



EPOC

Engagement and Performance
Operations Center

IPv6 Monitoring and Performance Measurement



ESnet

ENERGY SCIENCES NETWORK

IPv6 Monitoring

How eat an elephant... How do you monitor IPv6?

One service, one network at a time

Progress Bar:

8:30a - 9:15a

Questions or Discussion topics?

IPv6 Monitoring: Suggested Plan (ScienceDMZ focus)

- ❖ Know your upstream providers and have open communications with them**
- ❖ Turn up IPv6 at your Border/Perimeter Router with R&E/I2
- ❖ Hold on commodity ISP until 100% comfortable
- ❖ Adjust BGP route space for IPv4 and IPv6 between 1-2 AS hop to full tables
- ❖ Add IPv6 BOGONS (slide 16 in this presentation)
- ❖ Complete MANRS
- ❖ Jumbo frames, enable them.
- ❖ Configure and collect Border Routers eyes and ears (e.g. NetFlow/IPFIX or sFlow)
- ❖ Document how to check IPv4 and IPv6 Router BGP Table sizes
- ❖ Create an IPv4 vs IPv6 chart with in your NetFlow/IPFIX or sFlow collector
- ❖ Setup BGP monitoring with a package such as Artemis







IPv6 Monitoring: Suggested Plan (ScienceDMZ)

- ❖ Turn up a dual stack jumbo framed LAN on your Science DMZ and have your perfSONAR server(s) ready.
 - Monitor NetFlow/IPFIX or sFlow at your Science DMZ
 - Start IPv4 and IPv6 testing from your perfSONAR server(s) to and ESnet or regional pS server
- ❖ Build IPv4/IPv6 test network off of the core and add a small perfSONAR Server
 - Verify IPv6 as well as IPv4 routing through from test LAN through core, firewall out to Science DMZ perfSONAR server(s) and return connectivity and path.
 - Monitor TCAM tables and OSPF/ISIS/IGP routes
- ❖ Once testing is complete, monitoring is complete, and security is as good as it will get, turn up IPv6 BGP to commodity ISPs.
 - Turn BGP preference to R&E networks (especially if there are transit costs)
 - Complete pS testing again to R&E and commodity ISPs
- ❖ Rinse and repeat for other segments and networks as they arrive online (Instruments, project groups, etc...)

IPv6 test - <https://test-ipv6.com/>

<https://test-ipv6.com/> from a IPv4 address

Summary Tests Run Share Results / Contact

-  Your IPv4 address on the public Internet appears to be 207.237.186.122
-  Your Internet Service Provider (ISP) appears to be RCN-AS
-  No IPv6 address detected [\[more info\]](#)
-  You appear to be able to browse the IPv4 Internet only. You will not be able to reach IPv6-only sites.
-  To ensure the best Internet performance and connectivity, ask your ISP about native IPv6. [\[more info\]](#)
-  Your DNS server (possibly run by your ISP) appears to have IPv6 Internet access.

Your readiness score

0/10 for your IPv6 stability and readiness, when publishers are forced to go IPv6 only

IPv6 test - <https://test-ipv6.com/>

<https://test-ipv6.com/> from a IPv6 address



Since you have IPv6, we are including a tab that shows how well you can reach other IPv6 sites.
[\[more info\]](#)



Your DNS server (possibly run by your ISP) appears to have IPv6 Internet access.

Your readiness score

10/10

for your IPv6 stability and readiness, when publishers are forced to go IPv6 only

Click to see [Test Data](#)

(Updated server side IPv6 readiness stats)

This instance (newark.test-ipv6.com) is hosted at Linode.

Copyright (C) 2010, 2024 Jason Fesler. All rights reserved. Version 1.1.1000 (fe2dfca)

[Mirrors](#) | [Source](#) | [Email](#) - [Attributions](#) | [Debug](#) | [Open US](#)

This is a mirror of test-ipv6.com. The views expressed here may or may not reflect the views of the mirror owner.

IPv6 test - https://test-ipv6.com/

Summary Tests Run Share Results / Contact For the Help Desk

How this test works: Your browser will be instructed to reach a series of URLs. The combination of successes and failures tells a story about how ready you are for when publishers start offering their web sites on IPv6.

Click to see [Technical Info](#)

Test with IPv4 DNS record	ok (1.651s) using ipv4
Test with IPv6 DNS record	bad (0.598s)
Test with Dual Stack DNS record	ok (1.611s) using ipv4
Test for Dual Stack DNS and large packet	ok (1.544s) using ipv4
Test IPv6 large packet	bad (0.383s)
Test if your ISP's DNS server uses IPv6	ok (1.564s) using ipv4
Find IPv4 Service Provider	ok (1.689s) using ipv4 ASN 6079
Find IPv6 Service Provider	bad (0.468s)

Test your IPv6 connectivity.

Summary Tests Run Share Results / Contact Other IPv6 Sites

How this test works: Your browser will be instructed to reach a series of URLs. The combination of successes and failures tells a story about how ready you are for when publishers start offering their web sites on IPv6.

