Measuring IPv6

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What's the question?

How "well" are we going with the transition to IPv6?

What's the question?

How "well" are we going with the transition to IPv6?

That's a very difficult question to measure!

APRICOT 2014

"Measurable" Questions

- How much traffic uses IPv6?
- How many connections use IPv6?
- How many routes are IPv6 routes?
- How many service providers offer IPv6?
- How many domain names have AAAA RRs?
- How many domain NS's use AAAA's?
- How many DNS queries are for AAAA RRs?
- How many DNS queries are made over IPv6?
- How many end devices have IPv6?
- How many end devices use IPv6?

    …

Back to the Question

- None of these specific measurement questions really embrace the larger question

- They are all aimed at measuring IPv6 within particular facets of the network infrastructure, but they don't encompass all of the infrastructure of the network at once

Back to the Question

- To make an IPv6 connection everything else (routing, forwarding, DNS, transport) has to work with IPv6

- So can we measure how many connected devices on today's Internet are capable of making IPv6 connections?

- The best answer we can offer to this question is to use scripting on a web server to text the capabilities of clients via a scripted set of related web object fetches

But…

- We really need to use a massively popular web service to conduct this experiment
  - But "massively popular web services" worry constantly about service resiliency and privacy of their data regarding users
  - So they tend to be extremely suspicious of adding script elements to their service that performs third party dual stack tests with their clients (and I can't blame them!)

- So we need to rethink this approach…

How to measure a million end users for their IPv6 capability

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- Be Google (or any other massively popular web service provider)

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or

How to measure a million end users for their IPv6 capability

- Be Google (or any other massively popular web service provider)

or

- Get your code to run on a million users' machines via online advertisements, using Flash/actionscript embedded in the ad

Measuring IPv6 via Ads

- Use Flash code that is executed on ad impression
  - Client retrieves set of "tests" that use unique DNS labels from an ad-controller

    (http://drongo.rand.apnic.net/measureipv6id.cgi?advertID=9999)

  - 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, or was it terminated early?

Experiment Server config

- There are three servers, identically configured (US, Europe, Australia)

- Server runs Bind, Apache and tcpdump

- Experiment directs the client to the "closest" server (to reduce rtt-related timeouts) based on simple /8 map of client address to region

Collected Data

- Per Server, Per Day:
  - http-access log
    - (successfully completed fetches)
  - dns.log
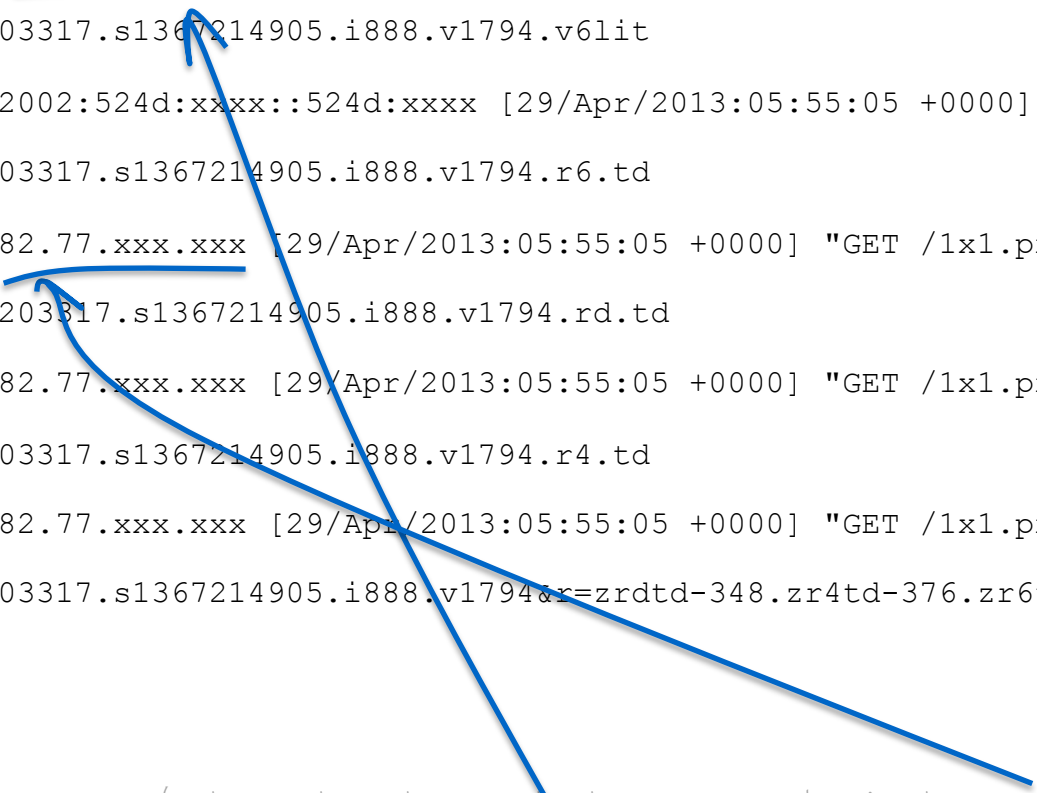   - (incoming DNS queries)
  - Packet capture
    - All packets

