IPv6 Background Radiation

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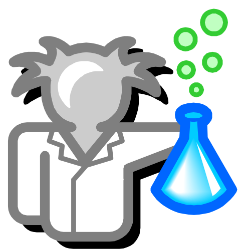
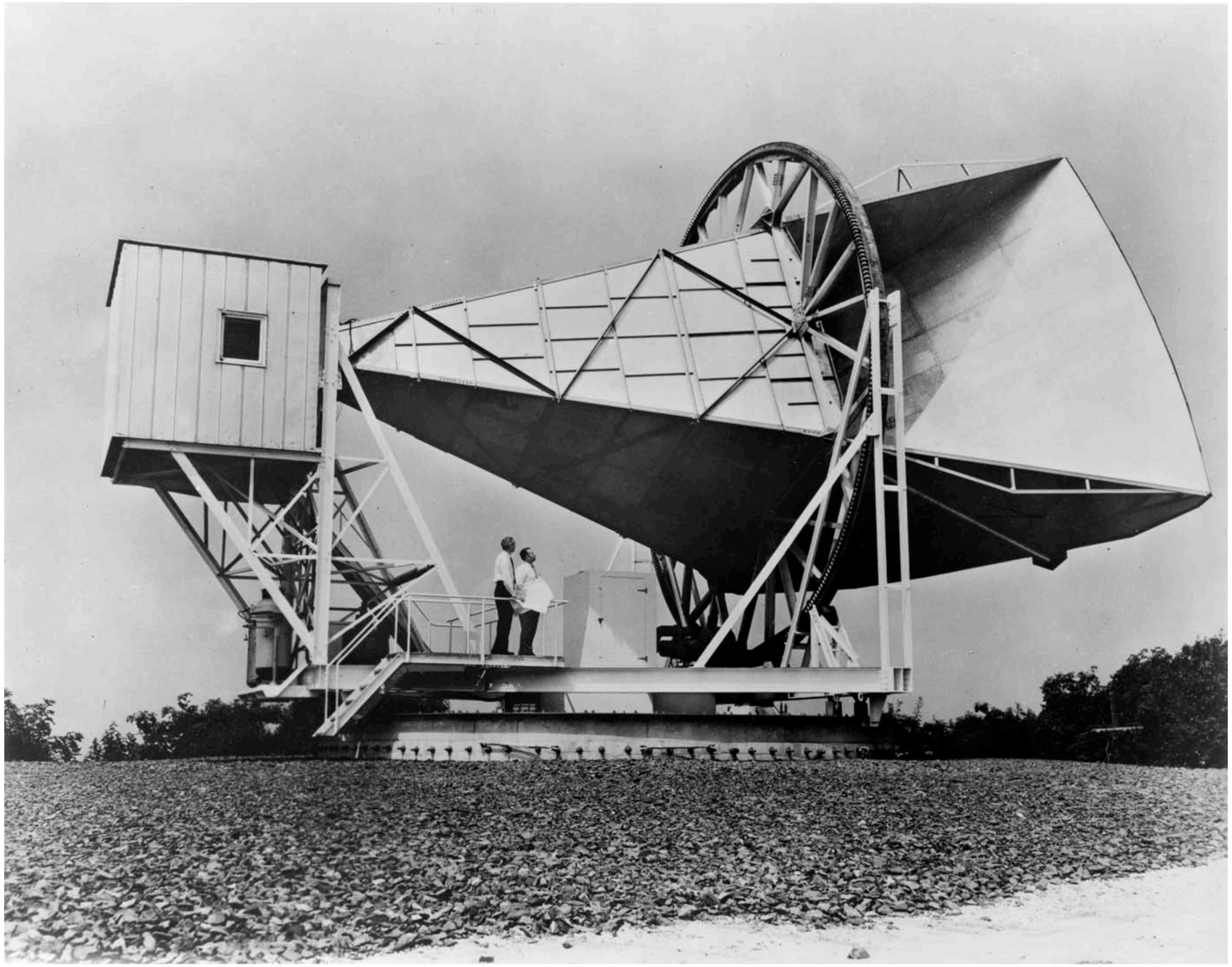
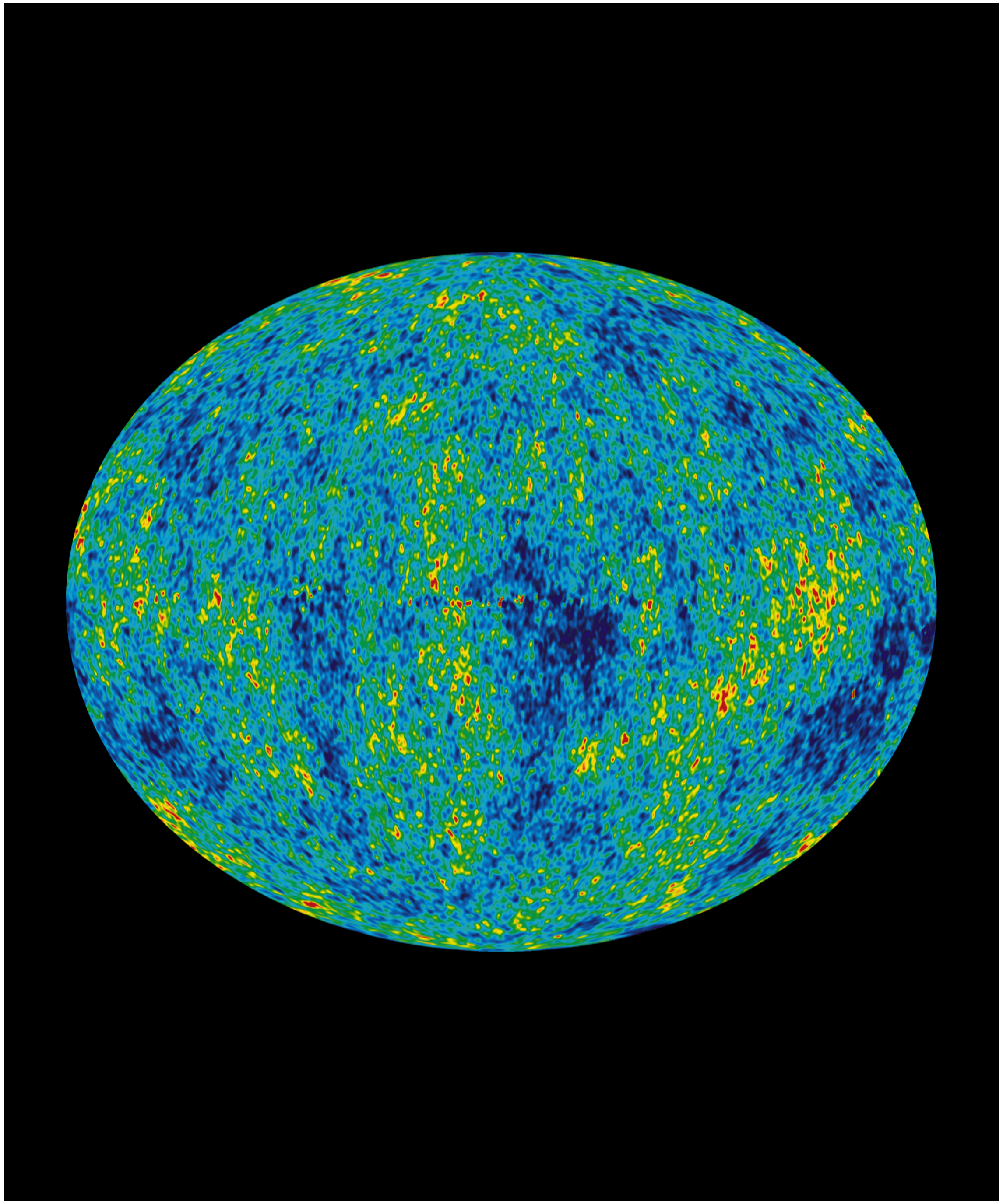
APNIC R&D



