perfSONAR Global Monitoring and Analytics Framework Update

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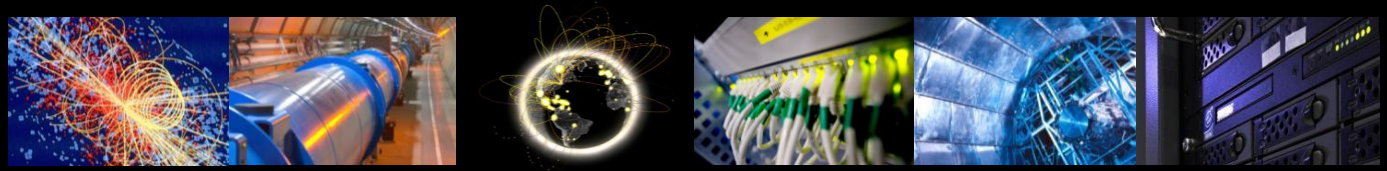
on behalf of WLCG Network Throughput WG

March 29, 2023

At the Spring 2023 HEPiX in Taipei, Taiwan

https://indico.cern.ch/event/1222948/contributions/5321010/



WLCG Worldwide LHC Computing Grid

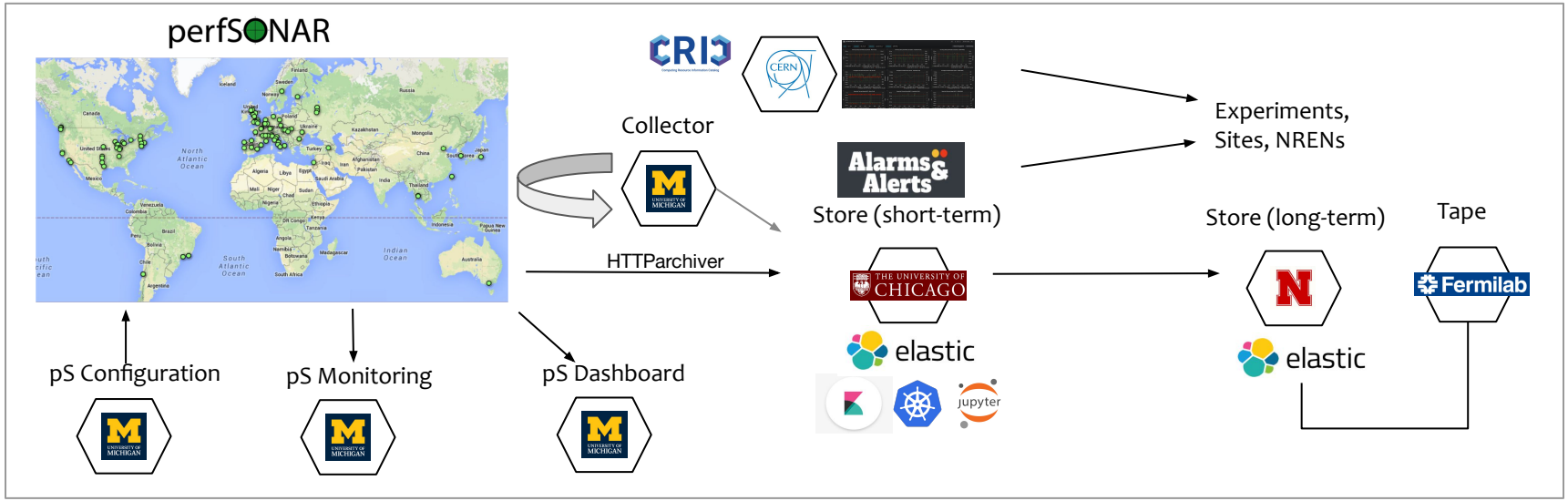
Open Science Grid

Outline

- OSG/WLCG Network Monitoring and 100G work
- perfSONAR community updates
- Upcoming network data pipeline transition
- New Analytics and Tools
- Summary

Network Measurement Platform Evolution

- Our platform collects, stores, configures and transports all network metrics
  - Distributed deployment - operated in collaboration
- Planned evolution based on the perfSONAR 5 already partially implemented.
  - Directly publishing results from perfSONARs to ES@UC (have test_* indices)
  - High-level services provided to the experiments/users (Alerting, Dashboards)



100Gbps Testing

- The group just met last week (March 21)
  - Most discussion was around existing perfSONAR issues and upcoming v5.0 release
  - Notes at https://docs.google.com/document/d/1Wm439TzTmax0Zjw-yIjxxitqanVmoeCYtkZNDYexPqI/edit?usp=sharing
  - Group goal: Aim to achieve 10% of avail. capacity (~10Gbps) on a regular basis
  - wlcg-perfsonar-100g mailing list (join)
- Tunings
  - Used psetf along with ES/Kibana dashboards to check status
  - TCP buffers and MTU appear to have made the biggest difference
    - TCP buffers by default at ~ 200MB, need to be increased to 1GB
  - References:
    - https://fasterdata.es.net/host-tuning/linux/100g-tuning/
  - *Most effective changes seem to be going to an OS with a 5.14+ kernel*
  - NIC interrupts/core sync only possible via manual tests
- Can check our host-based Grafana dashboard to see data graphs

perfSONAR News

- perfSONAR 5 beta has been out since last summer
  - ElasticSearch as local archive (replacing esmond/Cassandra) + Logstash.
  - Grafana visualisations (dashboards).
  - Toolkit support for latest Debian, RHEL8 compatible systems (Alma).
    - Will require full reinstall (backup **not** needed).
  - **Release of 5.0 targeted for ~ April 17, 2023**
- We still see various issues that impact our WLCG-wide deployment, even in the current beta of perfSONAR 5.
  - There are problems that seem to arise due to the scale of our deployment and the number of tests we are running.
  - Issues we have identified are open with the perfSONAR team.
  - Especially important for us is the ability to reliably configure the use of the HTTP archiver so we can directly send data from Toolkits to Elasticsearch.

Infrastructure: Network Data Pipeline Transition

- We are updating our network data pipeline which gathers perfSONAR data.
- This is primarily motivated by two things
  - The operational experience with using RabbitMQ (high latency; too many parts)
  - The upcoming perfSONAR v5 change to the “default” Measurement Archive (MA), the location that hosts the measurement results
- We are in the process of transitioning away from using a message bus and instead sending data directly to Elasticsearch from each perfSONAR toolkit.
  - **Pros**: Reduces latency, simplifies pipeline with less components required, matches direction the perfSONAR developer have chosen allowing us to utilize and benefit from their work, should be easier to operate and monitor
  - **Cons**: All dependencies on the RabbitMQ bus must be transformed to use the HTTP archiver. To maintain the ability to grab data for those toolkits that cannot “push” also requires updating the perfsonar_collector to send data directly to Elasticsearch. (**SOLVED**)
- **TIMELINE**: Estimate is end of **June 2023** (Approximately 2 months after working pS 5 release)

Tools and Applications for Network Data

- To organize access to all the various resources we recommend using our Toolkitinfo page: https://toolkitinfo.opensciencegrid.org/
- Reminder: we already have Kibana dashboards looking at
  - Bandwidth
  - Traceroute
  - Packetloss / Latency
  - Infrastructure
- For this meeting we want to update our recent work towards a user subscribable alerting and alarming service
  - User interface to subscribe is **AAAS** (ATLAS Alerting and Alarming Service)
  - Tool to explore alerts is **pS-Dash** (Plotly base perfSONAR dashboard UI tool)

