

ESnet High Touch

I2 TechEx 2023

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Structure of the talk

- What is High Touch Telemetry
 - Hardware
 - Grafana / Python / SQL Tools
- Use Cases
 - Network visibility
 - Operations debug / auditing
 - Network Planning
 - AI / ML Research

High Touch in a nutshell

1:1 Monitoring on up to 4 Terabits of traffic
Hardware (FPGA) Accelerated Data Reduction
Hardware (FPGA) 1ns accurate time stamping

Kafka based 24/7 Streaming to a data lake
PCAP capture of any subset of flows

SQL Backend running on fast servers

Header capture on the NOKIA router.
No impact to production traffic.

Data Lake
2 PB Fast SSD + CEPH

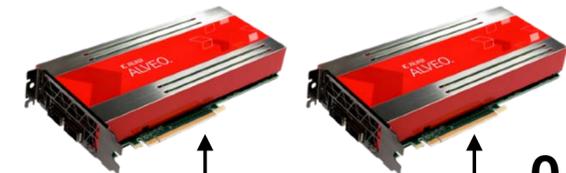
Telemetry to Data Lake

0.4G

Beefy FPGA Host Servers



Xilinx 2x100G x2



0.4T

4T



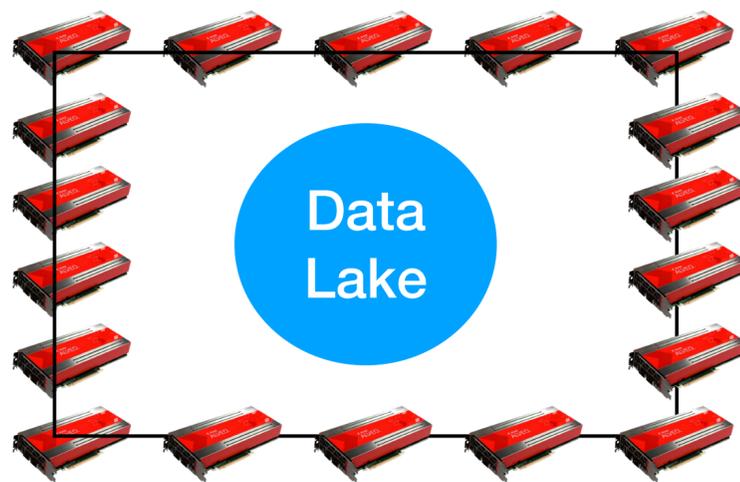
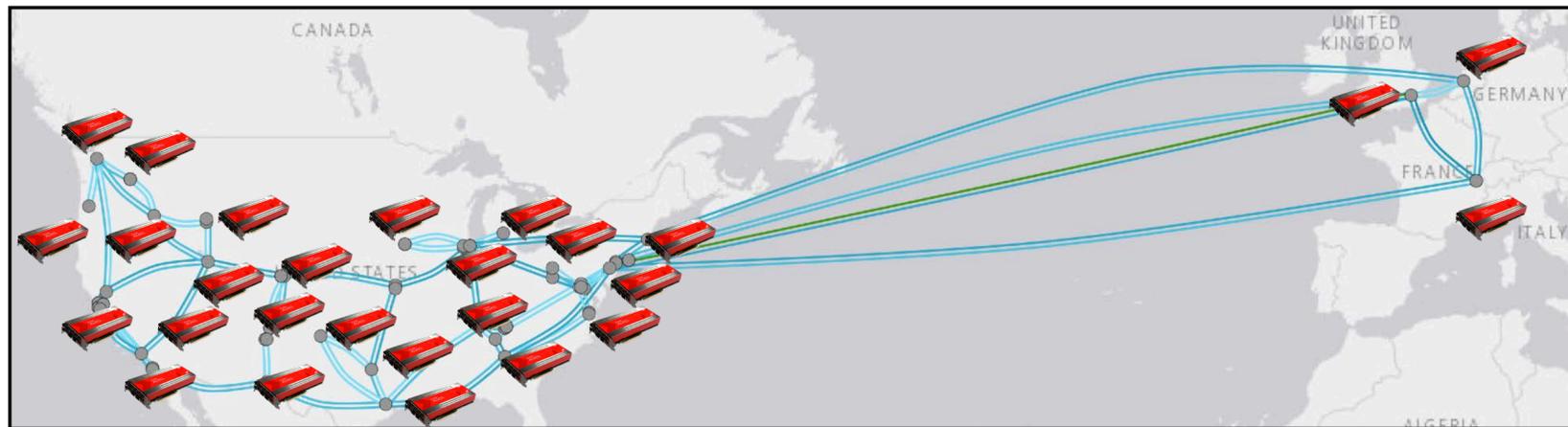
4T



NOKIA 400G Routers

High Touch in a nutshell

High Touch Nodes at all ESnet Edge Routers



Complete Perimeter for all traffic

- ✓ 100 % Packet Inspection
- ✓ 100 % Perimeter Coverage

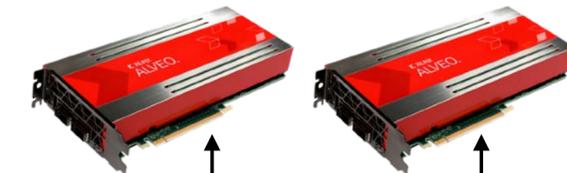
Beefy FPGA Host Servers



Data Lake
2 PB Fast SSD + CEPH

Telemetry to Data Lake

Xilinx 2x100G x2



NOKIA 400G Routers

Tools

SQL CLI

```
SELECT
  exporting_node,
  count(*) AS total_records
FROM ht.all_flows
GROUP BY exporting_node
FORMAT PrettyCompactMonoBlock
```

Query id: 3101a6b0-9ae6-4e94-b78c-d

exporting_node	total_records
bnl515-ht1	282710771
bost-ht2	1104520
eqxch2-ht2	1809320
slac50s-ht1	8545951
salt-ht2	568492
lbnl59-ht2	882130013
newy1118th-ht2	1071826
elpa-ht2	480642
ornl5600-ht1	45841556
atla-ht2	772929
eqxsv5-ht1	2835203590
anl541b-ht2	924414
slac50n-ht1	2221787835
nash-ht2	696555
atla-ht1	108835837
bois-ht2	432433
anl541b-ht1	65303026
eqxsv5-ht2	1189111
ornl5600-ht2	721476
newy1118th-ht1	2991159948

