

APNIC **36**
CONFERENCE



XI'AN, CHINA
20 - 30 August 2013

Launch+365

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6 June 2012



Was it only a year ago?

One year later...

- Did it work? What has changed in the past 12 months?
- Who is deploying IPv6?
- Where are they?
- What have we seen?
- What have we measured?

Measuring IPv6 via Ads

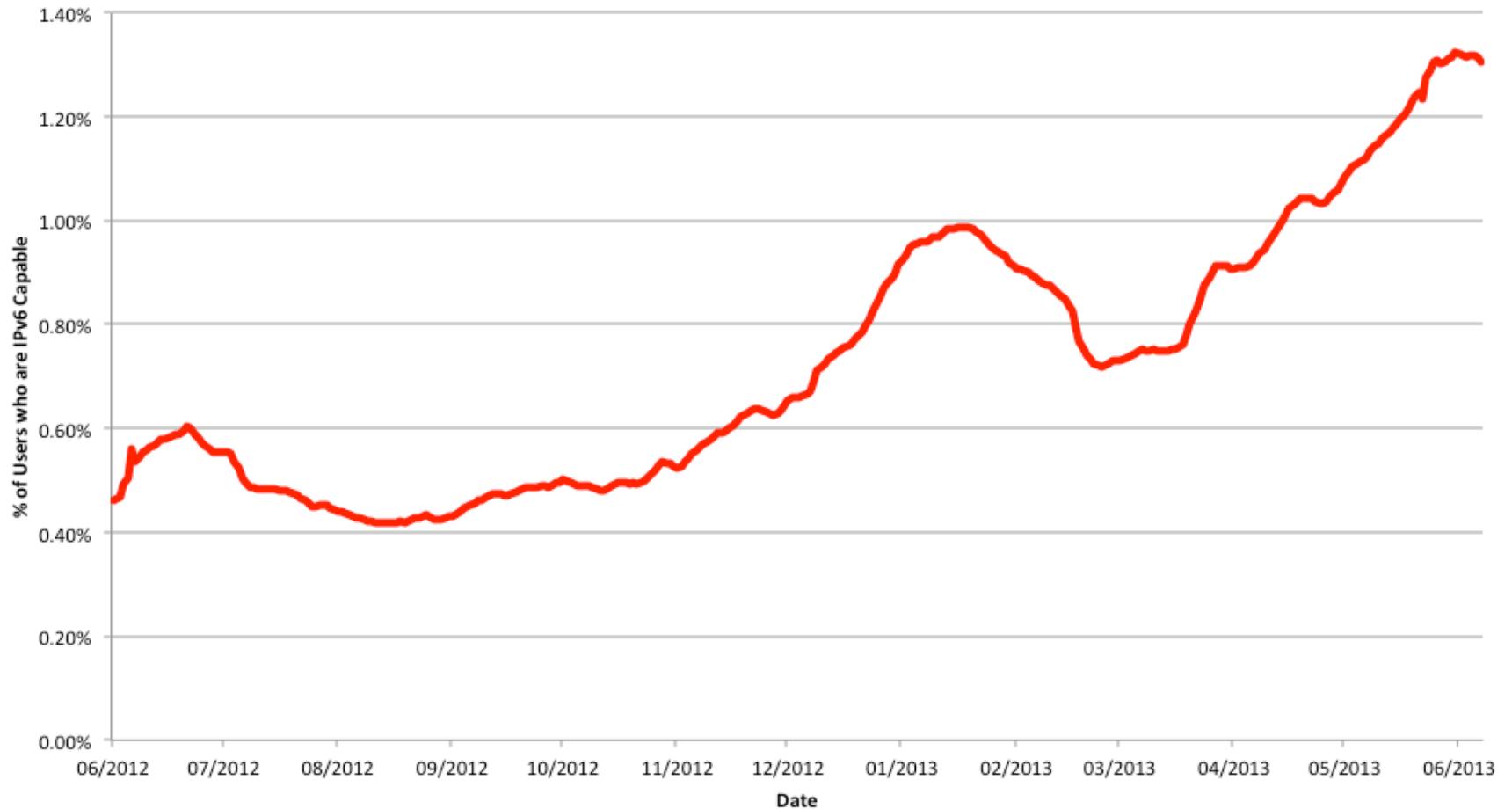
- Use Flash code embedded in an advertisement
 - Code is triggered by the impression of the ad, not by the “clock”
 - Client retrieves set of “tests” that use unique DNS labels from an ad-controller
 - Client is given 5 URLs to load:
 - Dual Stack object
 - V4-only object
 - V6-only object
 - V6 literal address (no DNS needed)
 - Result reporting URL (10 second timer)
- All DNS is dual stack

Why These Tests?

- Dual Stack URL
 - Which protocol will the client PREFER to use?
- V4 only URL
 - Control comparison (Reliability, RTT)
- V6 only URL
 - Is the client CAPABLE of using IPv6?
- V6 Literal URL
 - Does the client have an IPv6 stack at all?
- Result URL
 - Did the client keep the experiment running for 10 seconds, or was it terminated early?

