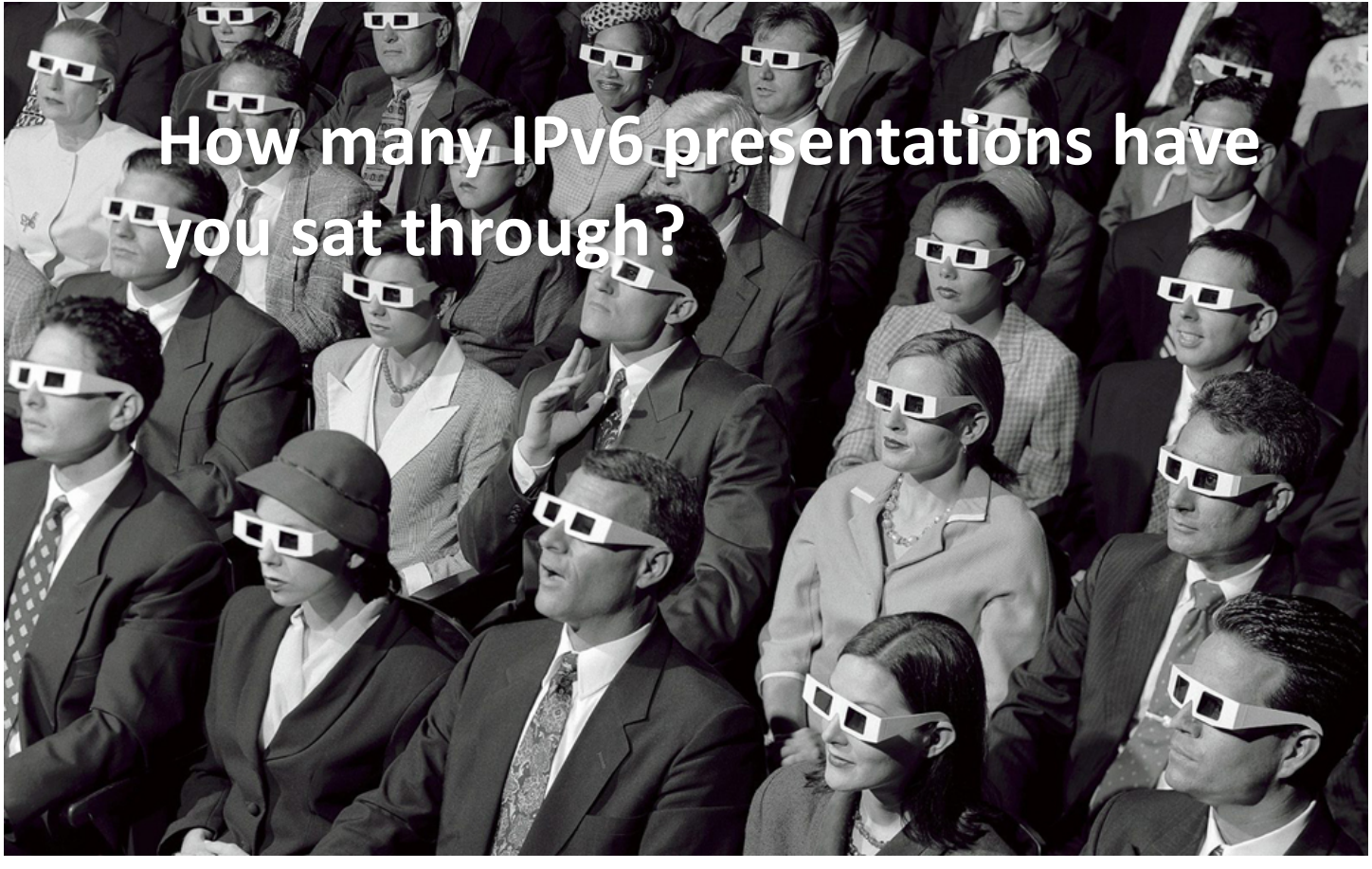
Are we there yet?

Measuring IPv6 in 2016

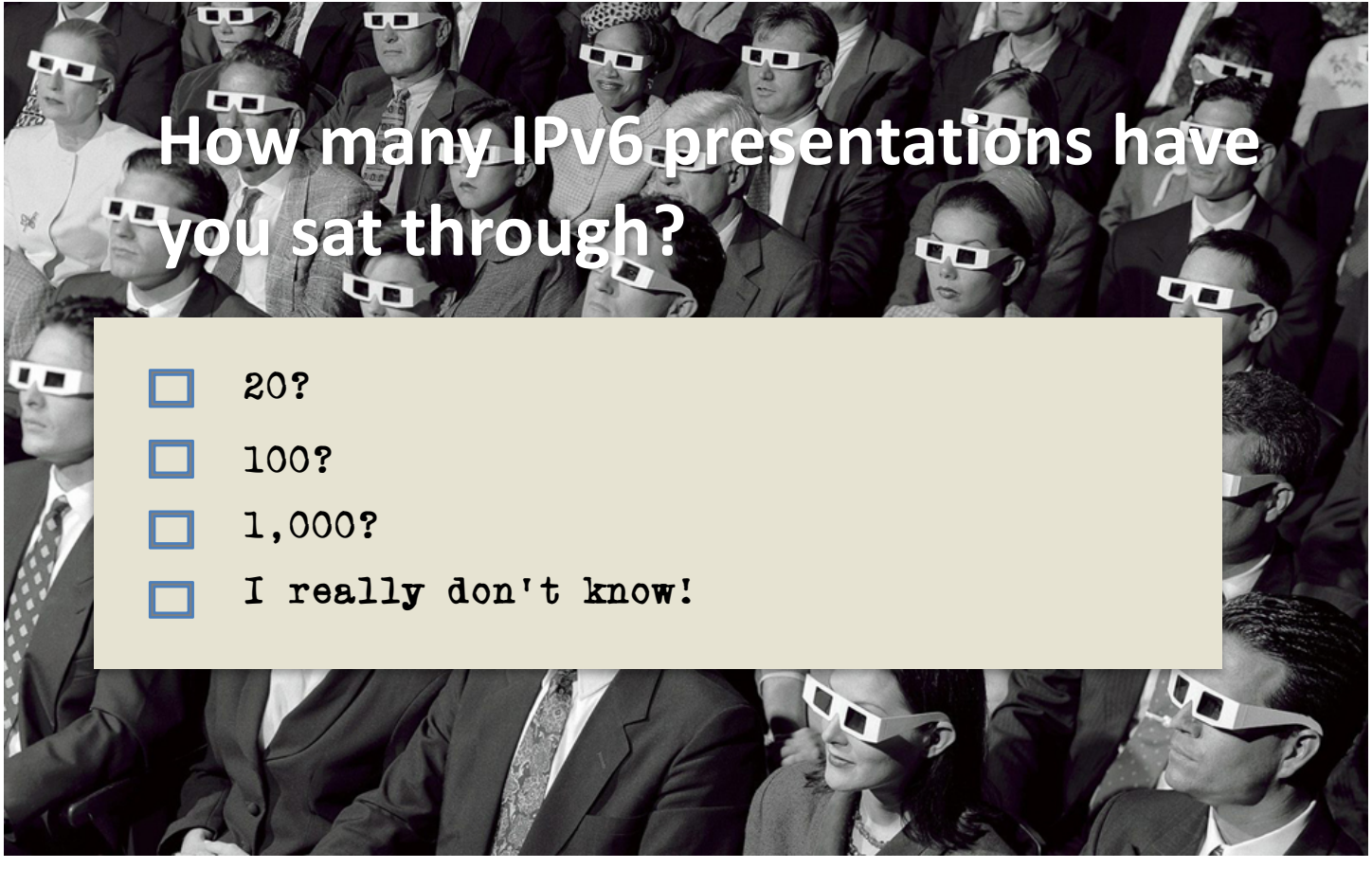
Geoff Huston
APNIC

A question to each of you…

A question to each of you…



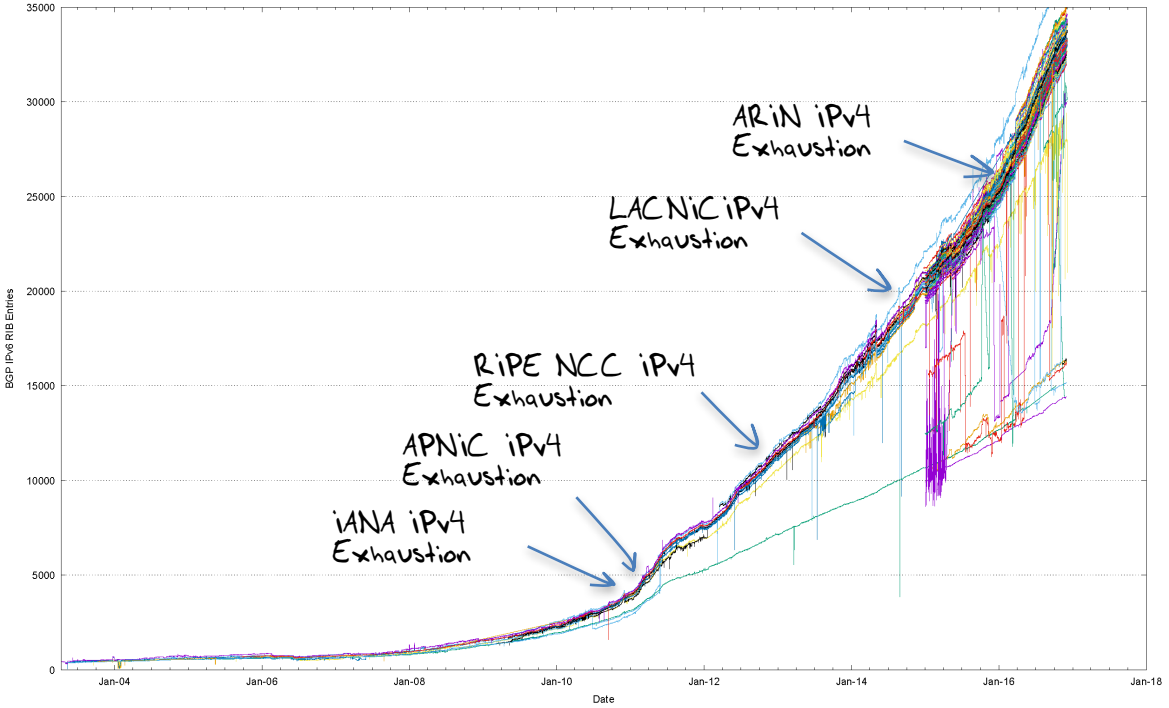
A question to each of you…



Measuring IPv6

How can we “measure” the uptake of IPv6?

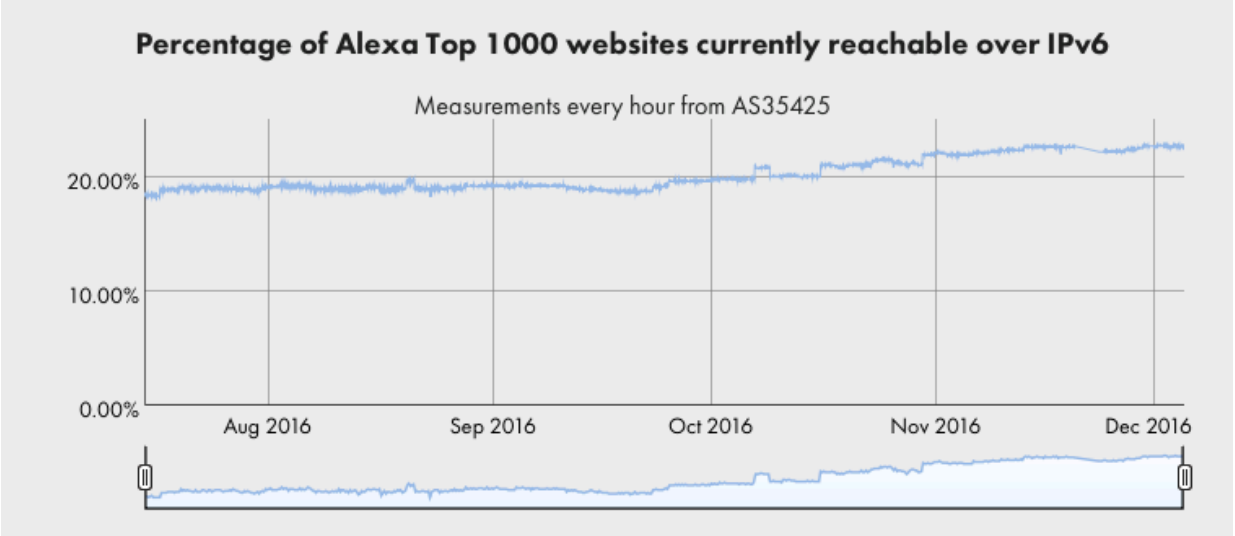
– BGP: Network Deployment numbers



Measuring IPv6

How can we “measure” the uptake of IPv6?

– Alexa Lists: Dual Stack services

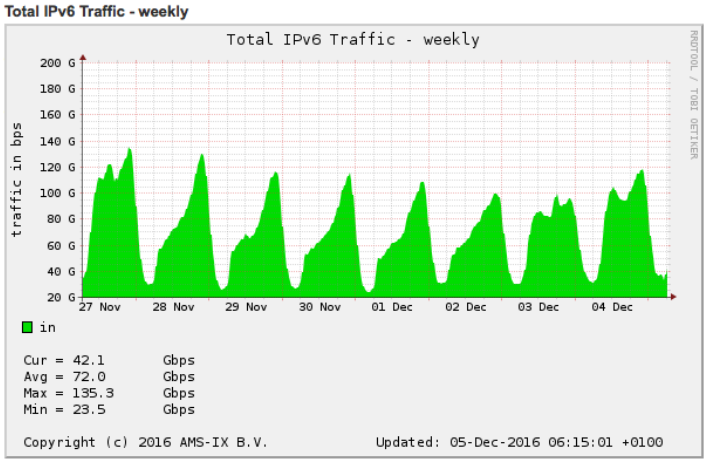


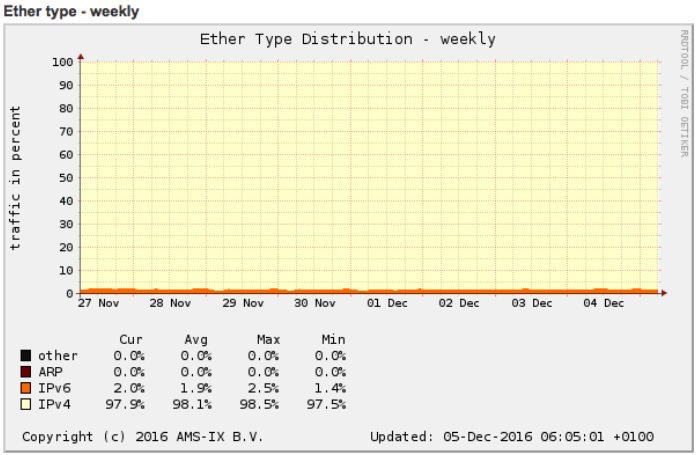
ISOC 360 Deploy Pages

Measuring IPv6

How can we “measure” the uptake of IPv6?

