

# Measuring IPv6

Geoff Huston

APNIC Labs, August 2013



# What's the question?

## The Big Question:

How “well” are we going with the transition to IPv6?

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

*That's a very difficult question to measure!*

# “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 **Big 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 **Big 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?

# An Observation...

The conventional view of transition was that end hosts would use a very simple protocol selection algorithm:

- If the local host has an IPv6 interface, and the remote host has an IPv6 address, then always try to connect using IPv6.
- Otherwise use IPv4.

# How to measure IPv6 in the Internet

- Set up a service on both IPv6 and IPv4
- Measure the proportion of users who connect to the service using IPv6

# But...

- We tried this on <http://www.apnic.net> in 2010
  - We found a very high number of IPv6 users (~5%)
  - Why?
  - Small, geek-centric client population of users of this service have biased the measurement!

# 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 Javascript 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)



# How to measure a million end users for their IPv6 capability

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

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

# Ads are ubiquitous

**REMINDER: SOMETIMES YOU NEED TO LET THE WILD OUT**  
(remember to breathe)

should not profit from region's name

80 comments

**Cutting cord too early 'risks health'**

**Exclusive:** Childbirth experts query policy after research suggests early clamping of umbilical cord can lead to iron deficiency anaemia

46 comments

Mother sings praises of delayed clamping

**Chinese official sacked for excess**

Communist boss in Jiangsu province begs in vain for forgiveness after campaigners gatecrash lavish dinner

17 comments

**Measles cases rise to 942 in Wales**

Figure for greater Swansea area rises by 56 as experts warn epidemic shows no sign of easing

- Big drive to halt measles outbreak
- Measles vaccination campaign begins
- Outbreak triggers fresh emphasis on vaccination
- The story behind the MMR scare
- Measles and MMR: the essential guide

**PM handed press regulation dilemma**

Cross-party plans rejected as papers launch audacious bid to set up own royal charter-backed body

197 comments

- Read the draft alternative royal charter
- Alternative regulation plans: the key differences
- Editorial: time for a ceasefire

**Ukip election candidate suspended**

Antisemitic comments were allegedly posted on conspiracy theory website under Anna-Marie Crampton's name but she says she is hacking victim

- Farage: Ukip candidates may have BNP past
- Clegg kills 'snooper's charter' bill
- Nick Thornsby: Clegg reminded he is a liberal

10 of the worst

**George Monbiot**  
My search for a smartphone that isn't soaked in blood

**Spare Rib**  
Back for more

**Box set gold**  
Big Train

**Measles & MMR**  
Essential guide

Turner prize

**Ballads of a thin man**

★★★★★

Iggy and the Stooges can still make a racket, but the best songs on Ready to Die are the ballads, writes Alexis Petridis

17 comments

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Plagued by an armed militia, villagers in the Democratic Republic of the Congo have fought back - but at a cost

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**AC Jimbo's European papers review**