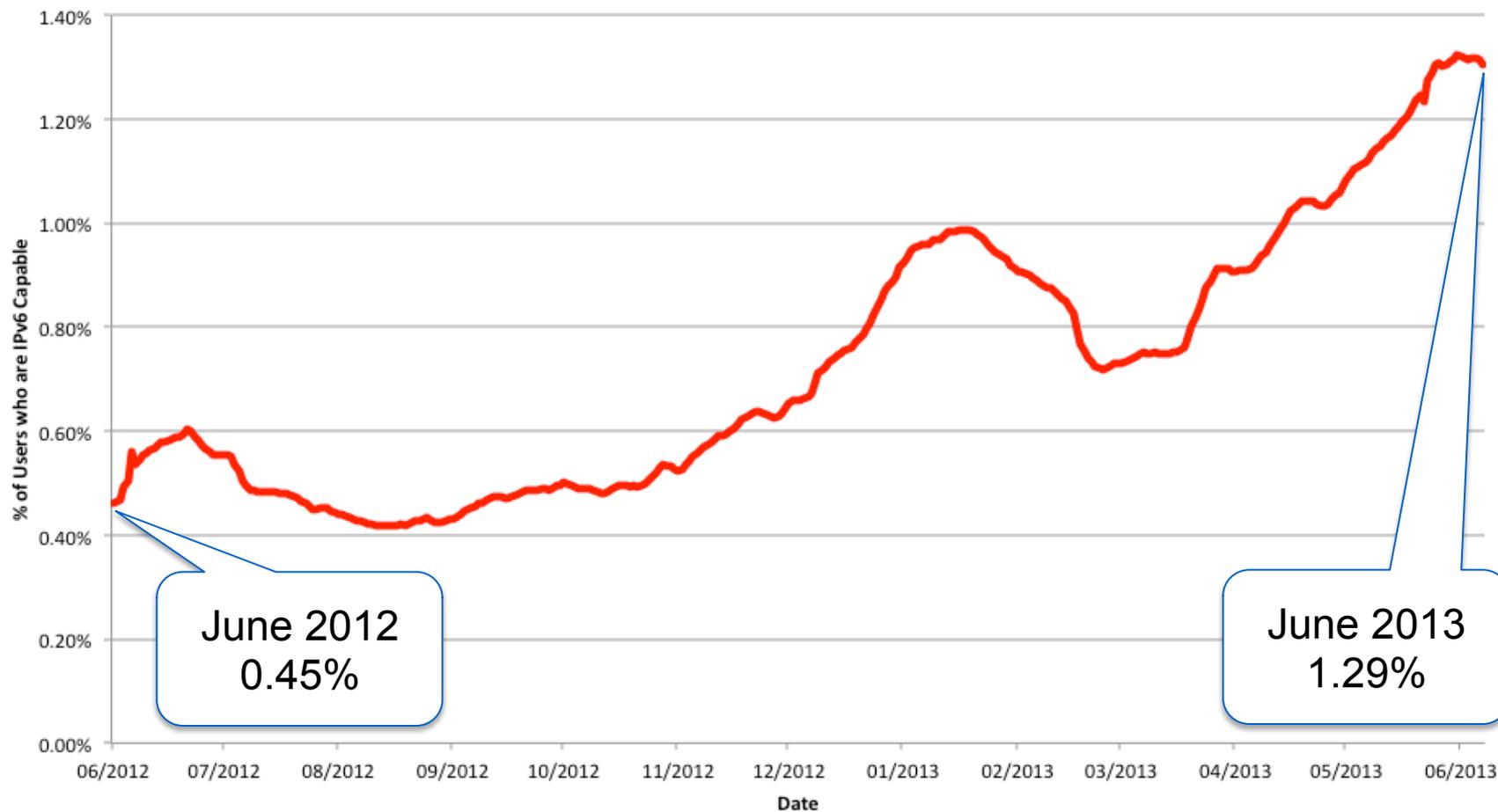
IPv6, Globally

IPv6 Deployment Measurement



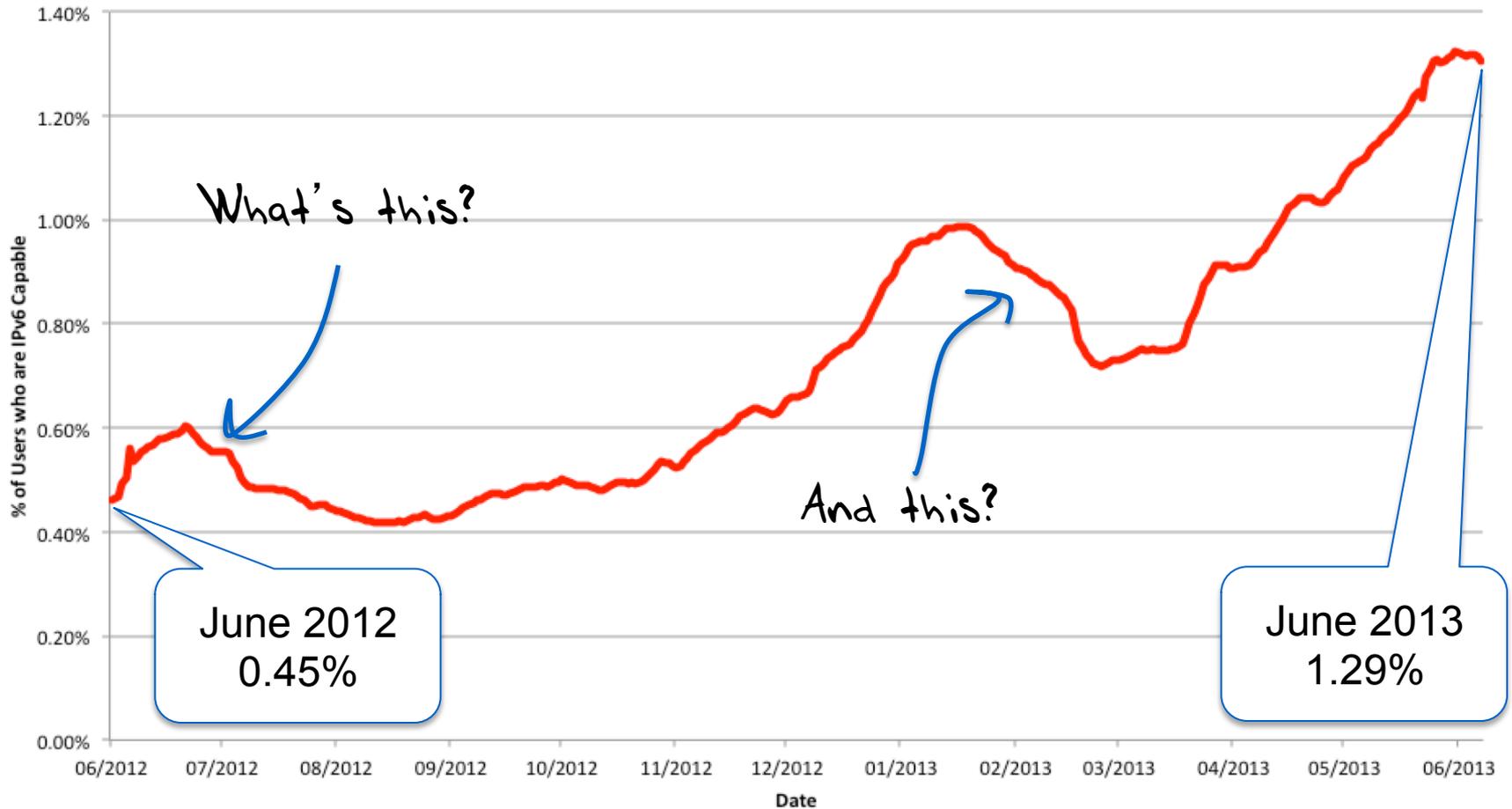
