

# IPv6 Performance

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APNIC Labs  
November 2015

# What are we looking at:

- How “reliable” are IPv6 connections?
- How “fast” are IPv6 connections?

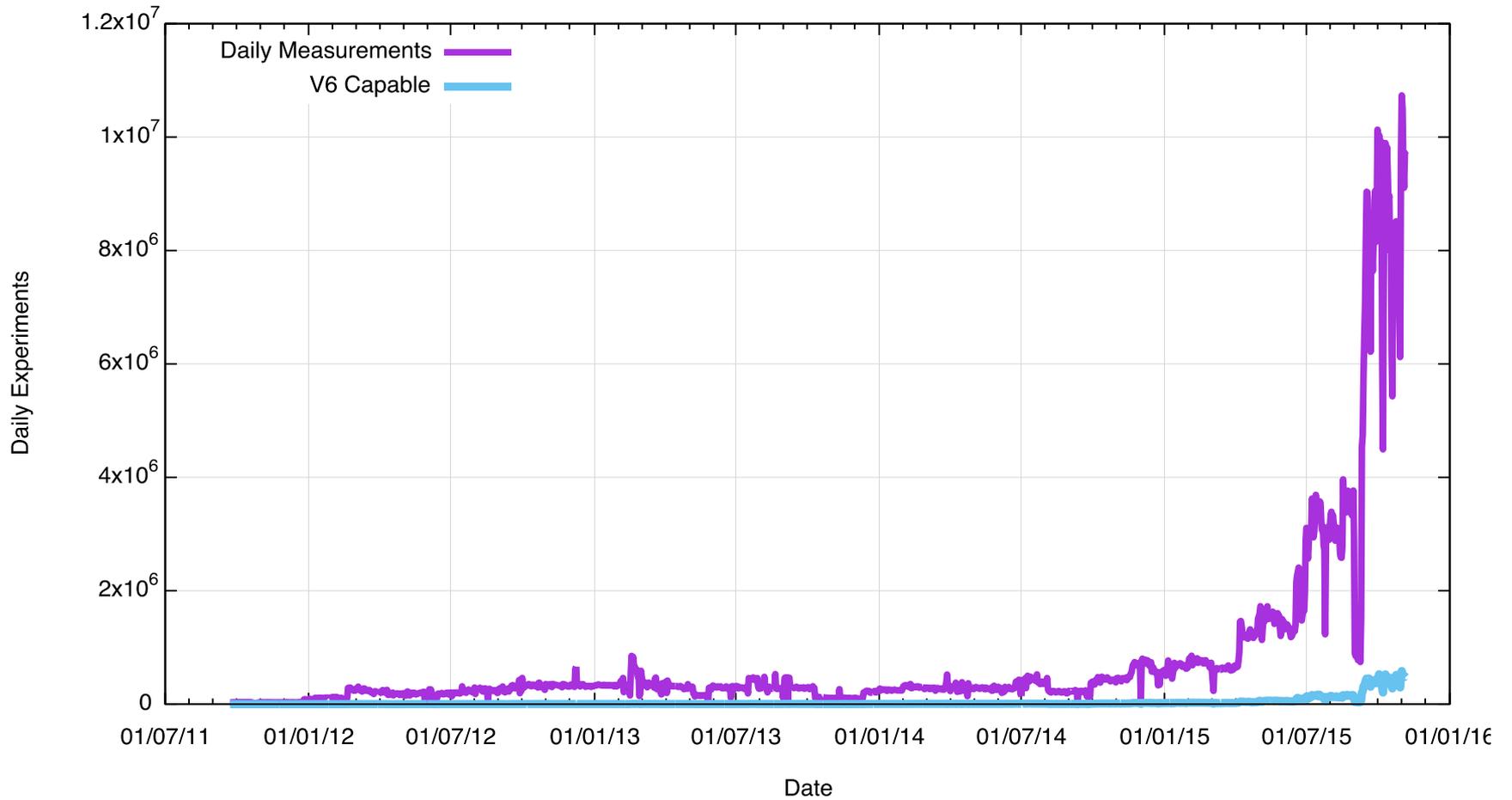
# What are we looking at:

- How “reliable” are IPv6 connections?  
Do all TCP connection attempts succeed?
- How “fast” are IPv6 connections?  
is V6 slower than V4?

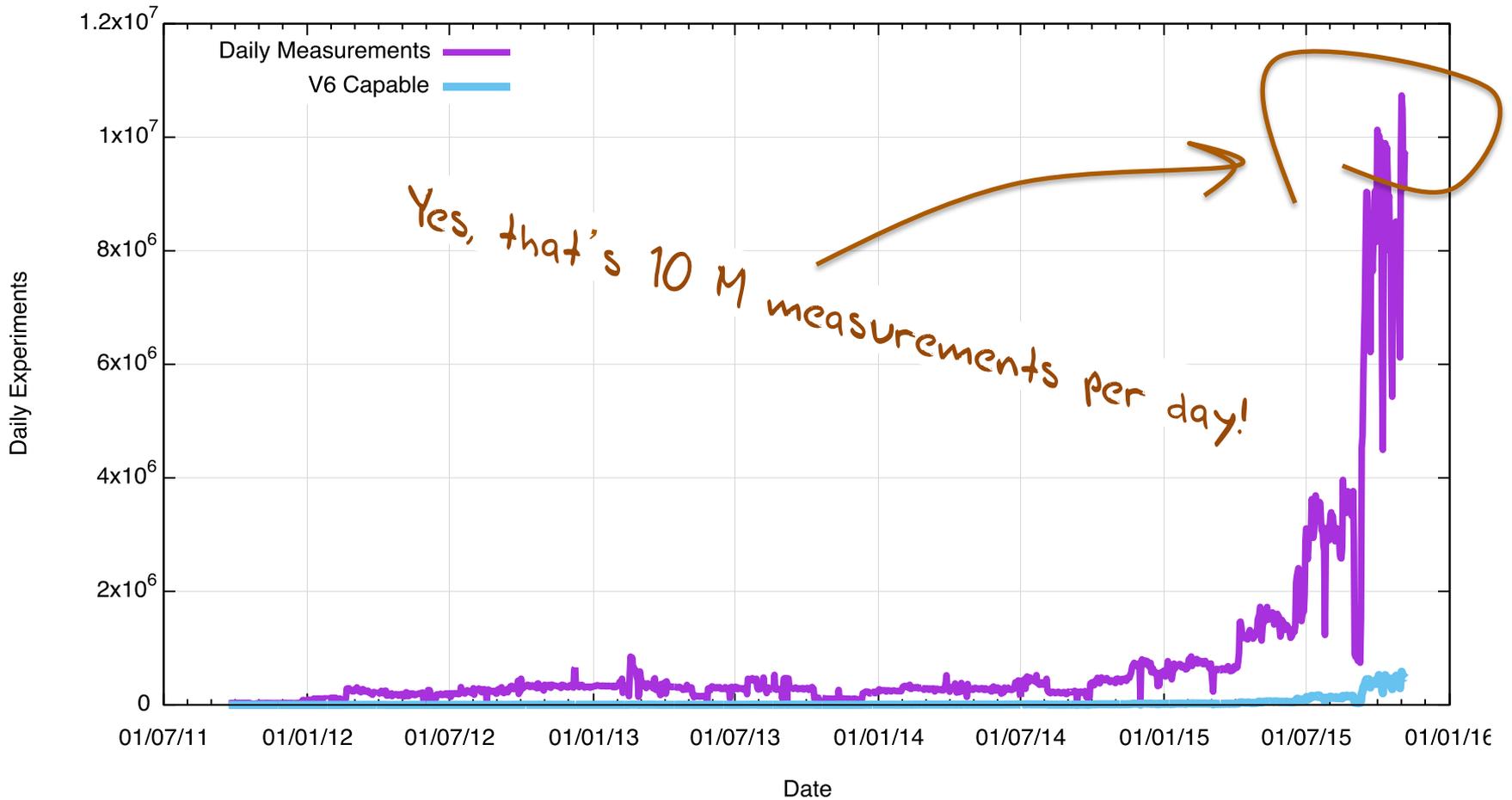
# The Measurement Technique

- Embed a script in an online ad
- Have the script generate a set of URLs to fetch
- Examine the packets seen at the server to determine reliability and RTT