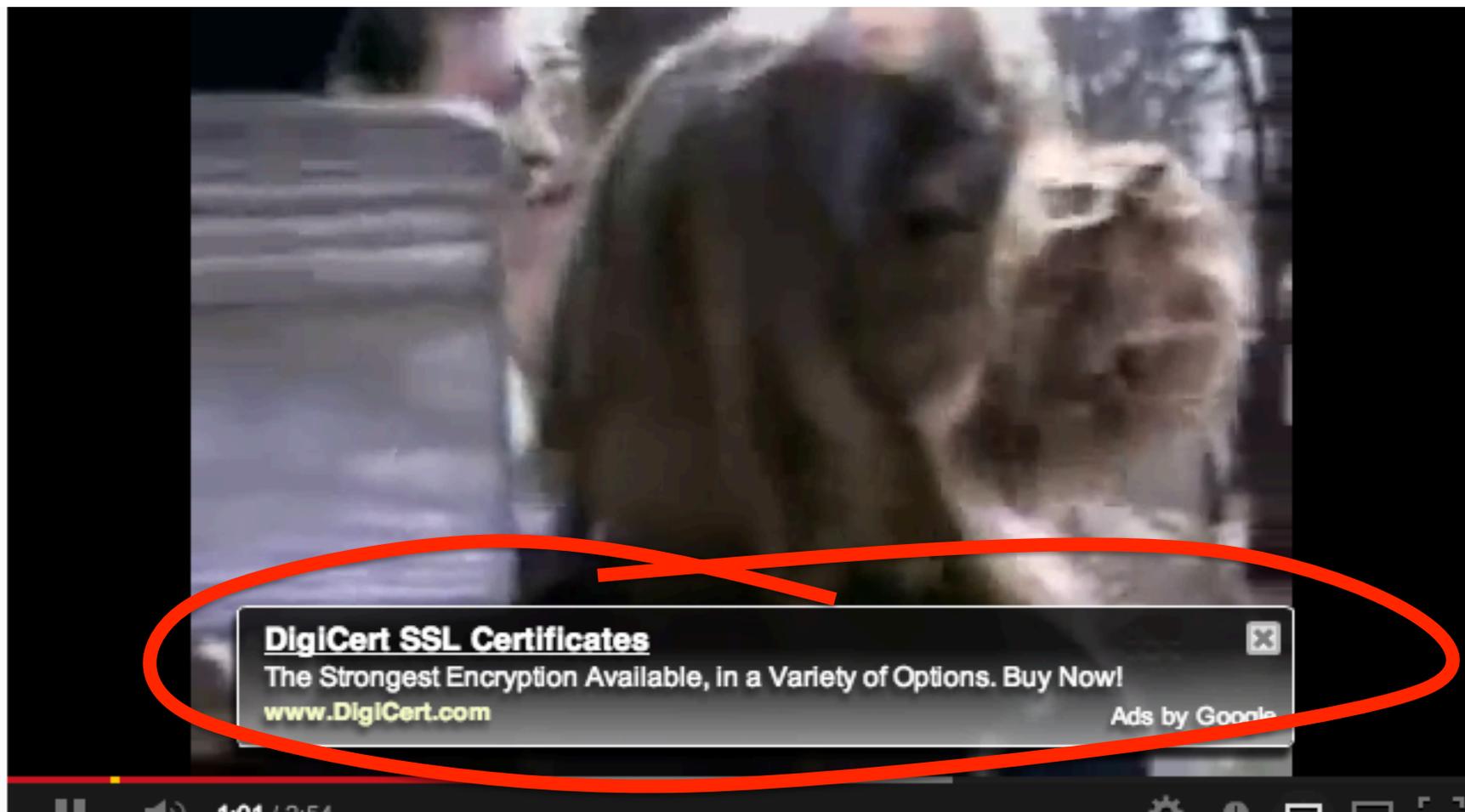
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Corrections  
Crosswords  
Digital archive  
Digital edition  
G24  
guardian.co.uk in 1821  
Guardian mobile

# Ads are ubiquitous



# Ads are ubiquitous



# Ads are implemented in Adobe Flash

- Advertising channels use Flash to make ads interactive
  - This is not just an ‘animated gif’



# Flash makes ads interactive

- [Apply Now] hover-over is interactive, and responds when selected.

0% p.a.  
on purchases

\*New cards only.  
Conditions apply.

Apply now

on a  
Low Rate Credit Card

with an ongoing  
purchase rate of  
13.49% p.a. (variable).

Apply now

# Flash and the network

- Flash includes primitives in 'actionscript' to fetch 'network assets'
  - Typically used to load alternate images, sequences
  - Not a generalized network stack, subject to constraints:
    - Port 80
    - crossdomain.xml on hosting site must match source name (wildcard syntax)
- Flash has asynchronous 'threads' model for event driven, sprite animation

# APNIC's measurement technique

- Craft flash/actionscript which fetches network assets to measure.
- Assets are reduced to a notional '1x1' image which is not added to the DOM and is not displayed
- Assets can be named (gethostbyname()) or use literals (bypass DNS based constraints)
- Encode data in the name of fetched assets
  - Result is returned by DNS name with wildcard

