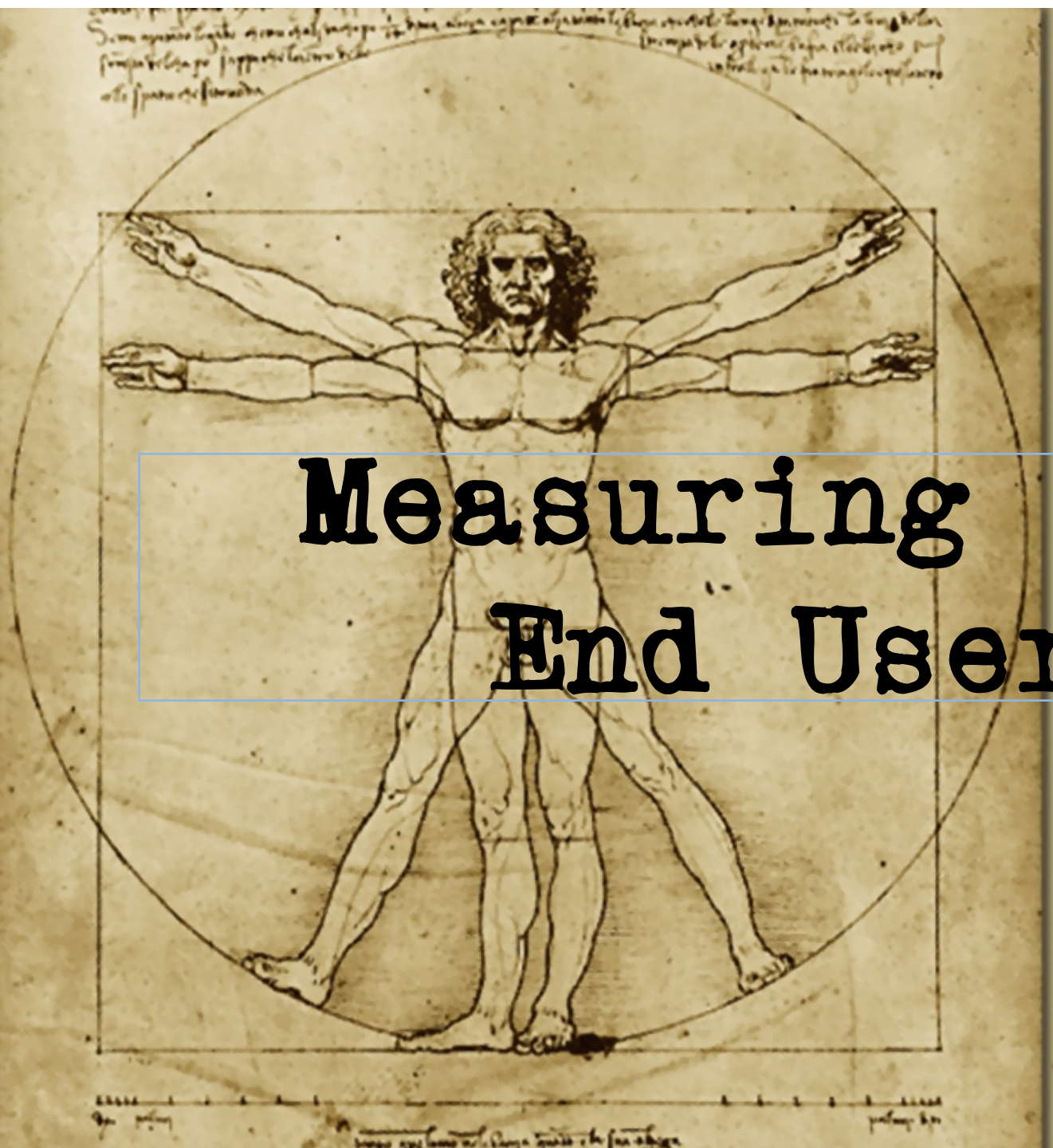


Measuring the End User

Geoff Huston
APNIC Labs

Measurement Bias

When we first looked at measuring in the Internet, it was all about the network, and the distinction between network management and network measurement was not very clear

We ended up measuring what's *easy to measure* and often missed measuring what's *useful to understand*

"Measurable" Questions?

- How many routes are IPv6 routes?
- How many service providers offer IPv6?
- How many domain names have AAAA RRs?
- How many domains are DNSSEC signed?
- How many DNS queries are made over IPv6?
- How much traffic uses IPv6?
- How many connections use IPv6?

…

Users vs Infrastructure

None of these specific measurement questions really embrace the larger questions about the end user experience

They are all aimed at measuring an aspect of of behaviour within particular parameters of the network infrastructure, but they don't encompass how the end user assembles a coherent view of the network


The Internet is all about
US!

What's the question?

*How many **users** experience <x>?*

- How many **users** are capable of using IPv6?
- How many **users** can resolve a DNS name?
- How many **users** are performing DNSSEC validation?
- How many **users** support ECDSA in digital signatures in DNSSEC?

etc

The Challenge:

How can we undertake meaningful public measurements that:

quantify aspects of users' experiences

drawn from across the entire Internet

that don't rely on access to private data?

For example… IPv6

- It would be good to know how we are going with the transition to IPv6
- And it would be good everyone to know how everyone else is going with the transition to IPv6
- What **can** we measure?
  - IPv6 in the DNS – AAAA records in the Alexa top N
  - IPv6 in routing – IPv6 routing table
  - IPv6 traffic exchanges – traffic graphs
- What **should** we measure?
  - How many connected devices on today's Internet are capable of making IPv6 connections?

How to measure millions of end devices for their IPv6 capability?

How to measure millions of end devices for their IPv6 capability?

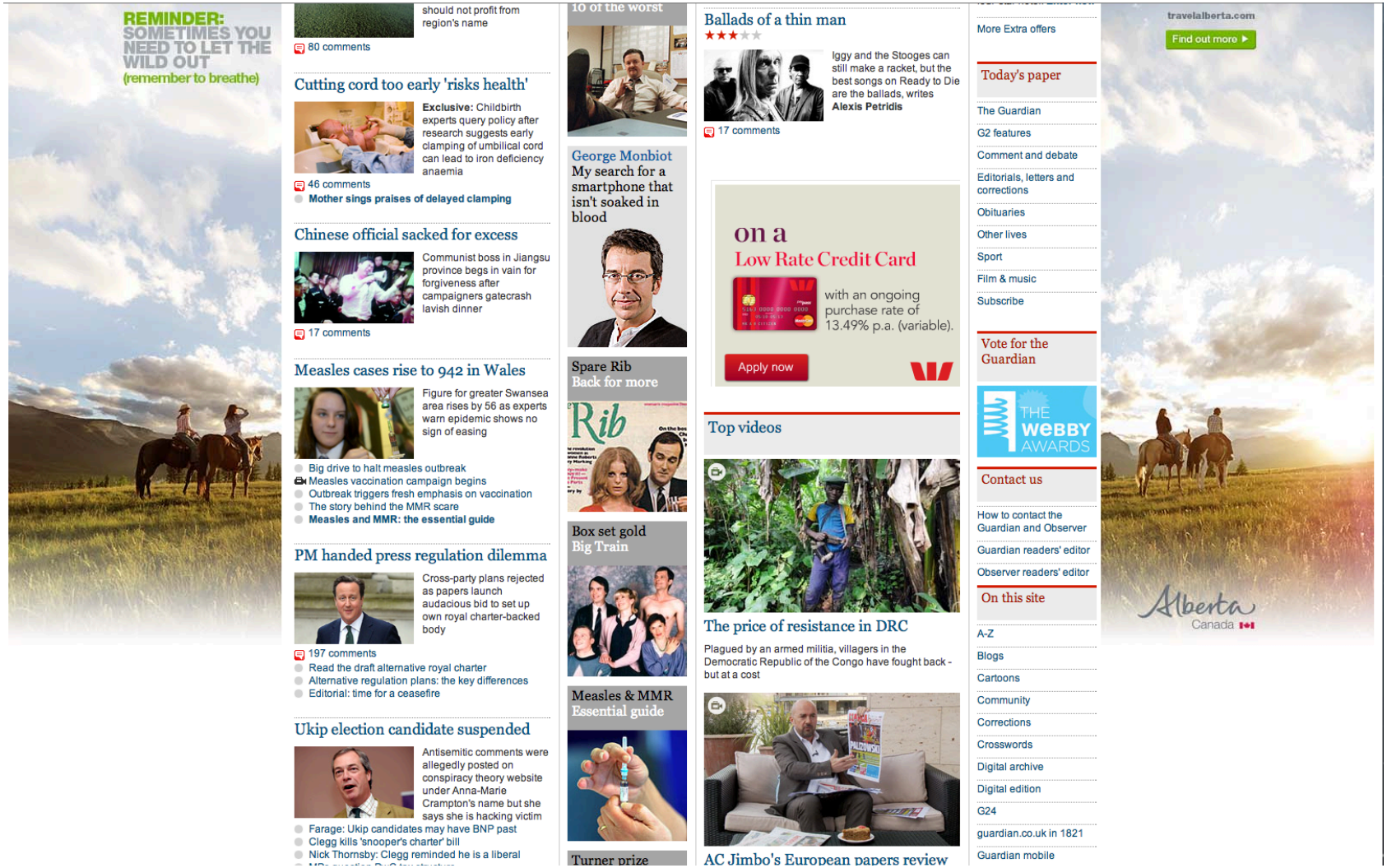
a) Be

How to measure millions of end devices for their IPv6 capability?

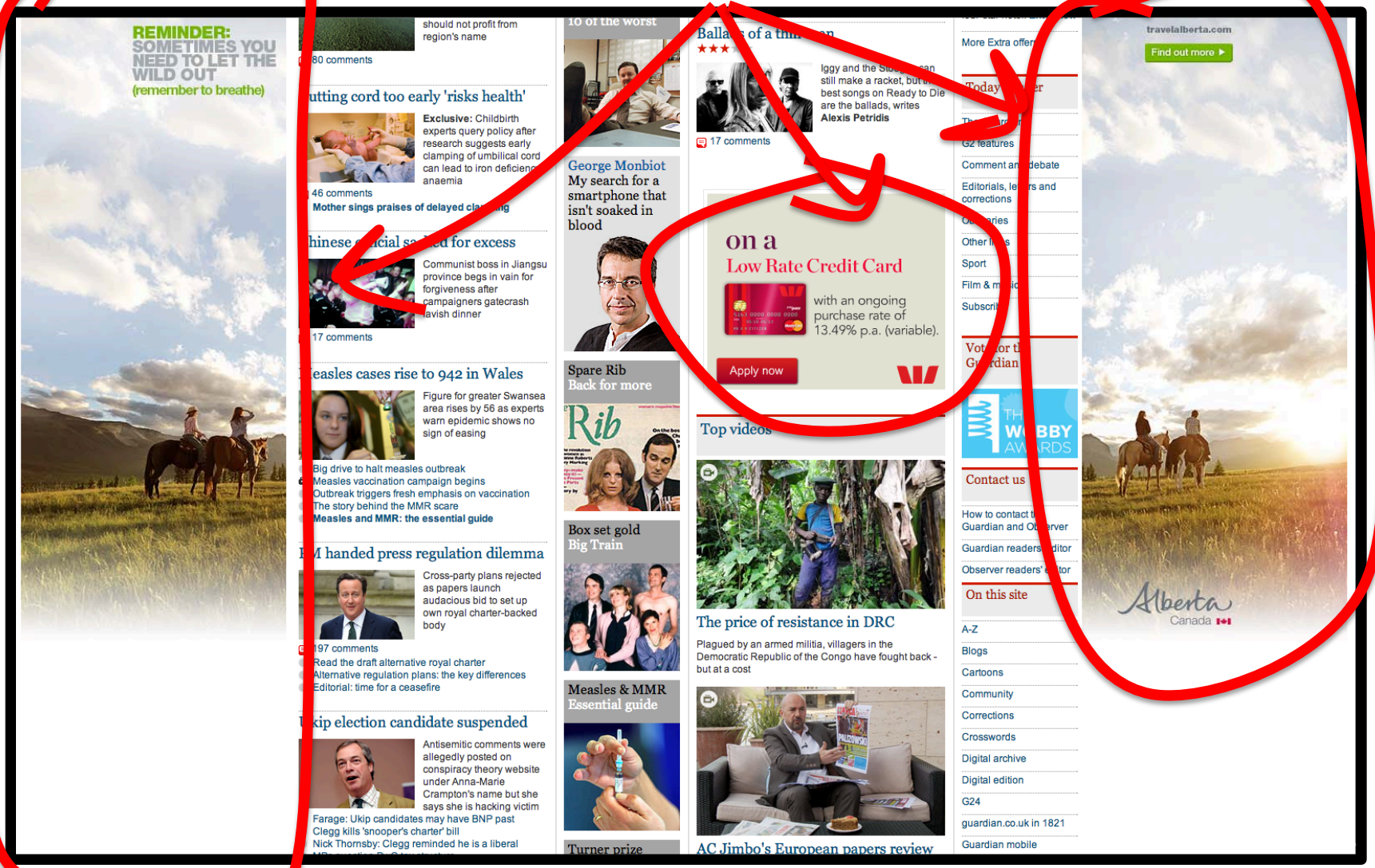
OR

Have your measurement code run on a million end devices

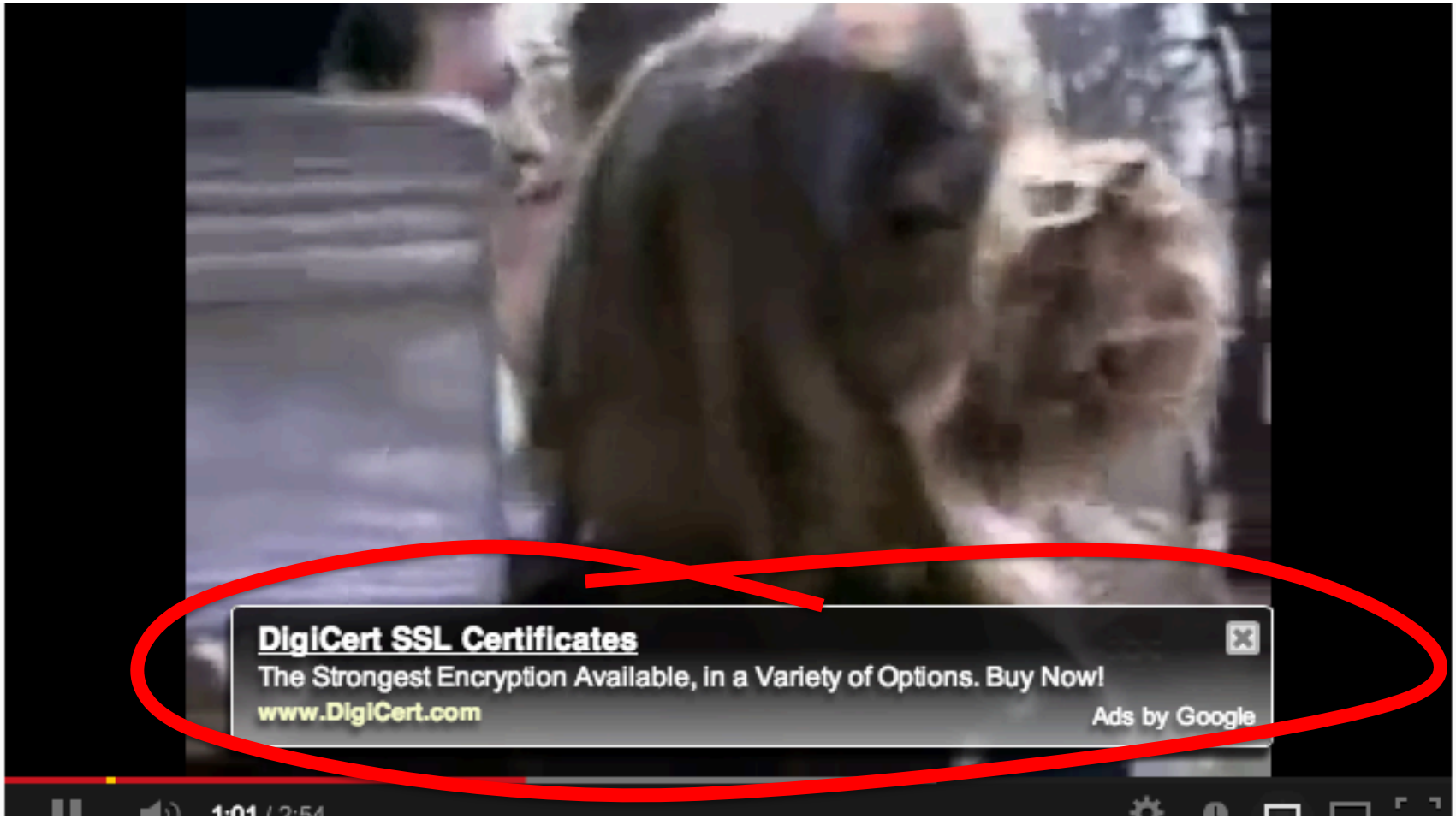
Ads are ubiquitous



Ads are ubiquitous



Ads are ubiquitous



Ads use active scripts

- Advertising channels use active scripting to make ads interactive
  - This is not just an 'animated gif' – it uses a script to sense mouse hover to change the displayed image

Adobe 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 over what connections can be made
- Flash has asynchronous ‘threads’ model for event driven, sprite animation

Adobe Flash and the network

html5

- Flash includes primitives in 'actionscript' to fetch 'network assets'
  - ... load to load alternate images, sequences
  - ... ject to
  - ... ade
- Flash has asynchronous ... for event driven, sprite animation

Flash is disappearing in today's devices, so these days we use HTML5 as the vehicle for the measurement script

APNIC's measurement technique

- Craft a script which fetches a set of URLs to measure
- URLs are reduced to a notional '1x1' image which is not added to the browser's display manager and is not displayed
- URLs trigger DNS resolution via whatever name resolution mechanism is used by the local browser and host
- And report back:

  We encode data transfer from the client to the server in the name of fetched URLs
  - Could use the DNS as the information conduit:
    - Result is returned by DNS name
  - Could use HTTP as the information conduit
    - Result is returned via parameters attached to an HTTP GET command