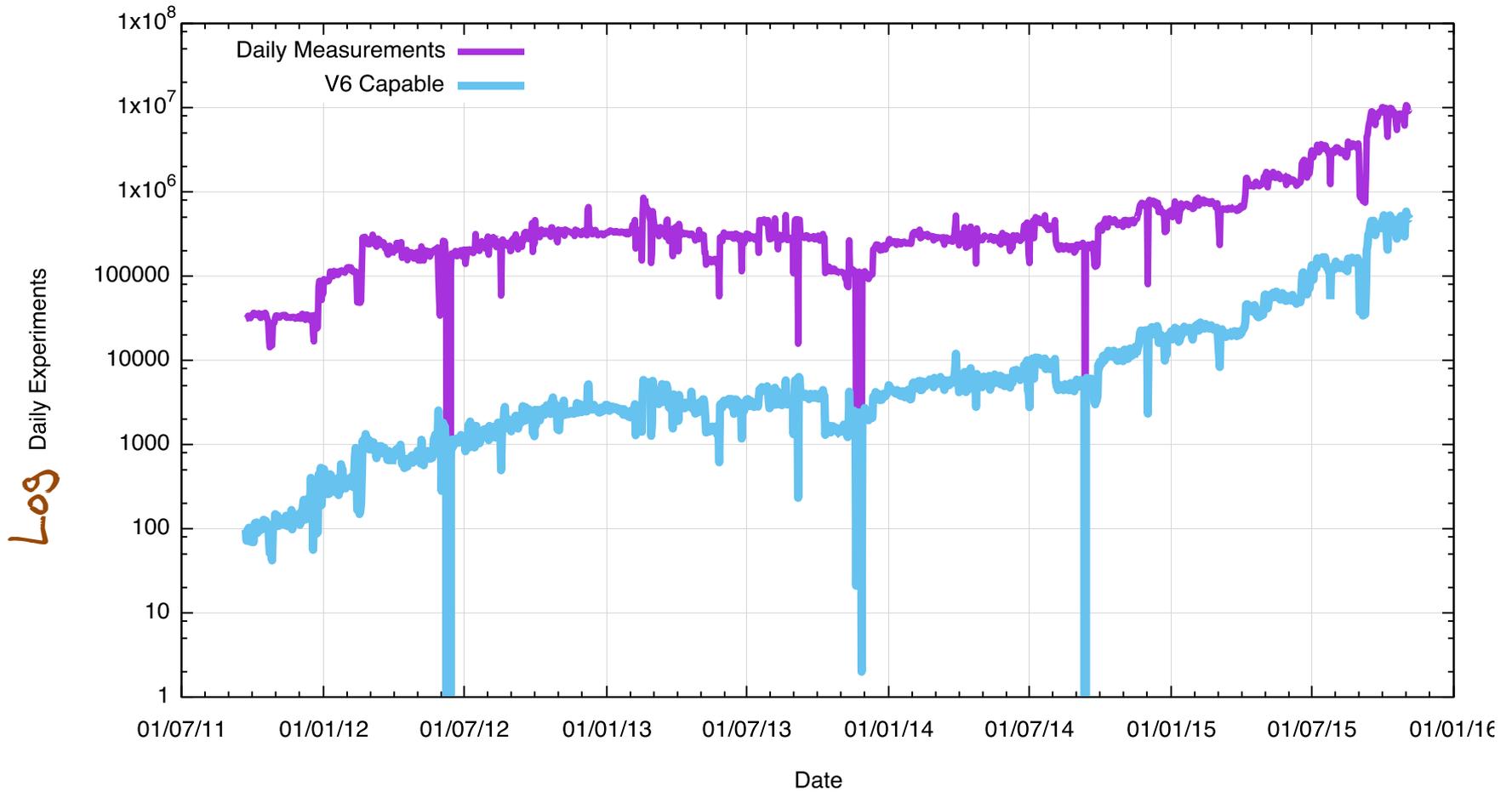
# Measurement Count



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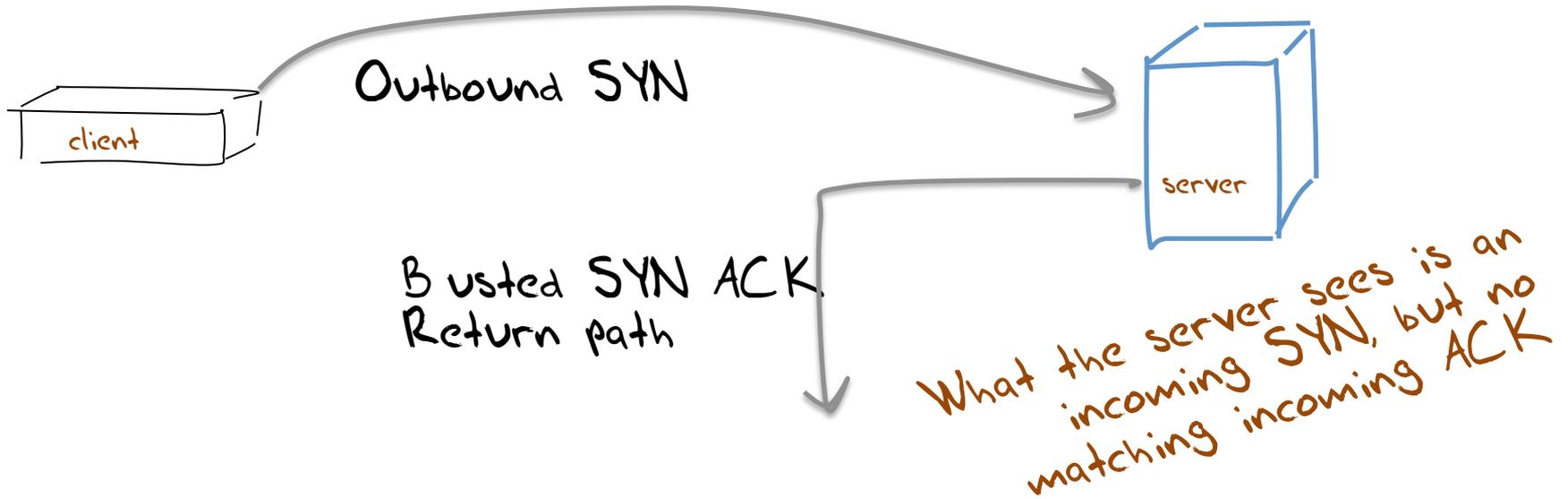
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# What are we looking at:

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# Connection Failure

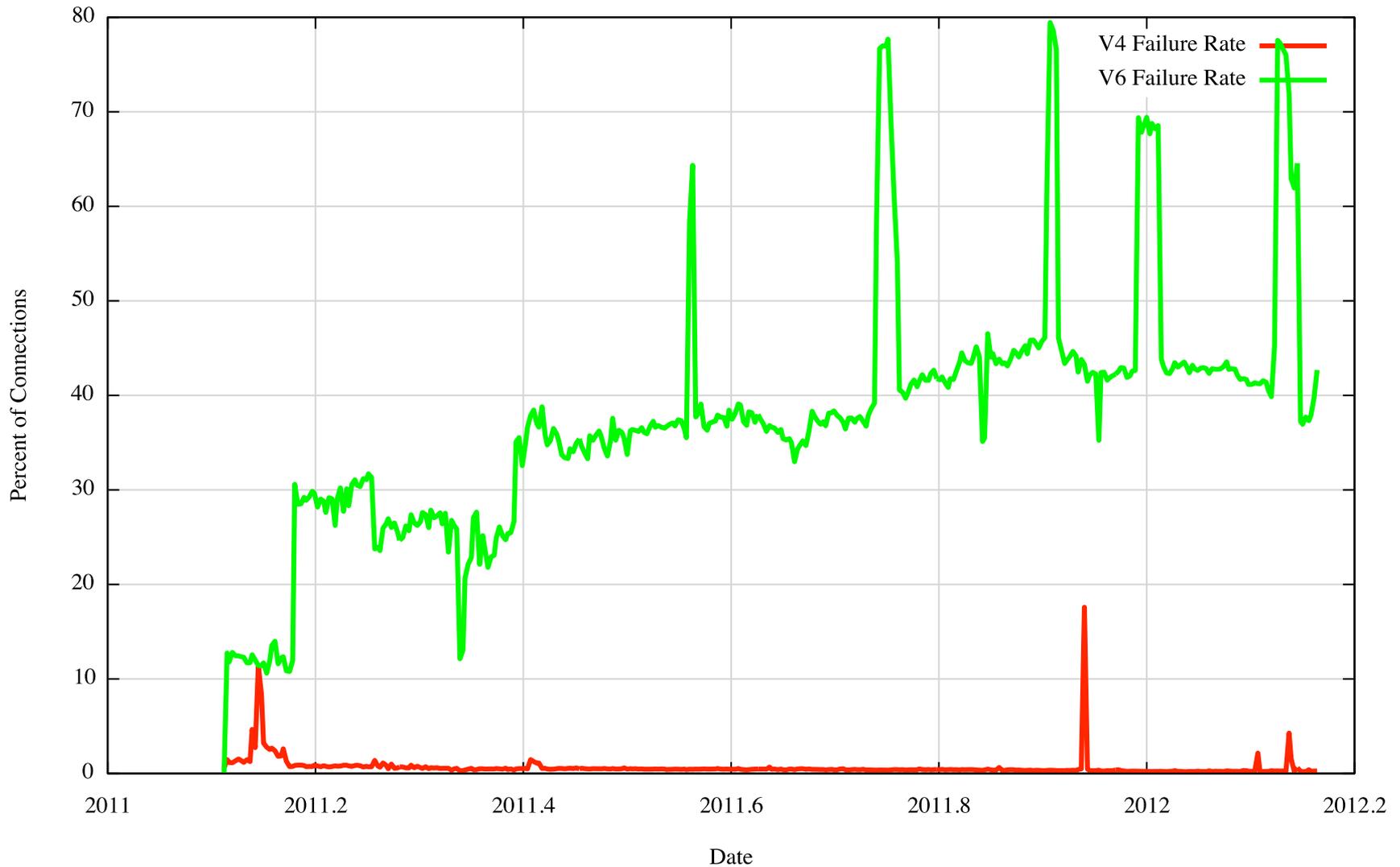


# Compare two data sets

- 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
  - Missing comparative IPv4 data for the period September – October ☹️

# 2011 - Measuring Failure

Connection Failure Rate



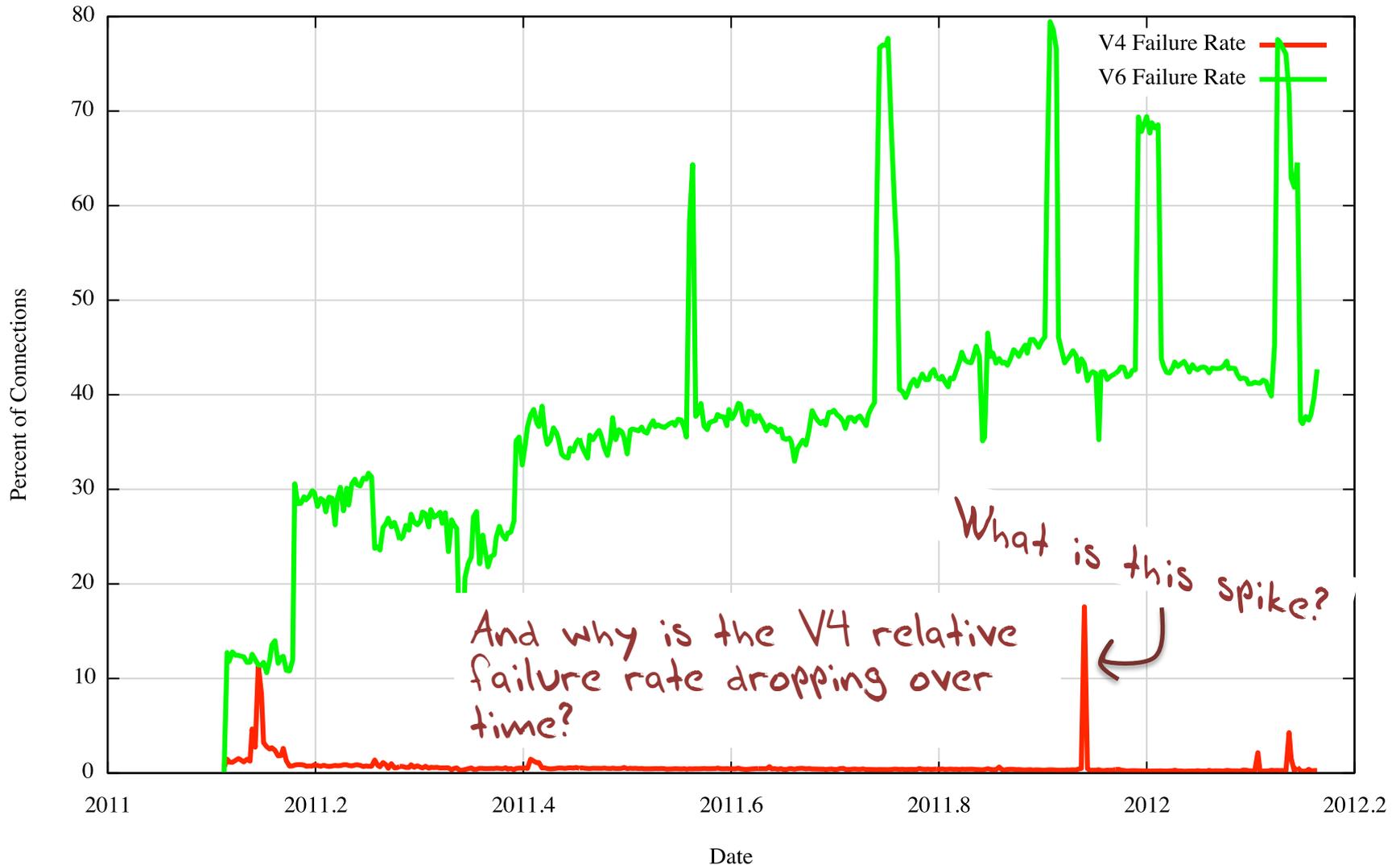
# 2011 - Relative Connection Failure Rates

