Measuring IPv6
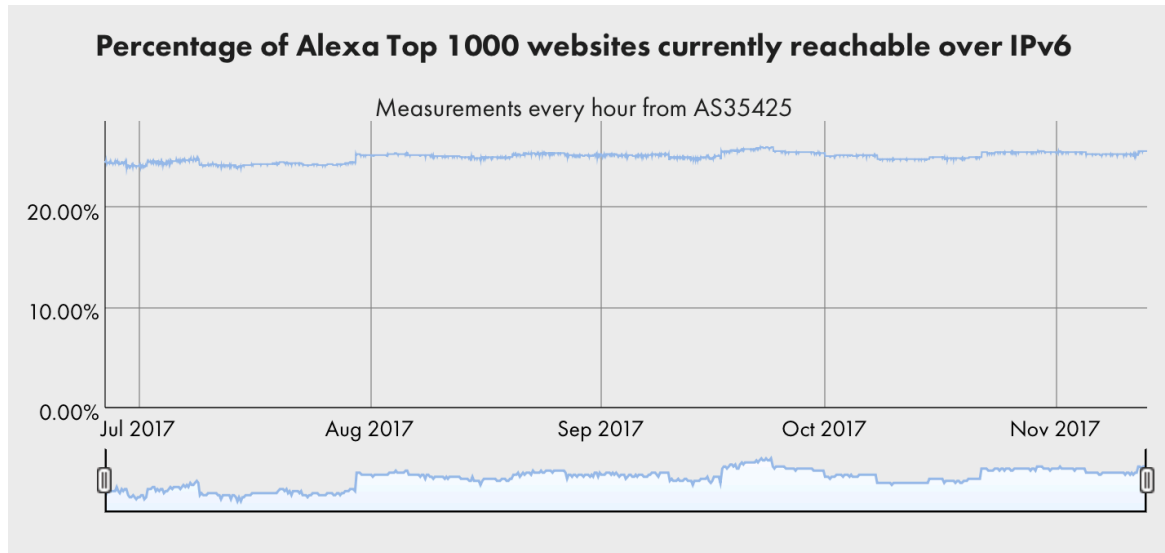
Geoff Huston
APNiC

Measuring IPv6

How can we "measure" the uptake of IPv6?

   – Alexa Lists: Dual Stack services
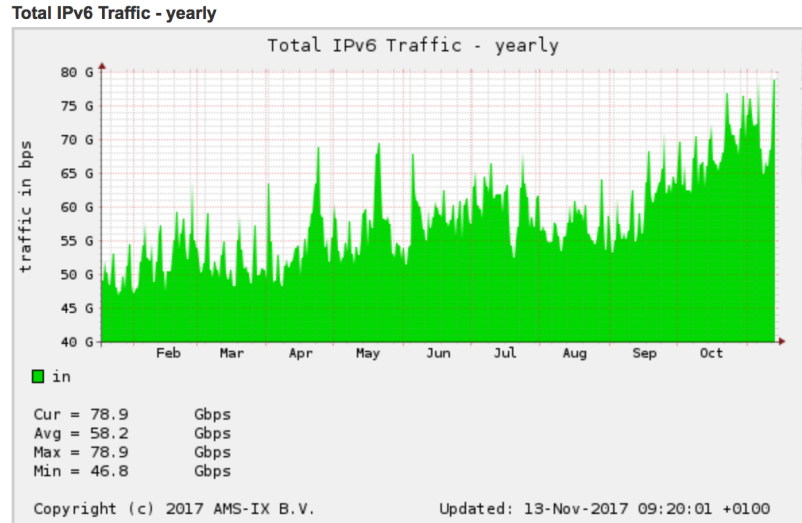
Percentage of Alexa Top 1000 websites currently reachable over IPv6

Measurements every hour from AS35425

Steady at some 24% of sites for the past 5 months

ISOC 360 Deploy Pages

Measuring IPv6

How can we "measure" the uptake of IPv6?

- IX stats: IPv6 traffic stats

30% increase in traffic volumes over the past 12 months

AMSIX Traffic Statistics

What should be be looking for?

- Generating measurements from the network is endless!
  - There are many aspects of the network infrastructure that can be measured
- But are they helpful measurements?

- In some ways measuring the infrastructure is getting it backwards!
- If we want to know what users can (or cannot) do, then why not measure the user?

User-Centric measurements

- How fast is your Internet connection?

- How reliable is your connection?

- How fast is your DNS service?

- Can you retrieve a web object over IPv6?

- Given a choice of IPv6 and IPv4 what protocol will your browser prefer to use to retrieve a web obejct?

Measuring as a User

- How can we "see" the Internet as users see it?
- One approach is to put measurement equipment at the edge of the Internet
  - RIPE Atlas, CAIDA Archipelago, Sam Knows, etc
- Another approach is to get users to run the measurement tests
  - ICSI Netalyser, Google M-Lab
- We can ride on the back of a widely distributed software platform
  - And insert a measurement script into this environment