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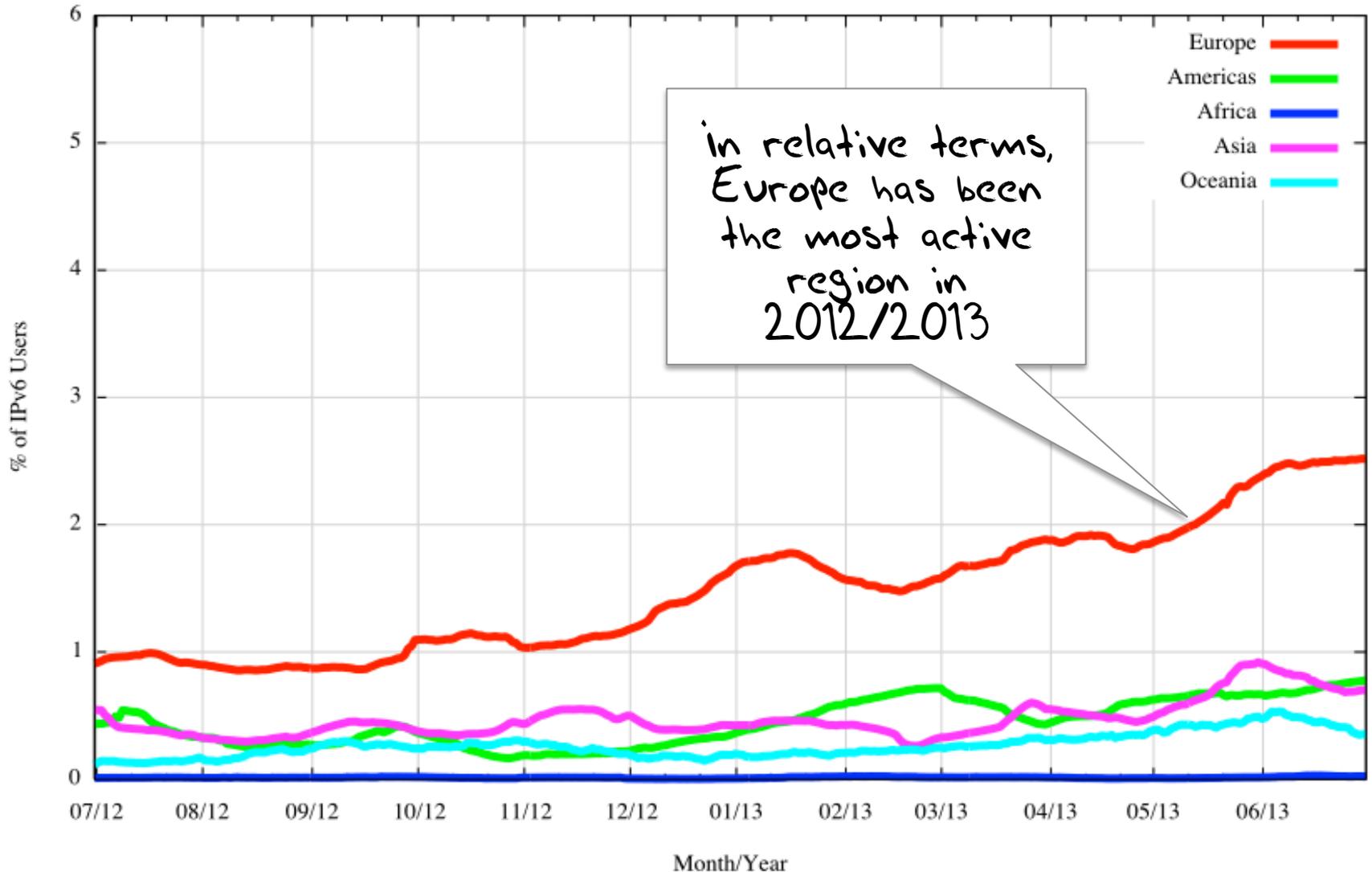
IPv6, Globally

