Measuring IPv6 ISP Performance

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July 2016

What are we looking at:

- How “reliable” are IPv6 connections?

  Do all TCP connection attempts succeed?

- How “fast” are IPv6 connections?

  is V6 slower than V4?

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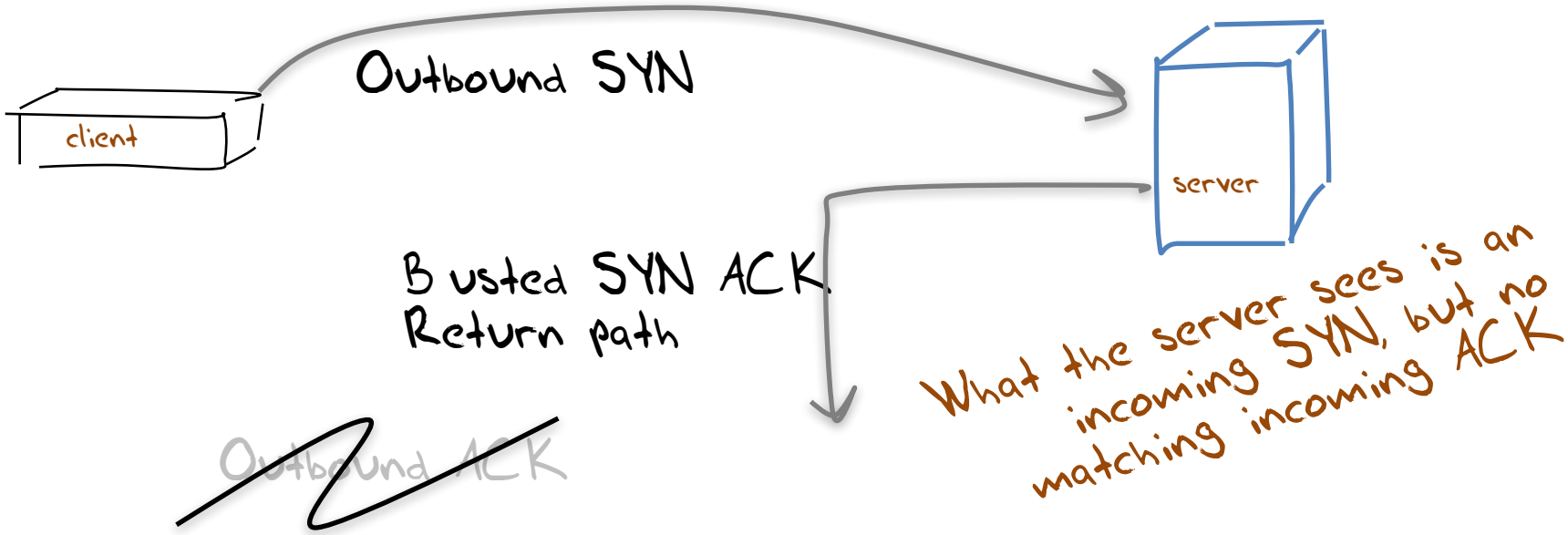
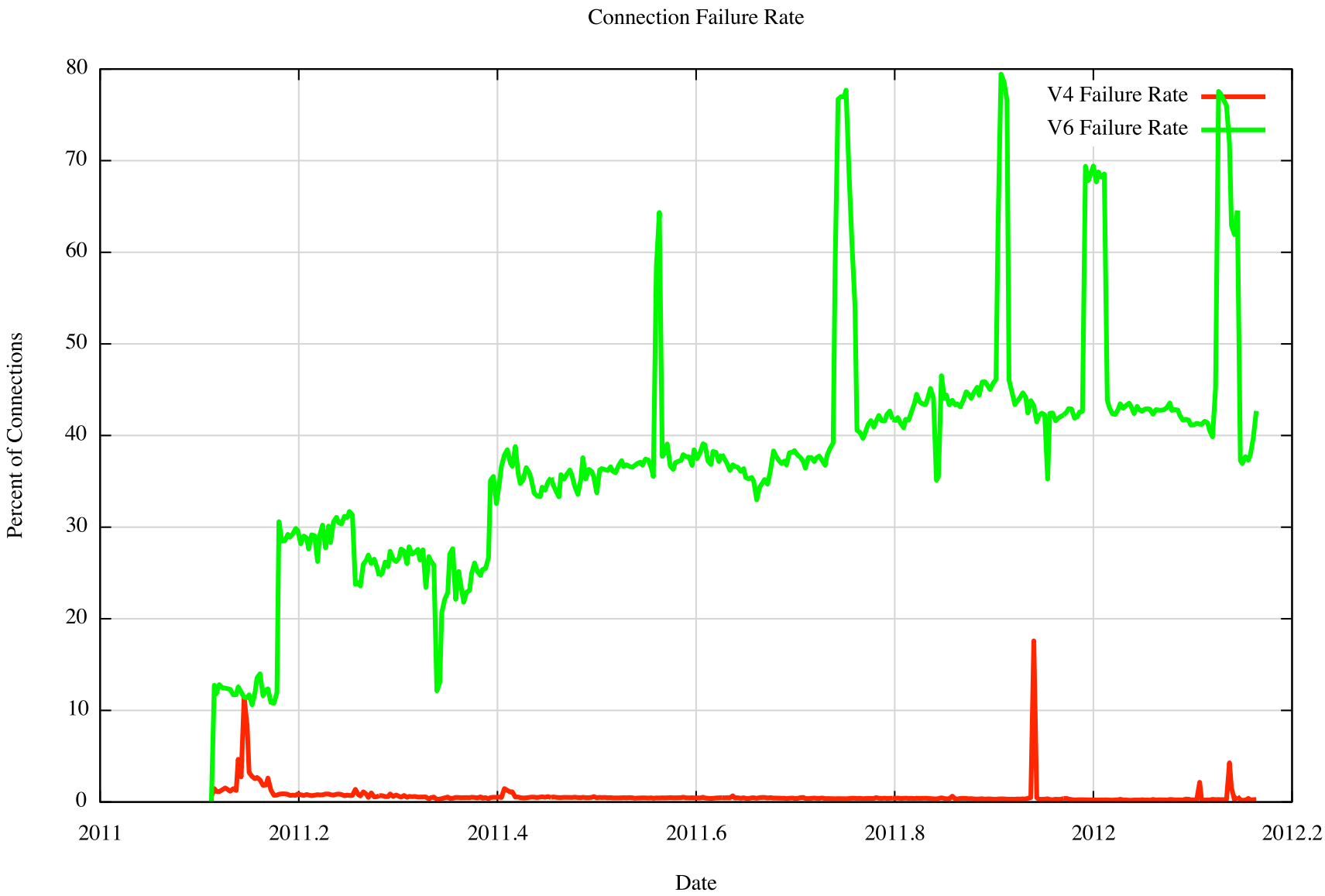
Connection Failure



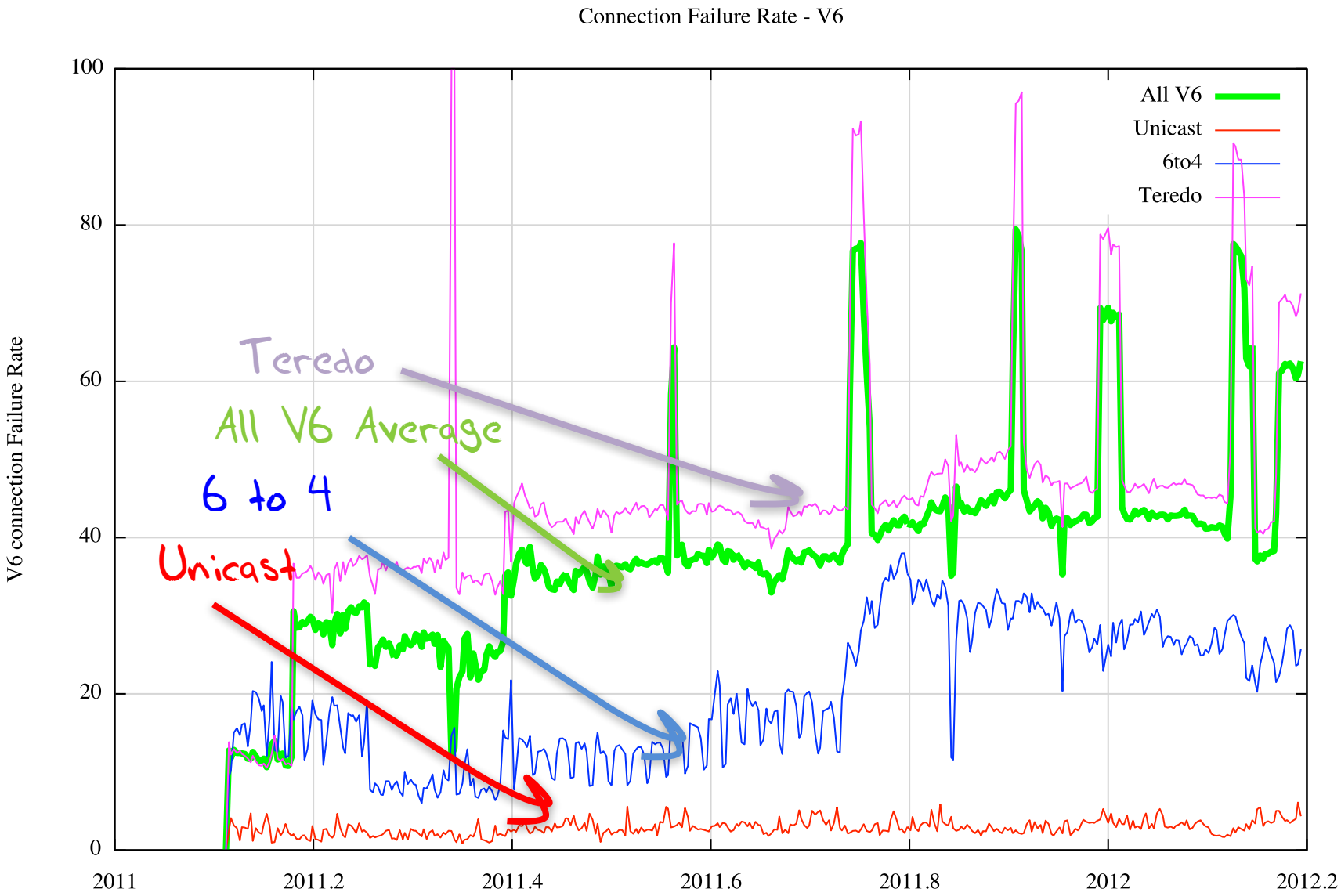
Compare two data sets

- The first data set has been collected across 2011
  - Teredo and 6to4 were still active as IPv6 mechanisms
  - Little in the way of other IPv6 services
- The second data set has been collected across 2015/2016

