service indexes historical network related data while providing predictive capabilities for near term network throughput performance.
- Primary functions:
  - Aggregate, and index, network related data associated with WLCG "links"
  - Serve derived network analytics to ATLAS production, DDM & analysis clients
  - Provide a generalized network analytics platform for other communities in the OSG
- Part of ATLAS Analytics platform
  - https://cds.cern.ch/record/2056257/files/ATL-SOFT-SLIDE-2015-752.pdf

- Uses CERN IT streaming/messaging interface, which is publicly available:
  - Contains all perfSONAR measurements gathered by Network Measurement Platform including latencies, packet-loss, TTLs, throughputs, TCP retransmits, traceroutes/tracepaths
  - Now also includes some derived metrics, such as simulated link utilization for all LHCONE links
  - As well as LHCOPN and ESNet traffic/netflows

Network Analytics Example

- Example Kibana dashboard looking at sites with network paths having >2% packet-loss over a 1 hour period (site is dest(left) or src(right))
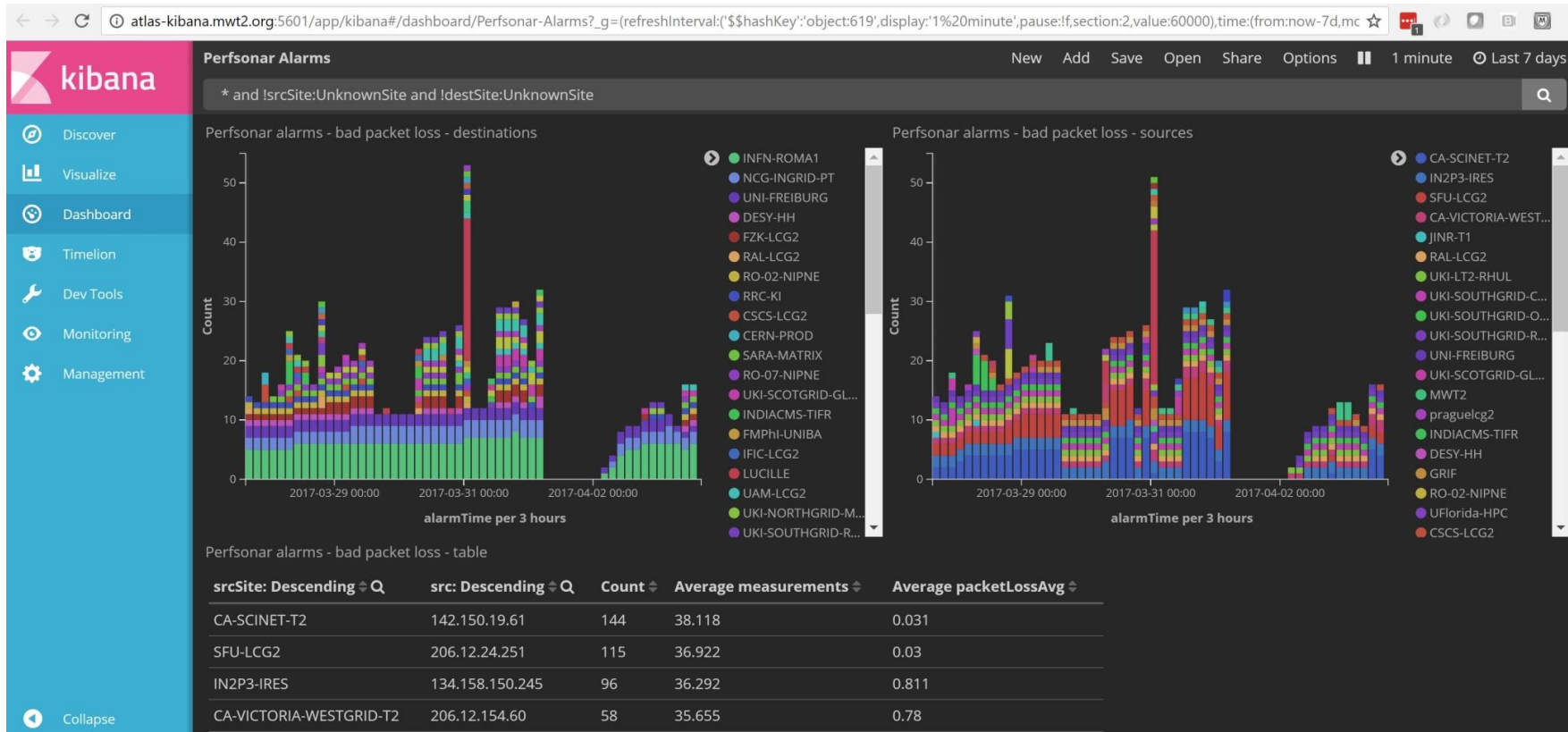
Alerts/Notifications