  We use a combination of http requests and server logs

The Ad Measurement Technique

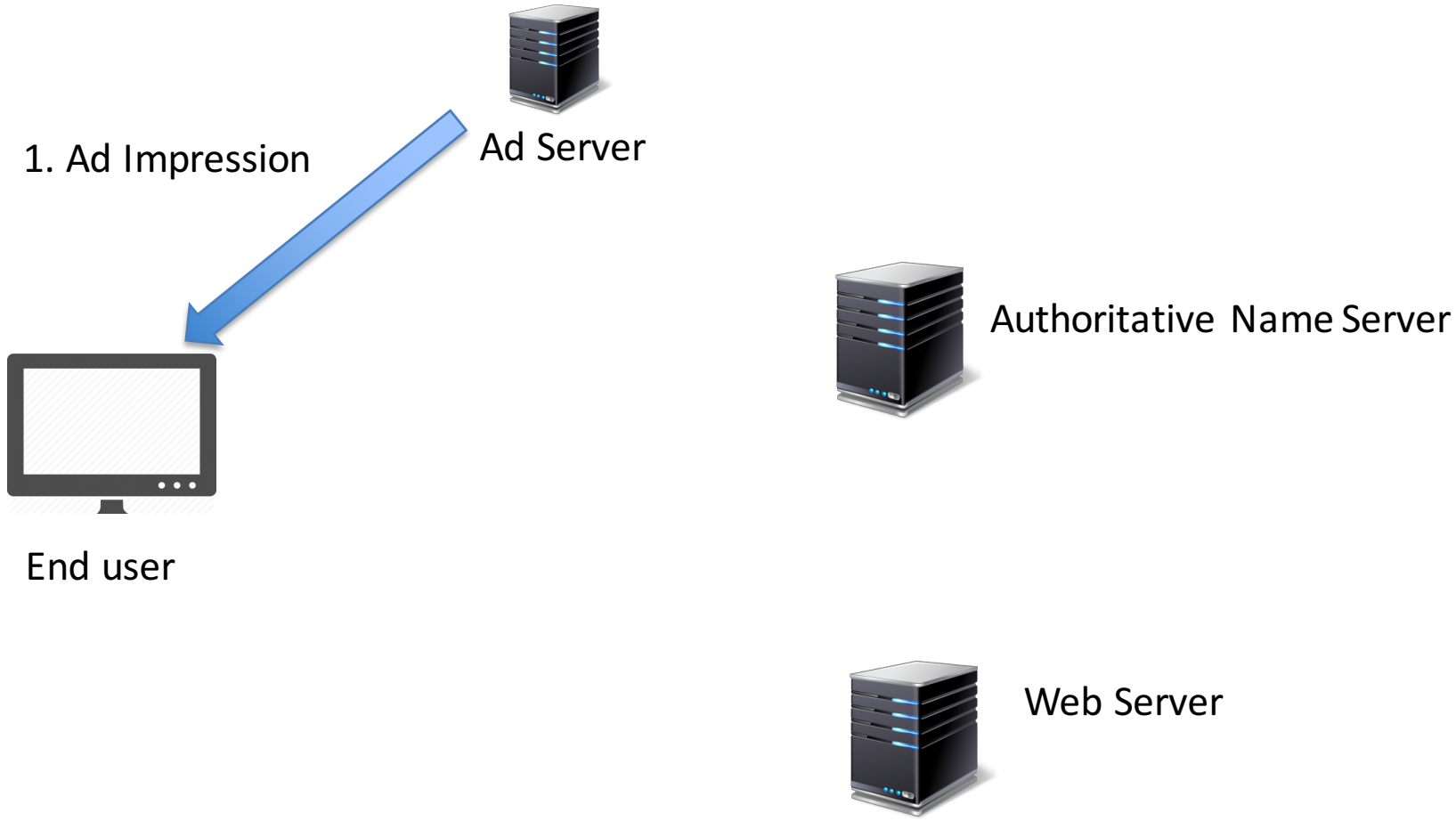
Ad Server

Authoritative Name Server

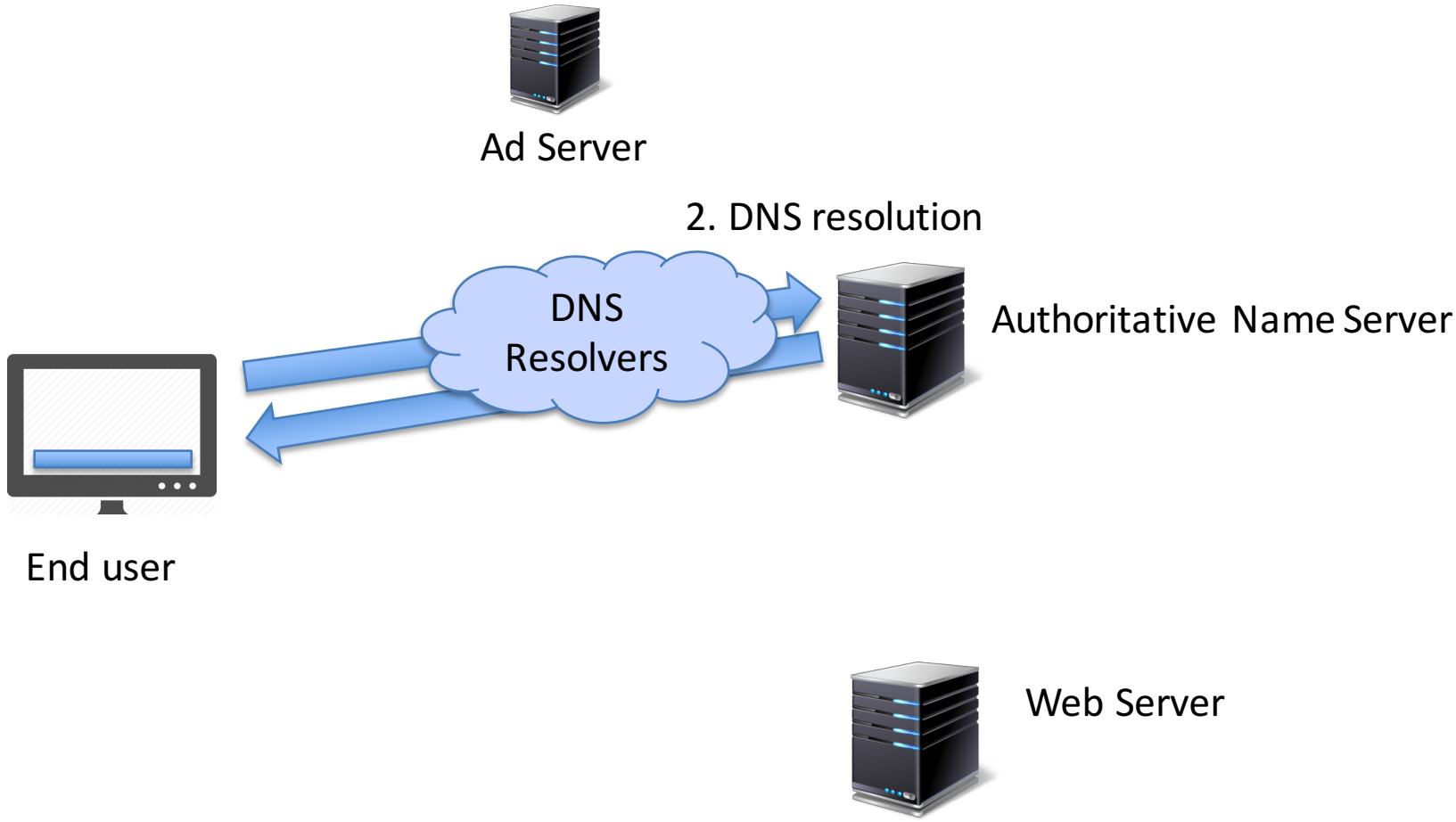
End user

Web Server

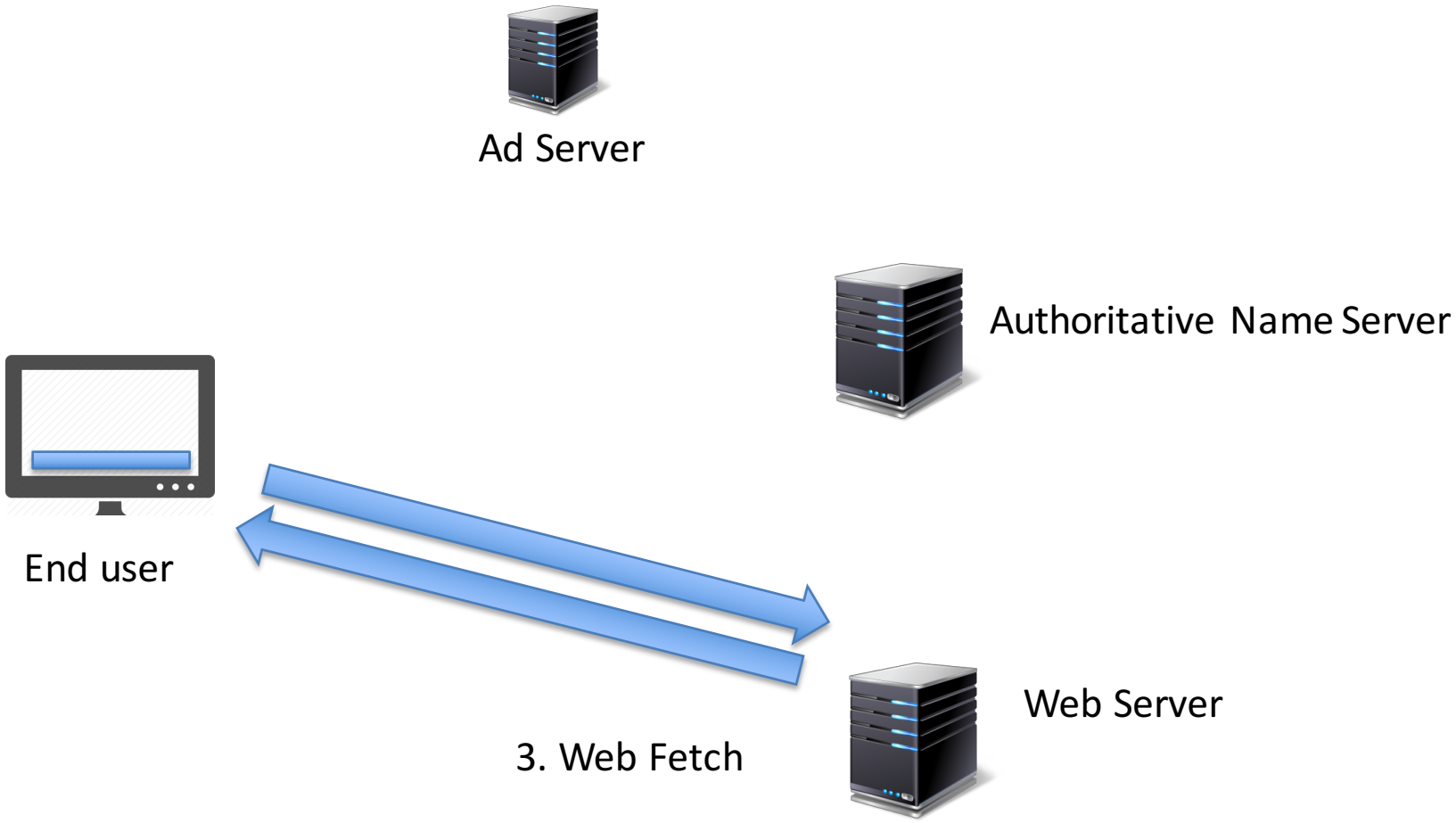
The Ad Measurement Technique



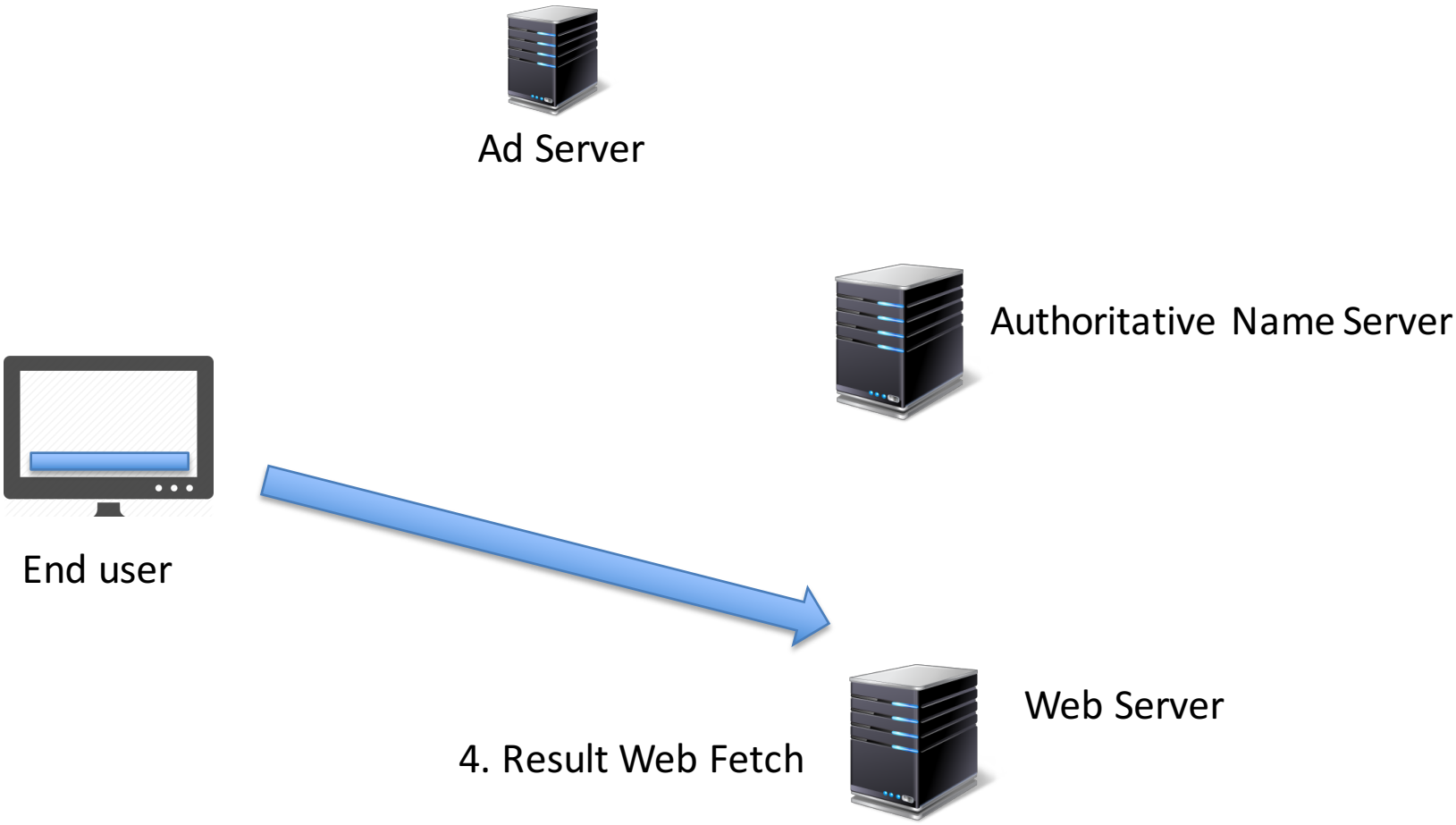
The Ad Measurement Technique



The Ad Measurement Technique



The Ad Measurement Technique



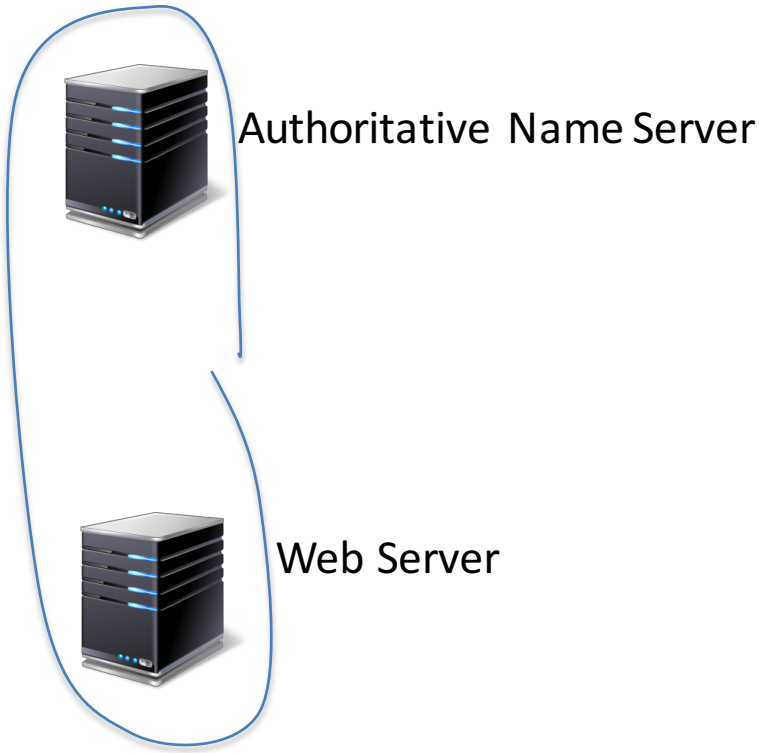
The Ad Measurement Technique

Linode servers (x6)

DNS: Customised EVLDNS server allowing DNSSEC-signed pseudo wildcard signed subdomains*

WEB: NGINX – small dynamic content Server

TCPDUMP: full packet capture log



* Thanks to Ray Bellis and ISC for this!

Experiment Variables

DNS

- DNSSEC
- DNSSEC signing algorithms
- Response size
- TCP support
- V4 vs V6 DNS transport
- UDP behaviour
- UDP Fragmentation
- CNAME / DNAME support
- DNS Robustness
- Resolver distribution

Experiment Variables

URL

- V4 / V6
- RTT variance
- TCP handshake robustness
- OS / Browser variance
- TCP MSS / Packet fragmentation
- Path MTU behaviour
- URL stalking
- Address permanence characteristics

Experiment Variables

DNS + URL

- User to Resolver mapping
- Cache refresh characteristics

What's it good for?

This approach allows us to analyze user behaviour when presented with particular tests

- DNS: response size, TCP behaviour, resolver distribution, matching resolvers to users, resolver timers, EDNS0 use, EDNS0 client subnet use and accuracy, dual stack behaviour, response size,…
- Web: Protocol preference, dual stack behaviour, response size, fragmentation behaviour, …

(Some) Studies so far

We've used this platform to look at large scale measurements of:

- IPv6 penetration
- IPv6 performance and robustness
- DNSSEC Validation
- DNSSEC performance
- Packet Fragments / Path MTU
- gTLD acceptance
- Name Collisions
- DNS response size behaviours

But…

It’s not a general purpose compute platform, so it can’t do many things

- Ping, traceroute, etc
- Send data to any destination
- Pull data from any destination
- Use different protocols

This is a “many-to-one” styled setup where the server instrumentation provides insight on the inferred behaviour of the edges

In Summary…

- Measuring what happens at the user level by measuring some artifact or behaviour in the infrastructure and inferring some form of user behaviour is always going to be a guess of some form
- If you really want to measure user behaviour then its useful to trigger the user to behave in the way you want to study or measure
- The technique of embedding simple test code behind ads is one way of achieving this objective
  - for certain kinds of behaviours relating to the DNS and to URL fetching

Thanks!