Radiation Detection



The Holmdel Horn Antenna, at Bell Labs, on which Penzias and Wilson discovered the cosmic microwave background radiation

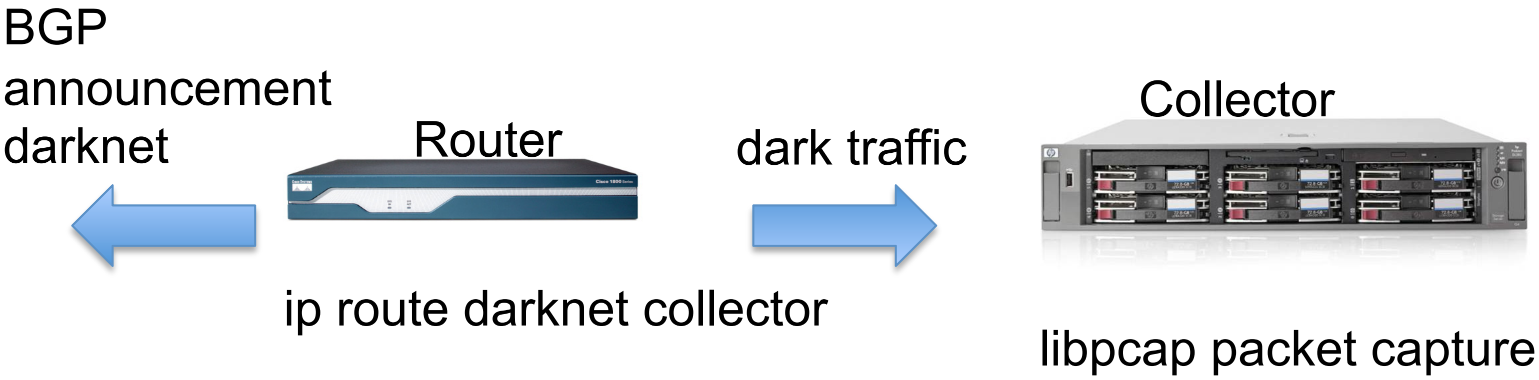


The detailed, all-sky picture of the infant universe created from five years of WMAP data. The image reveals 13.7 billion year old temperature fluctuations (shown as color differences) that correspond to the seeds that grew to become the galaxies. The signal from the our Galaxy was subtracted using the multi-frequency data. This image shows a temperature range of ± 200 microKelvin.

Credit: NASA / WMAP Science Team

Radiation Detection for Amateurs!

IP Radiation Detector



Passive Detector: all incoming traffic is recorded
collector emits no traffic in response

Active Detector (Internet sink*): all incoming traffic recorded
ICMP, TCP and UDP responses generated
Application responses for HTTP, FTP, SMB,…

* "On the Design and Use of Internet Sinks for Network Abuse Monitoring",
Vinod Yegneswaran1 and Paul Barford1 and Dave Plonka2, University of Wisconsin, Madison
In *Proceedings of Symposium on Recent Advances in Intrusion Detection, 2004*
http://pages.cs.wisc.edu/~pb/isink_final.pdf

IPv4 Background Radiation

- We understand that the IPv4 address space is now heavily polluted with background traffic
  - Background levels of traffic associated with scanning, backscatter, mis-configuration and leakage from private use contexts contributing to the traffic volume
  - Average background traffic level in IPv4 is around 300 – 600 bps per /24, or an average of 1 packet every 3 seconds
  - There is a "heavy tail" to this distribution, with some /24s attracting well in excess of 1Mbps of continuous traffic
  - The "hottest" point in the IPv4 network is 1.1.1.0/24. This prefix attracts some 100Mbps as a constant incoming traffic load

IPv4 vs IPv6

- Darknets in IPv4 have been the subject of numerous studies for many years
- What about IPv6?
  - Previous published findings on IPv6 Darknets
    - Matt Ford et al, 2006; “Initial Results from an Ipv6 Darknet”, In Proceedings of International Conference on Internet Surveillance and Protection (ICISP'06)
      - advertised a “dark” /48 for 15 months at UK6x
      - received 12 packets, all ICMPv6
      - < 1ppm (packet per month!) per /48

Does IPv6 Radiate in the Dark?

- The IPv4 address scanning approach does not work in IPv6
  - Much of the scanning traffic in IPv4 is seen to perform a +1 incremental “walk” of the IPv4 address space – this is infeasible in IPv6
- Random address selection will not work either
- Reverse walking DNS zones is feasible, but this will not result in traffic directed to dark nets unless the DNS itself includes pointers to dark nets
- Backscatter from spoofed source addresses in IPv6 is also less feasible due to the absence of convenient socket-level source address spoofing in IPv6
  - source address spoofing in IPv6 requires construction of the entire Ether-framed packet from scratch, and use of a raw device interface, which makes viral construction more challenging in most hosts
- So it does appear that IPv6 will not have much background dark traffic
  - Perhaps 1 ppm per /48 of dark IPv6 traffic is unexceptional

This Experiment

- Investigates what happens to the IPv6 dark traffic profile when we increase the size of the IPv6 Darknet
- This experiment used a /12 as the basis of the dark traffic measurement

2400::/12

Allocated to APNIC on 3 October 2006

Currently 2400::/12 has:

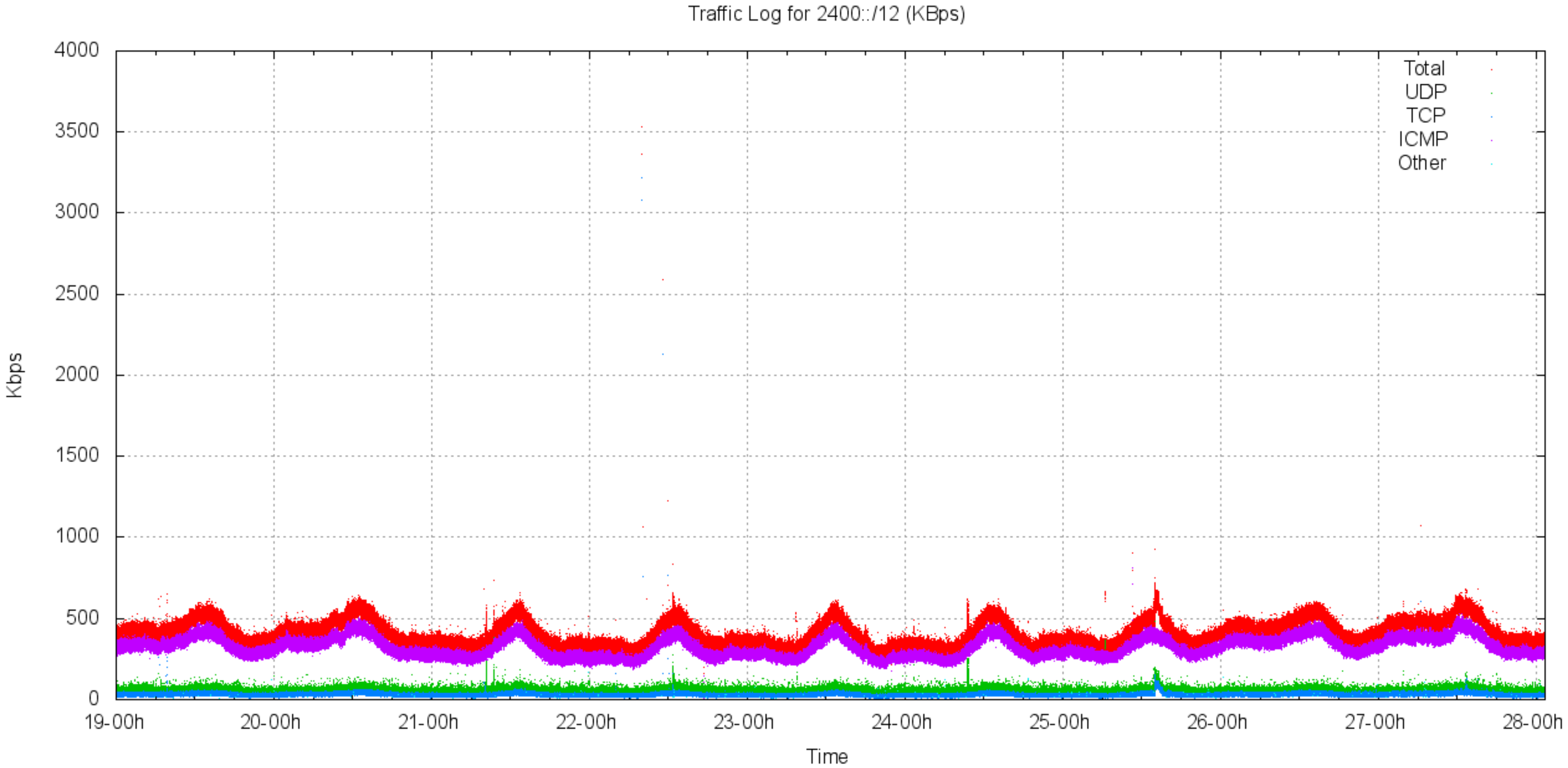
- 709 address allocations, spanning a total of:
  - 16,629 /32's
  - 71,463,960,838,144 /64's
  - 1.59% of the total block
- 323 route advertisements, spanning a total of:
  - 9,584 /32's
  - 41,164,971,903,233 /64's
  - 0.91% of the /12 block

0.91% of the block is covered by existing more specific advertisements
0.68% of the block is unadvertised allocated address space
98.41% of the block is unadvertised and unallocated

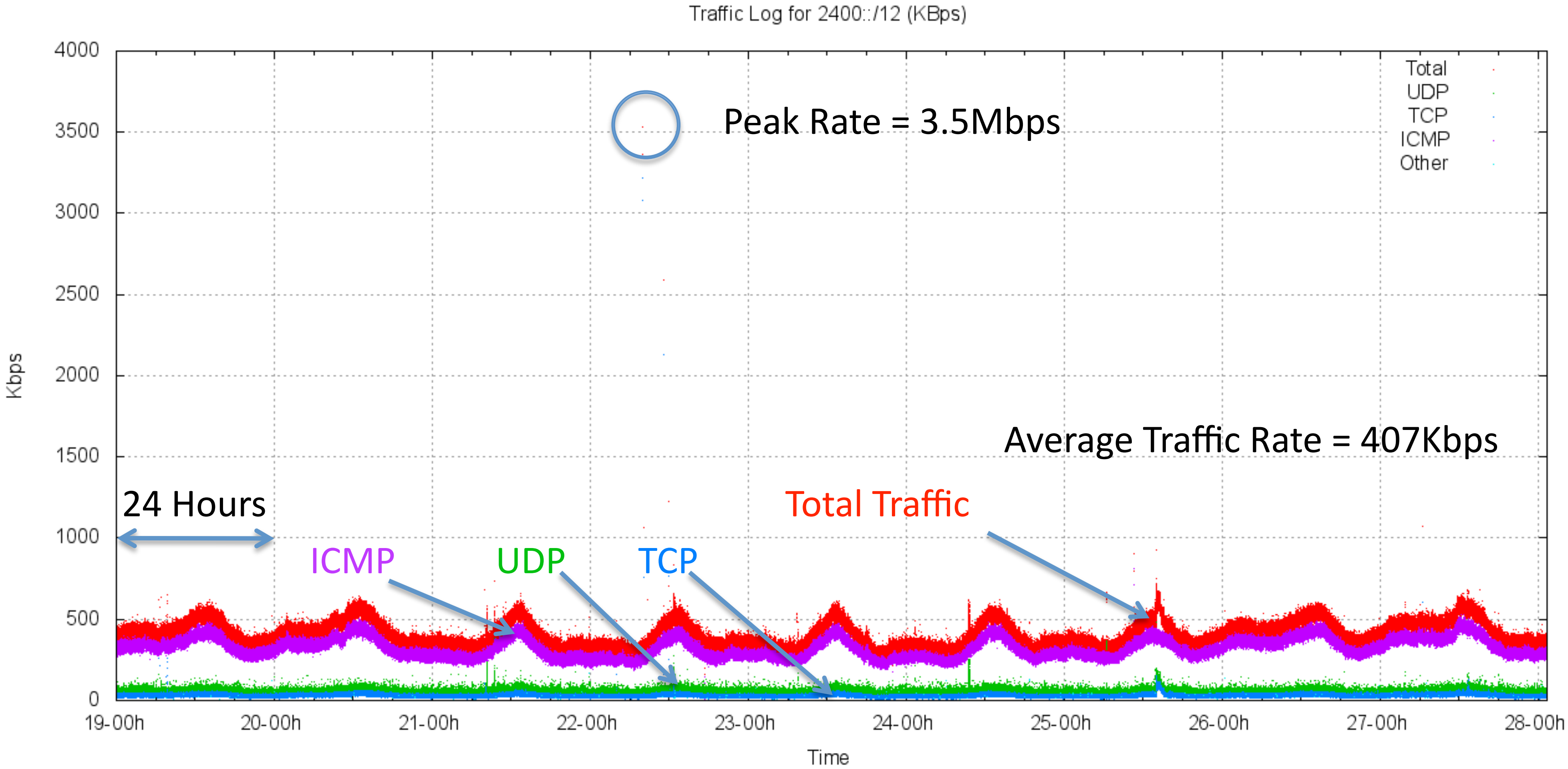
Advertising 2400::/12

- Advertised by AS7575 (AARNet)
- Passive data collection (no responses generated by the measurement equipment)
- Darknet experiment performed between 19th June 2010 – 27th June 2010