IPv6 Deployment Measurement



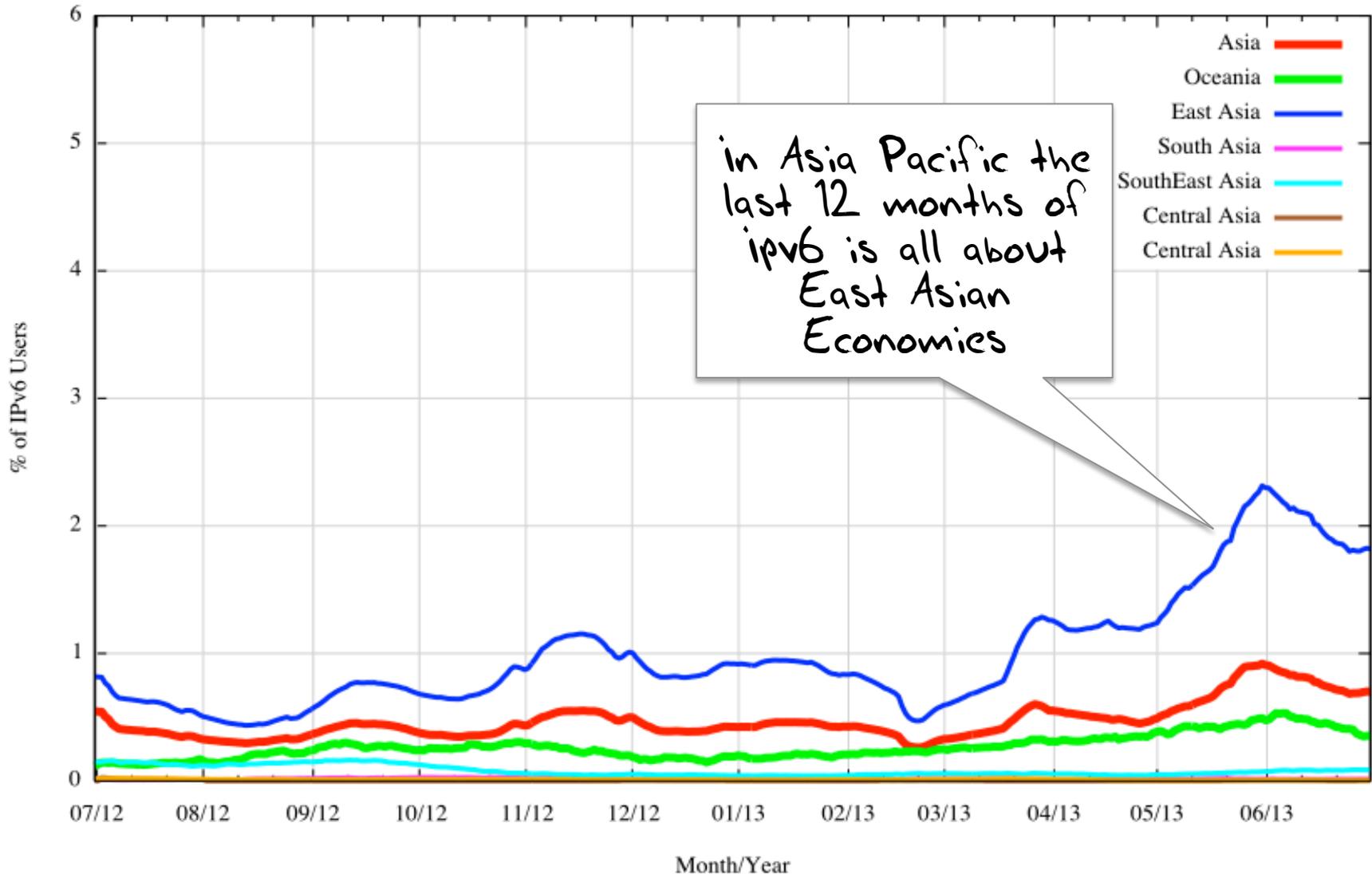
IPv6, Regionally

IPv6 Preferred - by Region



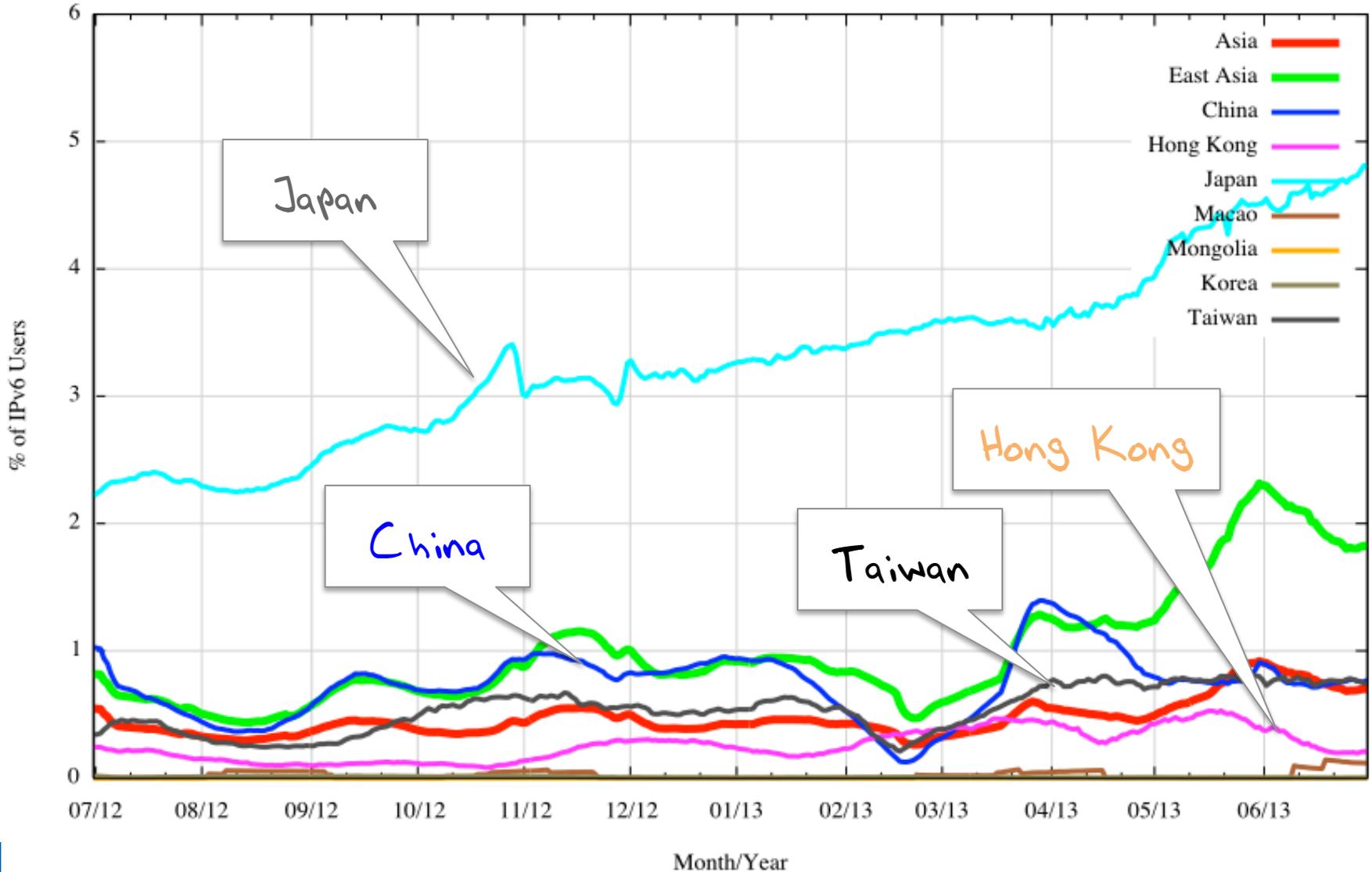
IPv6 in the AP Region

IPv6 Preferred in Asia - by SubRegion



IPv6 in East Asia

IPv6 Preferred in Asia - by SubRegion



Globally Speaking

- IPv6 did not happen everywhere and all at once in 2012 / 2013
- Some economies have been very active in terms of IPv6 deployment
- So lets look at this on a country-by-country basis...

Where is IPv6?

The National Top 20 – Then and Now

2012

Rank	Economy	% of Internet Users	# of IPv6 Users (est)
1	Romania	7.40%	641,389
2	France	4.03%	2,013,920
3	Luxembourg	2.59%	12,049
4	Japan	1.75%	1,766,799
5	Slovenia	1.07%	15,175
6	United States	1.01%	2,500,684
7	China	1.01%	5,209,030
8	Croatia	0.85%	22,551
9	Switzerland	0.80%	51,575
10	Lithuania	0.66%	13,845
11	Czech Republic	0.55%	39,694
12	Norway	0.51%	23,333
13	Slovakia	0.44%	19,112
14	Russian Fed.	0.39%	238,576
15	Germany	0.32%	217,494
16	Hungary	0.31%	19,896
17	Portugal	0.30%	16,406
18	Netherlands	0.27%	40,870
19	Australia	0.25%	49,425
20	Taiwan	0.24%	38,843

2013

Rank	Economy	% of Internet Users	# of IPv6 Users (est)
1	Romania	10.84%	1,053,237
2	Switzerland	10.72%	700,777
3	Luxembourg	6.96%	32,535
4	France	5.46%	2,824,465
5	Belgium	4.17%	339,651
6	Japan	4.13%	4,137,476
7	Germany	3.24%	2,212,062
8	United States	2.72%	6,768,264
9	Peru	2.42%	273,370
10	Czech Republic	2.12%	157,203
11	Singapore	1.58%	54,060
12	Norway	1.21%	53,677
13	Slovenia	0.92%	13,230
14	China	0.90%	4,651,953
15	Greece	0.78%	44,572
16	Portugal	0.76%	45,408
17	Taiwan	0.72%	120,180
18	Netherlands	0.70%	109,425
19	Australia	0.69%	121,256
20	Slovakia	0.52%	21,169

Where is IPv6?