Additional Slides

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 impression

- If you select a preference for impressions, then the channel tries hard to present your ad to as many unique IPs as possible

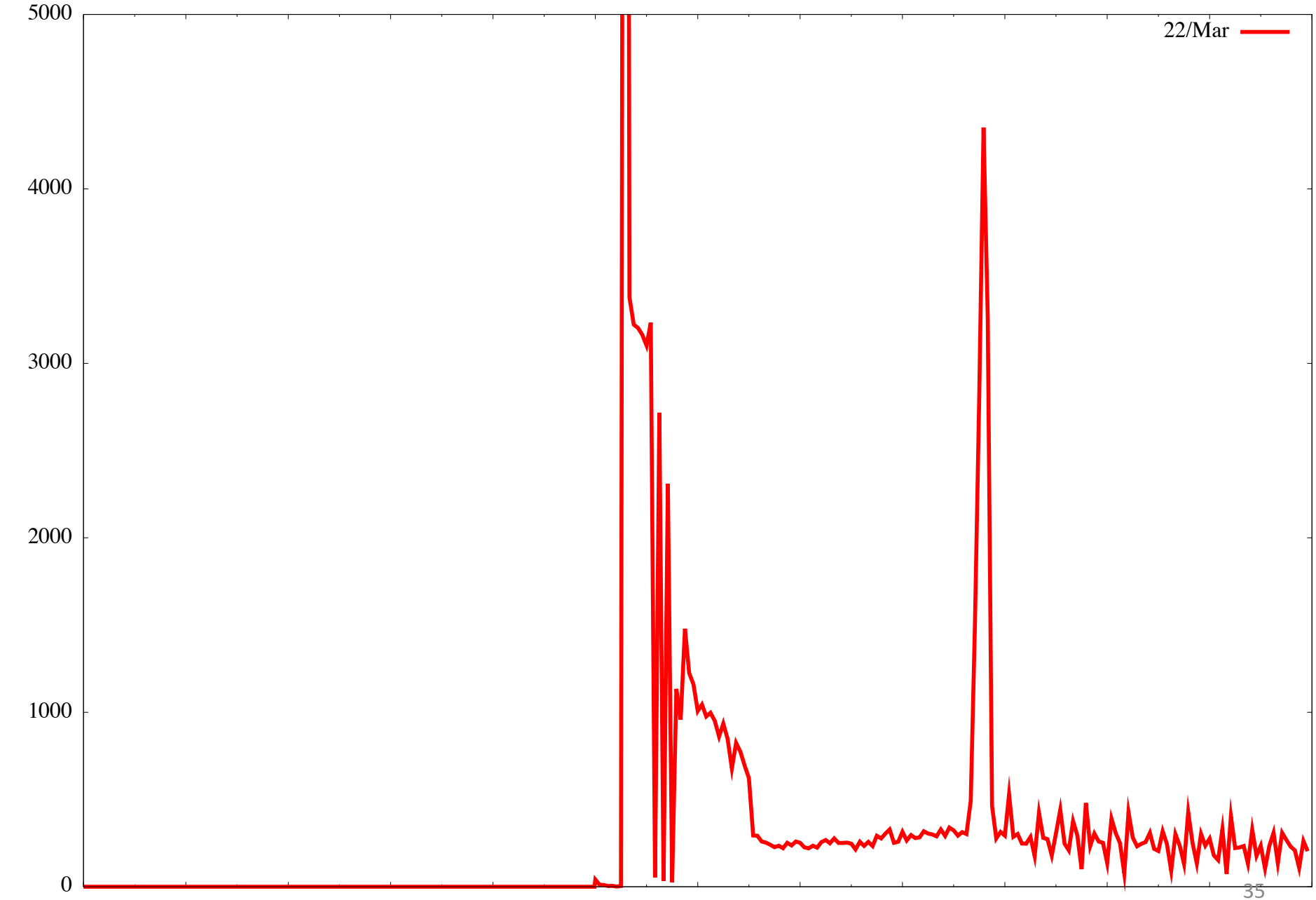
Time/Location/Context tuned

- 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

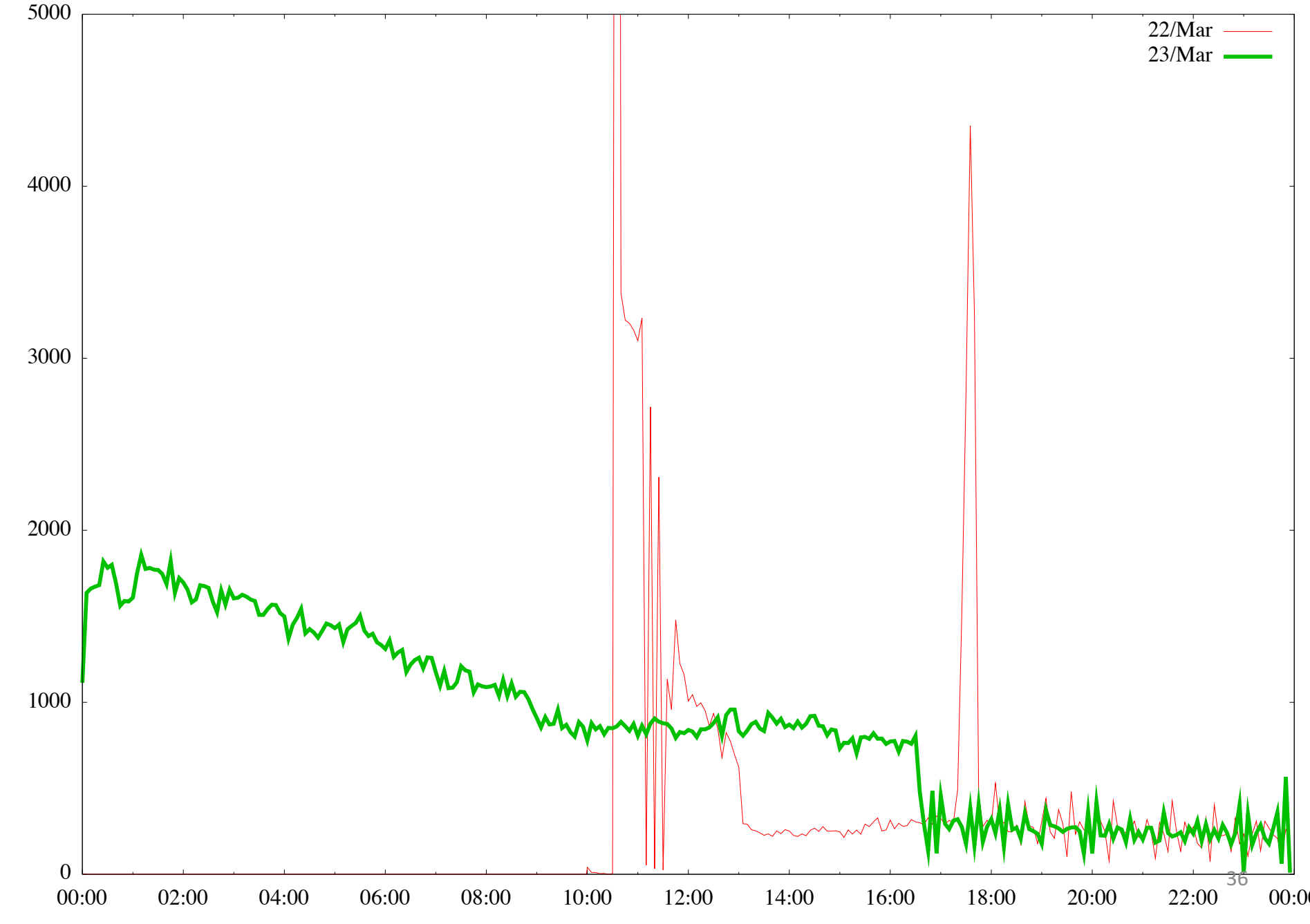
Aim to fill budget

- If you request $100 of placement a day, then inside the ad placement machinery an algorithm tries hard to achieve even placement loads, but in the end, will 'soak' place your ad to achieve enough views to bill you that target of $100