– IX stats: IPv6 traffic stats





AMSIX Traffic Statistics

Measuring IPv6

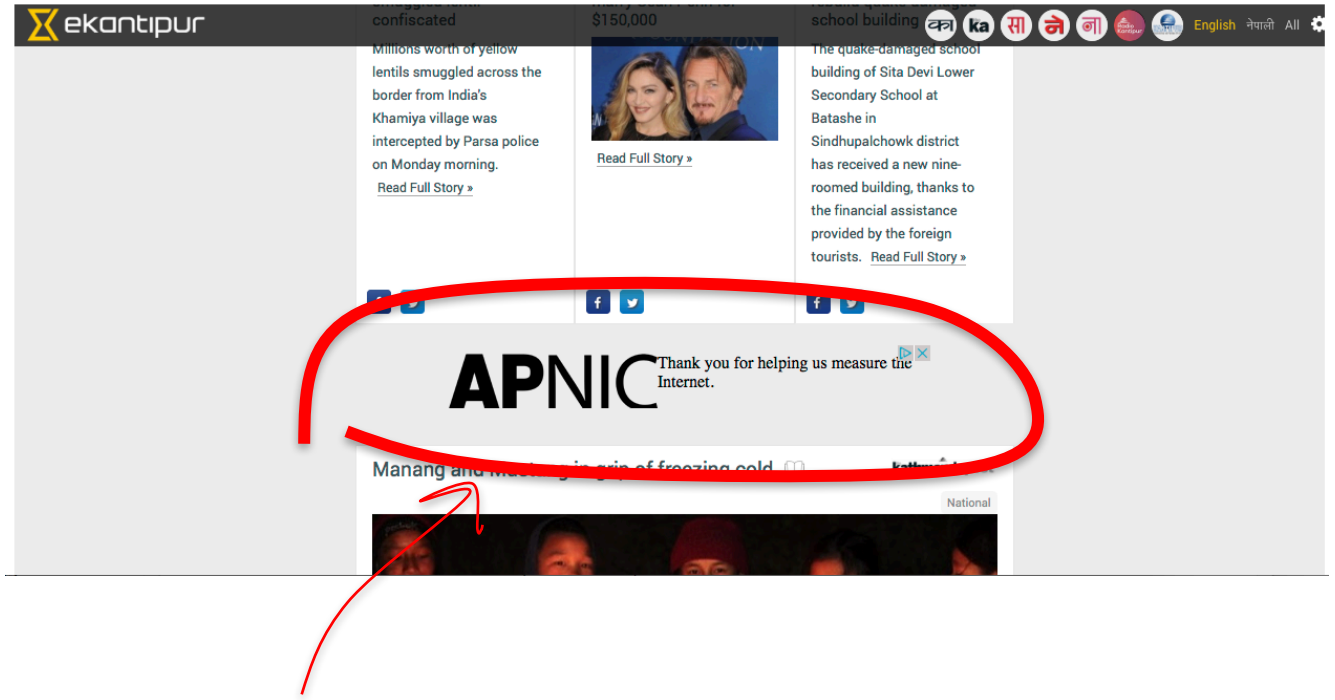
How can we “measure” the uptake of IPv6?

- End User Capability: APNIC measurements

APNIC's Measurement Technique

- Embed a test script in an online ad
- Have the script generate a set of URLs to fetch
  - Each script uses unique names to avoid caching distortion
- Direct all the DNS and the HTTP traffic to a set of measurement servers
- Examine the traffic profile seen at the server

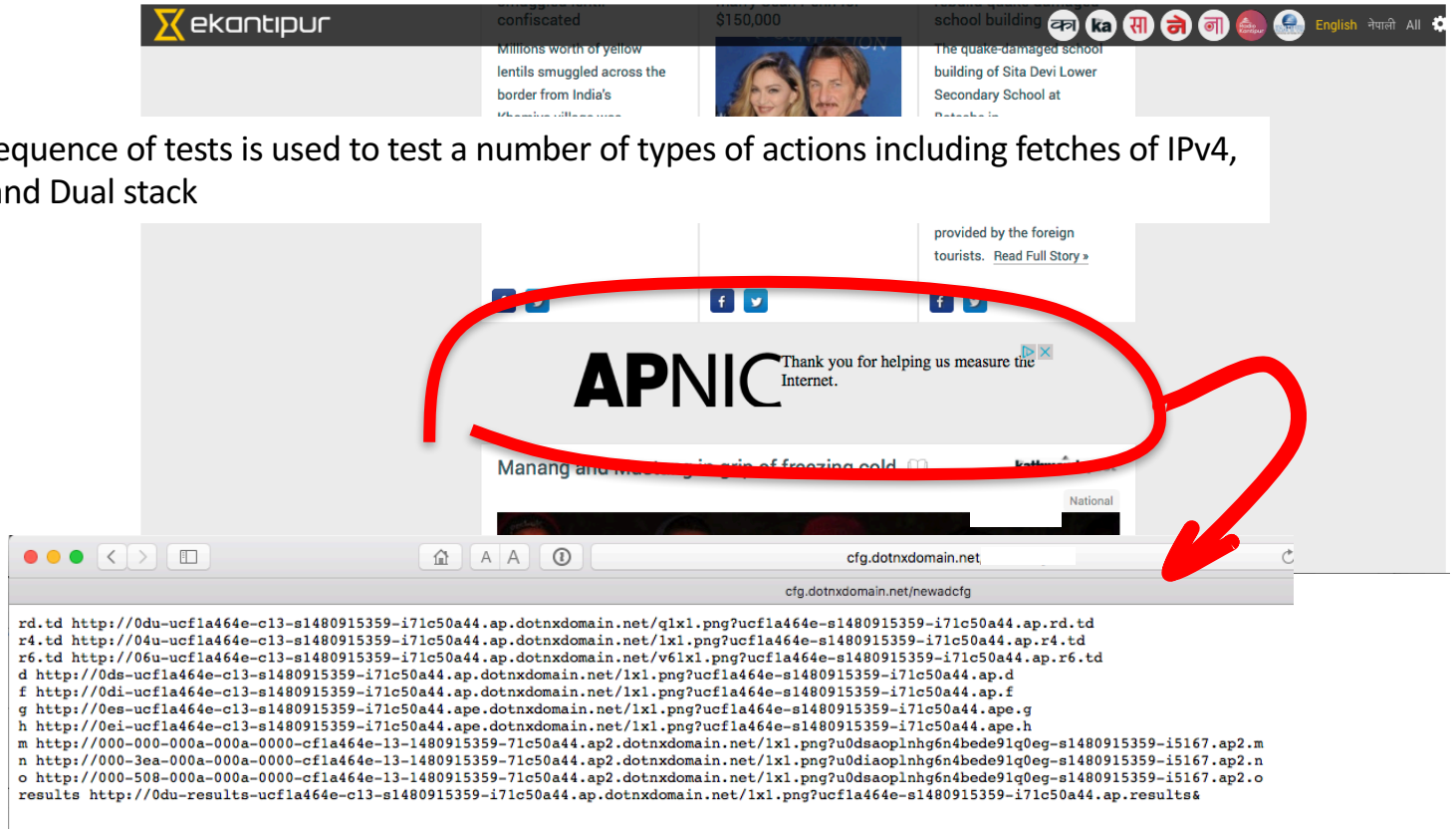
How We Measure



We use an online ad to present a sequence of small fetches to the user's browser

How We Measure

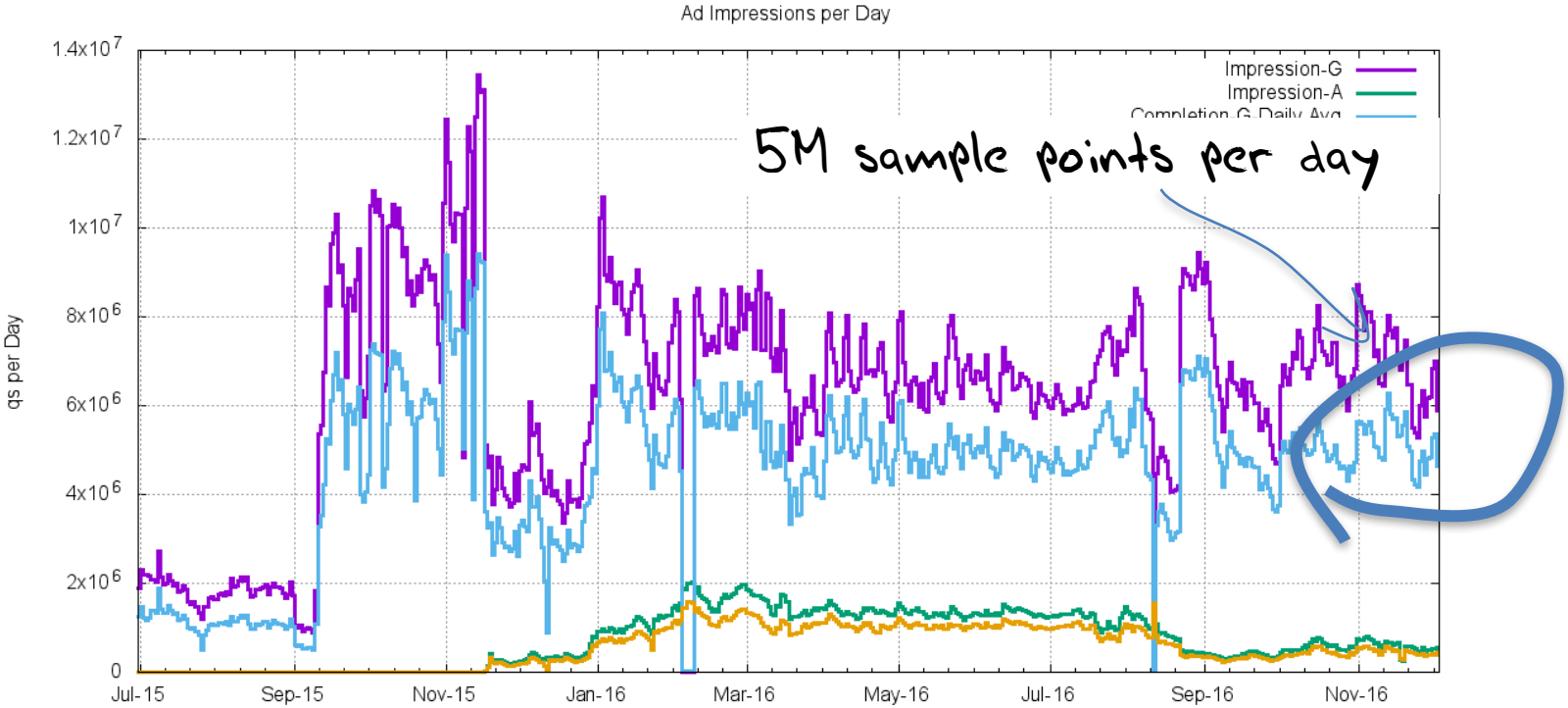
The sequence of tests is used to test a number of types of actions including fetches of IPv4, IPv6 and Dual stack



How We Measure

We use full packet capture to record all packet activity at the experiment's servers

How Much do We Measure?



Where are we today?

- Originally we thought that the Internet would avoid complete IPv4 exhaustion and adopt IPv6 while there was still some IPv4 left in the unallocated address pools

Where are we today?

- Originally we thought that the Internet would avoid complete IPv4 [illegible] adopt IPv6 while there was still some IPv4 left in the unallocated address pools

This has not happened!

Where are we today?

- Originally we thought that the Internet would avoid complete IPv4 exhaustion and adopt IPv6 while there was still some IPv4 left in the unallocated address pools

This has not happened!

- Then we thought that the reality of IPv4 exhaustion would prompt all service providers to accelerate their IPv6 deployment plans

Where are we today?

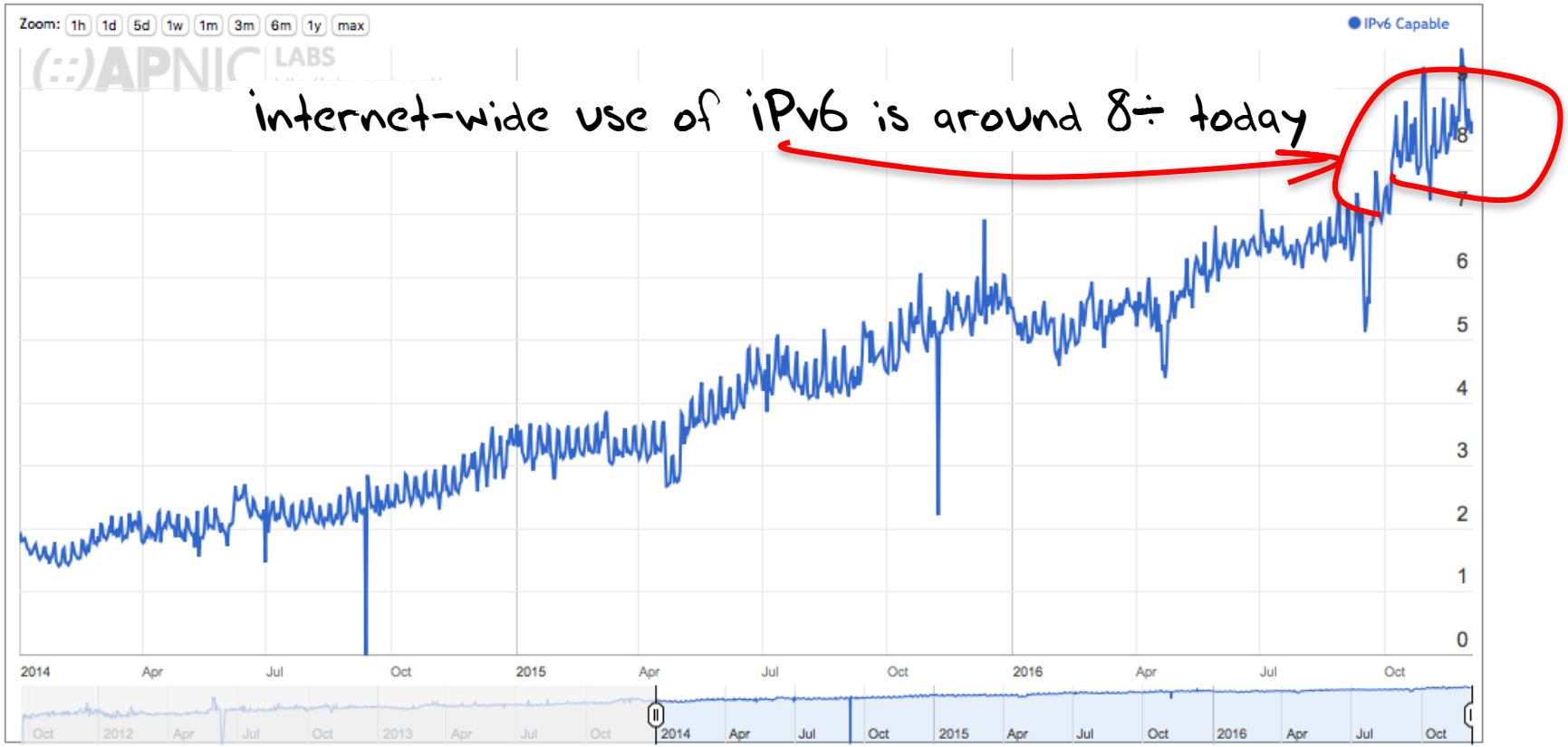
- Originally we thought that the Internet would avoid complete IPv4 exhaustion and adopt IPv6 while there was still some IPv4 left in the unallocated address pools

This has not happened!