- OSG is targeting alerting users when sites they are interested in are experiencing problems
    - We must be careful; don't spam recipients for problems not relevant to them
    - Solution is to allow self-subscription for sites of interest
    - Example email:

Dear Shawn McKee,

   This mail is to let you know that there are significant changes in the number of paths with large packet-loss detected by perfSONAR for sites you requested alerting about.

The site CA-SCINET-T2 (142.150.19.61)'s network paths have improved, the count of src-destination paths with packet-loss went from 7 to 0.

The site UKI-SOUTHGRID-OX-HEP (163.1.5.210)'s network paths have improved, the count of src-destination paths with packet-loss went from 21 to 1.

   UKI-SOUTHGRID-OX-HEP (163.1.5.210) ---> INFN-ROMA1 (141.108.35.18)

To get more information about this alert message and its interpretation, please visit:

 http://twiki.opensciencegrid.org/bin/view/Documentation/NetworkingInOSG/PacketLossAlert

If you suspect a network problem and wish to follow up on it please email the appropriate support list:

   For OSG sites: goc@opensciencegrid.org using Subject: Possible network issue

   For WLCG sites: wlcg-network-throughput@cern.ch using Subject: Possible network issue

Please include this alert email to help expedite your request for network debugging support.

 To change your alerts preferences please you the following link:

https://docs.google.com/forms/d/e/1FAIpQLSfwwtAvMrqp4Ot_LYfmNu75_v33dtAxiXg7ZvVdn1X5v7TEgg/viewform?edit2=2_ABaOnudW1aM_Iw2Ub3gE1c MSCZJyqjpIOaAvdg0pb68_3ViPF77dyEy62OK_BQ

Best regards,

ATLAS Networking Alert Service

Improving Transfer Efficiency

- One of the main goals of the WG to identify and help fix network issues in our infrastructure
- Network analytics, alerts/notifications are the primary drivers in this activity
  - Detection and analysis of the issues has significantly improved
- In addition, WG has created a support unit to help sites and experiments with network-relates issues
  - Tickets opened in the support group can be triaged to the right destination
  - Many issues are potentially resolvable within the working group
  - Real network issues can be identified and directed to the appropriate network support centers
- Documented at https://twiki.cern.ch/twiki/bin/view/LCG/NetworkTransferMetrics#Network_Performance_Incidents
- Two recent example cases: ASGC and TRIUMF/SFU

ASGC case

- A ticket was opened in March 2016
  https://ggus.eu/index.php?mode=ticket_info&ticket_id=119820

"Hello,

ATLAS recently suffers from various network related problems with access to resources in ASGC. Problems reported via proper channels are solved but soon they reappear. Examples of recent issues: stratum-1 at ASGC (GGUS ticket 119557) ; NDGF - ASGC transfer problems (GGUS ticket 119276). WLCG weekly meeting suggest to open this general ticket and assign it to WLCG Network Monitoring unit, which could use perfsonar infrastucture to better understand these problems.