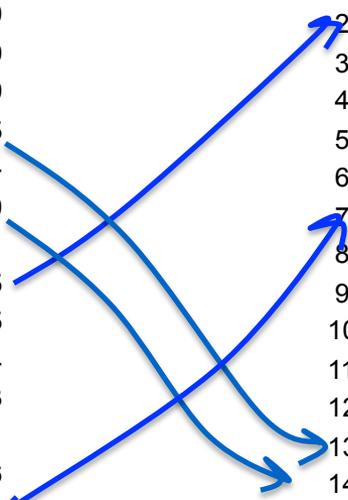
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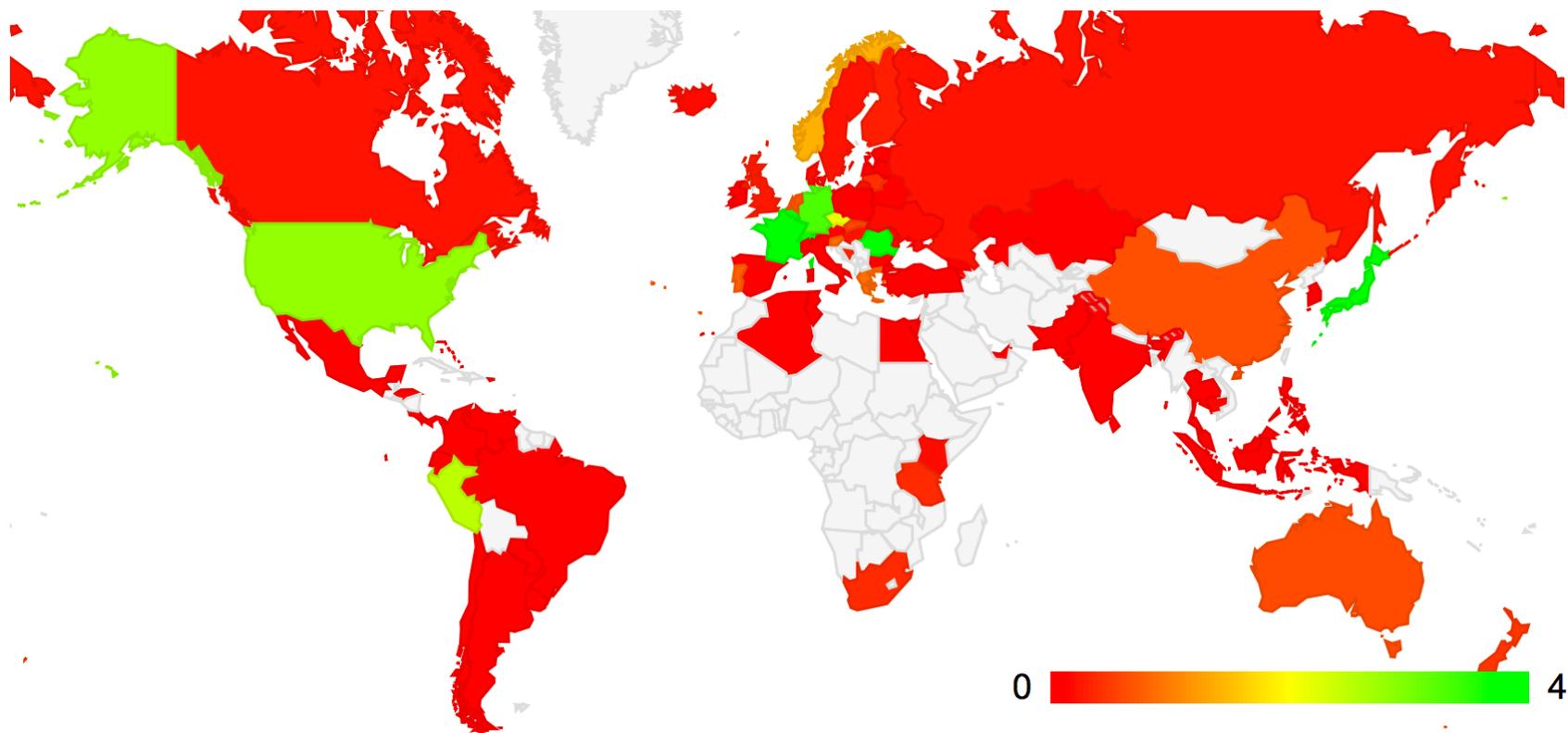
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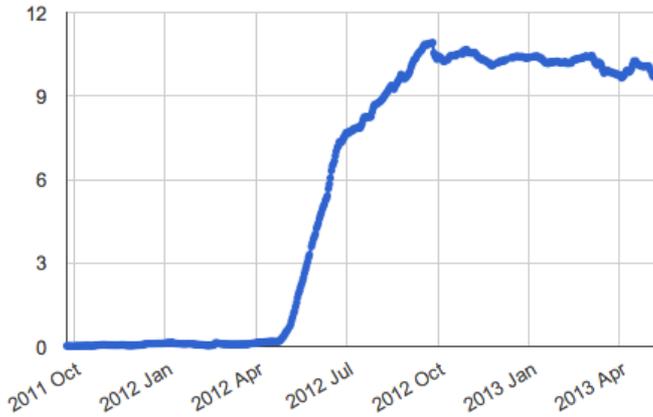
Geographically Speaking...



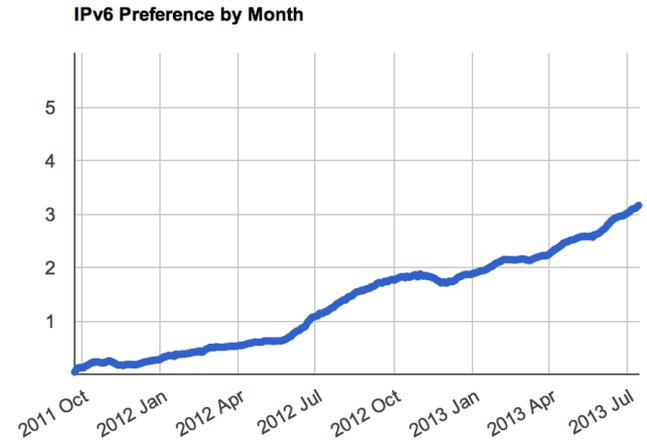
Nationally, who's deploying IPv6 over the past year?

2013 Rank	Economy	Diff (%)	Diff IPv6 User Count
1	Switzerland	+9.92%	+ 649,202
2	Luxembourg	+4.37%	+ 20,486
3	Belgium	+4.07%	+ 331,153
4	Romania	+3.44%	+ 411,848
5	Germany	+2.92%	+1,994,568
6	Peru	+2.41%	+ 272,327
7	Japan	+2.38%	+2,370,677
8	United States	+1.71%	+4,267,580
9	Czech Republic	+1.57%	+ 117,509
10	Singapore	+1.43%	+ 48,524
11	France	+1.43%	+ 810,545
12	Greece	+0.70%	+ 40,530
13	Norway	+0.70%	+ 30,344
14	Taiwan	+0.48%	+ 81,337
15	Portugal	+0.46%	+ 29,002
16	Australia	+0.44%	+ 71,831
17	Netherlands	+0.43%	+ 68,555
18	New Zealand	+0.35%	+ 13,174
19	South Africa	+0.33%	+ 34,022
20	Bosnia and Herz.	+0.32%	+ 8,914

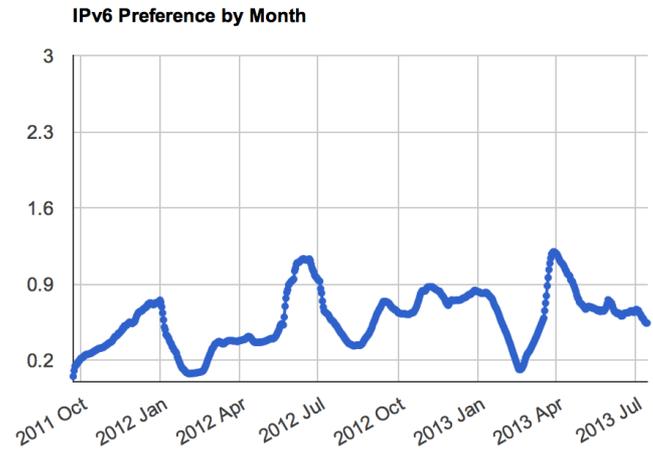
And Some Countries...



