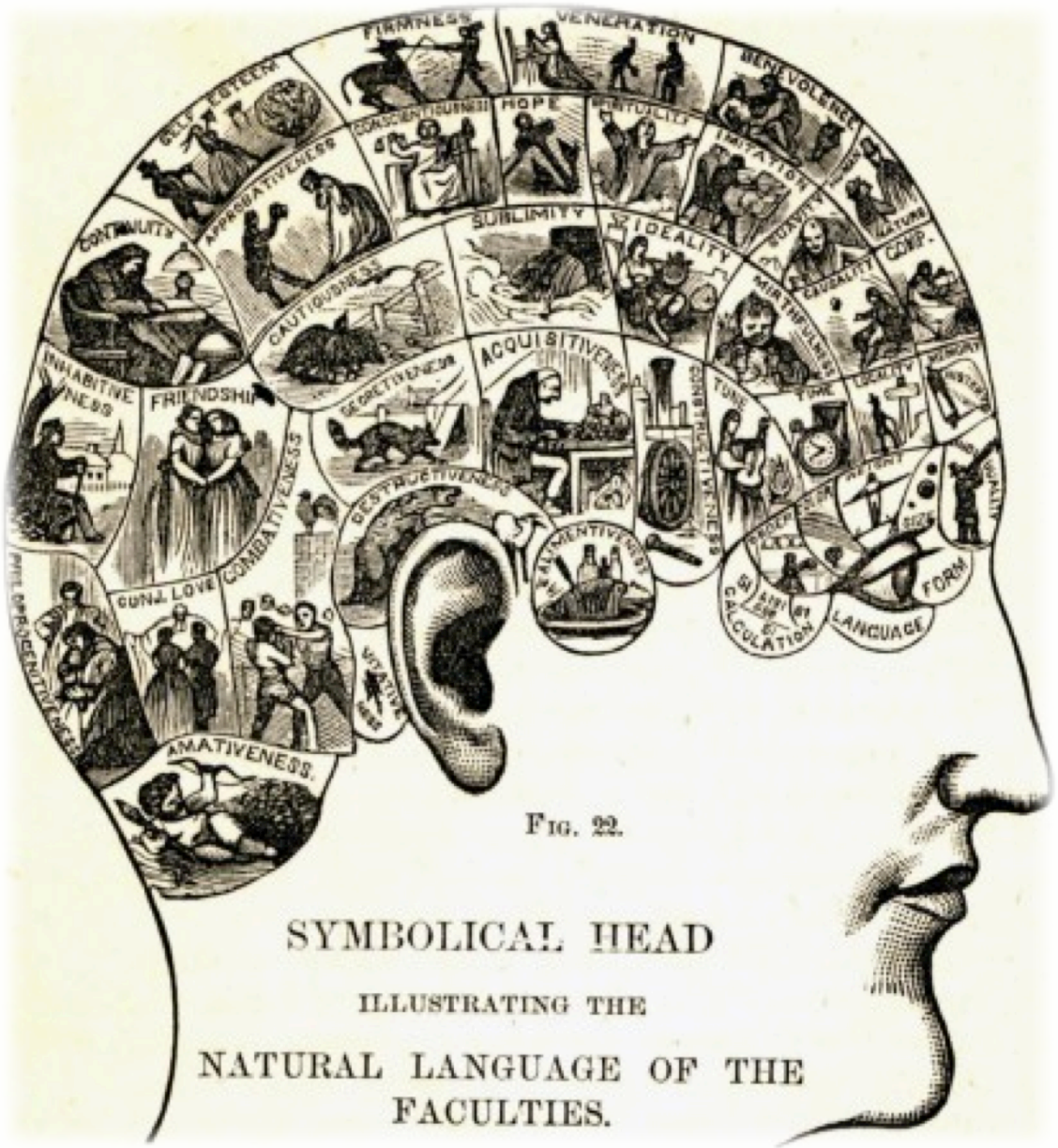


Fig. 22.

SYMBOLICAL HEAD

ILLUSTRATING THE

NATURAL LANGUAGE OF THE FACULTIES.

End-User Measurement through Paid Avertisements

George Michaelson, APNIC

Mark Allman on network measurements….

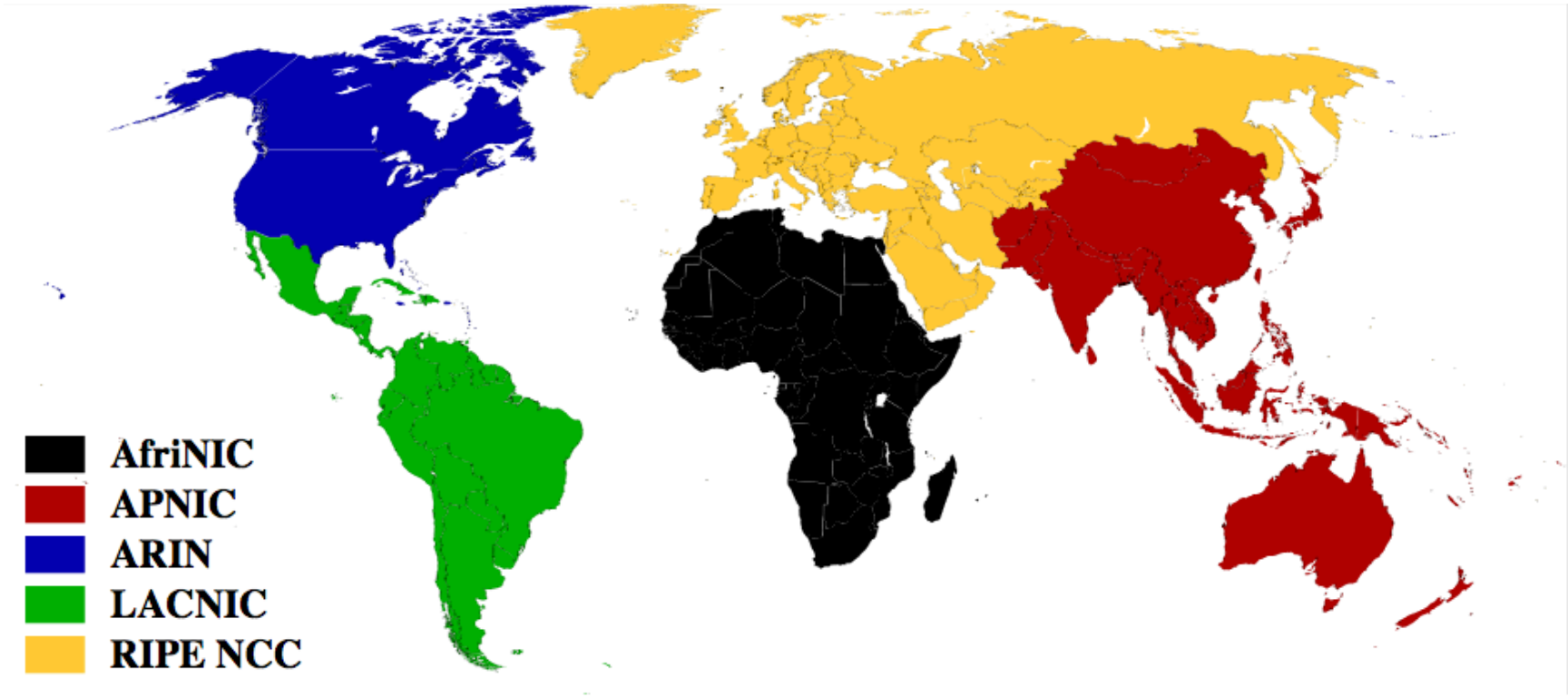
- http://www.icir.org/mallman/talks/better-empiricalism-pam15.pdf

- This is a really good paper on motivations doing measurement on the Internet, data sharing.