We use Ads!
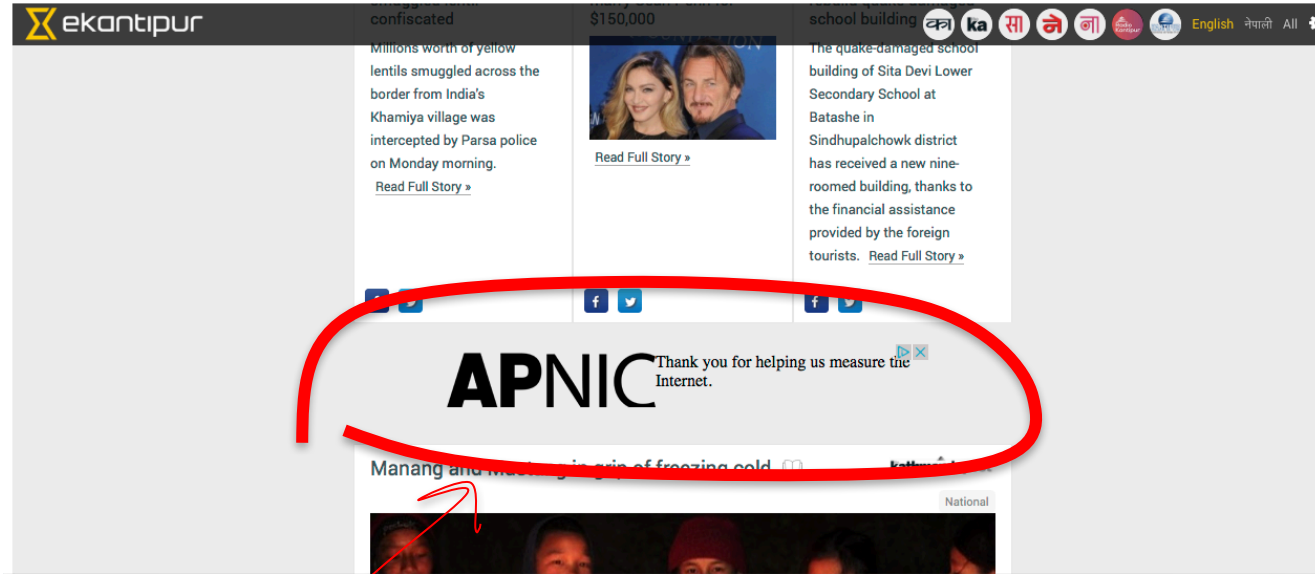
APNIC's Measurement Technique

- 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
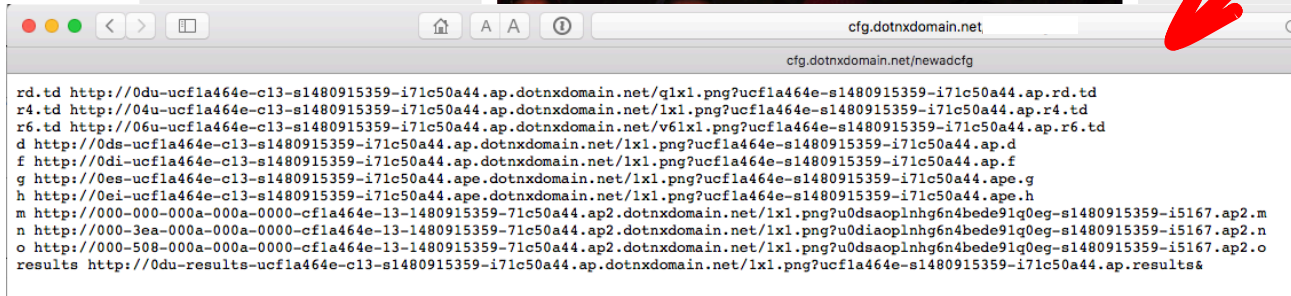- Examine the traffic profile seen at the server

How We Measure

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

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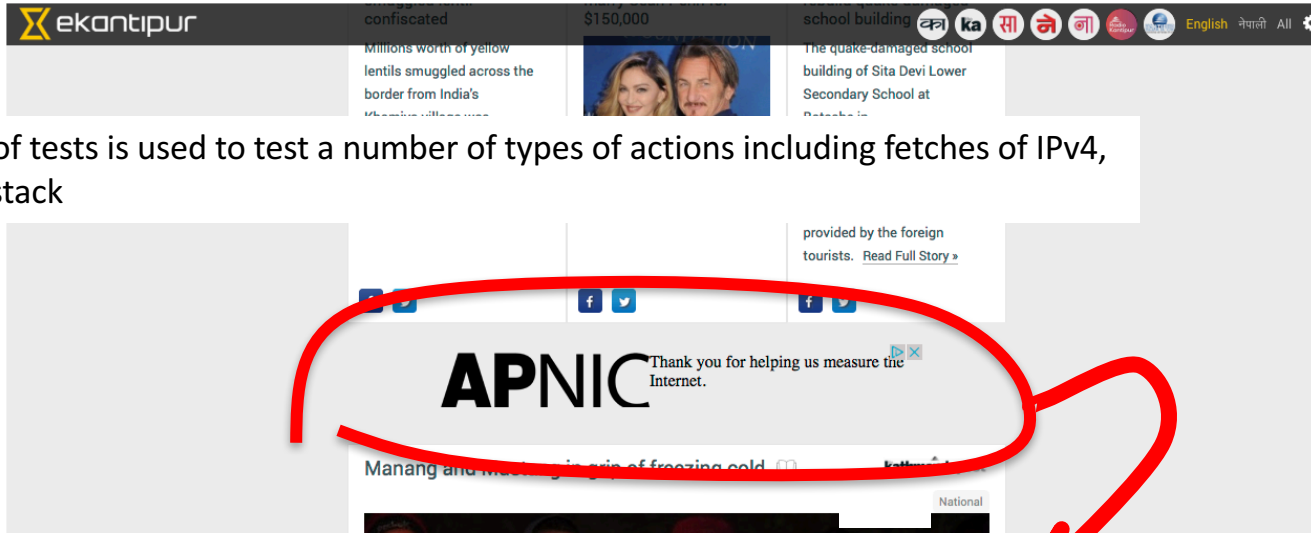
The sequence of tests is used to test a number of types of actions including fetches of IPv4, IPv6 and Dual stack

How We Measure

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

How Much do We Measure?