Alarms & Alerts Service

Components

Database
Elasticsearch

REST API and Web frontend
Node.js + express + pug

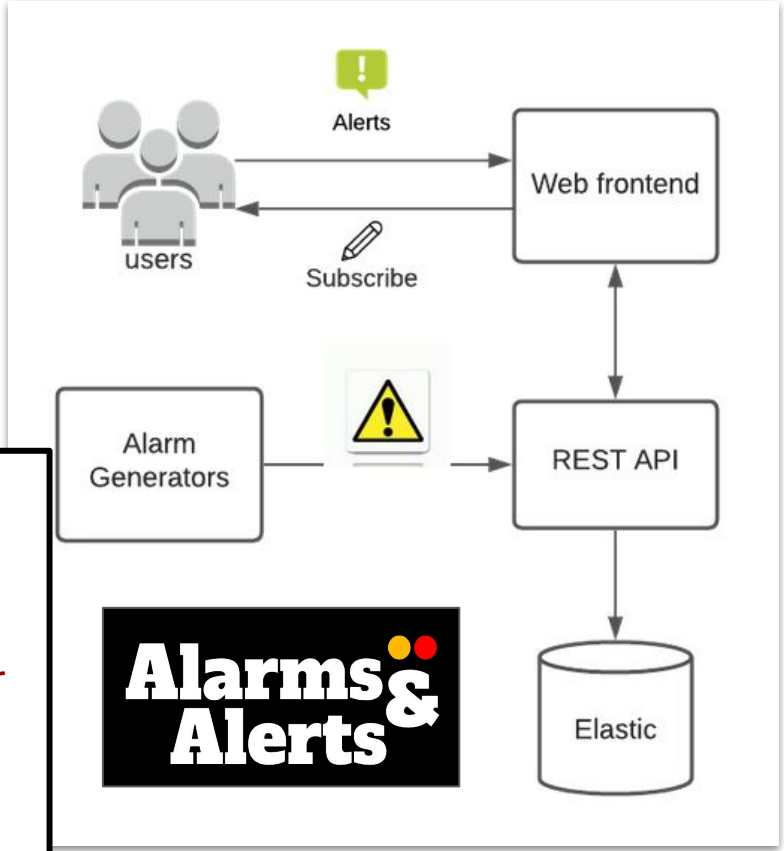
Deployment
Docker, K8s, Helm (soon)

Authentication
Globus InCommon

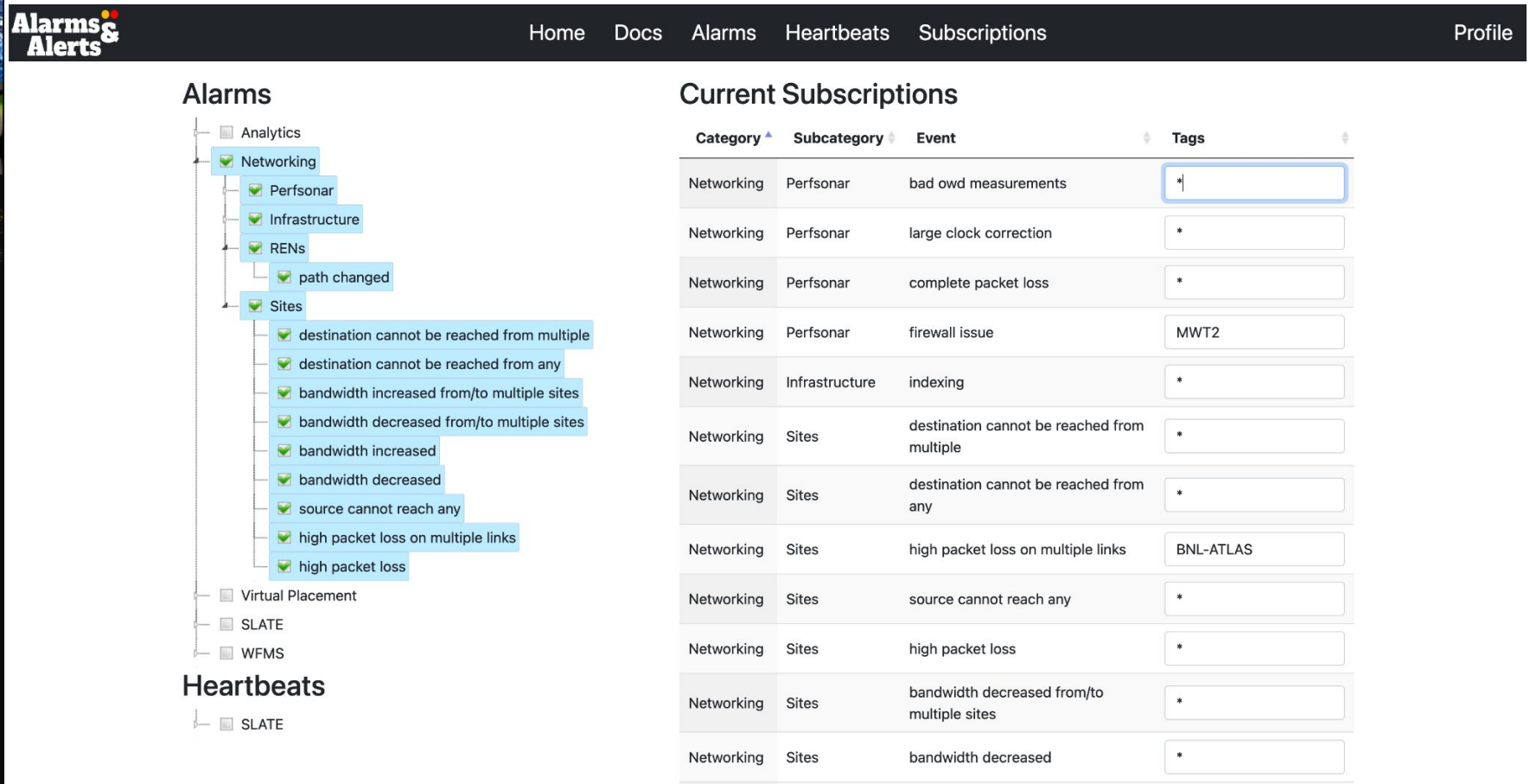
Authorization
API key

Mail
Mailgun

https://aaas.atlas-ml.org/
(Uses EDUGain/InCommon)
Purpose: provides user-subscribable alerting for specific types of network issues found by analyzing perfSONAR data



The Alerting and Alarming Tools Subscription Interface



Alarm Types and Relation to perfSONAR Data

All based on perfSonar data

One-Way Delay

- bad owd measurements
- large clock correction

Traceroute

- path changed
- destination cannot be reached
- source cannot reach any

Packet loss

- complete packet loss
- firewall issue
- high packet loss (on multiple links)

Throughput

- bandwidth decreased (from/to multiple sites)
- bandwidth increased (from/to multiple sites)

pSDash (perfSONAR Dashboard)

perfSONAR Toolkit Information | Kibana: Packet Loss in OSG/WLCG | Kibana: Packet Loss Tracking | MEPHi Tracer: Traceroute explorer | Alarms description

ps dash | SITES OVERVIEW | SEARCH ALARMS | EXPLORE PATHS

Selected site: UKI-NORTHGRID-LIV-HEP

Alarms reported in the past 24 hours (2023-03-05 19:00 UTC)