Connection Failure Rate



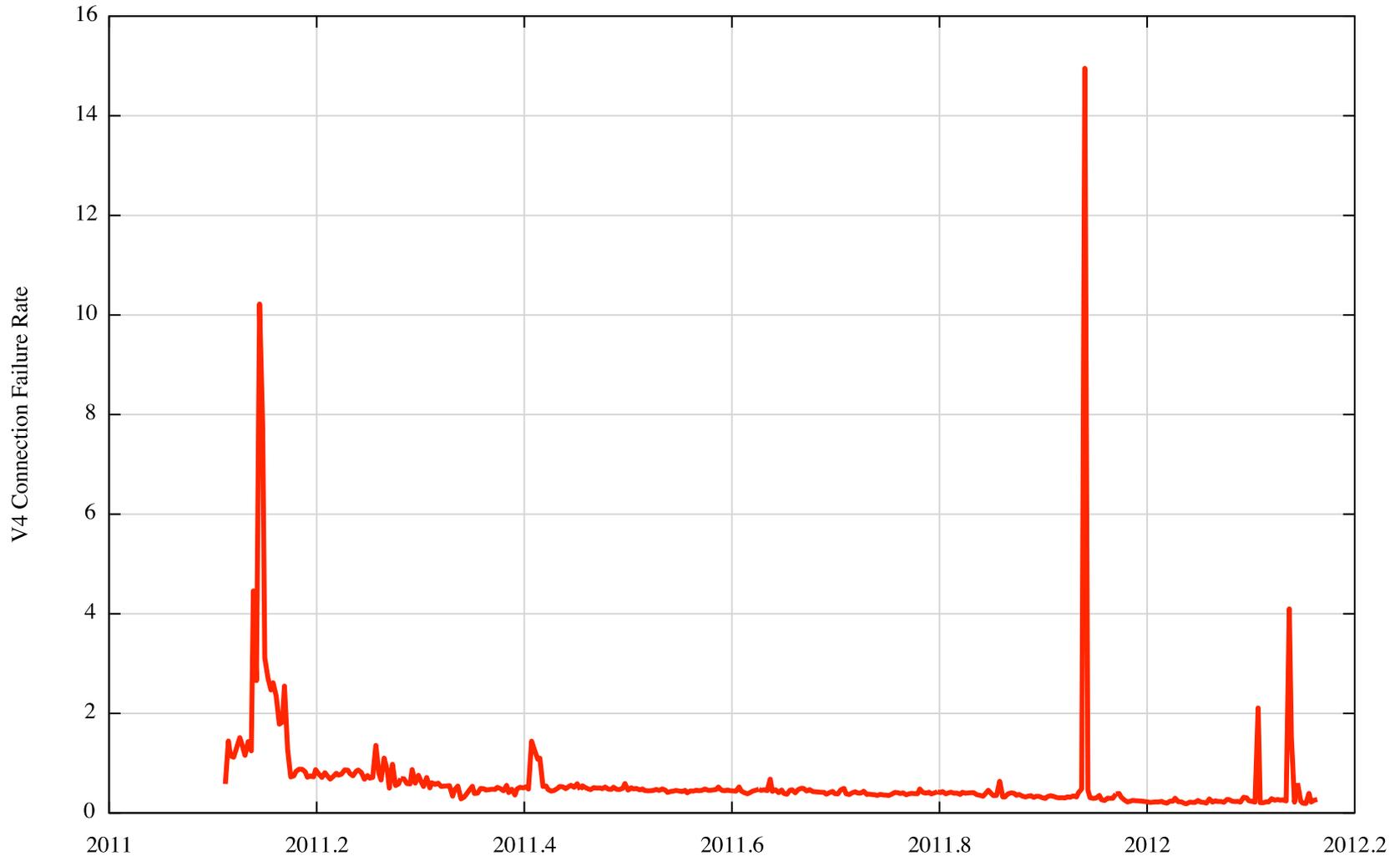
# 2011 - Relative Connection Failure Rates

Connection Failure Rate



# What is going on with IPv4?

Connection Failures - IPv4



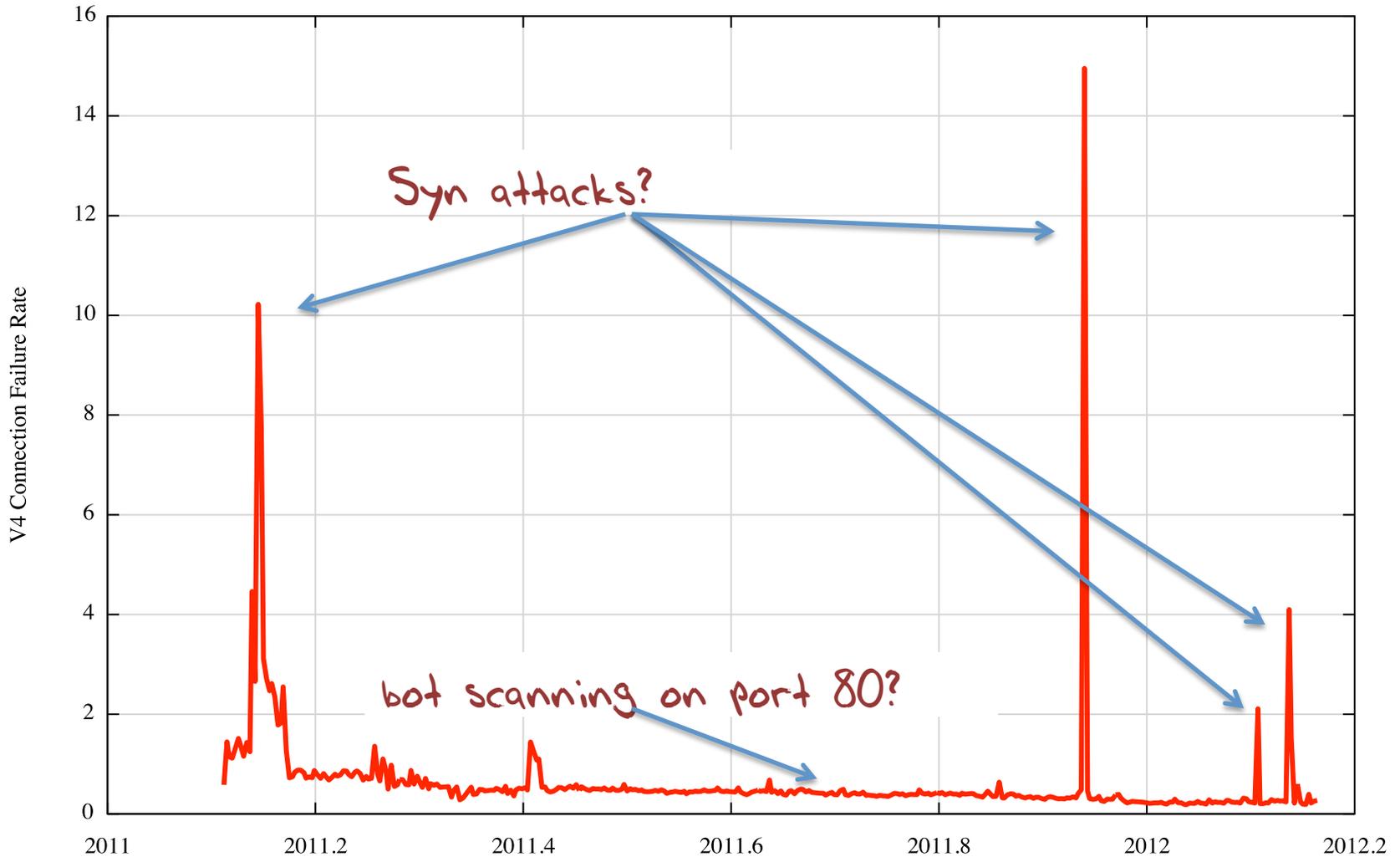
# What is going on with IPv4?

The failure rate for V4 decreases as the volume of experiments increases – which implies that the number of “naked SYNs” being sent to the servers is not related to the number of tests being performed.

Aside from residual IPv4 failures in the image fetch due to device resets, connection dropouts, etc, the bulk of the recorded failures here is probably attributable to ~~researchers~~ bots doing all-of-address scanning on port 80

# What is going on with IPv4?

Connection Failures - IPv4



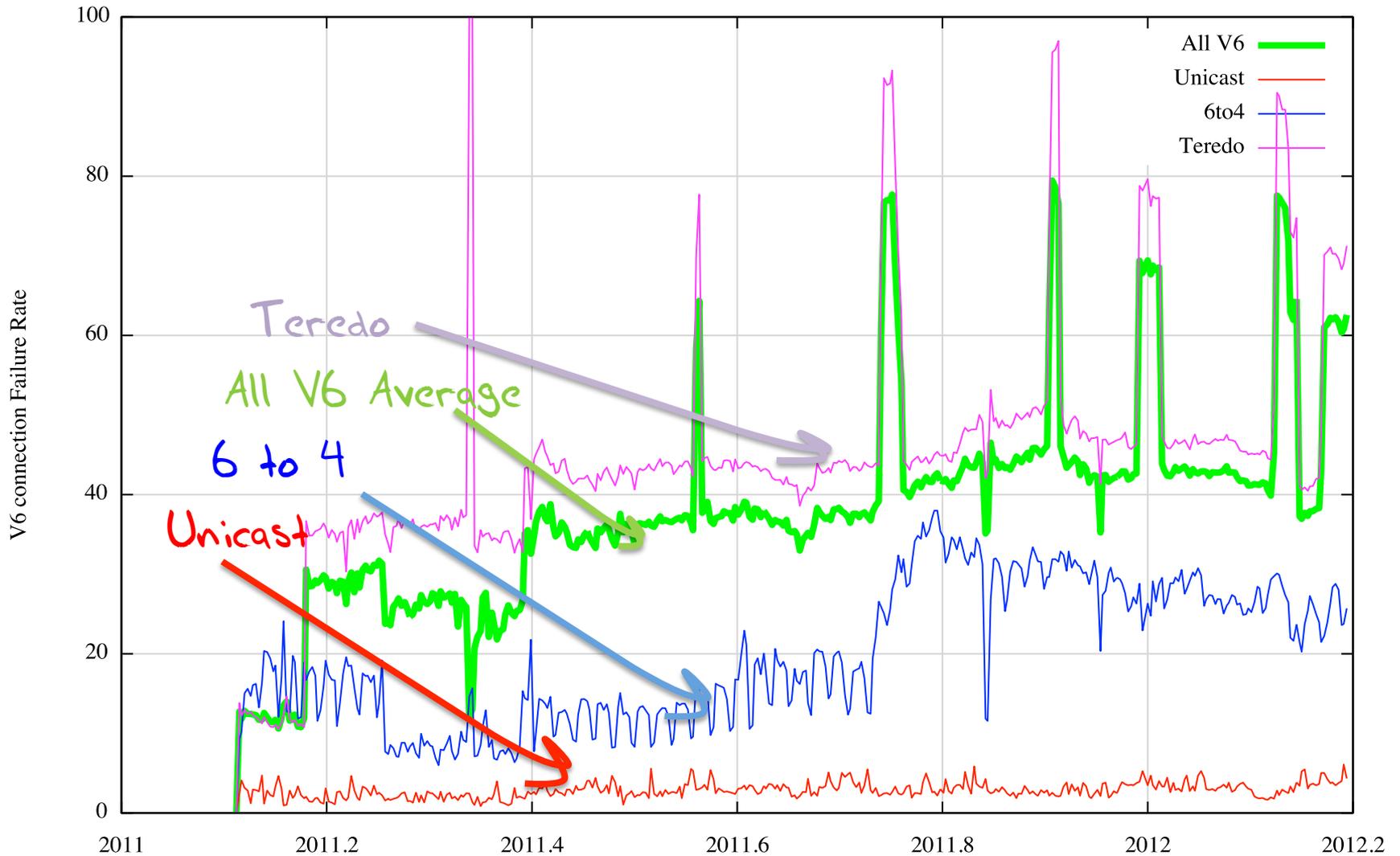
# What about IPv6?