2011 - Measuring Failure



V6 Failure Rate by Address Type



6to4 Failure is Local Failure

6to4 failure appears to be related to two factors:

1. The client's site has a protocol 41 firewall filter rule for incoming traffic (this is possibly more prevalent in AsiaPac than in Europe)
2. Load / delay / reliability issues in the server's chosen outbound 6to4 relay (noted in the data gathered at the US server)

Even so, the 10% to 20% connection failure rate for 6to4 is unacceptably high!

V6 Unicast Failures

January – March 2012:

- 110,761 successful V6 connecting endpoints
- 6,227 failures
- That's a failure rate of 5.3%!

- 7 clients used fe80:: link local addresses
- 7 clients used fc00:/7 ULA source addresses
- 2 clients used fec0::/16 deprecated site local addresses
- 16 clients used 1f02:d9fc::/16
- Nobody used 3ffe::/16 prefixes!

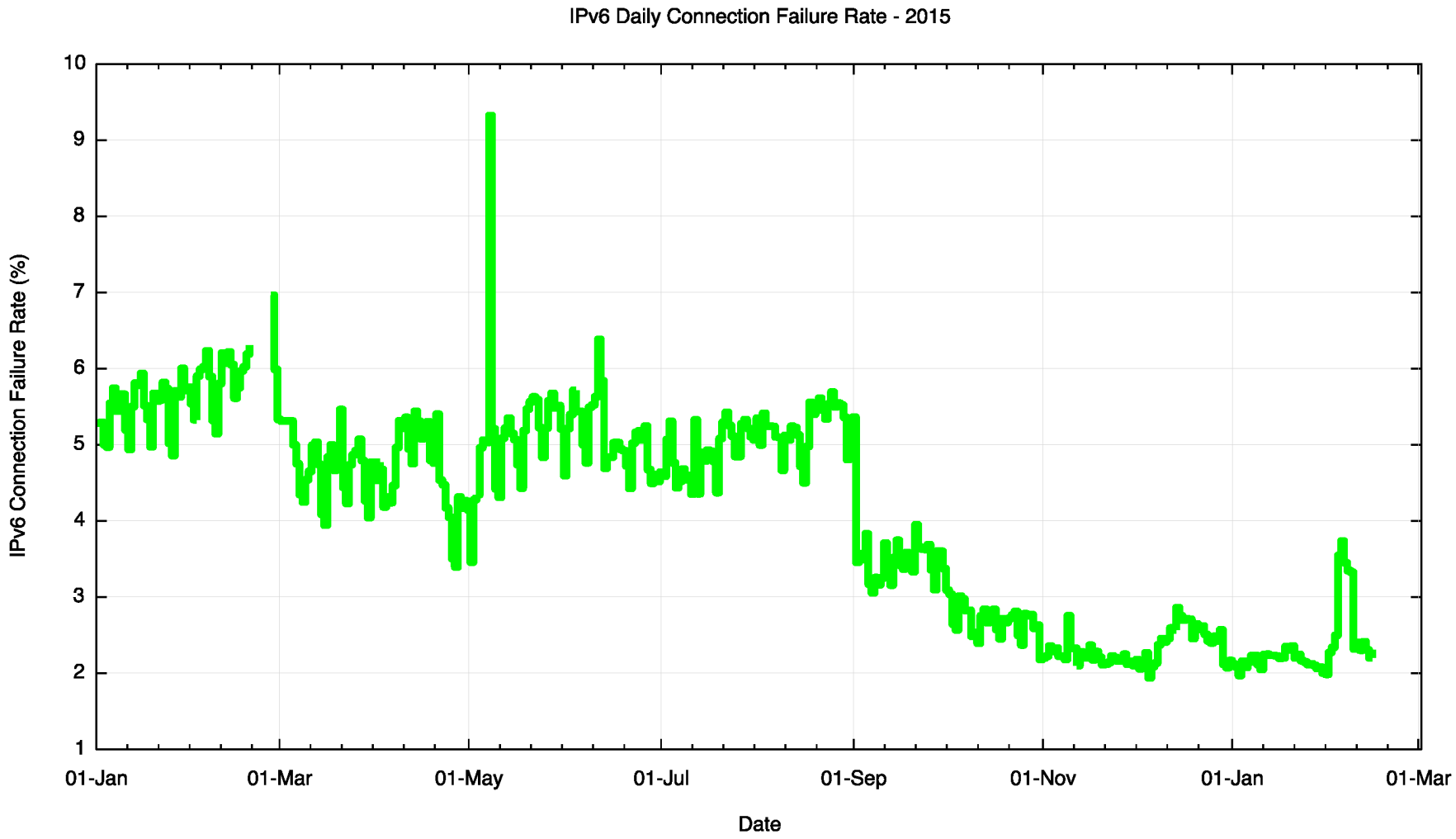
Data Set 2: Connection Failure in 2015/2016

January 2015– January 2016

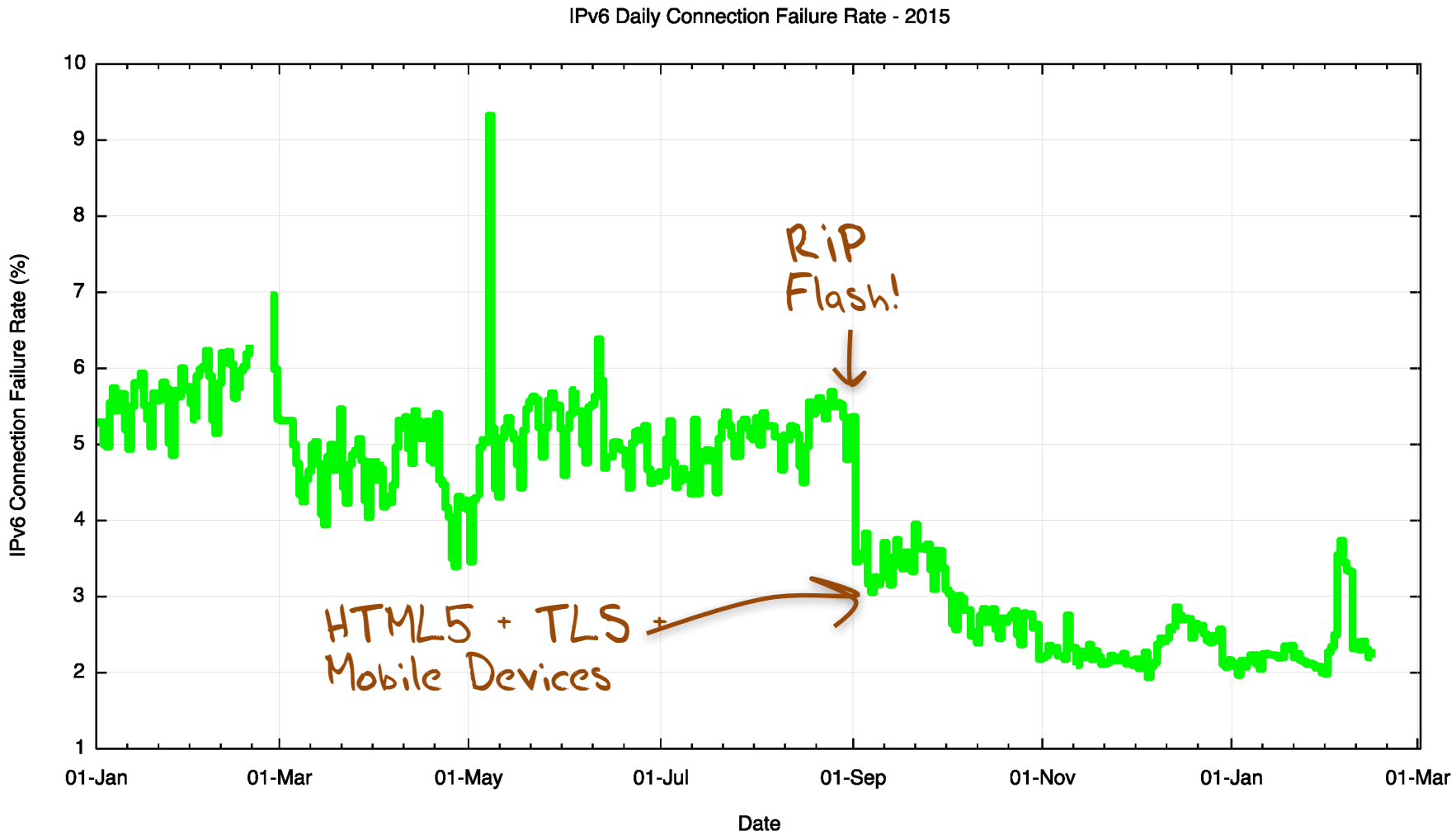
40,359,805 IPv6 endpoints

1,361,256 Failure rate (3.37%)