# Advertising placement logic

- Fresh Eyeballs == Unique IPs
  - We have good evidence the advertising channel is able to sustain a constant supply of unique IP addresses
- Pay by click, or pay by impression
  - If you select a preference for impressions, then the channel tries hard to present your ad to as many unique IPs as possible
- Time/Location/Context tuned
  - Can select for time of day, physical location or keyword contexts (for search-related ads)
  - But if you don't select, then placement is generalized
- Aim to fill budget
  - If you request \$100 of placement a day, then inside 24h algorithm tries hard to even placement but in the end, will 'soak' place your ad to achieve enough views, to bill you \$100

# Advertising placement logic

- Budget: \$100 per day, at \$1.00 'CPM' max
  - Clicks per millepressions: aim to pay no more than \$1 per click but pay up to \$1 for a thousand impressions
- Relatively even distribution of ads throughout the day
- No constraint on location, time
- Outcome: ~350,000 placements per day, on a mostly even placement model with end of day 'soak' to achieve budget goal

# 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

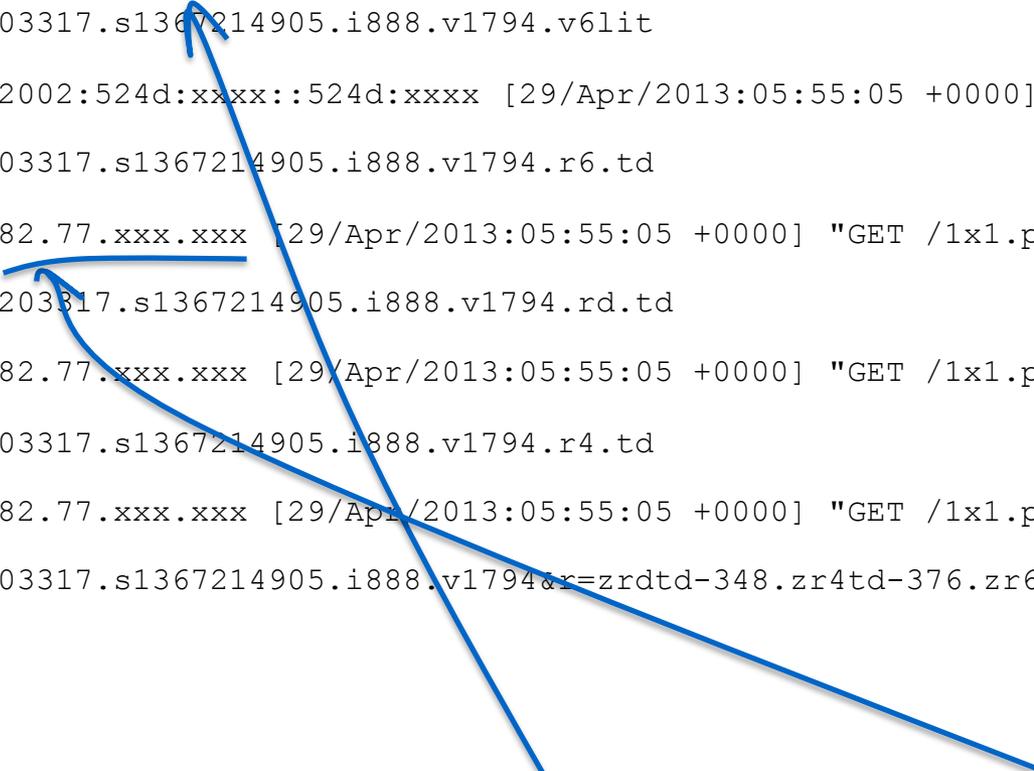
## Web Logs:

```
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:

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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

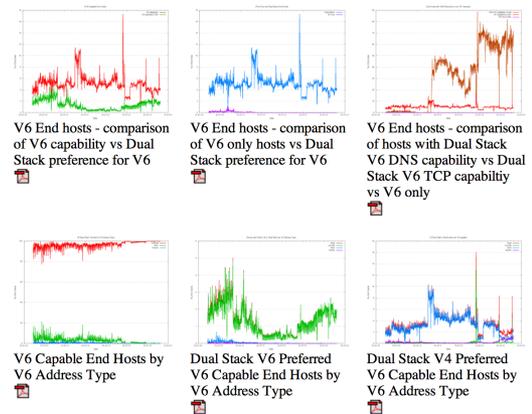
<http://www.potaroo.net/ipv6/>

**IPv6 Measurements**

This page contains an index of reports generated by the IPv6 capability test script. A description of the script itself and the statistics gathered by the script in April 2010 can be found in the article "Measuring More IPv6" (<http://www.potaroo.net/ispcol/2010-04/ipv6-measure.html>).

An associated [report](#) contains data that examines the connection failure rate recorded as part of this measurement activity.