Connection Failure Rate - V6



# V6 Failure Rate by Address Type

Connection Failure Rate - V6



# 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

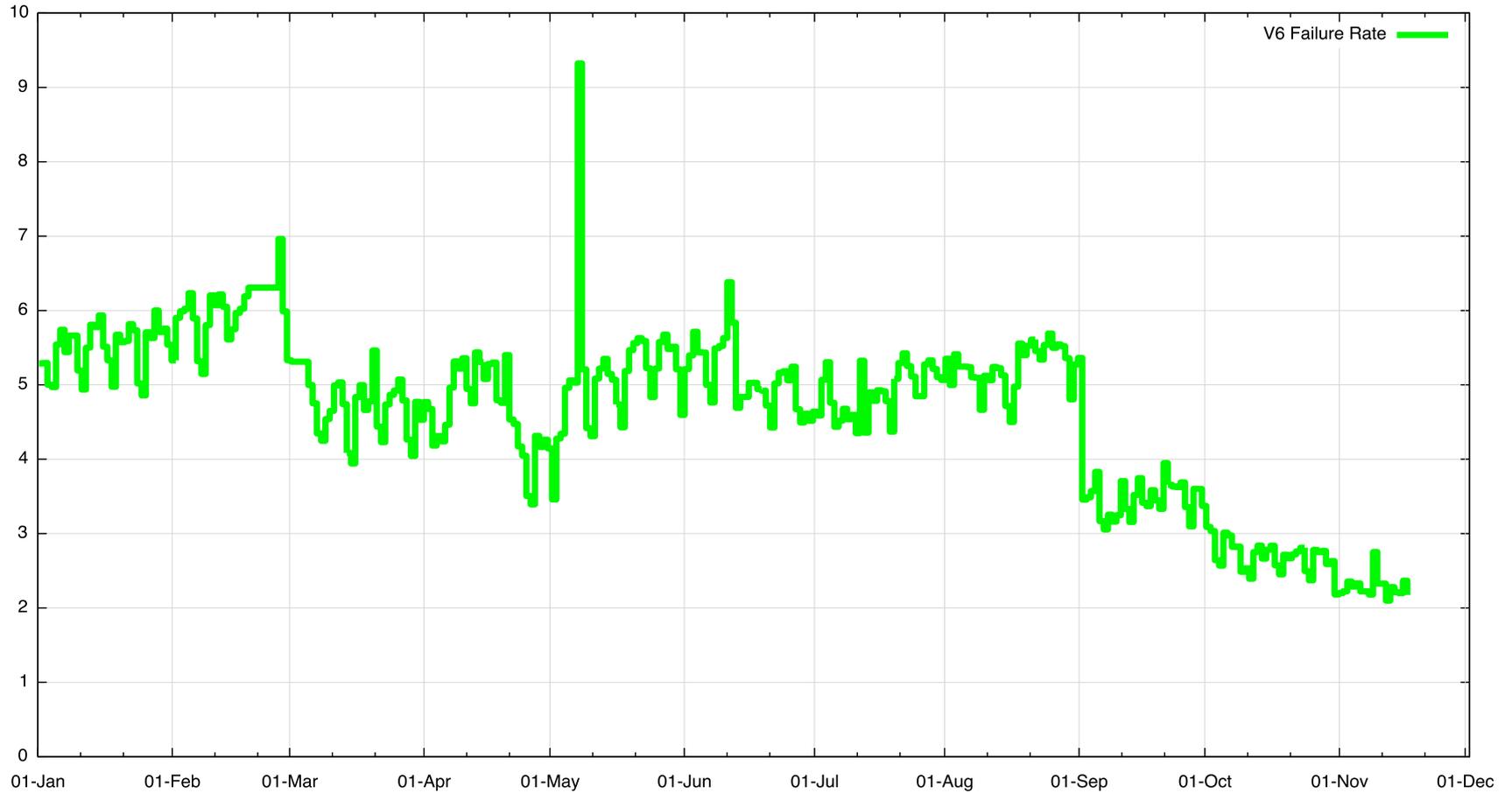
January– November 2015

24,212,563 IPv6 endpoints

352,919 Failure rate (4.1%)