Daily IPv6 Failures



Daily IPv6 Failures



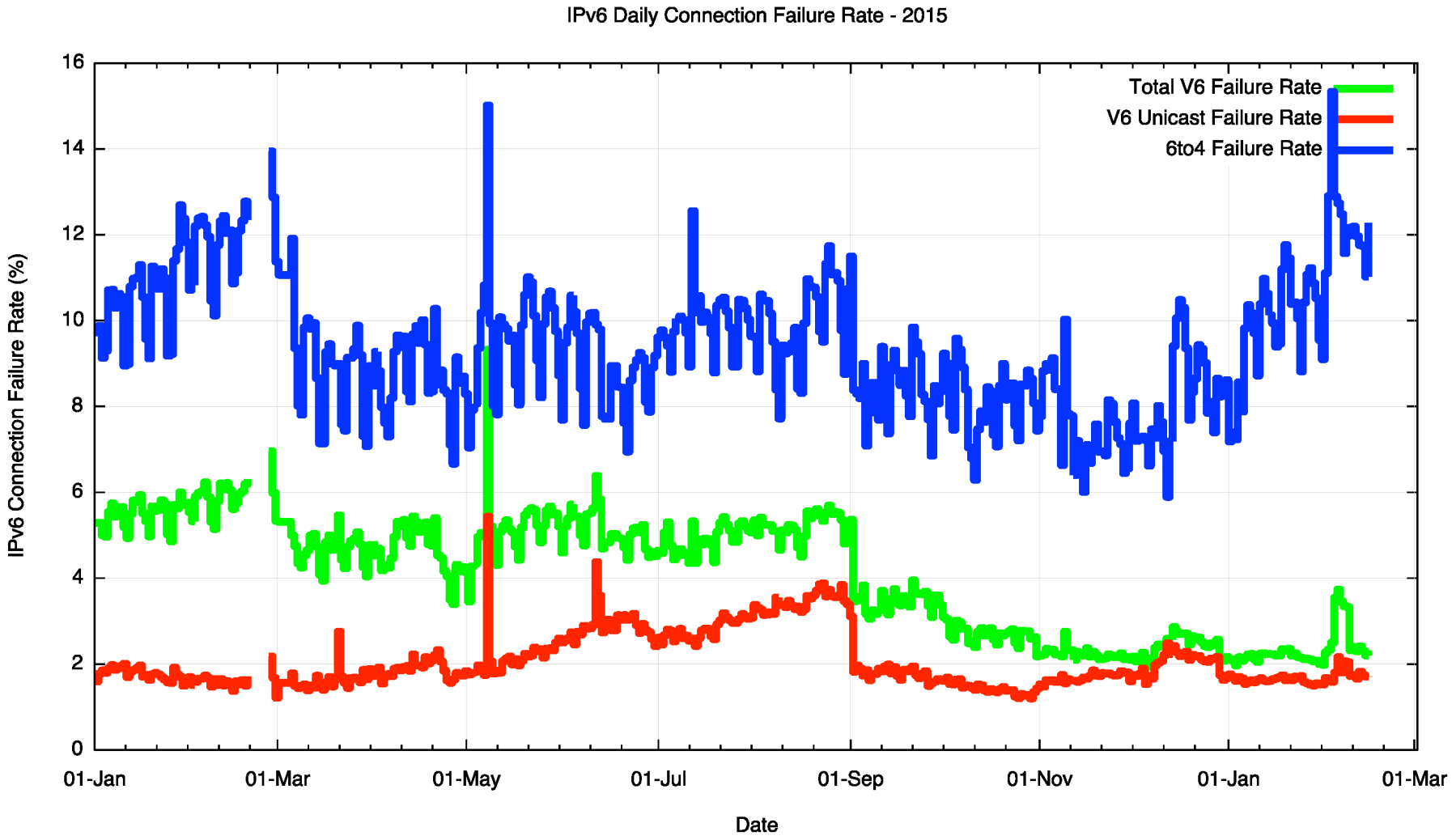
6to4

This is still very high!

7,693,849 6to4 endpoints

- 19% of all IPv6 used 6to4
- 9% failure rate within the set of 6to4 connections

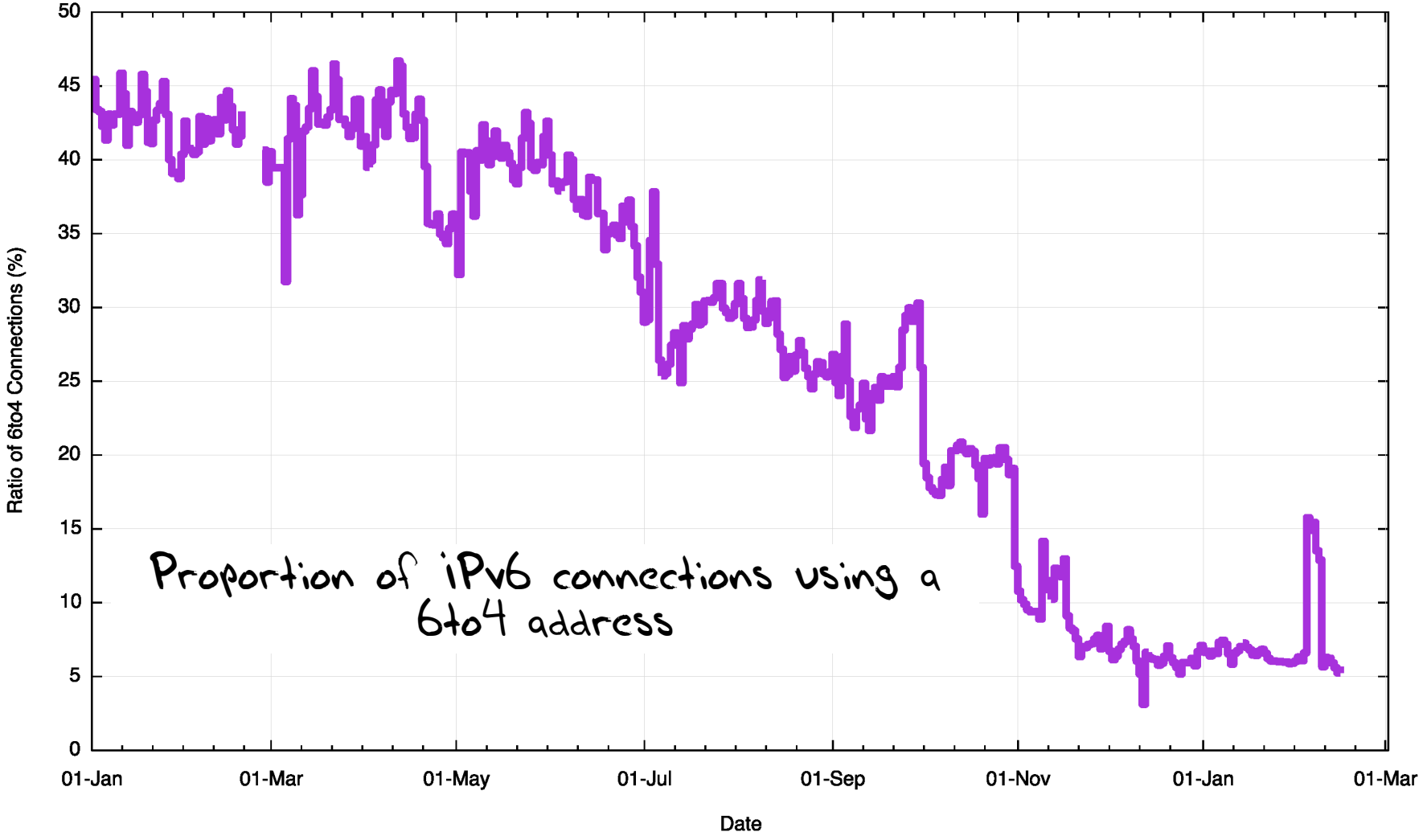
Daily IPv6 Failures



Daily IPv6 Failures

- 6to4 failure rate has improved from 15%-20% in 2011 to 9% in 2015
- Teredo has all but disappeared
- Unicast failure rate is between 1.5% and 4% in 2015
  - Current unicast failure rate is 2%

Killing off 6to4



IPv6 Failures - Sep 2015 - Jan 2016

20,872,173 unique IPv6 Addresses

464,344 failing IPv6 addresses

142,362 6to4 addresses
138 teredo addresses
68 fe80:: local scope addresses
834 unallocated addresses
1,244 unannounced addresses
319,698 addresses from unicast allocated routed space

216,620 unique /64s

Origin AS's with High IPv6 Failure Rates

AS	Failure Rate	Samples	AS Name
AS13679	97.33%	374	Centros Culturales de Mexico, A.C.,MX
AS201986	93.69%	222	ARPINET Arpinet LLC,AM
AS17660	65.14%	1,374	DRUKNET-AS DrukNet ISP,BT
AS10349	60.29%	763	TULANE - Tulane University,US
AS21107	46.97%	692	BLICNET-AS Blicnet d.o.o.,BA
AS20880	42.65%	762	TELECOLUMBUS Tele Columbus AG,DE
AS12779	36.70%	109	ITGATE IT.Gate S.p.A.,IT
AS46261	35.64%	101	QUICKPACKET - QuickPacket, LLC,US
AS9329	35.29%	119	SLTINT-AS-AP Sri Lanka Telecom Internet,LK
AS52888	27.92%	265	UNIVERSIDADE FEDERAL DE SAO CARLOS,BR
AS30036	27.55%	60,228	Mediacom Communications Corp,US
AS45920	25.77%	163	SKYMESH-AS-AP SkyMesh Pty Ltd,AU
AS210	25.04%	571	WEST-NET-WEST - Utah Education Network,US
AS28343	24.57%	985	TPA TELECOMUNICACOES LTDA,BR
AS7477	21.72%	488	TEREDONN-AS-AP SkyMesh Pty Ltd,AU
AS24173	21.48%	256	NETNAM-AS-AP Netnam Company,VN
AS28580	21.48%	1,341	CILNET Comunicacao e Informatica LTDA.,BR
AS32329	20.63%	126	MONKEYBRAINS - Monkey Brains,US
AS17451	19.35%	248	BIZNET-AS-AP BIZNET NETWORKS,ID
AS5707	19.35%	155	UTHSC-H - The University of Texas Health

It's not good!