**V6 Capability and Dual Stack Preference**



The figure consists of six line graphs arranged in a 2x3 grid. Each graph plots data over time, with the x-axis representing time and the y-axis representing a percentage or count. The graphs show various trends and peaks, indicating the fluctuation of IPv6 capabilities and preferences over time.

- V6 End hosts - comparison of V6 capability vs Dual Stack preference for V6**
- V6 End hosts - comparison of V6 only hosts vs Dual Stack preference for V6**
- V6 End hosts - comparison of hosts with Dual Stack V6 DNS capability vs Dual Stack V6 TCP capability vs V6 only**
- V6 Capable End Hosts by V6 Address Type**
- Dual Stack V6 Preferred V6 Capable End Hosts by V6 Address Type**
- Dual Stack V4 Preferred V6 Capable End Hosts by V6 Address Type**

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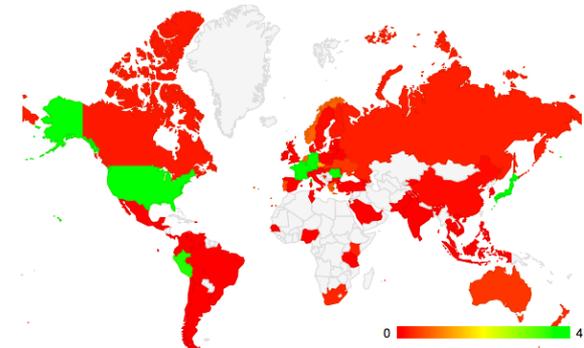
<http://labs.apnic.net/index.shtml>

Labs.APNIC.NET

## World IPv6 Adoption

As a continuing activity following on from the [World IPv6 Launch](#) we report on the levels of IPv6 deployment measured by client end-to-end capability. This is reported by economy, AS, and by regional and organizational breakdowns. These can be found at [labs.apnic.net/ipv6-measurement](http://labs.apnic.net/ipv6-measurement).

Click on an Economy to jump to its graphs



# Reports

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

- a) A “summary” report of capabilities
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- 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	RO	9715236	10.6587%	1035517	22070052	Romania
2	LU	468653	8.0921%	37923	515627	Luxembourg
3	EU	0	6.6177%	0	0	European Union
4	FR	51823998	5.7936%	3002475	65121888	France
5	CH	6539955	5.5336%	361894	7676004	Switzerland
6	JP	99484888	4.6031%	4579388	125850586	Japan
7	BE	8150710	4.2253%	344391	10449629	Belgium
8	DE	68166448	3.9990%	2725976	82128251	Germany
9	US	248890874	3.6797%	9158437	319664622	United States of America