Collected Data

Web Logs:

h.labs.apnic.net 2002:524d:xxxx::524d:xxxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

    t10000.u7910203317.s1367214905.i888.v1794.v6lit

h.labs.apnic.net 2002:524d:xxxx::524d:xxxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

    t10000.u7910203317.s1367214905.i888.v1794.r6.td

h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

     t10000.u7910203317.s1367214905.i888.v1794.rd.td

h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

    t10000.u7910203317.s1367214905.i888.v1794.r4.td

h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

    t10000.u7910203317.s1367214905.i888.v1794&r=zrdtd-348.zr4td-376.zr6td-316.zv6lit-228

Collected Data

Web Logs:

h.labs.apnic.net 2002:524d:xxxx::524d:xxxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?

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(In this case the client is using 6to4 to access IPv6, and prefers to use IPv4 in a dual stack context)
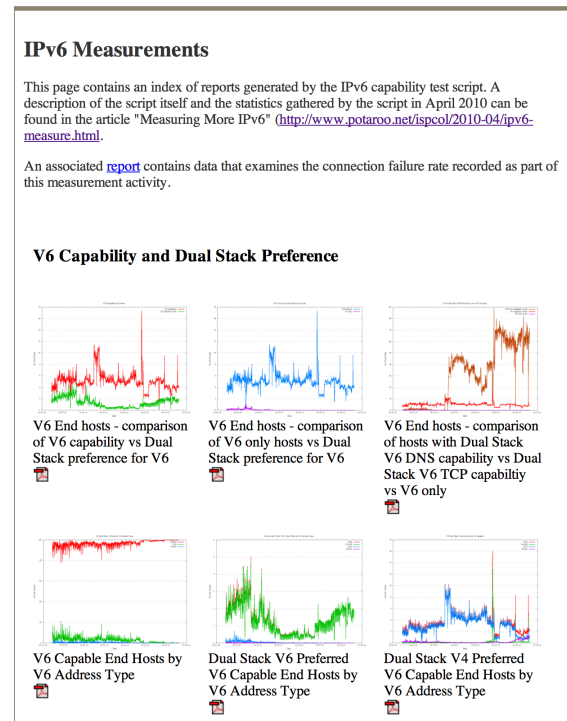
Data Processing

- Web Logs:
  - V6 Capable/Preferred host counts
  - Breakdown of Teredo/6to4 vs Unicast

- Packet Logs:
  - Connection Failure counts (incomplete TCP handshake)
  - Performance measurements (TCP RTT)

Reports

We perform a basic scan of the daily data and produce a number of reports:
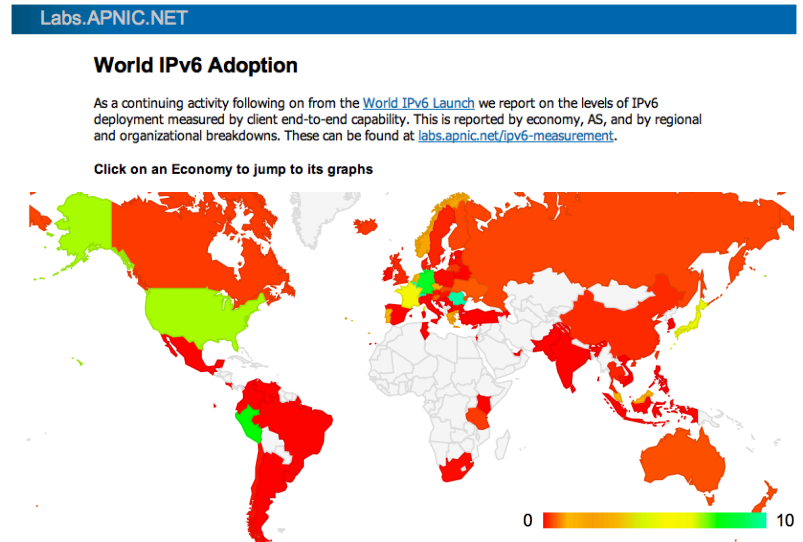
a)   A "summary" report of capabilities