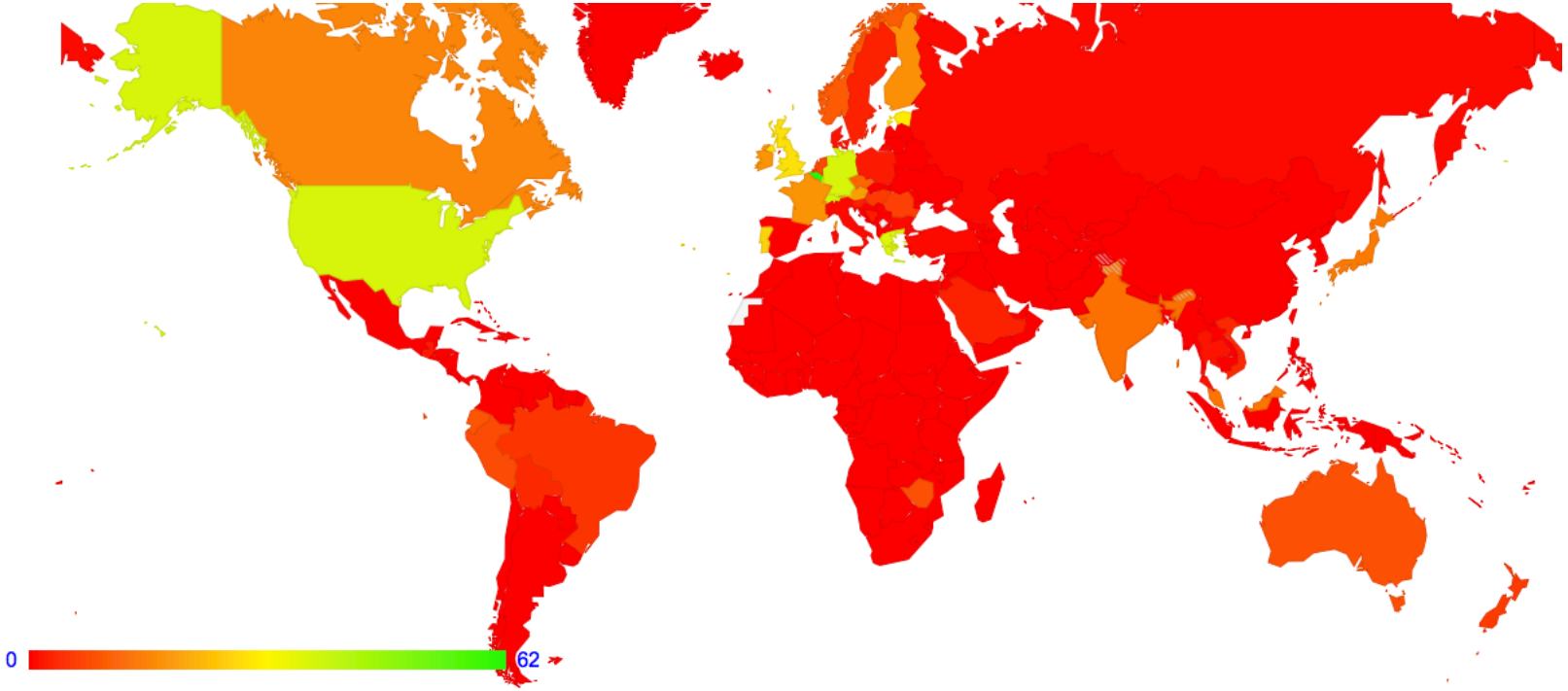
- Then we thought that the reality of exhaustion would prompt providers to accelerate their deployment plans

This appears to be happening in some areas with some providers

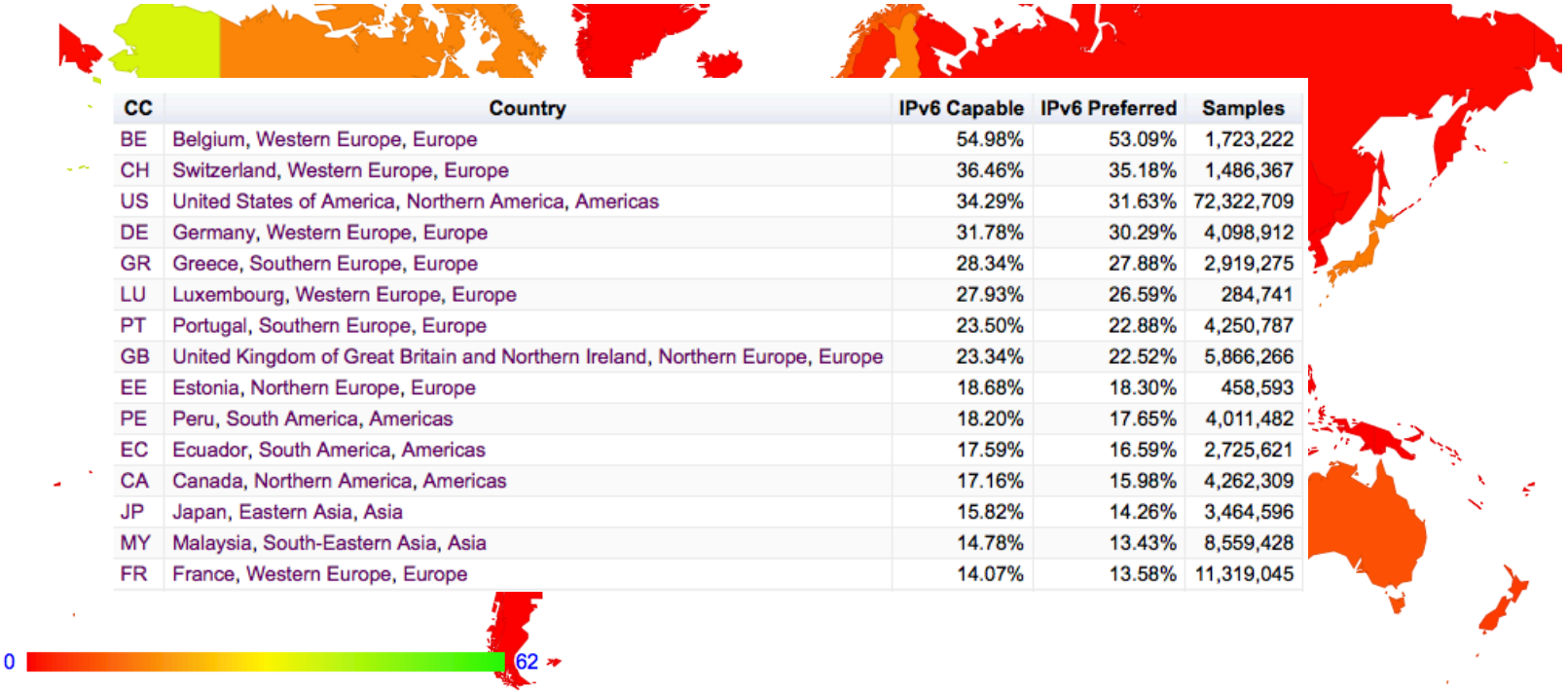
Global Use of IPv6



Where are IPv6 Users?

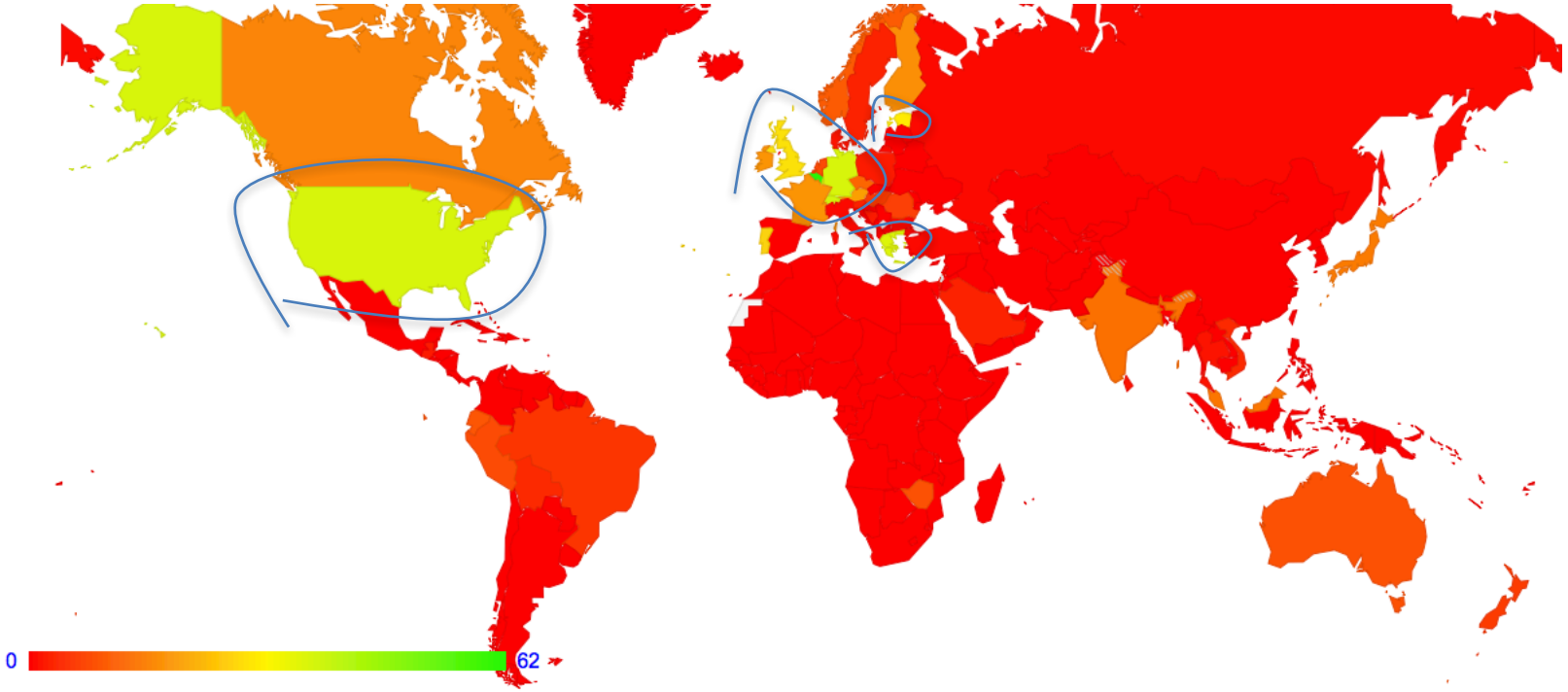


Where are IPv6 Users?

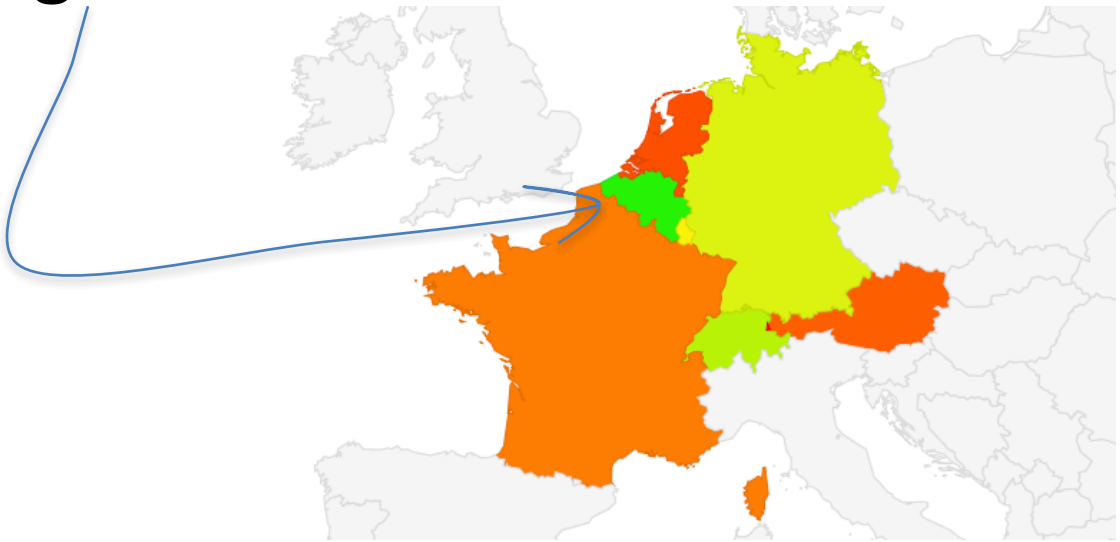


CC	Country	IPv6 Capable	IPv6 Preferred	Samples
BE	Belgium, Western Europe, Europe	54.98%	53.09%	1,723,222
CH	Switzerland, Western Europe, Europe	36.46%	35.18%	1,486,367
US	United States of America, Northern America, Americas	34.29%	31.63%	72,322,709
DE	Germany, Western Europe, Europe	31.78%	30.29%	4,098,912
GR	Greece, Southern Europe, Europe	28.34%	27.88%	2,919,275
LU	Luxembourg, Western Europe, Europe	27.93%	26.59%	284,741
PT	Portugal, Southern Europe, Europe	23.50%	22.88%	4,250,787
GB	United Kingdom of Great Britain and Northern Ireland, Northern Europe, Europe	23.34%	22.52%	5,866,266
EE	Estonia, Northern Europe, Europe	18.68%	18.30%	458,593
PE	Peru, South America, Americas	18.20%	17.65%	4,011,482
EC	Ecuador, South America, Americas	17.59%	16.59%	2,725,621
CA	Canada, Northern America, Americas	17.16%	15.98%	4,262,309
JP	Japan, Eastern Asia, Asia	15.82%	14.26%	3,464,596
MY	Malaysia, South-Eastern Asia, Asia	14.78%	13.43%	8,559,428
FR	France, Western Europe, Europe	14.07%	13.58%	11,319,045

Where are IPv6 Users?