IPv6 Unicast Failure rate: 1.6% (falling)

IPv4 Failure rate: 0.2% (steady)

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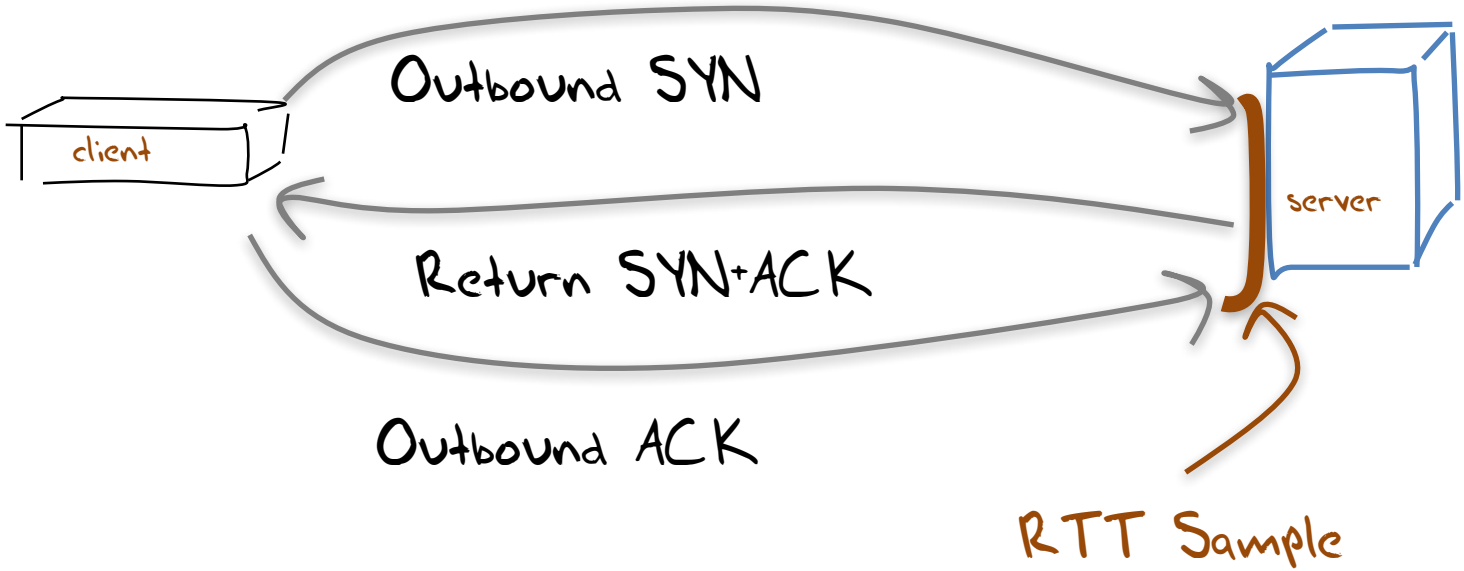


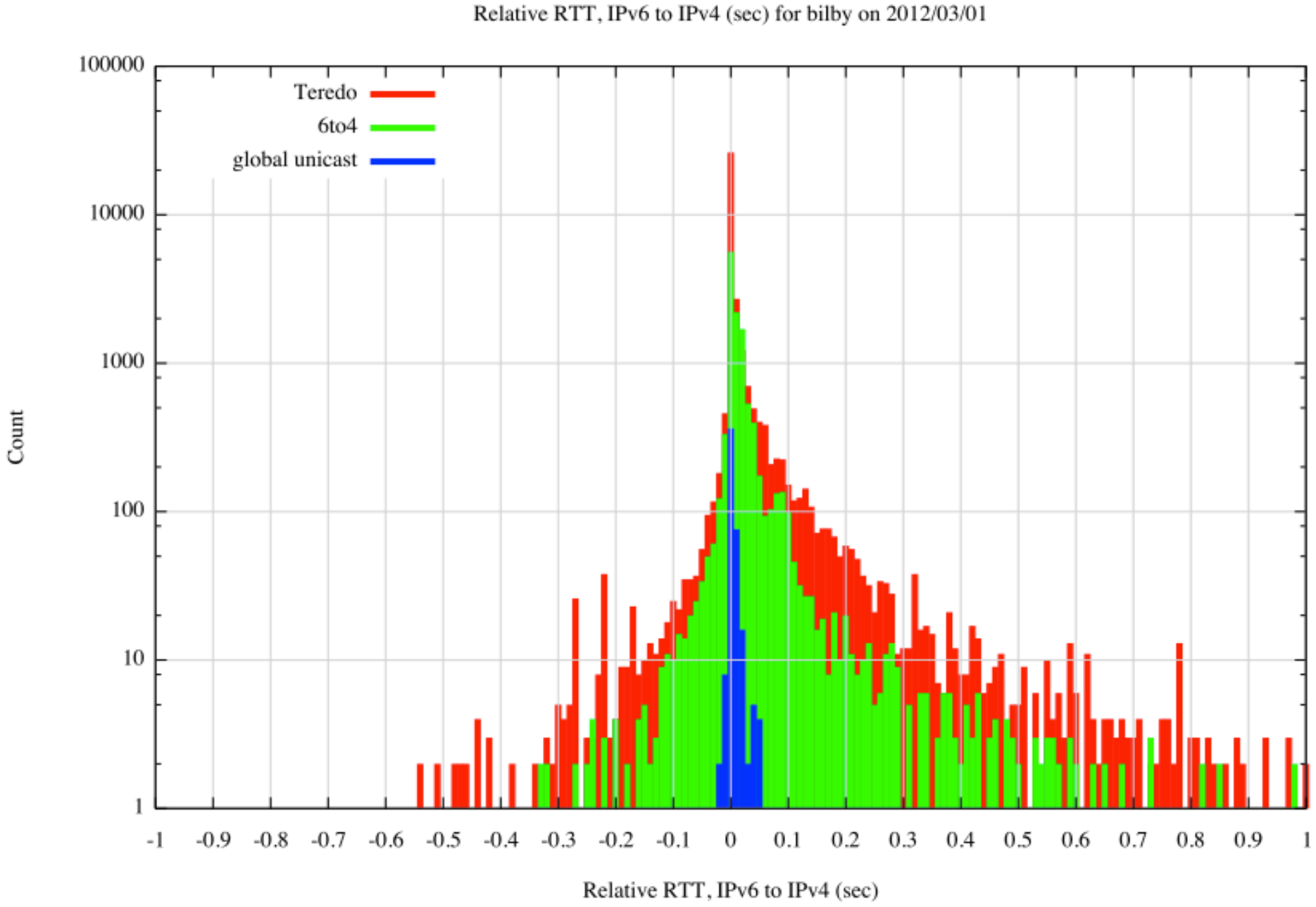
Why SYN Handshakes?

- Every TCP session starts with a SYN handshake
- It's typically a kernel level operation, which means that there is little in the way of transport protocol or application level interaction with the SYN exchange
- On the downside there is only a single sample point per measurement