Total Traffic Profile



Total Traffic Profile



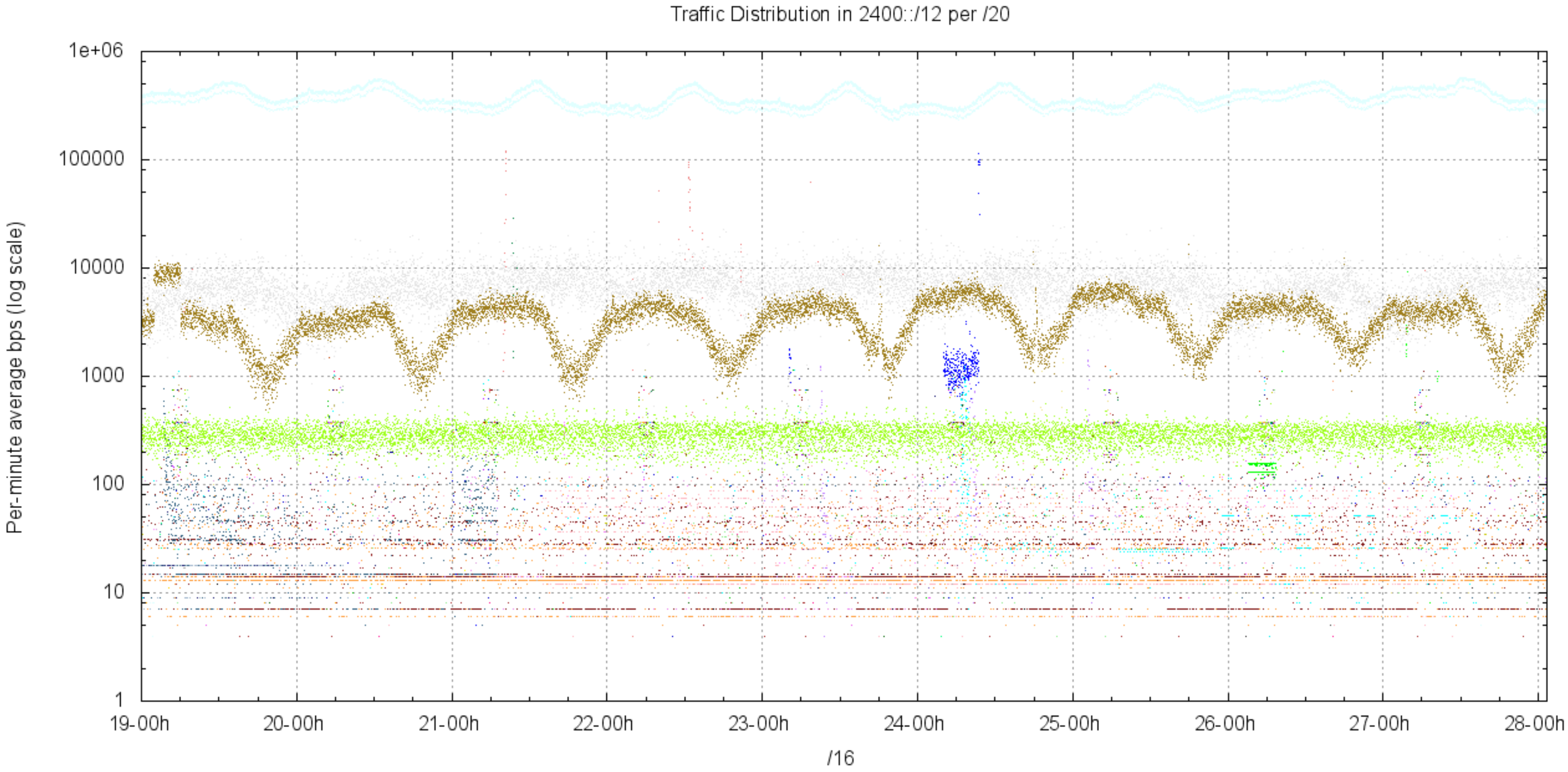
Traffic Profile

Average Traffic Rate: 407 Kbps (726 packets per second)

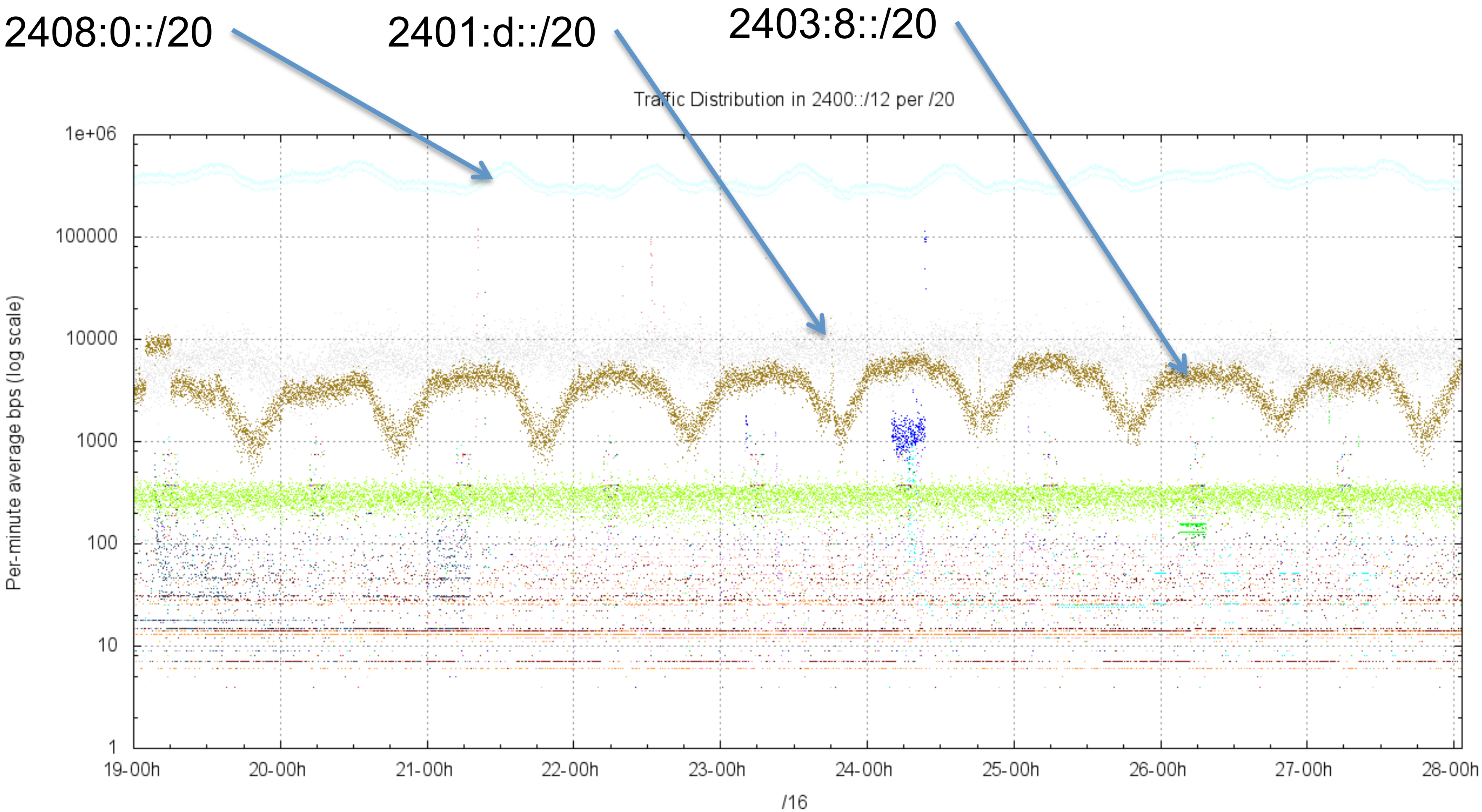
- ICMP: 323 Kbps (611 pps)
- UDP: 54 Kbps (68 pps)
- TCP: 30 Kbps (45 pps)