Jiri Chudoba as ATLAS Computing Run Coordinator"

- ASGC connected by dedicated 10Gbit via StarLight and then via AMS to CERN; perfSONAR coverage in Asia quite limited
- Testing to ASGC from many places showed no more than **500Mbit**; StarLight to ASGC was not more than **200Mbit**, so moved focus to ASGC
- Asked ASGC for network map and asked them to re-connect their bwctl node directly to border router while keeping latency node on Cisco N7K
  - Testing from StarLight directly to ASGC border router revealed Cisco N7K to be the problem…buffers too small for WAN transfers (72MB shared with 12 ASICs)
  - **Solution**: Move perfSONAR and DTNs off Cisco and onto border router

ASGC Result

- **Investigation took less than 30 days** (we posted recommendation to ASGC in May 2016 and there were some initial delays before we got going)
  - **perfSONAR** was critical to achieving this
  - We managed to gain factor 10, ASGC is at **~ 4.4Gbps** now
  - Can we get better ?
- Major achievement for WLCG network throughput, shows that at least in Asia (but we have other cases showing that also elsewhere) there are benefits to be gained from analyzing our metrics to locate problems.
- With respect to LHCOPN/LHCONE we're clearly missing guidance on high-latency (distant) sites network architectures and sizing the router buffers
  - Coordinating with ESnet/Fasterdata on getting this improved

TRIUMF/CA case

- The beta version of the alerting system shown earlier has been showing that all the Canadian WLCG sites are seeing periods of large packet loss.

- Rolf Seuster/UVic, the WLCG network contact for the Canadian cloud, was interested in trying to use our network metrics and associated co-located Jupyter instance to try to identify the location of the problem

  - He was given access to the system and pointed at a few existing examples of analyzing network metrics

  - Results from just a few days ago follows

Analyzing SFU to DESY Zeuthen

Using the network metrics available in ElasticSearch, Rolf created some Python code in Jupyter to analyze the data

- To make the problem manageable he focused on two specific sites: SFU and DESY_ZN
- For a **1h time window** when the packet loss was bad, he got all measurements for packet losses correlated with all traceroutes originating from SFU.
- Additionally, for the same time window he got all measurements going into DESY Zeuthen.
- Then just count how many measurements showed packet-loss (**bad**) or not (**good**) for each router between the sites
- This shows how often each router is part of a good or bad end-to-end packet-loss test.
- Only 1 router had no good measurements: **62.40.126.145** a.k.a**. canarie-lhcone-gw.mx1.lon.uk.geant.net** has to be the faulty router.

Router(IP)	Good(CA)	Good(ZN)	Bad(CA)	Bad(ZN)
206.12.24.225	61	0	44	2
206.12.9.96	43	0	24	2
205.189.32.175	25	0	44	4
205.189.32.177	25	0	44	4
205.189.32.181	27	0	44	4
62.40.126.145	0	0	24	3
62.40.98.81	0	21	20	5
62.40.126.168	0	22	6	3
62.40.126.169	0	22	6	3
188.1.153.14	0	22	4	3
141.34.249.22	0	48	2	5
141.34.249.218	0	70	2	5
141.34.249.209	0	70	2	5
141.34.200.29	0	70	2	5

Plans

- ## perfSONAR deployment – targeting 4.1 release
  - New deployment models for OSG/WLCG
  - Upstream contributions to perfSONAR
    - Direct publishing to ActiveMQ/Kafka
    - SNMP pscheduler plugin to add site ingress/egress traffic from routers to perfSONAR MA

- ## OSG Network Measurement Platform
  - The goal is to provide an end-user friendly interface to our measurement and analytics data
  - Focus on supporting users in identifying network problems and bottlenecks through documentation and self-subscribed targeted alerting

- ## Analytics
  - Improve Kibana dashboards
    - Add infrastructure status dashboard
  - Test Grafana for better time-series visualization
  - Adding netflows to stream/messaging API
    - ESNet, GEANT, Internet2 and Canarie

Summary

- We have a working infrastructure in place to monitor and measure our networks
- perfSONAR provides lots of capabilities to understand and debug our networks
- Work on new applications is underway
  - Notifications/alerting
  - Predictive capabilities
  - Current utilization and capacity planning
  - Evaluating network performance of commercial clouds
- We (OSG and WLCG) welcome feedback on how to further improve

Questions or Comments?