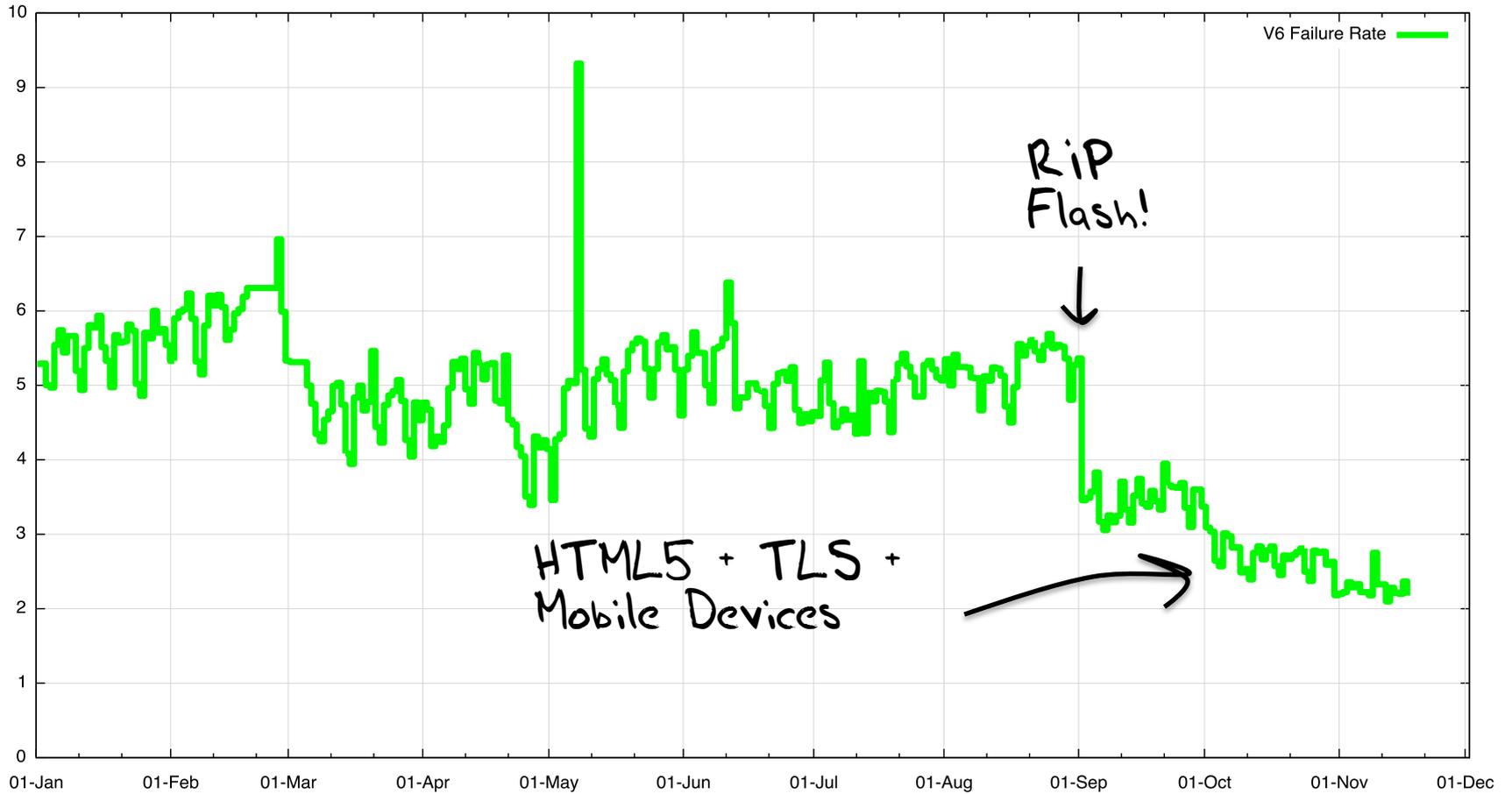
# Daily IPv6 Failures

Connection Failure Rate - 2015



# Daily IPv6 Failures

Connection Failure Rate - 2015



# 6to4

6,634,660 6to4 endpoints

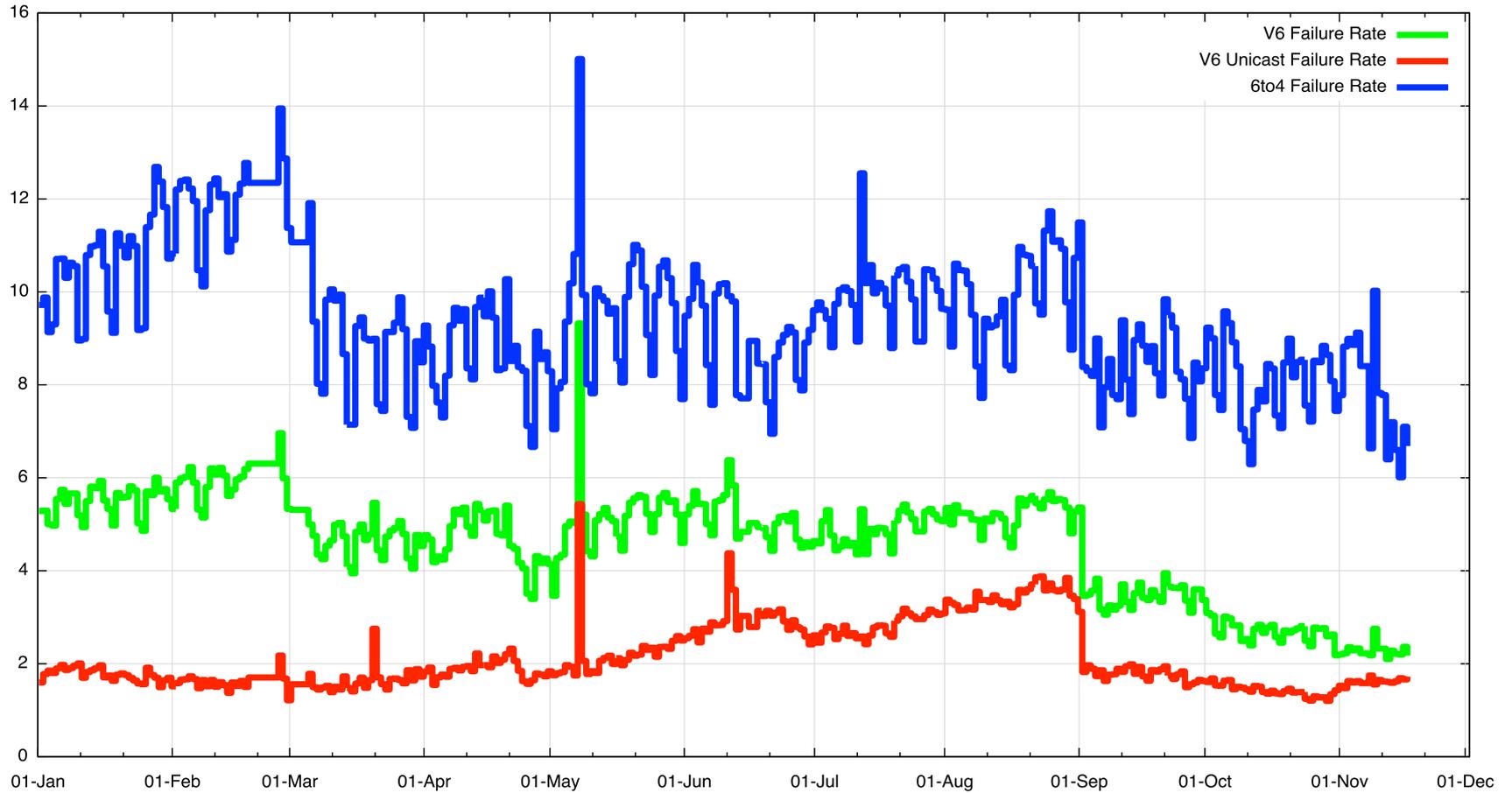
– 27% of all IPv6 used 6to4

– 9% failure rate within the set of 6to4 connections

*This is still very high!*

# Daily IPv6 Failures

Connection Failure Rate - 2015



# 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%

# Origin AS's with High IPv6 Failure Rates

AS	Failure Rate	Samples	AS Name
AS13679	99.69%	318	Centros Culturales de Mexico, A.C., MX
AS201986	94.74%	133	ARPINET Arpinet LLC, AM
AS5511	90.68%	161	OPENTRANSIT Orange S.A., FR
AS20880	72.56%	962	TELECOLUMBUS Tele Columbus AG, DE
AS17660	57.06%	1,041	DRUKNET-AS DrukNet ISP, BT
AS21107	46.64%	7,564	BLICNET-AS Blicnet d.o.o., BA
AS4755	40.82%	316	TATACOMM-AS TATA Communications formerly VSNL is Leading ISP, IN
AS37992	40.25%	159	THAMMASAT-BORDER-AS Thammasat University in thailand, TH
AS28580	39.64%	1,158	CILNET Comunicacaoe Informatica LTDA., BR
AS17412	35.58%	163	WOOSHWIRELESSNZ Woosh Wireless, NZ
AS52207	33.62%	931	TULA-AS JSC "ER-Telecom Holding", RU
AS4796	32.61%	414	BANDUNG-NET-AS-AP Institute of Technology Bandung, ID
AS30036	30.59%	17,001	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom Communications Corp, US
AS9329	29.35%	184	SLTINT-AS-AP Sri Lanka Telecom Internet, LK
AS7477	28.10%	153	TEREDONN-AS-AP SkyMesh Pty Ltd, AU
AS52888	25.79%	190	UNIVERSIDADE FEDERAL DE SAO CARLOS, BR
AS28343	24.52%	681	TPA TELECOMUNICACOES LTDA, BR
AS210	22.27%	247	WEST-NET-WEST - Utah Education Network, US
AS29632	19.25%	239	NASSIST-AS NetAssist LLC, UA
AS20857	18.10%	105	TRANSIP-AS TransIP B.V., NL

# Origin AS's with Zero Failure Rates

AS3223	0.00%	3,138	VOXILITY Voxility S.R.L., RO
AS16265	0.00%	2,761	LEASEWEB-NETWORK LeaseWeb Network B.V., NL
AS24961	0.00%	2,644	MYLOC-AS myLoc managed IT AG, DE
AS39832	0.00%	1,945	NO-OPERA Opera Software ASA, NO
AS2686	0.00%	1,824	ATGS-MMD-AS - AT&T Global Network Services, LLC, US
AS33070	0.00%	1,633	RMH-14 - Rackspace Hosting, US
AS55536	0.00%	1,351	PSWITCH-HK PACSWITCH GLOBAL IP NETWORK, HK
AS21191	0.00%	1,210	ASN-SEVERTTK Closed Joint Stock Company TransTeleCom, RU
AS22584	0.00%	1,165	NTELOS-PCS - Ntelos Inc., US
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AS12510	0.00%	762	SAP_AG_WDF SAP SE, DE
AS21837	0.00%	757	OPERASOFTWARE - Opera Software Americas LLC, US
AS13213	0.00%	741	UK2NET-AS UK2 - Ltd, GB
AS9619	0.00%	672	SSD Sony Global Solutions Inc., JP
AS19994	0.00%	660	RACKSPACE - Rackspace Hosting, US
AS32934	0.00%	654	FACEBOOK - Facebook, Inc., US
AS25513	0.00%	639	ASN-MGTS-USPD OJS Moscow city telephone network, RU
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Ranked by IPv6 measurement count

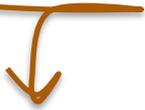
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Ranked by IPv6 measurement count

# IPv6 Failures - Q3 2015

279,116 failing IPv6 addresses



143,357 6to4 addresses

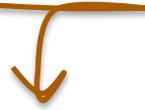
118 teredo addresses

92 fe80:: local scope addresses

709 unallocated addresses

1,358 unannounced addresses

133,482 addresses from unicast allocated routed space



102,826 unique /64s

# What about IPv4 Connection Failures?

2011: failure rate 0.2%

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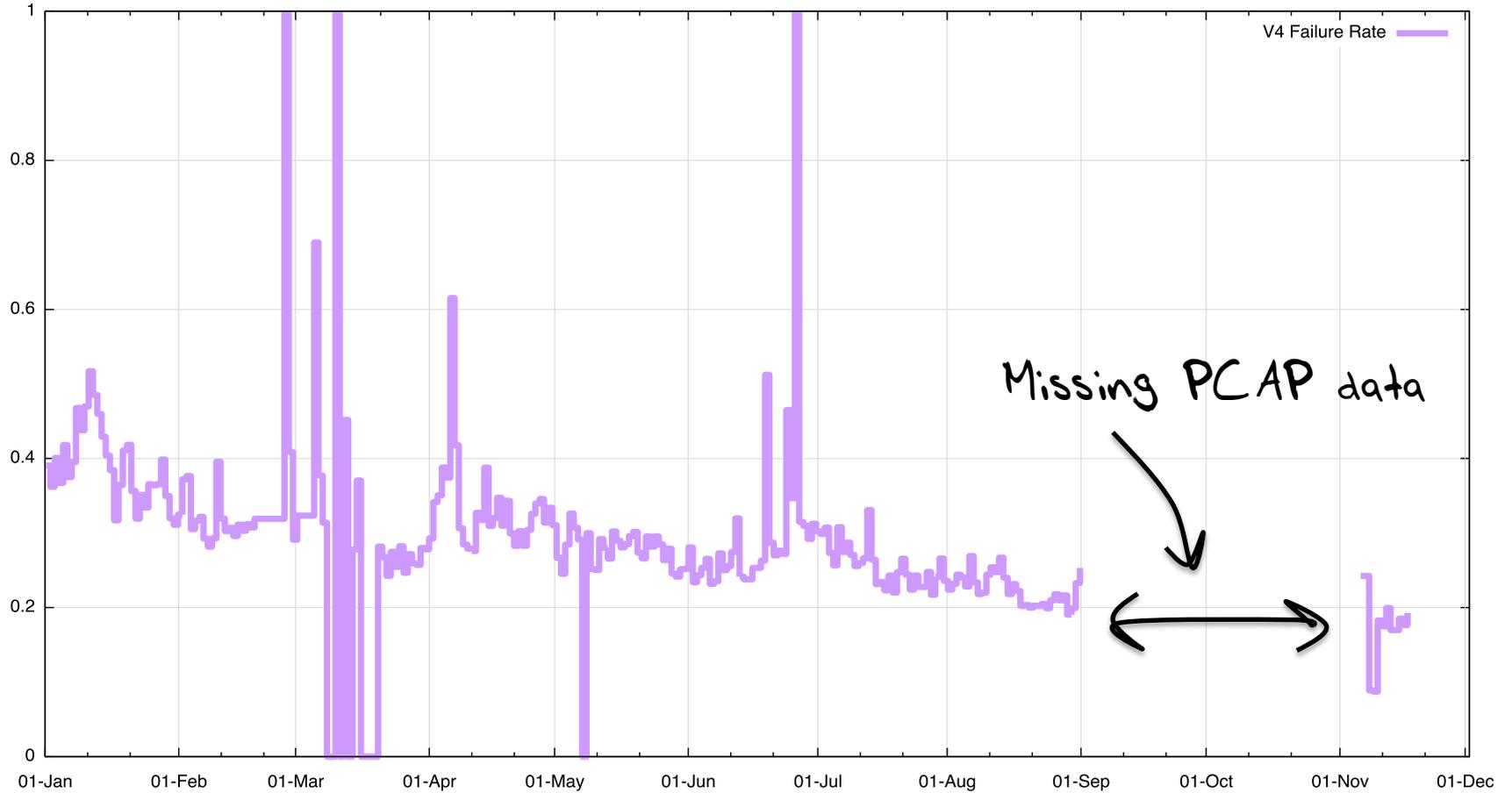
2015:

334,957,192 IPv4 endpoints

1,197,903 Connection Failures (0.3%)

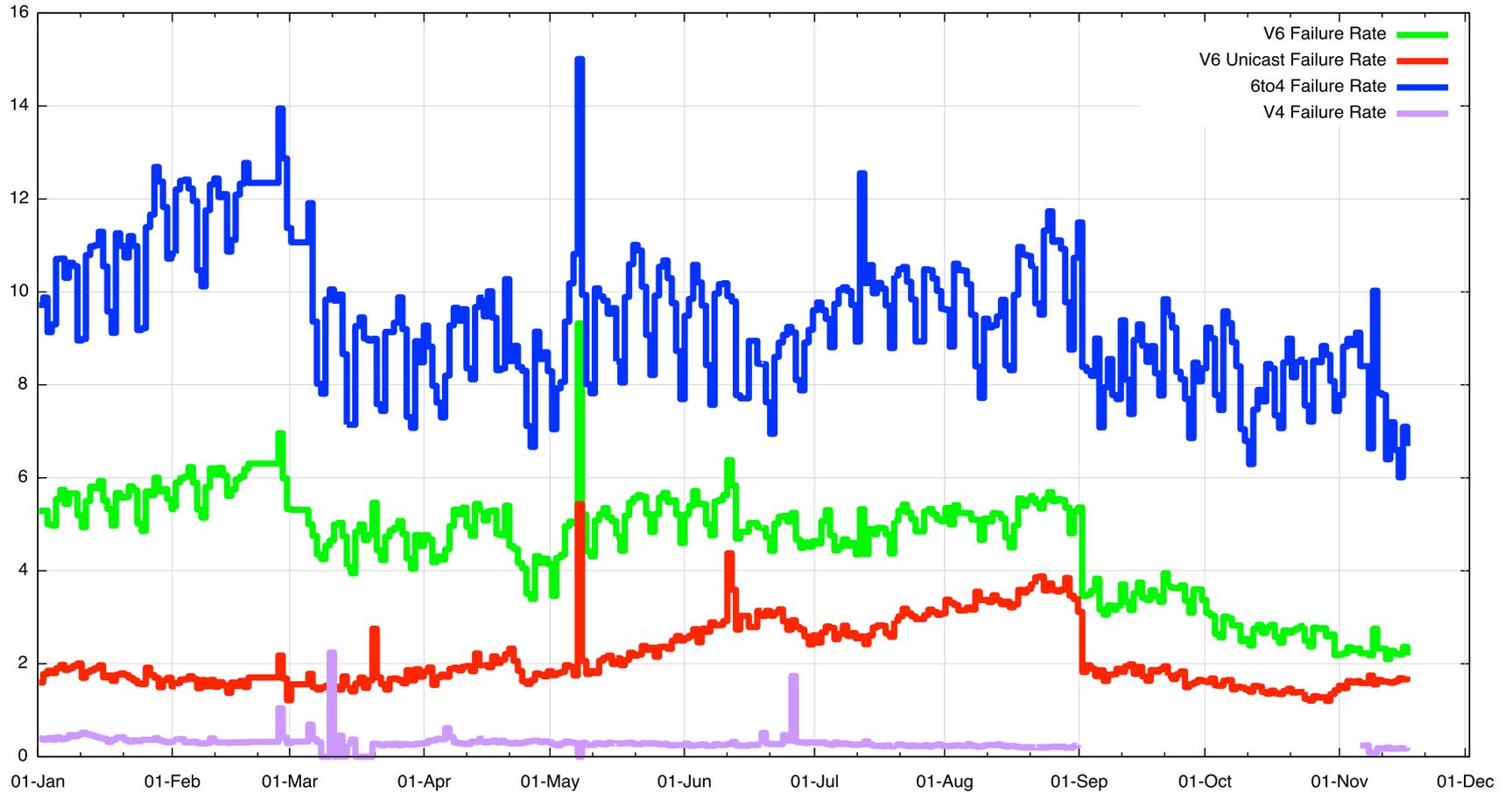
# IPv4 Connection Failure

Connection Failure Rate - 2015



# Comparison

Connection Failure Rate - 2015



# Comparison: Unicast

Connection Failure Rate - 2015



# Comparison: Unicast

Connection Failure Rate - 2015



It's still not good!