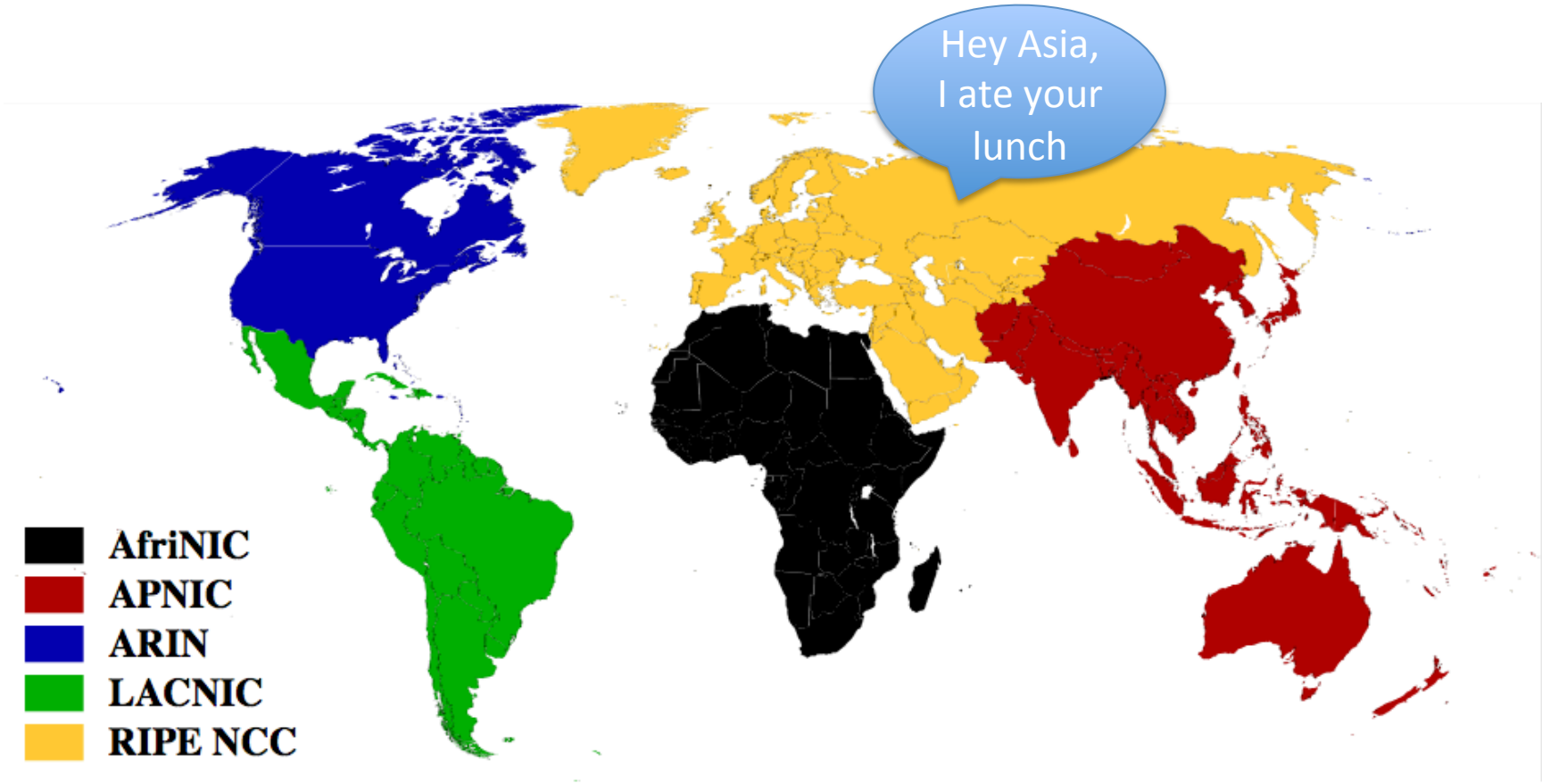
About me

- I work in a Regional Internet Registry (RIR)
  - In the labs (science group)
- RIR coordinate Internet Number Resource (INR) distribution in their region
  - And collectively, worldwide
- A consensus-based, non-profit, industry neutral function
- “responsible address management”