Jupyter Lab / Pandas

```
[9]: # Quick preview to see what the data frame looks like
df.drop_duplicates(subset='flow_id')
```

```
[9]:
```

	dst	dport	src	sport	proto	time	dst_org	src_org	src_network	dst_network	flow_id
0	104.196.237.25	42948	198.129.224.35	80	6	2022-02-15T11:09:59.994-0800	UNDEF	ESNET	198.129.224.0/24	104.196.237.0/24	1
1	134.79.146.247	34432	45.137.21.208	48138	6	2022-02-15T11:09:59.984-0800	SLAC	UNDEF	45.137.21.0/24	134.79.146.0/24	2
2	134.79.25.243	33566	92.63.196.25	47014	6	2022-02-15T11:09:59.974-0800	SLAC	UNDEF	92.63.196.0/24	134.79.25.0/24	3
3	198.128.14.236	48690	198.124.155.24	22	6	2022-02-15T11:09:59.974-0800	ESNET	ESNET	198.124.155.0/24	198.128.14.0/24	4
4	128.3.18.26	53422	128.55.136.54	27017	6	2022-02-15T11:09:59.964-0800	LBNL	NERSC	128.55.136.0/24	128.3.18.0/24	5
...
166483	128.55.244.94	50264	89.248.168.172	56292	6	2022-02-15T10:20:00.504-0800	NERSC	UNDEF	89.248.168.0/24	128.55.244.0/24	86741
166484	131.225.205.56	34749	128.55.224.115	57714	6	2022-02-15T10:20:00.474-0800	FNAL	NERSC	128.55.224.0/24	131.225.205.0/24	86742
166487	84.220.141.235	57150	128.55.206.106	443	6	2022-02-15T10:20:00.404-0800	UNDEF	NERSC	128.55.206.0/24	84.220.141.0/24	86743
166493	128.55.109.9	15529	112.31.169.97	4183	6	2022-02-15T10:20:00.093-0800	NERSC	UNDEF	112.31.169.0/24	128.55.109.0/24	86744
166494	198.129.217.96	57599	173.194.152.170	443	17	2022-02-15T10:20:00.083-0800	SLAC	UNDEF	173.194.152.0/24	198.129.217.0/24	86745

86745 rows x 11 columns

Wireshark

tv-netflix-problems-2011-07-06.pcap

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
343	65.142415	192.168.0.21	174.129.249.228	TCP	66	40555 → 80 [ACK] S
344	65.142715	192.168.0.21	174.129.249.228	HTTP	253	GET /clients/netfl
345	65.230738	174.129.249.228	192.168.0.21	TCP	66	80 → 40555 [ACK] S
346	65.240742	174.129.249.228	192.168.0.21	HTTP	828	HTTP/1.1 302 Moved
347	65.241592	192.168.0.21	174.129.249.228	TCP	66	40555 → 80 [ACK] S
348	65.242532	192.168.0.21	192.168.0.1	DNS	77	Standard query 0x2
349	65.276870	192.168.0.1	192.168.0.21	DNS	489	Standard query res
350	65.277992	192.168.0.21	63.80.242.48	TCP	74	37063 → 80 [SYN] S
351	65.297757	63.80.242.48	192.168.0.21	TCP	74	80 → 37063 [SYN, A
352	65.298396	192.168.0.21	63.80.242.48	TCP	66	37063 → 80 [ACK] S
353	65.298687	192.168.0.21	63.80.242.48	HTTP	153	GET /us/nrd/client
354	65.318730	63.80.242.48	192.168.0.21	TCP	66	80 → 37063 [ACK] S
355	65.321733	63.80.242.48	192.168.0.21	TCP	1514	[TCP segment of a

Frame 349: 489 bytes on wire (3912 bits), 489 bytes captured (3912 bits)

Ethernet II, Src: Globalsec_00:3b:0a (f0:ad:4e:00:3b:0a), Dst: Vizio_14:8a:e1 (00:19:93:14:8a:e1)

Internet Protocol Version 4, Src: 192.168.0.1, Dst: 192.168.0.21

User Datagram Protocol, Src Port: 53 (53), Dst Port: 34036 (34036)

Domain Name System (response)

[Request In: 348]

[Time: 0.034338000 seconds]

Transaction ID: 0x2188

Flags: 0x0180 Standard query response, No error

Questions: 1

Answer RRs: 4

Authority RRs: 9

Additional RRs: 9

Queries

- cdn-0.nflximg.com: type A, class IN

Answers

Authoritative nameservers

```
0020 00 15 00 35 84 f4 01 c7 83 3f 21 88 81 80 00 01 ...5... .?.....
0030 00 04 00 09 00 09 05 63 64 6e 2d 30 07 6e 66 6c .....c dn-0.nfl
0040 78 69 6d 67 03 63 6f 6d 00 00 01 00 01 c0 0c 00 ..... ximg.com .....
0050 05 00 01 00 00 05 29 00 22 06 69 6d 61 67 65 73 .....). ".images
0060 07 6e 65 74 66 6c 69 78 03 63 6f 6d 09 65 64 67 .netflix .com.edg
0070 65 73 75 69 74 65 03 6e 65 74 00 c0 2f 00 05 00 esuite.n et./...
```

Grafana / Stardust

HT / Martians

Summary Information

Total Martian Flows	Total Martian Packets	IPs Sending Martians	Organization Senders	Type of Martians	Martian Packets Forwarded
838,895	1,002,676	470	8	6	0

Senders of Martians

Flows	Packets	Unique Senders	Unique AS Destinations	Sender Org
414628	421280	206	414628	BNL-AS
280178	418749	124	280178	NERSC
122043	127846	44	122043	ESNET
15175	16044	1	15175	ESNET-EAST
4719	5677	38	4719	SLAC
1917	1917	43	1917	Martian
146	11074	1	146	ESNET-WEST
89	89	13	89	ORNL-MSRNET

Types of Martians

- link local
- private network
- unique local address
- documentation
- future use
- ipv4/ipv6 translation

Per Source Address Information

Flows	Packets	Source	Port	Destination(s)	# Src Ports	Source Org.	Martian Type	Observed At	SAP	SAP Type	BGP Policy	SAP Routing Instance
14757	14763	2001:400:201:74::31	9100	unknown	[*fd4:f1ff:99da:261c::1]	3879	ESNET	unique local address	lbnl59-ht1	esnet_se-425	Layer 3 Virtual Interface	Site Base
1	1	128.55.206.109	42658	unknown	[*10.128.4.128]	1	NERSC	private network	lbnl59-ht1	nersc_se-503	Layer 3 Virtual Interface	Site Base

```
SELECT
  count(*) AS total_flows,
  sum(bytes) AS total_bytes,
  sum(packets) AS total_packets
FROM ht.all_flows
```

Query id: 6b3c7f73-8dda-4950-b819-67f112102944

total_flows	total_bytes	total_packets
13612804466	1475967324390170	774102047235

1 row in set. Elapsed: 37.291 sec. Processed 13.61 billion rows.



“Use Cases”

Internet Background Radiation



Comparison of probes that generated a bi-directional syn_ack when sent a syn probe

The effectiveness of syn_only probes can be checked against the number of syn_ack responses they generate. In this diagram, we plot the total number of syn_only probes, as well in the line below, we plot only the probes that got a syn_ack message in response. This provides a measure of hosts, and ports that are successfully enumerated by the scanner.

- By looking at the Number of IP's probed bar chart, we can see that only a small number of hosts being scanned, are returning any responses.
- By looking at the number of source IPs we can see that some of the scanners source IPs's are completely unsuccessful at getting any responses.