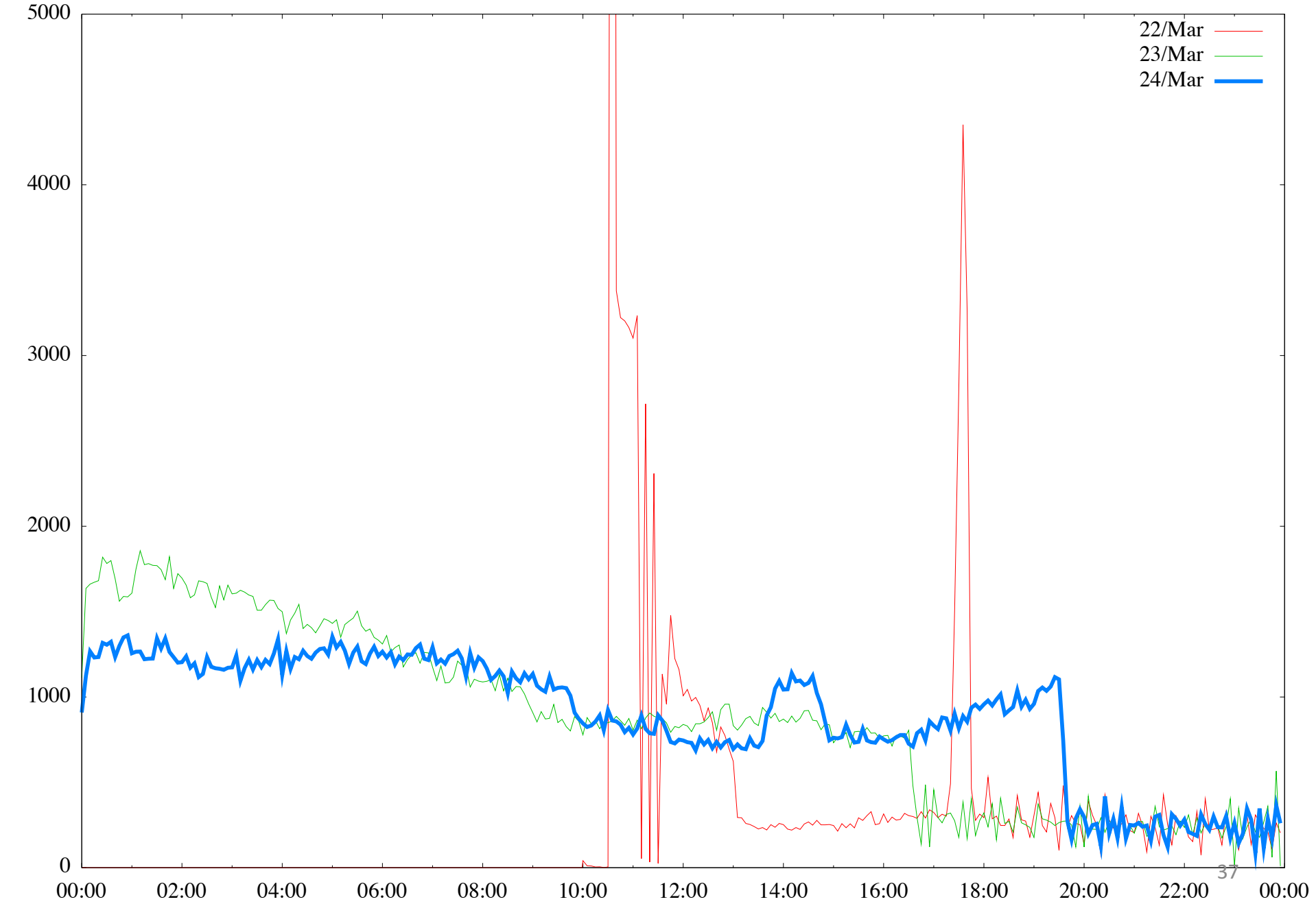
Ad Placement Training - Day 1



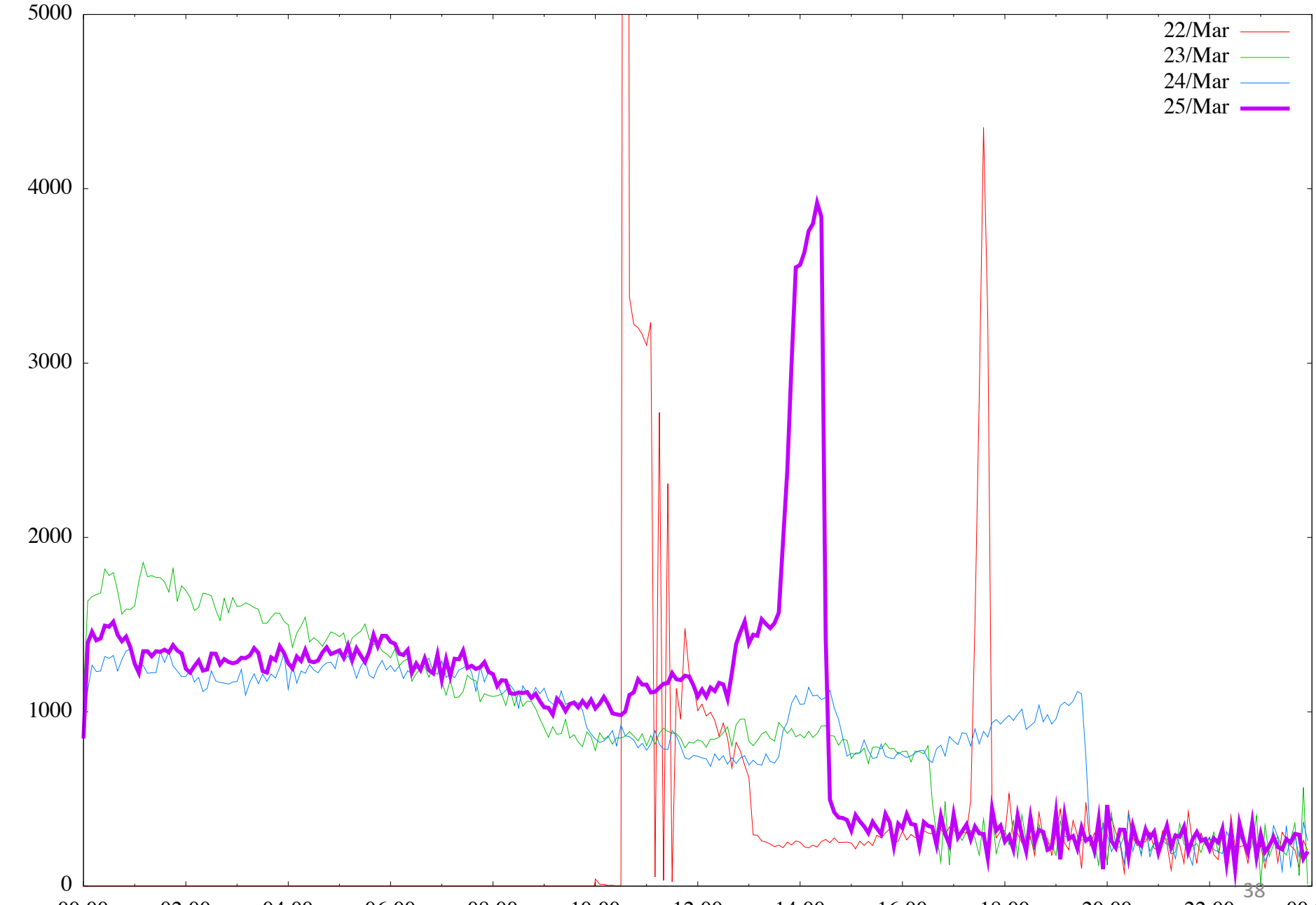
Ad Placement Training - Day 2



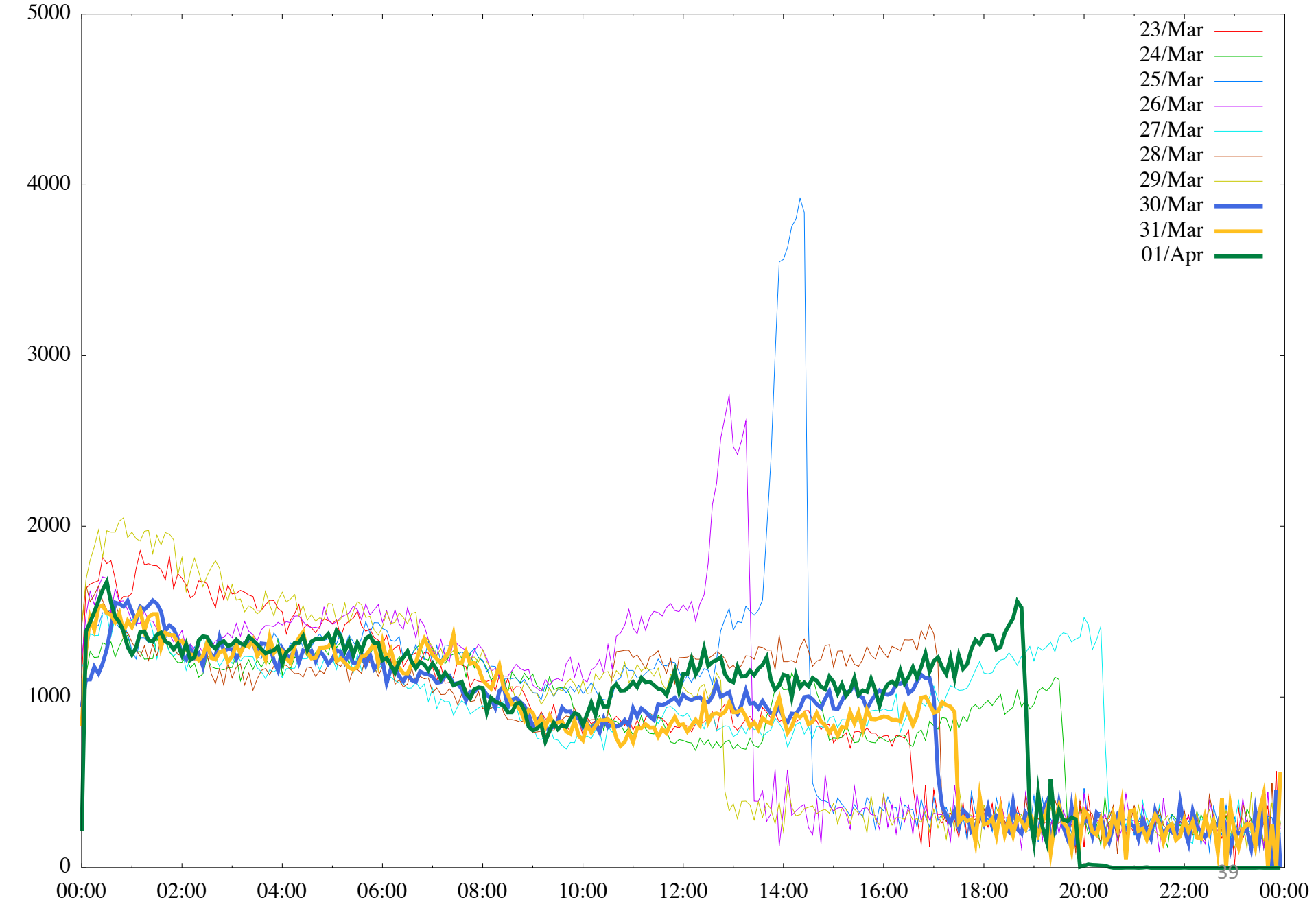
Ad Placement Training - Day 3



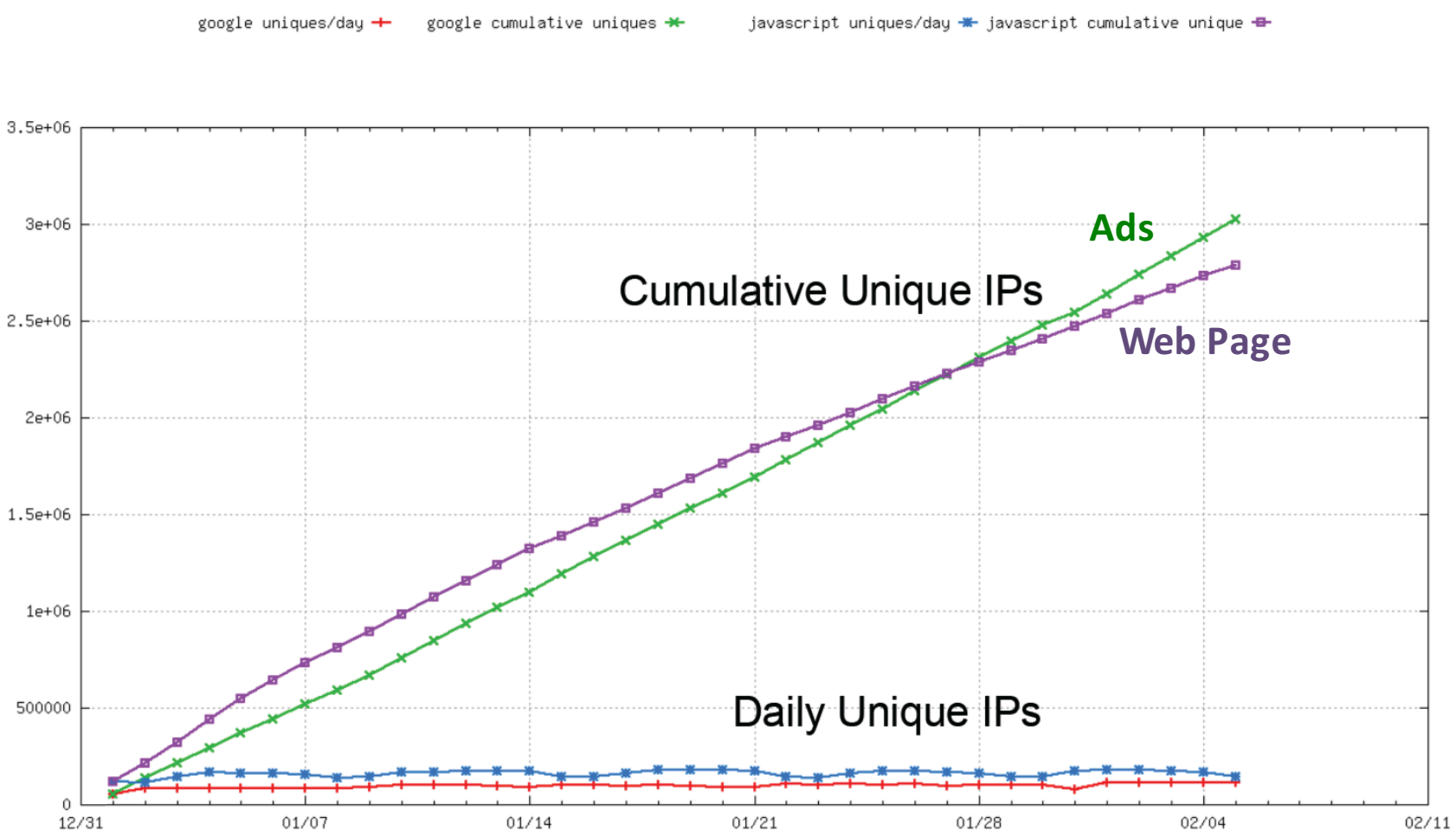
Ad Placement Training - Day 4



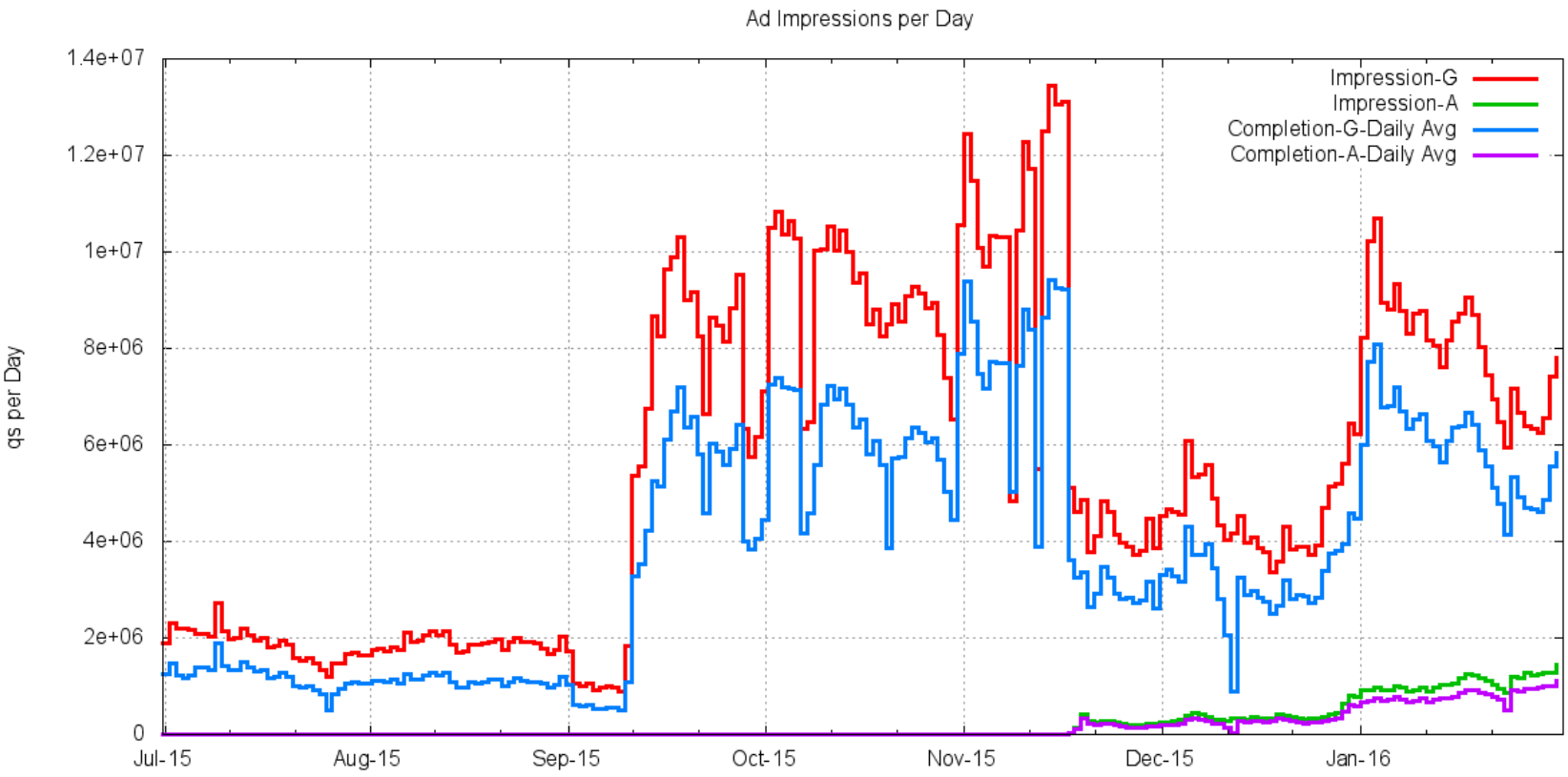
Ad Placement Training - Days 5, 6 & 7



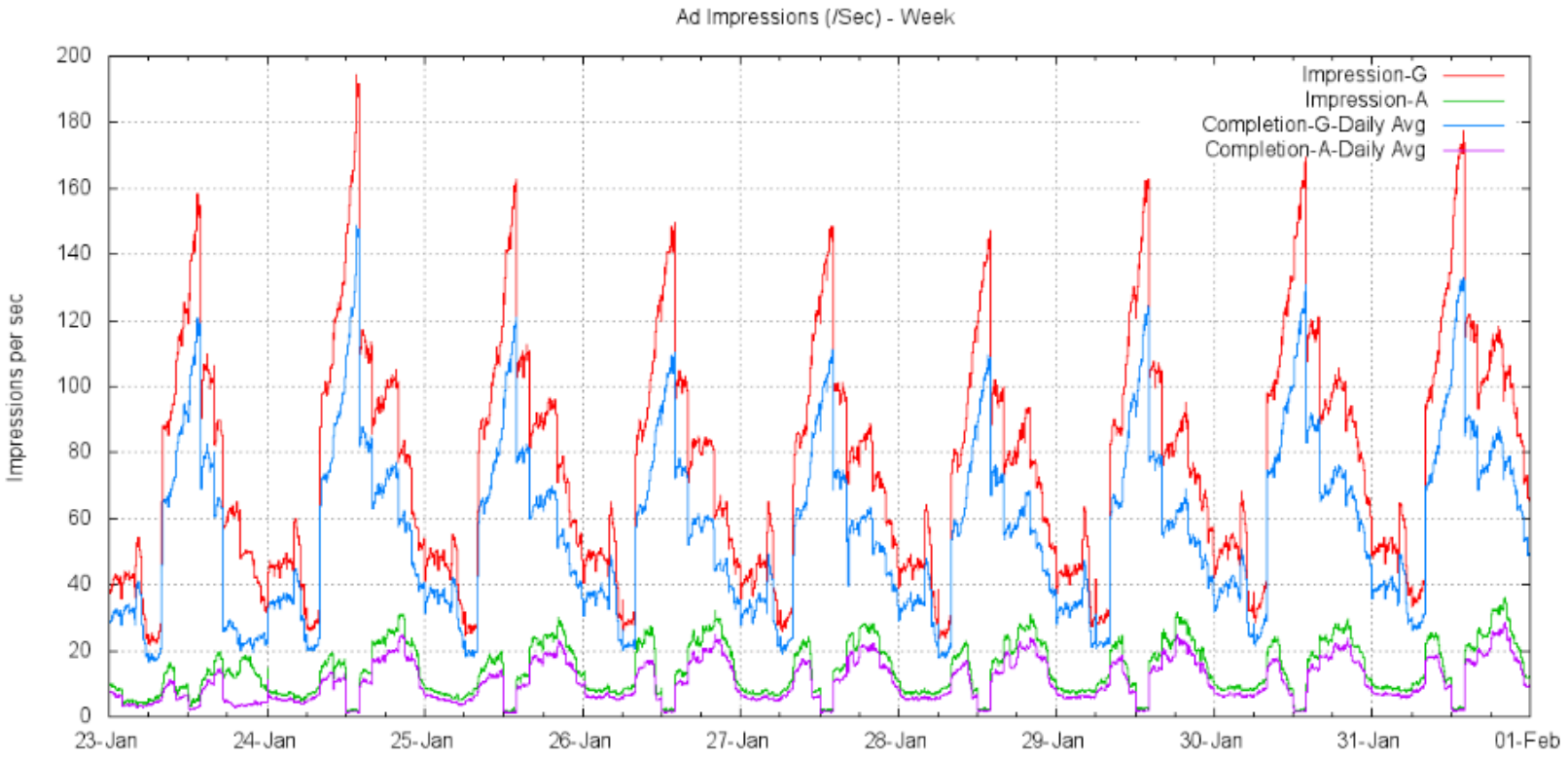
Fresh Eyeballs



Ad Placement Profile



Daily Variance in Placements



Success!

- 2.5M – 10M samples per day – mostly new!
- Large sample space across much of the known Internet
- Assemble a rich data set of end user addresses and DNS resolvers

Success … of a sort!

- What we are after is a random sample of the entire Internet

  And we are close

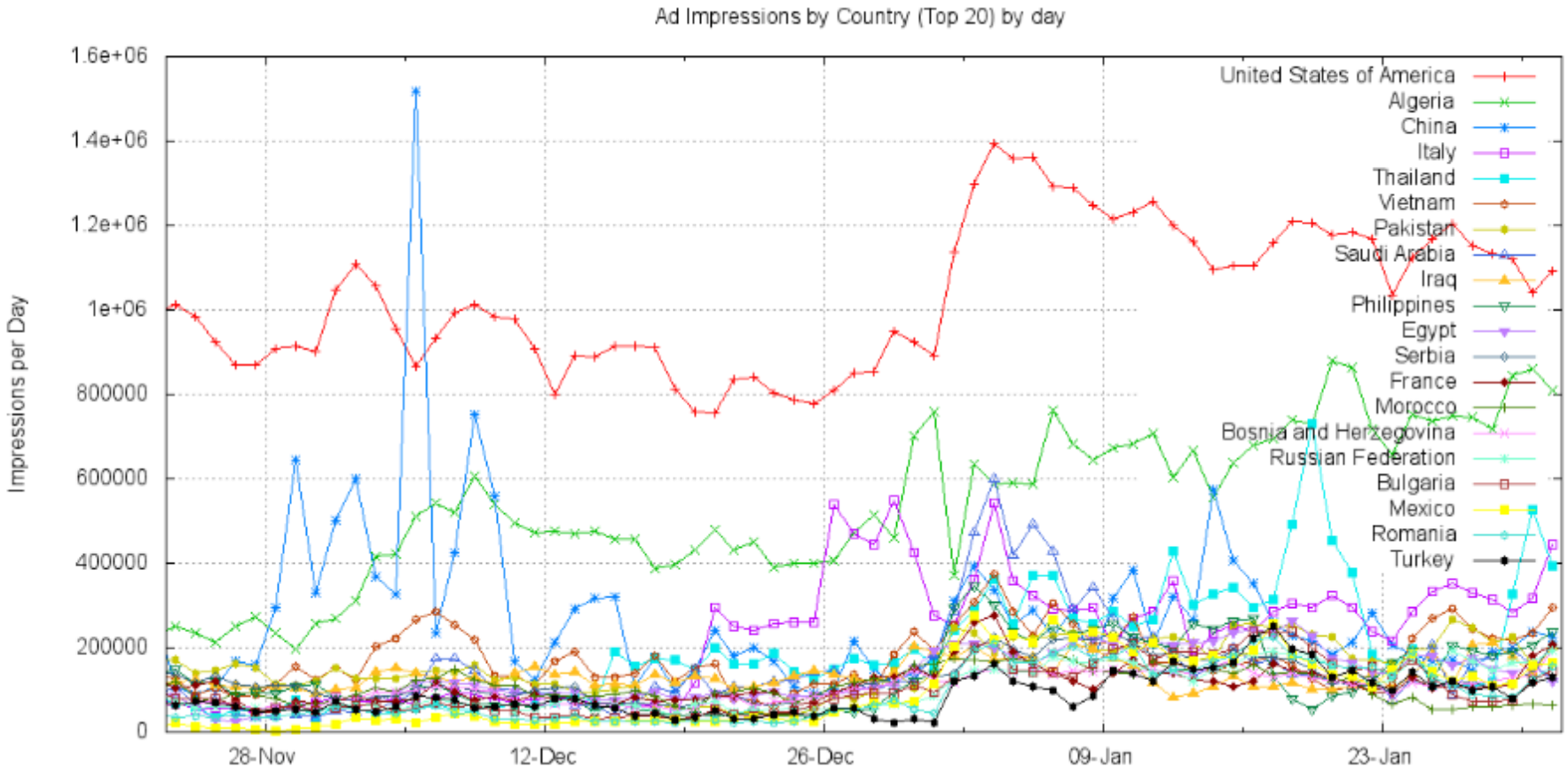
- But what we have is a data set biased towards "cheap" eyeballs in fixed networks

"Raw" AD counts per day

155,430	VN	Vietnam
103,517	CN	China
92,107	MX	Mexico
79,092	TH	Thailand
73,702	IN	India
65,402	PK	Pakistan
64,121	BR	Brazil
54,637	TR	Turkey
52,532	US	United States of America
52,240	AR	Argentina
48,315	CO	Colombia
45,216	ID	Indonesia
39,839	PE	Peru
36,962	RU	Russian Federation
34,529	PH	Philippines
33,899	EG	Egypt
22,983	TW	Taiwan
22,712	RO	Romania
22,490	UA	Ukraine
22,403	ES	Spain

IP address to country code mapping for experiments placed on the 24th May 2015

Impressions per Country



ITU-T's Internet User Census

155,430	VN Vietnam
103,517	CN China
92,107	MX Mexico
79,092	TH Thailand
73,702	IN India
65,402	PK Pakistan
64,121	BR Brazil
54,637	TR Turkey
52,532	US United States of America
52,240	AR Argentina
48,315	CO Colombia
45,216	ID Indonesia
39,839	PE Peru
36,962	RU Russian Federation
34,529	PH Philippines
33,899	EG Egypt
22,983	TW Taiwan
22,712	RO Romania
22,490	UA Ukraine
22,403	ES Spain

668,493,485	China
282,384872	United States of America
252,482905	India
110,345878	Brazil
109,390190	Japan
87,305661	Russian Federation
72,663301	Nigeria
71,823404	Indonesia
71,174958	Germany
61,579582	Mexico
57,306333	United Kingdom of Great Britain and Northern Ireland
54,114094	France
45,416941	Iran (Islamic Republic of)
45,019465	Egypt
42,187842	Republic of Korea
41,780667	Philippines
40,980368	Vietnam
39,256999	Bangladesh
35,793673	Italy
35,503461	Turkey

iTU's estimates of number of internet users per country

"Weighting" sample data to correct AD Placement bias

We “weight” the raw data by:

- Geolocating the IP address to a particular country
- Multiplying the sample by the relative weight of the country

Weighting the Results

CC	Country	DNSSEC Validates	Uses Google PDNS	Samples	Weight	Weighted Samples
CN	China, Eastern Asia, Asia	3.75%	8.84%	6726432	2.62	17603898
US	United States of America, Northern America, Americas	22.71%	10.05%	2654162	2.8	7436237
IN	India, Southern Asia, Asia	9.60%	21.22%	2788239	2.38	6648806
BR	Brazil, South America, Americas	25.96%	19.77%	3654367	0.8	2905814
JP	Japan, Eastern Asia, Asia	7.31%	4.77%	421526	6.83	2880651
RU	Russian Federation, Eastern Europe, Europe	14.19%	10.36%	2331208	0.99	2299084
NG	Nigeria, Western Africa, Africa	13.75%	42.50%	33555	57.03	1913494
ID	Indonesia, South-Eastern Asia, Asia	13.69%	14.46%	2399551	0.79	1891377
DE	Germany, Western Europe, Europe	16.66%	4.73%	437365	4.29	1874295
MX	Mexico, Central America, Americas	4.78%	8.82%	3852726	0.42	1621619
GB	United Kingdom of Great Britain and Northern Ireland, Northern Europe, Europe	7.25%	6.33%	609639	2.48	1509090
FR	France, Western Europe, Europe	24.23%	3.59%	1067161	1.34	1425021
IR	Iran (Islamic Republic of), Southern Asia, Asia	21.05%	37.95%	5895	202.88	1195992
EG	Egypt, Northern Africa, Africa	14.86%	16.53%	1478598	0.8	1185526
KR	Republic of Korea, Eastern Asia, Asia	1.78%	2.56%	871624	1.27	1110963
PH	Philippines, South-Eastern Asia, Asia	10.93%	12.62%	1360250	0.81	1100239
VN	Vietnam, South-Eastern Asia, Asia	29.67%	46.79%	5580740	0.19	1079161
BD	Bangladesh, Southern Asia, Asia	31.78%	42.05%	459167	2.25	1033783
IT	Italy, Southern Europe, Europe	15.78%	19.39%	805477	1.17	942582

Measuring ALL of the Internet

It's not perfect by any means, but it is a reasonable first pass to correct for the implicit ad placement bias in the raw data

So now we have a method to measure a sample of Internet users and a process that can relate that measurement back to the Internet as a whole.