References

- Network Documentation
  https://www.opensciencegrid.org/bin/view/Documentation/NetworkingInOSG
- Deployment documentation for OSG and WLCG hosted in OSG
  https://twiki.opensciencegrid.org/bin/view/Documentation/DeployperfSONAR
- Measurement Archive (MA) guide
  http://software.es.net/esmond/perfsonar_client_rest.html
- Modular Dashboard and OMD *Prototypes*
  - http://maddash.aglt2.org/maddash-webui

    https://maddash.aglt2.org/WLCGperfSONAR/check_mk
- **OSG Production instances for OMD, MaDDash and Datastore**
  - http://psmad.grid.iu.edu/maddash-webui/
  - https://psomd.grid.iu.edu/WLCGperfSONAR/check_mk/
  - http://psds.grid.iu.edu/esmond/perfsonar/archive/?format=json
- Mesh-config in OSG https://oim.grid.iu.edu/oim/meshconfig
  - Being updated to a new standalone mesh-config application (ready for v3.6?)
- Use-cases document for experiments and middleware
  https://docs.google.com/document/d/1ceiNlTUJCwSuOuvbEHZnZp0XkWkwdkPQTQic0VbH1mc/edit

Backup slides
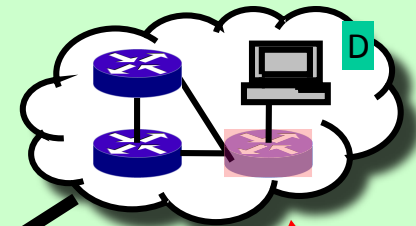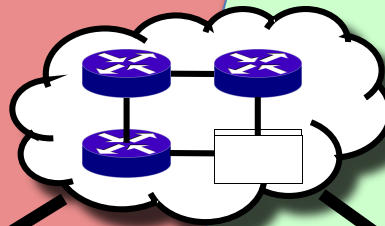
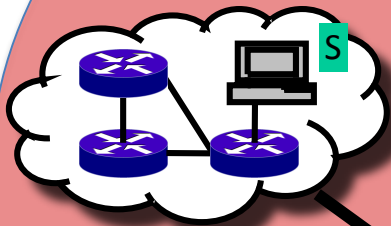# Latency and packet loss matters

Performance is poor when RTT exceeds ~10 ms

Performance is good when RTT is < ~10 ms

R&E Backbone

Source Campus

Destination Campus

S

D

0.0046% loss (1 out of 22k packets) on 10G link
- **with 1ms RTT: 7.3 Gbps**
- **with 51ms RTT: 122Mbps**
- **with 88ms RTT: 60 Mbps (factor 80)**

Regional

Regional

Switch with small buffers

WLCG
Worldwide LHC Computing Grid

Packet ordering and jitter

Source Campus

R&E Backbone

Network introducing delays and out of order packets

Destination Campus

At 70ms RTT on 10G link, 60 seconds test
- with 1% re-ordering, 0.2 ms jitter: 8.45 Gbps
- with 1% re-ordering, 1ms jitter: 1.1 Gbps