IPv6 Unicast Failure rate: 1.8% (steady)

IPv4 Failure rate: 0.2% (and falling!)

# What are we looking at:

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Let's dive into SYNs!

# Why SYNs?

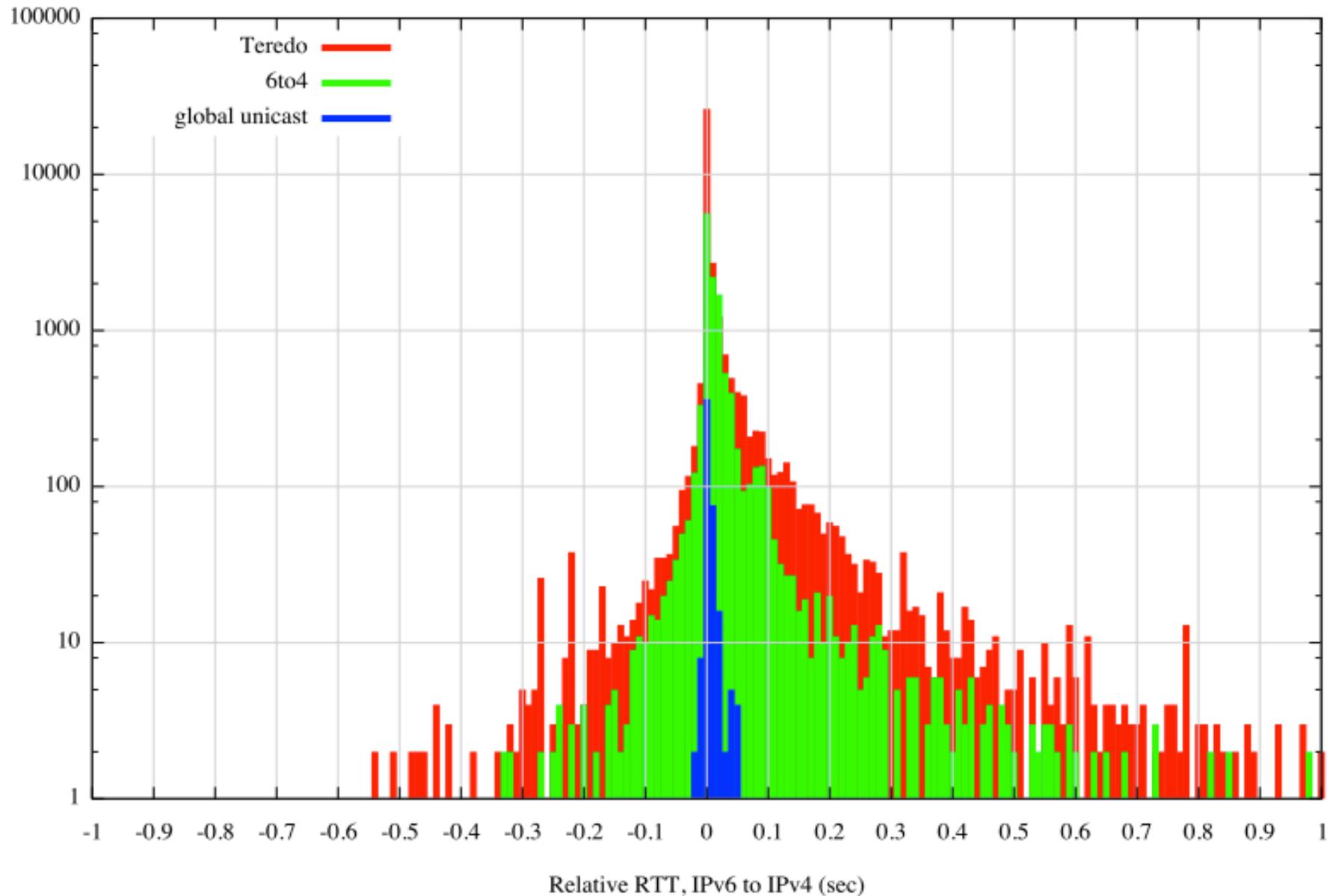
- Every TCP session starts with a SYN handshake
- Its typically a kernel level operation, which means that there is little in the way of application level interaction with the SYN exchange
- On the downside there is only a single sample point per measurement

# Generating a comparative RTT profile

- For each successful connection couplet (IPv4 and IPv6) 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