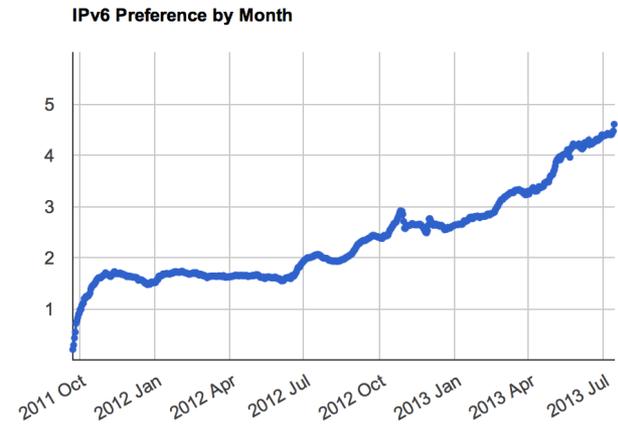
Romania



United States



China



Japan

Drilling down to the AS level...

Economy AS Number AS Name 2012 IPv6 (%) 2013 IPv6 (%)

United States of America

AS6939	Hurricane Electric	29%	37%
AS22394	Cellco Partnership DBA Verizon Wireless	6%	20%
AS7018	AT&T Services	6%	15%
AS3561	Savvis	1%	5%
AS7922	Comcast	1%	3%

Japan

AS2516	KDDI	16%	27%
AS18126	Chubu Telecomm	0%	23%
AS17676	Softbank	1%	4%

Germany

AS3320	Deutsche Telekom AG	0%	5%
AS31334	Kabel Deutschland	1%	7%
AS29562	Kabel BW GmbH	0%	10%

France

AS12322	Free SAS	19%	22%
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Switzerland

AS67722	Swisscomm	0%	23%
AS559	Switch	11%	18%

Romania

AS8708	RCS & RDS SA	11%	24%
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Belgium

AS12392	Brutele SC	0%	33%
AS2611	BELNET	2%	22%

Peru

AS6147	Telefonica del Peru SA	0%	3%
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Czech Republic

AS2852	CESNET z.s.p.o.	20%	27%
AS5610	Telefonica Czech	0%	3%
AS51154	Internethome; s.r.o.	0%	2%

Economy AS Number AS Name 2012 IPv6 (%) 2013 IPv6 (%)

United Kingdom

AS786	JANET	51%	68%
AS13213	UK2 Ltd	0%	23%

Taiwan

AS9264	Academic Sinica	0%	21%
AS1659	Taiwan Academic	2%	8%

Australia

AS7575	AARNet	13%	21%
AS4739	Internode	5%	11%

Netherlands

AS3265	XS4ALL Internet	6%	27%
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Singapore

AS7472	Starhub Internet	0%	13%
AS4773	MobileOne Ltd.	0%	10%

Greece

AS5408	Greek R&D	17%	19%
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South Africa

AS2018	TENET	0%	3%
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Canada

AS6453	TATA Comms.	10%	13%
AS22995	Xplornet Comms	0%	9%

Norway

AS224	Uninett	16%	24%
AS39832	Opera Software	1%	100%
AS57963	Lynet Internett	0%	56%

Portugal

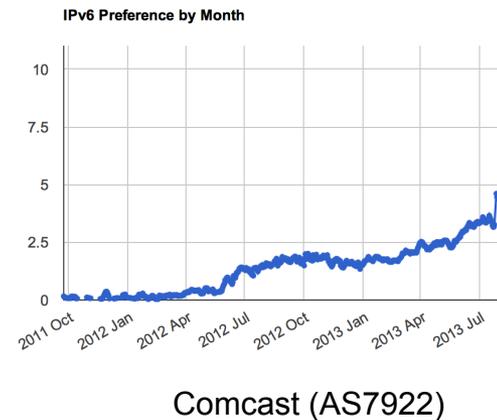
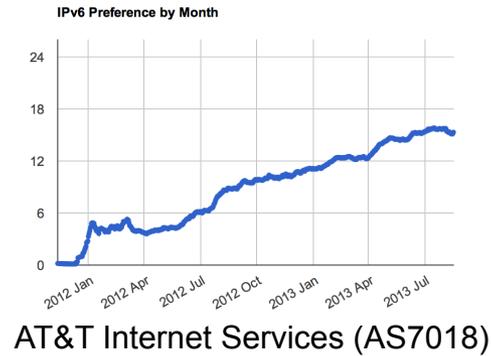
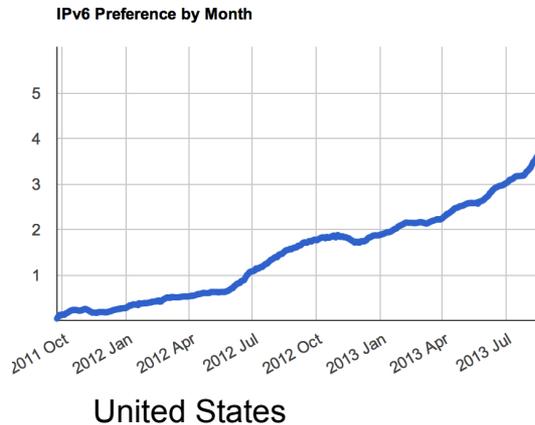
AS3243	PT Comunicacoes	0%	1%
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Luxembourg

AS6661	Postes et Telecom	4%	14%
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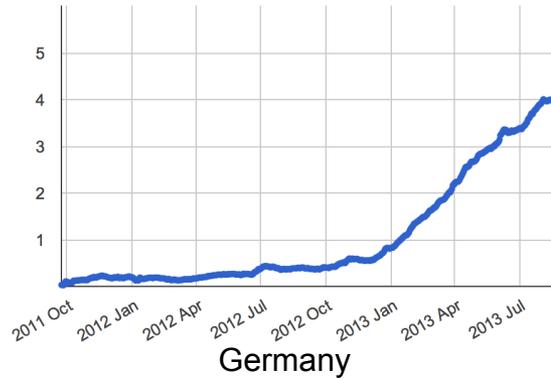
Update to Today...