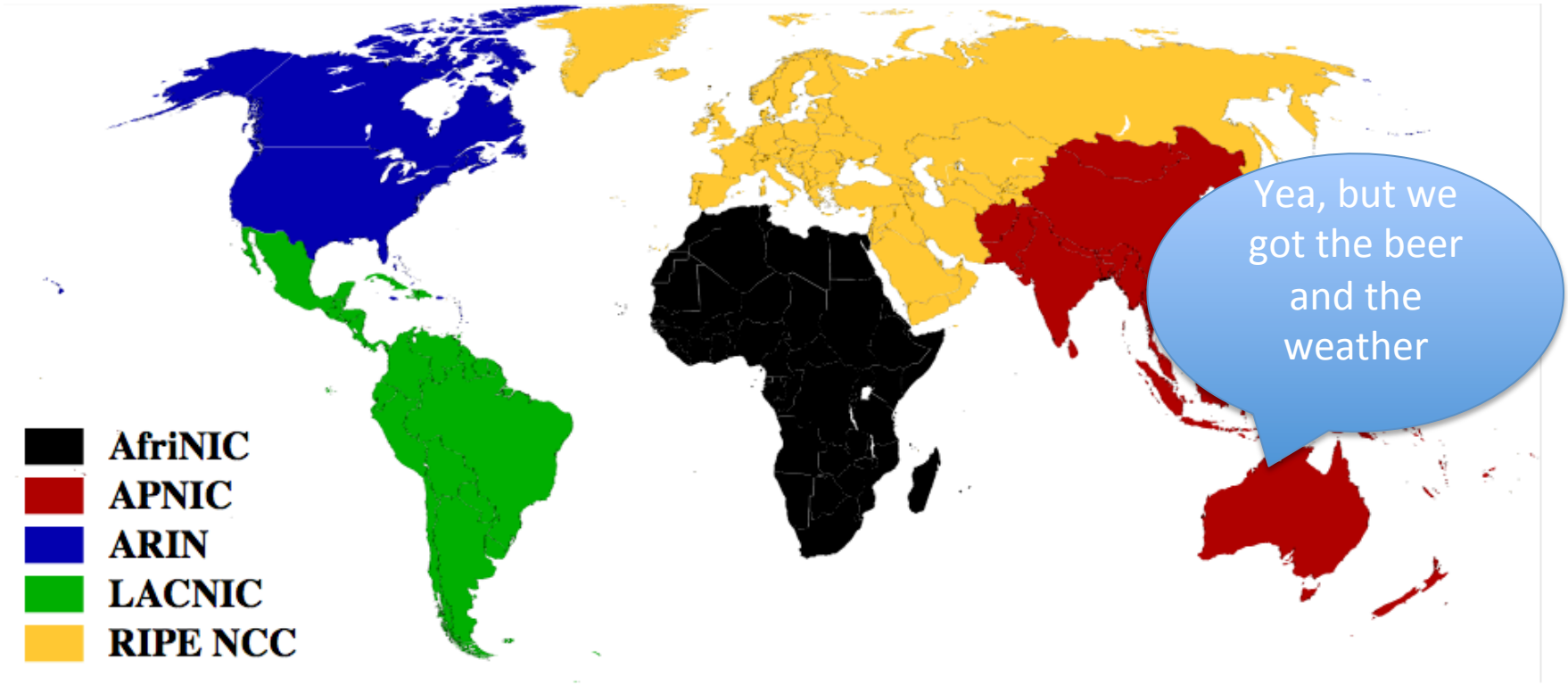
The RIR



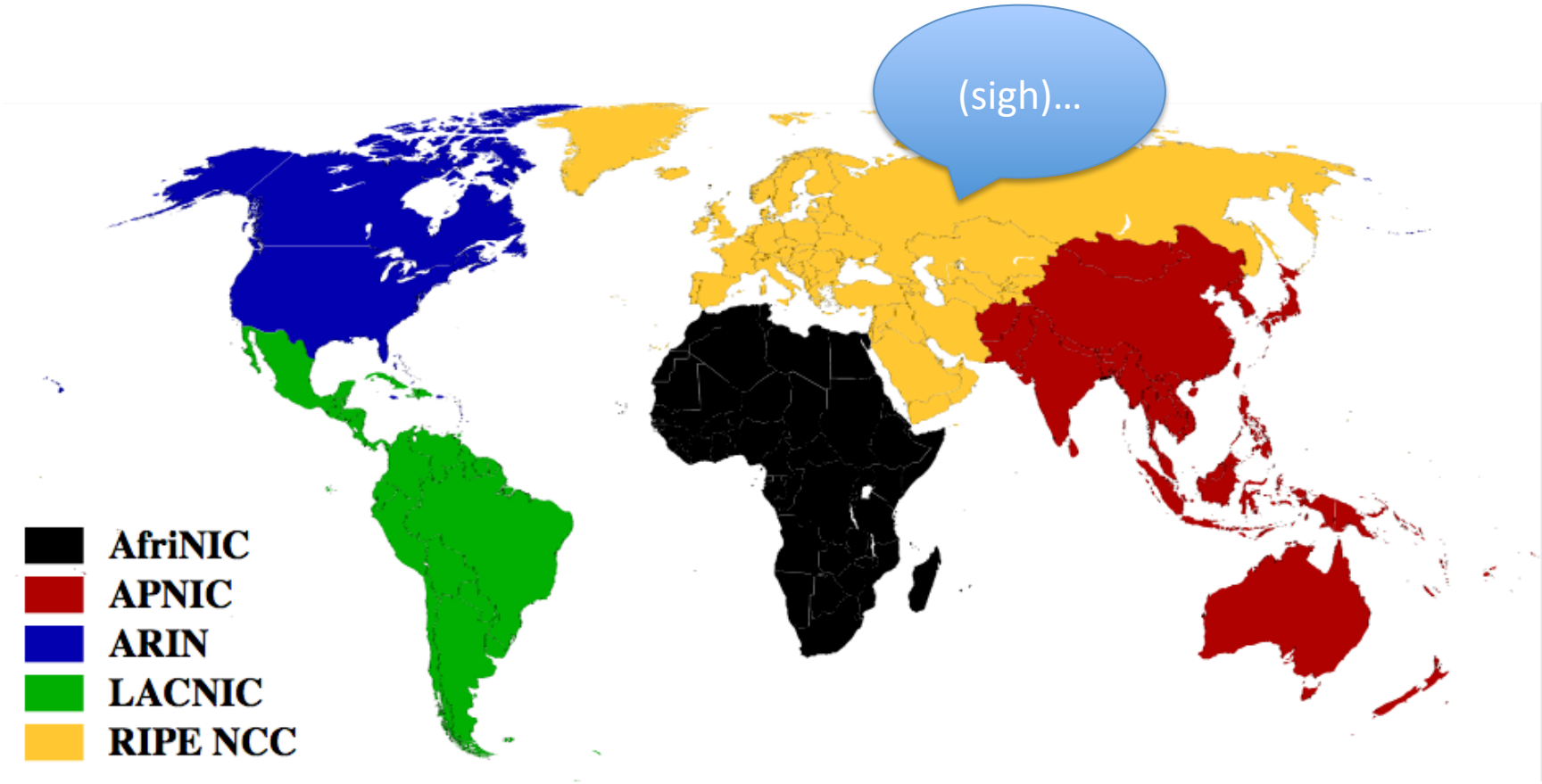
The RIR



The RIR


AfriNIC
APNIC
ARIN
LACNIC
RIPE NCC
Yea, but we got the beer and the weather

The RIR



Background: we have this system…

- Flash adverts placed worldwide, running controlled sequences of (undisplayed) pixel fetches
  - 350,000 to 750,000 randomized placements/day on current budget
  - Current System capable of handling 8-10 million samples, scaleable
- IPv6 and DNS(SEC) and general IP qualities
  - Dual Stack v4/v6 V6 only
  - V6 dns DNSSEC, badly signed DNSSEC
  - Large packets, Tunnel detection
- Under continuous development
  - Exploring TLS/SSL/SNI in 2015