Daily Total Ad Impressions for Servers - Month: 08-Oct to 12-Nov

14M -20M sample points per day!
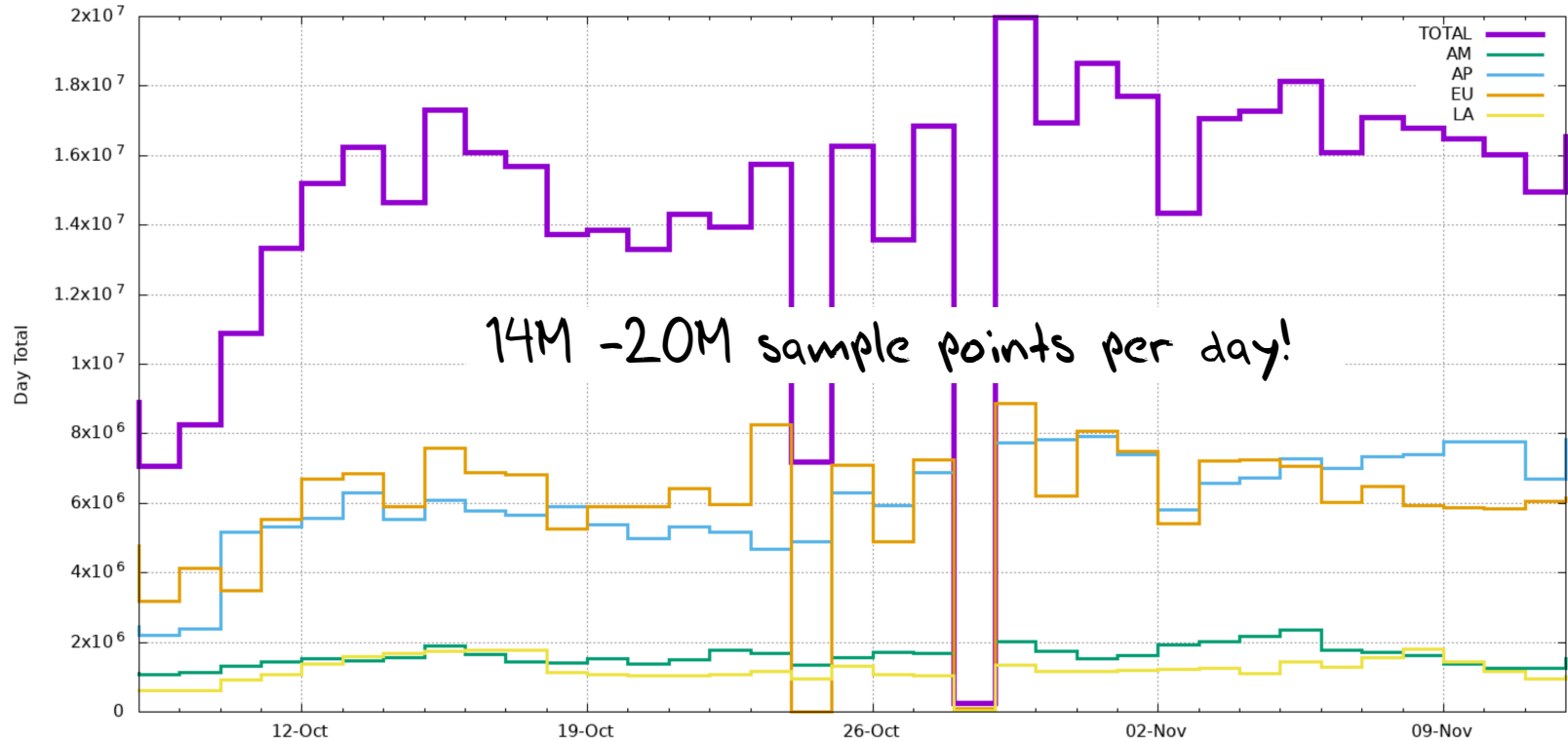
Measuring IPv6

In the Ad we have two URLs:
- one can only be fetched if the user is able to complete the fetch using IPv6 - IPv6 "CAPABLE"
- Another can be fetched using either IPv4 or IPv6 – we are interested in which protocol is "PREFERRED" when given the choice

We count the results and group it by economy and by network per day, giving up a long term picture about the global update of IPv6 in the Internet by users

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 ex~~~~~ ~~~~ adopt IPv6 while there was still some ~~~~ 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 IPv4 exhaustion would prompt all service providers to accelerate their IPv6 deployment plans

So far NATs appear to be used instead!