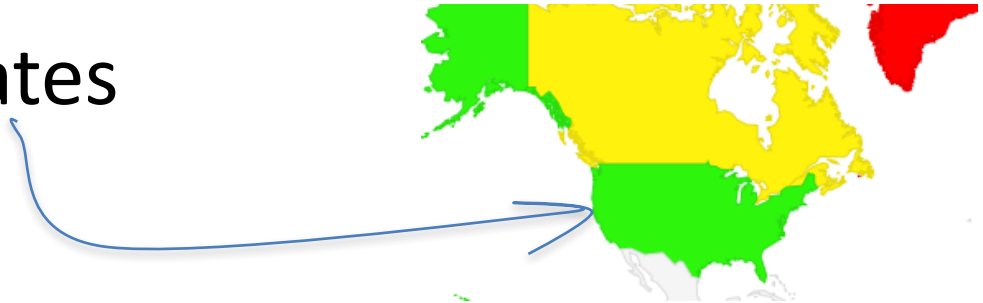


Belgium



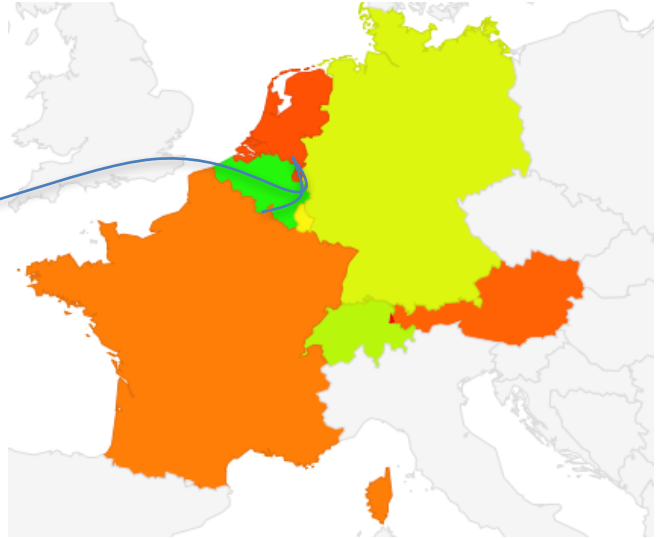
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS5432	BELGACOM-SKYNET-AS Proximus NV	46.56%	44.34%	788,560
AS6848	TELENET-AS Telenet N.V.	71.68%	68.80%	731,978
AS12392	ASBRUTELE Brutele SC	74.99%	72.96%	198,174
AS47377	MES Mobistar SA	0.18%	0.06%	43,463
AS21502	ASN-NUMERICABLE NC Numericable S.A.	0.00%	0.00%	36,698

United States



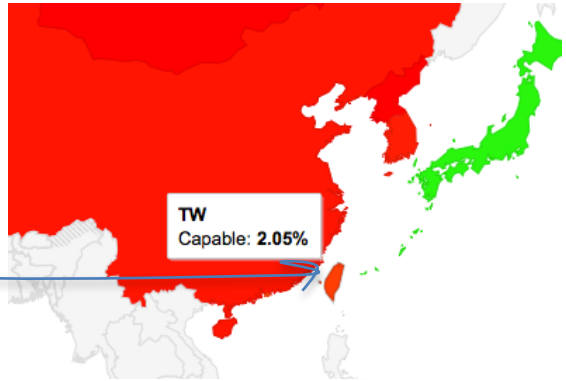
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	63.58%	59.24%	15,018,049
AS7018	ATT-INTERNET4 - ATT Services, Inc.	82.18%	75.24%	8,733,815
AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business	0.17%	0.02%	4,421,927
AS20115	CHARTER-NET-HKY-NC - Charter Communications	0.12%	0.02%	3,518,064
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	26.85%	25.05%	3,293,274
AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	89.64%	82.16%	2,487,117
AS209	CENTURYLINK-US-LEGACY-QWEST - Qwest Communications Company, LLC	0.15%	0.08%	2,338,251
AS20057	ATT-MOBILITY-LLC-AS20057 - ATT Mobility LLC	10.74%	10.57%	2,318,700
AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	45.31%	41.84%	2,066,142
AS5650	FRONTIER-FRTR - Frontier Communications of America, Inc.	0.11%	0.01%	2,015,253
AS10796	SCRR-10796 - Time Warner Cable Internet LLC	23.02%	21.64%	1,992,576
AS6128	CABLE-NET-1 - Cablevision Systems Corp.	0.11%	0.01%	1,880,988
AS21928	T-MOBILE-AS21928 - T-Mobile USA, Inc.	57.51%	56.31%	1,724,203
AS11427	SCRR-11427 - Time Warner Cable Internet LLC	43.50%	40.42%	1,326,276

Germany

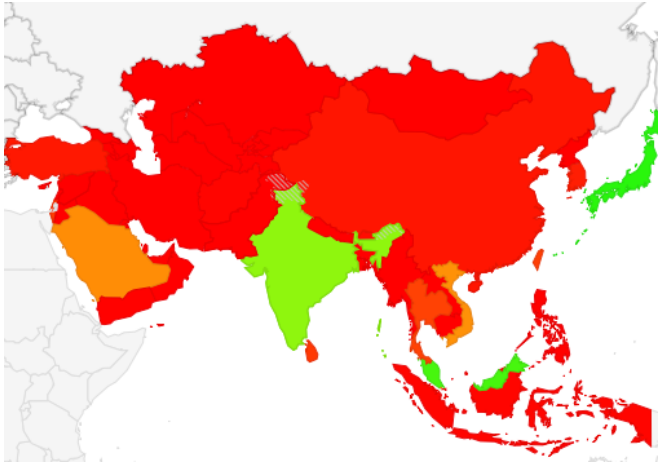


ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS3320	DTAG Deutsche Telekom AG	50.76%	49.65%	1,189,841
AS3209	VODANET Vodafone GmbH	0.08%	0.05%	535,812
AS31334	KABELDEUTSCHLAND-AS Vodafone Kabel Deutschland GmbH	64.65%	63.32%	423,616
AS6805	TDDE-ASN1 Telefonica Germany GmbH Co.OHG	0.89%	0.85%	320,312
AS6830	LGI-UPC Liberty Global Operations B.V.	50.11%	48.73%	279,115
AS200185	XANDMAIL-ASN X AND MAIL SA	0.05%	0.05%	187,570
AS29562	KABELBW-ASN Kabel BW GmbH	44.96%	43.71%	180,830
AS24940	HETZNER-AS Hetzner Online GmbH	5.05%	4.26%	95,066
AS39706	O2-GERMANY-AS Telefonica Germany GmbH Co.OHG	0.51%	0.30%	60,953
AS28753	LEASEWEB-DE Leaseweb Deutschland GmbH	45.58%	0.13%	56,935

Taiwan



ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS3462	HINET Data Communication Business Group	0.28%	0.23%	2,966,141
AS24158	TAIWANMOBILE-AS Taiwan Mobile Co., Ltd.	0.00%	0.00%	683,446
AS17421	EMOME-TW Long Distance Mobile Business Group	0.00%	0.00%	669,919
AS9674	FET-TW Far EastTone Telecommunication Co., Ltd.	0.00%	0.00%	595,399
AS9924	TFN-TW Taiwan Fixed Network, Telco and Network Service Provider.	0.00%	0.00%	218,983
AS9416	MULTIMEDIA-AS-AP Hoshin Multimedia Center Inc.	0.00%	0.00%	192,982
AS38841	KBRO-AS-TW kbro CO. Ltd.	0.00%	0.00%	130,666
AS24157	VIBO-NET-AS Vibo Telecom Inc.	0.00%	0.00%	125,685
AS131596		0.00%	0.00%	107,484
AS4780	SEEDNET Digital United Inc.	0.00%	0.00%	104,431
AS18418	TWNIC-AS Taiwan Network Information Center	76.55%	76.14%	95,543
AS131591	AMBIT-AS-TW Ambit Microsystem Corporation	0.00%	0.00%	80,417
AS1659	ERX-TANET-ASN1 Taiwan Academic Network (TANet) Information Center	19.02%	17.67%	63,336
AS18182	SONET-TW Sony Network Taiwan Limited	0.00%	0.00%	61,769
AS24164	YJL-MEDIATV-NET YEONG JIA LEH CABLE TV CO., LTD.	0.00%	0.00%	57,377
AS4662	QTCN-ASN1 GCNet (Reach Range Inc.)	0.00%	0.00%	53,351
AS9311	HITRON-AS-AP HITRON TECHNOLOGY INC.	99.45%	98.54%	39,237
AS18419	DADA-AS-TW DaDa Broadband LTD.	0.00%	0.00%	30,725



Asia

CC	Country	IPv6 Capable
JP	Japan, Eastern Asia, Asia	15.85%
MY	Malaysia, South-Eastern Asia, Asia	14.76%
IN	India, Southern Asia, Asia	12.10%
SG	Singapore, South-Eastern Asia, Asia	4.84%
VN	Vietnam, South-Eastern Asia, Asia	4.70%
SA	Saudi Arabia, Western Asia, Asia	4.59%
HK	Hong Kong Special Administrative Region of China, Eastern Asia, Asia	2.24%
TH	Thailand, South-Eastern Asia, Asia	2.14%
TW	Taiwan, Eastern Asia, Asia	2.05%
IL	Israel, Western Asia, Asia	1.93%
LK	Sri Lanka, Southern Asia, Asia	1.81%
KR	Republic of Korea, Eastern Asia, Asia	0.98%
TR	Turkey, Western Asia, Asia	0.77%
CN	China, Eastern Asia, Asia	0.68%

What are we seeing?

IPv6 deployment is not happening everywhere.

IPv6 is not happening all at once.

But it IS happening.

But..

- We still hear that many ISPs think that IPv6 is slow and reliable, and they are waiting for the situation to improve

- So lets look at IPv6 performance

What are we looking at when we say “IPv6 Performance”?

- How “reliable” are IPv6 connections?

- How “fast” are IPv6 connections?

What are we looking at when we say "IPv6 Performance"?

- How "reliable" are IPv6 connections?

Do all TCP connection attempts succeed?

- How "fast" are IPv6 connections?

is V6 slower than V4?

What are we looking at:

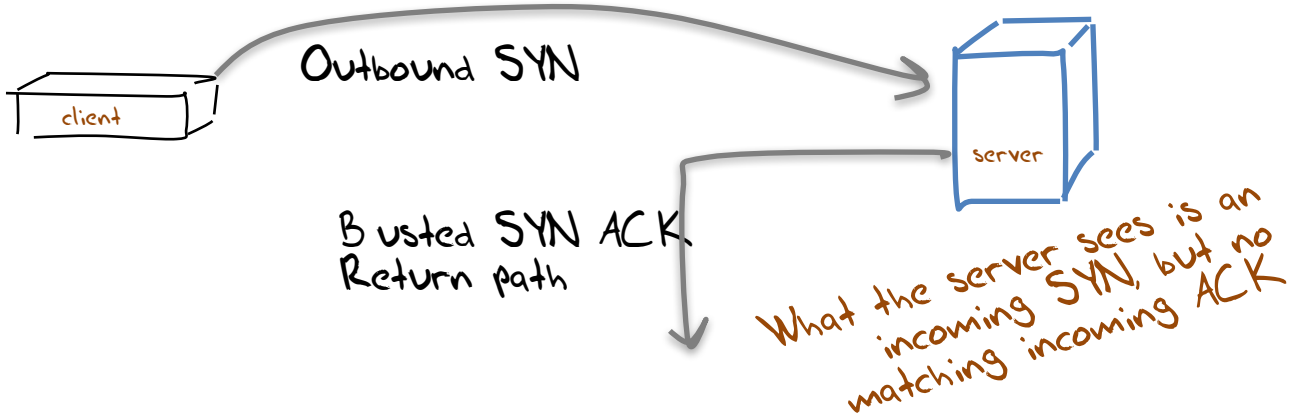
- How “reliable” are IPv6 connections?

Do all TCP connection attempts succeed?

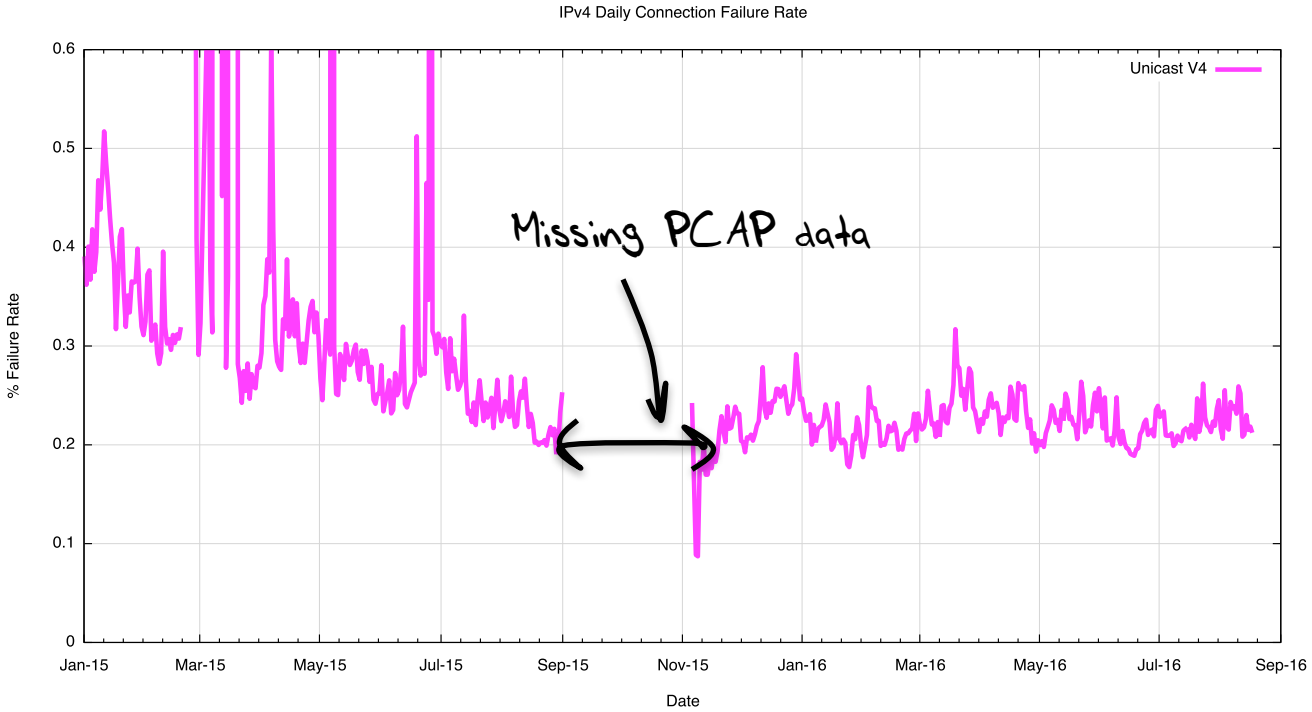
- How “fast” are IPv6 connections?

is V6 slower than V4?