Regional

Regional

Worldwide LHC Computing Grid
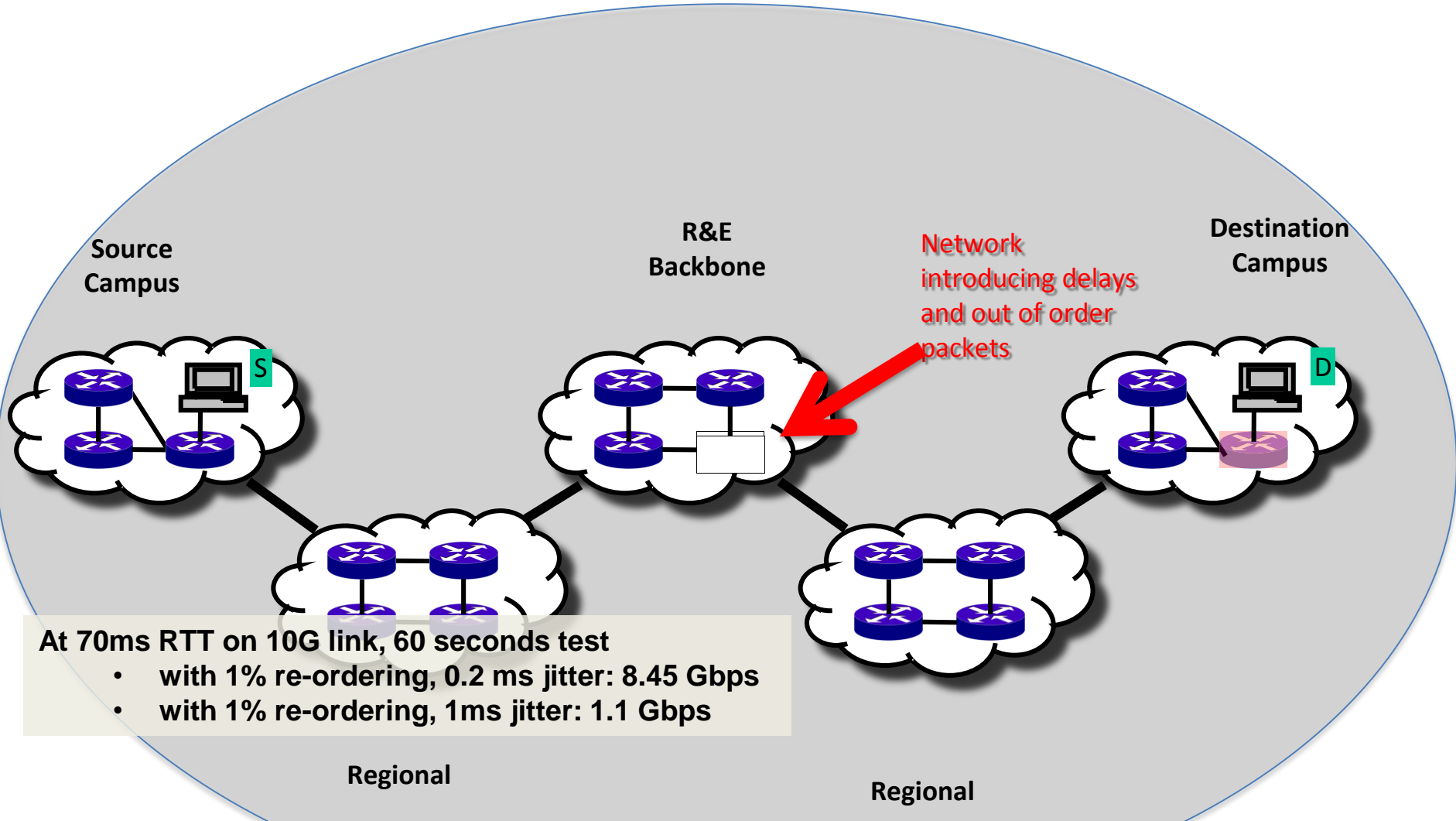
Throughput predictions

- Throughput measurements are expensive so done at low frequency. Delays and packet loss rate are cheap.
- Idea is to use delays and packet loss rate to predict maximum possible throughput.