Global Uptake of IPv6
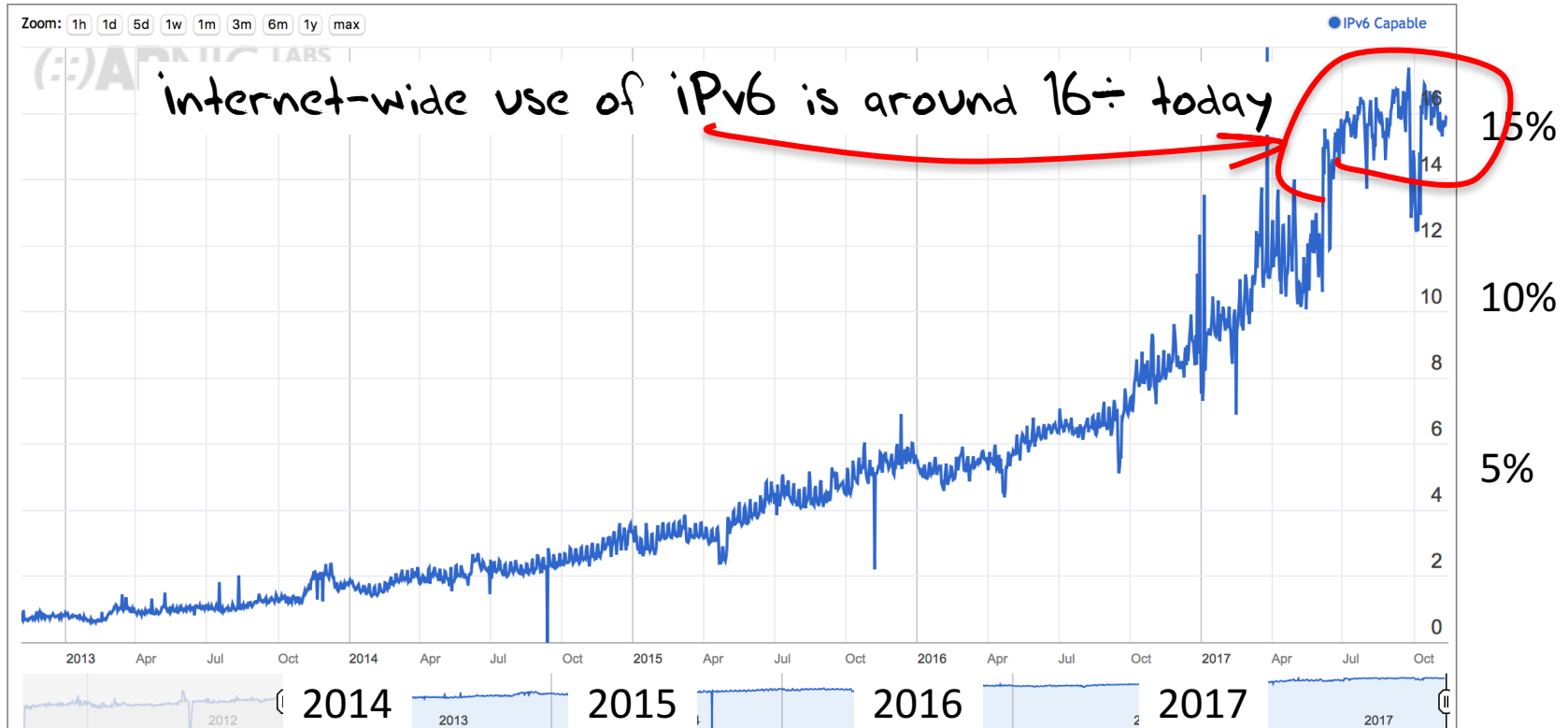
Where are these IPv6 Users?
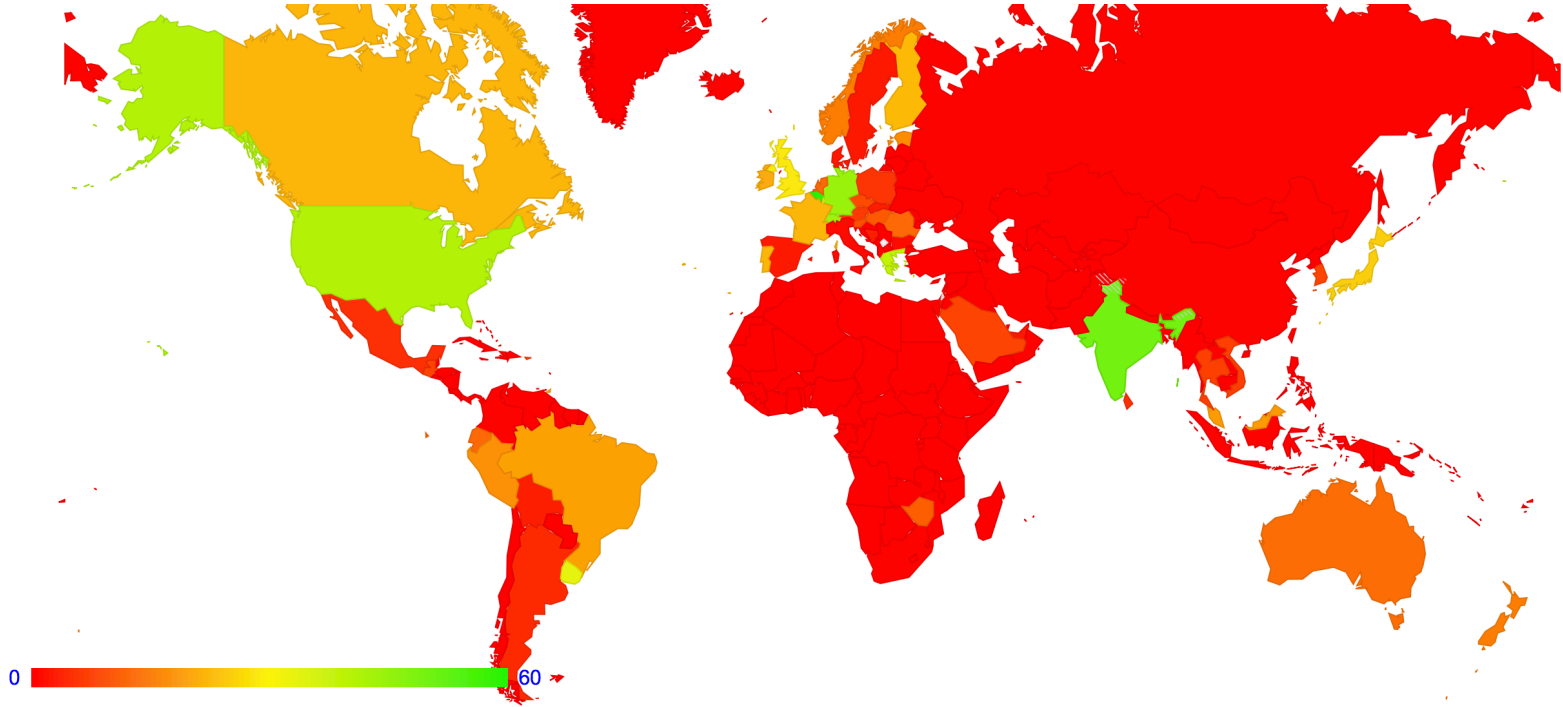
Where are these IPv6 Users?