All the dst ports that GET A SYN and no further packets

All the ports that accept a TCP-SYN and return SYNACK

Org Name

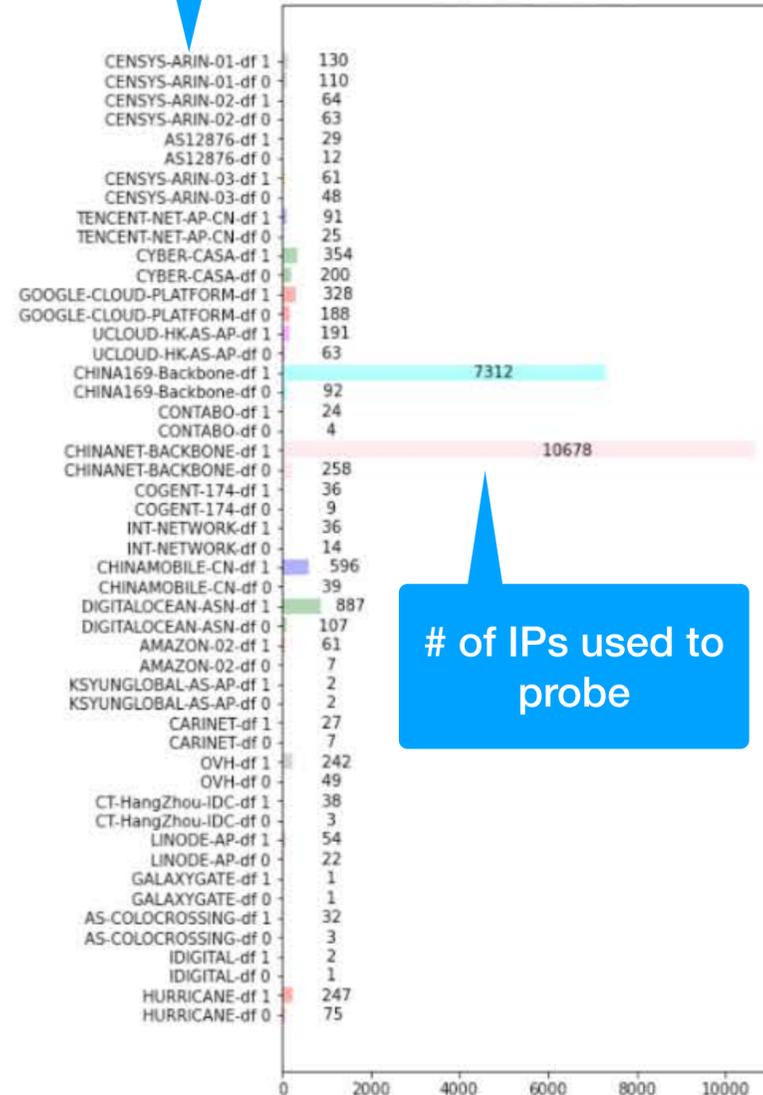
_bidi , df] , 'top' , 25)

Number of source IPs

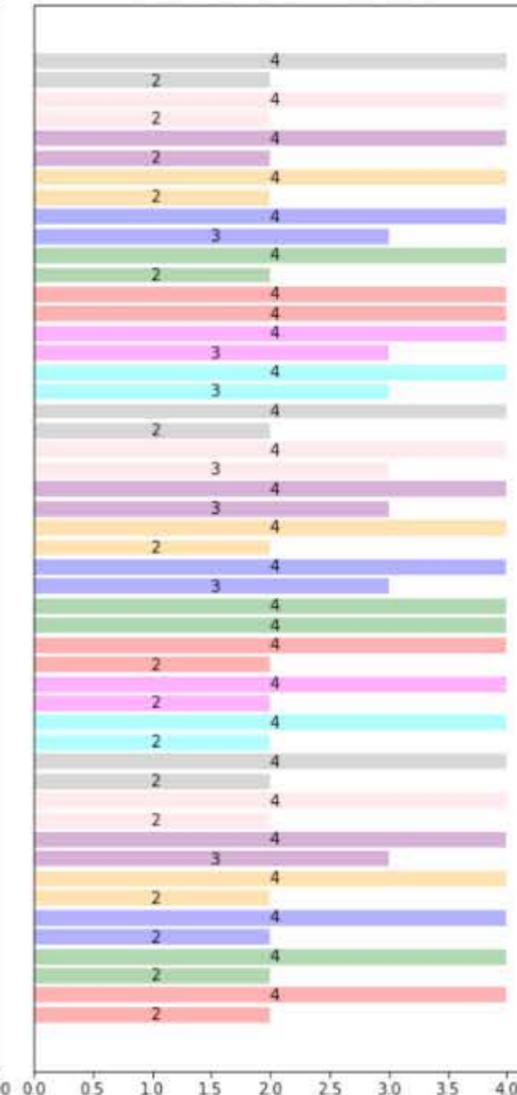
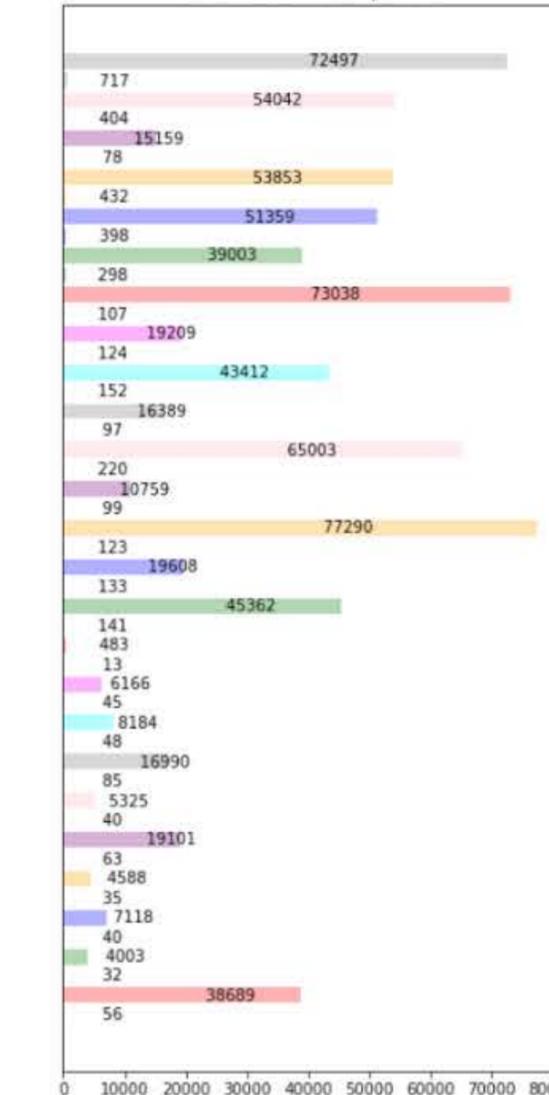
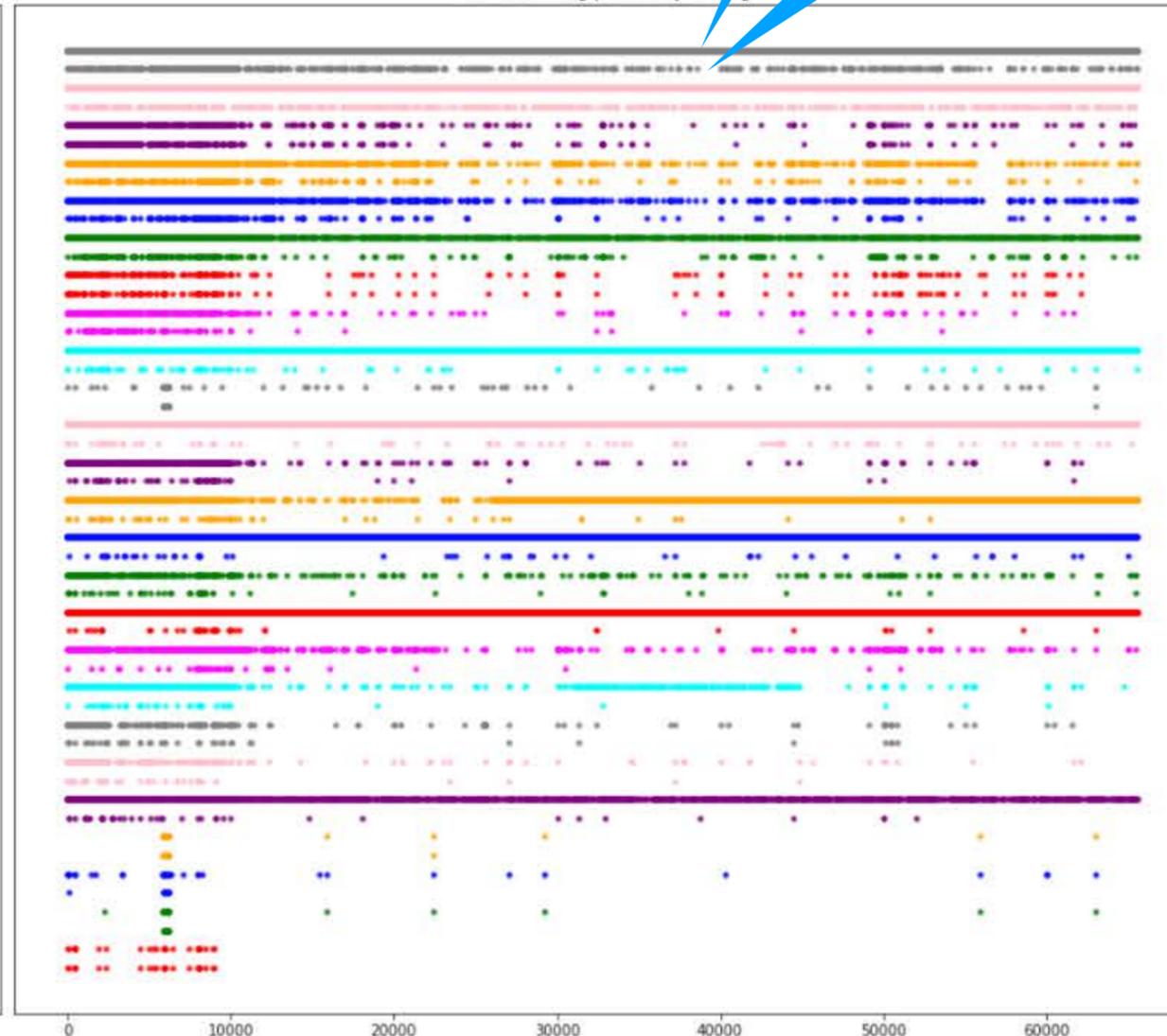
Dst Ports being probed by src org