10	PE	11168085	3.5454%	395953	31022460	Peru
11	SG	3427726	2.0627%	70703	4827784	Singapore
12	CZ	7418520	1.5100%	112019	10166535	Czech Republic
13	NL	15680146	0.8703%	136464	16988241	Netherlands
14	NO	4439774	0.8130%	36095	4724672	Norway
15	GR	5717112	0.7369%	42129	10787005	Greece
16	PT	6247622	0.6435%	40203	10816521	Portugal
17	SK	4088687	0.4651%	19016	5492595	Slovakia
18	UA	12785442	0.4525%	57854	44533065	Ukraine
19	AU	17732277	0.4480%	79440	22304751	Australia
20	NZ	3760114	0.3878%	14581	4372226	New Zealand
21	TW	16687082	0.3253%	54283	23176504	Taiwan
22	ZA	16656220	0.3201%	53316	49032147	South Africa
23	BA	2774697	0.3031%	8410	4624495	Bosnia and Herzegovina
24	KE	12123279	0.2964%	35933	43297426	Kenya
25	RU	67295058	0.2712%	182504	137336854	Russian Federation

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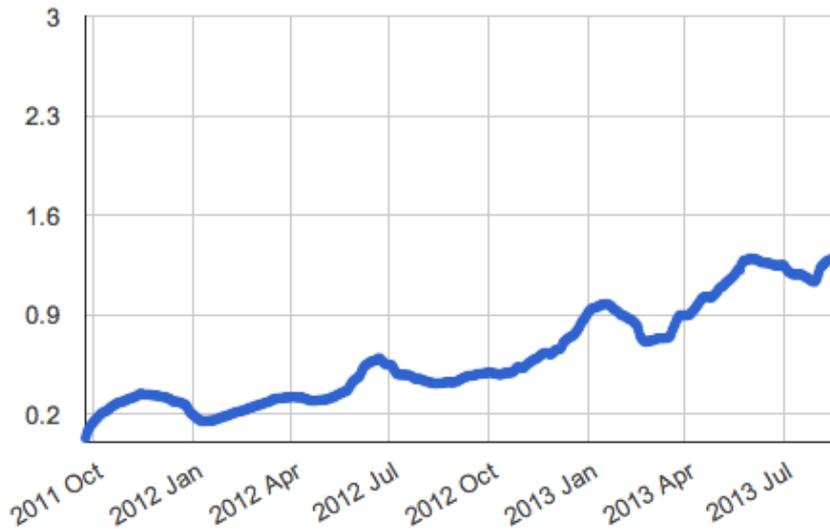
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35	GB	53686776	0.1335%	71671	61822635	United Kingdom of Great Britain and Northern Ireland
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40	NG	45947414	0.1098%	50450	161615949	Nigeria
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56	IN	123241492	0.0333%	41039	1223847993	India
16	PT	6247622	0.6435%	40203	10816521	Portugal
2	LU	468653	8.0921%	37923	515627	Luxembourg
14	NO	4439774	0.8130%	36095	4724672	Norway

# The IPv6 ASN League Table

Economy	ASN	AS Name	# samples	v6 capable	v6 preferred
<a href="#">CN</a>	<a href="#">AS23910</a>	CNGI-CERNET2-AS-AP China Next Generation Internet CERNET2	347	100	100
<a href="#">US</a>	<a href="#">AS19782</a>	INDIANAGIGAPOP - Indiana University	533	99.8124	99.8124
<a href="#">AU</a>	<a href="#">AS38083</a>	CURTIN-UNI-AS-AP Curtin University	395	98.481	97.2152
<a href="#">AU</a>	<a href="#">AS4608</a>	APNIC-AP Asia Pacific Network Information Centre	347	96.83	91.0663
<a href="#">JP</a>	<a href="#">AS55394</a>	GREE-NET GREE; Inc.	261	89.6552	66.6667
<a href="#">US</a>	<a href="#">AS15169</a>	GOOGLE - Google Inc.	7371	80.057	7.5295