Where are IPv6 Users?

CC	Country	IPv6 Capable
BE	Belgium, Western Europe, Europe	60.44%
IN	India, Southern Asia, Asia	51.01%
DE	Germany, Western Europe, Europe	41.83%
US	United States of America, Northern America, Americas	40.67%
CH	Switzerland, Western Europe, Europe	40.17%
GR	Greece, Southern Europe, Europe	37.07%
LU	Luxembourg, Western Europe, Europe	30.20%
GB	United Kingdom of Great Britain and Northern Ireland, Northern Europe, Europe	27.11%
JP	Japan, Eastern Asia, Asia	25.07%
PT	Portugal, Southern Europe, Europe	23.86%
FR	France, Western Europe, Europe	23.42%
TT	Trinidad and Tobago, Caribbean, Americas	21.84%
CA	Canada, Northern America, Americas	21.63%
BR	Brazil, South America, Americas	19.54%
EE	Estonia, Northern Europe, Europe	19.39%
FI	Finland, Northern Europe, Europe	19.11%
UY	Uruguay, South America, Americas	18.60%
MY	Malaysia, South-Eastern Asia, Asia	18.33%
IE	Ireland, Northern Europe, Europe	18.11%
AU	Australia, Australia and New Zealand, Oceania	17.56%

0

Which ISPs offer IPv6?

Visible ASNs: Customer Populations (Est.)

ASN	AS Name	CC	Users (est.)	V6 Users (est) ▽	% of AS
AS55836	RELIANCEJIO-IN Reliance Jio Infocomm Limited	IN	253,329,150	224,493,397	88.62
AS7922	COMCAST-7922 - Comcast Cable Communications, LLC	US	49,564,281	34,997,149	70.61
AS7018	ATT-INTERNET4 - ATT Services, Inc.	US	28,690,839	23,505,271	81.93
AS3320	DTAG Internet service provider operations	DE	22,771,877	13,881,372	60.96
AS5607	BSKYB-BROADBAND-AS	GB	14,904,373	13,602,587	91.27
AS21928	T-MOBILE-AS21928 - T-Mobile USA, Inc.	US	12,437,505	10,983,012	88.31
AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	US	11,919,972	10,418,084	87.4
AS2516	KDDI KDDI CORPORATION	JP	18,767,464	9,848,834	52.48
AS28573	CLARO S.A.	BR	25,592,920	9,334,494	36.47
AS45271	ICLNET-AS-AP Idea Cellular Limited	IN	30,477,688	9,073,769	29.77
AS3215	AS3215	FR	18,387,417	8,006,805	43.55
AS17676	GIGAINFRA Softbank BB Corp.	JP	22,351,193	7,861,076	35.17
AS31334	KABELDEUTSCHLAND-AS	DE	9,721,998	6,744,795	69.38
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	US	12,045,284	5,907,955	49.05
AS18881	TELEFNICA BRASIL S.A	BR	17,021,711	5,599,772	32.9
AS12322	PROXAD	FR	13,845,655	5,210,968	37.64
AS20057	ATT-MOBILITY-LLC-AS20057 - ATT Mobility LLC	US	10,085,376	4,945,586	49.04
AS4713	OCN NTT Communications Corporation	JP	21,780,913	4,717,811	21.66
AS6830	LGI-UPC formerly known as UPC Broadband Holding B.V.	DE	6,442,545	4,422,213	68.64
AS8151	Uninet S.A. de C.V.	MX	32,435,960	3,927,096	12.11
AS27699	TELEFNICA BRASIL S.A	BR	9,705,648	3,836,841	39.53