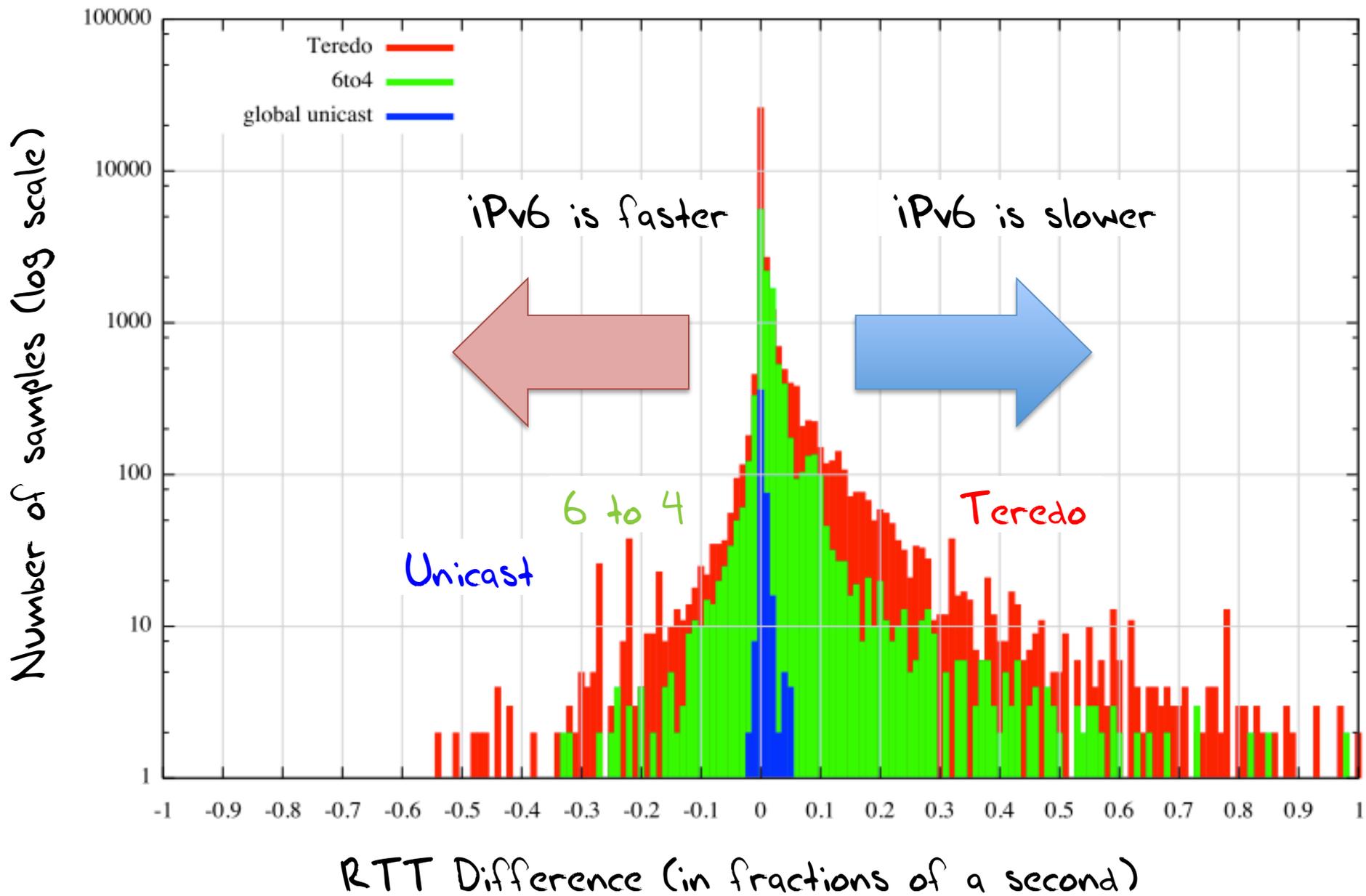
# 2012 Data

Relative RTT, IPv6 to IPv4 (sec) for bilby on 2012/03/01

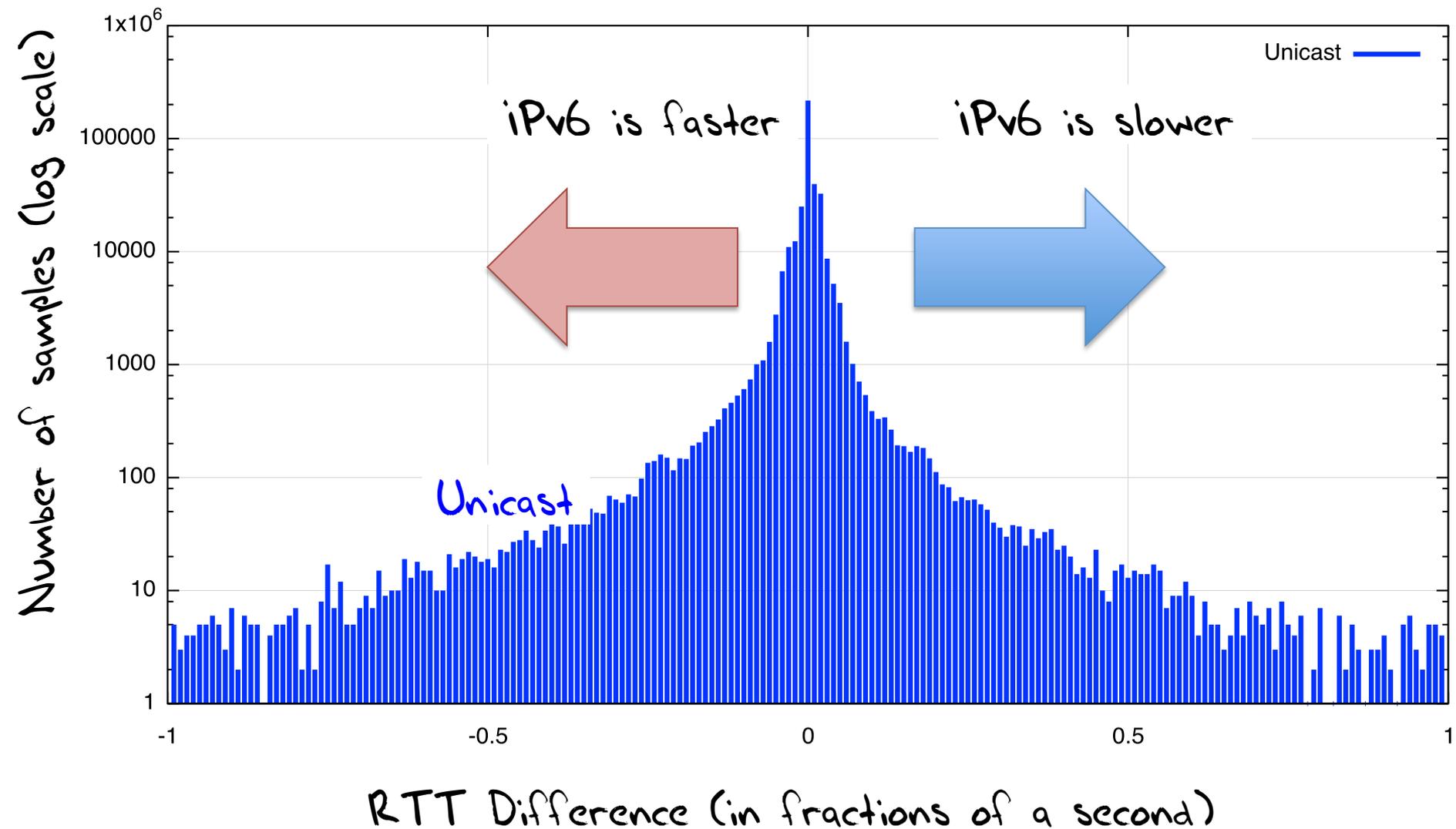


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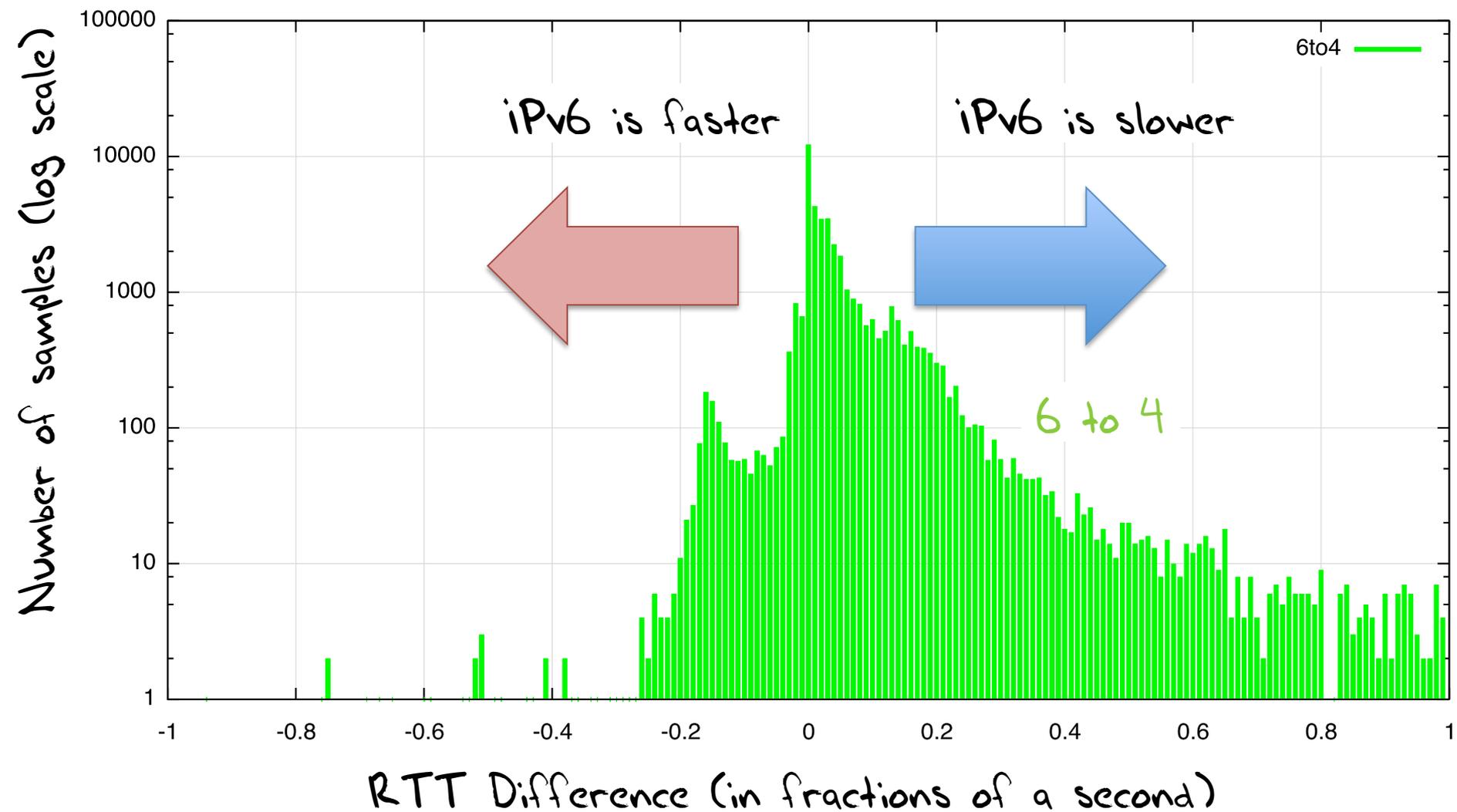
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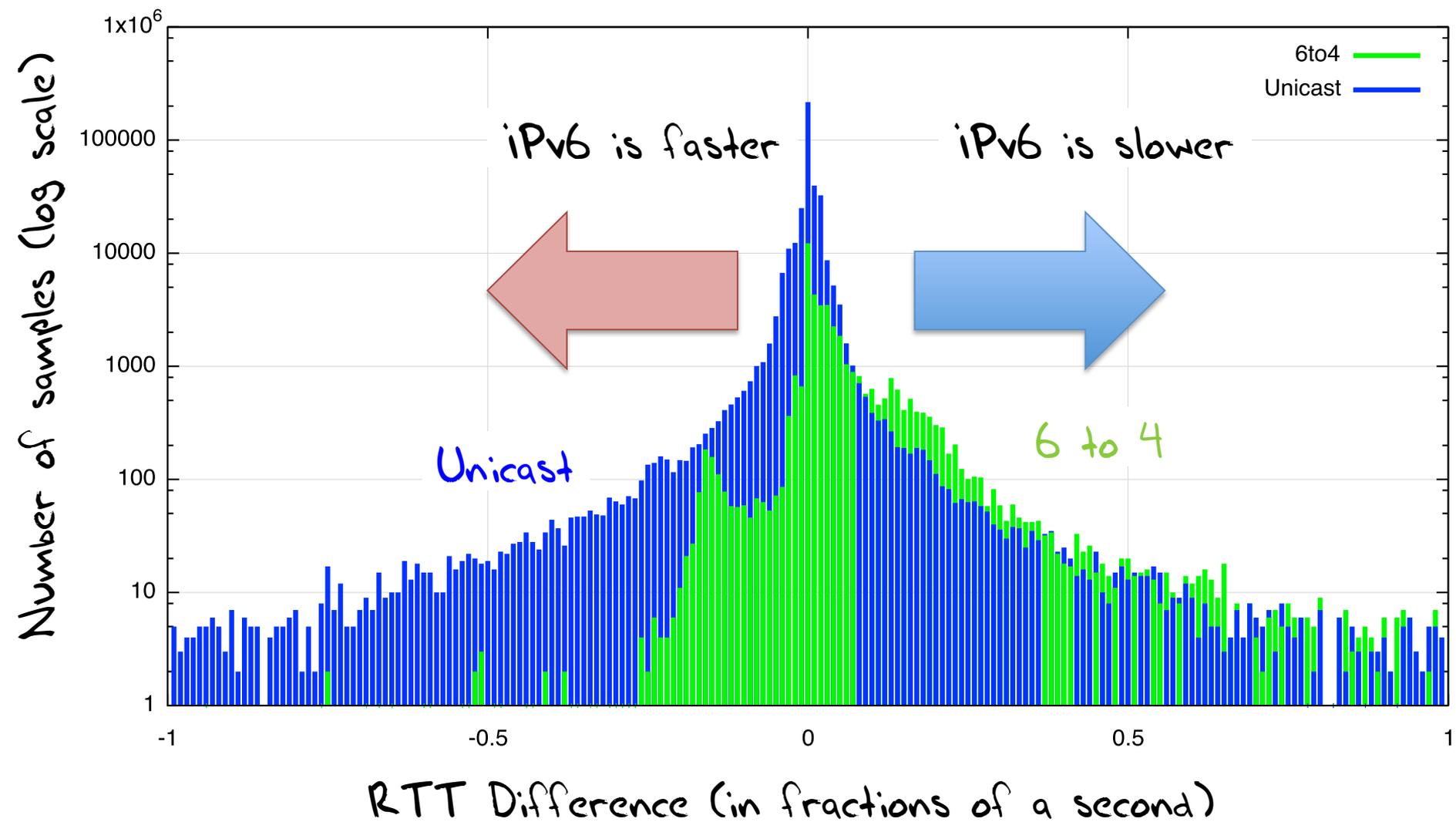
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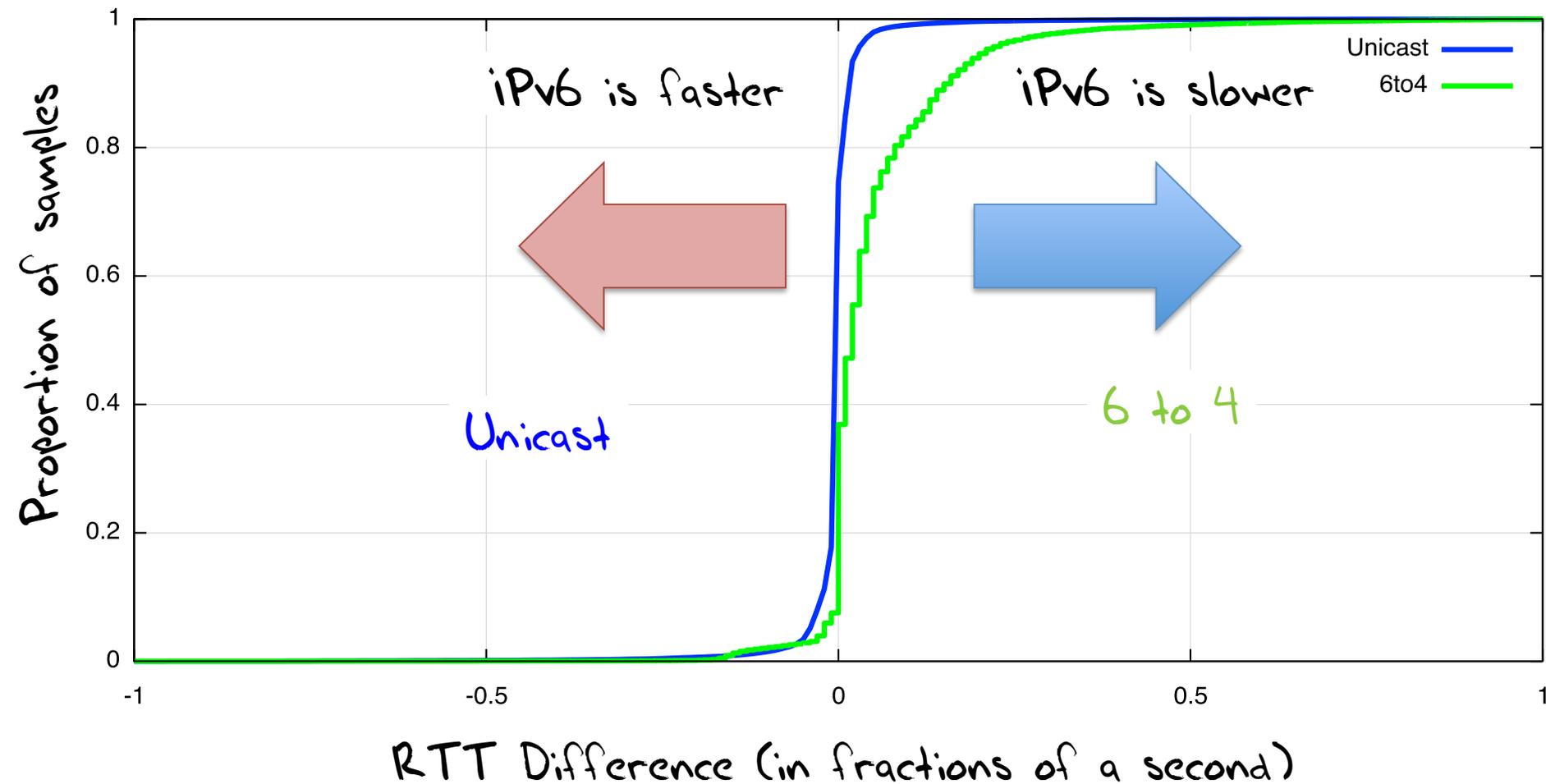