Number of dest IPs probed

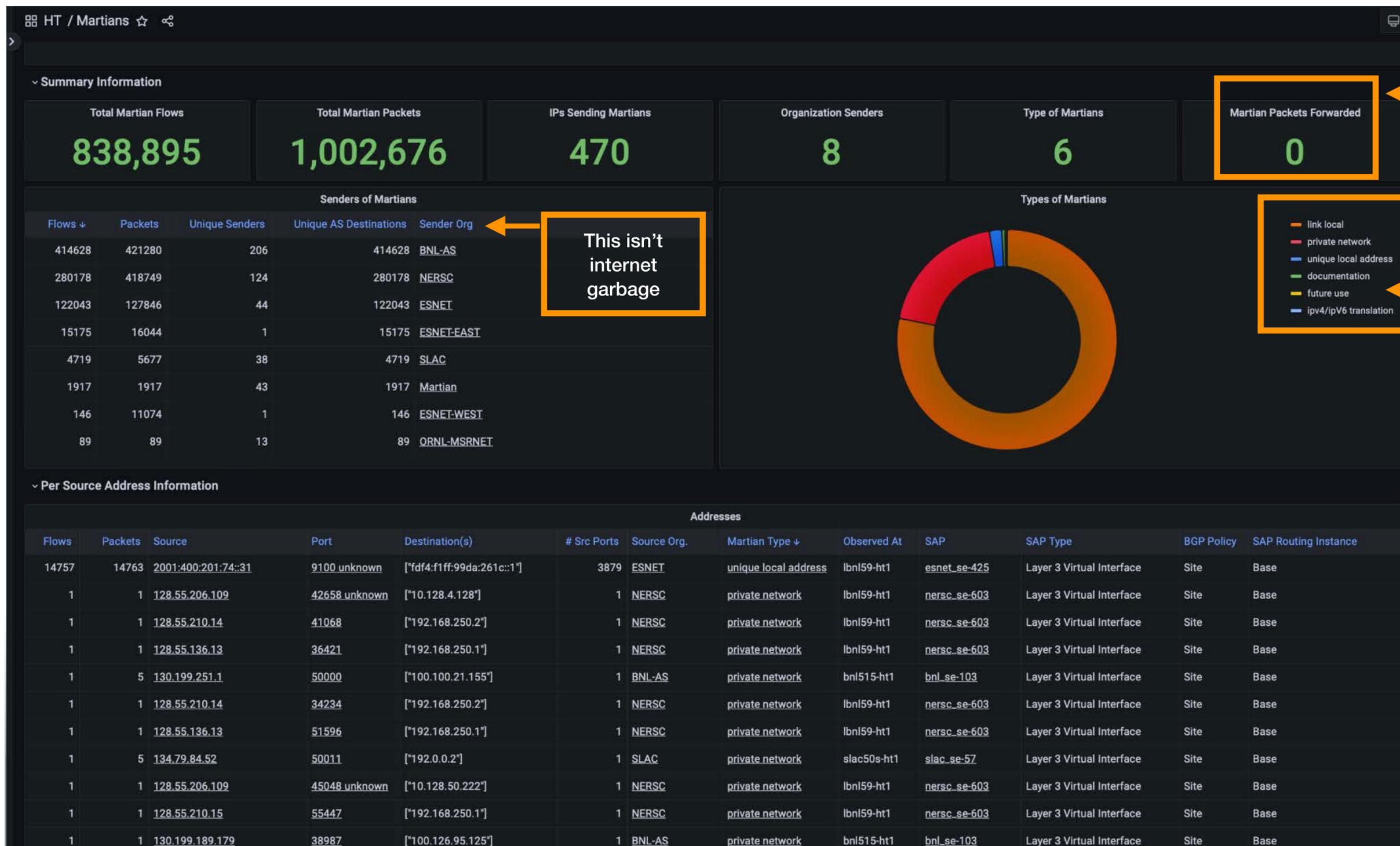
Number of ESnet sites involved



of IPs used to probe



Network Audits - Martians



NICE ! Kudos ESnet Router Configs

Why do we have documentation addresses in our network ?