0

Belgium
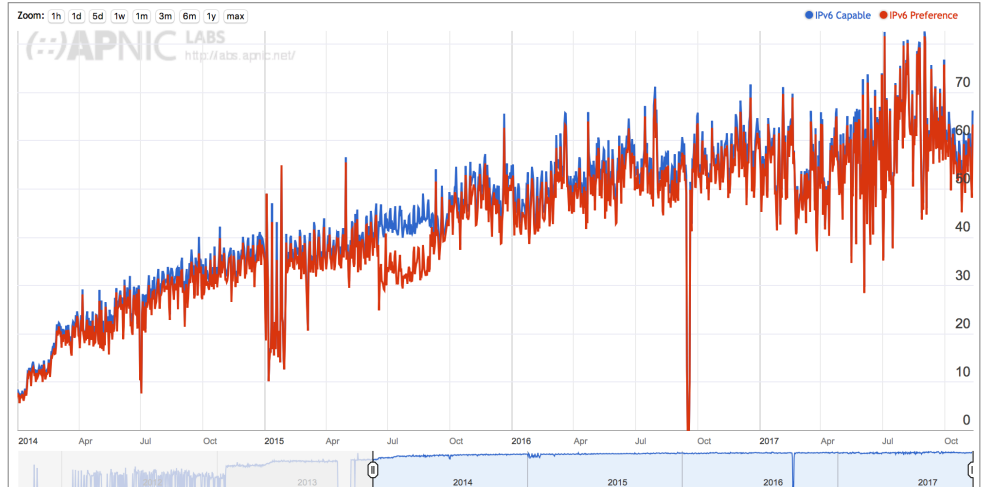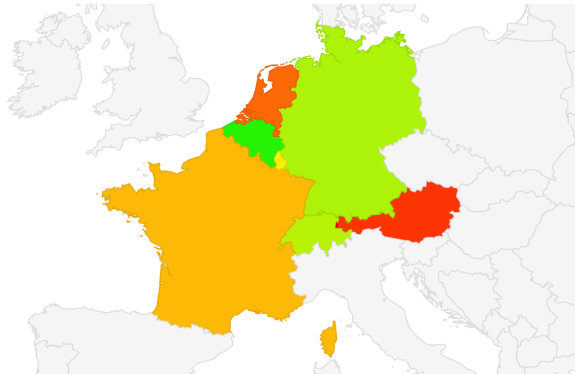
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS5432	BELGACOM-SKYNET-AS	58.54%	56.32%	793,654
AS6848	TELENET-AS	75.67%	73.65%	451,616
AS12392	ASBRUTELE VOO	77.52%	74.81%	208,118
AS47377	MES KPN Belgium Business NV has been acquired by Mobistar	0.06%	0.02%	54,475
AS21502	ASN-NUMERICABLE	0.01%	0.01%	37,213
AS2611	BELNET	7.11%	6.90%	12,458
AS44944	BASE-AS Telenet Group BVBASPRL	0.36%	0.13%	11,168

India

Use of IPv6 for India (IN)
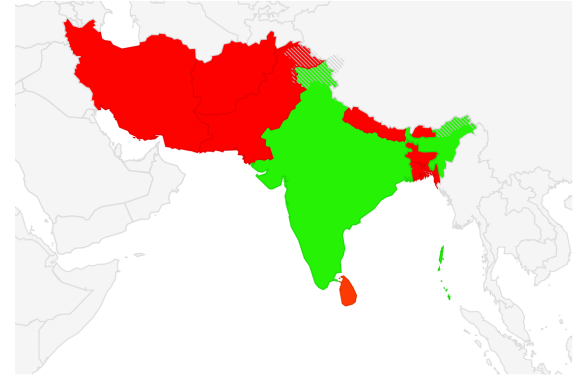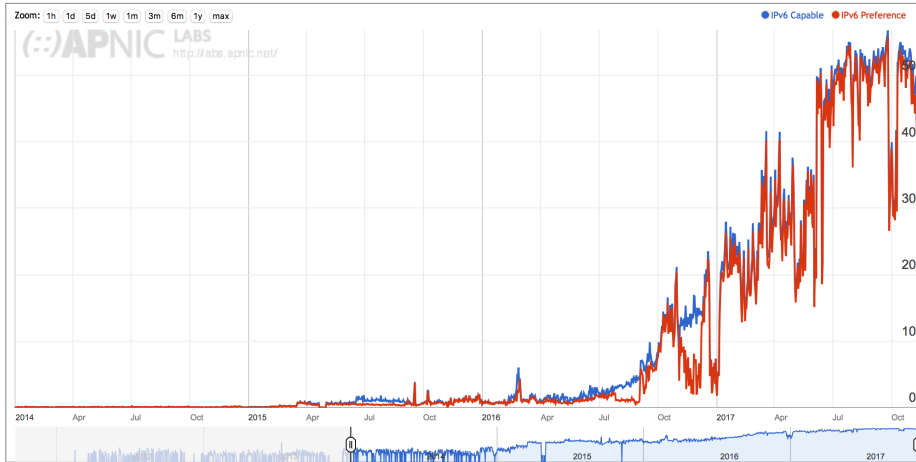
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS55836	RELIANCEJIO-IN Reliance Jio Infocomm Limited	88.69%	85.38%	68,291,551
AS45609	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service	2.57%	2.47%	14,200,162
AS45271	ICLNET-AS-AP Idea Cellular Limited	31.88%	25.71%	8,296,320
AS38266	HUTCHVAS-AS Vodafone Essar Ltd., Telecommunication - Value Added Services	12.57%	11.56%	6,798,834
AS9829	BSNL-NIB National Internet Backbone	0.03%	0.02%	6,189,645