The pace of deployment continues in some countries

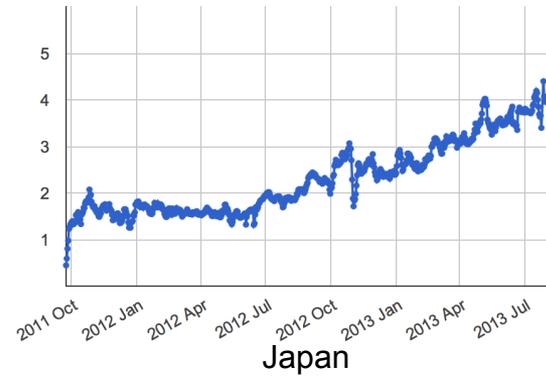


Update to Today...

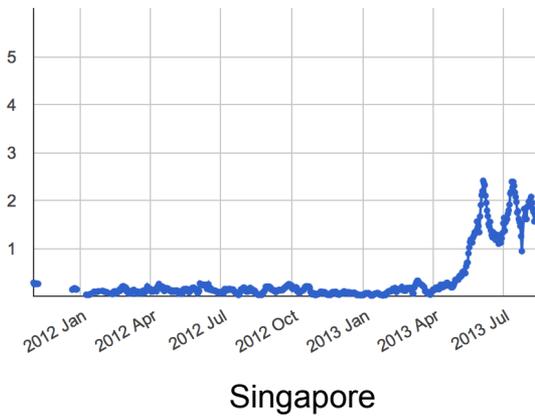
IPv6 Preference by Month



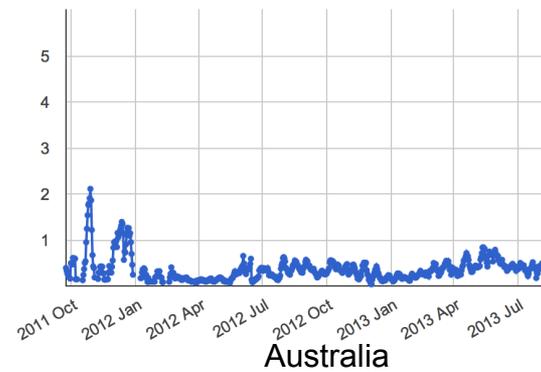
IPv6 Preference by Month



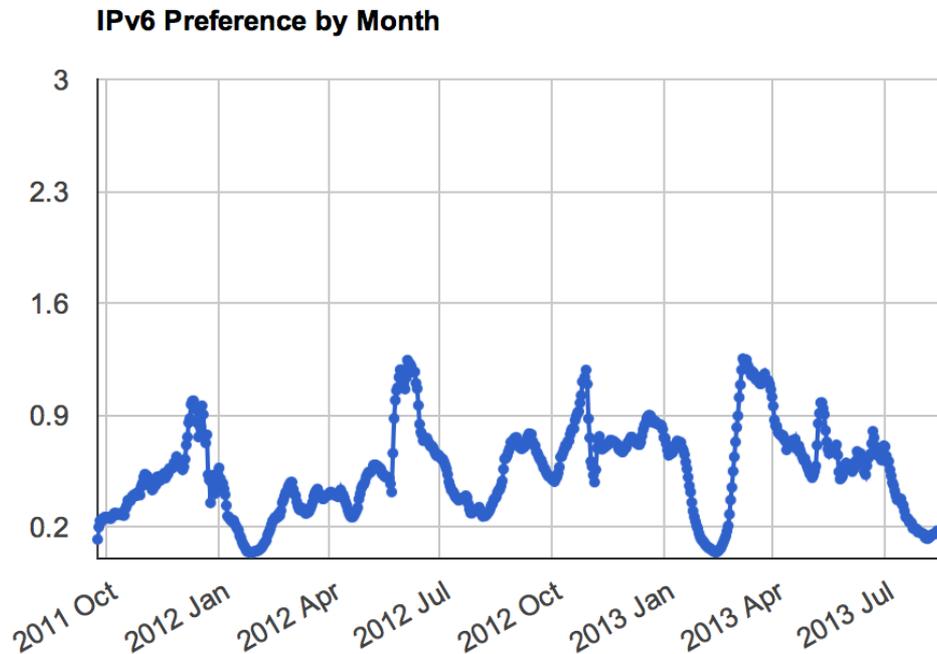
IPv6 Preference by Month



IPv6 Preference by Month



And then there's China...



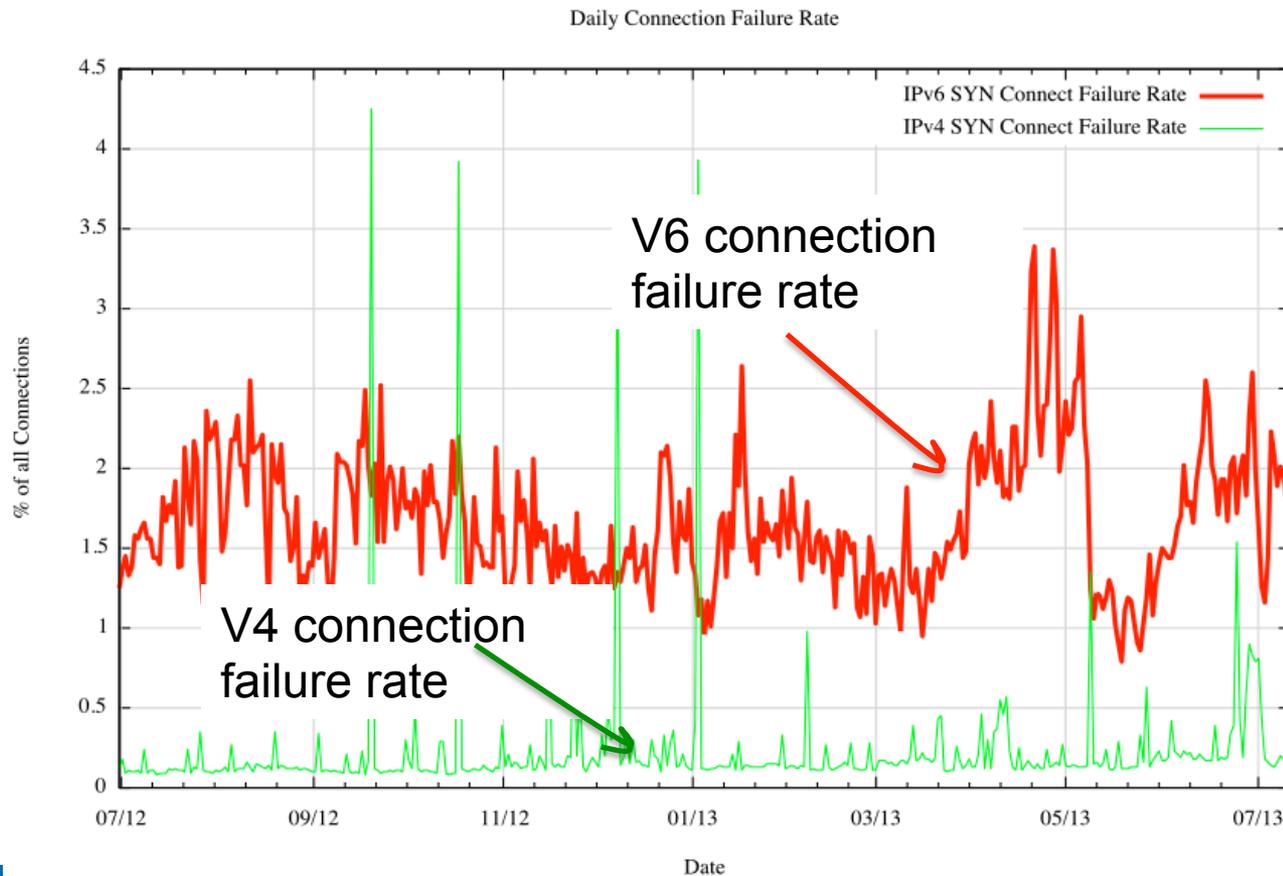
This high variance is difficult to explain. This is a view of clients' IPv6 capabilities when the client is located within China and the server is external to China. The picture may be different if the experiment's server was located within China as well.