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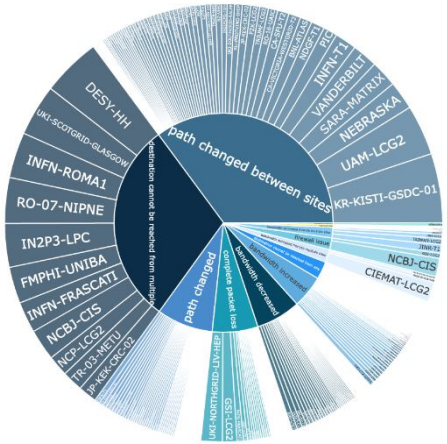
ps dash | SITES OVERVIEW | SEARCH ALARMS | EXPLORE PATHS



Search & Explore the Networking Alarms

03/04/2023 → 03/05/2023

Rounded to the day

Search for a site

Search for an event type

List of alarms

BANDWIDTH DECREASED

from	to	src_site	dest_site	ipv	ipv6	last3days_avg	%change	alarm_link
filter data...								
2023-02-12 04:08	2023-03-05 04:08	AGLT2	RRC-KI-T1	ipv4	false	96	-64	VIEW
2023-02-12 04:08	2023-03-05 04:08	IN2P3-CC	FZK-LCG2	ipv4	false	1008	-74	VIEW

WLCG perfSONAR Path Statistics

We uniquely identify each traceroute (route **IP** path) with a SHA1 hash.

	route-sha1
count	19995.000000
mean	19.911678
std	43.373343
min	1.000000
25%	2.000000
50%	4.000000
75%	12.000000
max	377.000000

5264 links tested Link=”hop” (IP-to-IP)

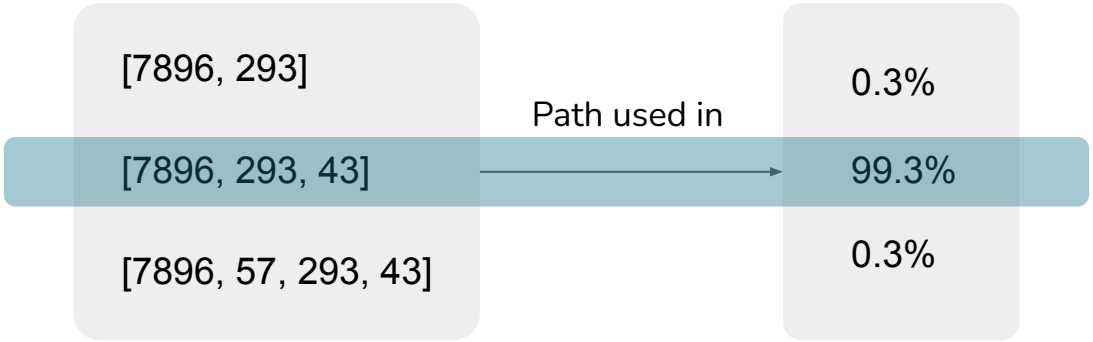
4415 traversed nodes Node=”router”

Statistics on the left concern all the “paths” we are tracking with about 20K unique paths found
About 50% of src-dest pairs have 4 or less paths.

AS (Autonomous System) Path Changed

NOTE: Paths denoted by route IP are too noisy; instead use AS number

ASN sequence	Reduced ASNs
[7896, 7896, 293, 293, 293, 293, 293, 293]	[7896, 293]
[7896, 7896, 293, 293, 293, 293, 293, 293, 43]	[7896, 293, 43]
[7896, 7896, 7896, 7896, 57, 57, 57, 293, 293, 293, 293, 293, 293, 43]	[7896, 57, 293, 43]



Baseline

[7896, 293, 43]

57

Example: LHCOPN/LHCONE Load Balancing

Source

INFN-T1

2001:760:4205:254::11

Destination

SARA-MATRIX

2001:610:108:203a::31

Total number of traceroute measures: 280
Other networking alarms: None found

BASELINE PATH

Taken in 50% of time — Always reaches destination: NO

137 513 1103

ALTERNATIVE PATHS

Taken in 50.0% of time — Always reaches destination: NO

137 20965 1103

Taken in 0.0% of time — Always reaches destination: NO

137 20965

At position	Typically goes through	Changed to
3	**513** CERN, CH	**20965** GEANT The GEANT IP Service, NL
4	**513** CERN, CH	**20965** GEANT The GEANT IP Service, NL
5	**513** CERN, CH	**20965** GEANT The GEANT IP Service, NL
6	**1103** SURFNET-NL SURFnet, The Netherlands, NL	**20965** GEANT The GEANT IP Service, NL

Example: LHCOPN Alternate via ESnet

USCMS-FNAL-WC1->CERN-PROD

Source

USCMS-FNAL-WC1

131.225.205.23

Destination

CERN-PROD

128.142.208.134

Total number of traceroute measures: 248

Other networking alarms: None found

BASELINE PATH

Taken in 99% of time | Always reaches destination: NO

3152 513

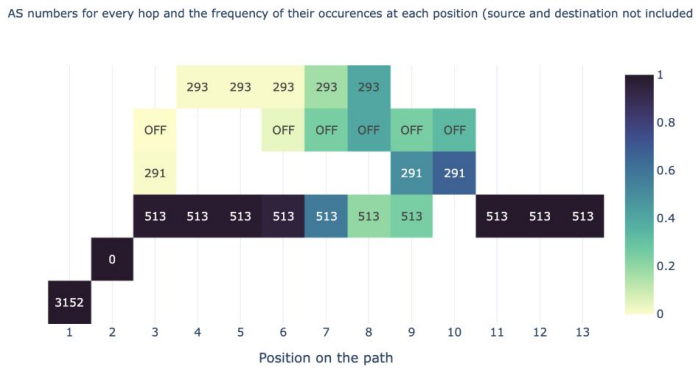
ALTERNATIVE PATHS

Taken in 0.0% of time | Always reaches destination: NO

3152

Taken in 1.0% of time | Always reaches destination: NO

3152 291 293 513



At position	Typically goes through	Changed to
3	**513** CERN, CH	**291** ESNET-EAST, US

At position	Typically goes through	Changed to
4	**513** CERN, CH	**293** ESNET, US

At position	Typically goes through	Changed to
5	**513** CERN, CH	**293** ESNET, US

Example: FNAL Incident (BW drop)