Three Qualities which help make the Internet what it is

1. A Routing Architecture
2. A mapping from names to addresses
3. Uniquely assigned addresses

Three Qualities which help make the Internet what it is

1. A Routing Architecture **BGP**
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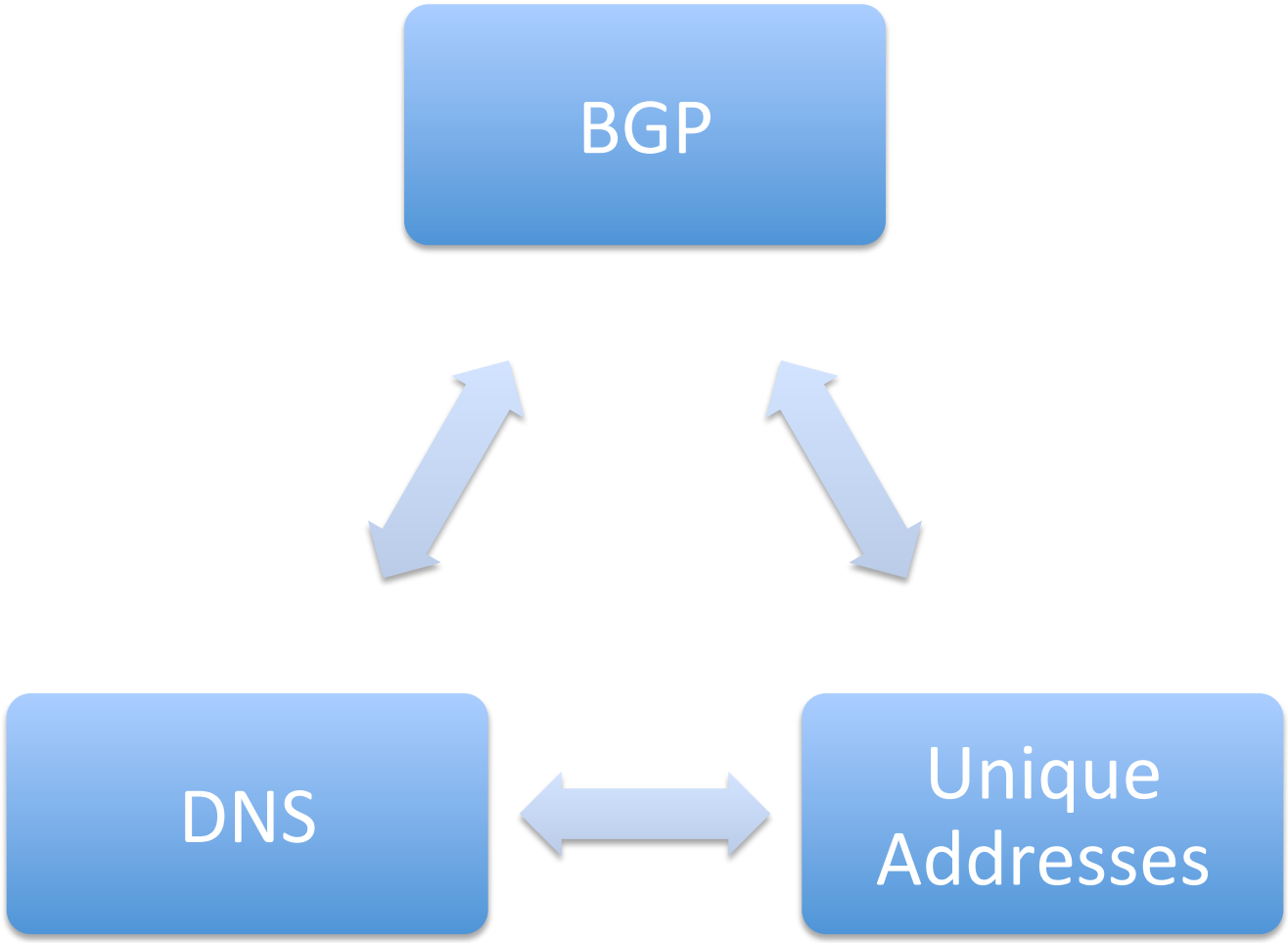
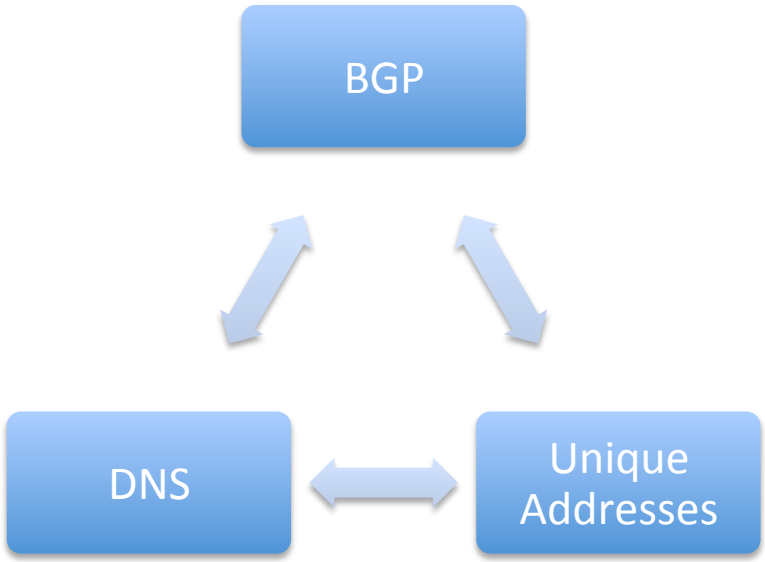
The (un)holy trinity



The (un)holy trinity



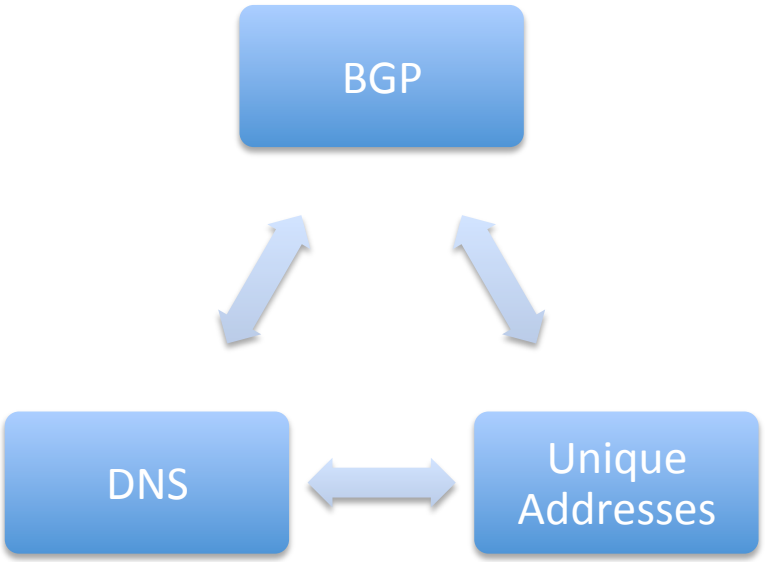
There is a relationship, a dynamic tension between these three which is interesting. Sometimes we say things about routing (BGP) which implicitly depend on the uniqueness properties, hierarchical allocation of addresses (prefixes, routing)

Sometimes we say things about dns names which implicitly depend on functional routing models, and unique addresses.

The emergence of Carrier Grade Nat (CGN) and ubiquitous NAT at home, calls the Address function into question.

LISP… (locator-ID separation, routing in novel ways)

Separated Management

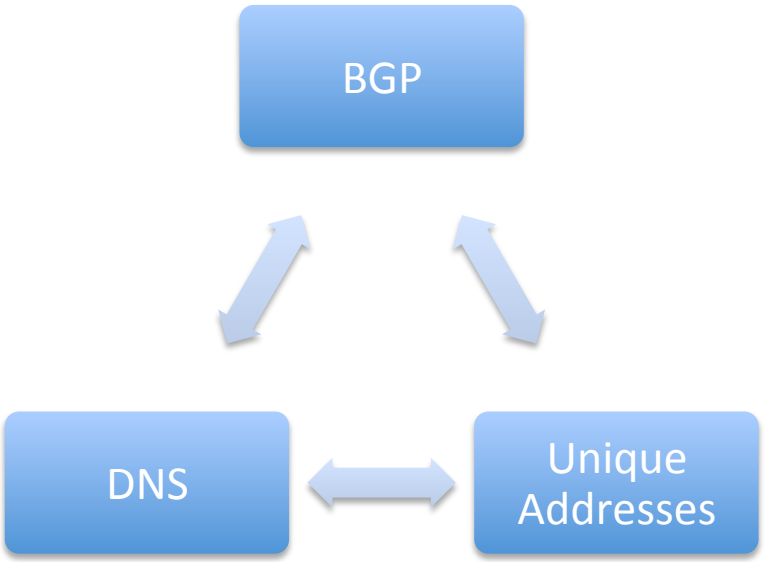


BGP is self-managed by the operations community, based on assumptions (operational expectations) over uniqueness in Internet Number Resources (INR) managed in the RIR system

DNS names are self managed under ICANN and independently operating ccTLD, gTLD

The RIR system is a self-managing domain of responsible address management in community led, consensus decision making over address policy

So how well are we doing?



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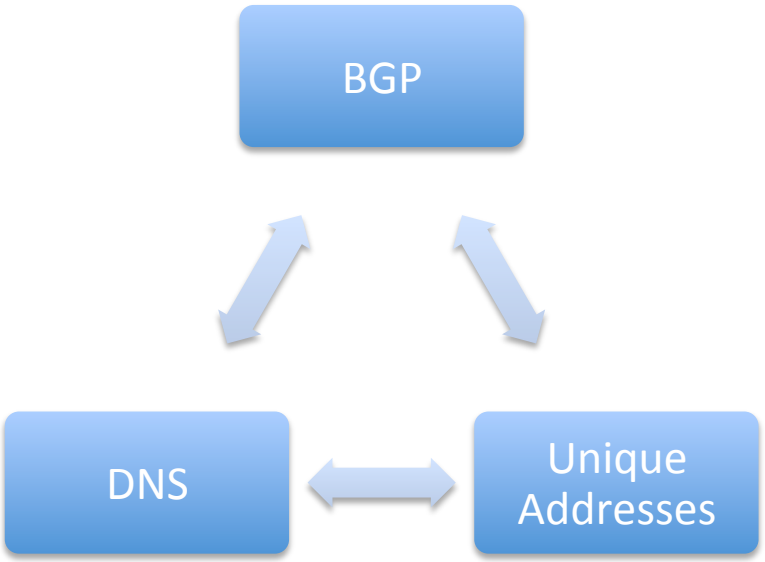


How do we go about measuring how well we're doing in these three spaces?