<a href="#">US</a>	<a href="#">AS3598</a>	MICROSOFT-CORP-AS - Microsoft Corp	594	76.936	69.8653
<a href="#">BR</a>	<a href="#">AS22548</a>	Nlxfacleo de Informalxe7ixe3o e Coordena\xe7\xe3o do Ponto BR	285	68.0702	62.1053
<a href="#">GB</a>	<a href="#">AS786</a>	JANET The JNT Association	84274	64.8812	55.1155
<a href="#">US</a>	<a href="#">AS8071</a>	MICROSOFT-CORP—MSN-AS-BLOCK - Microsoft Corp	355	63.3803	61.6901
<a href="#">US</a>	<a href="#">AS6621</a>	HNS-DIRECPC - Hughes Network Systems	1118	62.9696	66.458
<a href="#">US</a>	<a href="#">AS109</a>	CISCO-EU-109 Cisco Systems Global ASN - ARIN Assigned	323	58.2043	47.3684
<a href="#">AU</a>	<a href="#">AS56132</a>	MONASHUNI-AU-AS-AP Monash University;	889	50.3937	48.0315
<a href="#">CA</a>	<a href="#">AS12093</a>	UWATERLOO - University of Waterloo	209	42.5837	40.6699
<a href="#">HK</a>	<a href="#">AS4528</a>	HKU-AS-HK The University of Hong Kong	258	40.3101	37.9845
<a href="#">US</a>	<a href="#">AS87</a>	INDIANA-AS - Indiana University	1302	39.9386	36.1751
<a href="#">CN</a>	<a href="#">AS7497</a>	CSTNET-AS-AP Computer Network Information Center	458	38.4279	31.8777
<a href="#">SG</a>	<a href="#">AS24482</a>	SGGS-AS-AP SG.GS	266	37.594	37.594
<a href="#">US</a>	<a href="#">AS22394</a>	CELLCO - Cellco Partnership DBA Verizon Wireless	11565	35.668	33.1431
<a href="#">BE</a>	<a href="#">AS12392</a>	ASBRUTELE Brutele SC	5448	34.8201	33.2048
<a href="#">JP</a>	<a href="#">AS2516</a>	KDDI KDDI CORPORATION	35190	31.2191	29.1162
<a href="#">SE</a>	<a href="#">AS12552</a>	IPO-EU IP-Only Telecommunication Networks AB	272	30.5147	30.5147
<a href="#">MY</a>	<a href="#">AS17564</a>	GITN-PCN-AS-AP GITN (M) Sdn. Bhd.	236	30.0847	25.8475
<a href="#">SG</a>	<a href="#">AS7472</a>	NUS-AS-AP Computer Centre	216	29.1667	23.1481
<a href="#">JP</a>	<a href="#">AS18126</a>	CTCX Chubu Telecommunications Company; Inc.	3380	29.0533	26.8343