Germany
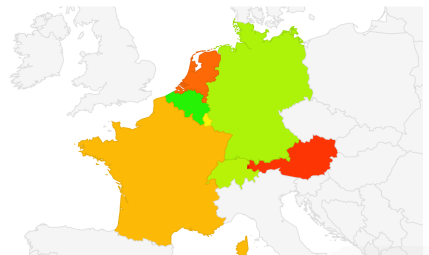
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS3320	DTAG Internet service provider operations	60.89%	59.73%	2,056,846
AS3209	VODANET International IP-Backbone of Vodafone	0.03%	0.02%	955,507
AS31334	KABELDEUTSCHLAND-AS	68.63%	67.59%	825,355
AS6830	LGI-UPC formerly known as UPC Broadband Holding B.V.	67.05%	65.85%	551,091
AS6805	TDDE-ASN1	4.96%	4.86%	539,929
AS29562	KABELBW-ASN	55.85%	54.89%	268,299
AS8422	NETCOLOGNE	21.60%	20.93%	101,555

United States

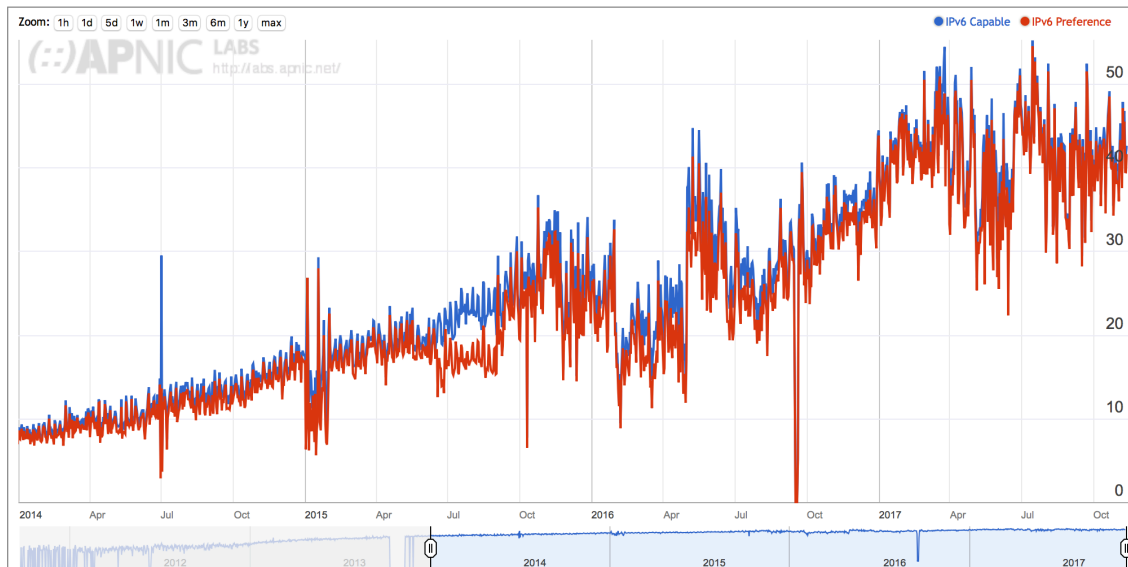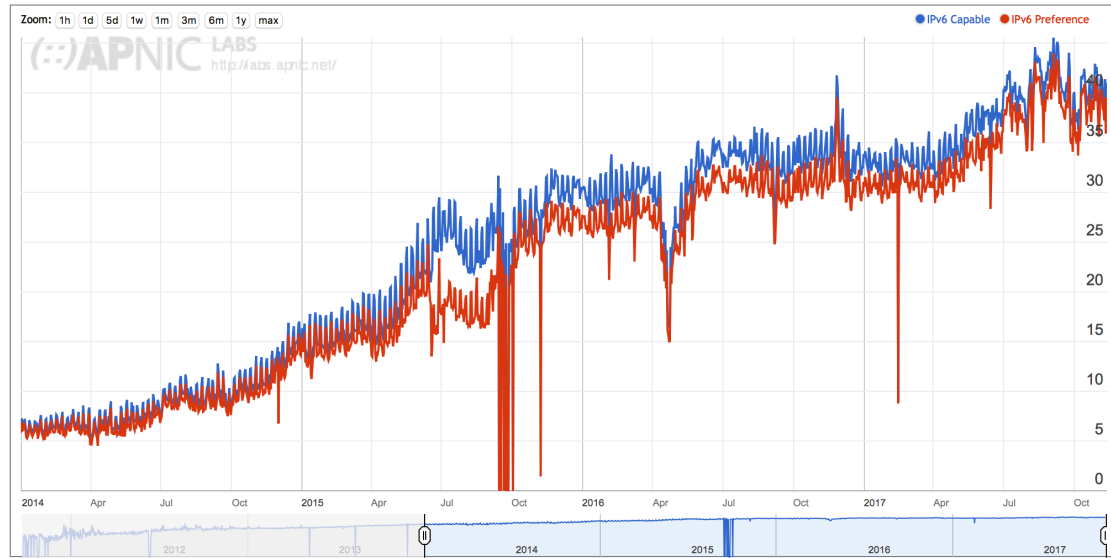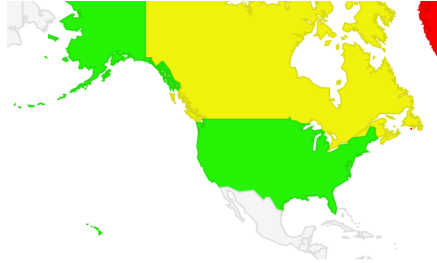| ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS7922	COMCAST-7922 - Comcast Cable Communications, LLC	70.69%	68.03%	15,778,372
AS7018	ATT-INTERNET4 - ATT Services, Inc.	82.45%	78.53%	9,105,707
AS20115	CHARTER-NET-HKY-NC - Charter Communications	11.93%	11.27%	5,549,054
AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business	0.26%	0.02%	4,533,275
AS21928	T-MOBILE-AS21928 - T-Mobile USA, Inc.	88.85%	87.62%	3,954,016
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	49.01%	46.80%	3,891,016
AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	87.83%	84.23%	3,860,221
AS209	CENTURYLINK-US-LEGACY-QWEST - Qwest Communications Company, LLC	0.11%	0.06%	3,420,768
AS20057	ATT-MOBILITY-LLC-AS20057 - ATT Mobility LLC	49.82%	48.91%	3,237,511
AS10796	SCRR-10796 - Time Warner Cable Internet LLC	41.24%	39.88%	2,763,738
AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	50.30%	48.22%	2,289,901