SONIC - Open Source Switches
 Docker - Data Center Auto Config

Beware when you download and get instant gratification from the internet.



LHCONE - CRIC Audit



Undocumented Sources to Documented Destinations

LHC One Undocumented Sources									
Num. Flows	Total Bytes	Router	Interface	Src AS	Src Org.	Dst IP	Dst AS	Dst Org.	
39	1.56 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.24.197	3671	SLAC	
38	1.52 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.110.7	3671	SLAC	
38	1.52 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.60.133	3671	SLAC	
38	1.52 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.244.2	3671	SLAC	
38	1.56 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.188.23	3671	SLAC	
37	1.48 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.22.48	3671	SLAC	
36	1.44 kB	atla-cr6	1/1/c3/1	4621	UNINET-AS-AP	128.227.246.204	6356	NERDCNET	
36	1.44 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.140.185	3671	SLAC	
36	1.48 kB	slac50s-cr6	1/1/c2/1	4621	UNINET-AS-AP	134.79.14.233	3671	SLAC	

CERN / CRIC
Source of Truth for what
prefixes are on LHCONE

HT SQL Database

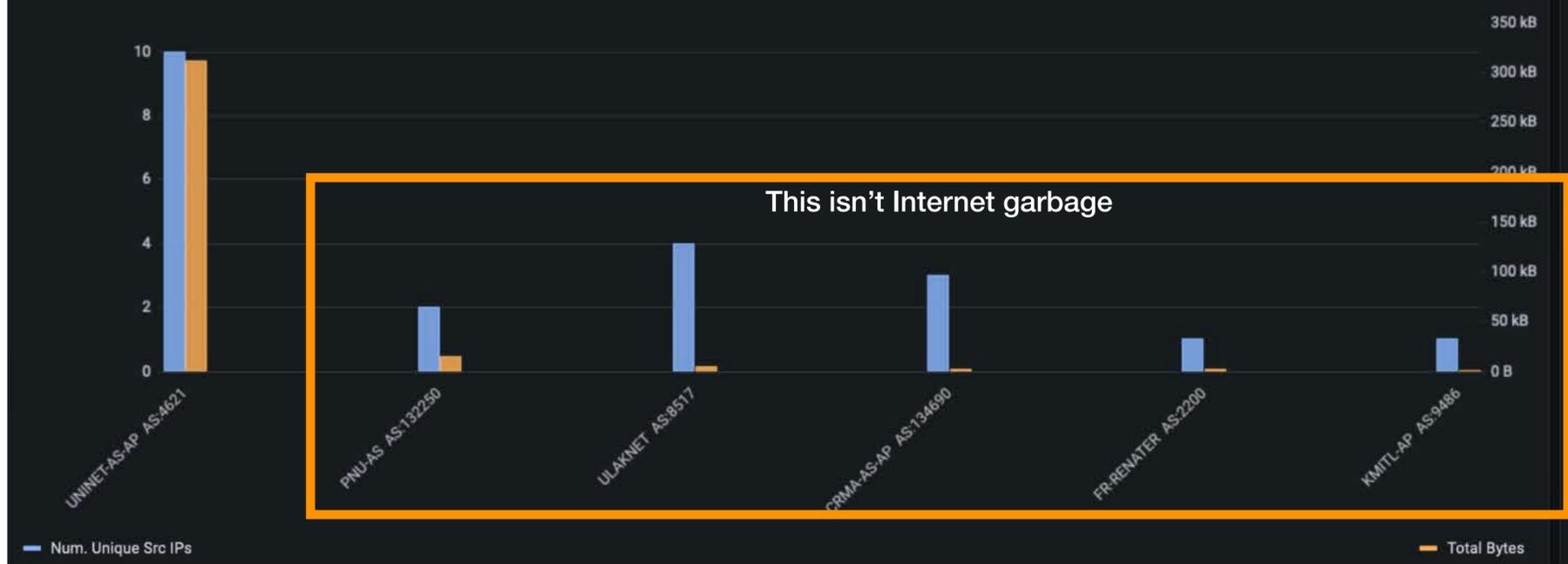
JSON
Query

Select *
NOT in JSON

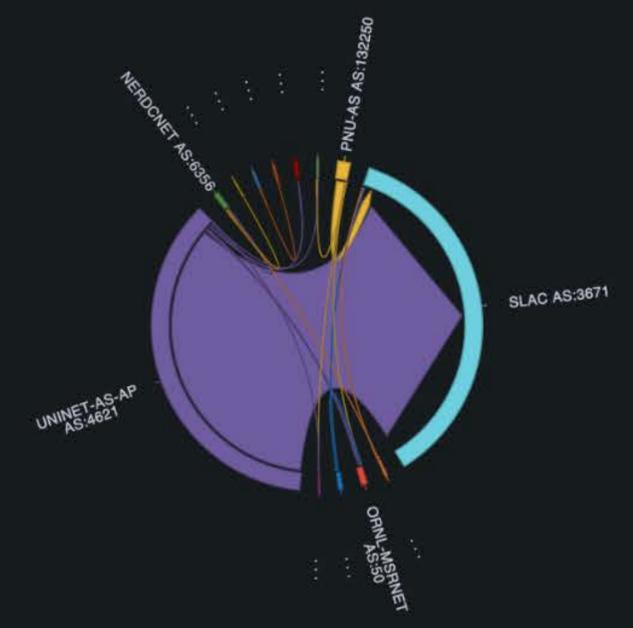
[]