USCMS-FNAL-WC1 to NDGF-T1

Source

USCMS-FNAL-WC1

Destination

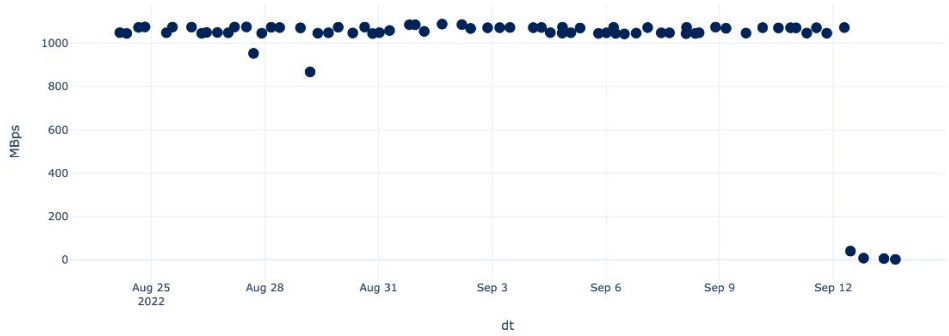
NDGF-T1

Change: -100%

Total number of throughput measures: 71

Other networking alarms

| High packet loss: 2 | High packet loss on multiple links: 1 |



push	MA	src	dest	src_host	dest_host	ipv6	src_site	src_VO	dest_site	dest_VO	src_production	dest_production	timestamp	throughput	pair	dt	MBps
filter da																	
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1661561263000	1048161726	131.225.205.23->109.105.124.88	2022-08-27T00:47:43	1048.16
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1661618925000	952946516	131.225.205.23->109.105.124.88	2022-08-27T16:48:45	952.95
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662626239000	1045220096	131.225.205.23->109.105.124.88	2022-09-08T08:37:19	1045.22
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1661678463000	1072068304	131.225.205.23->109.105.124.88	2022-08-28T09:21:03	1072.07
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662439905000	1072905581	131.225.205.23->109.105.124.88	2022-09-06T04:51:45	1072.91
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1661659004000	1073324325	131.225.205.23->109.105.124.88	2022-08-28T03:56:44	1073.32
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662672411000	1074163359	131.225.205.23->109.105.124.88	2022-09-08T21:26:51	1074.16
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662902418000	1071231326	131.225.205.23->109.105.124.88	2022-09-11T13:20:18	1071.23
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662093921000	1085912472	131.225.205.23->109.105.124.88	2022-09-02T04:45:21	1085.91
false	131.225.205.23	131.225.205.23	109.105.124.88	psonar3.fnal.gov	perfsonar-ps2.ndgf.org	false	USCMS-FNAL-WC1	UNKNOWN	NDGF-T1	ATLAS	true	true	1662696230000	1068710540	131.225.205.23->109.105.124.88	2022-09-09T04:03:50	1068.71

Example: Fail-over to Commodity Network

Nebraska -> RAL-LCG2

Source

Nebraska

2600:900:6:1102:2eea:7fff:fef5:d140

Destination

RAL-LCG2

2001:630:58:1820::82f6:b06d

Total number of traceroute measures: 280

Other networking alarms: None found

BASELINE PATH

Taken in 99% of time — Always reaches destination: NO

7896 11537 20965 786

ALTERNATIVE PATHS

Taken in 1.0% of time — Always reaches destination: NO

7896 6939 786

Taken in 0.0% of time — Always reaches destination: YES

7896 7029 6461 3257 1299 786

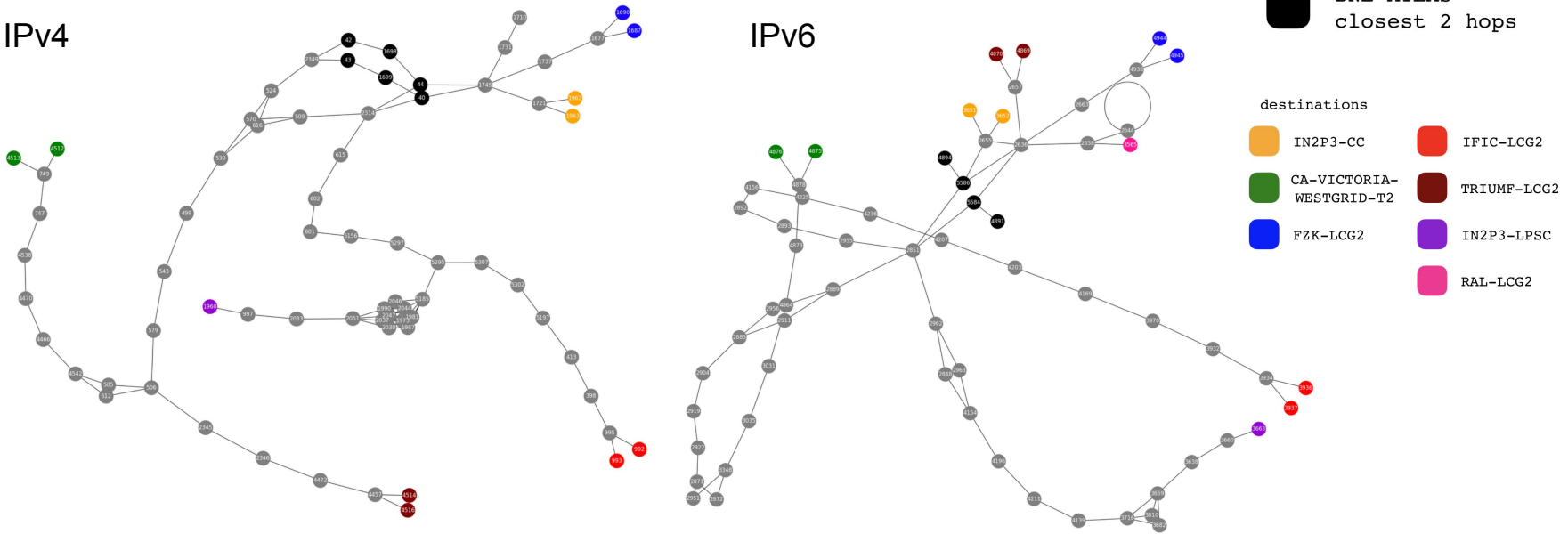
At position	Typically goes through	Changed to
4	**11537** INTERNET2-RESEARCH-EDU, US	**7029** WINDSTREAM, US

At position	Typically goes through	Changed to
7	**11537** INTERNET2-RESEARCH-EDU, US	**6939** HURRICANE, US

At position	Typically goes through	Changed to
7	**6461** ZAYO-6461, US	**6939** HURRICANE, US