http://www.potaroo.net/ipv6/

Reports

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a) A "summary" report of capabilities

b) A map of the IPv6 world

http://labs.apnic.net/index.shtml

Reports

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a)   A "summary" report of capabilities

b)   A map of the IPv6 world

c)   Per-ASN and Per-Country reports

   http://labs.apnic.net/ipv6-measurement/

Reports

We perform a basic scan of the daily data and produce a number of reports:

a) A "summary" report of capabilities

b) A map of the IPv6 world

c) Per-ASN and Per-Country reports

d) Daily Per-Country statistics report

http://labs.apnic.net/dists/v6cc.html

The IPv6 Country League Table

| Index	ISO-3166 Code	Internet Users	V6 Use ratio	V6 Users (Est)	Population	Country
1	BE	8153098	12.2758%	1000858	10452690	Belgium
2	CH	6545201	11.9436%	781732	7682161	Switzerland
3	RO	9709501	10.5828%	1027537	22057023	Romania
4	LU	470579	10.4989%	49405	517746	Luxembourg
5	DE	68151404	8.4037%	5727253	82110126	Germany
6	SG	3438265	8.0503%	276788	4842627	Singapore
7	PE	11215122	7.9756%	894473	31153117	Peru
8	US	249751047	6.9190%	17280200	320769391	United States of America
9	FR	51923187	5.3949%	2801193	65246529	France
10	JP	99396568	5.1186%	5087722	125738859	Japan
11	EU	0	3.4091%	0	0	European Union
12	CZ	7415514	2.7356%	202858	10162415	Czech Republic
13	NO	4445097	2.6816%	119197	4730337	Norway
14	MY	16907614	1.4812%	250440	27717400	Malaysia
15	PT	6253086	1.3507%	84461	10825981	Portugal
16	NL	15702326	1.0971%	172274	17012271	Netherlands
17	GR	5719413	0.9931%	56799	10791346	Greece
18	SI	1375388	0.6382%	8777	1993317	Slovenia
19	UA	12755764	0.5365%	68430	44429692	Ukraine
20	FI	4709609	0.4425%	20840	5269788	Finland
21	AU	17805749	0.4355%	77541	22397169	Australia
22	SK	4090631	0.4353%	17807	5495206	Slovakia
23	NZ	3772197	0.4260%	16068	4386276	New Zealand
24	RU	67177206	0.4215%	283129	137096339	Russian Federation
25	CA	28805469	0.3916%	112797	34705385	Canada

http://labs.apnic.net/dists/v6dcc.html

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27	GB	53741482	0.2654%	142640	61885632	United Kingdom of Great Britain and Northern Ireland
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25	CA	28805469	0.3916%	112797	34705385	Canada
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50	IN	123839985	0.0489%	60553	1229791312	India
17	GR	5719413	0.9931%	56799	10791346	Greece
4	LU	470579	10.4989%	49405	517746	Luxembourg
28	TW	16699864	0.2544%	42484	23194256	Taiwan

http://labs.apnic.net/dists/v6dcc.html

The IPv6 ASN League Table

| Economy	ASN	AS Name	# samples	v6 capable	v6 preferred
US	AS19782	INDIANAGIGAPOP - Indiana University	867	100.00%	100.00%
CN	AS23910	CNGI-CERNET2-AS-AP China Next Generation Internet CERNET2	367	100.00%	100.00%
JP	AS55898	YAHOO-CORP Yahoo Japan Corporation	349	98.85%	97.71%
JP	AS7521	MFEED INTERNET MULTIFEED CO.	278	98.56%	97.48%
US	AS32934	FACEBOOK - Facebook; Inc.	521	97.89%	97.70%
AU	AS38083	CURTIN-UNI-AS-AP Curtin University	373	97.86%	95.71%
US	AS15169	GOOGLE - Google Inc.	9203	92.18%	5.24%
US	AS16591	GOOGLE-FIBER - Google Fiber Inc.	167	88.02%	83.23%
RU	AS13238	YANDEX Yandex LLC	1030	85.73%	43.01%
US	AS2698	IASTATE-AS - Iowa State University	185	80.54%	76.22%
AU	AS4608	APNIC-SERVICES Asia Pacific Network Information Centre	560	80.18%	77.50%
TH	AS9464	PSU-TH-AS-AP Prince of Songkla University (Sritrang'NET)	151	76.16%	63.58%
JP	AS23780	CTB CTB Media Inc.	318	76.10%	57.23%
US	AS6621	HNS-DIRECPC - Hughes Network Systems	1311	72.16%	72.77%
GB	AS786	JANET JISC Collections And Janet Limited	182324	71.76%	70.01%
CZ	AS197451	VUTBR-AS Brno University of Technology	272	67.28%	65.44%
US	AS1312	VA-TECH-AS - Virginia Polytechnic Institute and State Univ.	279	65.95%	62.72%
BR	AS22548	N\xfacleo de Inf. e Coord. do Ponto BR - NIC.BR	217	64.98%	59.91%
RO	AS12675	UAIC-NETWORK Alexandru Ioan Cuza University	171	63.16%	51.46%
US	AS109	CISCO-EU-109 Cisco Systems Global ASN - ARIN Assigned	668	63.02%	47.31%
US	AS3598	MICROSOFT-CORP-AS - Microsoft Corporation	611	51.23%	50.57%
US	AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	13966	50.96%	47.67%
SG	AS7472	NUS-AS-AP Computer Centre	165	48.48%	44.85%
CA	AS12093	UWATERLOO - University of Waterloo	294	45.58%	40.82%
NL	AS1133	UTWENTE-AS University Twente	177	44.07%	39.55%
US	AS87	INDIANA-AS - Indiana University	2980	41.68%	37.28%