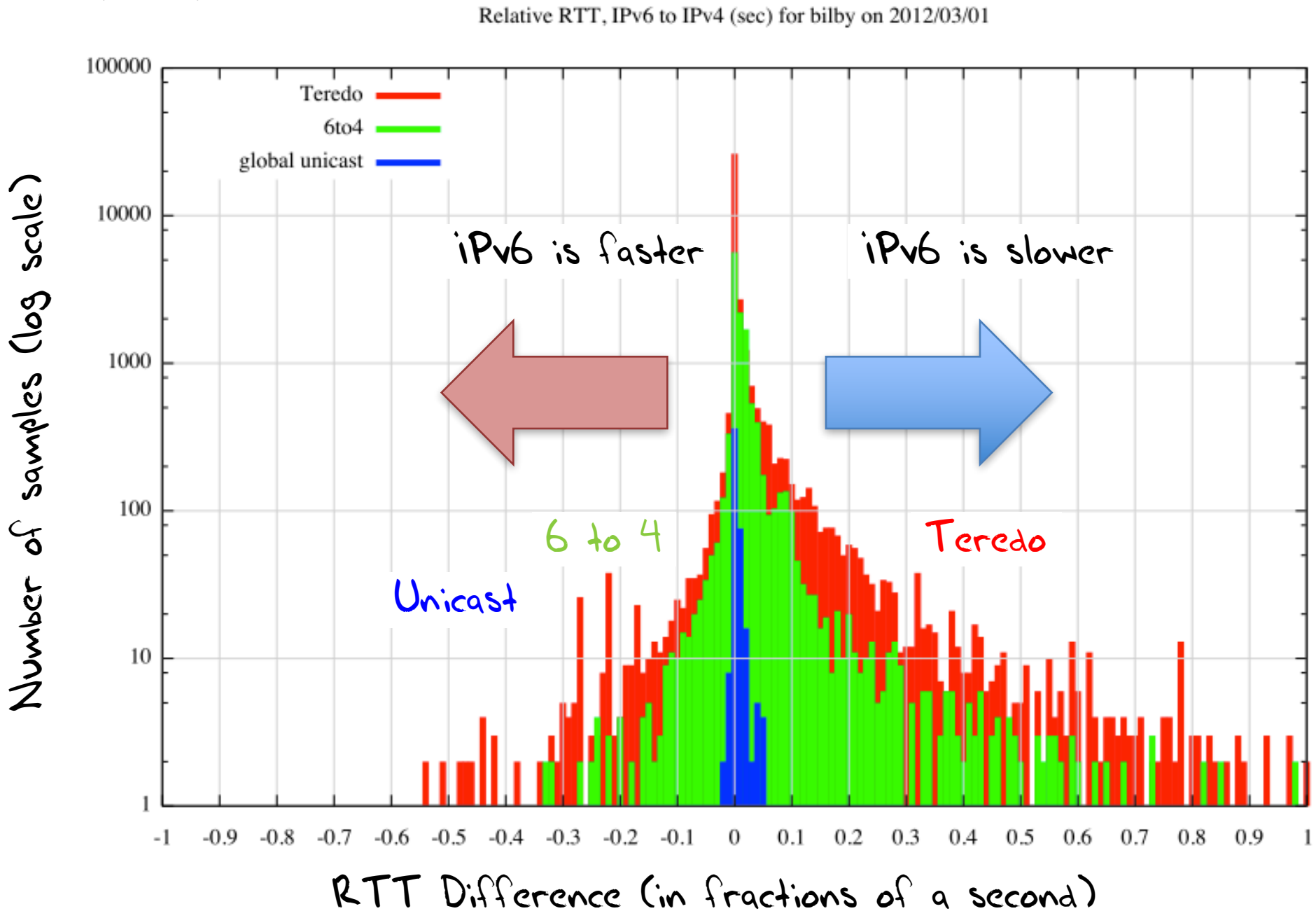
Generating a comparative RTT profile

- For each successful connection couplet (IPv4 and IPv4) from the same endpoint, gather the pair of RTT measurements from the SYN-ACK exchanges
  - Use the server's web logs to associate a couplet of IPv4 and IPv6 addresses
  - Use the packet dumps to collect RTT information from the SYN-ACK Exchange
  - Plot the difference in RTT in buckets

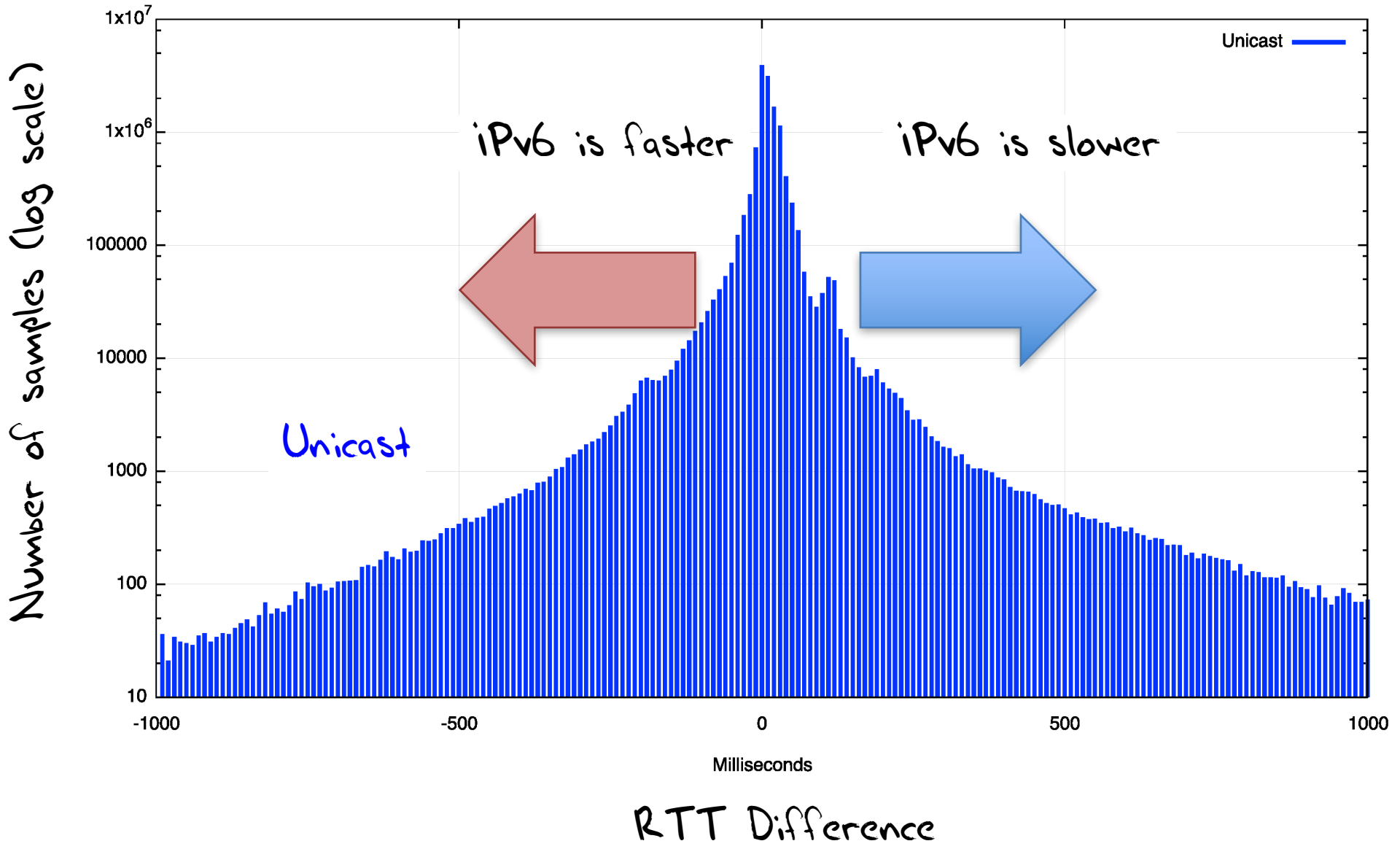
2012 Data


Relative RTT, IPv6 to IPv4 (sec) for bilby on 2012/03/01
Teredo
6to4
global unicast
Count
100000
10000
1000
100
10
1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Relative RTT, IPv6 to IPv4 (sec)

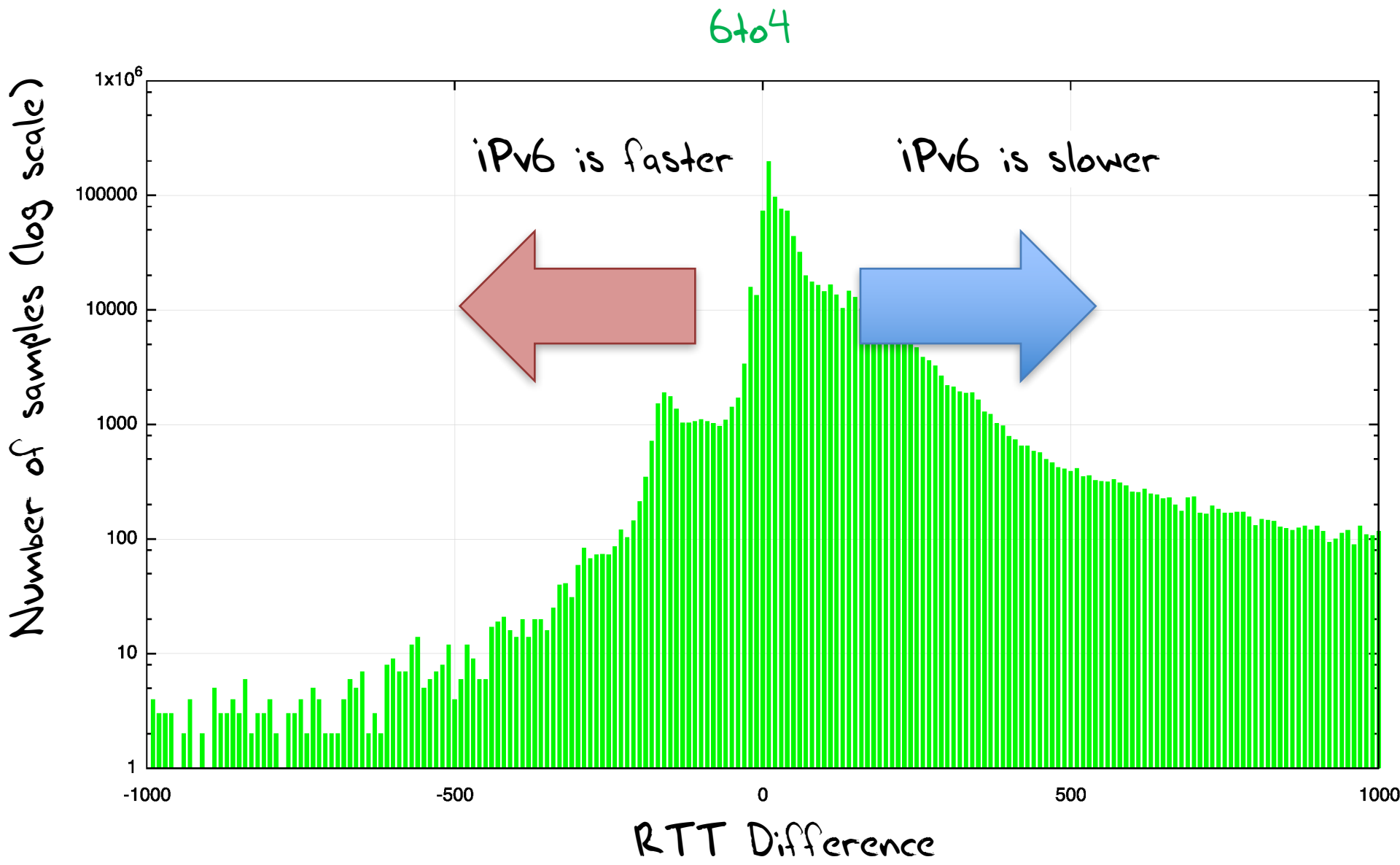
2012 Data


Relative RTT, IPv6 to IPv4 (sec) for bilby on 2012/03/01
Teredo
6to4
global unicast
IPv6 is faster
IPv6 is slower
6 to 4
Teredo
Unicast
Number of samples (log scale)
100000
10000
1000
100
10
1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
RTT Difference (in fractions of a second)