Challenges and Ongoing Work

Paths differ significantly



Correlating Tests with Paths: Two Timescales

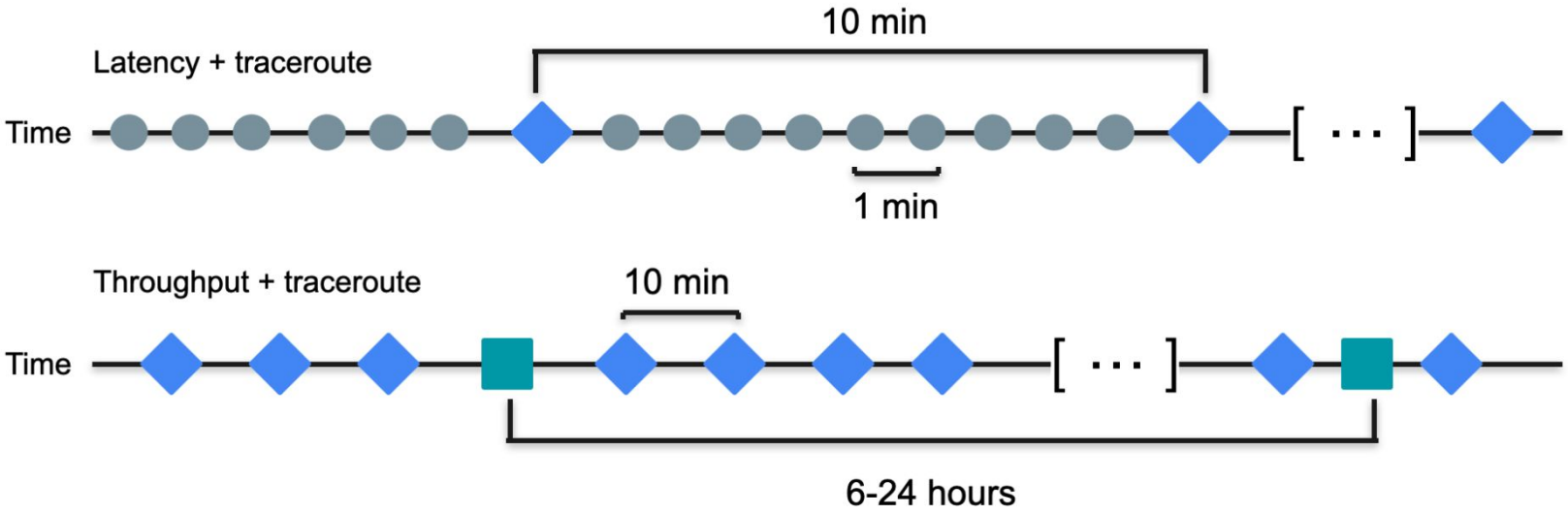
Latency tests: **every minute**

Throughput tests: **6-24 hours**

Traceroute tests: **every 10 min**

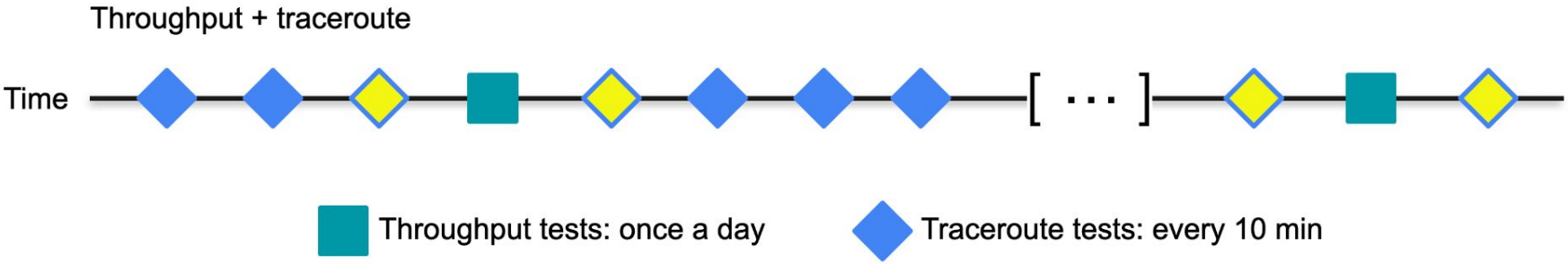
The problem: All tests run independently

How do we combine them?



Connecting Throughput to Traceroute

Can we consider the trace routes closest in time to the throughput records?

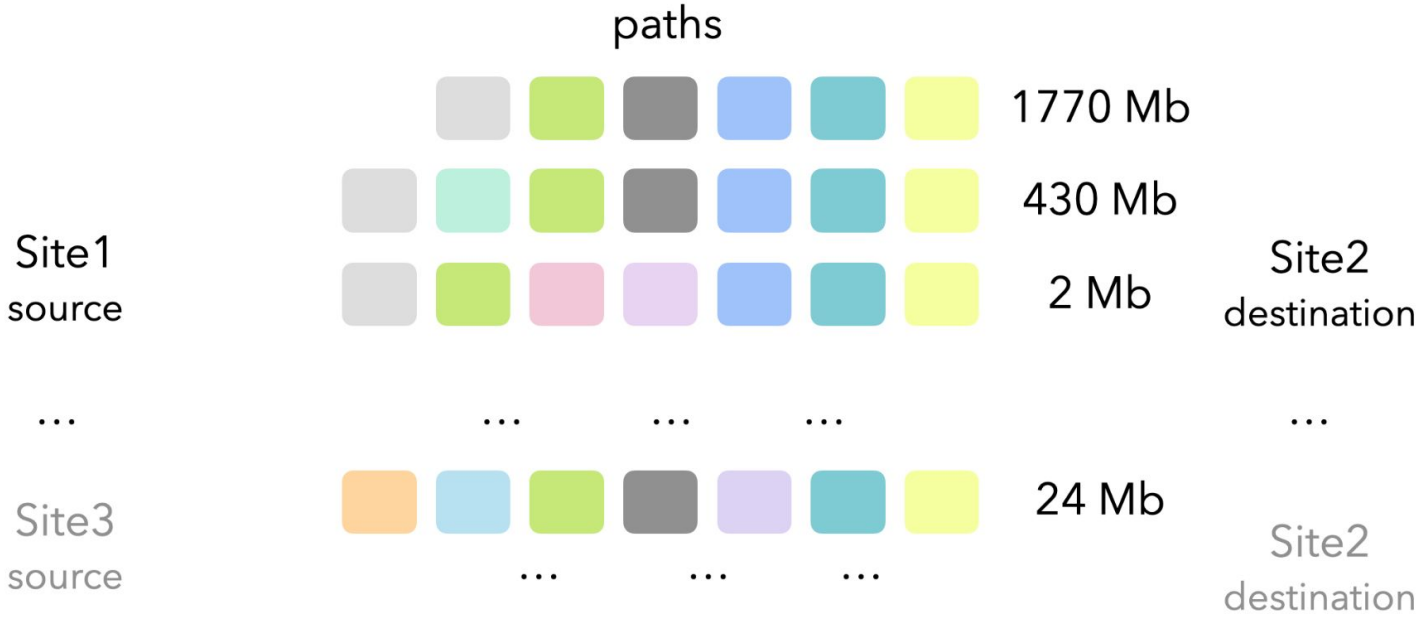


Our starting choice: Use **both** tracepaths (just before; just after) as valid paths and attribute BW to both.

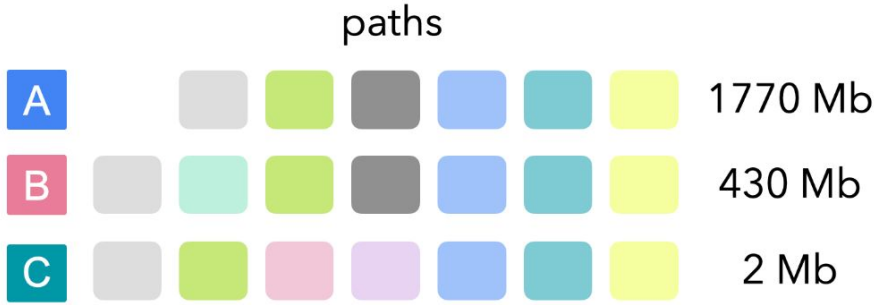
Have to see if this is superior to just using the last measured route before the measurement…