How can we use this?

What does this allow?

In providing an end user with a set of URLs to retrieve we can examine:

- Protocol behaviour

  e.g.: V4 vs V6, protocol performance, connection failure rate

- DNS behaviours

  e.g.: DNSSEC use, DNS resolution performance, DNS response size, crypto protocol performance,…

1. Measuring IPv6

Measuring IPv6

Client is given 4 unique URLs to load:

- Dual Stack object
- V4-only object
- V6-only object
- Result reporting URL (10 second timer)

We want to compare the number of end devices that can retrieve the V6-only object to the number of devices that can retrieve the V4-only object (V6 Capable)

We can also look at the number of end devices that use IPv6 to retrieve the Dual Stack Object (V6 Preferred)

What we see (Web Log)

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:29 +0000] "GET /newadcfg/ad.py?A=2121&N&R&F HTTP/1.1" 200 799 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 u281fd425-s1438646489 1438646489.894 cfg.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.rd.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.e HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r6.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.578 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.f HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.871 0di-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.d HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.159 0ds-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r4.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.448 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.results&zrdtd-390.zr4td-1548.zr6td-678.zd-1258.ze-390.zf-971. HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.815 0du-results-u281fd425-x-i5097.ap.dotnxdomain.net

What we see (Web Log)

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:29 +0000] "GET /newadcfg/ad.py?A=2121&N&R&F HTTP/1.1" 200 799
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "**Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36**" 0.000 u281fd425-s1438[illegible]9 1438646489.894 cfg.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.rd.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

This is a Mac OSX system, using OS X 10.9.5, with Chrome 44.0.2403.125

ap.e HTTP/1.1" 200 68
leWebKit/537.36 (KHTML,

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r6.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.578 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.f HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.871 0di-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.d HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.159 0ds-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r4.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.448 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.results&zrdtd-390.zr4td-1548.zr6td-678.zd-1258.ze-390.zf-971. HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.815 0du-results-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

What we see (Web Log)

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:29 +0000] "GET /newadcfg/ad.py?A=2121&N&R&F HTTP/1.1" 200 799 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "**Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36**" 0.000 u281fd425-s1438646489 1438646489.894 cfg.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.rd.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.e HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r6.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.578 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.f HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.871 0di-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

This system can do IPv6, and prefers to use IPv6 in dual stack contexts

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r4.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.448 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.results&zrdtd-390.zr4td-1548.zr6td-678.zd-1258.ze-390.zf-971. HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.815 0du-results-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

What we see (Web Log)

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:29 +0000] "GET /newadcfg/ad.py?A=2121&N&R&F HTTP/1.1" 200 799
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "**Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36**" 0.000 u281fd425-s1438646489 1438646489.894 cfg.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.rd.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

This experiment ran through to completion

temora.ra 1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r6.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.578 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.f HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.871 0di-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.d HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.159 0ds-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r4.td HTTP/1.1" 200 68
"https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.448 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.results&zrdtd-390.zr4td-1548.zr6td-678.zd-1258.ze-390.zf-971. HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.815 0du-results-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

What we see (Web Log)

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:29 +0000] "GET /newadcfg/ad.py?A=2121&N&R&F HTTP/1.1" 200 799 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "**Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36**" 0.000 u281fd425-s1438646489 1438646489.894 cfg.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.rd.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.e HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.290 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

This user is a customer of TMNET in Malaysia, AS4788

TP/1.1" 200 68
537.36 (KHTML,

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:30 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.f HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646490.871 0di-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

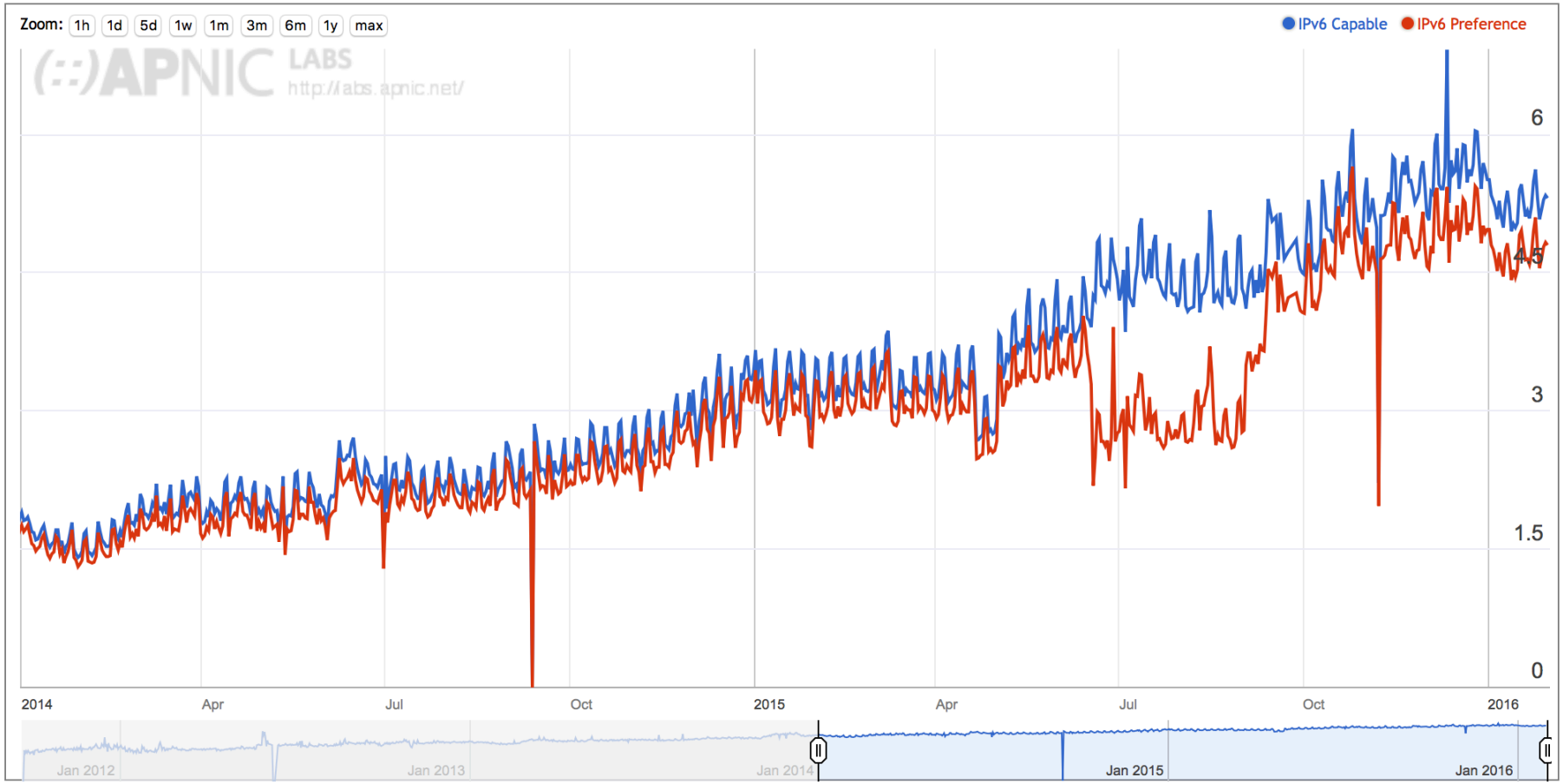
temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.d HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.159 0ds-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 124.13.125.185 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.r4.td HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.448 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

temora.rand.apnic.net 2001:e68:5431:519e:f002:854e:2741:278 [04/Aug/2015:00:01:31 +0000] "GET /1x1.png?u281fd425-s1438646489-i5097.ap.results&zrdtd-390.zr4td-1548.zr6td-678.zd-1258.ze-390.zf-971. HTTP/1.1" 200 68 "https://tpc.googlesyndication.com/sadbundle/7103675352697911246/basic/index.html" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/44.0.2403.125 Safari/537.36" 0.000 https 1438646491.815 0du-results-u281fd425-s1438646489-i5097.ap.dotnxdomain.net

IPv6 Deployment

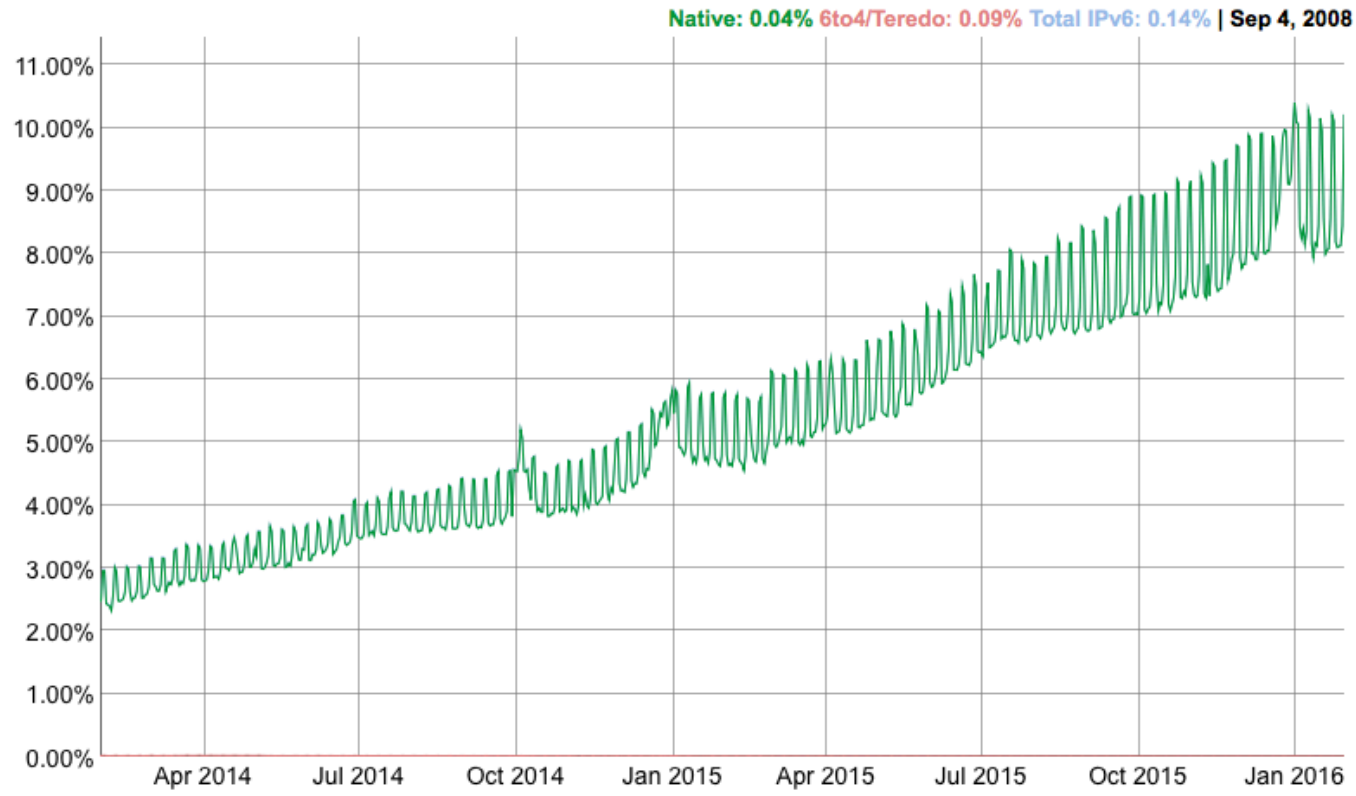
Use of IPv6 for World (XA)



Google's view:

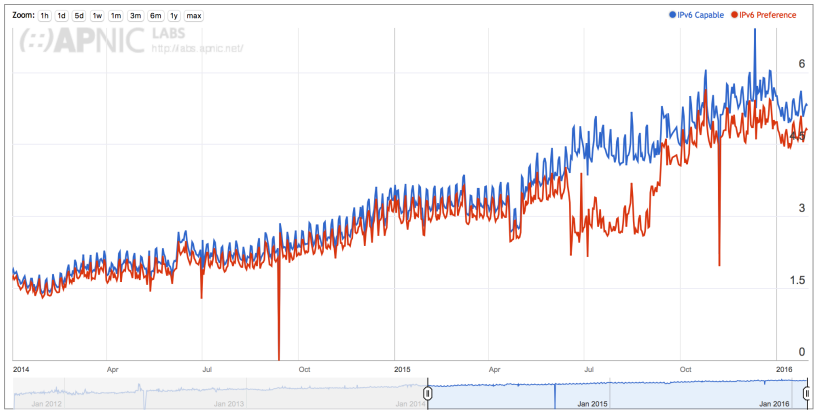
IPv6 Adoption

We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



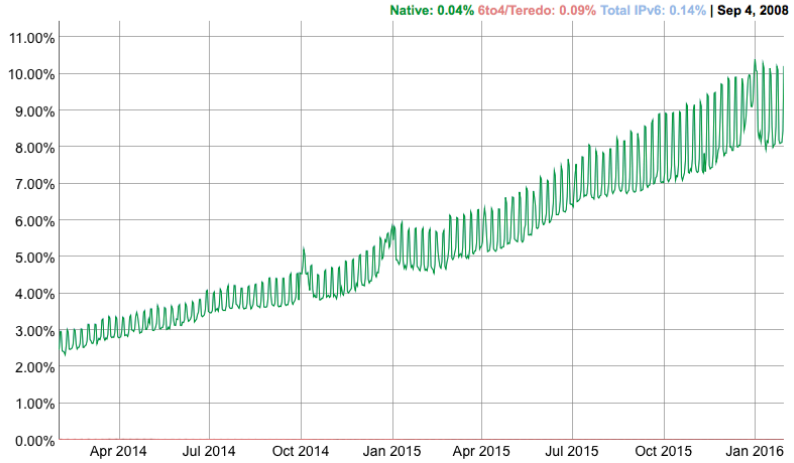
Why are they different?

Use of IPv6 for World (XA)



IPv6 Adoption

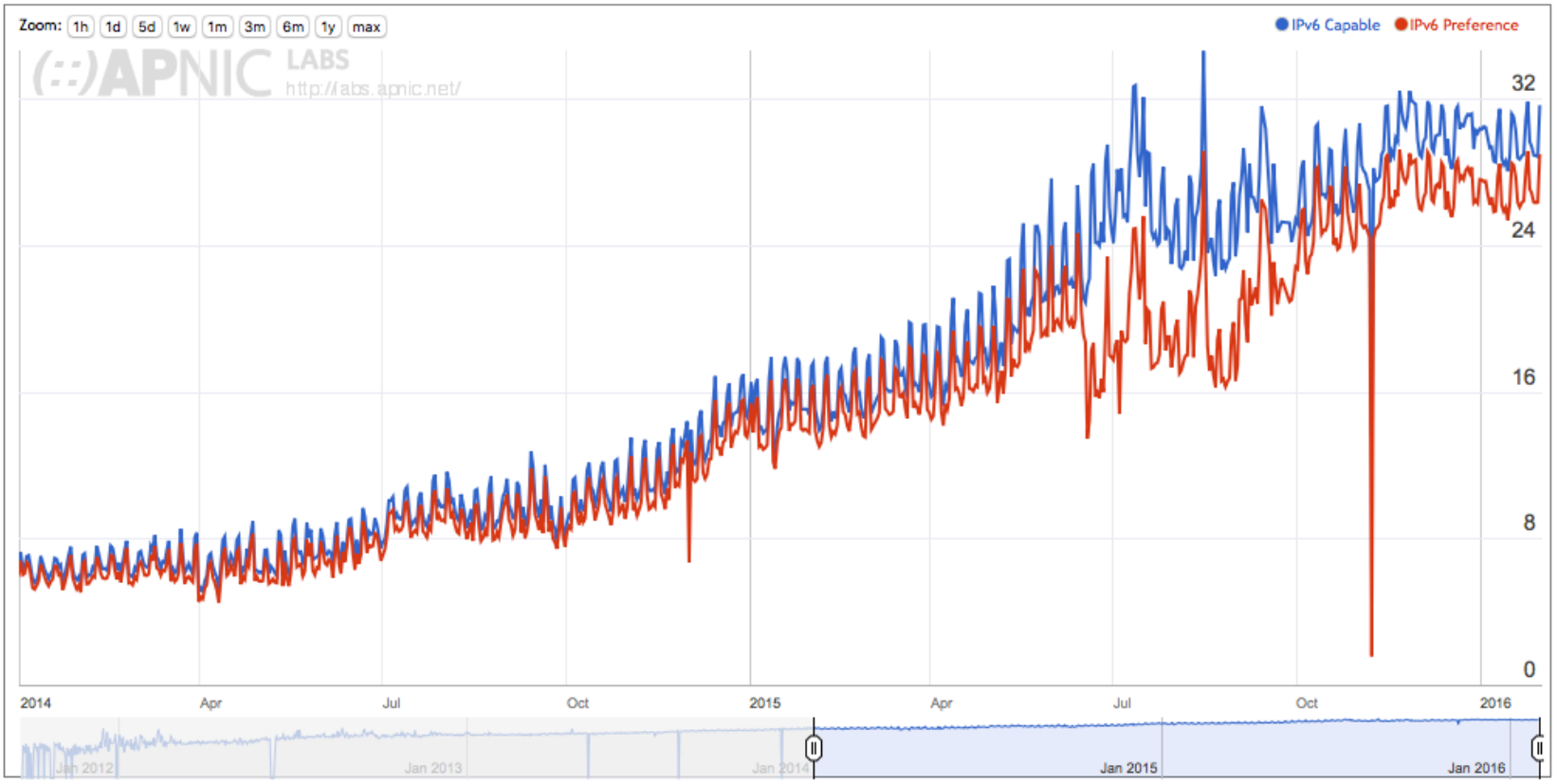
We are continuously measuring the availability of IPv6 connectivity among Google users. The graph shows the percentage of users that access Google over IPv6.