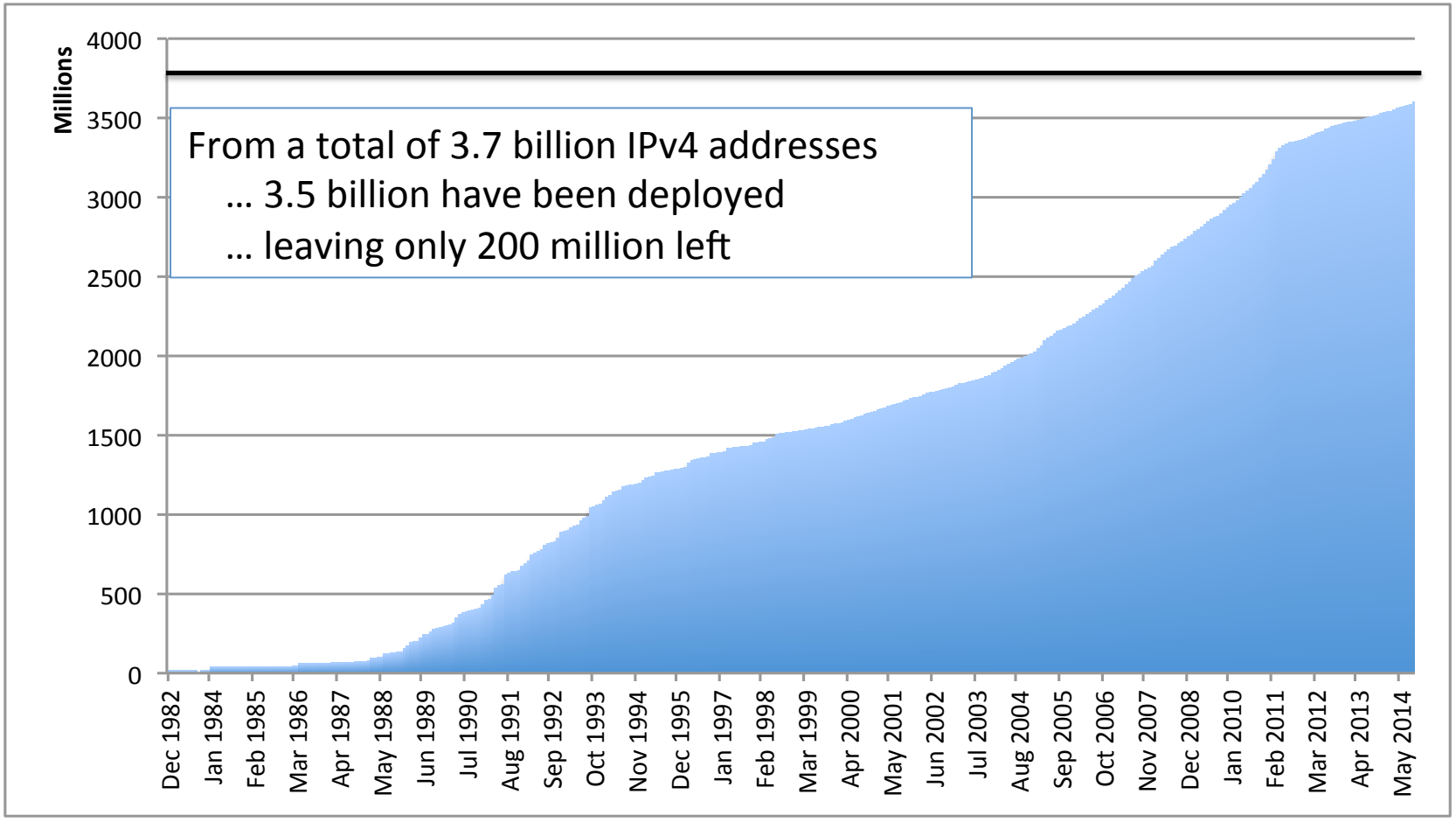
How well is policy shaping the Internet?

How applicable are the policy decisions we are taking?

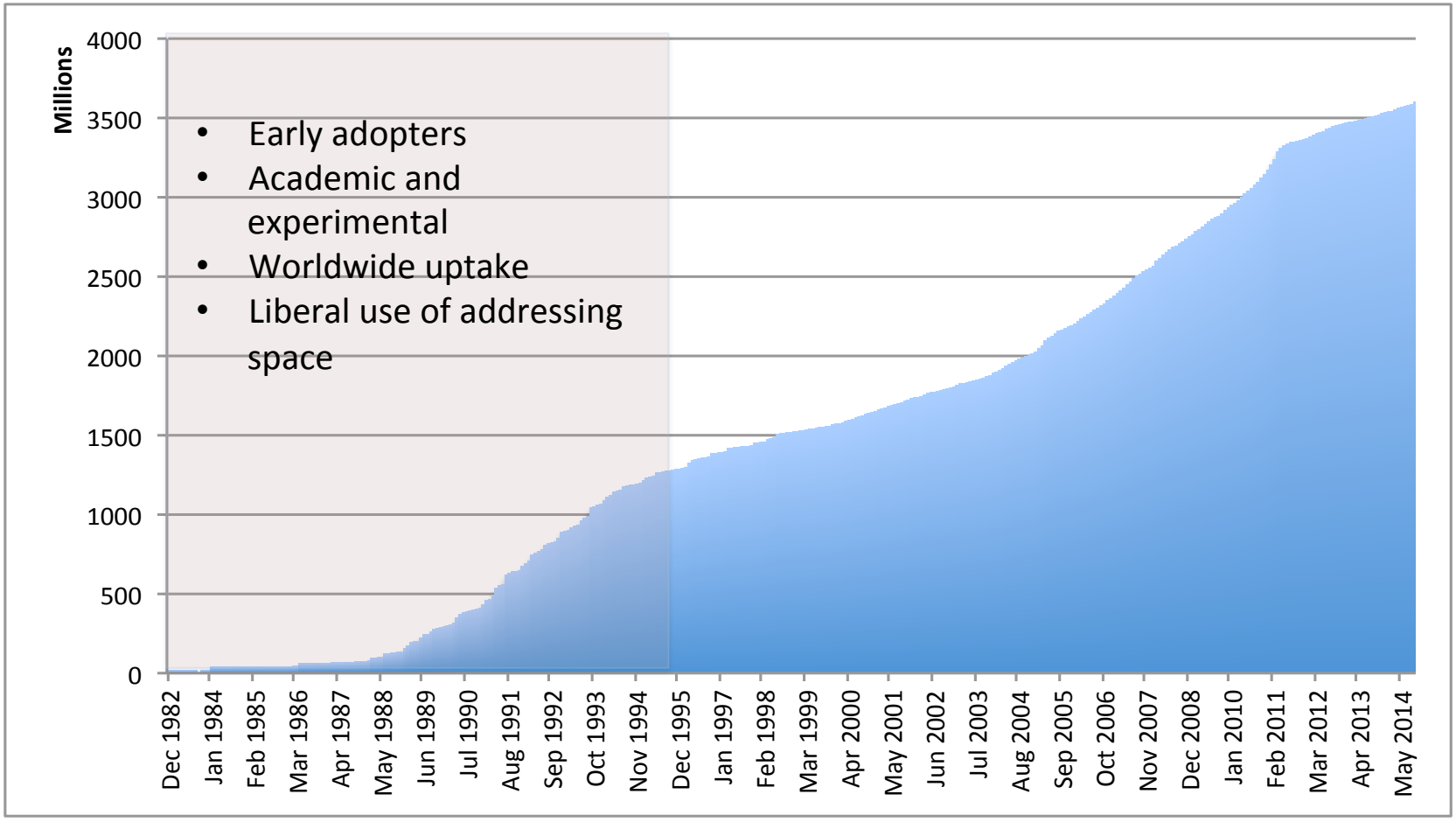
Specifically, how about IPv6?