Should be empty set

Unique Undocumented Senders and Traffic Moved By Organization



Top Talkers by Count of Flows



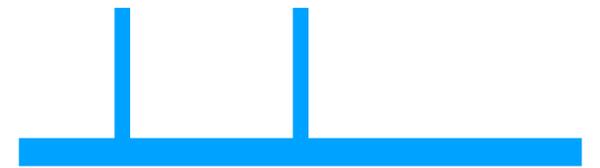


Network Planning - Elephants or Big Foot

	caida_org_name_src	caida_org_name_dst	ip_src	ip_dst	Gbps
0	U-CHICAGO-AS	ARGONNE-AS	192.170.224.134	140.221.68.2	30.037561
1	ARGONNE-AS	U-CHICAGO-AS	140.221.68.2	192.170.224.134	27.532194
2	ESNET	ESNET	2001:400:f010:200::1	2001:400:f010:240::1	26.215328
3	ESNET	ESNET	2001:400:ee00:20::1	2001:400:ee00:21::1	26.209250
4	ESNET	ESNET	2001:400:f010:640::1	2001:400:f010:641::1	26.208939
5	ESNET	ESNET	2001:400:ee00:880::1	2001:400:ee00:881::1	26.208344
6	ESNET	ESNET	2001:400:ee00:221::1	2001:400:ee00:220::1	26.208284
7	ESNET	ESNET	2001:400:ee00:881::1	2001:400:ee00:880::1	26.207954
8	ESNET	ESNET	2001:400:ee00:601::1	2001:400:ee00:600::1	26.207889
9	ESNET	ESNET	2001:400:ee00:881::1	2001:400:ee00:882::1	26.207831
10	ESNET	ESNET	2001:400:ee00:200::1	2001:400:ee00:201::1	26.206976
11	ESNET	ESNET	2001:400:f010:200::1	2001:400:f010:221::1	26.206912
12	ESNET	ESNET	2001:400:ee00:200::1	2001:400:ee00:202::1	26.206903
13	ESNET	ESNET	2001:400:ee00:882::1	2001:400:ee00:881::1	26.206468
14	ESNET	ESNET	2001:400:f010:240::1	2001:400:f010:221::1	26.206126
15	ESNET	ESNET	2001:400:ee00:200::1	2001:400:ee00:220::1	26.205755
16	ESNET	ESNET	2001:400:ee00:240::1	2001:400:ee00:221::1	26.205489
17	ESNET	ESNET	2001:400:f010:221::1	2001:400:f010:220::1	26.204826
18	ESNET	ESNET	2001:400:f010:200::1	2001:400:f010:220::1	26.204172
19	ESNET	ESNET	2001:400:ee00:220::1	2001:400:ee00:200::1	26.203990
20	ESNET	ESNET	2001:400:f010:241::1	2001:400:f010:200::1	26.203445
21	ESNET	ESNET	2001:400:f010:221::1	2001:400:f010:241::1	26.203144
22	ESNET	ESNET	2001:400:ee00:b03::1	2001:400:ee00:10::1	26.203090
23	ESNET	ESNET	2001:400:ee00:b02::1	2001:400:ee00:10::1	26.203027
24	ESNET	ESNET	2001:400:ee00:20::1	2001:400:ee00:b03::1	26.202994
25	ESNET	ESNET	2001:400:ee00:221::1	2001:400:ee00:240::1	26.202628
26	ESNET	ESNET	2001:400:ee00:10::1	2001:400:ee00:b03::1	26.202129
27	ESNET	ESNET	2001:400:ee00:200::1	2001:400:ee00:240::1	26.201956
28	ESNET	ESNET	2001:400:ee00:241::1	2001:400:ee00:221::1	26.201614
29	ESNET	ESNET	2001:400:ee00:240::1	2001:400:ee00:200::1	26.201460
30	ESNET	ESNET	2001:400:ee00:200::1	2001:400:ee00:241::1	26.201034
31	ESNET	ESNET	2001:400:f010:240::1	2001:400:f010:200::1	26.201015
32	ESNET	ESNET	2001:400:ee00:10::1	2001:400:ee00:b02::1	26.200805
33	ESNET	ESNET	2001:400:ee00:20::1	2001:400:ee00:b02::1	26.200350
34	ESNET	ESNET	2001:400:ee00:221::1	2001:400:ee00:241::1	26.200129
35	ESNET	ESNET	2001:400:ee00:10::1	2001:400:ee00:b01::1	26.200096
36	ESNET	ESNET	2001:400:f010:200::1	2001:400:f010:241::1	26.198824
37	NCSA-AS	ESNET	2620:0:c80:300::2	2001:400:ee00:221::1	26.198818
38	ESNET	ESNET	2001:400:f010:241::1	2001:400:f010:221::1	26.198072
39	ESNET	ESNET	2001:400:ee00:20::1	2001:400:ee00:10::1	26.197927
40	ESNET	ESNET	2001:400:ee00:10::1	2001:400:ee00:b04::1	26.197207
41	ESNET	ESNET	2001:400:ee00:10::1	2001:400:ee00:20::1	26.196922
42	ESNET	ESNET	2001:400:ee00:820::1	2001:400:ee00:821::1	26.196839
43	ESNET	ESNET	2001:400:ee00:b01::1	2001:400:ee00:10::1	26.196467
44	ESNET	ESNET	2001:400:ee00:115::1	2001:400:ee00:110::1	26.192698
45	ESNET	ESNET	2001:400:ee00:821::1	2001:400:ee00:820::1	26.192622

hostname_src	hostname_dst
scidmz-ps4.scidmz.uchicago.net.	typhoon.pub.alcf.anl.gov.
typhoon.pub.alcf.anl.gov.	scidmz-ps4.scidmz.uchicago.net.
eqxch2-ps-tp.lhccone.es.net.	fnalfcc-ps-tp.lhccone.es.net.
lbnl59-ps-tp.es.net.	lbnl50-ps-tp.es.net.
bnl515-ps-tp.lhccone.es.net.	bnl515b-ps-tp.lhccone.es.net.
ornl1064-ps-tp.es.net.	ornl5600-ps-tp.es.net.
anl541b-ps-tp.es.net.	anl221-ps-tp.es.net.
ornl5600-ps-tp.es.net.	ornl1064-ps-tp.es.net.
newy1118th-ps-tp.es.net.	newy32aoa-ps-tp.es.net.
ornl5600-ps-tp.es.net.	orau-ps-tp.es.net.
eqxch2-ps-tp.es.net.	chic-ps-tp.es.net.
eqxch2-ps-tp.lhccone.es.net.	anl541b-ps-tp.lhccone.es.net.
eqxch2-ps-tp.es.net.	star-ps-tp.es.net.
orau-ps-tp.es.net.	ornl5600-ps-tp.es.net.
fnalfcc-ps-tp.lhccone.es.net.	anl541b-ps-tp.lhccone.es.net.
eqxch2-ps-tp.es.net.	anl221-ps-tp.es.net.
fnalfcc-ps-tp.es.net.	anl541b-ps-tp.es.net.
anl541b-ps-tp.lhccone.es.net.	anl221-ps-tp.lhccone.es.net.
eqxch2-ps-tp.lhccone.es.net.	anl221-ps-tp.lhccone.es.net.
anl221-ps-tp.es.net.	eqxch2-ps-tp.es.net.
fnalgcc-ps-tp.lhccone.es.net.	eqxch2-ps-tp.lhccone.es.net.
anl541b-ps-tp.lhccone.es.net.	fnalgcc-ps-tp.lhccone.es.net.
slac50s-ps-tp.es.net.	eqxsv5-ps-tp.es.net.
slac50n-ps-tp.es.net.	eqxsv5-ps-tp.es.net.
lbnl59-ps-tp.es.net.	slac50s-ps-tp.es.net.
anl541b-ps-tp.es.net.	fnalfcc-ps-tp.es.net.
eqxsv5-ps-tp.es.net.	slac50s-ps-tp.es.net.
eqxch2-ps-tp.es.net.	fnalfcc-ps-tp.es.net.
fnalgcc-ps-tp.es.net.	anl541b-ps-tp.es.net.
fnalfcc-ps-tp.es.net.	eqxch2-ps-tp.es.net.
eqxch2-ps-tp.es.net.	fnalgcc-ps-tp.es.net.
fnalfcc-ps-tp.lhccone.es.net.	eqxch2-ps-tp.lhccone.es.net.
eqxsv5-ps-tp.es.net.	slac50n-ps-tp.es.net.
lbnl59-ps-tp.es.net.	slac50n-ps-tp.es.net.
anl541b-ps-tp.es.net.	fnalgcc-ps-tp.es.net.
eqxsv5-ps-tp.es.net.	llnl-ps-tp.es.net.
eqxch2-ps-tp.lhccone.es.net.	fnalgcc-ps-tp.lhccone.es.net.
Timeout	anl541b-ps-tp.es.net.
fnalgcc-ps-tp.lhccone.es.net.	anl541b-ps-tp.lhccone.es.net.
lbnl59-ps-tp.es.net.	eqxsv5-ps-tp.es.net.
eqxsv5-ps-tp.es.net.	NXDOMAIN
eqxsv5-ps-tp.es.net.	lbnl59-ps-tp.es.net.
nash-ps-tp.es.net.	chat-ps-tp.es.net.
llnl-ps-tp.es.net.	eqxsv5-ps-tp.es.net.
losa-ps-tp.es.net.	sand-ps-tp.es.net.
chat-ps-tp.es.net.	nash-ps-tp.es.net.