As far as I am aware, Google do not perform per-country weighting, and it is likely that they are over-sampling the US and Western Europe and also likely that they are under-sampling in China, Africa and South America

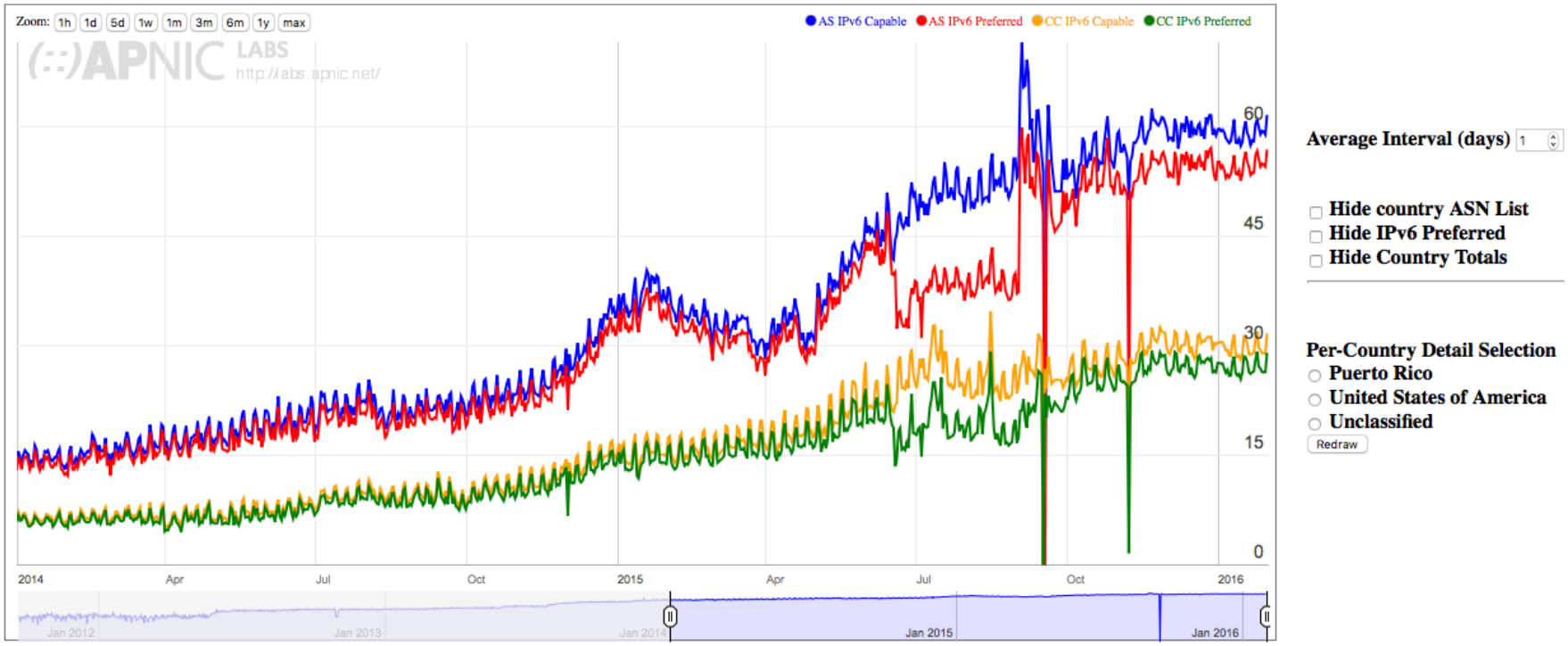
IPv6 Deployment in the US

Use of IPv6 for United States of America (US)

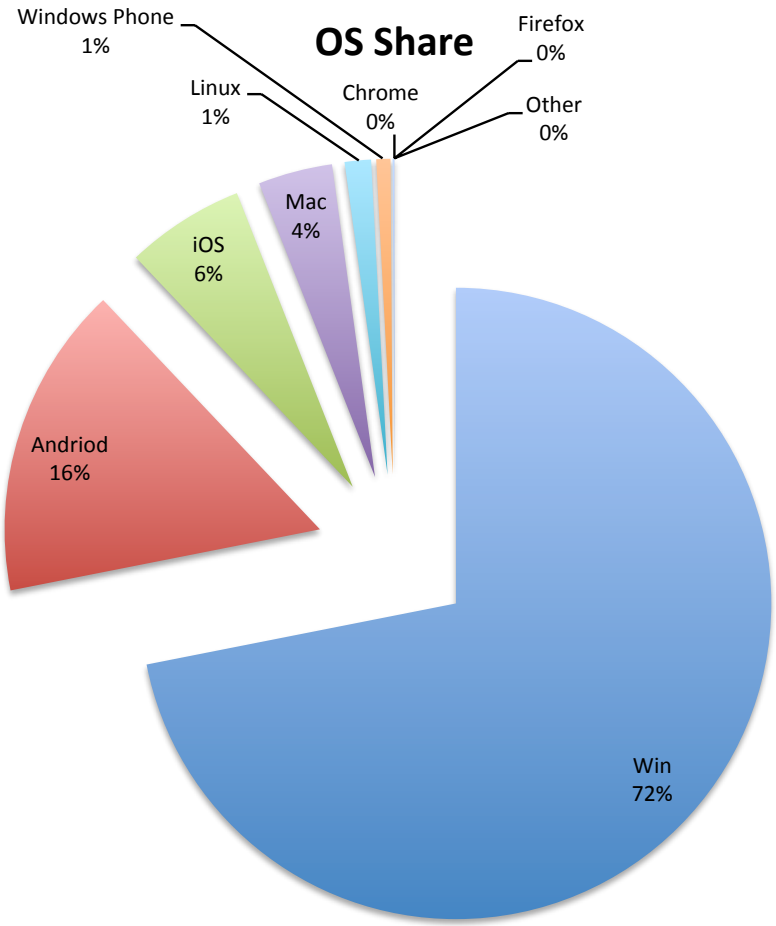


IPv6 Deployment in Comcast

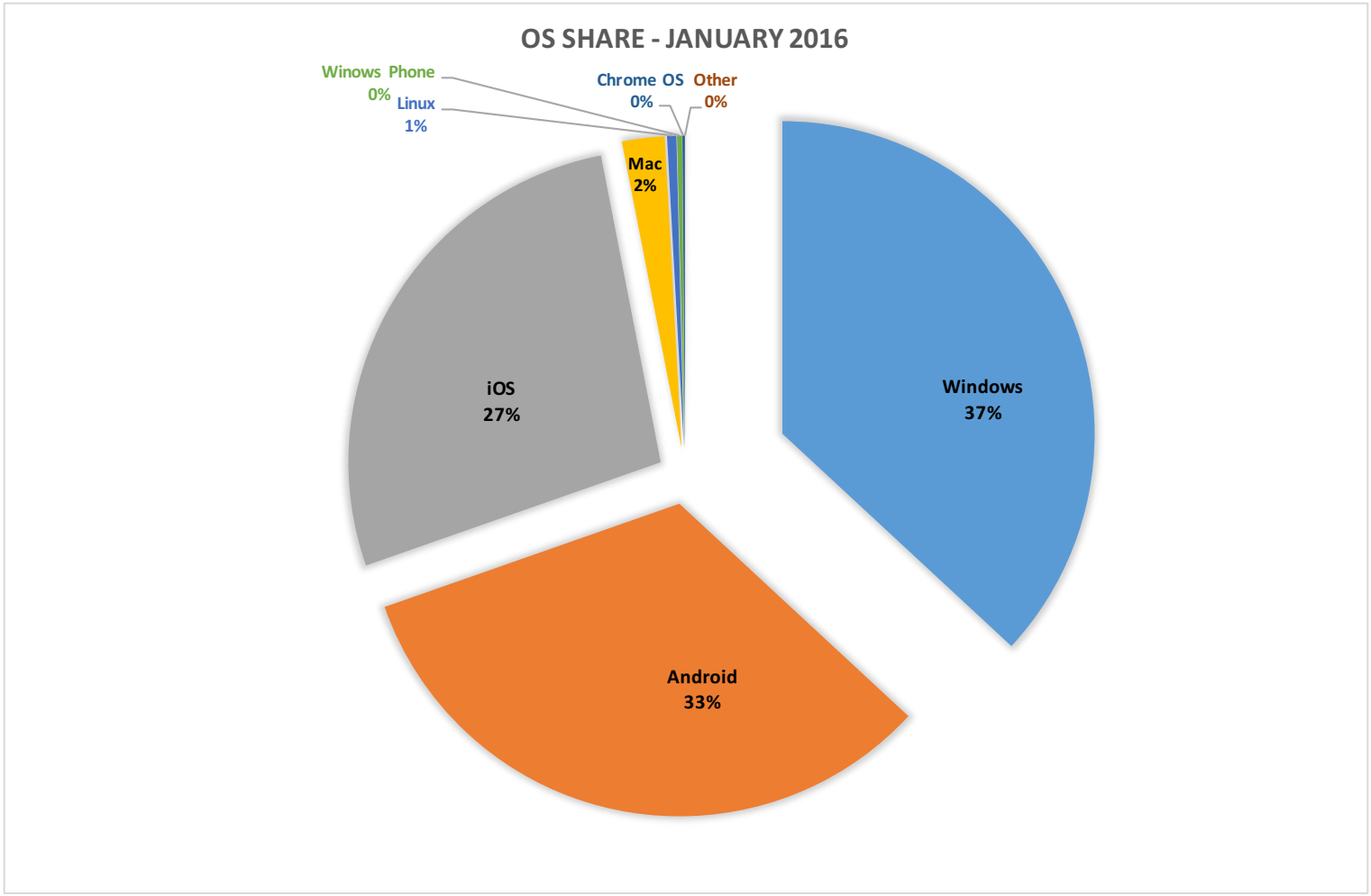
IPv6 Per-Country Deployment for AS7922: COMCAST-7922 - Comcast Cable Communications, Inc., United States of America (US)



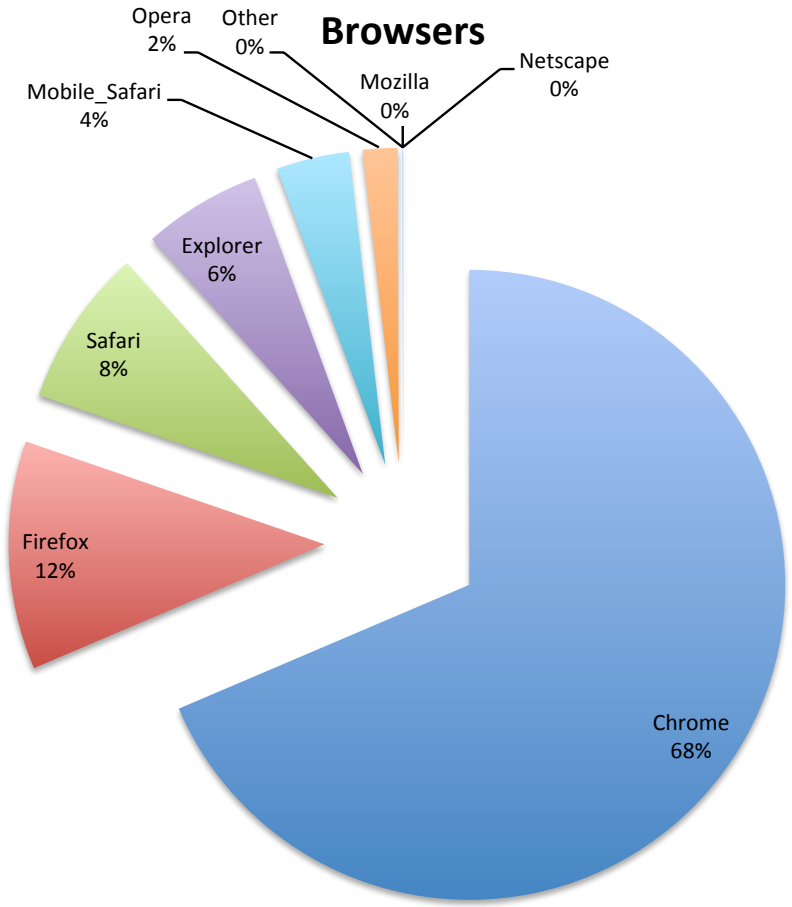
Measuring Platforms - July 2015



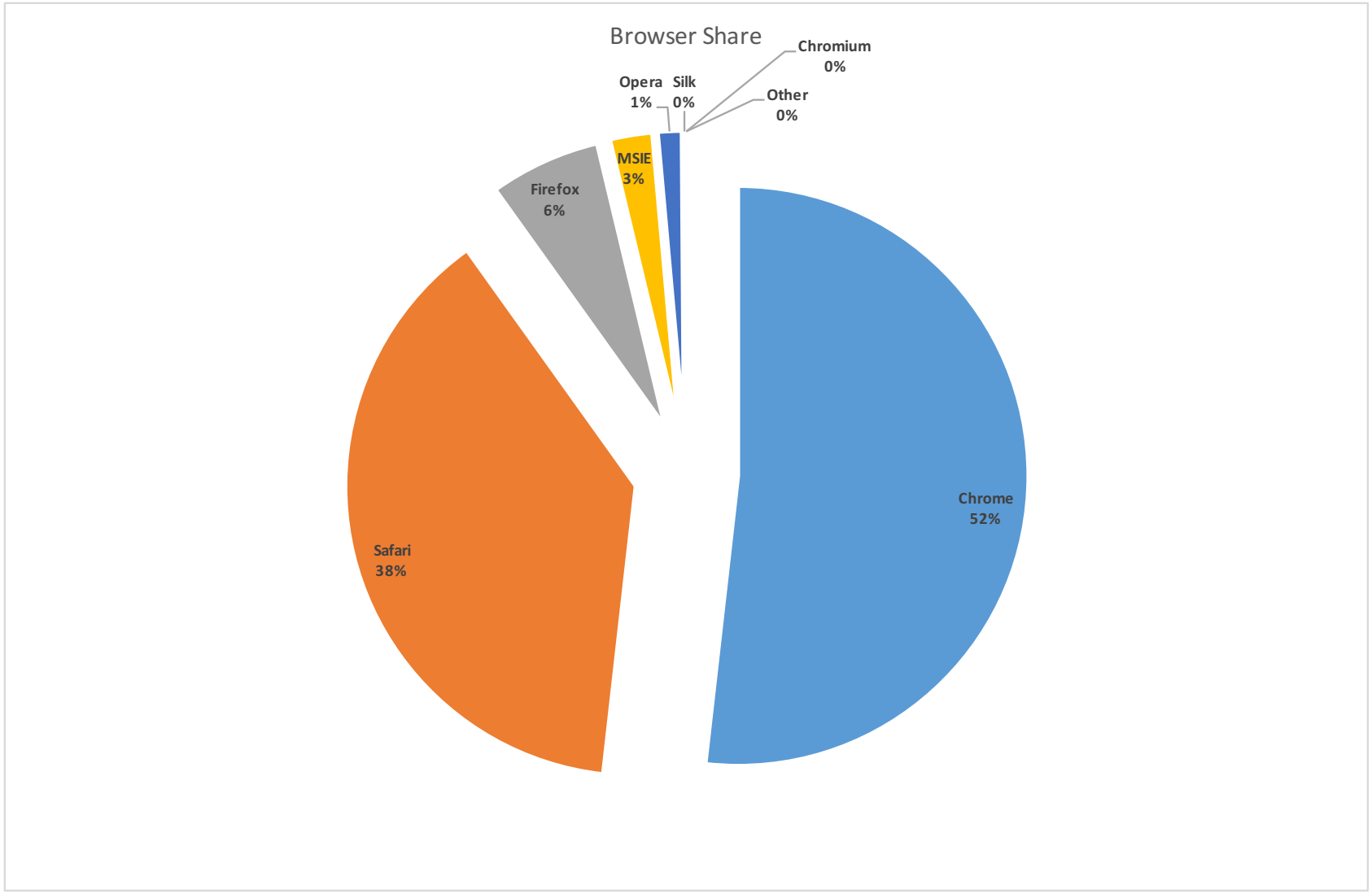
Measuring Platforms - January 2016



Measuring Browsers - July 2015



Measuring Browsers - January 2016



2. Measuring DNS Behaviours

Measuring DNSSEC

Client is given 4 unique URLs to load:

- DNSSEC-validly signed DNS name
- DNSSEC-invalidly signed DNS name
- Unsigned DNS name (control)
- Result reporting URL (10 second timer)

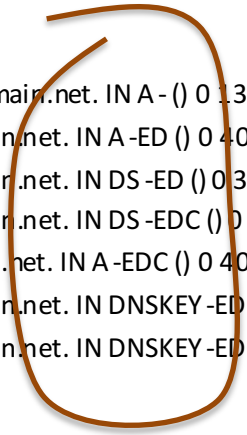
All DNS is IPv4

What We See (DNS Log)

1438646489.920 [ap] 04-Aug-2015 00:01:29.920 202.188.0.254#14118 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net. IN AAAA -ED () 0 157
1438646489.920 [ap] 04-Aug-2015 00:01:29.920 202.188.0.254#2911 04u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net. IN A -ED () 0 145
1438646489.921 [ap] 04-Aug-2015 00:01:29.921 202.188.0.254#40461 0du-u281fd425-s1438646489-i5097.ap.dotnxdomain.net. IN A -ED () 0 145
1438646489.922 [ap] 04-Aug-2015 00:01:29.922 202.188.0.254#48755 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net. IN AAAA -ED () 0 157
1438646489.923 [ap] 04-Aug-2015 00:01:29.923 202.188.0.254#12230 06u-u281fd425-s1438646489-i5097.ap.dotnxdomain.net. IN A -ED () 0 203

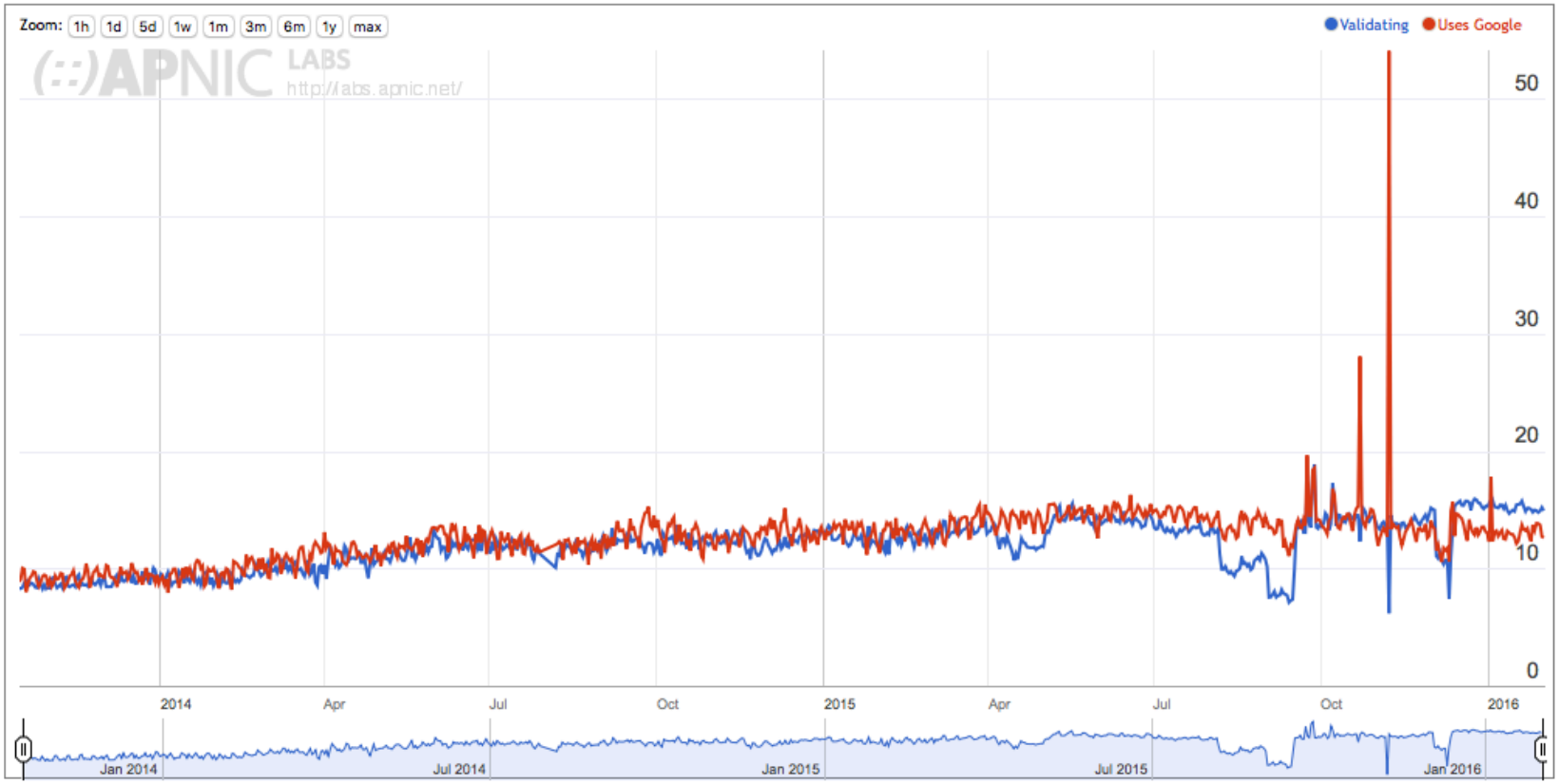
DNSSEC Validation "signature"