IPv6 Performance

Is IPv6 getting more reliable over the past 12 months?

IPv6 Performance

Is IPv6 getting more reliable over the past 12 months?



IPv6 Performance

Is IPv6 getting more reliable over the past 12 months?

Not really

IPv6 shows a SYN handshake failure rate that appears to be around 10x that of IPv4, at around 2% of all IPv6 connections

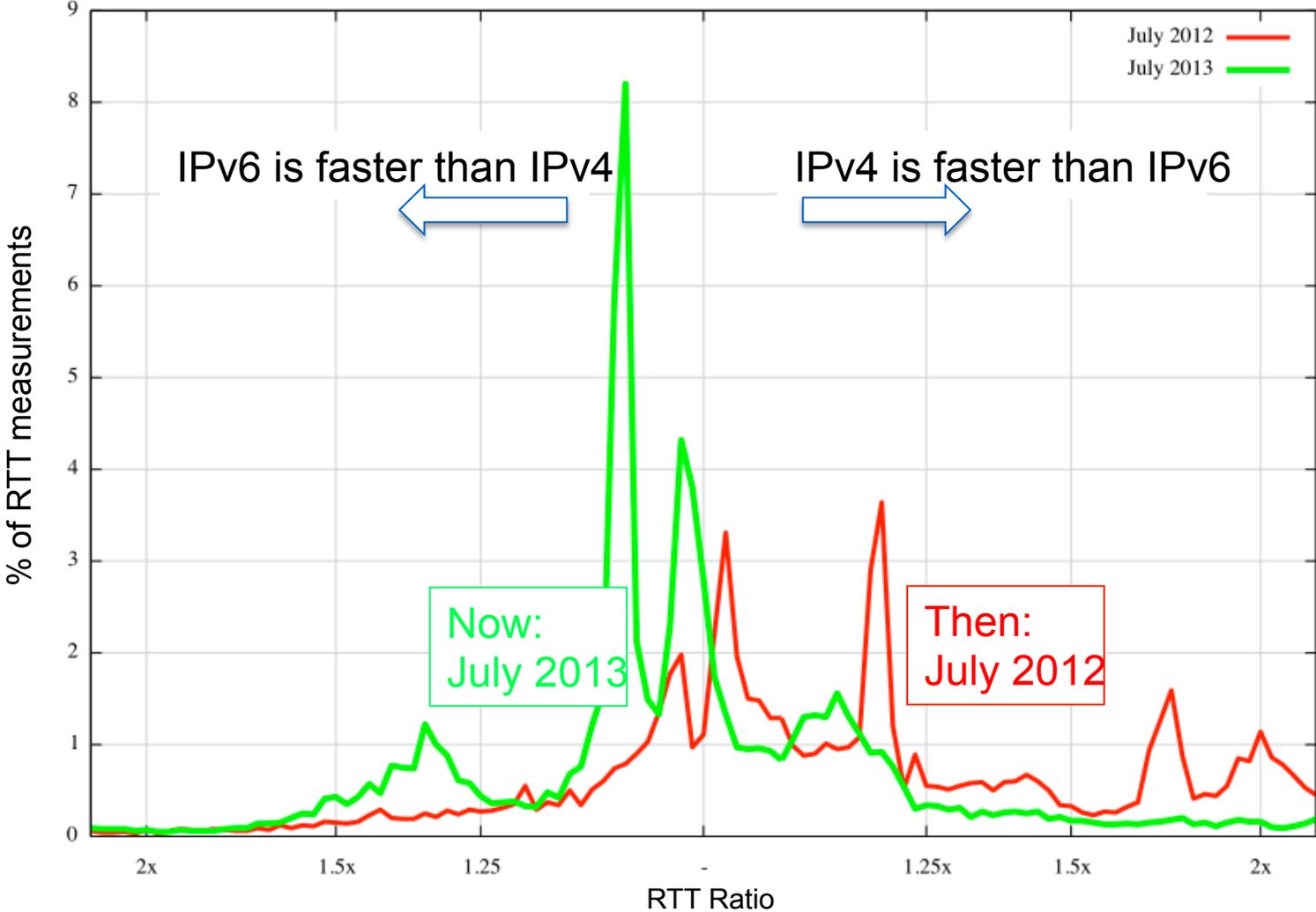
This has not really changed over the past year

So, no, its not getting any more reliable over the past 12 months

What about Relative Performance?

- This experiment allows us to gather IPv6 and IPv4 pairs that appear to refer to the same endpoint
 - Because the same client retrieves both IPv4 and IPv6 objects and the web server logs allows us to associate the two addresses back to the same client
- And out of the TCP packet dump we get the elapsed time at the server between the SYN and ACK of the initial TCP handshake, which is equal to 1 RTT time interval between client and server
 - Because the TCP handshake happens at the TCP driver, not in the browser, which gives us a slightly better view of the underlying RTT
- What's the distribution of the ratio of these paired RTT measurements?

Paired RTT Distribution



Performance

- When it works, IPv6 is working **far** better than a year ago
 - It's often faster in RTT terms than IPv4!
(Which seems counter-intuitive)
 - And its generally no more that 25% slower than IPv4 in terms of relative RTT times between the same two endpoints

What are we seeing?

IPv6 deployment is not happening everywhere.

IPv6 is not happening all at once.

IPv6 is happening in a small number of countries, with still a relatively small set of service providers.

What are we seeing?

What we appear to be seeing are concentrated areas of quite intense IPv6 activity.

Is IPv6 still “A Waiting Game”?

So far what we have heard from many industry actors about IPv6 is:

“I’m waiting for others. I’ll jump when they jump.”

In the past year we have seen a number of major commercial network service operators, primarily in the United States, Japan, Germany, France, Switzerland and Romania, launch programs that integrate IPv6 services into their mass market retail offerings.

Is this effort “enough” to break out of the waiting game?

Whether this effort will provide sufficient impetus to motivate other providers to also commit to a similar program of IPv6 deployment is perhaps still an open issue today, but there is some evidence that there is now a building momentum and possibly an emerging sense of inexorable progress with the deployment of IPv6.

Thank You

Questions?