What we see: Connection Failure



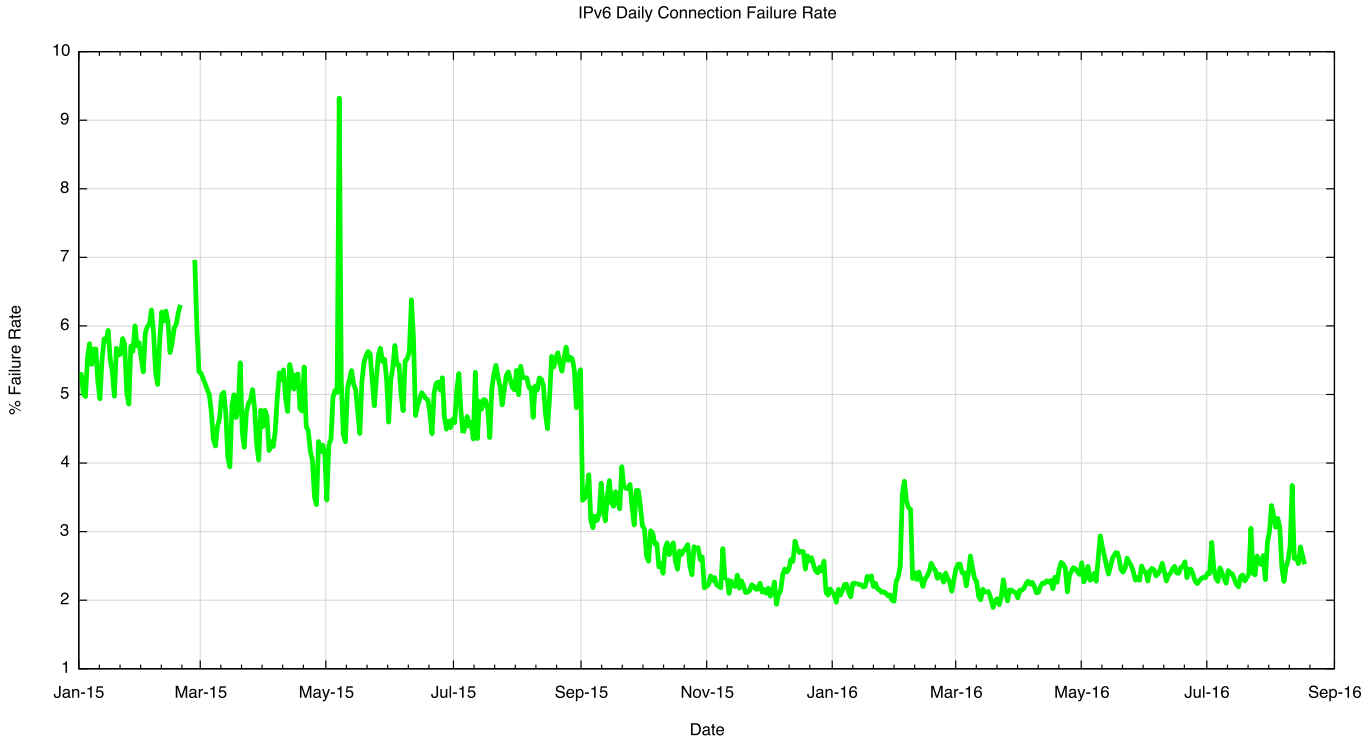
IPv4 Connection Failure



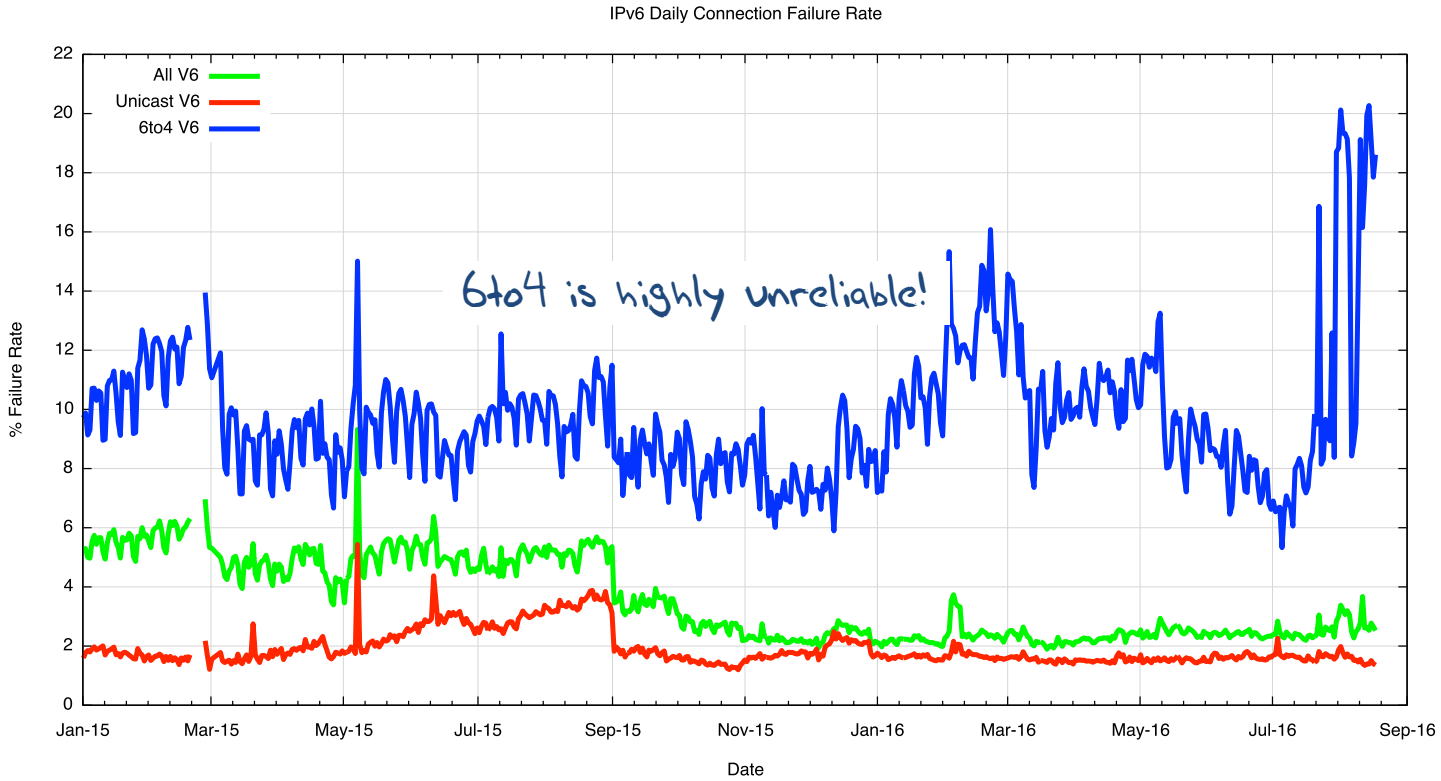
IPv4 Failures

- IPv4 failures are around 1 in 500 connection attempts
- How does IPv6 compare?

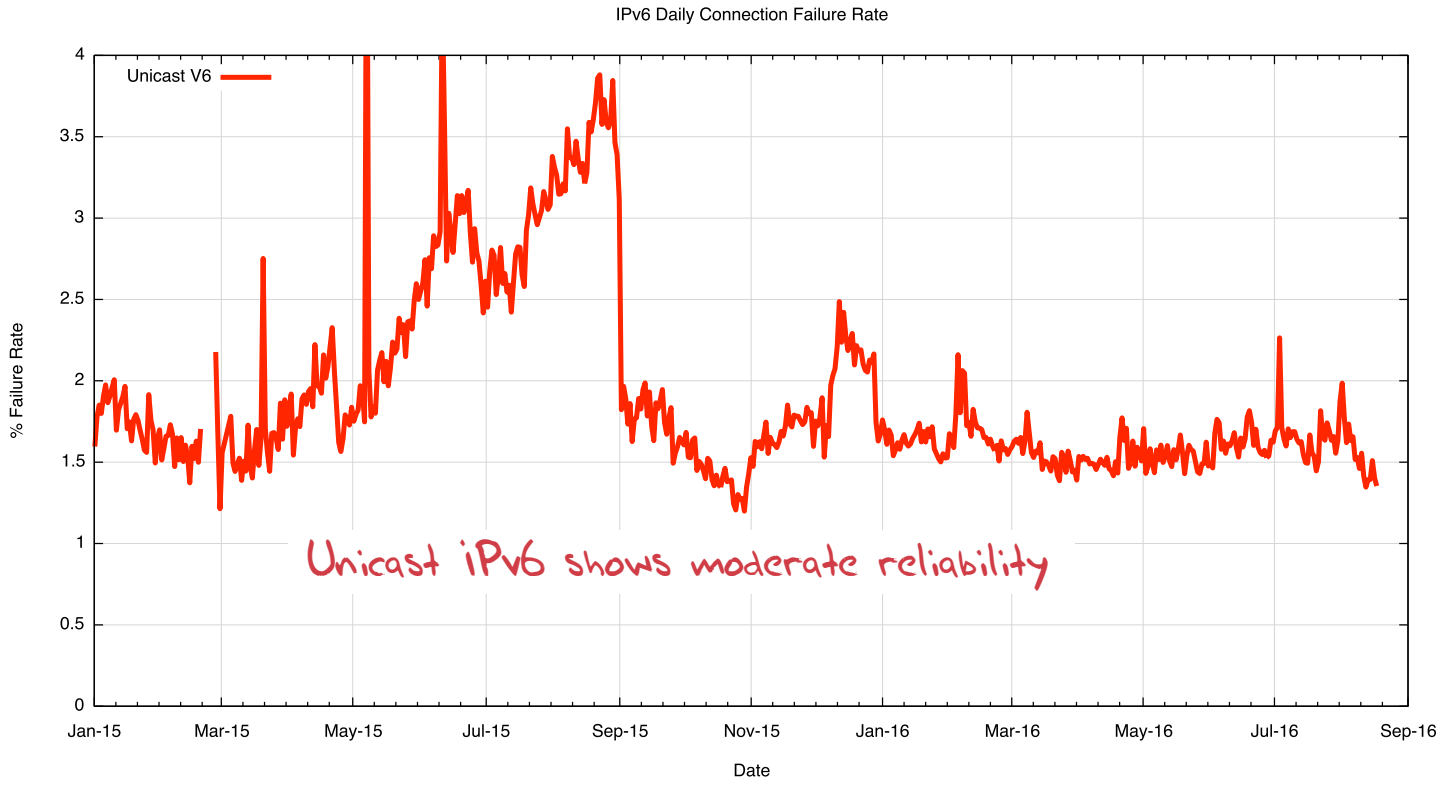
Daily IPv6 Failures



Daily IPv6 Failures



Daily IPv6 Failures

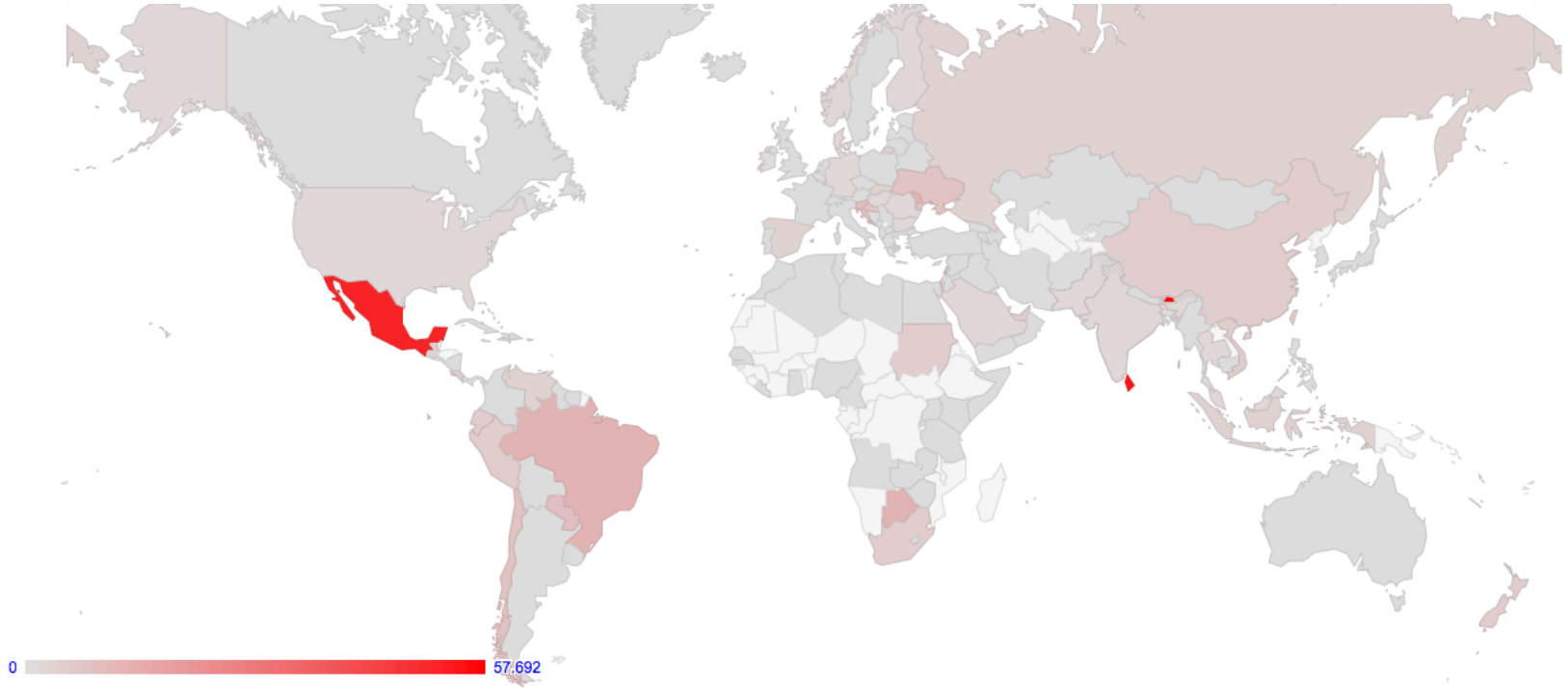


IPv6 Failures

- 1 in 70 connection failure for unicast V6 is still unacceptable!
  - IPv4 has a comparable 1 in 500 failure rate
- Why is this happening in IPv6?
  - Auto-tunnelling?
  - Lousy CPE firmware?
  - Strange firewall filters?
  - Asymmetric routing

Is IPv6 failure uniformly distributed?

Is IPv6 failure uniformly distributed?



Failure by Country

Code	Region	V6 Failure Rate	V6 Samples
LK	Sri Lanka, Southern Asia, Asia	51.11%	29,226
MX	Mexico, Central America, Americas	47.86%	234
BW	Botswana, Southern Africa, Africa	10.88%	147
MD	Republic of Moldova, Eastern Europe, Europe	10.77%	325
BR	Brazil, South America, Americas	10.56%	63,105
SI	Slovenia, Southern Europe, Europe	7.80%	5,336
UA	Ukraine, Eastern Europe, Europe	6.40%	1,125
IL	Israel, Western Asia, Asia	5.98%	1,891
EC	Ecuador, South America, Americas	4.95%	66,622
TW	Taiwan, Eastern Asia, Asia	4.87%	1,067
PE	Peru, South America, Americas	4.81%	81,372
SD	Sudan, Northern Africa, Africa	4.35%	230
AE	United Arab Emirates, Western Asia, Asia	4.12%	194
CN	China, Eastern Asia, Asia	4.12%	16,760
VN	Vietnam, South-Eastern Asia, Asia	4.07%	58,339
NZ	New Zealand, Australia and New Zealand, Oceania	3.95%	5,348
VE	Venezuela, South America, Americas	3.12%	128
GT	Guatemala, Central America, Americas	3.09%	1,490
RU	Russian Federation, Eastern Europe, Europe	2.67%	7,267
ID	Indonesia, South-Eastern Asia, Asia	2.61%	690
ES	Spain, Southern Europe, Europe	2.52%	477
DK	Denmark, Northern Europe, Europe	2.42%	3,218
SA	Saudi Arabia, Western Asia, Asia	2.37%	15,509
IN	India, Southern Asia, Asia	2.09%	589,056
TT	Trinidad and Tobago, Caribbean, Americas	2.04%	3,720