December 2015/January 2016



December 2015/January 2016



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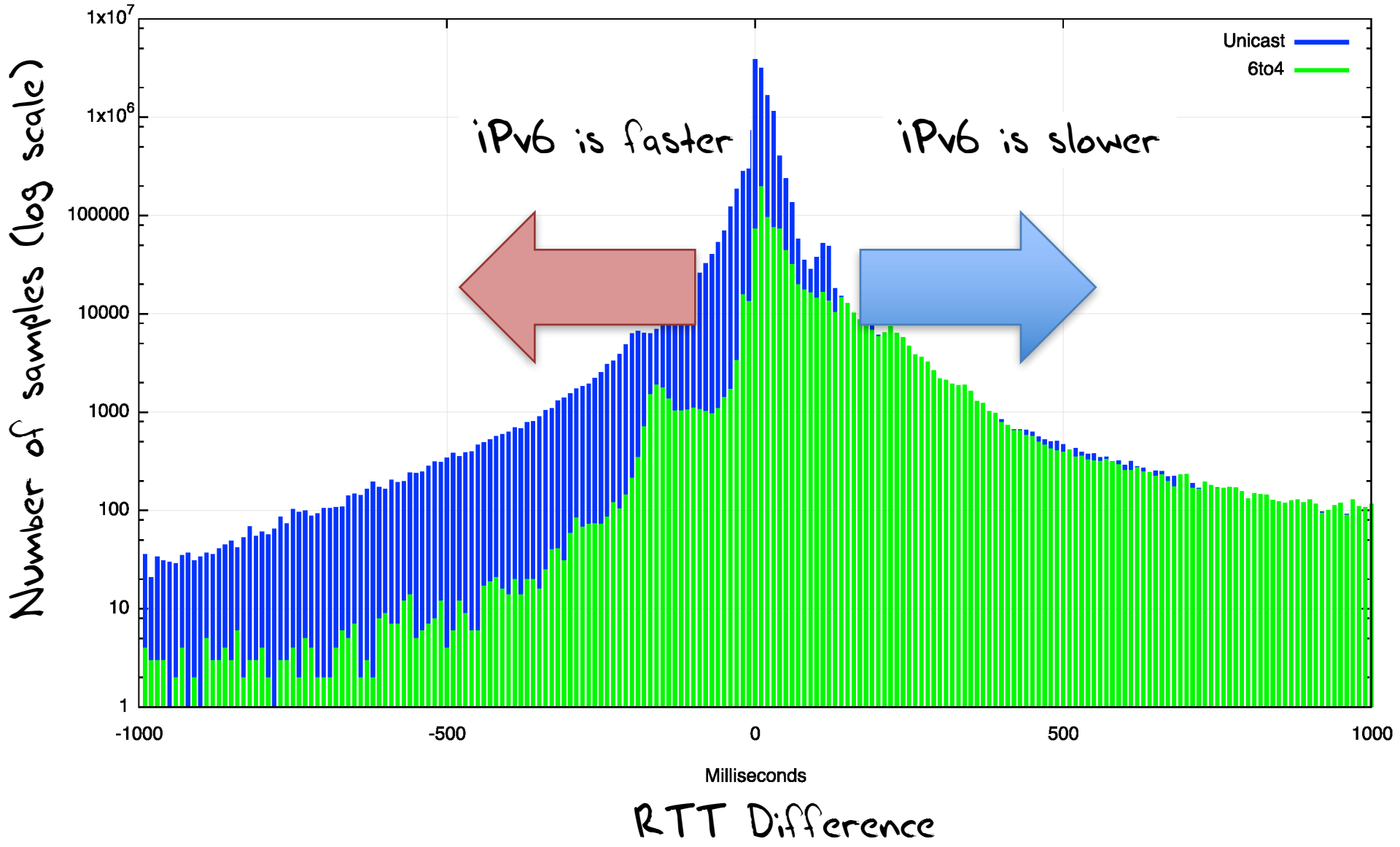
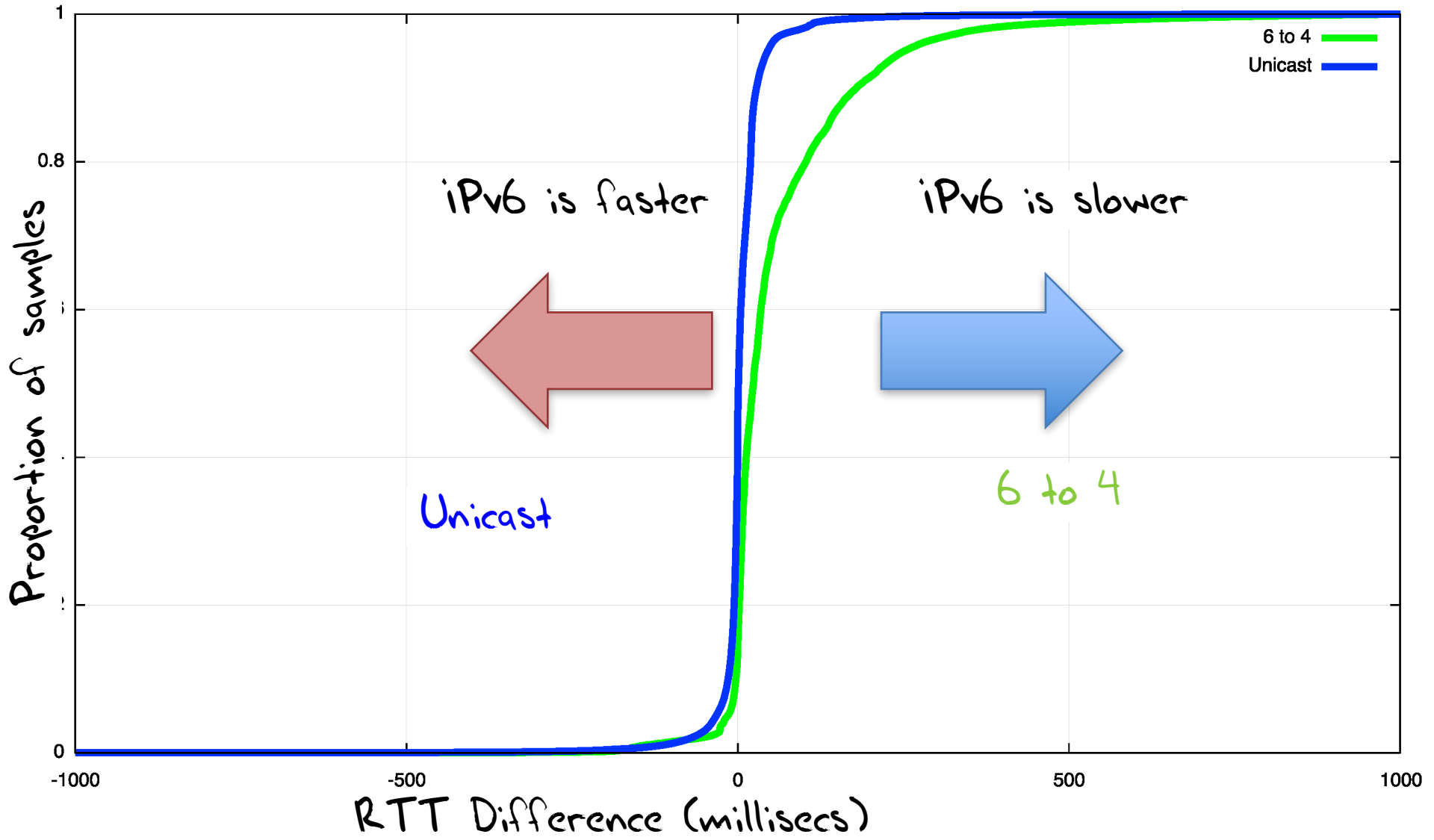