1453248859.615 [ap] 20-Jan-2016 00:14:19.615 117.102.103.194#58270 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN A - () 0 134
1453248860.616 [ap] 20-Jan-2016 00:14:20.616 202.155.0.150#55430 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN A -ED () 0 405
1453248860.708 [ap] 20-Jan-2016 00:14:20.708 202.155.0.150#38914 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN DS -ED () 0 393
1453248860.798 [ap] 20-Jan-2016 00:14:20.798 202.155.135.9#27698 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN DS -EDC () 0 393
1453248860.887 [ap] 20-Jan-2016 00:14:20.887 202.155.135.9#5344 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN A -EDC () 0 405
1453248860.978 [ap] 20-Jan-2016 00:14:20.978 202.155.0.150#11434 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN DNSKEY -ED () 0 537
1453248861.067 [ap] 20-Jan-2016 00:14:21.067 202.155.135.9#43705 0ds-ucae20ea3-s1453248859-i5121.ap.dotnxdomain.net. IN DNSKEY -EDC () 0 537



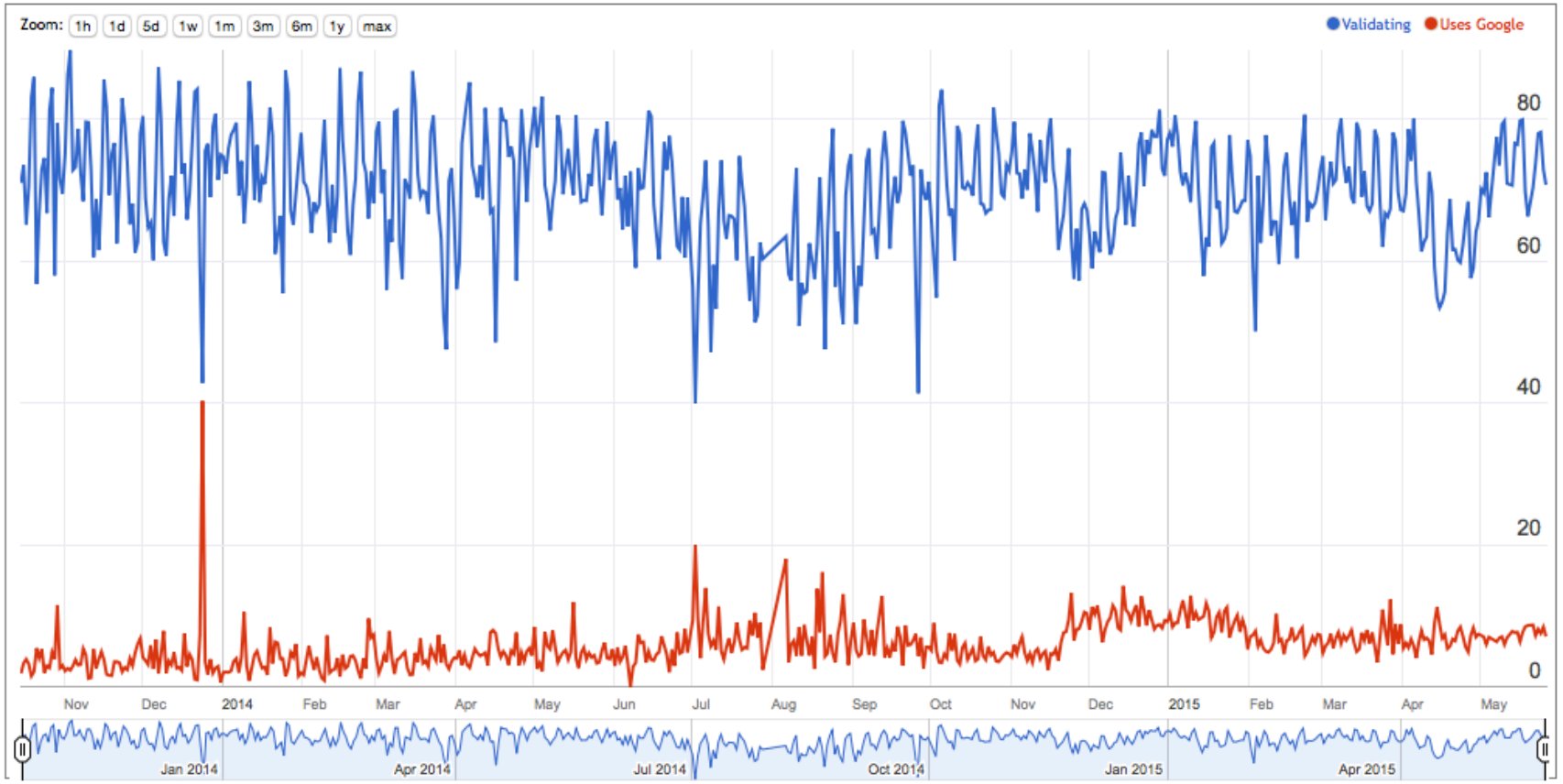
DNSSEC Validation

Use of DNSSEC Validation for World (XA)



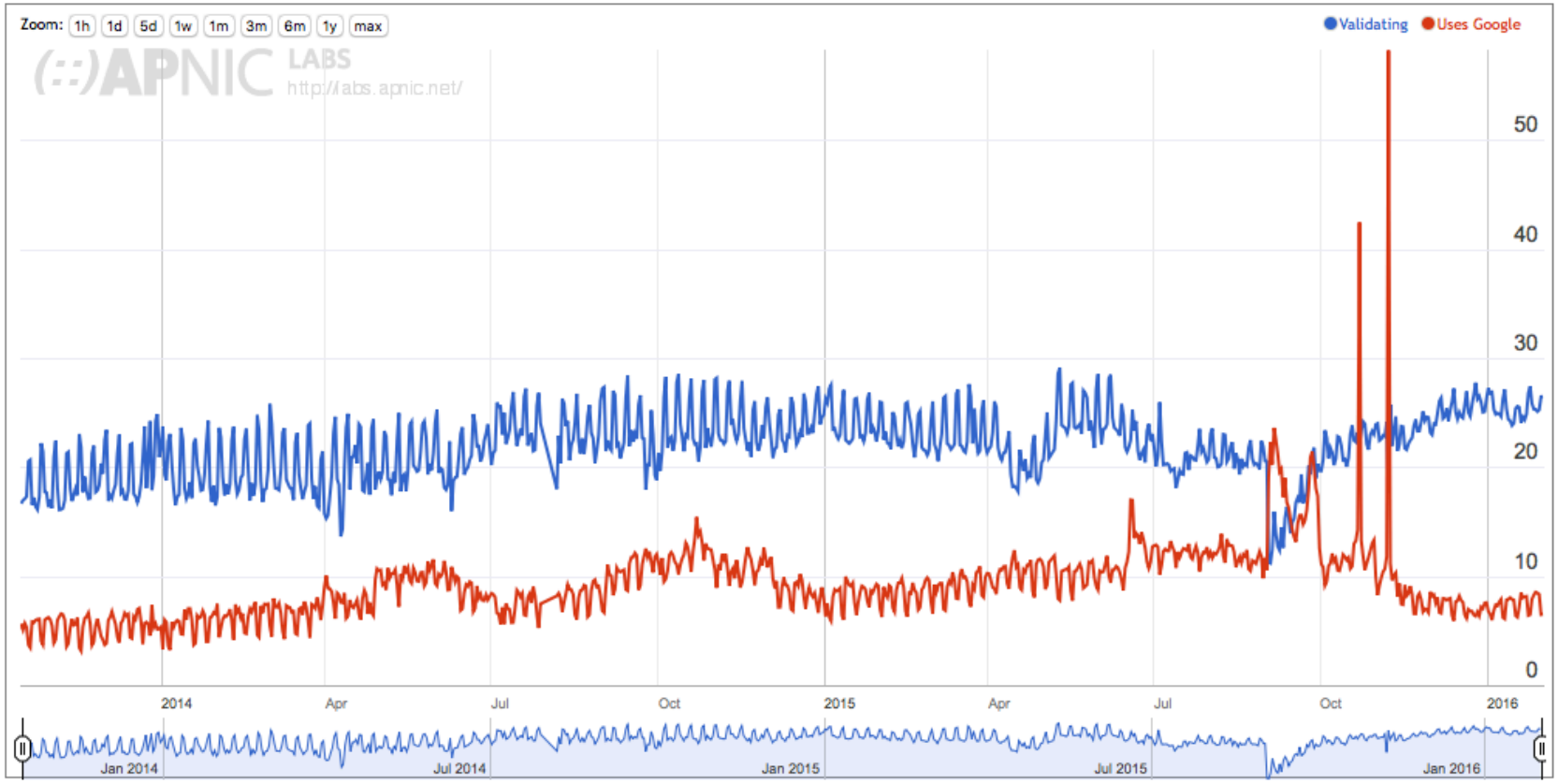
DNSSEC Validation in Sweden

Use of DNSSEC Validation for Sweden (SE)



DNSSEC Validation in US

Use of DNSSEC Validation for United States of America (US)



What Else?

- The “market” for DNS resolution: how many users send their queries through Google’s Public DNS servers?
- How many users use resolvers located in a foreign country?
- Which countries?

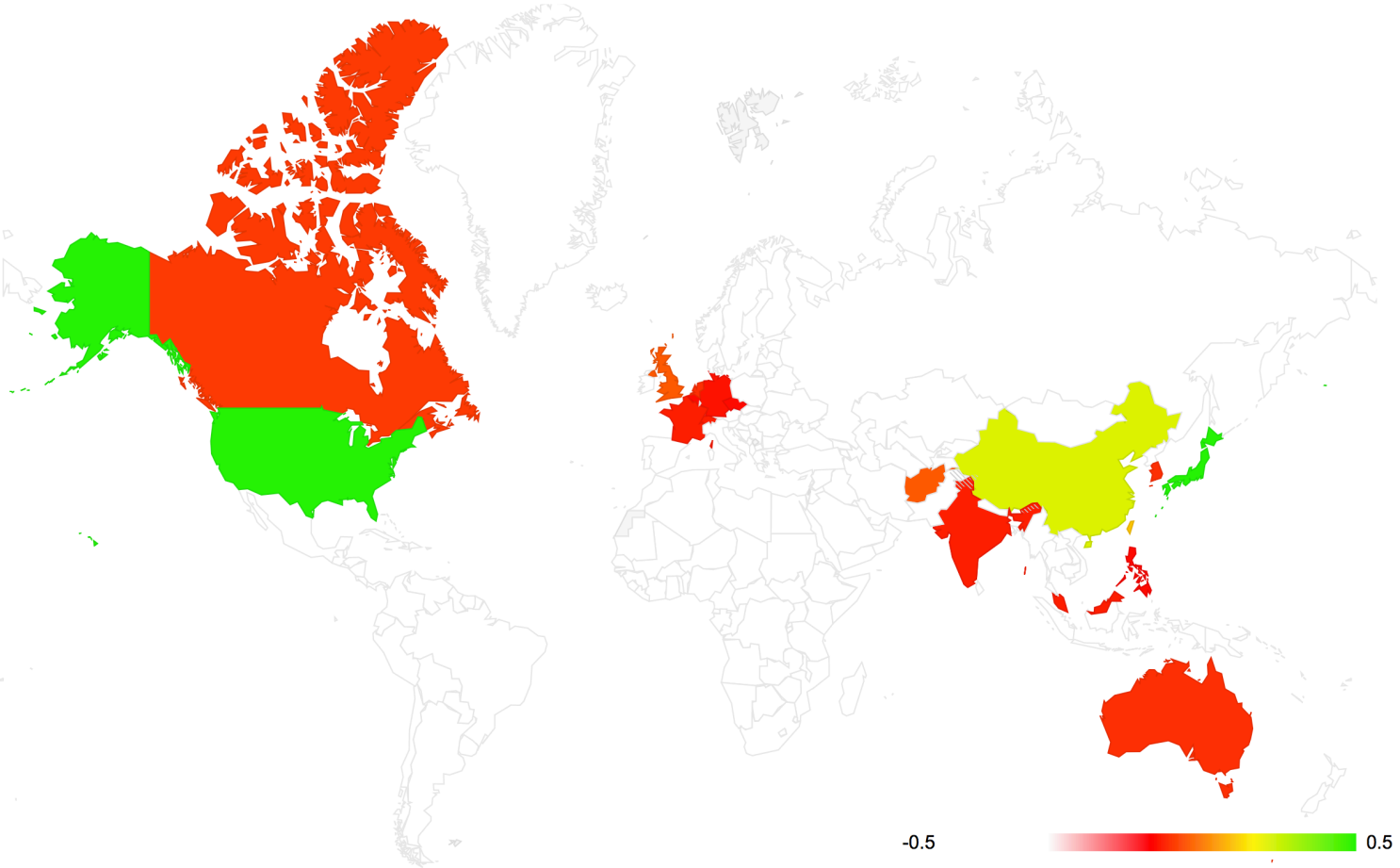
Foreign (CC) Resolution: Top Resolvers by AS

Rank	AS	Use	AS Name
1	15169	42.69%	GOOGLE - Google Inc.,US
2	3356	7.47%	LEVEL3 - Level 3 Communications, Inc.,US
3	36692	7.05%	OPENDNS - OpenDNS, LLC,US
4	19994	2.56%	RACKSPACE - Rackspace Hosting,US
5	174	1.87%	COGENT-174 - Cogent Communications,US
6	16880	1.70%	AS2-TRENDMICRO-COM - TREND MICRO INCORPORATED,US
7	2914	1.09%	NTT-COMMUNICATIONS-2914 - NTT America, Inc.,US
8	4134	0.91%	CHINANET-BACKBONE No.31,Jin-rong Street,CN
9	29791	0.70%	VOXEL-DOT-NET - Voxel Dot Net, Inc.,US
10	3462	0.67%	HINET Data Communication Business Group,TW
11	9121	0.64%	TTNET Turk Telekomunikasyon Anonim Sirketi,TR
12	3303	0.64%	SWISSCOM Swisscom (Switzerland) Ltd,CH
13	6939	0.63%	HURRICANE - Hurricane Electric, Inc.,US
14	6147	0.50%	Telefonica del Peru S.A.A.,PE
15	6713	0.48%	IAM-AS,MA
16	8048	0.47%	CANTV Servicios, Venezuela,VE
17	3257	0.47%	TINET-BACKBONE Tinet SpA,DE
18	13238	0.43%	YANDEX Yandex LLC,RU
19	45595	0.41%	PKTELECOM-AS-PK Pakistan Telecom Company Limited,PK
20	9299	0.40%	IPG-AS-AP Philippine Long Distance Telephone Company,PH
21	7643	0.39%	VNPT-AS-VN Vietnam Posts and Telecommunications (VNPT),VN
22	45758	0.39%	TRIPLETNET-AS-AP TripleT Internet Internet service provider Bangkok,TH
23	8151	0.38%	Uninet S.A. de C.V.,MX
24	7470	0.35%	TRUEINTERNET-AS-AP TRUE INTERNET Co.,Ltd.,TH
25	4837	0.35%	CHINA169-BACKBONE CNCGROUP China169 Backbone,CN

Total: 21,770,77[illegible] (28% of total) end user query sets

Offshore DNS from HK Users

Foreign Resolver Distribution for Hong Kong Special Administrative Region of China (2014) (57610 samples, 7174 foreign resolution instances (12%))



Offshore DNS from HK Users

Foreign Resolver Distribution for Hong Kong Special Administrative Region of China (2014) (57610 samples, 7174 foreign resolution instances (12%))