Failure by Network

ASN	AS Name	V6 Fail Rate ▼	V6 Fail Count	V6 Samples
AS20880	TELECOLUMBUS Tele Columbus AG, DE	62.15%	156	251
AS17660	DRUKNET-AS DrukNet ISP, BT	58.52%	79	135
AS18001	DIALOG-AS Dialog Axiata PLC., LK	54.34%	18,799	34,593
AS203953	HIPER Hiper ApS, DK	35.39%	86	243
AS2107	ARNES-NET ARNES, SI	31.86%	338	1,061
AS28343	TPA TELECOMUNICACOES LTDA, BR	27.07%	36	133
AS7470	TRUEINTERNET-AS-AP TRUE INTERNET Co.,Ltd., TH	26.32%	85	323
AS18881	Global Village Telecom, BR	23.38%	6,038	25,820
AS7477	TEREDONN-AS-AP SkyMesh Pty Ltd, AU	23.08%	24	104
AS42689	CABLECOM-AS Cablecom Networking Limited, GB, NL	22.11%	272	1,230
AS197922	FIRSTHEBERG Techcrea Solutions Sarl, FR	22.07%	196	888
AS14868	COPEL Telecom S.A., BR	20.52%	401	1,954
AS13188	BANKINFORM-AS CONTENT DELIVERY NETWORK LTD, UA	16.38%	57	348
AS34779	T-2-AS T-2, d.o.o., SI	15.52%	108	696
AS2200	FR-RENATER Reseau National de telecommunications pour la Technologie, FR	13.37%	27	202
AS26615	Tim Celular S.A., BR	13.32%	330	2,477
AS1547	IDK-NETWORK JSCC Interdnestrcom, MD	10.58%	38	359
AS25513	ASN-MGTS-USPD OJS Moscow city telephone network, RU	10.07%	148	1,469
AS55850	TRUSTPOWERLTD-AS-AP TrustPower Ltd, NZ	9.25%	31	335
AS28580	CILNET Comunicacao e Informatica LTDA., BR	8.46%	17	201
AS23655	SNAP-NZ-AS Snap Internet Limited, NZ	7.99%	136	1,703
AS2614	ROEDUNET Agentia de Administrare a Retelei Nationale de Informatica pentru Educatie si Cercetare, RO	7.30%	13	178
AS1659	ERX-TANET-ASN1 Taiwan Academic Network (TANet) Information Center, TW	6.68%	46	689
AS47956	XFONE XFone 018 Ltd, IL	6.53%	138	2,112
AS4818	DIGIIX-AP DiGi Telecommunications Sdn. Bhd., MY	5.98%	104	1,739
AS8167	Brasil Telecom SA - Filial Distrito Federal, BR	5.86%	124	2,117
AS37197	SUDREN, SD	5.86%	15	256
AS42652	DELUNET inexio Informationstechnologie und TelekommunikationKGaA, DE	5.38%	15	279
AS6147	Telefonica del Peru S.A.A., PE	5.07%	5,067	100,002
AS14420	CORPORACION NACIONAL DE TELECOMUNICACIONES - CNT EP, EC	4.85%	3,848	79,280
AS35804	ALNET-AS PP SKS-Lugan, UA	4.82%	30	622
AS35132	ENIVEST-AS Enivest AS, NO	4.82%	8	166
AS4134	CHINANET-BACKBONE No.31,Jin-rong Street, CN	4.74%	297	6,264

The view of Taiwan

ASN	AS Name	V6 Fail Rate	V6 Fail Count	V6 Samples
AS7539	TANET2-TW TANet2, sponsored by NSC, TAIWAN	7.41%	2	27
AS1659	ERX-TANET-ASN1 Taiwan Academic Network (TANet) Information Center	5.95%	86	1,445
AS18418	TWNIC-AS Taiwan Network Information Center	0.00%	0	73,149
AS3462	HINET Data Communication Business Group	0.00%	0	996
AS17713	NSYSU-TW National Sun Yat-sen University	0.00%	0	85
AS131150	KH-AS-TW Education Bureau, Kaohsiung City Government, Taiwan	0.00%	0	39
AS15169	GOOGLE - Google Inc.	0.00%	0	35
AS18420	NCU-TW National Central University	0.00%	0	31
AS4782	GSNET Data Communication Business Group	0.00%	0	26

A cautionary note

- These are “single shot” measurements rather than sustained repeated test, so there is some noise component here
- Its also likely that connection failure is related to consumer equipment rather than network-level failure, as a network level failure would conventionally give a failure rate closer to 100% than ~10%

What are we looking at:

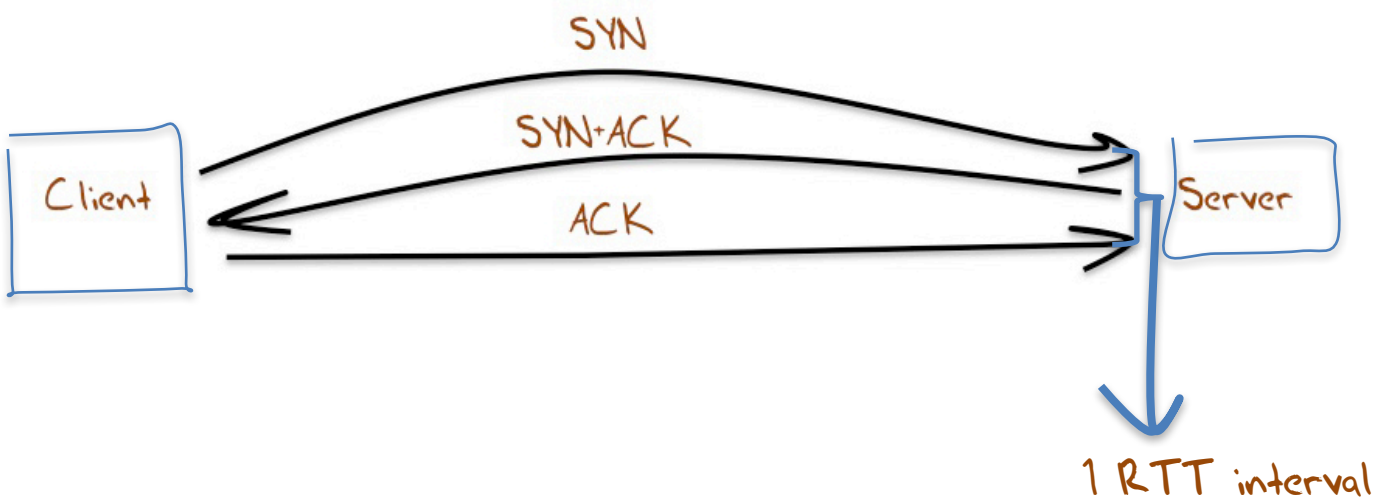
- How "reliable" are IPv6 connections?

Do all TCP connection attempts succeed?

- How "fast" are IPv6 connections?

is V6 slower than V4?

Let's look at TCP 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

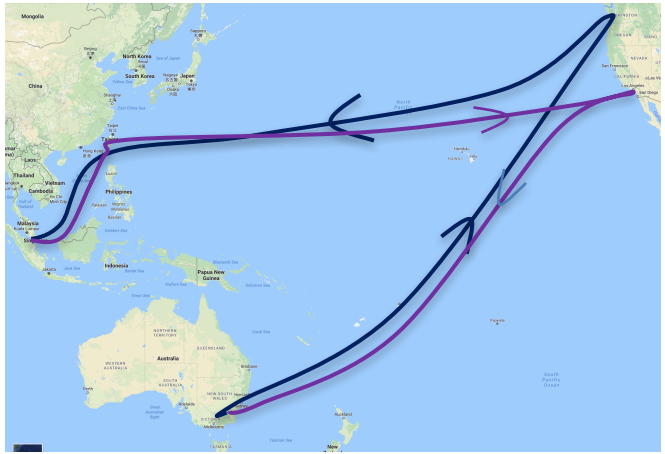
- For each successful connection couplet (IPv4 and IPv4) from the same endpoint, gather the pair of RTT measurements from the SYN-ACK exchanges
  - Use the server's web logs to associate a couplet of IPv4 and IPv6 addresses
  - Use the packet dumps to collect RTT information from the SYN-ACK Exchange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

An Example of Path Divergence

$ traceroute from Singapore to Canberra, IPv4
traceroute to 202.158.xxxx.yyy, 30 hops max, 60 byte packets
 1 103.3.60.3 0.672ms 0.796ms 0.899ms
 2 139.162.0.9 0.754ms 0.708ms 0.732ms
 3 te0-1-0-21.br03.sin02.pccwbtn.net 1.697ms 0.760ms 0.726ms
 4 ntt.fe3-18.br01.sin02.pccwbtn.net 69.526ms 69.644ms 69.754ms
 5 ae-10.r20.sngpsi05.sg.bb.gin.ntt.net 60.702ms 68.474ms 68.469ms
 6 ae-8.r22.snjsca04.us.bb.gin.ntt.net 168.447ms 168.532ms 168.138ms
 7 ae-19.r01.snjsca04.us.bb.gin.ntt.net 167.489ms 170.665ms 178.832ms
 8 xe-0-8-0-21.r01.snjsca04.us.ce.gin.ntt.net 330.084ms 323.556ms 329.772ms
 9 xe-1-0-1.pe1.msct.nsw.aarnet.net.au 330.020ms 323.738ms 334.474ms
10 et-3-3-0.pe1.rsby.nsw.aarnet.net.au 327.788ms 334.157ms 328.199ms
11 138.44.161.6 323.644ms 319.455ms 323.563ms
12 202.158.xxx.yyy 319.885ms 333.933ms 325.014ms

$ traceroute from Canberra to Singapore, IPv4
traceroute to 139.162.xxx.yyy, 64 hops max, 52 byte packets
 1 202.158.x.y 0.682ms 0.388ms 0.313ms
 2 xe-5-0-4-205.pe1.actn.act.aarnet.net.a 0.721ms 0.828ms 0.674ms
 3 et-0-3-0.pe1.rsby.nsw.aarnet.net.au 4.548ms 4.733ms 4.533ms
 4 et-7-1-0.pe1.brwy.nsw.aarnet.net.au 4.734ms 5.418ms 4.745ms
 5 et-0-3-0.pe1.bkvl.nsw.aarnet.net.au 5.117ms 5.512ms 5.524ms
 6 xe-0-0-0.bb1.b.sea.aarnet.net.au 148.017ms 148.019ms 148.131ms
 7 ge3-0.cr02.sea01.pccwbtn.net (206.81.80.13) 148.469ms 148.059ms 148.429ms
 8 tenge0-2-0-14.br03.sin02.pccwbtn.net 319.435ms 325.053ms 319.117ms
 9 tenge0-2-0-15.br03.sin02.pccwbtn.net 319.257ms 332.560ms 323.415ms
10 linode.te0-1-0-21.br03.sin02.pccwbtn.net 323.723ms 323.627ms 323.587ms
11 139.162.aaa.bbb 334.609ms 347.243ms 347.228ms
12 139.162.xxx.yyy 325.186ms 338.209ms 325.603ms

iPv4

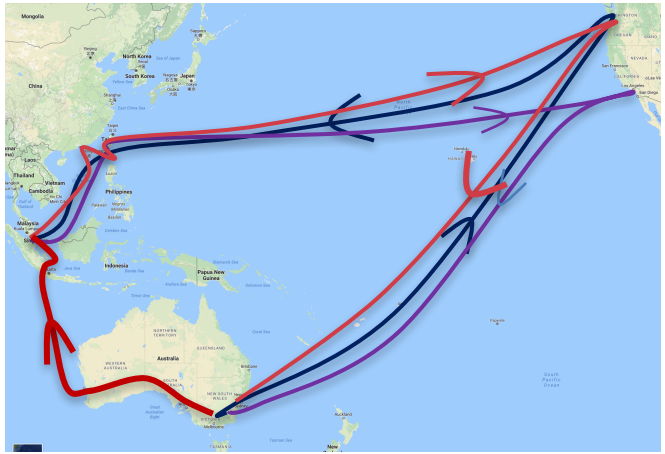


An Example of Path Divergence

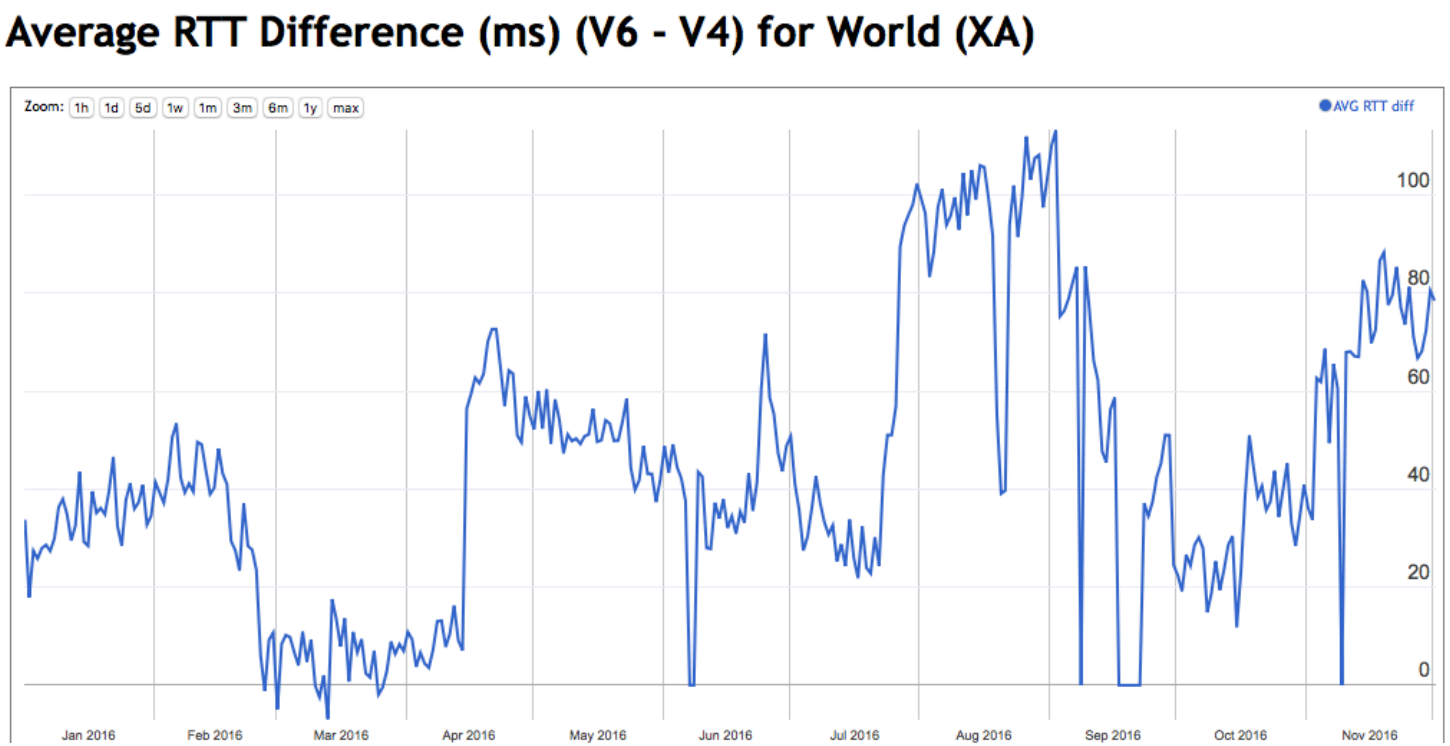
```
$ traceroute from Singapore to Canberra, IPv6
traceroute6 to 2001:388:1000:110:e4d:e9ff:x:y, 30 hops max, 80 byte packets
 1  2400:8901::5287:89ff:fe40:9fc1  0.897ms  0.912ms  1.051ms
 2  2400:8901:1111::1 0.851ms 0.827ms 0.792ms
 3  2001:cb0:2102:2:f::1 0.364ms  0.333ms  0.516ms
 4  2001:cb0:2102:2:f::1 0.502ms  0.461ms  0.431ms
 5  2001:cb0:21f0:1:17::2 2.512ms 2.176ms 3.445ms
 6  2001:cb0:21f0:1:17::2 2.354ms  2.382ms 1.238ms
 7  10gigabitethernet3-5.core1.sin1.he.net 1.080ms  1.034ms  1.020ms
 8  10ge1-5.core1.tyo1.he.net 88.053ms
    10ge1-16.core1.hkg1.he.net 39.369ms
    10ge1-5.core1.tyo1.he.net 88.084ms
 9  10ge1-5.core1.tyo1.he.net 88.157ms
    100ge8-1.core1.sea1.he.net 192.408ms  192.642ms
10  100ge8-1.core1.sea1.he.net 192.631ms  192.608ms  196.154ms
11  xe-1-0-1.pe2.brwy.nsw.aarnet.net.au 214.176ms 186.238ms 213.061ms
12  et-3-1-0.pe1.brwy.nsw.aarnet.net.au 211.298ms 211.300ms 214.200ms
13  et-1-1-0.pe1.rsby.nsw.aarnet.net.au 211.492ms 211.535ms 211.427ms
14  et-0-3-0.pe1.actn.act.aarnet.net.au 213.332ms 211.458ms  211.476ms
15  2001:388:1000:110:e4d:e9ff:x.y 213.274ms 213.159ms 213.169ms

$ traceroute from Canberra to Singapore, IPv6
traceroute6 to 2400:8901::f03c:91ff:a:b) 64 hops max, 12 byte packets
 1  2001:388:1000:110::x:y  0.808ms  0.899ms  1.586ms
 2  xe-5-0-4-205.pe1.actn.act.aarnet.net.au  1.633ms  0.646ms  0.578ms
 3  et-0-1-0.pe1.dksn.act.aarnet.net.au  0.682ms  0.649ms  0.694ms
 4  et-5-3-0.pe1.crlt.vic.aarnet.net.au  8.072ms  8.086ms  8.049ms
 5  et-5-1-0.pe1.wmlb.vic.aarnet.net.au  8.116ms  8.055ms  8.073ms
 6  et-0-3-0.pe1.adel.sa.aarnet.net.au  17.790ms  16.984ms  17.036ms
 7  et-1-1-0.pe1.prka.sa.aarnet.net.au  17.080ms  17.152ms
    et-0-3-0.pe1.eper.wa.aarnet.net.au  43.319ms
 8  et-0-3-0.pe1.knsg.wa.aarnet.net.au  43.357ms  43.443ms  43.353ms
 9  gigabitethernet-5-1-0.bb1.b.per.aarnet.net.au  43.849ms  43.919ms  43.850ms
10  so-0-0-0.bb1.a.sin.aarnet.net.au  92.219ms  92.275ms  92.189ms
11  as6939.singapore.megaport.com  212.347ms  212.426ms  212.471ms
12  * * *
13  2400:8901:1110::2  213.924ms 213.904ms  213.717ms
14  2400:8901::f03c:91ff:a:b  213.954ms  213.393ms  213.726ms
```