Attaching Throughput Results to Sets of Routers/Links

Each colored box represents a specific router along the path

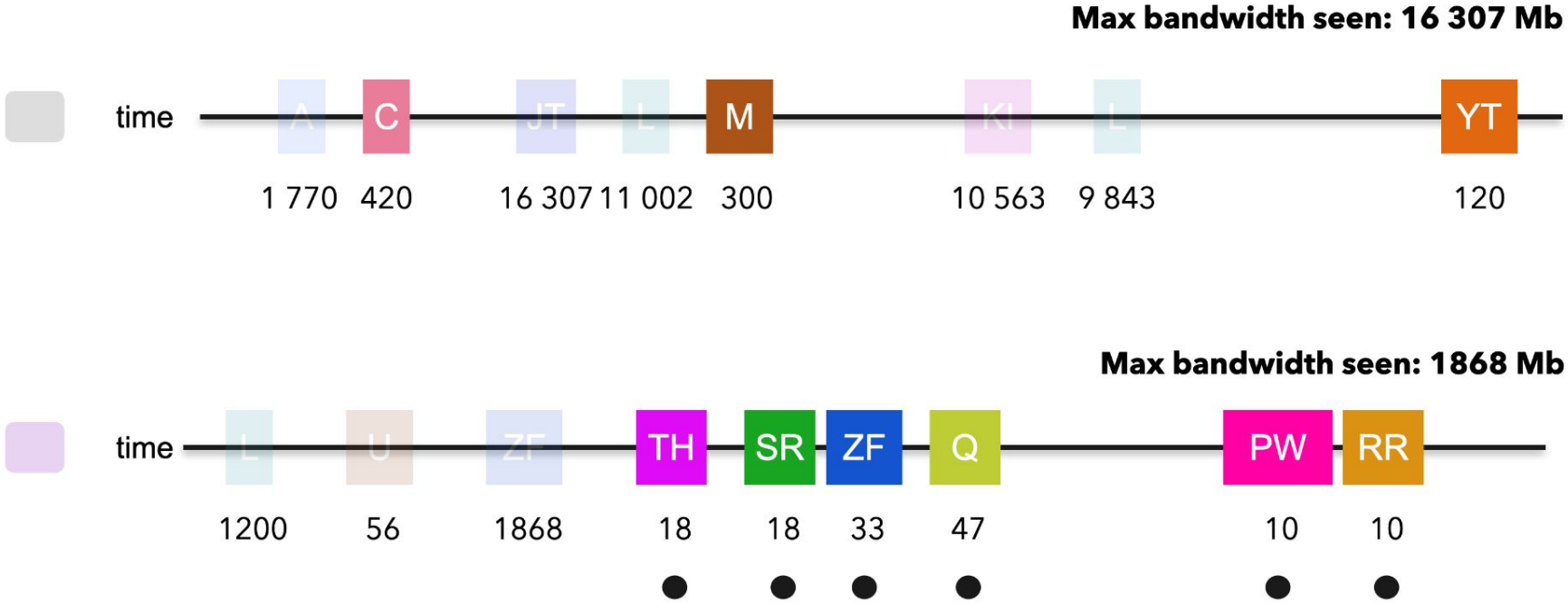


Example Throughput Attribution by Router



Each router on the path gets the closest (in time) throughput values

Checking Router Results vs Time

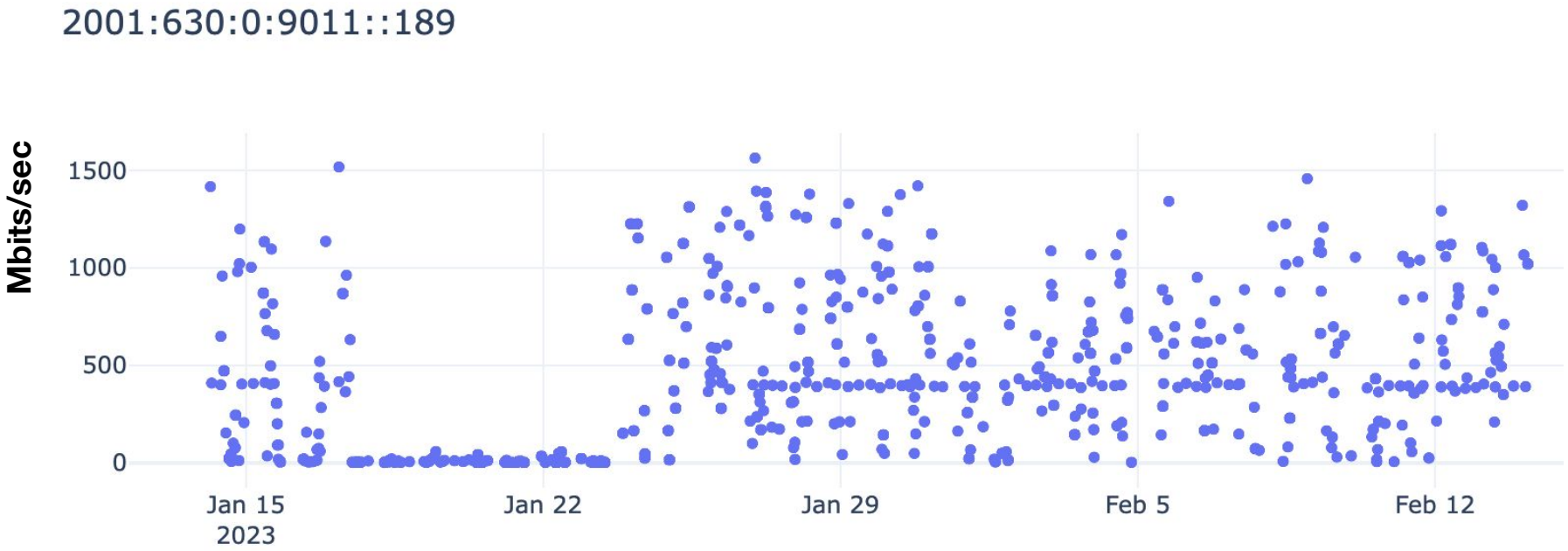


Look for a down trend

(threshold below 10% of the max throughput)

Is everything OK with/around that router?

Initial Example Result: One Router; Throughput vs Time



Each **point** represents the throughput values collected when the node was on the path

Other Activities / Plans

Working to organize and annotate our data for ML/AI work (Petya Vasileva)

Working with the RNTWG (see previous RNTWG update talk) on identifying and monitoring network traffic details via the SciTags initiative.

Exploring other network monitoring activities in the perfSONAR space including ARGUS

Planning to add WLCG-CRIC network meta data (which paths/networks are LHCOPN/LHCONE/Research&Education/Commercial)

Prepare for DC2: use perfSONAR to proactively debug our main network links before Data Challenge 2

Summary

- OSG in collaboration with WLCG operates a comprehensive network monitoring platform
  - Provides data and feedback to LHCOPN/LHCONE, HEPiX, WLCG and OSG communities
- The IRIS-HEP project and completed SAND project have produced some new tools for exploring and utilizing our network data that we continue to develop.
- Developing high-level services based on perfSONAR measurements that will help sites, experiments and R&Es receive targeted alarms/alerts on existing issues in the infrastructure
- We have to continue to watch our network monitoring infrastructure as it is a complex system with lots of areas for issues to develop.

Questions / Discussion?

Acknowledgements

We would like to thank the **WLCG**, **HEPiX**, **perfSONAR** and **OSG** organizations for their work on the topics presented.

In addition we want to explicitly acknowledge the support of the **National Science Foundation** which supported this work via:

- OSG: NSF MPS-1148698
- IRIS-HEP: NSF OAC-1836650

Useful URLs

- OSG/WLCG Networking Documentation
  - https://opensciencegrid.github.io/networking/
- perfSONAR Infrastructure Dashboard
  - https://atlas-kibana.mwt2.org:5601/s/networking/goto/9911c54099b2be47ff9700772c3778b7
- perfSONAR Dashboard and Monitoring
  - http://maddash.opensciencegrid.org/maddash-webui
  - https://psetf.opensciencegrid.org/etf/check_mk
- perfSONAR Central Configuration
  - https://psconfig.opensciencegrid.org/
- Toolkit information page
  - https://toolkitinfo.opensciencegrid.org/
- Grafana dashboards
  - http://monit-grafana-open.cern.ch/
- ATLAS Alerting and Alarming Service: https://aaas.atlas-ml.org/
- The perfSONAR Dashboard application: https://ps-dash.uc.ssl-hep.org/
- ESnet WLCG Stardust Dashboard: https://public.stardust.es.net/d/XkxDL5H7z/esnet-public-dashboards?orgId=1