China

Use of IPv6 for China (CN)
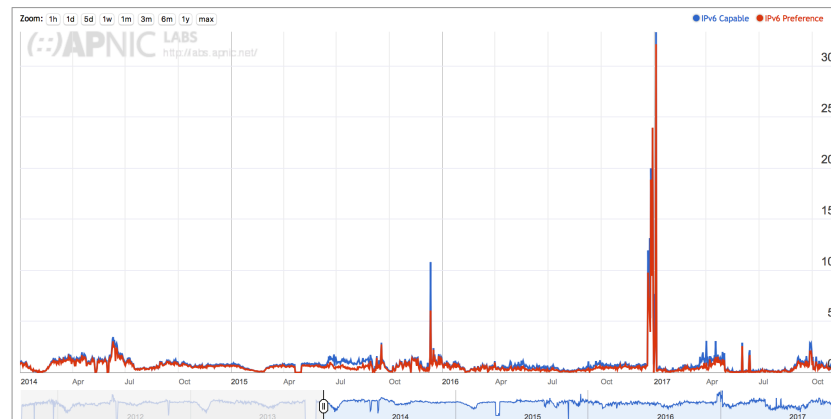
ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS4134	CHINANET-BACKBONE No.31,Jin-rong Street	0.34%	0.25%	5,756,637
AS4837	CHINA169-BACKBONE CHINA UNICOM China169 Backbone	0.41%	0.32%	2,537,732
AS9808	CMNET-GD Guangdong Mobile Communication Co.Ltd.	0.22%	0.13%	798,057
AS4812	CHINANET-SH-AP China Telecom (Group)	0.21%	0.13%	648,471
AS24444	CMNET-V4SHANDONG-AS-AP Shandong Mobile Communication Company Limited	0.09%	0.06%	516,368
AS4808	CHINA169-BJ China Unicom Beijing Province Network	1.58%	1.37%	419,583
AS56046	CMNET-JIANGSU-AP China Mobile communications corporation	0.21%	0.11%	364,250
AS56041	CMNET-ZHEJIANG-AP China Mobile communications corporation	0.03%	0.01%	345,680
AS56040	CMNET-GUANGDONG-AP China Mobile communications corporation	0.07%	0.04%	304,231
AS4847	CNIX-AP China Networks Inter-Exchange	4.13%	3.38%	145,982
AS4538	ERX-CERNET-BKB China Education and Research Network Center	29.21%	23.94%	126,205

Asia Ranking

CC	Country	IPv6 Capable
IN	India, Southern Asia, Asia	51.00%
JP	Japan, Eastern Asia, Asia	25.08%
MY	Malaysia, South-Eastern Asia, Asia	18.33%
TH	Thailand, South-Eastern Asia, Asia	11.26%
MO	Macao Special Administrative Region of China, Eastern Asia, Asia	9.27%
VN	Vietnam, South-Eastern Asia, Asia	8.99%
KR	Republic of Korea, Eastern Asia, Asia	8.85%
SA	Saudi Arabia, Western Asia, Asia	7.25%
LK	Sri Lanka, Southern Asia, Asia	6.32%
SG	Singapore, South-Eastern Asia, Asia	4.68%
IL	Israel, Western Asia, Asia	2.55%
AE	United Arab Emirates, Western Asia, Asia	2.08%
CN	China, Eastern Asia, Asia	0.72%
IR	Iran (Islamic Republic of), Southern Asia, Asia	0.44%
TW	Taiwan, Eastern Asia, Asia	0.38%
OM	Oman, Western Asia, Asia	0.38%
HK	Hong Kong Special Administrative Region of China, Eastern Asia, Asia	0.35%
ID	Indonesia, South-Eastern Asia, Asia	0.21%

Why this difference?

- Early adopters vs later adopters
  - Later adopters do not have a broad base of IPv4 installation, and have been pushed into using IPv6 as the common infrastructure with NAT64 edges (Jio in India is a good example)
  - Early adopters are not forced into IPv6 and can wait
- Carriage Economics
  - The economic returns in deploying IPv6 across an IPv4 infrastructure do not generate new revenues, nor generate operational savings or generate supply efficiencies
  - There is no "adoption pull" effect in IPv6

Why do it at all?

We don't think we can make IPv4 + NATS last forever

Deploying IPv6 is a case of timing, not choice

And the selection of timing is a case of risk determination:

> Nobody wants to shift to dual stack too early – that incurs cost without revenue

> But nobody wants to be the last "IPv4-only" network either!

For China

- Most ISPs in China are being cautious and waiting to see what others are doing

- But you can wait too long, and then you might have to perform a switchover at an inconvenient time

- Right now Chinese ISPs still have the luxury of choice in when to move to deploy IPv6
  - But that will not always be the case!

That's it!

http://stats.labs.apnic.net/v6