- Mathis formula is used to model impact of packet loss and latency on throughput
  - **Rate < (MSS/RTT)*(1 / sqrt(p))**
    - MSS – segment size
    - RTT – round trip time
    - p – packet loss
- Packet (re)ordering and jitter to be added as well
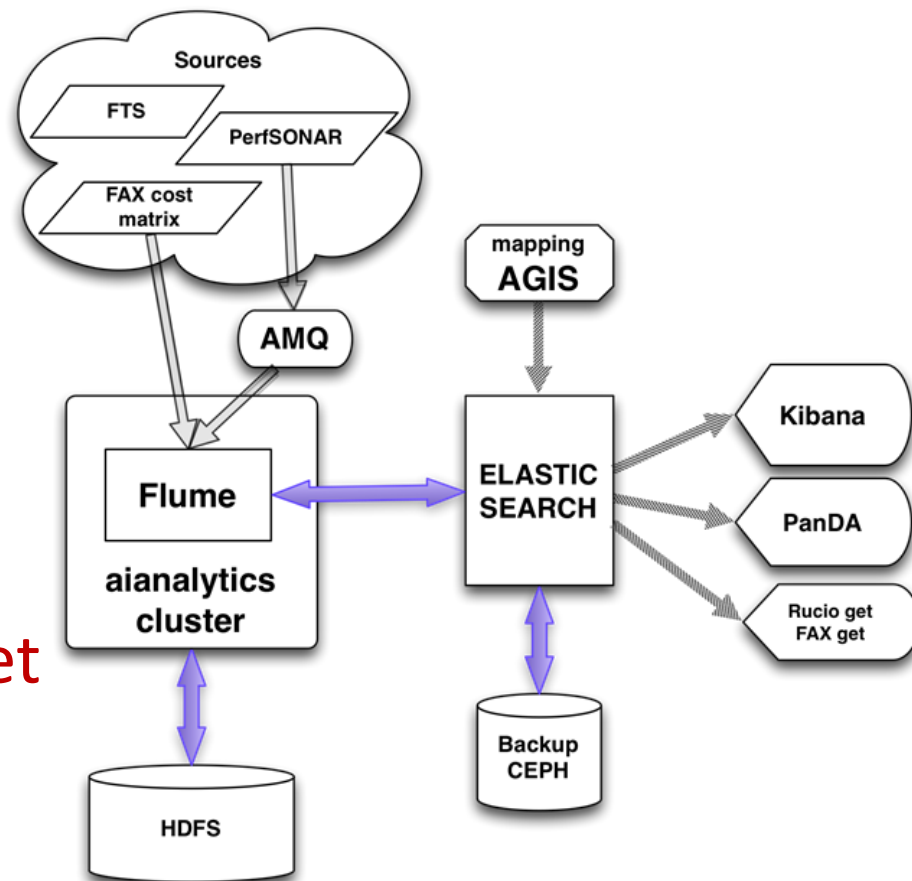
ATLAS Network Analytics

- Diagram shows the flow

- End-to-end+perfSONAR data both available to jointly analyze

- Kibana can be used to get customized views

  http://cl-analytics.mwt2.org:5601

- More details at: http://tinyurl.com/gt92zwb

Playing with SDN in ATLAS

- A group of people in the US from AGLT2, MWT2, SWT2 and NET2 are planning to explore SDN in ATLAS
  - Working with the LHCONE point-to-point effort as well
- The plan is to deploy Open vSwitch on ATLAS production systems at these sites (http://openvswitch.org/)
  - IP addresses will be move to virtual interfaces
  - No other changes; verify no performance impact
  - Traffic can be shaped accurately with little CPU cost
- The **advantage** is the our data sources/sinks become **visible** and **controllable** by OpenFlow controllers like OpenDaylight
- Follow tests can be initiated to provide experience with controlling networks in the context of ATLAS operations.
- *For more details talk to Rob Gardner or Shawn McKee*

Quick View of Latency Mesh

Future Directions

- The WLCG efforts at CERN are being reorganized and this is an opportunity to chart future directions for the working group

- We have a number of areas (projects; see next slide) we are considering and we need to understand where these efforts should be housed (Stay in WG, move to GDB, to LHCONE)

- There is a review of the working group scheduled for April 28th during the WLCG Operations Coordination meeting.

Possible Future Project Areas

- **Title:** LHCONE Traffic engineering
- **Areas:** LHCONE, routing, debugging, network orchestration
- **Title:** LHCONE L3VPN Looking Glass
- **Areas:** LHCONE, monitoring, debugging
- **Title:** Integration of network and transfer metrics to optimize experiments workflows
- **Areas:** FAX/Phedex, Rucio, perfSONAR, DIRAC
- **Title:** Advanced notifications/alerting for network incidents
- **Areas:** WAN, Advanced Notifications/Alerting, perfSONAR, Hadoop/Spark
- **Title:** Network performance of the commercial clouds
- **Areas:** Clouds, WAN connectivity, WAN performance (perfSONAR), establishing and testing network equipment at the cloud provider (VPN)
- **Title:** Software Defined Network Production Testbed
- **Areas:** WAN, SDN, LHCONE/LHCOPN, Storage/Data nodes