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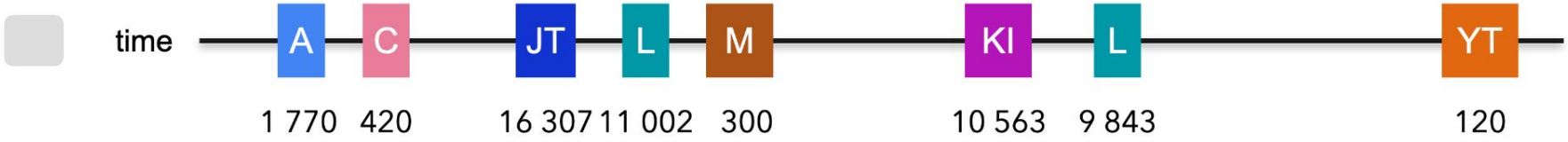
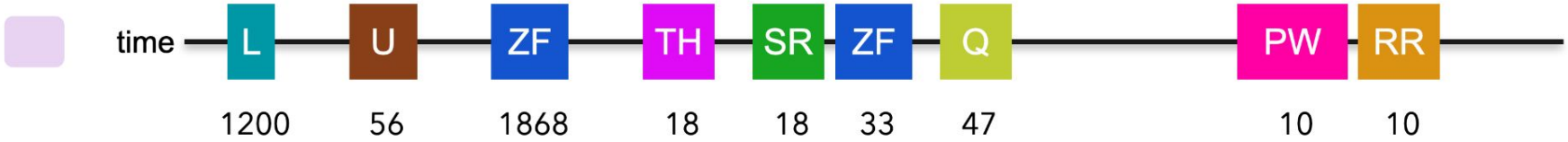
- perfSONAR Dashboard and Monitoring
  - http://maddash.opensciencegrid.org/maddash-webui
  - https://psetf.opensciencegrid.org/etf/check_mk
- perfSONAR Central Configuration
  - https://psconfig.opensciencegrid.org/
- Toolkit information page
  - https://toolkitinfo.opensciencegrid.org/
- Grafana dashboards
  - http://monit-grafana-open.cern.ch/
- ATLAS Alerting and Alarming Service: https://aaas.atlas-ml.org/
- The perfSONAR Dashboard application: https://ps-dash.uc.ssl-hep.org/
- ESnet WLCG Stardust Dashboard: https://public.stardust.es.net/d/XkxDL5H7z/esnet-public-dashboards?orgId=1

Backup Slides Follow

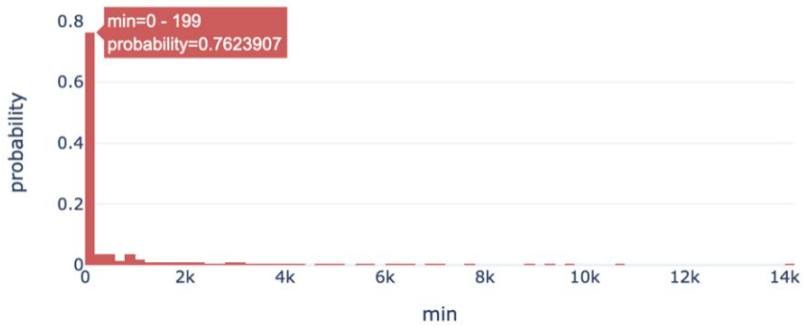




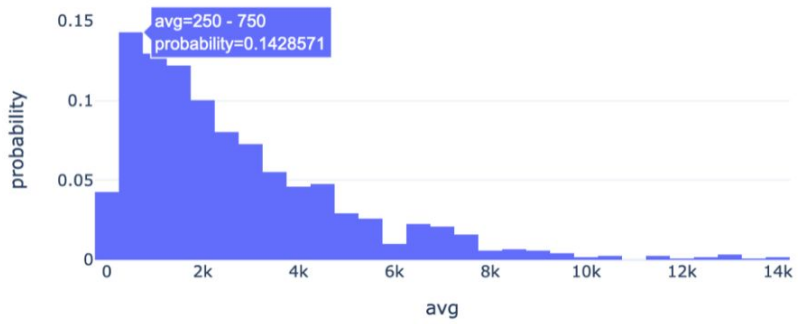
Look for a down trend

(threshold below 10% of the max throughput)