Select (*)
Where
Peak Rate > 10 Gbps
For at least 10 seconds
Order by Rate



What is .ps-tp ?

Because it generates our largest elephant flows.



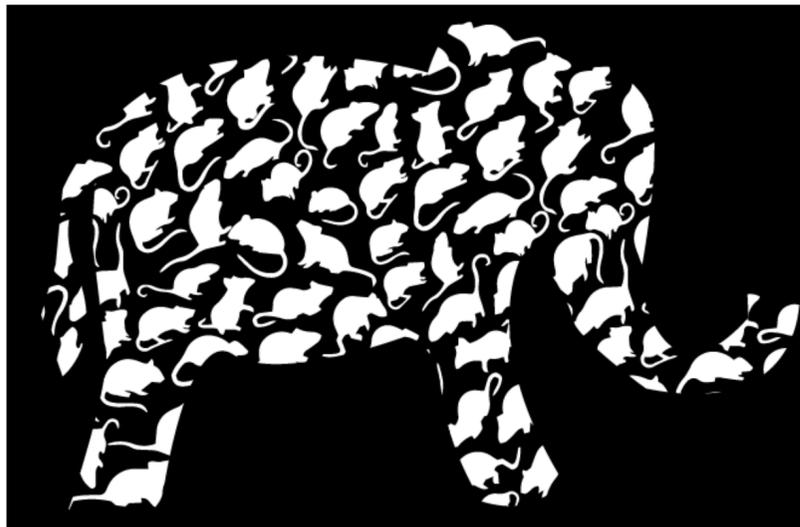
Network Planning - Slightly Bigger Picture

```
Query time .. 52.55099439620972
```

	caida_org_name_src	caida_org_name_dst	Gbps
0	U-CHICAGO-AS	ARGONNE-AS	30.037561
1	ARGONNE-AS	U-CHICAGO-AS	27.532194
2	ESNET	ESNET	26.215328
3	NCSA-AS	ESNET	26.198818
4	ESNET	NCSA-AS	26.189637
5	ESNET-WEST	ESNET-WEST	26.151662
6	ESNET-EAST	ESNET-EAST	26.150740
7	ESNET-EAST	ESNET-WEST	26.149878
8	ESNET-WEST	ESNET-EAST	26.145060
9	NCSA-AS	ESNET-WEST	26.136680
10	BNL-AS	ESNET	24.860384
11	ESNET-WEST	NCSA-AS	24.237054
12	ESNET-WEST	ARGONNE-AS	23.859718
13	NCSA-AS	ESNET-EAST	23.723869
14	BNL-AS	ESNET-EAST	22.466708
15	BNL-AS	NU-AS	22.372516
16	BNL-AS	ESNET-WEST	21.165468
17	ESNET-WEST	MISU-231	20.912281
18	MISU-231	ESNET-WEST	19.870178
19	TACCNET	ESNET-WEST	15.653456
20	STANFORD	ESNET-EAST	12.623604
21	TACCNET	ESNET-EAST	12.543568
22	MERIT-AS-6	ESNET	12.453257
23	ESNET-WEST	LBL	10.111514
24	SLAC	LBL	9.996838
25	ESNET	LBL	9.969307
26	ESNET	BNL-AS	9.965247
27	LBL	ESNET	9.956527
28	LBL	ESNET-WEST	9.954399
29	ULTRALIGHT	VANDERBILT	9.939852
30	ESNET	VANDERBILT	9.908270
31	CWRU-AS-1	ESNET-EAST	9.847033
32	OARNET-AS-2	ESNET-EAST	9.843675
33	OARNET-AS-2	ESNET-WEST	9.842789
34	U-CHICAGO-AS	ESNET	9.740794
35	BNL-AS	AMNH	9.710251
36	NCAR-AS	ESNET-EAST	9.660255
37	NCAR-AS	ESNET-WEST	9.625336
38	LBL	ESNET-EAST	9.459778
39	ARGONNE-AS	CSM-AS	9.362607
40	UCLA	ESNET-EAST	9.349517
41	WASH-NSF-AS	ESNET-EAST	9.282061
42	ESNET-EAST	JANET	9.184101
43	JANET	ESNET-EAST	9.056038
44	ULTRALIGHT	ESNET	9.036059
45	UTARLINGTON	ESNET	8.758342
46	TENET-1	ESNET-EAST	8.341057
47	FNAL-AS	SLAC	8.287741
48	CSM-AS	ARGONNE-AS	8.128646
49	ESNET-WEST	WN-AZ-AS	7.991214

These are largely, if not entirely PerfSonar

99 % of our traffic averages 0.5 Gbps per flow.
LHC / Globus / everything...



This is how we do large transfers.
NO EXCEPTIONS !