Click to see [Technical Info](#)

Test with IPv4 DNS record	ok (0.311s) using ipv4
Test with IPv6 DNS record	ok (0.314s) using ipv6
Test with Dual Stack DNS record	ok (0.331s) using ipv6
Test for Dual Stack DNS and large packet	ok (0.256s) using ipv6
Test IPv6 large packet	ok (0.256s) using ipv6
Test if your ISP's DNS server uses IPv6	ok (0.513s) using ipv6
Find IPv4 Service Provider	ok (0.467s) using ipv4 ASN 19901
Find IPv6 Service Provider	ok (0.494s) using ipv6 ASN 209

IPv6 Service Monitoring - Don't let your customers be the monitor...

https://www.mrp.net/ipv6_survey/

- Verify IPv6 enabled services
- Check performance too...
 - HTTPS
 - eMail
 - DNS/DNS SEC
 - DHCP
 - Time / NTP / PTP
 - Monitoring suites
 - Management software
 - Policy at procurement?
- XMPP
- SIP/VoIP
- SecNet/NVRs
- LDAP/Access/shibboleth
- APIs
- Wireless
- perfSONAR
- Science DMZ
- DTNs

IPv6 DNS Resolution Monitoring

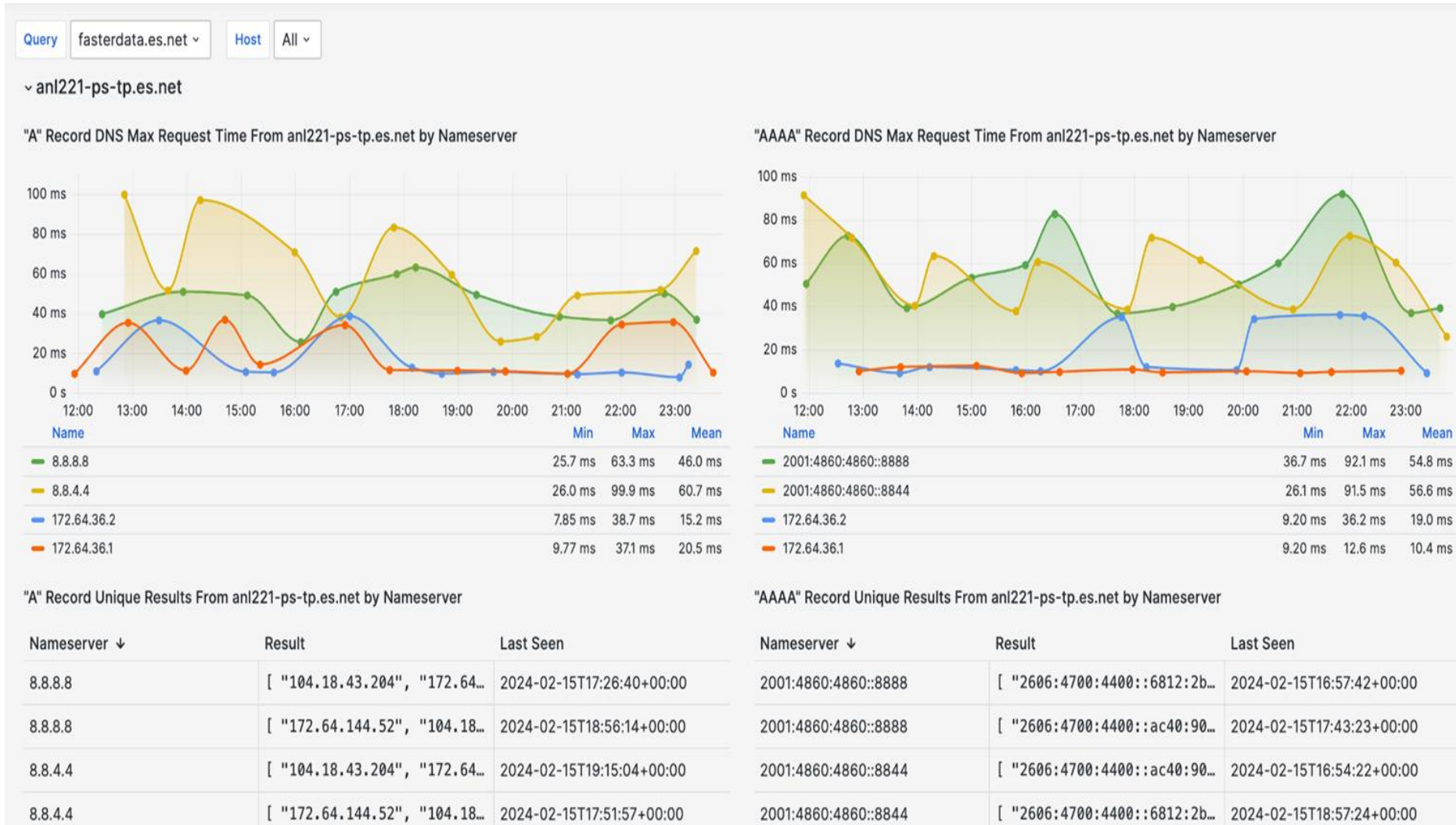
- Monitor DNS!
 - host AAAA record lookup failures and successful IPv4 A record lookups for the same query