- We didn't expect to be here
- We expected to have completed an IPv6 specification, and 'migrated' to IPv6 long, long ago
- We haven't wound up where we wanted to be

IPv4 space : where are we?



IPv4, first wave : 1983-1994



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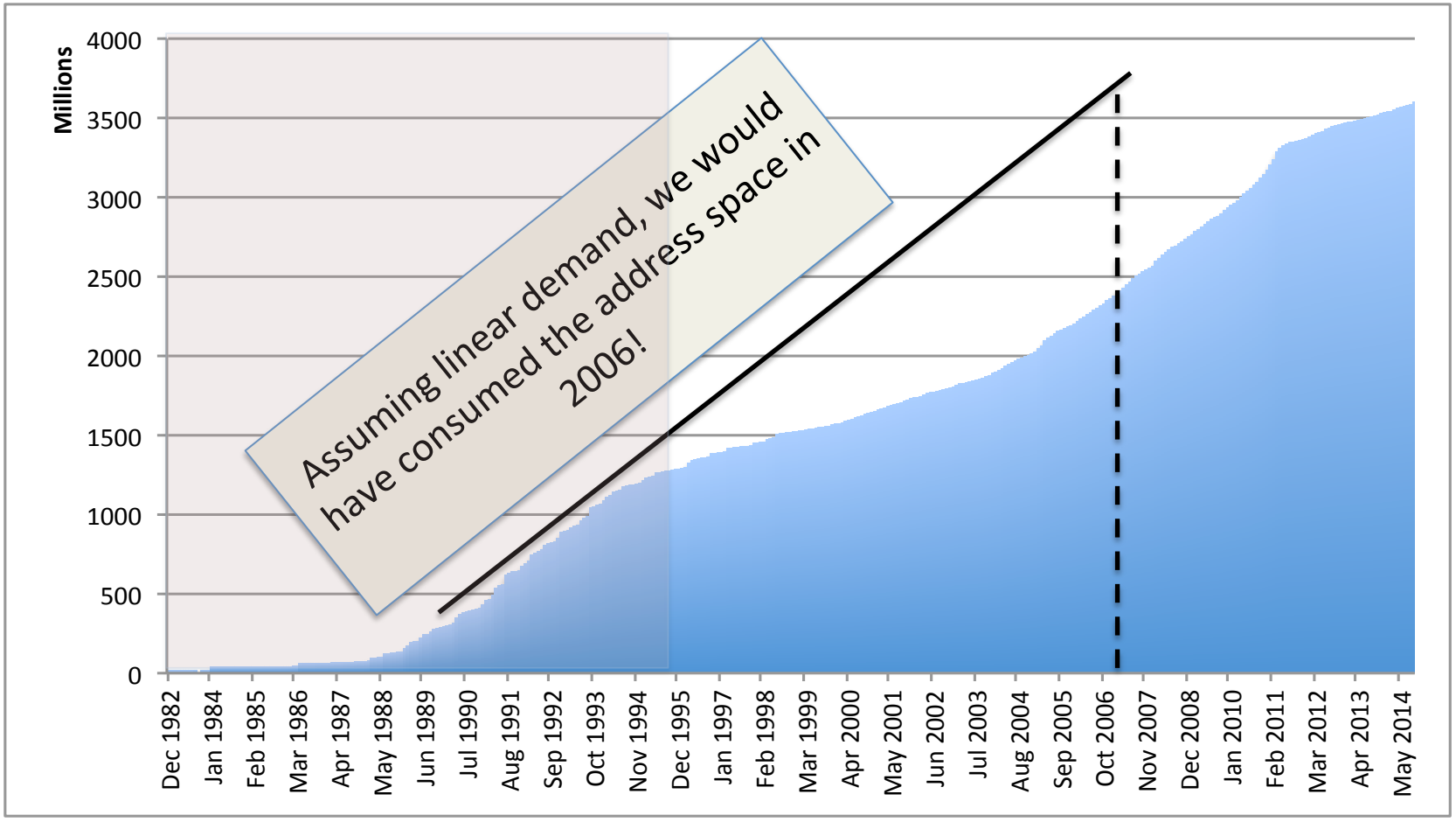
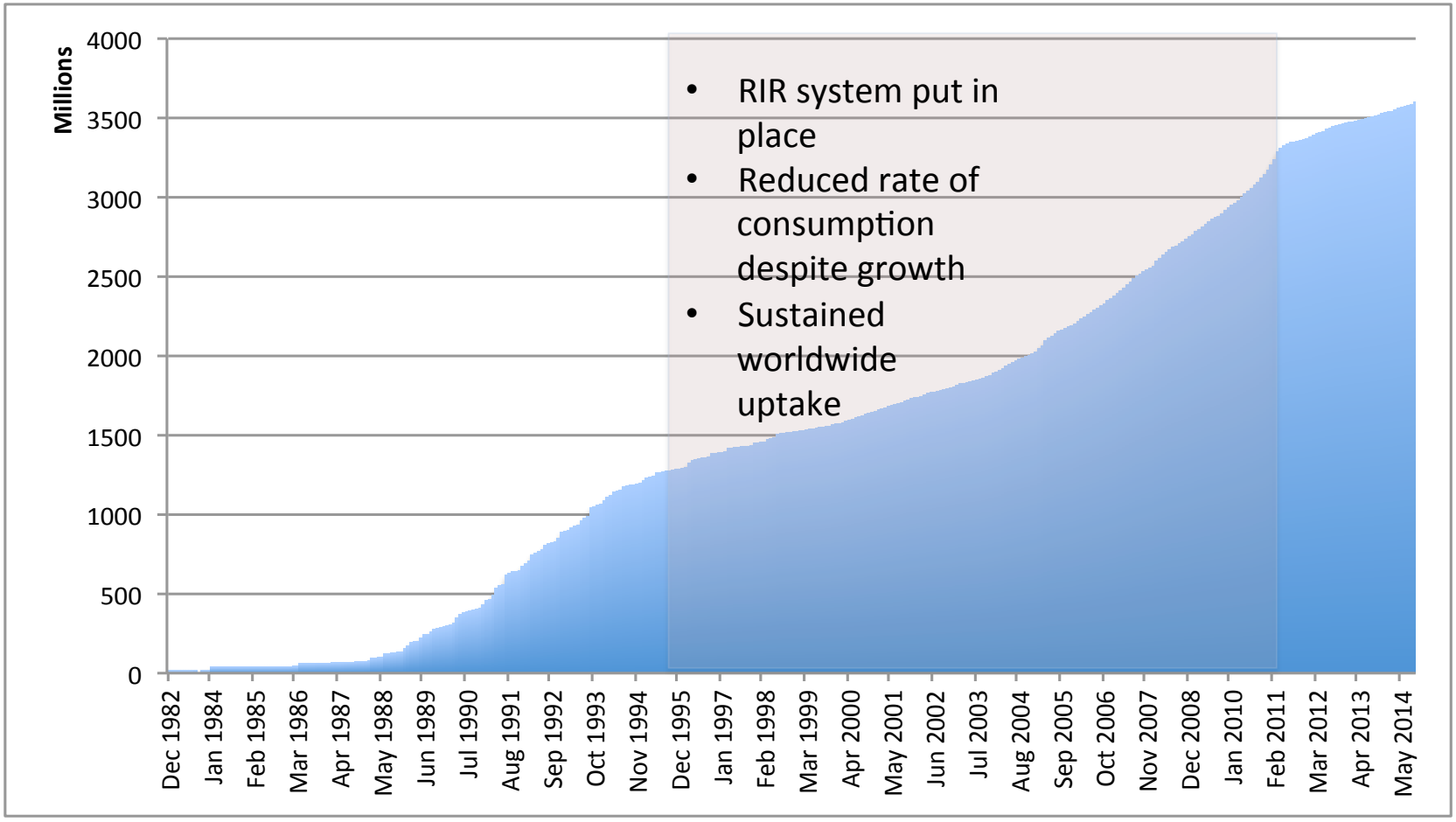