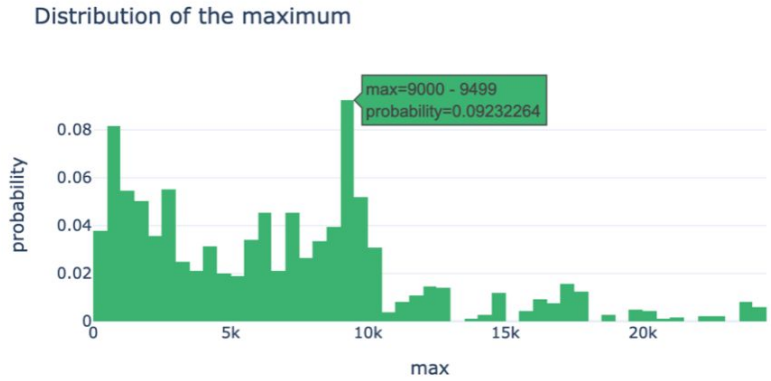
Distribution of the minimum



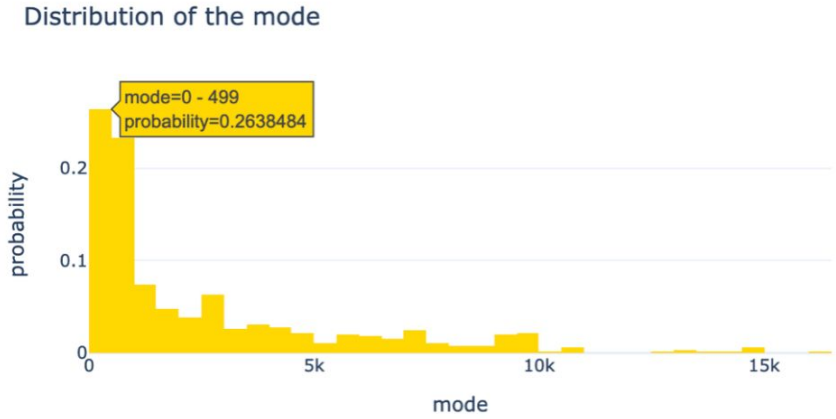
Distribution of the average



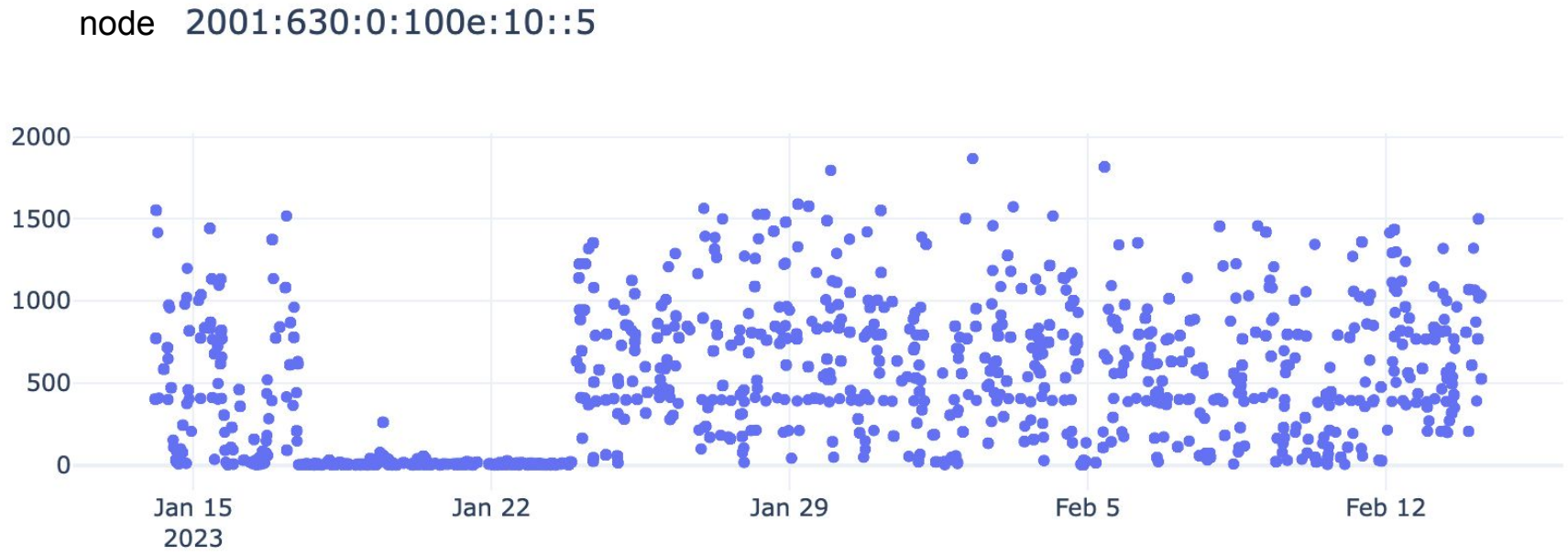
Distribution of the maximum



Distribution of the mode

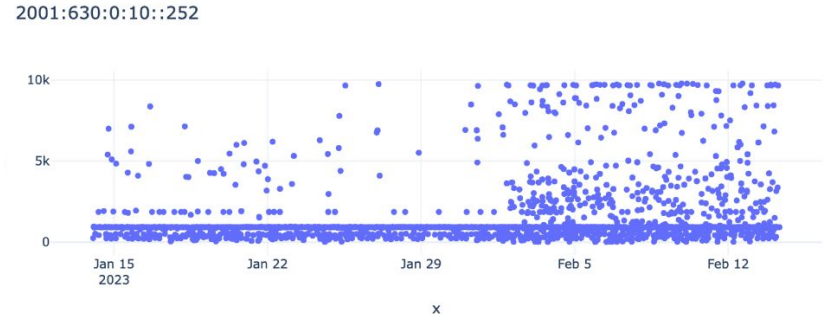


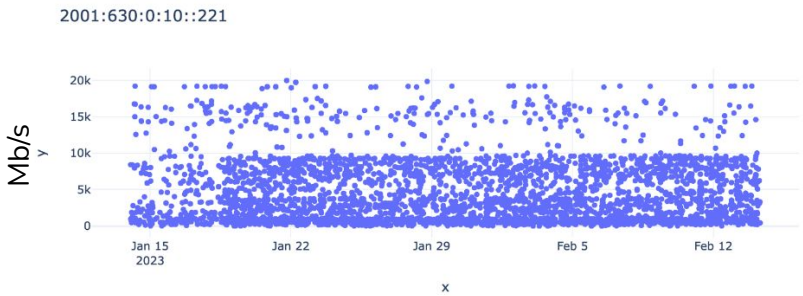
Preliminary results

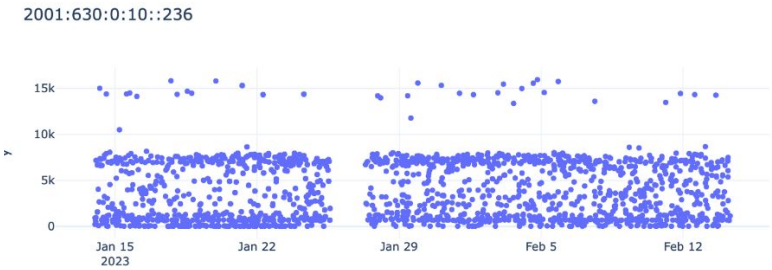


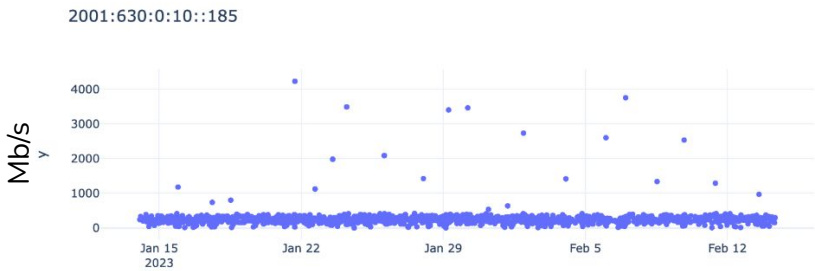
Each point represents the throughput values collected when the node was on the path

Preliminary results









Site/campus routing changes

NEBRASKA->UCSDT2

Source

NEBRASKA

2600:900:6:1102:2eea:7fff:fef5:d140

Destination

UCSDT2

2607:f720:1700:1b30::28

Total number of traceroute measures: 849

Other networking alarms: None found

BASELINE PATH

Taken in 66% of time — Always reaches destination: NO

7896 291 293 26397

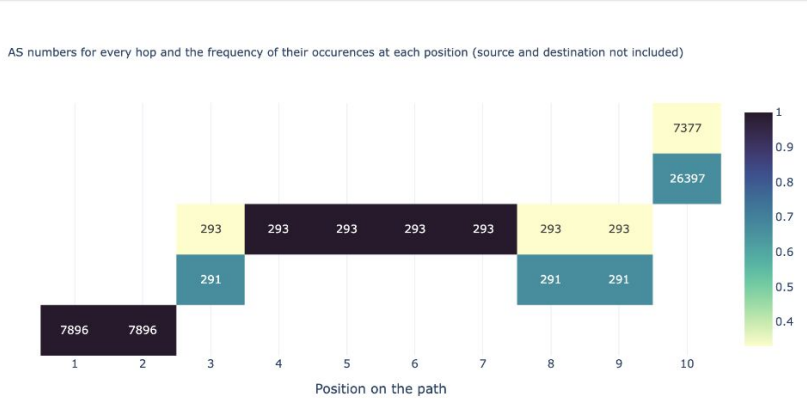
ALTERNATIVE PATHS

Taken in 33.0% of time — Always reaches destination: YES

7896 293 7377

Taken in 0.0% of time — Always reaches destination: NO

7896 291 293



At position	Typically goes through	Changed to
10	**26397** OPTIPUTER, US	**7377** UCSD, US

WLCG Network Throughput Support Unit

Support channel where sites and experiments can report potential network performance incidents:

- Relevant sites, (N)RENs are notified and perfSONAR infrastructure is used to narrow down the problem to particular link(s) and segment. Also tracking past incidents.
- Feedback to WLCG operations and LHCOPN/LHCONE community

Most common issues: MTU, MTU+Load Balancing, routing (mainly remote sites), site equipment/design, firewall, workloads causing high network usage

As there is no consensus on the MTU to be recommended on the segments connecting servers and clients, LHCOPN/LHCONE working group was established to investigate and produce a recommendation. (See coming talk :))

Importance of Measuring Our Networks

- End-to-end network issues are difficult to spot and localize
  - Network problems are multi-domain, complicating the process
  - Performance issues involving the network are complicated by the number of components involved end-to-end
  - Standardizing on specific tools and methods focuses resources more effectively and provides better self-support.
- **Network problems can severely impact experiments workflows and have taken weeks, months and even years to get addressed!**
- perfSONAR provides a number of standard metrics we can use
  - Latency, Bandwidth and Traceroute
  - These measurements are critical for network visibility
- **Without measuring our complex, global networks we wouldn't be able to reliably use those network to do science**