es.net has address 142.93.181.71

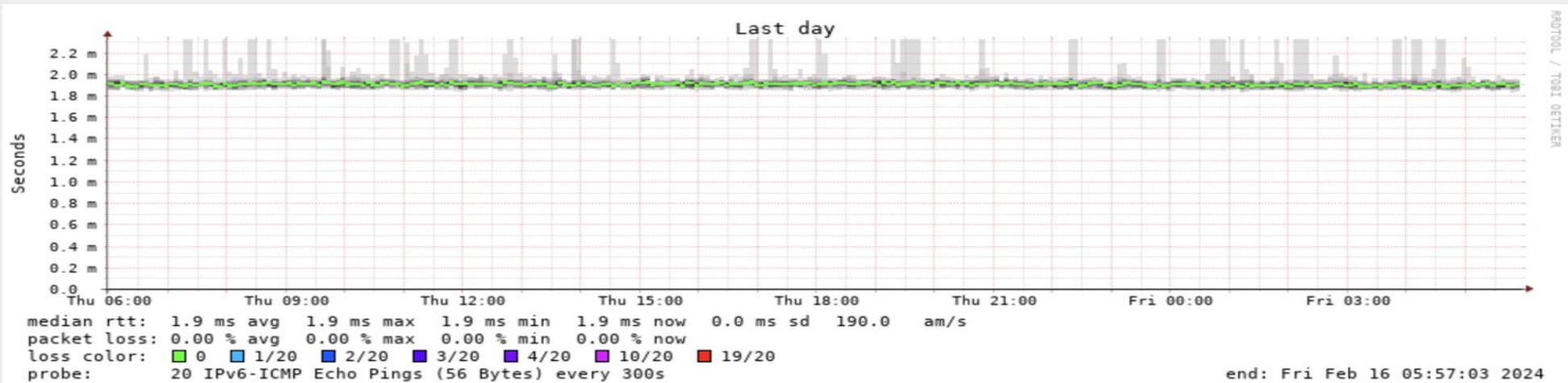
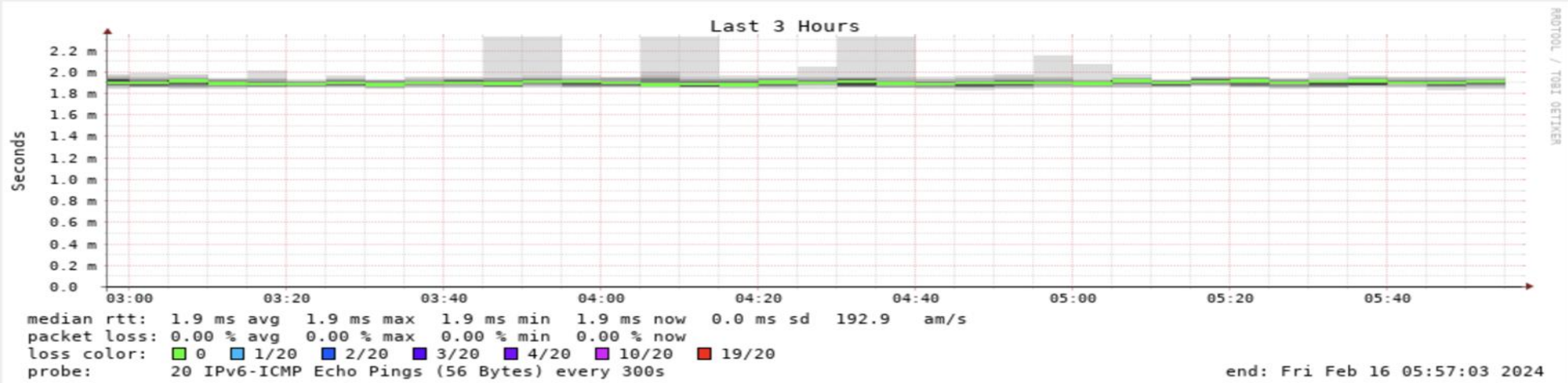
es.net has IPv6 address 2604:a880:800:c1::105:b001

- Review NetFlow/IPFIX or sFlow data for top talkers
- Review firewall logs for DNS queries
- Look at perfSONAR DNS latency monitoring -
https://docs.perfsonar.net/pscheduler_ref_tests_tools.html#dns-tests
- If you want an Example of the perfSONAR DNS latency config
- Other tools support this as well like smokeping, etc.