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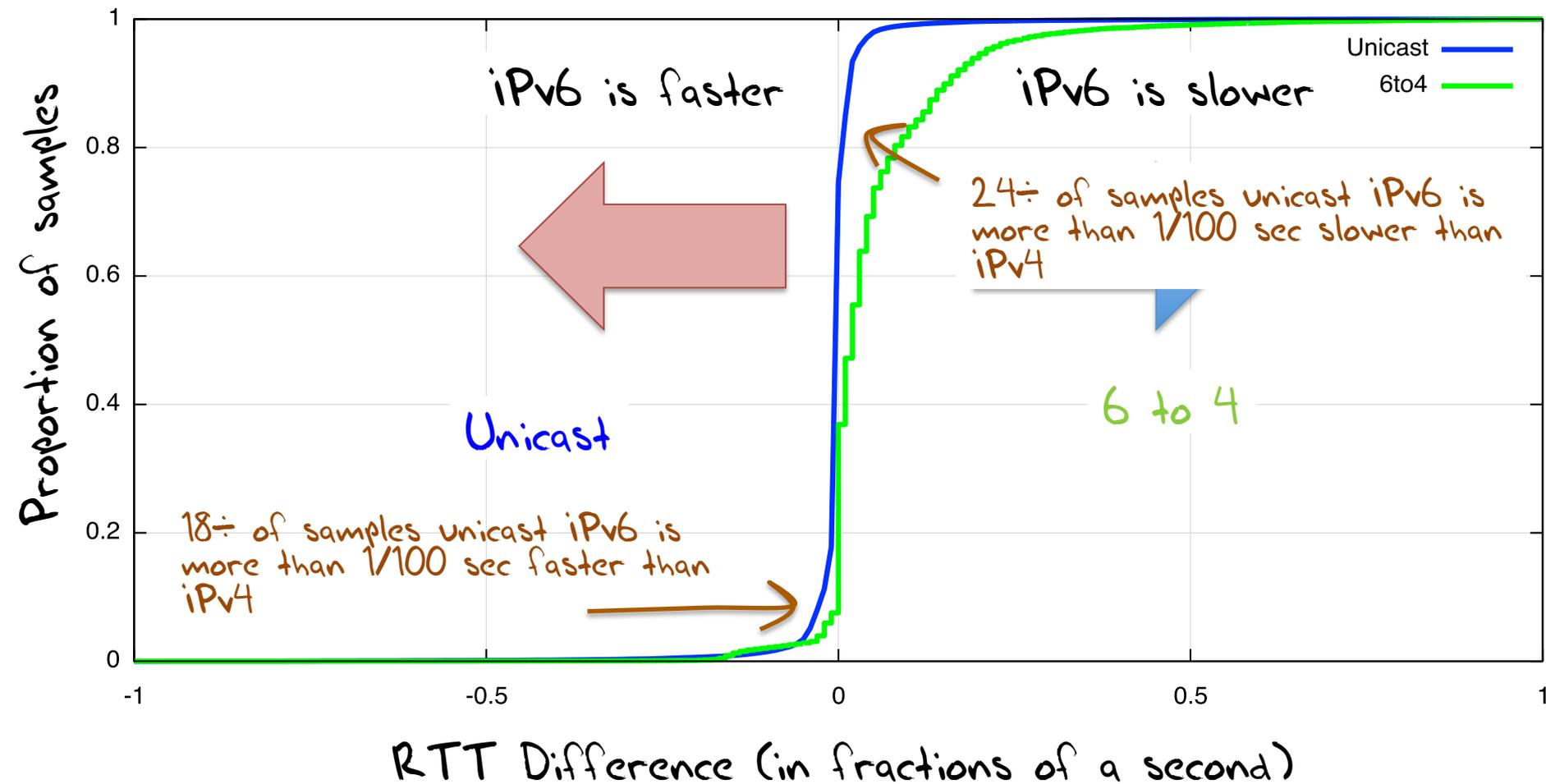
# 2015 Data CDF (using 10ms resolution)

Cumulative Distribution of Relative Time Difference



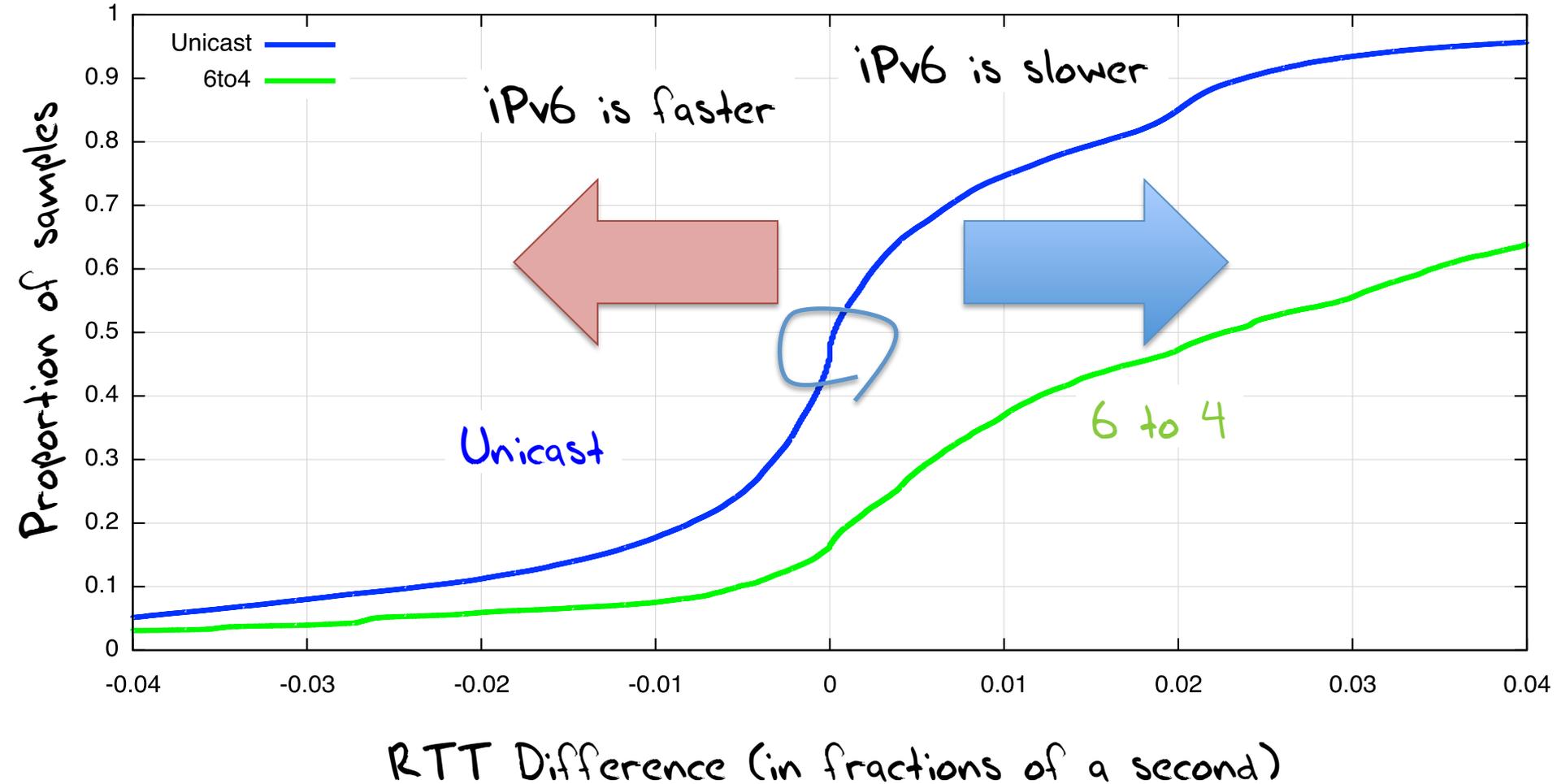
# 2015 Data CDF (using 10ms resolution)

Cumulative Distribution of Relative Time Difference



# 2015 Data CDF (using 0.1 ms resolution)

Cumulative Distribution of Relative Time Difference



Is IPv6 as "good" as IPv4?

# Is IPv6 as "good" as IPv4?

Is IPv6 as fast as IPv4?

Basically, yes

IPv6 is faster about half of the time

For 70% of unicast cases, IPv6 is within 10ms RTT of IPv4

So they perform at much the same rate

But that's just for unicast IPv6

The use of 6to4 makes this a whole lot worse!

# Is IPv6 as "good" as IPv4?

Is IPv6 as robust as IPv4?

IPv4 connection reliability currently sits at 0.2%

The base failure rate of Unicast V6 connection attempts at 1.8% of the total V6 unicast connections is not brilliant.

6to4 is still terrible!

It could be better.

It could be a whole lot better!

# Is IPv6 as "good" as IPv4?

If you can establish a connection, then IPv4 and IPv6 appear to have comparable RTT measurements across most of the Internet

But the odds of establishing that connection are still weighted in favour of IPv4!

That's it!



Questions?