IPv4 - IPv6

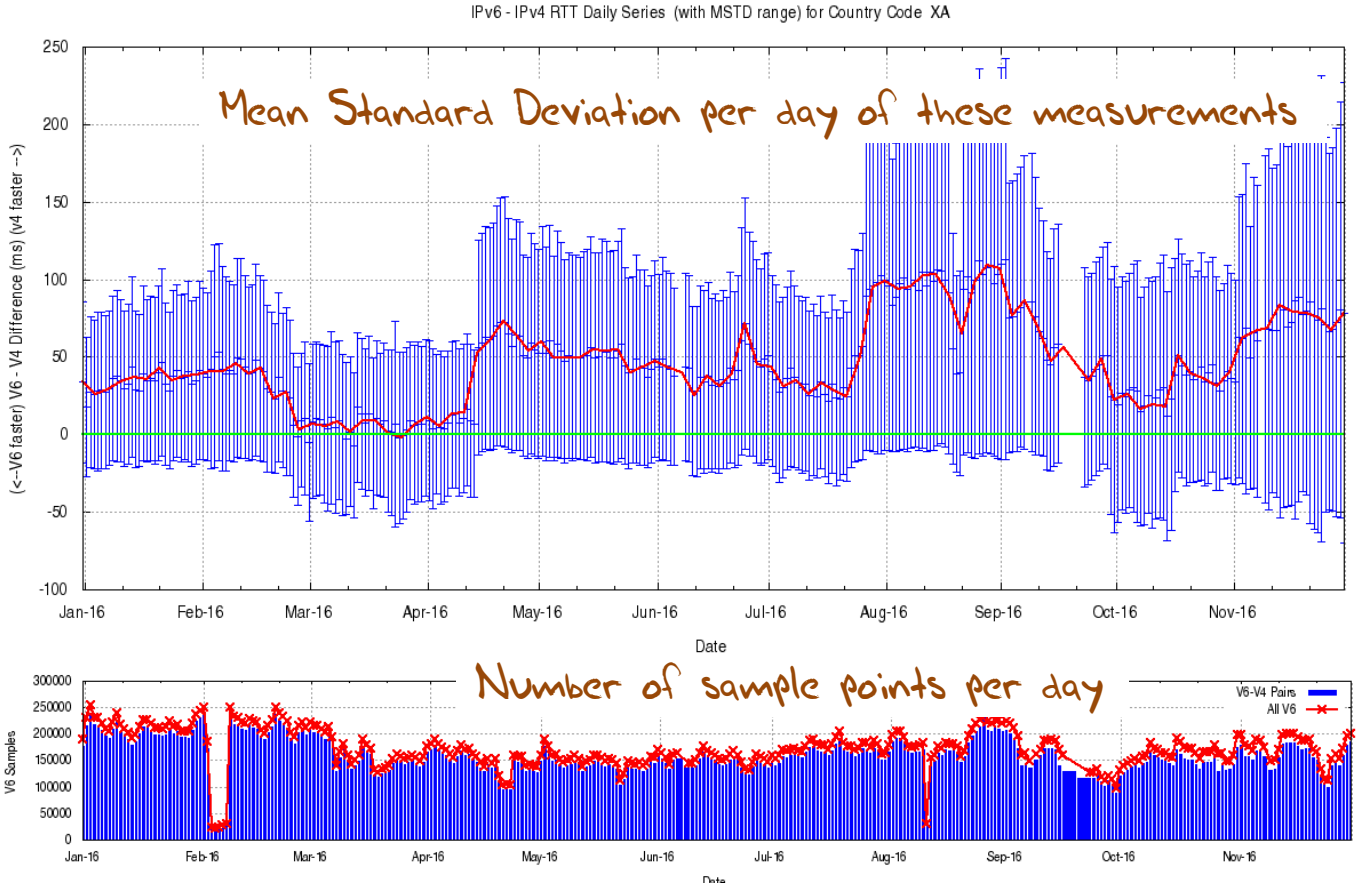


Global Results

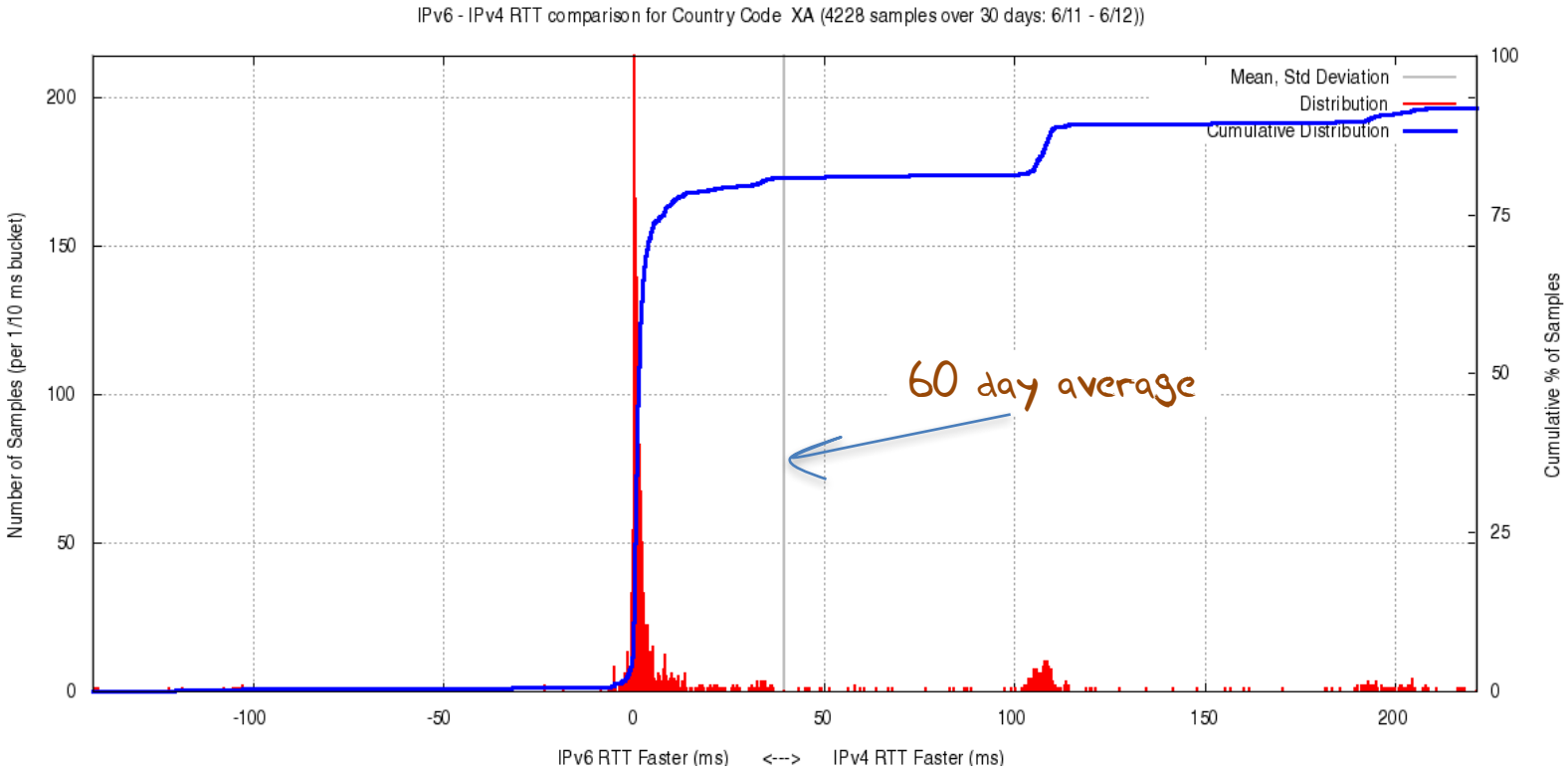


On average IPv6 is showing 10 - 20ms slower that IPv4

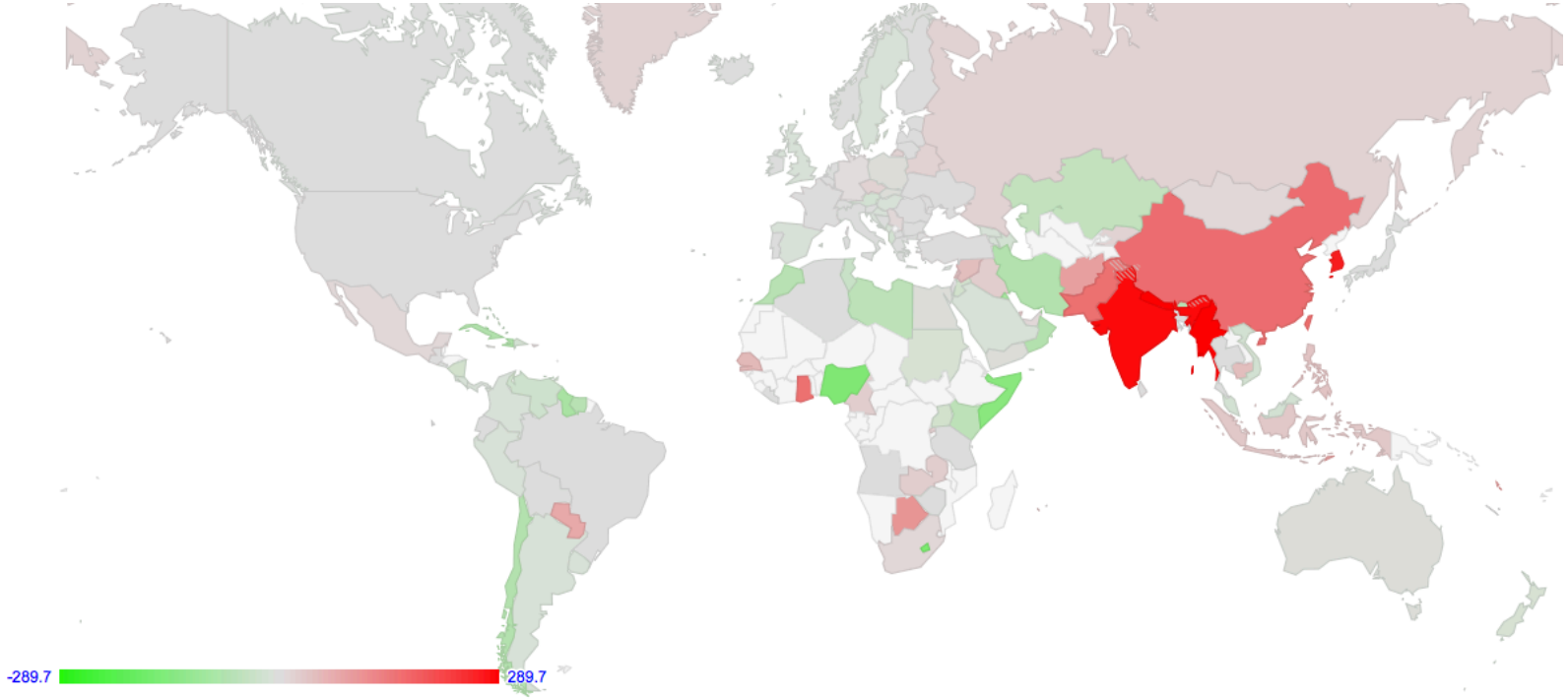
Global Results



Relative RTT Distribution



Performance by Country

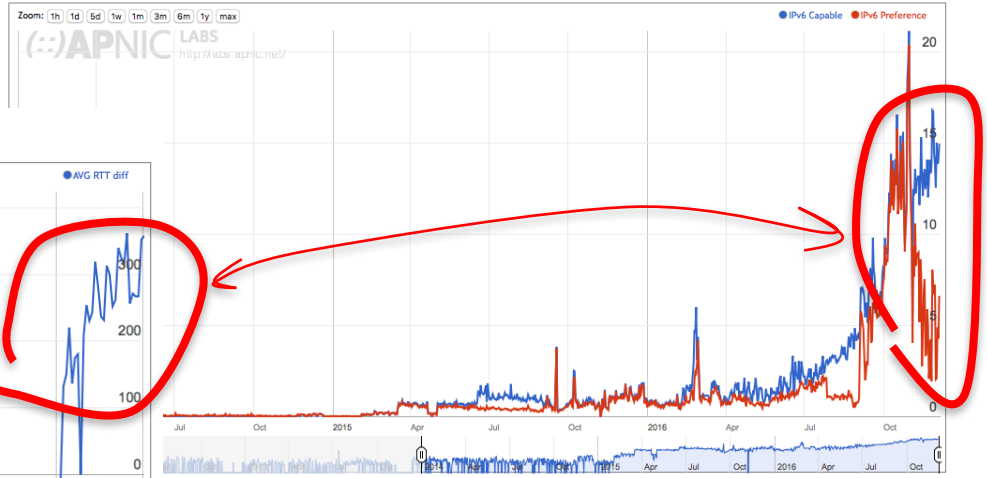


Performance by Network

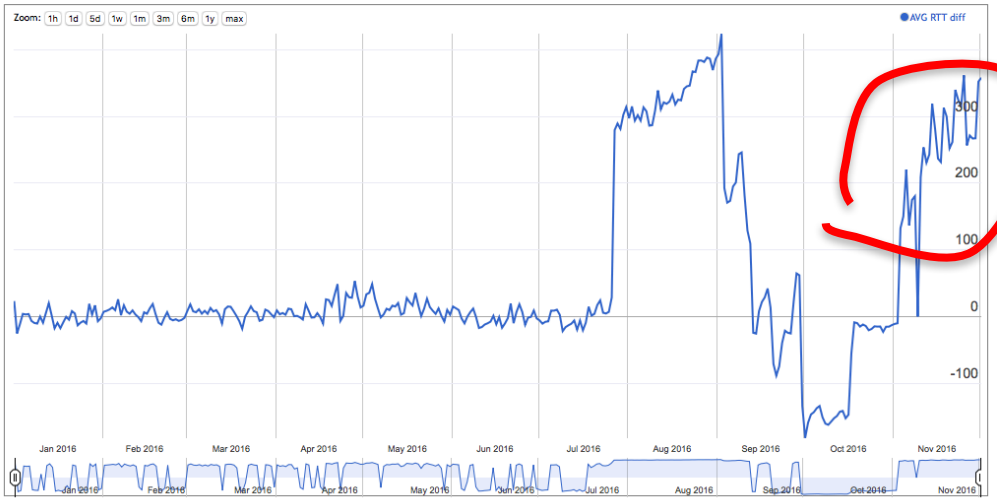
ASN	AS Name	RTT Diff (V6-V4)	Samples
AS1659	ERX-TANET-ASN1 Taiwan Academic Network (TANet) Information Center, TW	117.02 ms	408
AS4713	OCN NTT Communications Corporation, JP	101.52 ms	1,489
AS6147	Telefonica del Peru S.A.A., PE	63.53 ms	112,037
AS14420	CORPORACION NACIONAL DE TELECOMUNICACIONES - CNT EP, EC	56.01 ms	63,639
AS4608	APNIC-SERVICES Asia Pacific Network Information Centre, AU	52.83 ms	143
AS6584	MICROSOFT-GP-AS - Microsoft Corporation, GB	48.03 ms	205
AS45209	UPLB-AS-AP University of the Philippines, Los Banos Campus, PH	47.68 ms	236
AS23910	CNGI-CERNET2-AS-AP China Next Generation Internet CERNET2, CN	46.76 ms	20
AS4250	ALENT-ASN-1 - Alentus Corporation, US	46.02 ms	1,630
AS27839	Comteco Ltda, BO	43.85 ms	7,556
AS22284	DIOS - Department of the Interior, Office of theSecretary, US	43.52 ms	91
AS4818	DIGIIX-AP DiGi Telecommunications Sdn. Bhd., MY	41.32 ms	858
AS13778	JOHNSON-AND-JOHNSON - Johnson Johnson, US, EU	39.56 ms	105
AS4134	CHINANET-BACKBONE No.31,Jin-rong Street, CN	39.39 ms	737
AS46690	SNET-FCC - Southern New England Telephone Company and SNET America, Inc., US	37.20 ms	7,261
AS4837	CHINA169-BACKBONE CNCGROUP China169 Backbone, CN	36.64 ms	261
AS21321	ARETI-AS Areti Internet Ltd., CA, CZ, DE, FR, TR, US, DK, RU, UA, SE, ES, GB, IE	36.36 ms	5,278
AS4795	INDOSATM2-ID INDOSATM2 ASN, ID	35.68 ms	83
AS4538	ERX-CERNET-BKB China Education and Research Network Center, CN	34.01 ms	202
AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business, US	31.43 ms	1,206
AS12576	ORANGE-PCS EE Limited, GB	27.81 ms	126
AS33363	BHN-TAMPA - BRIGHT HOUSE NETWORKS, LLC, US	27.29 ms	152
AS6128	CABLE-NET-1 - Cablevision Systems Corp., US	24.73 ms	410
AS109	CISCOSYSTEMS - Cisco Systems, Inc., AU, CN, EU, GB, IN, SA, US, IL, SG, NL	23.87 ms	1,530
AS29180	O2-ONLINE-AS Telefonica UK Limited, GB	23.56 ms	135
AS9790	CALLPLUS-NZ-AP CallPlus Services Limited, NZ	21.57 ms	705
AS5650	FRONTIER-FRTR - Frontier Communications of America, Inc., US, CA	19.65 ms	401

India

Use of IPv6 for India (IN)

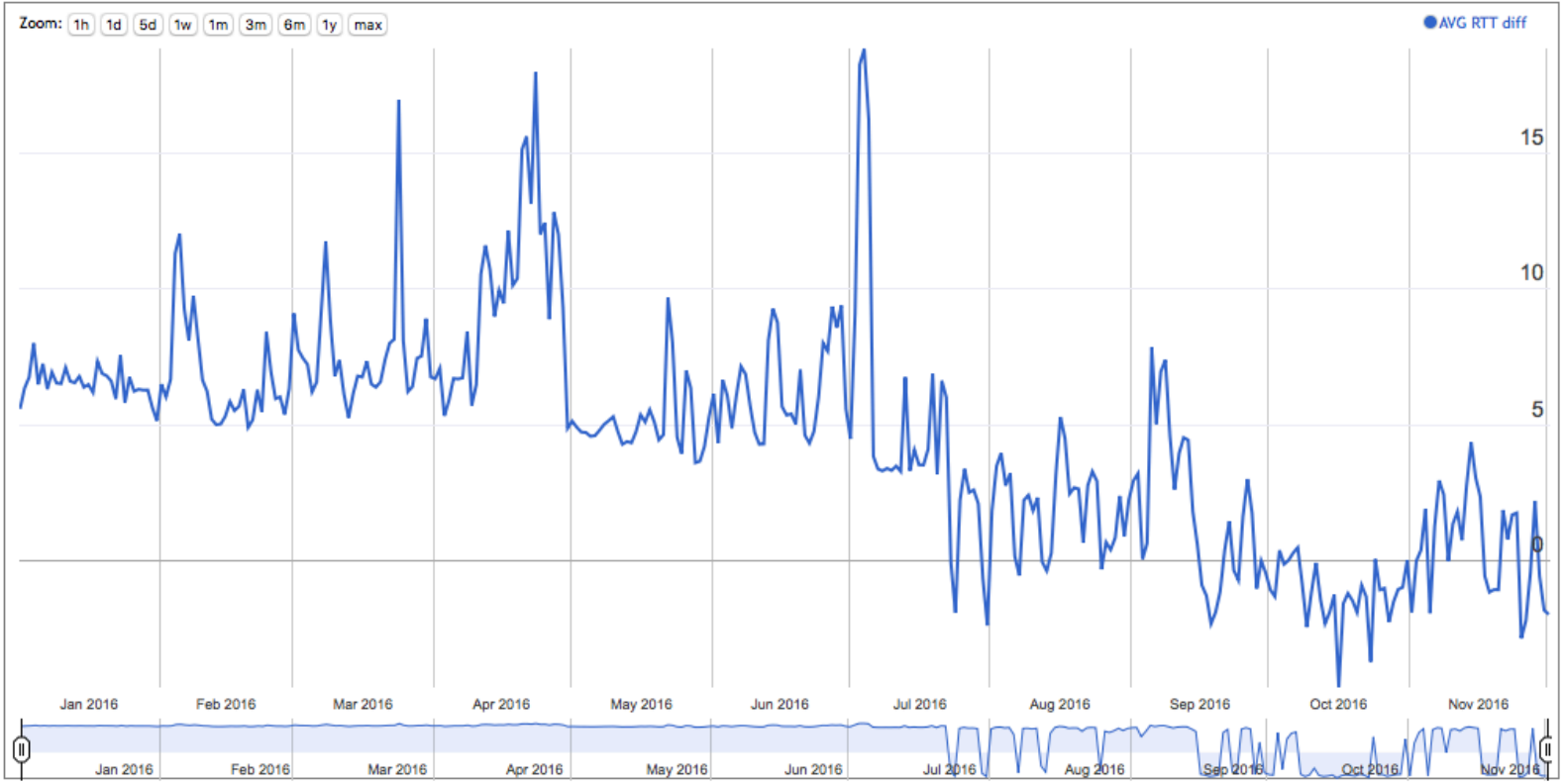


Average RTT Difference (ms) (V6 - V4) for India (IN)



The United States

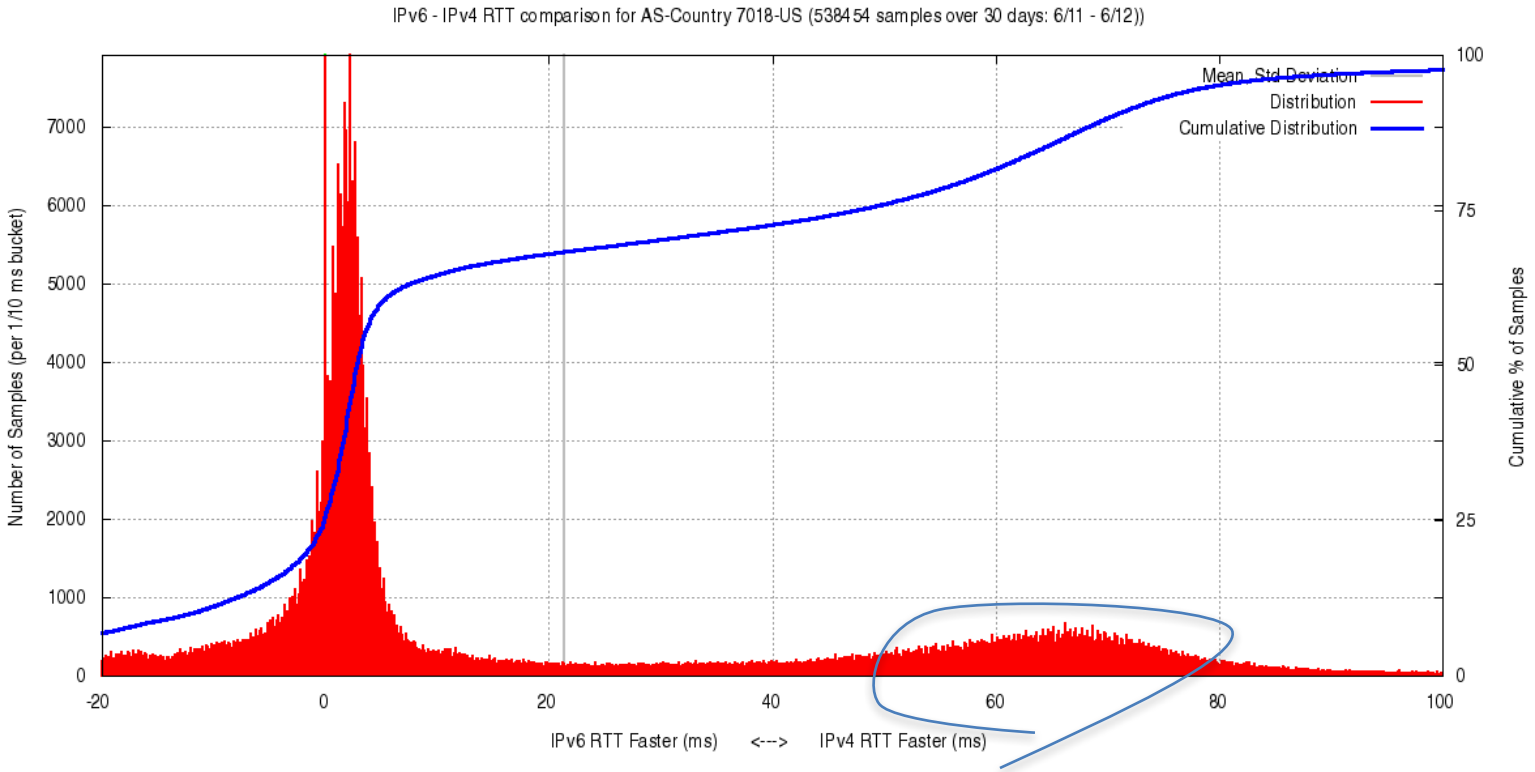
Average RTT Difference (ms) (V6 - V4) for United States of America (US)



The United States

ASN	AS Name	RTT Diff (V6-V4)	Samples	V6 Fail Rate	V6 Fail Count	V6 Samples	Dual Stack	Dual Stack (300ms)	V6 Use Rate
AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	-4.93 ms	892,442	0.94%	8,741	930,944	66.03%	94.30%	66.33%
AS7018	ATT-INTERNET4 - ATT Services, Inc.	14.08 ms	610,693	1.96%	12,859	654,585	31.80%	91.96%	82.36%
AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	-4.96 ms	287,284	0.31%	922	301,962	63.91%	95.08%	90.98%
AS21928	T-MOBILE-AS21928 - T-Mobile USA, Inc.	-3.38 ms	188,448	0.14%	278	196,543	62.63%	95.37%	80.40%
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	-0.95 ms	107,814	0.89%	1,005	112,489	52.57%	92.82%	39.52%
AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	-2.61 ms	86,782	2.80%	2,584	92,394	49.52%	92.97%	47.66%
AS11427	SCRR-11427 - Time Warner Cable Internet LLC	5.73 ms	54,277	2.64%	1,524	57,664	61.02%	91.09%	45.90%
AS11426	SCRR-11426 - Time Warner Cable Internet LLC	-7.89 ms	46,773	3.35%	1,675	49,978	78.78%	93.42%	41.09%
AS10796	SCRR-10796 - Time Warner Cable Internet LLC	-5.43 ms	46,550	2.57%	1,270	49,371	68.42%	93.99%	26.65%
AS20057	ATT-MOBILITY-LLC-AS20057 - ATT Mobility LLC	-0.94 ms	43,214	0.00%	2	45,537	64.41%	97.97%	20.61%
AS10507	SPCS - Sprint Personal Communications Systems	-2.78 ms	40,693	0.00%	0	40,693	59.92%	95.27%	31.37%
AS12271	SCRR-12271 - Time Warner Cable Internet LLC	-3.14 ms	34,835	3.01%	1,120	37,161	60.60%	92.13%	50.76%
AS15169	GOOGLE - Google Inc.	5.06 ms	34,015	0.31%	131	42,857	93.35%	1.52%	46.75%
AS11351	RR-NYSREGION-ASN-01 - Time Warner Cable Internet LLC	-4.02 ms	20,318	1.96%	418	21,326	62.52%	93.71%	21.13%
AS30036	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom Communications Corp	-9.37 ms	15,678	4.26%	719	16,859	78.22%	94.62%	27.26%
AS16591	GOOGLE-FIBER - Google Fiber Inc.	-4.39 ms	9,482	0.14%	14	9,916	78.16%	95.83%	87.27%
AS21321	ARETI-AS Areti Internet Ltd.	17.13 ms	8,608	0.00%	0	10,151	67.97%	93.84%	88.81%
AS11232	MIDCO-NET - Midcontinent Media, Inc.	-9.79 ms	8,373	3.26%	296	9,071	73.15%	93.17%	46.85%

AT&T - AS7018


IPv6 - IPv4 RTT comparison for AS-Country 7018-US (538454 samples over 30 days: 6/11 - 6/12))
Mean, Std Deviation
Distribution
Cumulative Distribution
Number of Samples (per 1/10 ms bucket)
Cumulative % of Samples
0
1000
2000
3000
4000
5000
6000
7000
0
25
50
75
100
-20
0
20
40
60
80
100
IPv6 RTT Faster (ms) <---> IPv4 RTT Faster (ms)

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 75% 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 1.5% of the total V6 unicast connections is not brilliant.

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

And that’s good!

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

And that’s not good!

That's it!

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

A question to each of you…

How many IPv6 presentations have you sat through?

- ☐ 21?
- ☐ 101?
- ☐ 1,001?
- ☑ I don't know - I was asleep by the end!