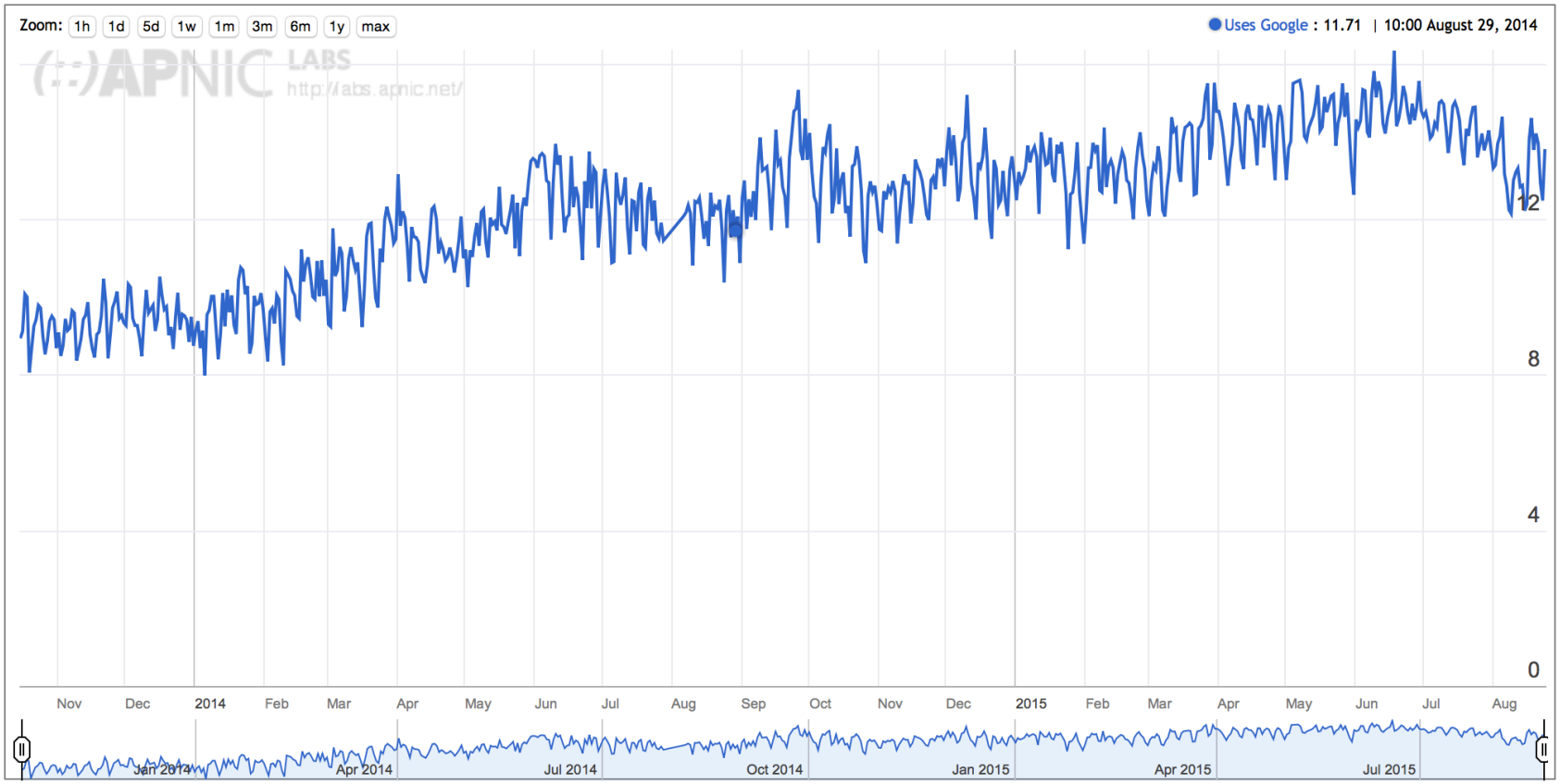
DNS Resolution Distribution for Hong Kong Special Administrative Region of China

CC	Country	Resolver Samples	Resolver Share
HK	Hong Kong Special Administrative Region of China	50436	87.55%
XX	Total Foreign DNS resolution	7174	12.45%
ZZ	Google Public DNS	5025	8.72%
US	United States of America	1042	1.81%
JP	Japan	314	0.55%
CN	China	166	0.29%
SG	Singapore	156	0.27%
TW	Taiwan	116	0.20%
AF	Afghanistan	54	0.09%
GB	United Kingdom of Great Britain and Northern Ireland	52	0.09%
CA	Canada	35	0.06%
KR	Republic of Korea	31	0.05%
AU	Australia	28	0.05%
NL	Netherlands	25	0.05%
MY	Malaysia	18	0.03%
FR	France	17	0.03%
IN	India	17	0.03%
EU	European Union	16	0.03%
CH	Switzerland	15	0.03%
DE	Germany	14	0.02%
BE	Belgium	8	0.01%
PH	Philippines	7	0.01%
CZ	Czech Republic	7	0.01%

0.5

Market Penetration of Google's Public DNS

Use of DNSSEC Validation for World (XA)



3. Digital Stalking

Street Art: Banksy

Some Stalker Numbers

In the first 248 days of 2014 we saw:

- 123,110,633 unique end-user IP addresses presented to our servers from these test scripts
- 317,309 of these end-user IP addresses presented HTTP GET strings to us that were subsequently presented to us from a different client IP address!

That's some **1 in 400*** users that seem to have attracted some kind of digital stalker!

* Or maybe a bit more, due to NATs hiding multiple end users behind a single public IP address

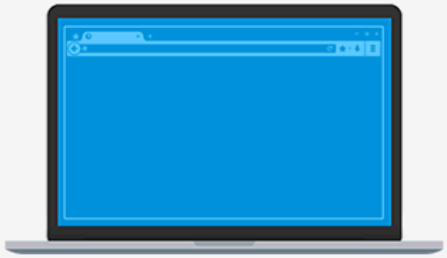
mozilla

Take the tour to see what's new »

Committed to you, your privacy and an open Web

Keep your Firefox in Sync

Access your bookmarks, passwords and more from any device.



Get started with Sync

Create an account from the menu panel

Online Privacy? Really?

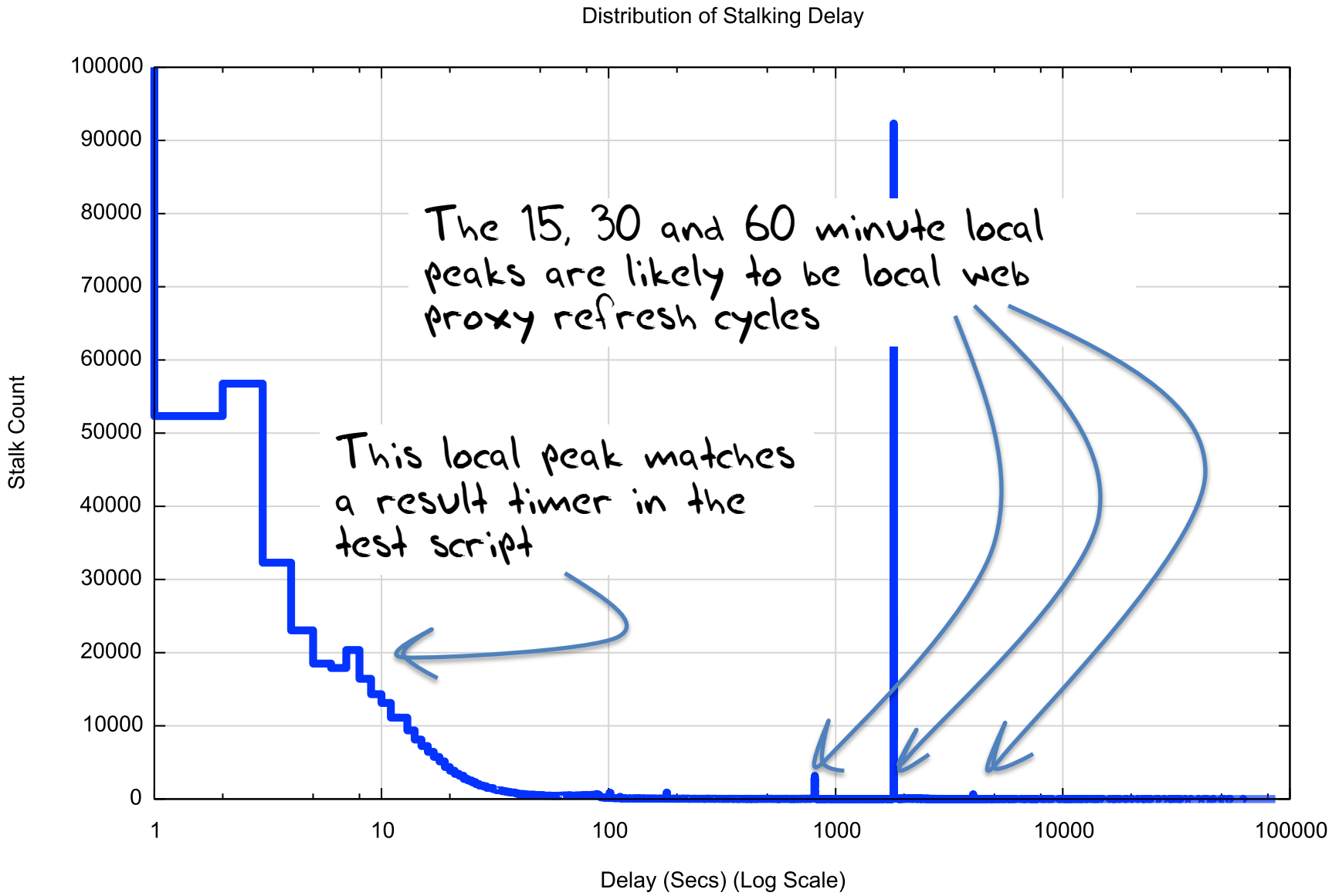
It's hard to believe that today's Internet respects personal privacy when it seems that around 1 in 400 users have attracted some kind of digital stalker that tracks the URLs they visit.

Stalking Rates by Country

CC	Samples	Stalked	Rate/1,000,000	Country
IR	674	111	164,688	Iran (Islamic Republic of)
LA	28,506	2,875	100,855	Lao People's Democratic Republic
MO	38,761	2,954	76,210	Macao Special Administrative Region of China
SG	240,188	17,406	72,468	Singapore
HK	486,101	22,136	45,537	Hong Kong Special Administrative Region of China
CN	10,419,638	435,040	41,751	China
GB	872,124	28,845	33,074	United Kingdom of Great Britain and Northern Ireland
TW	1,769,367	36,823	20,811	Taiwan
JP	1,500,779	23,971	15,972	Japan
AU	293,193	4,620	15,757	Australia
US	4,491,711	53,370	11,881	United States of America
MY	1,035,434	10,214	9,864	Malaysia
AL	437,399	4,043	9,243	Albania
CA	947,922	6,244	6,587	Canada
KH	143,886	897	6,234	Cambodia
MM	16,411	97	5,910	Myanmar
MK	458,820	2,214	4,825	The former Yugoslav Republic of Macedonia
BZ	8,139	35	4,300	Belize
MN	57,622	233	4,043	Mongolia
NZ	344,951	1,385	4,015	New Zealand
CV	3,742	14	3,741	Cape Verde
ME	223,005	775	3,475	Montenegro
FJ	14,892	47	3,156	Fiji
SR	44,116	136	3,082	Suriname
AW	11,123	34	3,056	Aruba

The top 25 countries in terms of observed URL stalking rates

Stalking Delay



Top 25 International Stalkers

Rank	IP Net	#	AVG Delay	AS	Description
1	119.147.146.0	205,033	130.7	4134	CHINANET-BACKBONE No.31,Jin-rong Street,CN
2	101.226.33.0	6,198	1,576.1	4812	CHINANET-SH-AP China Telecom (Group),CN
3	180.153.206.0	6,120	1,608.3	4812	CHINANET-SH-AP China Telecom (Group),CN
4	180.153.214.0	3,827	1,561.0	4812	CHINANET-SH-AP China Telecom (Group),CN
5	112.64.235.0	3,819	1,544.9	17621	CNCGROUP-SH China Unicom Shanghai network,CN
6	101.226.66.0	3,603	1,577.3	4812	CHINANET-SH-AP China Telecom (Group),CN
7	180.153.163.0	2,742	1,540.1	4812	CHINANET-SH-AP China Telecom (Group),CN
8	223.27.200.0	2,740	1.8	45796	BBCONNECT-TH-AS-AP BB Connect Co., Ltd.,TH
9	101.226.89.0	2,658	2,230.2	4812	CHINANET-SH-AP China Telecom (Group),CN
10	180.153.201.0	2,628	1,549.4	4812	CHINANET-SH-AP China Telecom (Group),CN
11	101.226.65.0	1,528	1,573.3	4812	CHINANET-SH-AP China Telecom (Group),CN
12	69.41.14.0	1,243	1,127.4	47018	CE-BGPAC - Covenant Eyes, Inc.,US
13	101.226.51.0	1,195	1,627.6	4812	CHINANET-SH-AP China Telecom (Group),CN
14	112.65.193.0	1,038	1,623.9	17621	CNCGROUP-SH China Unicom Shanghai network,CN
15	64.124.98.0	906	1,288.9	6461	ABOVENET - Abovenet Communications, Inc,US
16	180.153.114.0	819	1,632.6	4812	CHINANET-SH-AP China Telecom (Group),CN
17	180.153.205.0	765	1,497.7	4812	CHINANET-SH-AP China Telecom (Group),CN
18	208.184.77.0	649	1,419.5	6461	ABOVENET - Abovenet Communications, Inc,US
19	222.73.77.0	535	1,373.8	4812	CHINANET-SH-AP China Telecom (Group),CN
20	180.153.211.0	517	1,450.6	4812	CHINANET-SH-AP China Telecom (Group),CN
21	180.153.161.0	504	1,675.7	4812	CHINANET-SH-AP China Telecom (Group),CN
22	183.60.153.0	262	451.3	4134	CHINANET-BACKBONE No.31,Jin-rong Street,CN
23	222.73.76.0	255	1,512.7	4812	CHINANET-SH-AP China Telecom (Group),CN
24	101.226.102.0	235	2,012.7	4812	CHINANET-SH-AP China Telecom (Group),CN
25	208.80.194.0	227	10,731.5	13448	WEBSENSE - Websense, Inc,US

The Leakiest Browser!

Wow! "Public Security Equipment 110 No 00000000025!"

4. Access ISP Market Share

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

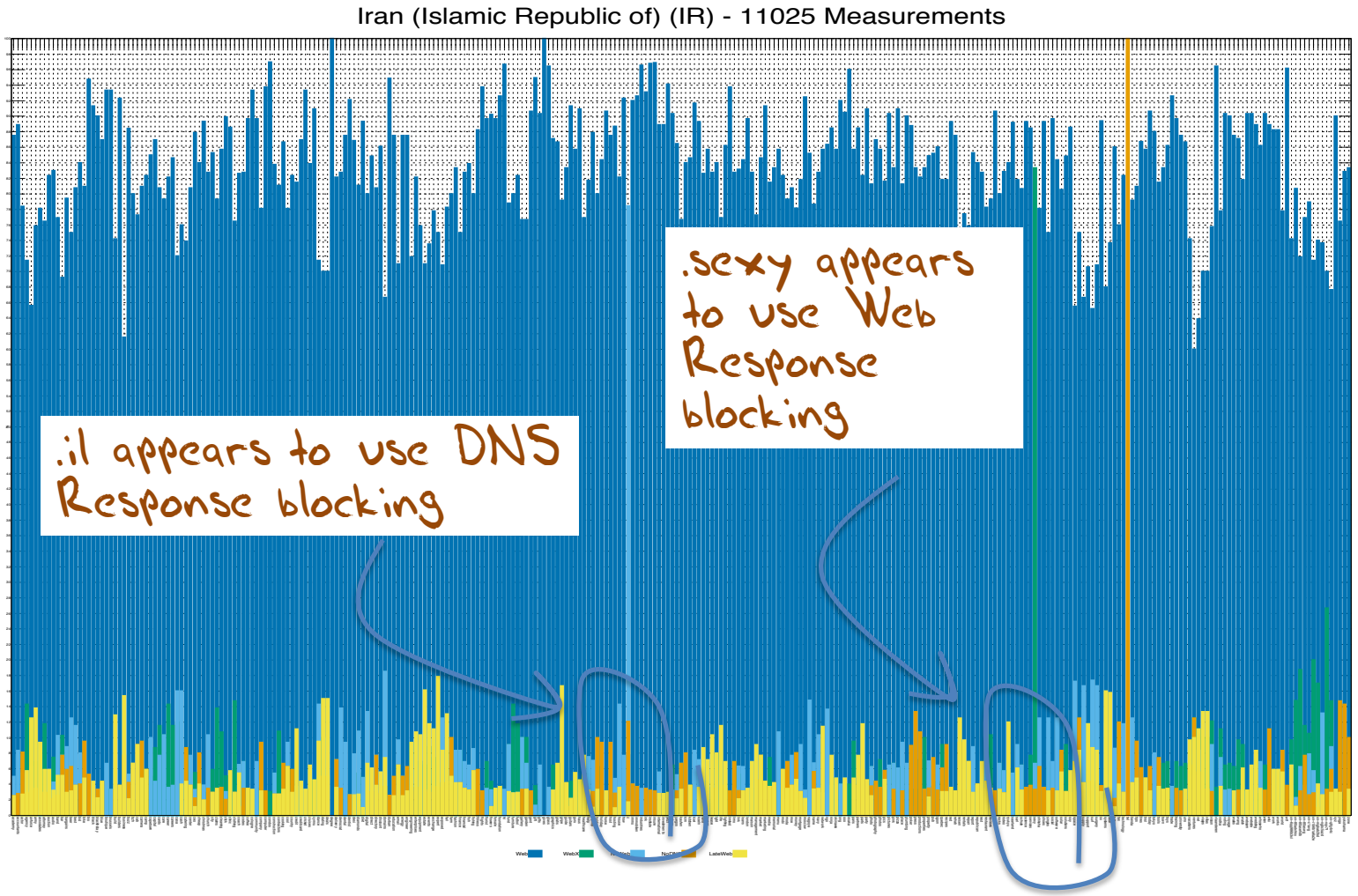
Market Share in HK

Rank	ASN	AS Name	CC	Users (est.)	% of country	% of Internet	Samples
1	AS4760	HKTIMS-AP PCCW Limited	HK	1758644	32.19	0.0569	249956
2	AS9269	HKBN-AS-AP Hong Kong Broadband Network Ltd.	HK	1632070	29.87	0.0528	231966
3	AS9304	HUTCHISON-AS-AP Hutchison Global Communications	HK	483944	8.86	0.0157	68783
4	AS9908	HKCABLE2-HK-AP HK Cable TV Ltd	HK	274826	5.03	0.0089	39061
5	AS9381	NEWTT-IP-AP Wharf TT Ltd.	HK	137022	2.51	0.0044	19475
6	AS10026	PACNET Pacnet Global Ltd	HK	118525	2.17	0.0038	16846
7	AS4515	ERX-STAR PCCW IMSBiz	HK	98740	1.81	0.0032	14034
8	AS38819	HKCSL-AS-AP HKCSL GPRS NETWORK	HK	91662	1.68	0.003	13028
9	AS55536	PSWITCH-HK PACSWITCH GLOBAL IP NETWORK	HK	89326	1.63	0.0029	12696
10	AS18116	HGC-AS-AP Hutchison Global Crossing	HK	87363	1.6	0.0028	12417
11	AS9231	IPEOPLESNET-AS-AP China Mobile Hong Kong Company Limited	HK	80137	1.47	0.0026	11390
12	AS17924	SMARTONE-MB-AS-AP SmarTone Mobile Communications Ltd	HK	60177	1.1	0.0019	8553
13	AS9474	SMARTONE-AS-AP SmarTone Telecommunications Ltd.	HK	46541	0.85	0.0015	6615
14	AS10103	HKBN-AS-AP HK Broadband Network Ltd.	HK	37796	0.69	0.0012	5372
15	AS10118	HTCL-IAS-HK-AP Hutchison Telephone Company Limited	HK	36586	0.67	0.0012	5200
16	AS9444	HKT-AS-AP Hong Kong Telecommunications (HKT) Limited	HK	29501	0.54	0.001	4193
17	AS4637	ASN-TELSTRA-GLOBAL Telstra Global	HK	21128	0.39	0.0007	3003
18	AS9229	SPEEDCAST-AP SPEEDCAST Limited	HK	17631	0.32	0.0006	2506
19	AS3661	ERX-CUHKNET The Chinese University of Hong Kong	HK	15098	0.28	0.0005	2146
20	AS9221	HSBC-HK-AS HSBC HongKong	HK	14768	0.27	0.0005	2099

What Else?

Analysis of failure patterns to detect evidence of structured interception of DNS and Web retrieval

Content Blocking in Iran?



Hong Kong

Hong Kong Special Administrative Region of China (HK) - 248750 Measurements