http://labs.apnic.net/ipv6-measurement/AS/

And some Time Series…
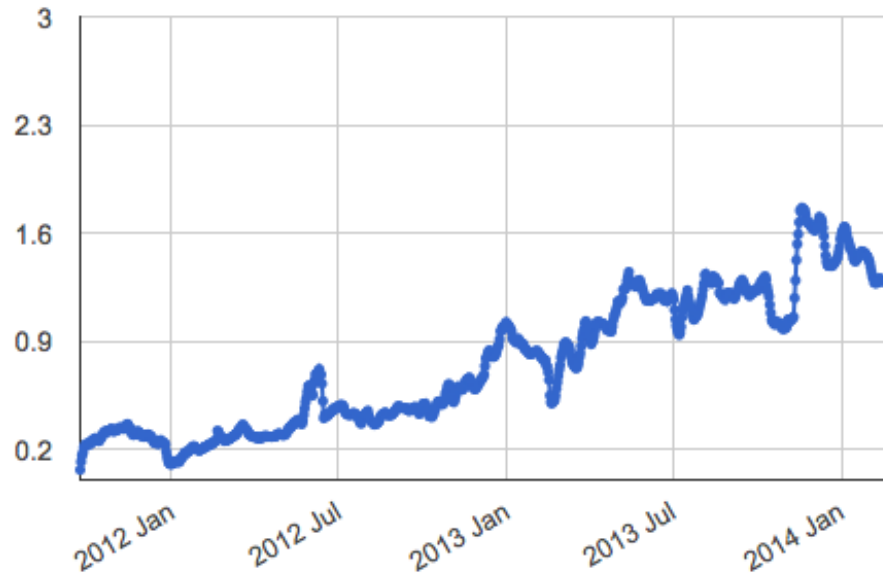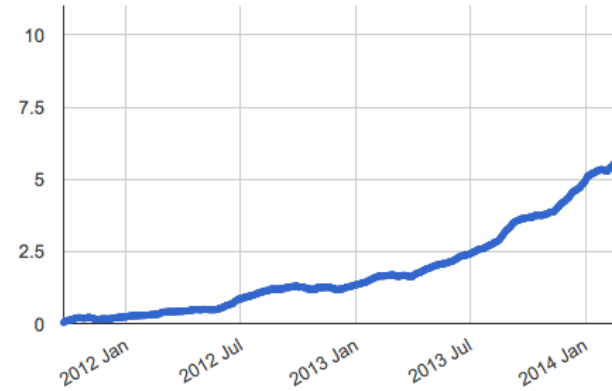
North America IPv6