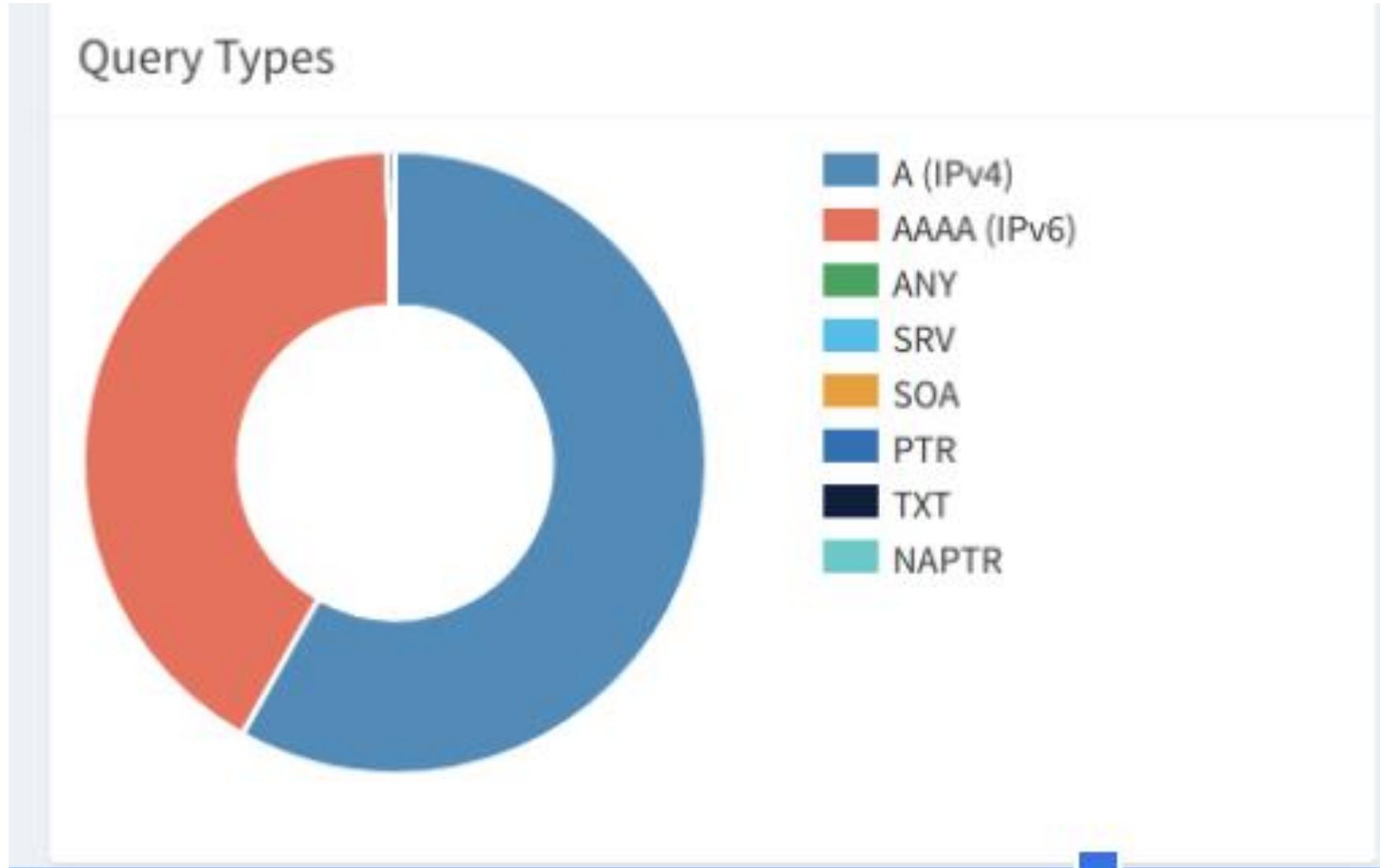
IPv6 DNS Resolution Monitoring



Google DNS IPv6



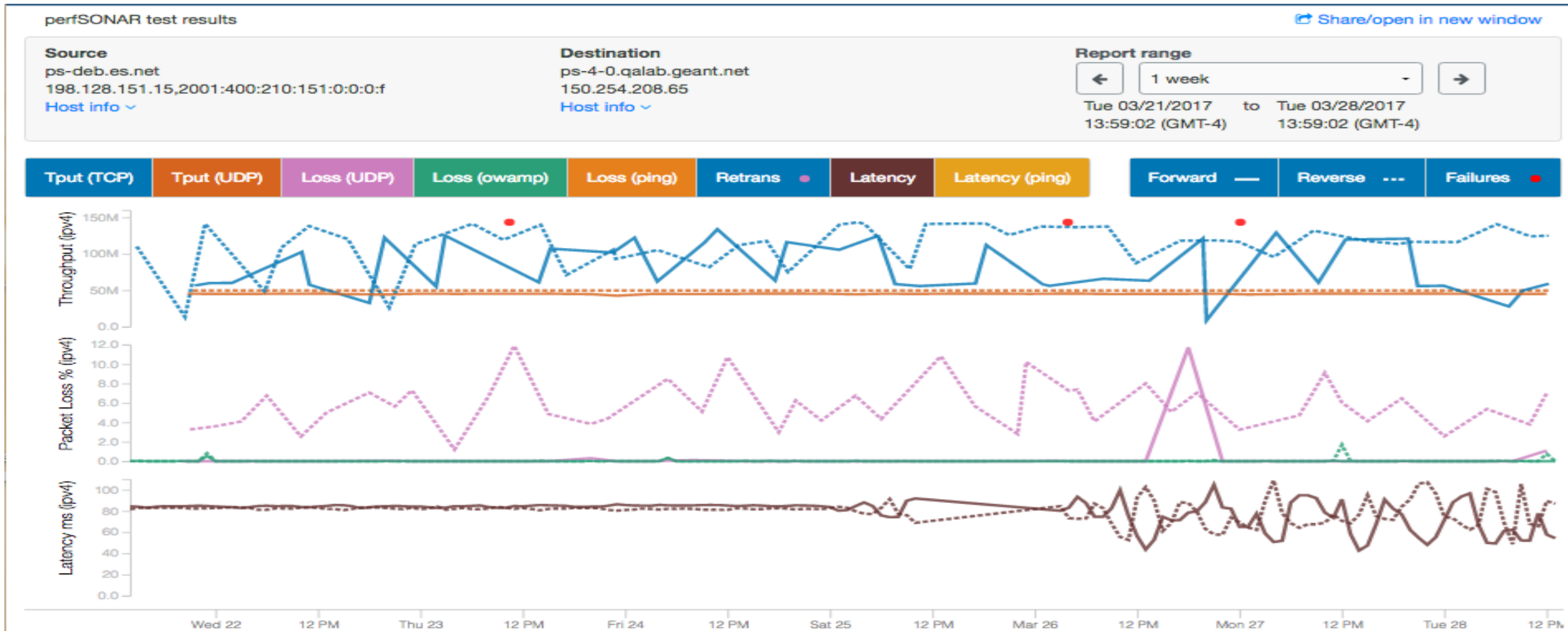
Home DNS monitoring and filtering with PiHole