IPv4, second wave : 1994-2011



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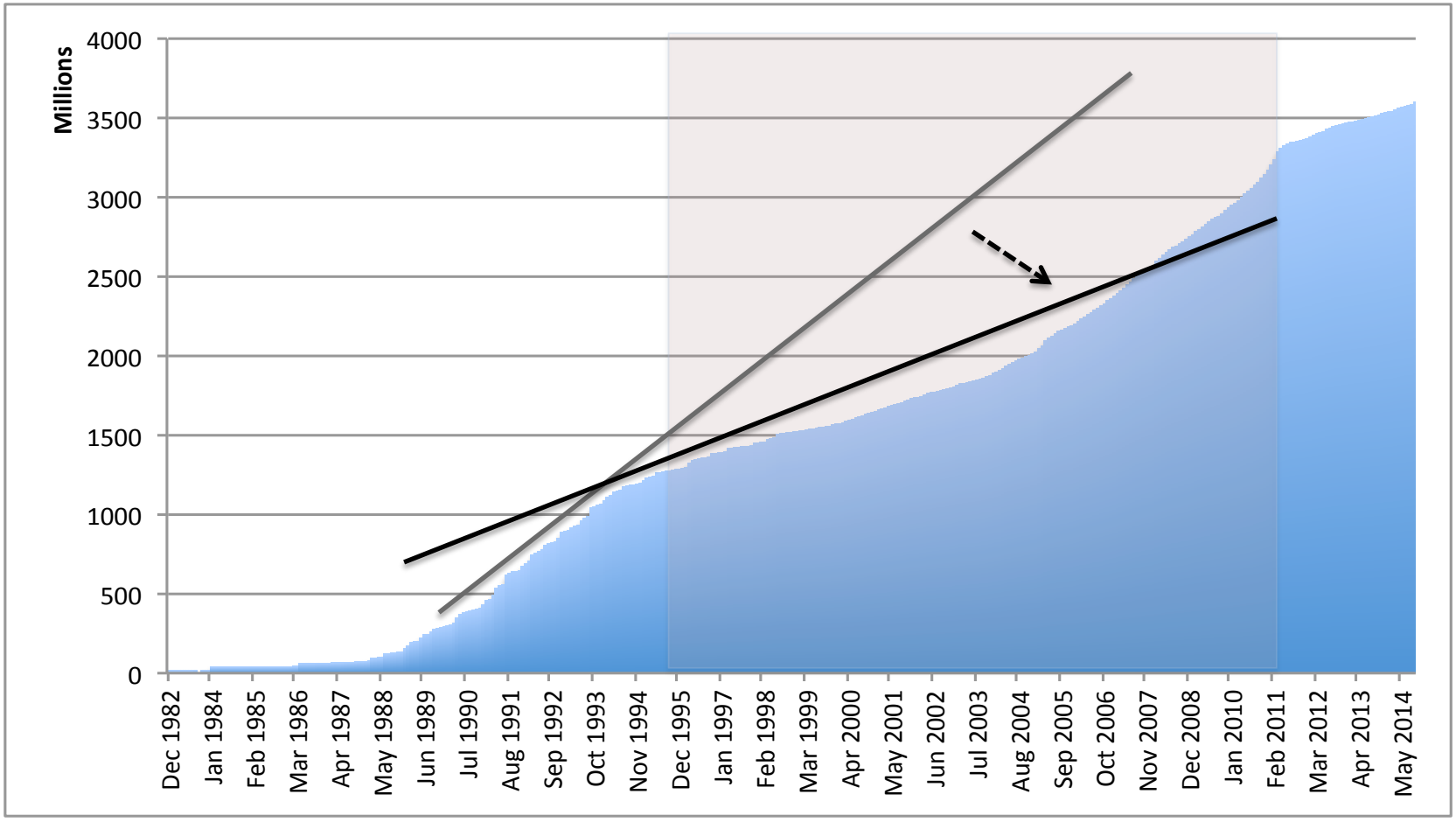
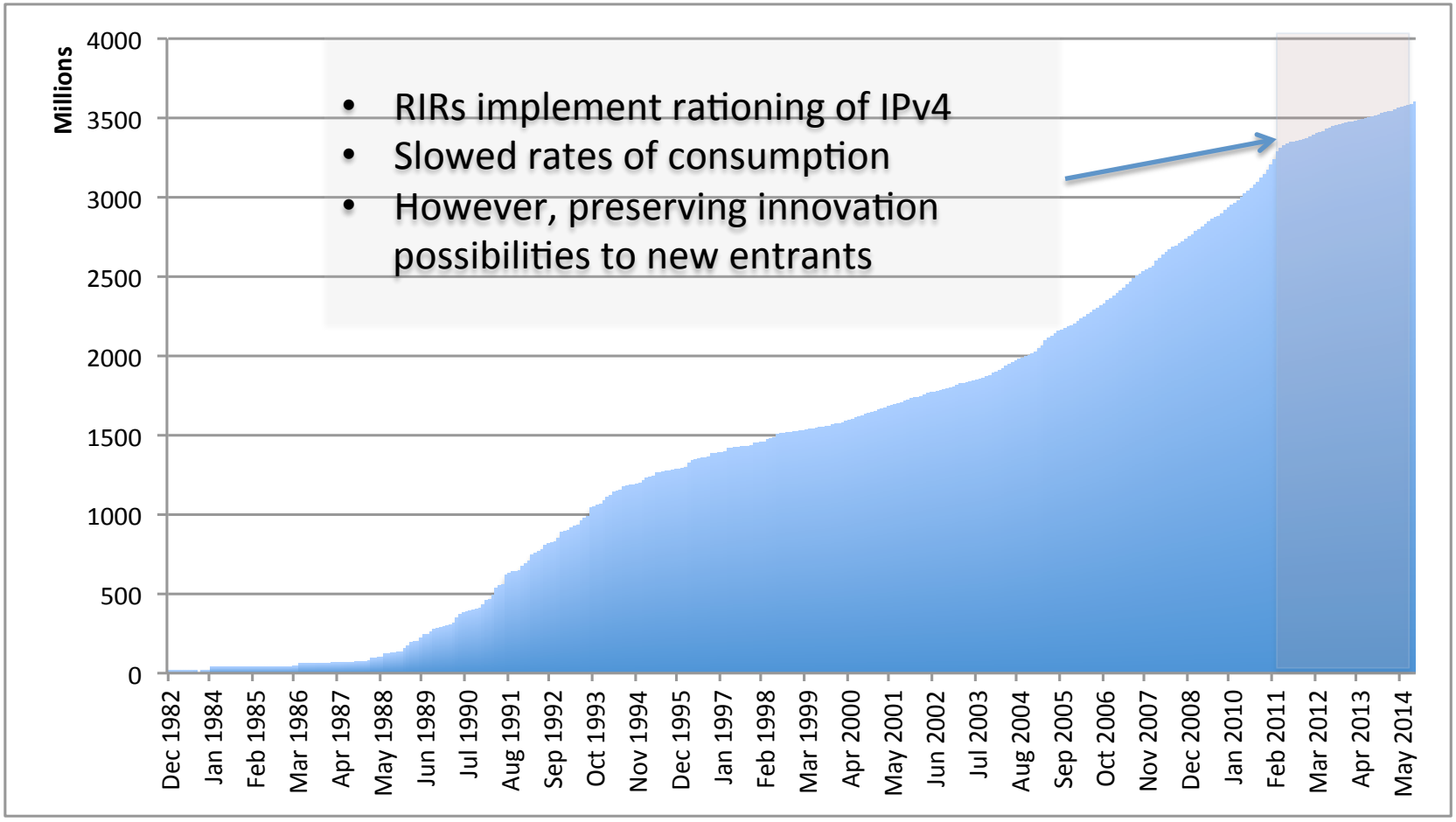
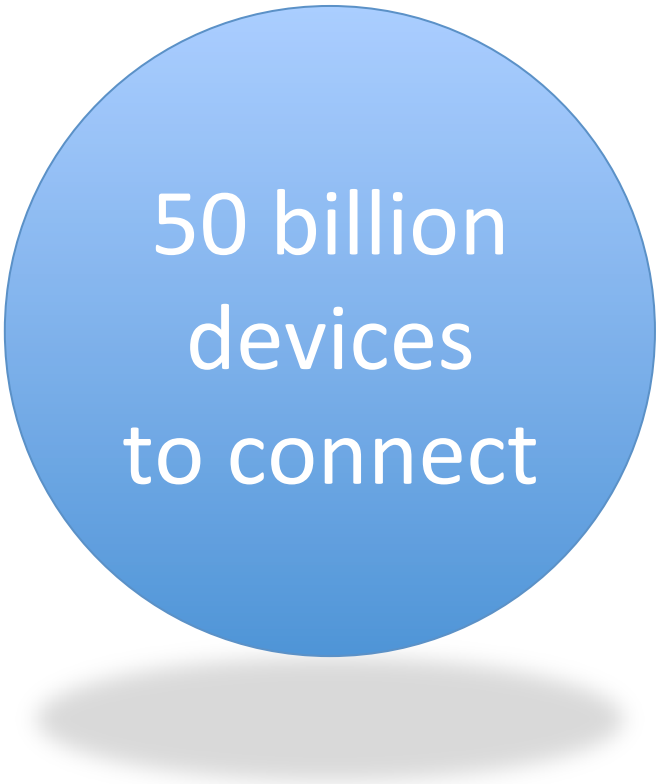
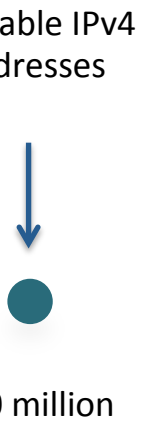