This is predominately ICMP traffic.

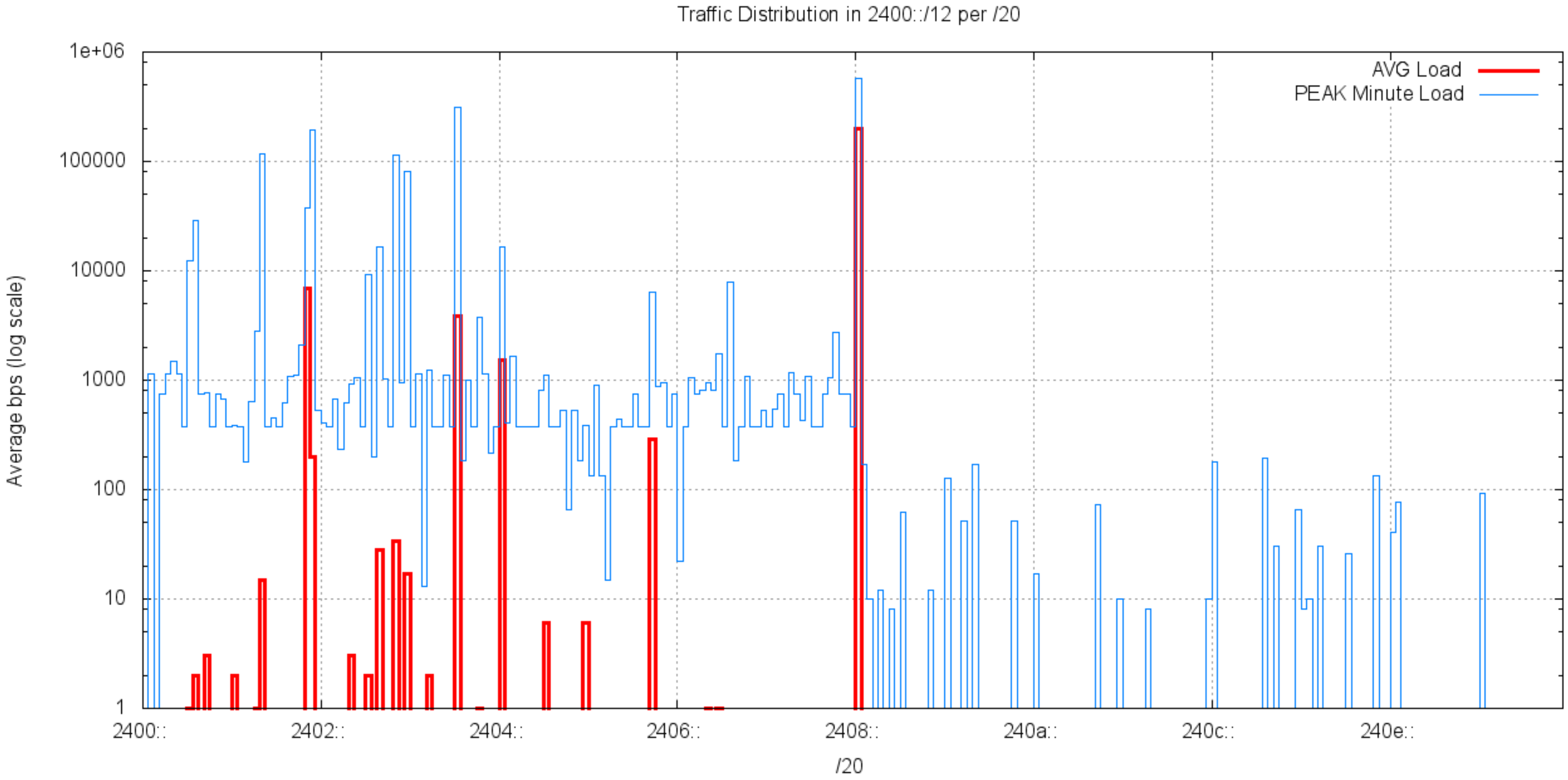
Destination Address Distribution



Destination Address Distribution



Destination Address Distribution



Top 5 /20s in 2400::/12

2408:0000:/20	197Kbps	Allocated: 2408::/22 – NTT East, JP
2401:d000::/20	7Kbps	8 x /32 allocations in this block
2403:8000::/20	4Kbps	4 x /32 allocations in this block
2404:0000::/20	1Kbps	29 allocations in this block
2405:b000::/20	0.3Kbps	4 x /32 allocations in this block