IPv6 Traffic Destinations - perfSONAR

- perfSONAR can test this, with **rtt tests**
- https://docs.perfsonar.net/pscheduler_ref_tests_tools.html#rtt-tests



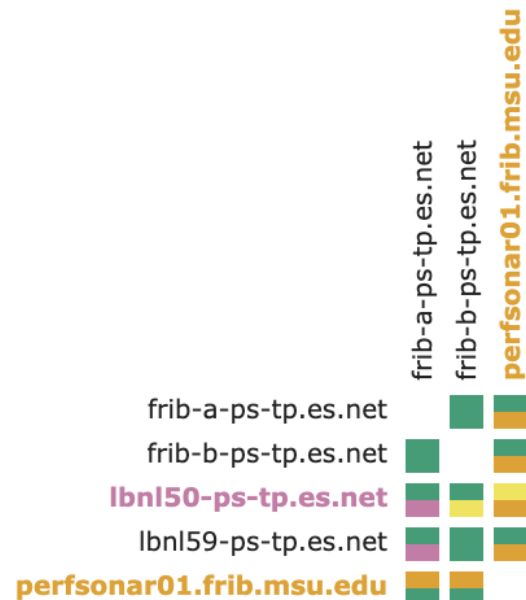
IPv6 Traffic Paths - perfSONAR

- perfSONAR can test this with **traceroute tests**
- https://docs.perfsonar.net/pscheduler_ref_tests_tools.html#trace-tests

ESnet - FRIB Traceroute Testing - Path Count

■ Paths = 1 packets ■ Paths > 1 ■ Paths > 2 ■ Unable to find test data ■ Check has not run yet

! Found a total of 2 problems involving 2 hosts in the grid



IPv6 BGP BOGONS

```
define BOGON_PREFIXES = [ ::/8+,          # RFC 4291 IPv4-compatible, loopback, et al
    0100::/64+,          # RFC 6666 Discard-Only
    2001:2::/48+,       # RFC 5180 BMWG
    2001:10::/28+,      # RFC 4843 ORCHID
    2001:db8::/32+,     # RFC 3849 documentation
    2002::/16+,         # RFC 7526 6to4 anycast relay
    3ffe::/16+,         # RFC 3701 old 6bone
    fc00::/7+,         # RFC 4193 unique local unicast
    fe80::/10+,        # RFC 4291 link local unicast
    fec0::/10+,        # RFC 3879 old site local unicast
    ff00::/8+          # RFC 4291 multicast
];
```

https://bgpfilterguide.nlnog.net/guides/bogon_prefixes/#configuration-examples-ipv6

<https://www.team-cymru.com/ty/cisco-router-traditional-bogons>

<https://manrs.org/netops/guide/>

IPv6 BGP Monitoring with Artemis

- ARTEMIS is an open-source tool, that implements a defense approach against BGP prefix hijacking attacks

Viewing Hijack Resolved Outdated

Live Update:

Hijack Information Acknowledged

Hijacker AS:	8522	Time Started:	2021-3-8 17:23:01
Type:	E 0 -	Time Detected:	2021-3-8 17:23:10
# Peers Seen:	3	Last Update:	2021-3-8 17:29:08
# ASes Infected:	7	Time Ended:	2021-3-11 12:06:22
Prefix:	2001:648:2c30::/48	Mitigation Started:	Never
Matched:	2001:648:2c30::/48	Community Annotation:	NA
Config:	2021-3-8 17:22:47	RPKI Status:	NA
Key:	de44cdb840785e4cc6c31c93afbd94e		

Display Peers Seen Hijack

[BGP Announcement](#) [BGP Withdrawal](#)

Hijack Actions

Mitigate Hijack [Apply](#)

Comments [Edit](#)

Related BGP Updates

Show 10 entries [DOWNLOAD TABLE](#)

Timestamp	Prefix	Matched Prefix	Origin AS	AS Path	Peer AS	Service	Type	Status	More
2021-3-8 17:29:08	2001:648:2c30::/48	2001:648:2c30::/48	8522	49673 48858 9002 21320 5408 8522	49673	ripe-ris -> rrc00	A		
2021-3-8 17:28:42	2001:648:2c30::/48	2001:648:2c30::/48	8522	8218 21320 5408 8522	8218	ripe-ris -> rrc21	A		
2021-3-8 17:23:01	2001:648:2c30::/48	2001:648:2c30::/48	8522	59890 9002 21320 5408 8522	59890	ripe-ris -> rrc20	A		

Showing 1 to 3 of 3 entries

View distinct values

IPv6 Security monitoring with Zeek, firewall with pfSense/OPNSense

- <https://zeek.org/>
 - <https://docs.securityonion.net/en/2.3/zeek.html>
 - <https://securityonionsolutions.com/>
- <https://corelight.com/>
- <https://www.pfsense.org/>
- <https://opnsense.org/>

IPv6 MTU Monitoring

- **Mismatched MTU's - EPOC's largest number of support tickets**
 - Define a MTU strategy
 - Personally, I jumbo frame enabled IPv4 (9198) and IPv6(9216) to the MAX MTU the device can handle for the border/perimeter, Science DMZ, core, and data center networks
 - Then enable whatever access/edge networks you need to
- Don't forget to set BOTH IPv4 and IPv6 on network, storage, and compute
- Verify Path MTU Discovery - later