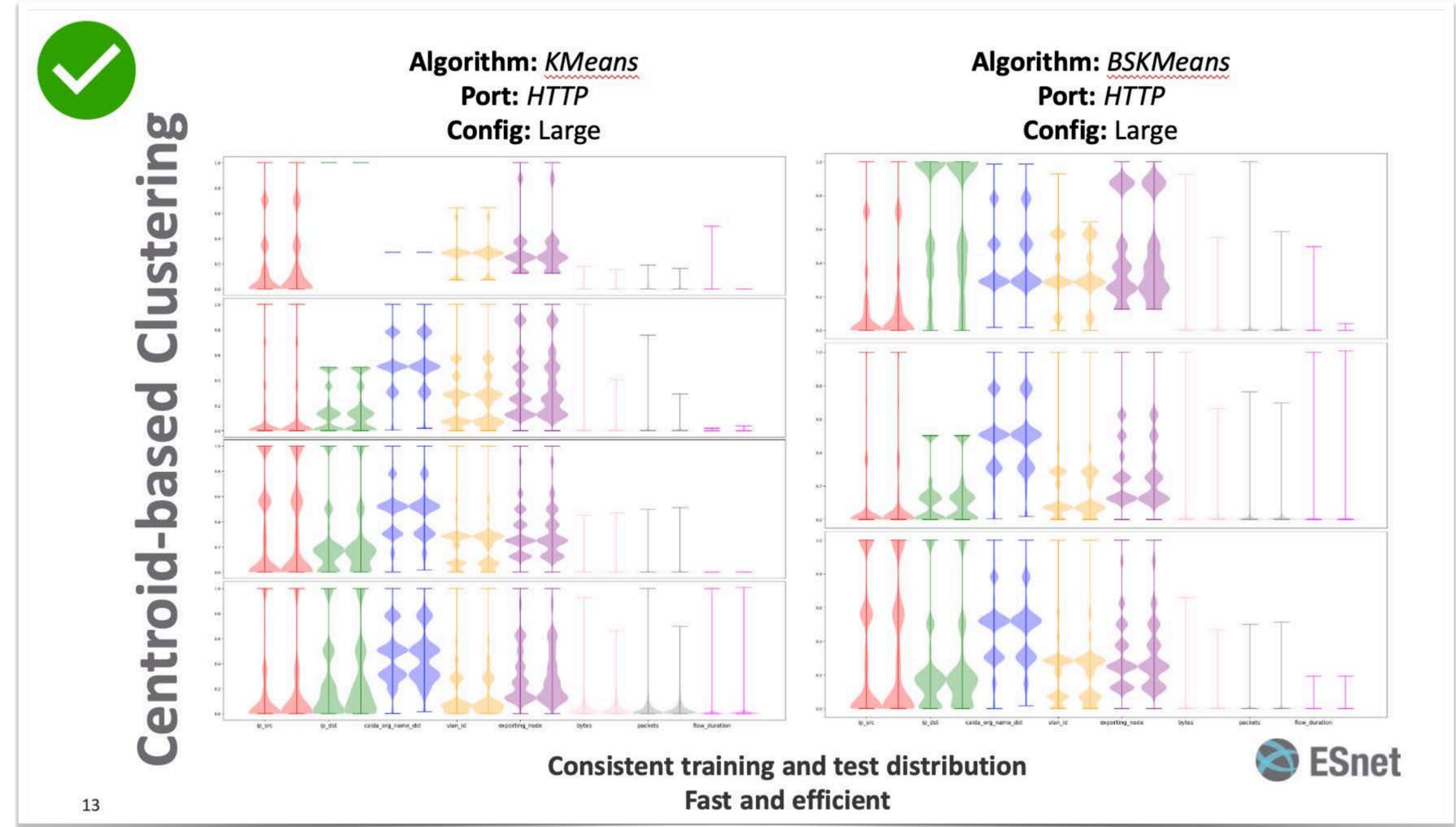
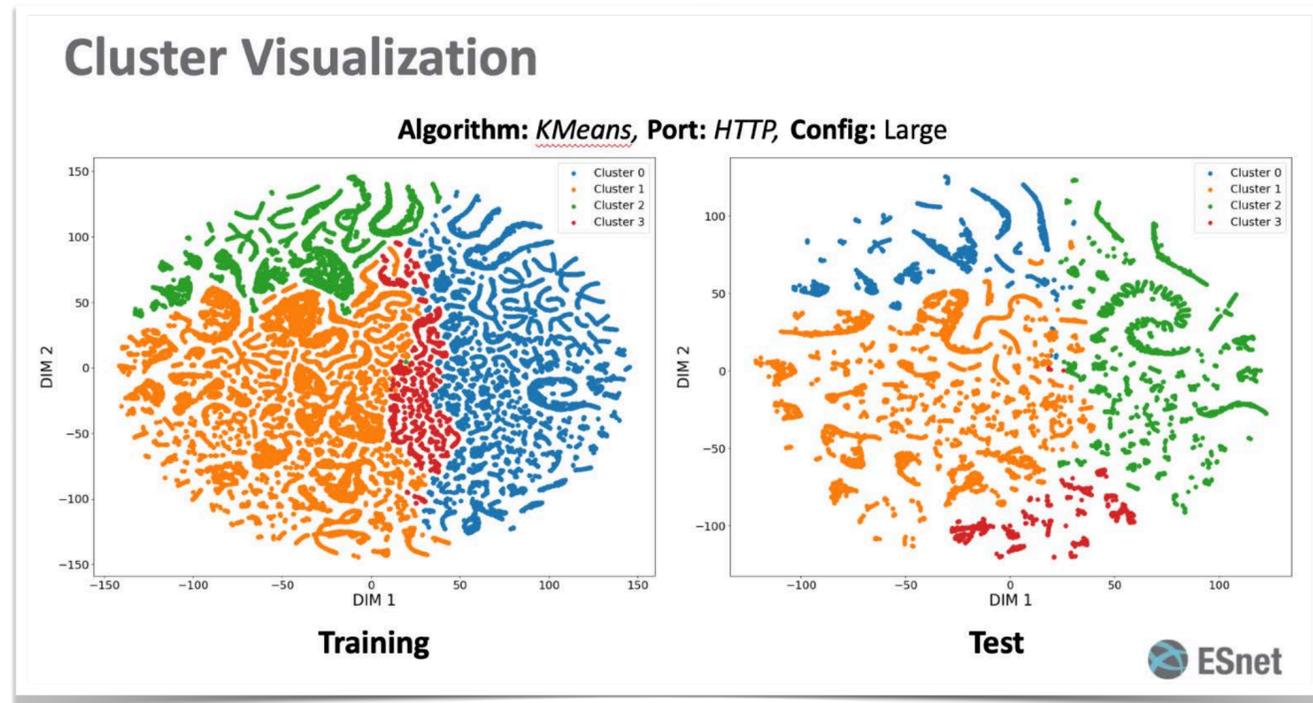
ECMP / LAG
Campus 100G Optimization
FlexE
9K MTUs

Everything else "peaks" at 10 Gbps
"average" is < 1 Gbps



This provides a context between
"Theory" and "Practice"

ML - Clustering / Self Similarity / Prediction etc..



Joint work with UCSD (Onat Gungor / Tajana Rosing)

Reliable auto clustering of our 12 billion flows / day ?

How repeatable are the statistics ?

Ans: 99% of the time the hundreds of thousands of nodes on ESnet do more or less the same thing everyday.

Good ! Then we can do capacity planning and prediction, without worrying about daily chaos.

Good ! Then we can look for exceptions automatically.

“Thank You”

Yatish Kumar