Private Addresses in IPv6

- There is no direct equivalent of RFC1918 private use addresses in IPv6

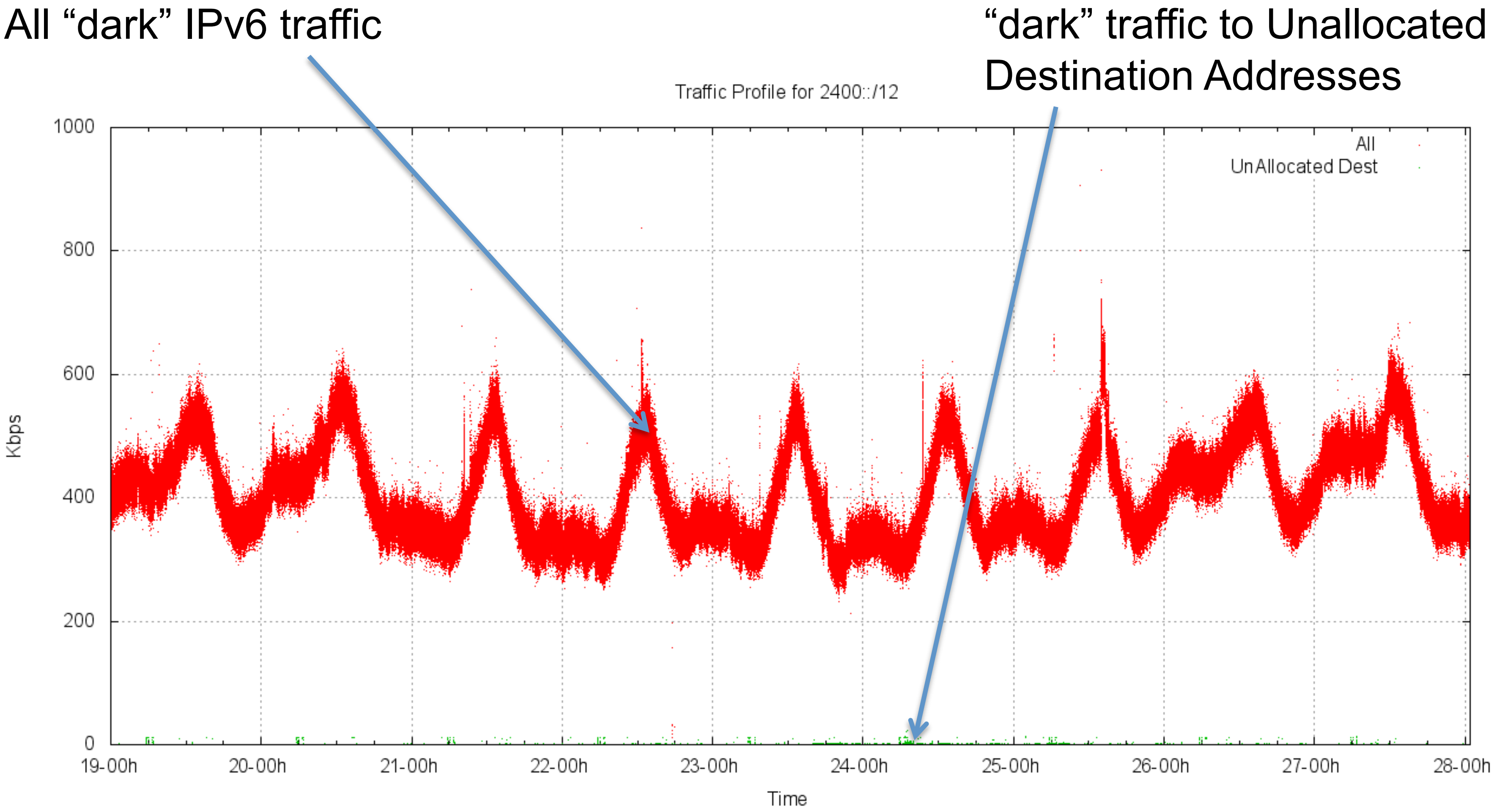
  (well, there are ULAs, but they are slightly different!)

- In IPv6 its conventional to use public IPv6 addresses in private contexts

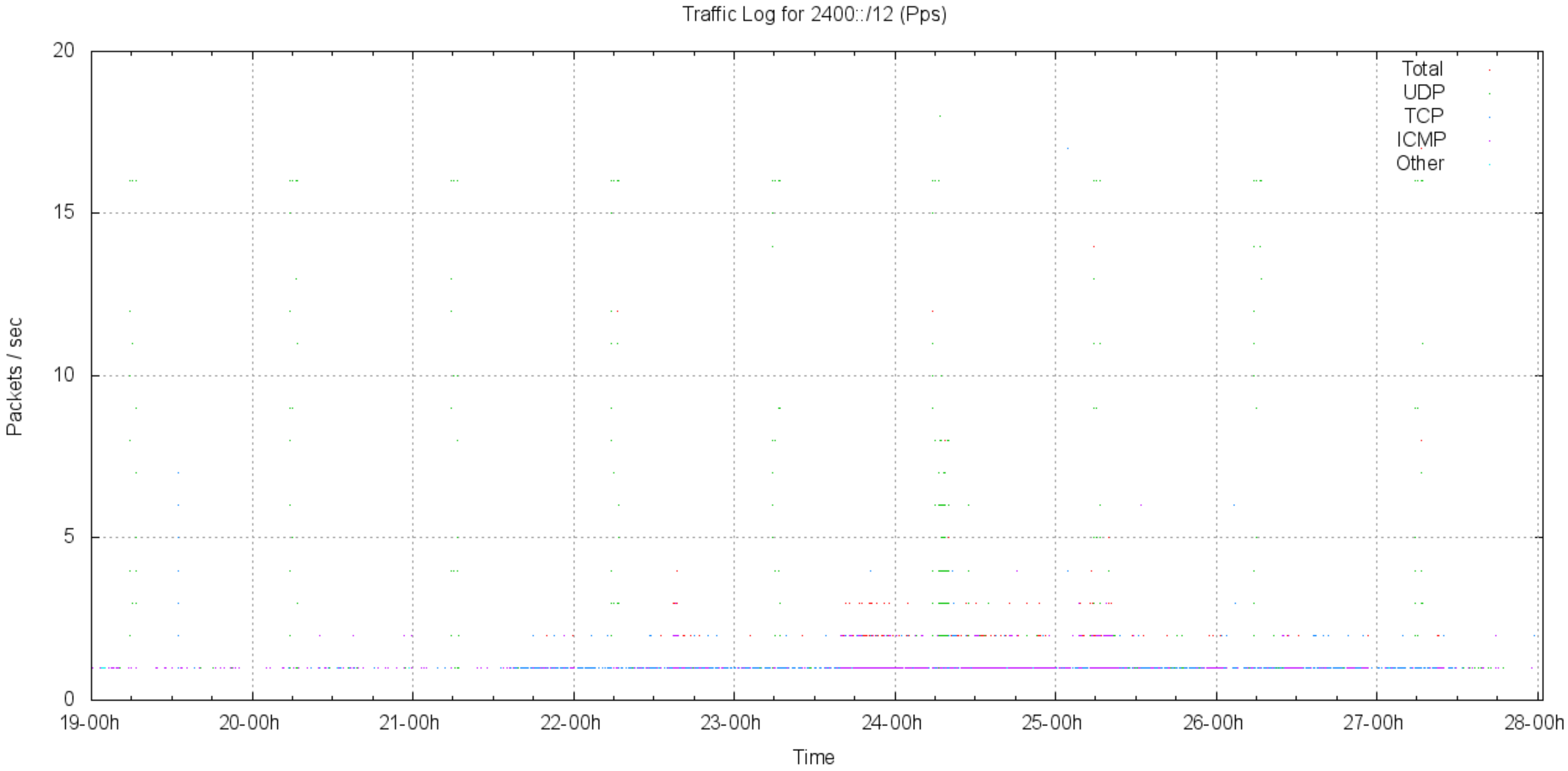
- **How much of this “dark” IPv6 traffic is a result of “leakage” from private contexts into the public network?**