<a href="#">DE</a>	<a href="#">AS12816</a>	MWN-AS Leibniz-Rechenzentrum	313	28.4345	24.6006
<a href="#">CN</a>	<a href="#">AS4538</a>	ERX-CERNET-BKB China Education and Research Network Center	1520	27.5658	25.1316
<a href="#">GR</a>	<a href="#">AS3323</a>	NTUA National Technical University of Athens	631	27.4168	26.6244

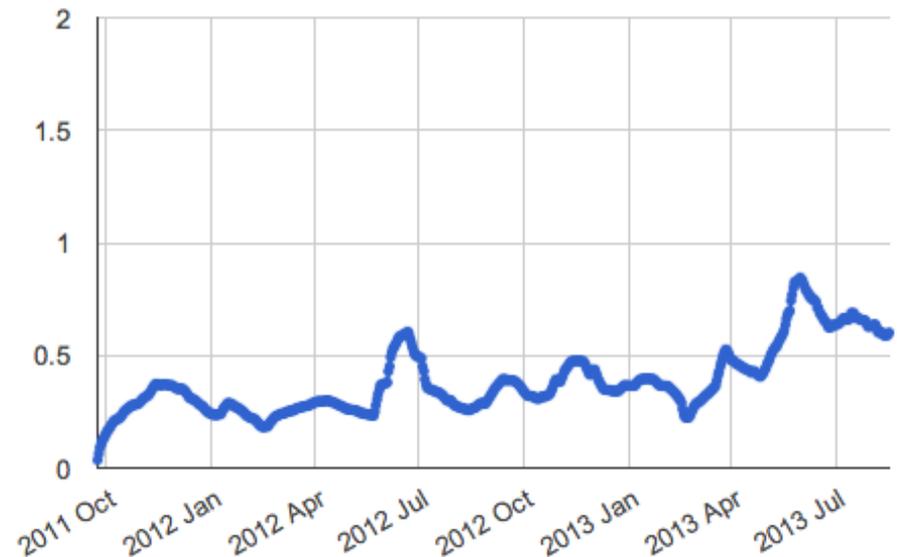
# And some Time Series...

IPv6 Preference by Month



Global IPv6

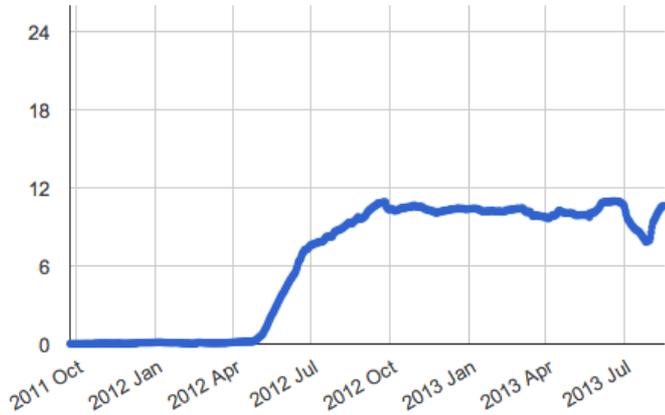
IPv6 Preference by Month



Asia IPv6

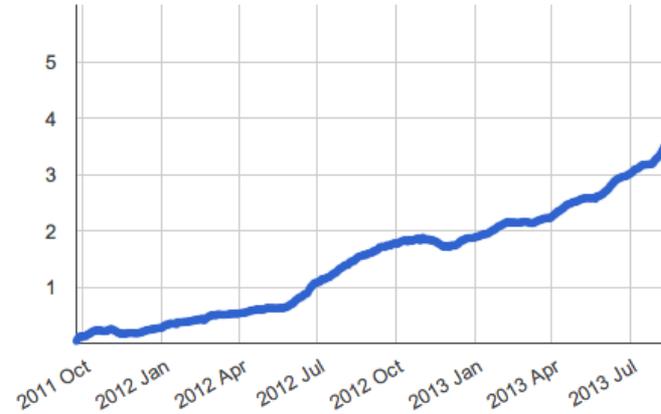
# And Some Countries...

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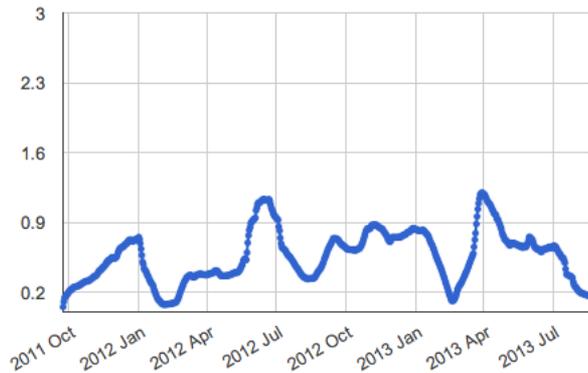
Romania

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USA

IPv6 Preference by Month



China

IPv6 Preference by Month



Japan

# What the....?

We noticed this class of entries in the web logs:

222.154.187.xx http://t10000.u1367873034830.s644708422.i647302.v10a.r6.td.labs.apnic.net/1x1.png

84.23.58.xx http://t10000.u1367873368824.s1566062113.i245974.v10i.r6.td.labs.apnic.net/1x1.png

We get some 200 of these web log entries every day

But \*.r6.td.labs.apnic.net has **NO** A record

So why are these clients attempting to fetch a V6-only URL using IPv4 as the transport protocol?

**No idea!**

# What the<sup>2</sup>....?

Even stranger...

202.124.201.xx http://[2401:2000:6660::f003]/1x1.png

118.148.0.xx http://[2401:2000:6660::f003]/1x1.png

We get some 16-20 of these web log entries every day

But this is a V6 literal form of URL!

Here's the origin Ases for this V4 fetch of a V6 literal URL for the 7th May

Origin AS	count	AS name
3352	1	TELEFONICA-DATA-ESPANA TELEFONICA DE ESPANA
4134	4	CHINANET-BACKBONE No.31,Jin-rong Street
4837	1	CHINA169-BACKBONE CNCGROUP China169 Backbone
35662	1	REDSTATION Redstation Limited
38793	8	NZCOMMS-AS-AP Two Degrass Mobile Limited
55443	1	BAKST-AS-AU Level 16, 55 Hunter Street

# Questions?

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