Global IPv6
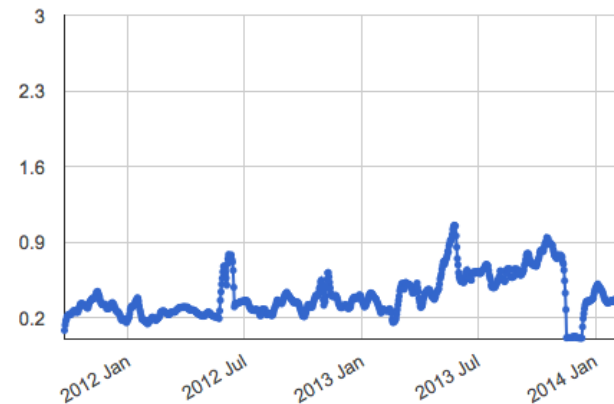
Asia IPv6

And Some Countries…
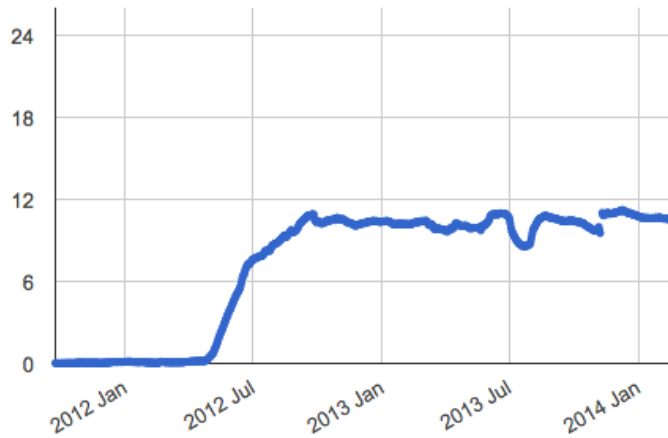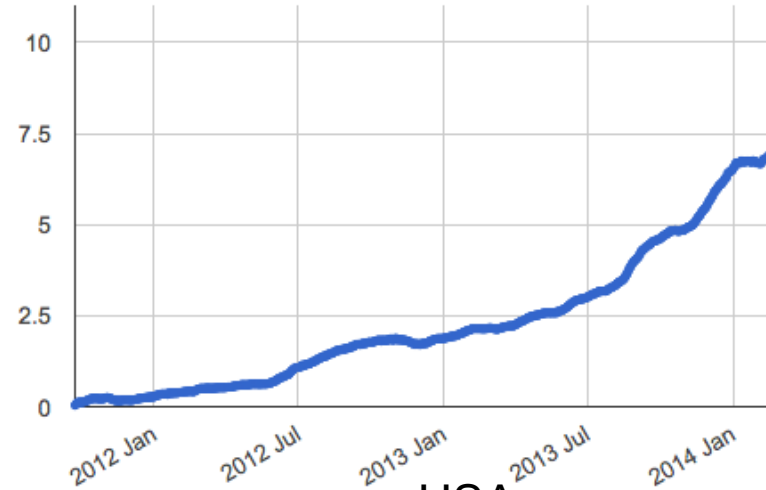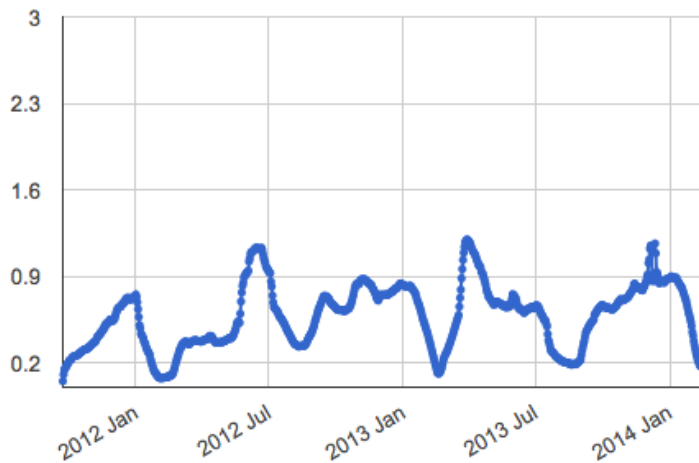

Romania

USA

China

Japan

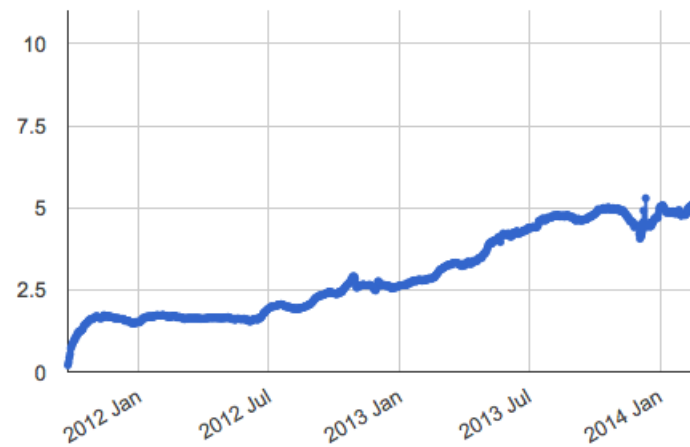# Questions?

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