- Lets filter the packets using the allocation data

Allocated vs Unallocated Dark Traffic

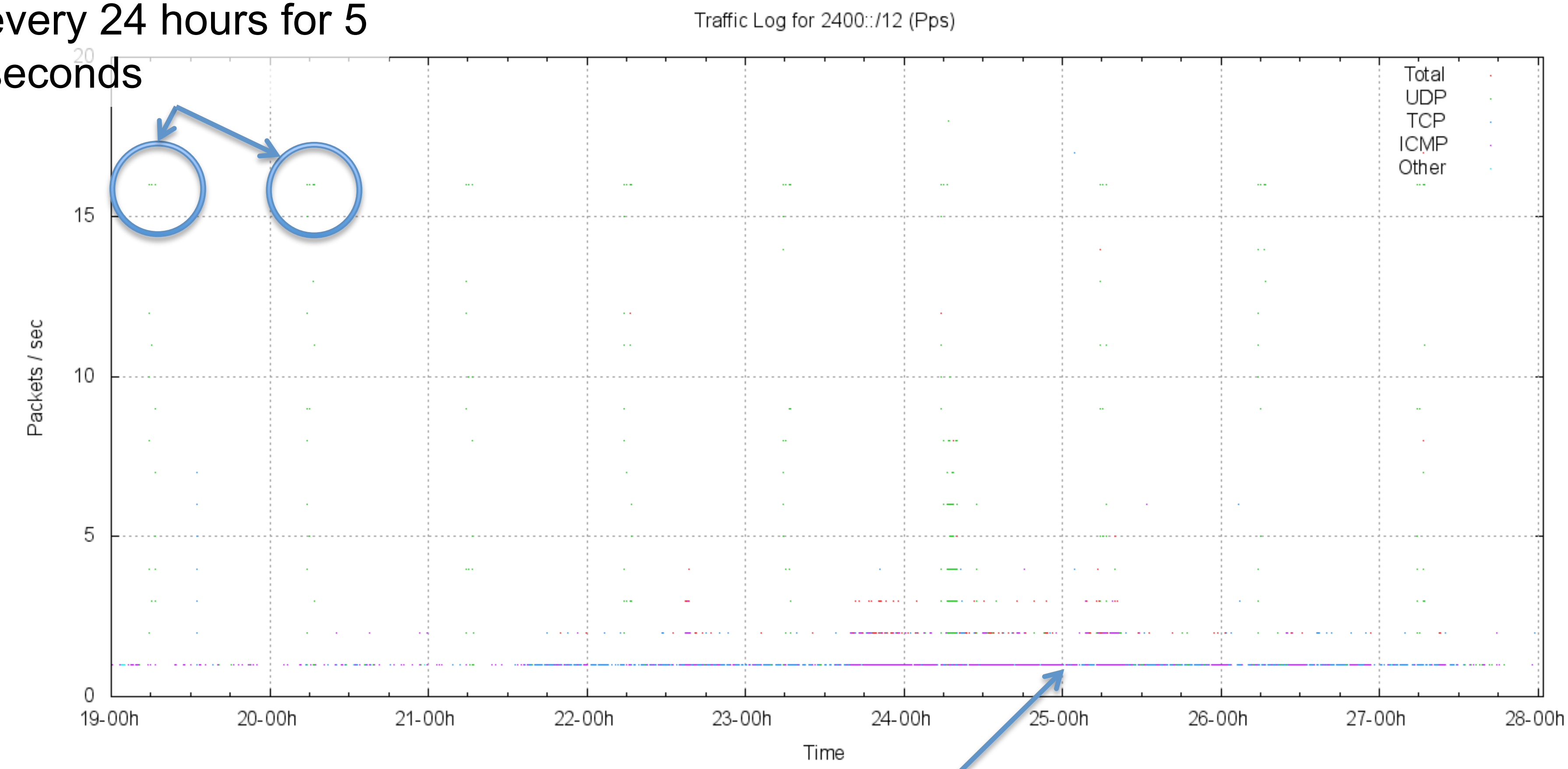


Dark Traffic to Dark Addresses



Dark Traffic to Dark Addresses

Yes, that's 16 UDP packets per second every 24 hours for 5 seconds



less than 1 packet per second of ICMP

Dark Traffic Profile

Traffic directed to unallocated IPv6 addresses:

- Collection period: 9 days
- Average Packet Rate: 1 packet per 36.8 seconds
- Packet Count: 21,166
  - ICMP: 7881 (37%)
  - TCP: 7660 (36%)
  - UDP: 5609 (26%)

TCP Profile

SYN packets: (wrong destination, DNS typos?)

1126

SYN+ACK packets: (wrong source, local config errors?)

6392

Others (Data packets):

141

TCP Oddities

Stateless TCP in the DNS?

(no opening handshake visible in the data collection – just the TCP response data!)

DNS TCP Response:

04:47:06.962808 IP6 (hlim 51, next-header TCP (6) payload length: 1351)

2001:468:1802:102::805b:fe01.53 > 2401:1a19::123:108:224:6.49121, Length: 1319 ACK: 1672186592 WIN 49980

Query: A? finlin.wharton.upenn.edu.

Response: finlin.wharton.upenn.edu. A 128.91.91.59

TCP Probing?

```
13:12:56.528487 IP6 (hlim 44, next-header TCP (6) payload length: 1460) 2001:250:7801:a400::1987:407.33729 > 2402:e968:6000::d27e:4ed:fb5b.2273: .,
    3207301626:3207303066(1440) ack 3706857348 win 63916
01:47:00.122909 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:2b75:2100:0:42:dc34:e8f3:52a4.3113: .,
    272892761:272892761(0) ack 2064800132 win 64800
01:50:47.197265 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:2f2a:179:341f:d6:dc34:e8f3:52a4.3113: .,
    302360250:302360250(0) ack 2091174988 win 64800
03:44:39.140290 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:a236:6000:0:4d8:dc34:e8f3:52a4.3113: .,
    829577701:829577701(0) ack 2622550921 win 64800
03:58:23.851708 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:9a23:100:2:d6:dc34:e8f3:52a4.3113: .,,
    829661294:829661294(0) ack 2702723699 win 64800
05:02:52.568996 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:1123:1ba:ec05:ef:f2c6:ce35:c40f.1158: .,
    1365702964:1365702964(0) ack 3293642040 win 64800
05:50:43.706430 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:76d9:16b:7320:d8:f2c6:ce35:c40f.1158: .,
    1409613792:1409613792(0) ack 3600529388 win 64800
07:20:15.728521 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:6219:4100:0:2b0:dc34:e8f3:52a4.3113: .,,
    830692465:830692465(0) ack 3672203022 win 64800
08:37:57.505208 IP6 (hlim 44, next-header TCP (6) payload length: 20) 2001:250:7801:a400::1987:407.57777 > 2402:b54e:1cc:e14:52:dc34:e8f3:52a4.3113: .,,
    831214068:831214068(0) ack 4169603866 win 64800
```

Repeated TCP packets, same source addresses and ports, no preceding SYN/ACK TCP handshake, different addresses addresses, small dest port set (1158, 3113, 2273)