2015/6 RTT Data CDF



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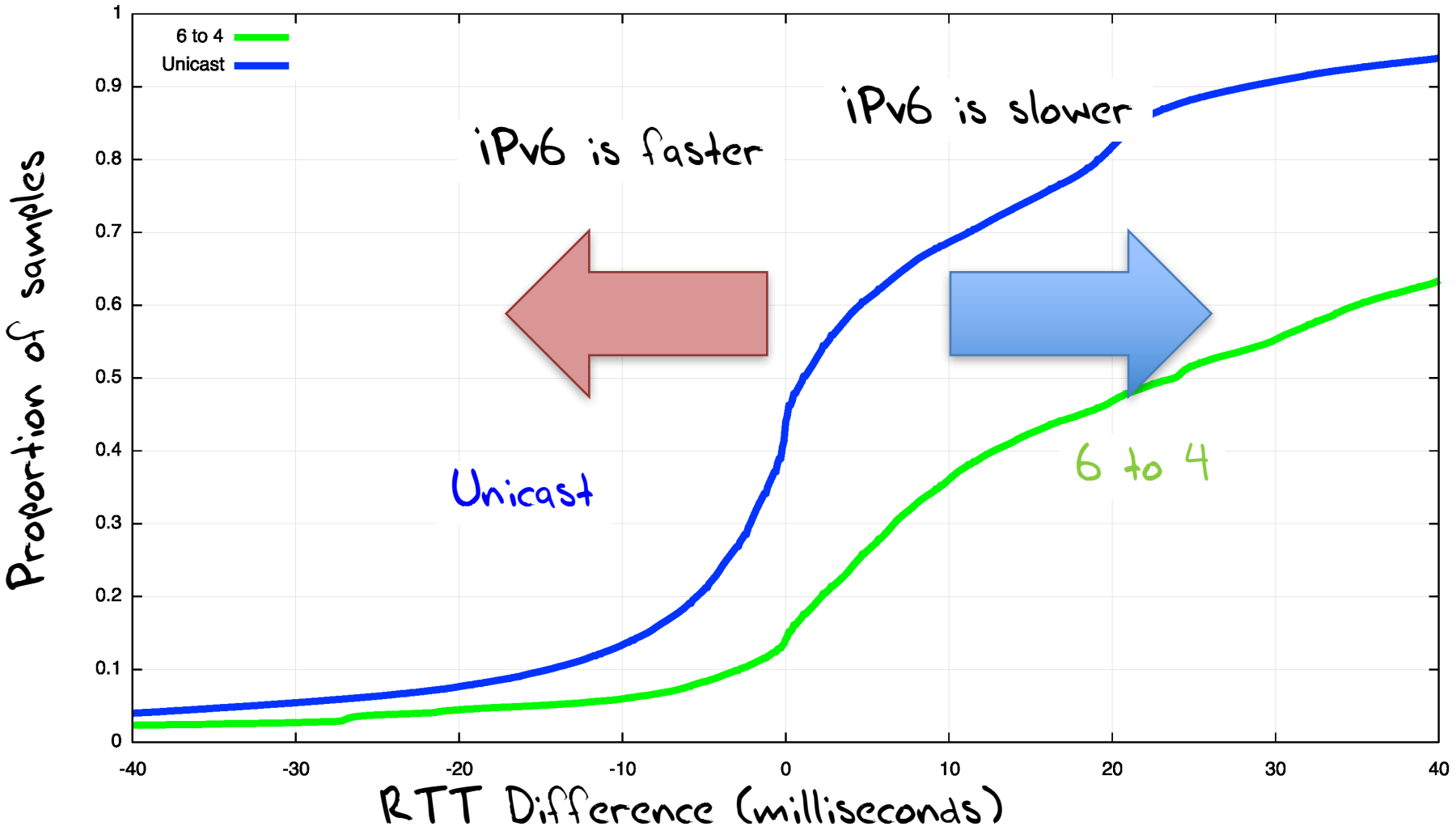

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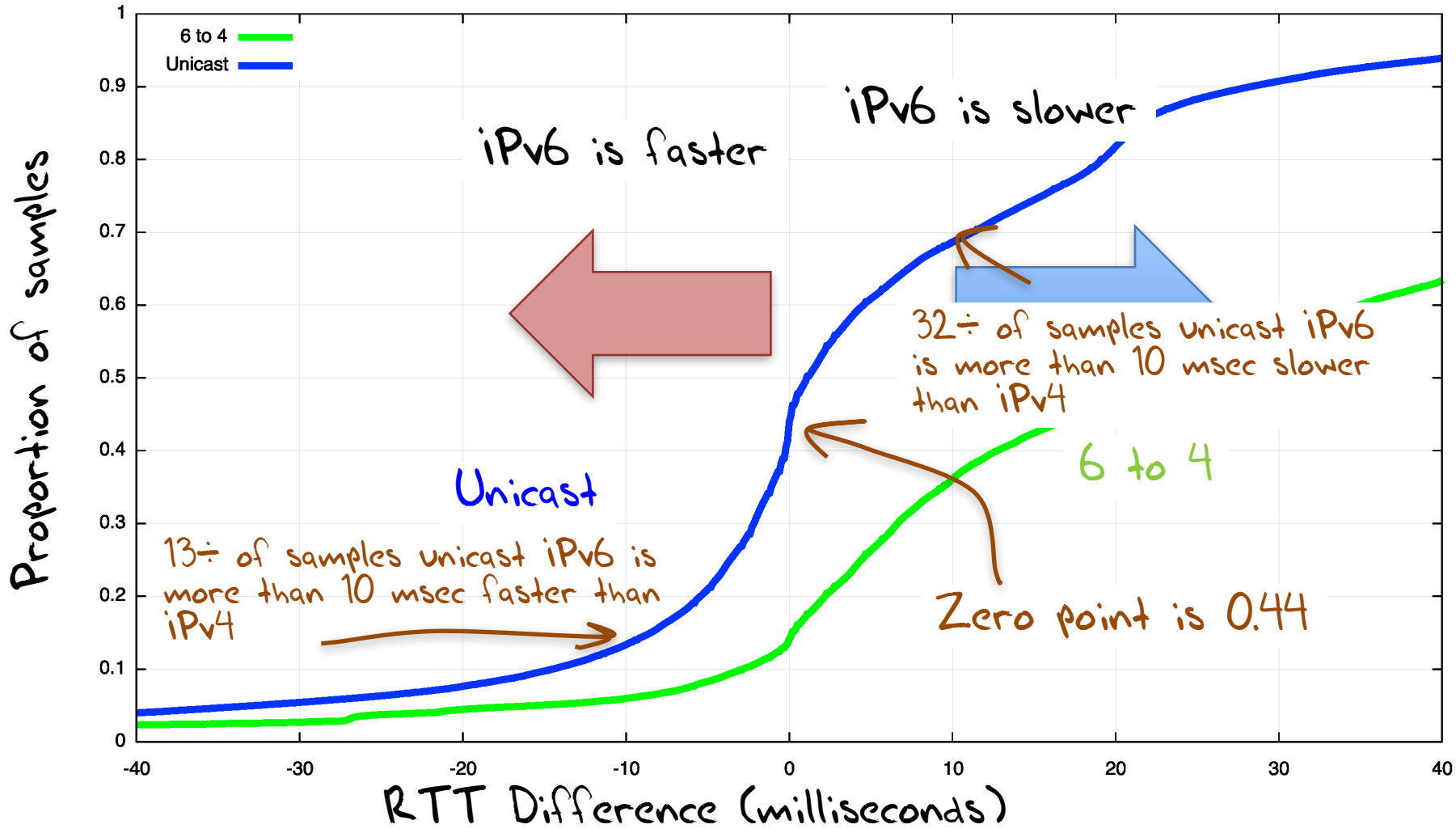


Mapping the Data

Convert the IPv4/IPv6 data points into Origin AS and Country Code

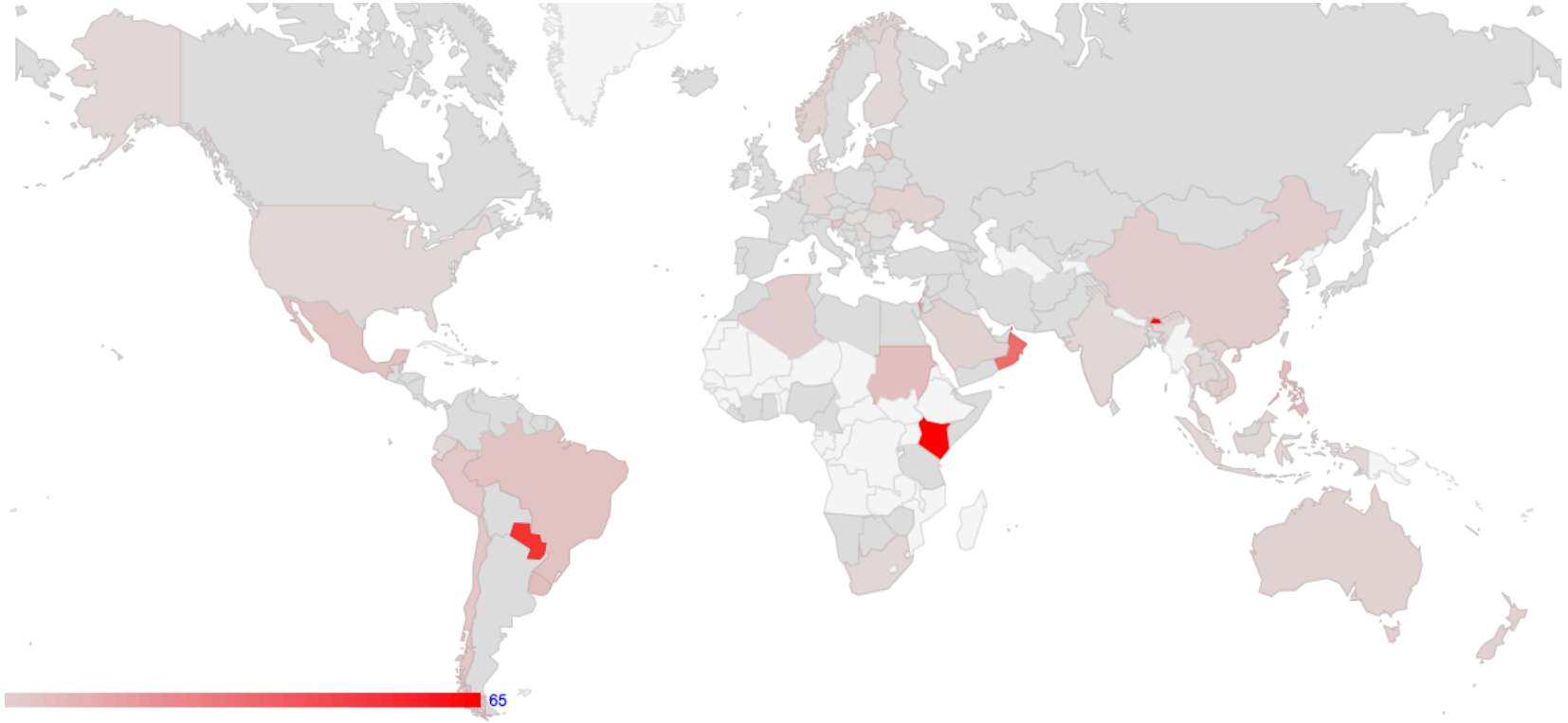
RTT:

- Compute Relative RTT by simple subtraction (IPv6 RTT – IPv4 RTT)
- Compute the Mean and the Mean Standard Deviation
- Strip out data points > 1 MSTD from the Mean
- Add data to daily Country and Origin AS data sets

Connection:

- Compute the ratio of failed IPv6 to total seen IPv6
- Add data to daily Country and Origin AS data sets

The Connection Reliability Map

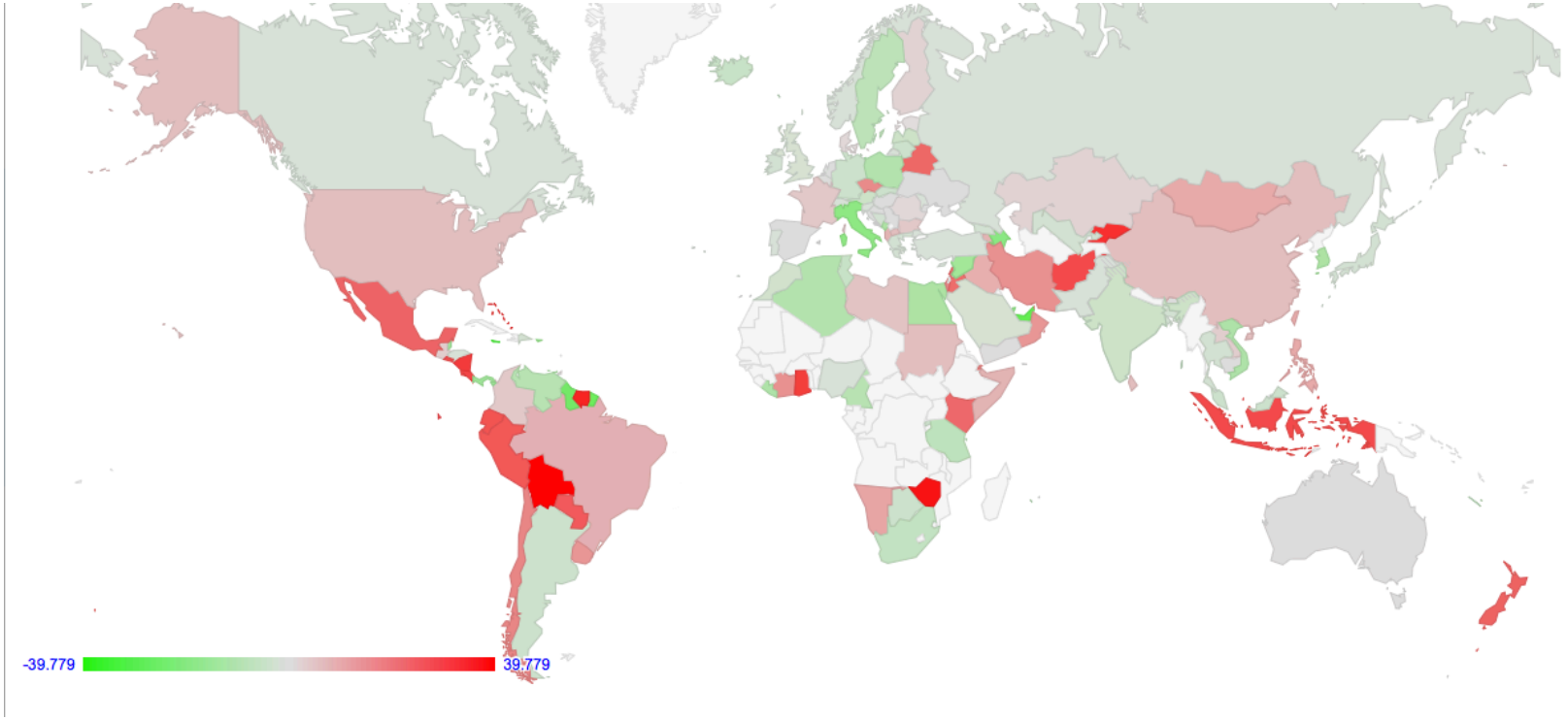


This is a 30 day average value of V6 systems. Units are %

http://stats.labs.apnic.net/v6perf

The Relative Performance Map

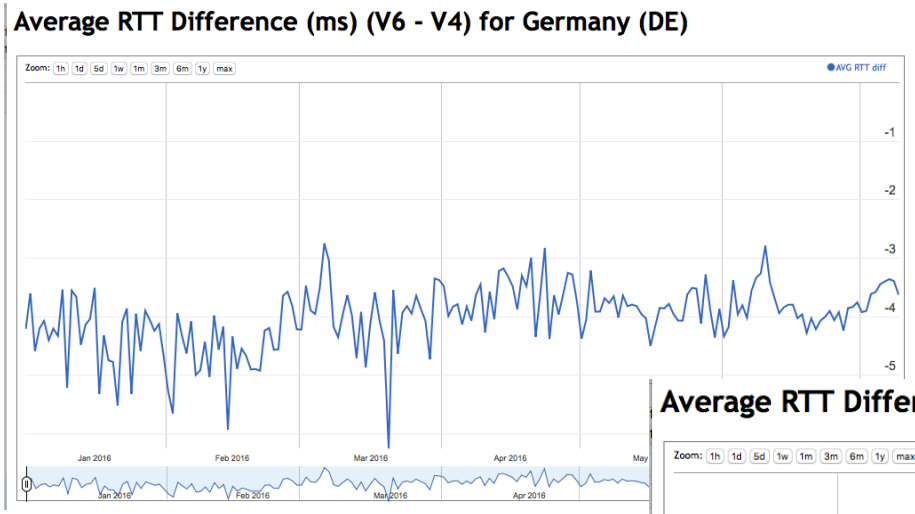
IPv6 – IPv4

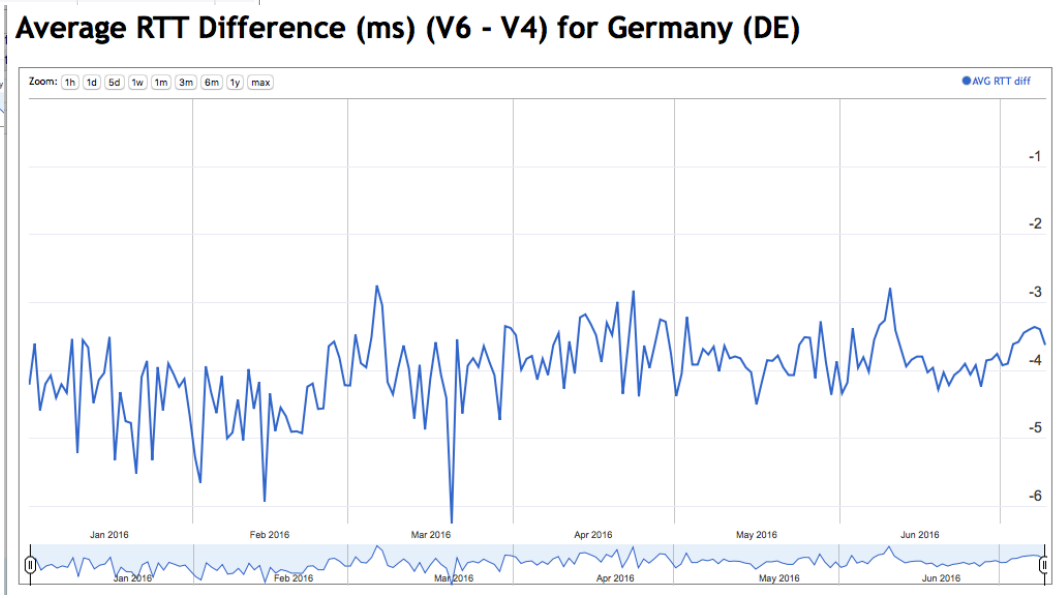


This is a 30 day average value of dual stack systems, comparing the V6 RTT to the V4 RTT by simple subtraction. Units are MS

http://stats.labs.apnic.net/v6perf

Country and per-AS reports





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Questions to you…

- is this helpful information?
- is the layout useful or not?
- What other views would be helpful to you?

Thanks!