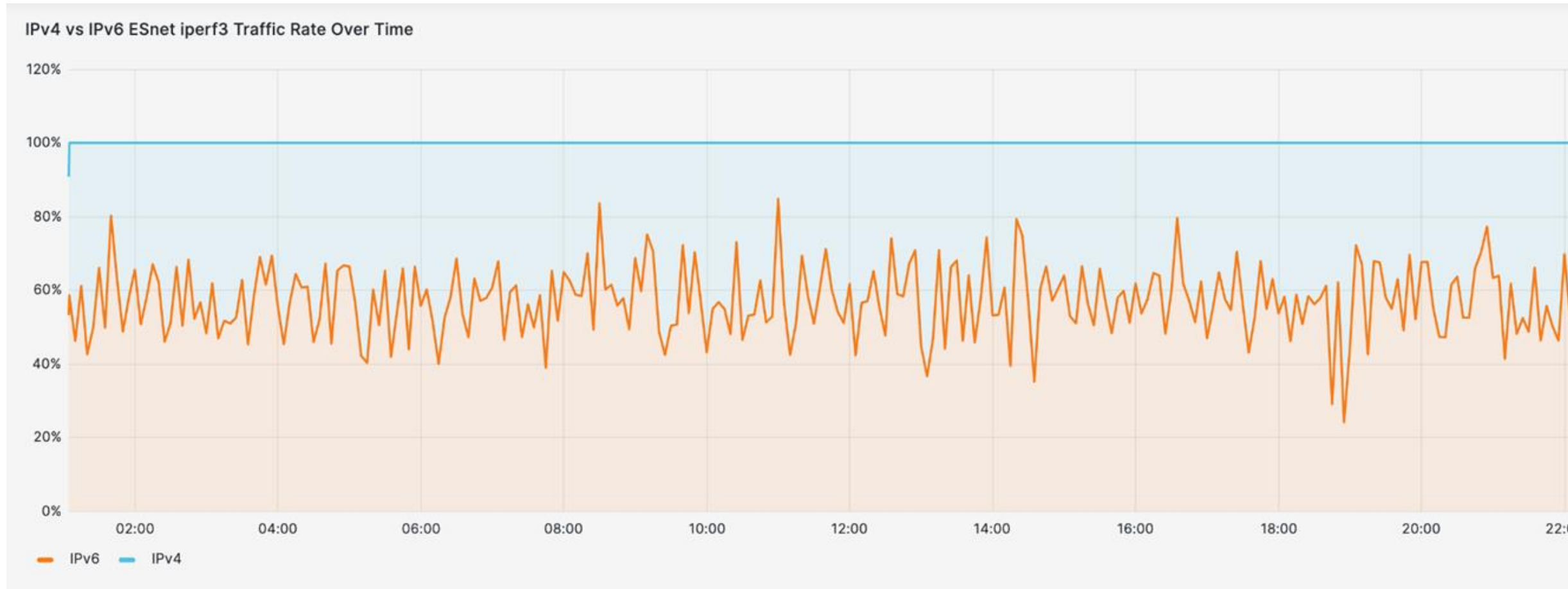
Network MTU (bytes)

16 Mbps Token Ring
4 Mbps Token Ring
FDDI
Ethernet
IEEE 802.3/802.2
PPPoE (WAN Miniport)
X.25
ATM
IEEE 802.11 Wi-Fi (WLAN)
T-Mobile Starlink
Ethernet Jumbo

Network MTU (bytes)

16 Mbps Token Ring 17914
4 Mbps Token Ring 4464
FDDI 4352
Ethernet 1500
IEEE 802.3/802.2 1492
PPPoE (WAN Miniport) 1480
X.25 576
ATM 4470
IEEE 802.11 Wi-Fi (WLAN) 2304 [19]
T-Mobile ~1420 STARLINK ~1472
Ethernet Jumbo 9000