TCP Probing, or…?

```
12:44:54.038234 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240a:f000:1405:6001:1cbc:f191:1384:7cde.1597: Flags [S.], seq 3889176058, ack 2381452531, win 8192, length 0
12:44:54.038358 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240b:f000:1685:6001:1cbc:f191:1384:7cde.1597: Flags [S.], seq 3889176058, ack 2381452531, win 8192, length 0
12:44:54.038613 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240c:f000:1905:6001:1cbc:f191:1384:7cde.1597: Flags [S.], seq 3889176058, ack 2381452531, win 8192, length 0
12:44:54.914216 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240c:f000:1905:6001:1cbc:f191:1384:7cde.1597: Flags [.], seq 1, ack 220, win 17080, length 0
12:44:54.914341 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240a:f000:1405:6001:1cbc:f191:1384:7cde.1597: Flags [.], seq 1, ack 220, win 17080, length 0
12:44:54.914466 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240b:f000:1685:6001:1cbc:f191:1384:7cde.1597: Flags [.], seq 1, ack 220, win 17080, length 0
12:49:52.061661 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240b:f000:1685:af01:b469:173f:8bc8:3411.3991: Flags [.], seq 536162733, ack 2327619384, win 16621, length 0
12:49:52.061785 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240c:f000:1905:af01:b469:173f:8bc8:3411.3991: Flags [.], seq 536162733, ack 2327619384, win 16621, length 0
12:49:52.061915 IP6 2001::4137:9e76:28ae:355f:8417:a083.80 > 240a:f000:1405:af01:b469:173f:8bc8:3411.3991: Flags [.], seq 536162733, ack 2327619384, win 16621, length 0
```

Same Teredo source address, but varying destination addresses

Self-Misconfiguration

10:56:20.719296 IP6 (hlim 57, next-header TCP (6) payload length: 40) 2001:470:1f04:815::2.25 > 2402:5000::250:56ff:feb0:11aa.37839: S, cksum 0x79db (correct), 2261394238:2261394238(0) ack 2082559012 win 64768 <mss 1420,sackOK,timestamp 128287793 3737661225,nop,wscale 11>

A mail server at he.net is (correctly) responding to a mail client at the (invalid) address 2402:5000::250:56ff:feb0:11aa. There are sequences of 8 packets paced over ~90 seconds with doubling intervals – typical signature of a SYN handshake failure

This single address pair generated a total of 6,284 packets over 9 days (corresponding to ~780 sendmail attempts!)

This leakage may have been tickled by this experiment – HE normally filter unallocated address space and the 2400::/12 advertisement would've been blocked by HE

UDP Traceroute6

16:42:15.769564 IP6 (hlim 1) 2001:470:9:babe::3.48038 > 2405:a800::1.33464: UDP, length 32
16:42:15.770189 IP6 (hlim 1) 2001:470:9:babe::3.40743 > 2405:a800::1.33465: UDP, length 32
16:42:15.921349 IP6 (hlim 1) 2001:470:9:babe::3.34520 > 2405:a800::1.33466: UDP, length 32
16:42:15.921849 IP6 (hlim 2) 2001:470:9:babe::3.44740 > 2405:a800::1.33467: UDP, length 32
16:42:15.989684 IP6 (hlim 2) 2001:470:9:babe::3.42310 > 2405:a800::1.33468: UDP, length 32
16:42:15.995430 IP6 (hlim 2) 2001:470:9:babe::3.52710 > 2405:a800::1.33469: UDP, length 32
16:42:15.996180 IP6 (hlim 3) 2001:470:9:babe::3.51306 > 2405:a800::1.33470: UDP, length 32
16:42:16.000302 IP6 (hlim 3) 2001:470:9:babe::3.55161 > 2405:a800::1.33471: UDP, length 32
16:42:16.000803 IP6 (hlim 3) 2001:470:9:babe::3.55674 > 2405:a800::1.33472: UDP, length 32

…

Source: 2001:470:9:babe::3, testing a path to 2405:a800::1, using UDP ports 33464 through to 33493 in sequence with increasing IPv6 hop limits

Total of 1,883 packets were seen between these two hosts!

Dark DNS

Queries: 2,892 queries over 7 days

from just 4 source addresses!

Backscattered Responses: 30

All of these look a lot like configuration errors in dual stack environments. These errors go largely unnoticed because of the fallback to V4 in dual stack.

DNS Oddities

```
11:01:21.259288 IP6 2001:468:1802:102::805b:fe01 53 > 2407:ed24::113:23:133:101 40288  97.229.175.128.in-addr.arpa. PTR roaming-229-97.nss.udel.edu.
22:50:24.316093 IP6 2607:f470:1003::3:3          53 > 2407:bde7::113:23:133:101 16554  noc3.dccs.upenn.edu. A 128.91.251.158, noc3.dccs.upenn.edu. RRSIG
00:59:40.623590 IP6 2001:468:1802:102::805b:fe01 53 > 2407:df5c::113:23:133:101 47237  knowledge.wharton.upenn.edu. A 128.91.87.103, knowledge.wharton.upe
06:37:59.021141 IP6 2607:f470:1003::3:3          53 > 2407:cd0d::113:23:133:101 44097: 94.80.91.130.in-addr.arpa. PTR masca7.museum.upenn.edu.
06:55:21.099014 IP6 2001:468:1802:102::805b:fe01 53 > 2407:29ca::113:23:133:101 47145: dns2.udel.edu. A 128.175.13.17
04:53:08.631077 IP6 2001:468:1802:102::805b:fe01 53 > 2407:f0e1::113:23:133:101 29201: noc3.dccs.upenn.edu. A 128.91.251.158, noc3.dccs.upenn.edu. RRSIG
20:04:03.879610 IP6 2001:468:1802:102::805b:fe01 53 > 2407:72c4::113:23:133:101 53336: 58.140.175.128.in-addr.arpa. PTR mbna58.be.udel.edu.
22:55:02.029732 IP6 2607:f470:1003::3:3          53 > 2407:6a85::113:23:133:101 40444: noc2.dccs.upenn.edu. A 128.91.254.1, noc2.dccs.upenn.edu. RRSIG
```

This looks like some form of backscatter from source address spoofing.

What's Left in dark UDP?

803 packets from 68 distinct sources, 45 of which are 6to4 source addresses

A lot of this looks like leakage from private contexts

Dark ICMP

- echo request packets (ping) – 7,802 packets
- 93 others – destination unreachables, and malformed packet headers

IPv6 Radiation - Malign or Benign?

- What happens in IPv4 does not translate into IPv6 .
- The nature of IPv6 is such that address scanning as a means of virus propagation is highly impractical
  - We may have seen some small number of guessing probes directed at ::1 and ::2 source addresses, but nothing else
- Walking the DNS for pointers to viable IPv6 addresses should be expected
  - but we did not see any of that form of behaviour in our data
- We've found no visible evidence of virus scanners attempting to probe into private use and dark address blocks in IPv6 – yet!

IPv6 Misconfiguration Rules!

- Most of the traffic in the dark space is leakage from private use contexts
  - There is a message here to all “private” networks: they really aren’t necessarily all that private!
- And a we’ve seen a very small amount of traffic that appears to be a result of poor transcription of IPv6 addresses into system configs and into DNS zone files

Thank You

Questions?