IPv4 vs IPv6 iperf3

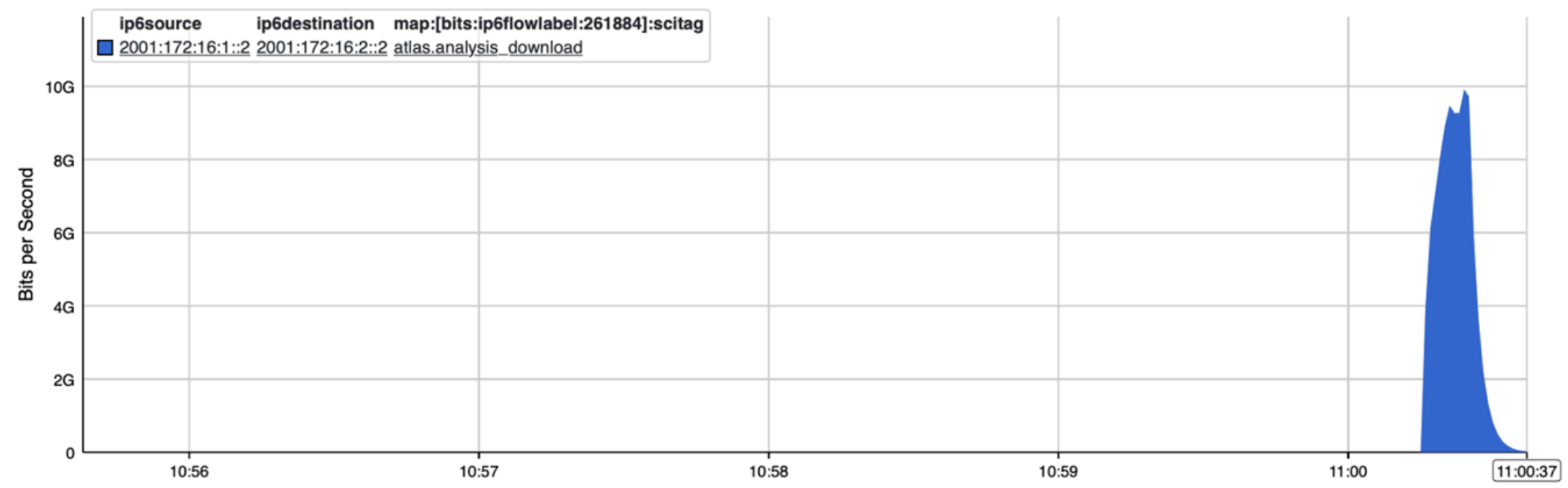


IPv6 Flow Labels - SCItags





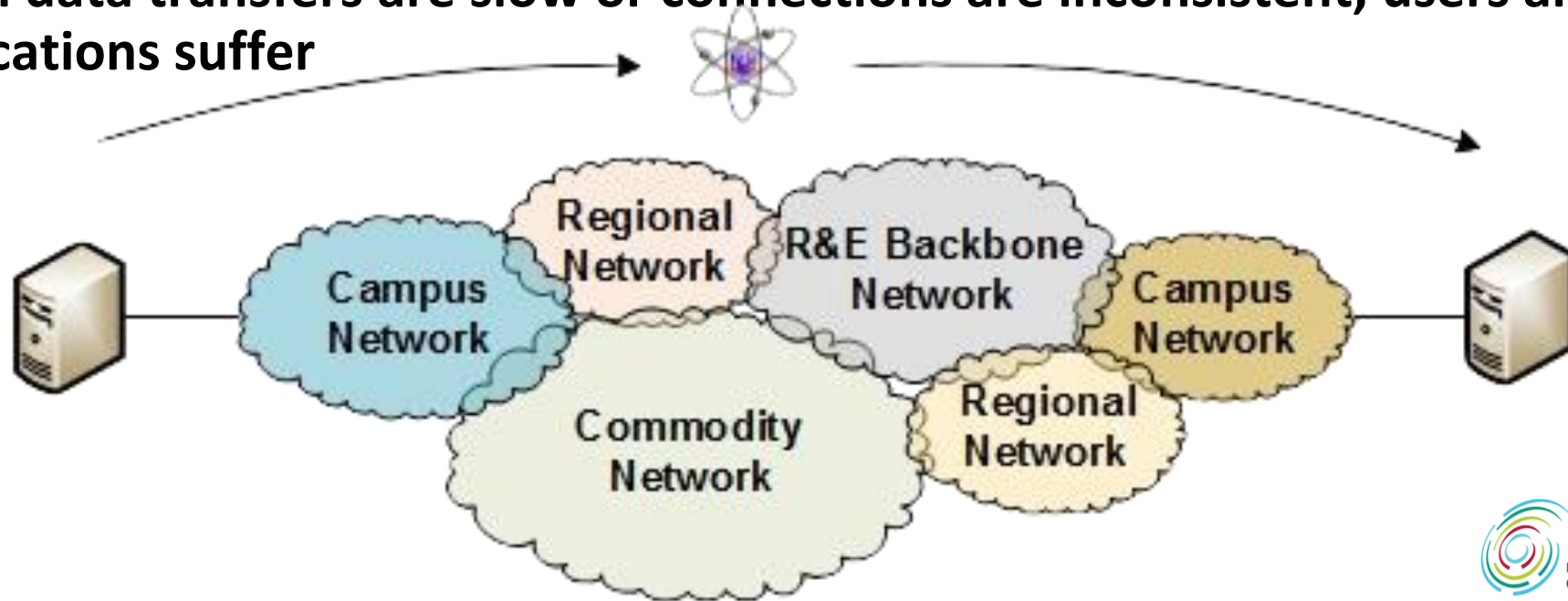
ip6source,ip6destination,map:[bits:ip6flc bps Filter **Reset** **Submit**



From IPv6 Monitoring to IPv6 Performance Measurement

Why performance measurement

- Data Transfers to/from your campus typically transfer over five different R&E networks
 - Only one of which you control
 - The others would require contacting each network operator to work with you and sharing their monitoring and configurations
- When data transfers are slow or connections are inconsistent, users and applications suffer



perfSONAR

- <https://www.perfsonar.net/>
- perfSONAR is the performance Service-Oriented Network monitoring ARchitecture, a network measurement toolkit designed to provide federated coverage of paths and help to establish end-to-end usage expectations.
- In addition to the RTT and Traceroute tools mentioned earlier:
 - latency tests are available through owamp, powstream, twamp
 - throughput tests are available through iperf3, nuttcp, and iperf2

NEW: iperf3 multi threaded Jan 2024:

<https://www.es.net/news-and-publications/esnet-news/2024/esnet-releases-new-version-of-iperf-network-performance-measurement-tool/>

perfSONAR IPv6

- **Q: How can I force testing over IPv4 or IPv6 in a pSConfig template?¶**
 - A: The exact option may vary depending on the test plug-in, but in a test object's spec most of the default plug-ins support an ip-version field that can get set to 4 or 6.
- **Q: How do I change the MTU for a device?¶**
 - A: Changing the MTU on your perfSONAR host should only be done if the underlying network supports the chosen size. Please work with your local network staff before making this change on any host. You can view the MTU of your network devices by executing the `/sbin/ifconfig` command. To temporarily change the MTU for a device, you use the `ifconfig` command and specify the device and the new MTU. For example: `ifconfig eth0 mtu 9000 up`
 - To make these changes permanent you need to modify the specific devices configuration file. These files are in `/etc/sysconfig/network-scripts/` and have names like `ifcfg-eth0` for the device `eth0` and `ifcfg-eth1` for `eth1`.
 - For example you could add the line `MTU="9000"` for IPv4 or `IPV6_MTU="9000"` for IPv6 to `/etc/sysconfig/network-scripts/ifcfg-eth0`. After making the changes you need to restart the network services by running the command `'service network restart'` as root.

perfSONAR IPv6 performance monitoring

<https://github.com/esnet/esnet-perfsonar-mesh/blob/master/psconfig/esnet-psconfig.json>

```
"ESnet6_LAT_1_v6" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "dest-node" : "{% pscheduler_address[1] %}",  
    "flip" : "{% flip %}",  
    "packet-count" : 600,  
    "packet-interval" : 0.1,  
    "packet-padding" : 0,  
    "source" : "{% address[0] %}",  
    "source-node" : "{% pscheduler_address[0] %}",  
    "ip-version": 6  
  },  
  "type" : "latencybg"  
},
```

```
"ESnet6_TP_1_v6" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "dest-node" : "{% pscheduler_address[1] %}",  
    "duration" : "PT10S",  
    "omit" : "PT5S",  
    "source" : "{% address[0] %}",  
    "source-node" : "{% pscheduler_address[0] %}",  
    "ip-version": 6,  
    "flow-label": 131080,  
    "bandwidth": 26000000000  
  },  
  "type" : "throughput"  
},
```

ESnet's perfSONAR central pSconfig

<https://github.com/esnet/esnet-perfsonar-mesh/blob/master/psconfig/esnet-psconfig.json>

<https://fasterdata.es.net/performance-testing/perfsonar/esnet-perfsonar-services/esnet-limits-file/>

perfSONAR psconfig IPv6 ping test text

```
"ESnet6_v6_rtt_icmp" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "count" : 10,  
    "source" : "{% address[0] %}",  
    "interval": "PT2S",  
    "length": 1000,  
    "ip-version": 6,  
    "flow-label": 131080  
  },  
  "type" : "rtt"  
},
```

perfSONAR psconfig IPv6 traceroute test text

```
"ESnet6_v6_trace" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "probe-type" : "icmp",  
    "sendwait" : "PT5S",  
    "source" : "{% address[0] %}",  
    "source-node" : "{% pscheduler_address[0] %}",  
    "wait" : "PT30S",  
    "ip-version": 6,  
    "flow-label": 131080  
  },  
  "type" : "trace"  
},
```


perfSONAR psconfig Ipv6 Latency test text

```
"ESnet6_LAT_1_v6" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "dest-node" : "{% pscheduler_address[1] %}",  
    "flip" : "{% flip %}",  
    "packet-count" : 600,  
    "packet-interval" : 0.1,  
    "packet-padding" : 0,  
    "source" : "{% address[0] %}",  
    "source-node" : "{% pscheduler_address[0] %}",  
    "ip-version": 6  
  },  
  "type" : "latencybg"  
},
```

perfSONAR psconfig IPv6 throughput test text

```
"ESnet6_TP_1_v6" : {  
  "spec" : {  
    "dest" : "{% address[1] %}",  
    "dest-node" : "{% pscheduler_address[1] %}",  
    "duration" : "PT10S",  
    "omit" : "PT5S",  
    "source" : "{% address[0] %}",  
    "source-node" : "{% pscheduler_address[0] %}",  
    "ip-version": 6,  
    "flow-label": 131080,  
    "bandwidth": 26000000000  
  },  
  "type" : "throughput"  
},
```

perfSONAR psconfig IPv6 DNS test text

```
"ESnet6_v6_DNS" : {  
  "spec" : {  
    "host": "{% address[0] %}",  
    "nameserver" : "{% address[1] %}",  
    "query": "fasterdata.es.net",  
    "record" : "aaaa"  
  },  
  "type" : "dns"  
},
```

```
"ESnet6_v4_DNS" : {  
  "spec" : {  
    "host": "{% address[0] %}",  
    "nameserver" : "{% address[1] %}",  
    "query": "fasterdata.es.net",  
    "record" : "a"  
  },  
  "type" : "dns"  
},
```

perfSONAR CLI Commands

- Ping RTT ICMP
 - `pscheduler task rtt --ip-version=6 --source ps-test-east.es.net --dest ps-test-west.es.net --flow-label=131080`
- Traceroute
 - `pscheduler task trace --ip-version=6 --source ps-test-east.es.net --dest ps-test-west.es.net --flow-label=131080`
- Traceroute - tracepath - Shows MTU per hop
 - `pscheduler task --tool=tracepath trace --ip-version=6 --source ps-test-east.es.net --dest ps-test-west.es.net --flow-label=131080`
- Latency - owamp
 - `pscheduler task latency --ip-version=6 --source ps-test-east.es.net --dest ps-test-west.es.net`
- Throughput - iperf3
 - `pscheduler task throughput --ip-version=6 --source ps-test-east.es.net --dest ps-test-west.es.net --flow-label=131080`

Globus IPv6 support

v5.4.70 (Nov 9, 2023)

Improvements

Support accessing GCS services on IPv6-only endpoints

Add support for the Dropbox connector