IPv4, last wave : 2011-2014…



…only 200m IPv4 addresses left





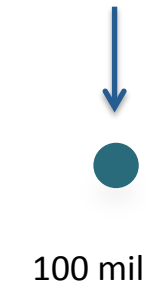
Source: APNIC Labs, IPv4 Resource Allocation, Sept 2014

The answer is IPv6

340,282,366,920,938,463,463,374,607,431,768,211,456 addresses

IPv6

50 billion devices to connect



Why do we need IPv6?

- IPv6 is the only viable option we have now
  - Much larger address space than IPv4
  - Enable sustainable growth of the Internet
  - Possibilities of emergence of new technologies
  - End-to-end connectivity

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  - End-to-end connectivity

- We may have over-achieved in IPv4
  - We seem to have extended its life beyond goals

So: how are we doing in IPv6?

So: how are we doing in IPv6?

- Which users can use IPv6?
- Which users can but don't use IPv6?
- How many are on Tunnelled IPv6?

- Does IPv6 perform better or worse than IPv4?
- How are different economies doing?
- Regions?
- ISPs within economies?

Basic technique

- Ask user to fetch web resources which are homed in:
  - IPv4 only
  - Dual-Stack IPv4 and IPv6
  - IPv6 only
  - (variations to capture tunnels, explore other aspects of IP behaviour)
- Have some way of uniquely identifying each user, and what they fetch
- Correlate their results: end user capability.

History of measurements

1. Measure yourself
   - We started with embedded tests in our own website
   - We forgot that the overwhelming majority of users were ISPS connecting from inside their core network architecture
   - The first place which is IPv6 enabled in any ISPs network is their own core network
2. Not surprisingly we over-estimated penetration

History of measurements

1. Measure yourself
2. Measure others you know
   - We have placements of javascript measurements on websites we know, and continue to collect from
     - Games.on.net, JANET & other academic placements
   - These are equally subject to skew, and favour specific communities with oversampling

History of measurements

1. Measure yourself
2. Measure others you know
3. Measure Everything
   - How can we find a way to get a good measurement of everyone, without having to approach every website to ask for placement?

How to measure a million end users

How to measure a million end users

- be www.google.net

…buy the measurement

Buying google adverts

- Impressions vs clicks
  - We tune to preference views of our ad (impressions) and de-preference clicking.
- Daily spend limit
  - We chose $200/day as a ceiling to spend.
- Clicks per Mille (CPM)
  - An industry standard bidding mechanism, which prices the effective bid you make for 1000 impressions hoping for a click: we bid low (0.25c)
- Google wants our money
  - Nobody wants to take this bid, so Google “soaks” the advert on youtube, to meet our daily bidding total at our cpm, preferring impressions.
- Result: a huge worldwide deployment of our advert via youtube to lots and lots of people.

Placement

At low CPM, the advertising network needs to present unique, new eyeballs to harvest impressions and take your money.

- Therefore, a 'good' advertising network provides a fresh crop of unique clients per day
- Pay for placement of ads, embed the measurement in flash.
- Result is lots of Unique IP addresses to measure.

Flash

- “actionscript” is a full programming language
- Includes a basic “getURL() function” with asynchronous report on delivery

1. Fetch list of experimental URLs to fetch
    1. Encodes unique experiment identity into URL set
2. For each URL:
    1. Fire a timer
    2. Fetch a URL
    3. Record time to fetch, or on fail (timeout) null
3. Report back results by fetching a URL

rd.td

- http://t10000.u915111887.s1428434174.i5080.v1111.rd.td.h.labs.apnic.net/1x1.png

r4.td

- http://t10000.u915111887.s1428434174.i5080.v1111.r4.td.h.labs.apnic.net/1x1.png

r6.td

- http://t10000.u915111887.s1428434174.i5080.v1111.r6.td.h.labs.apnic.net/1x1.png

d

- http://d.t10000.u915111887.s1428434174.i5080.v1111.61bd9.z.dotnxdomain.net/1x1.png

e

- http://e.t10000.u915111887.s1428434174.i5080.v1111.61bd9.z.dashnxdomain.net/1x1.png

f

- http://f.t10000.u915111887.s1428434174.i5080.v1111.61bda.z.dotnxdomain.net/1x1.png

m

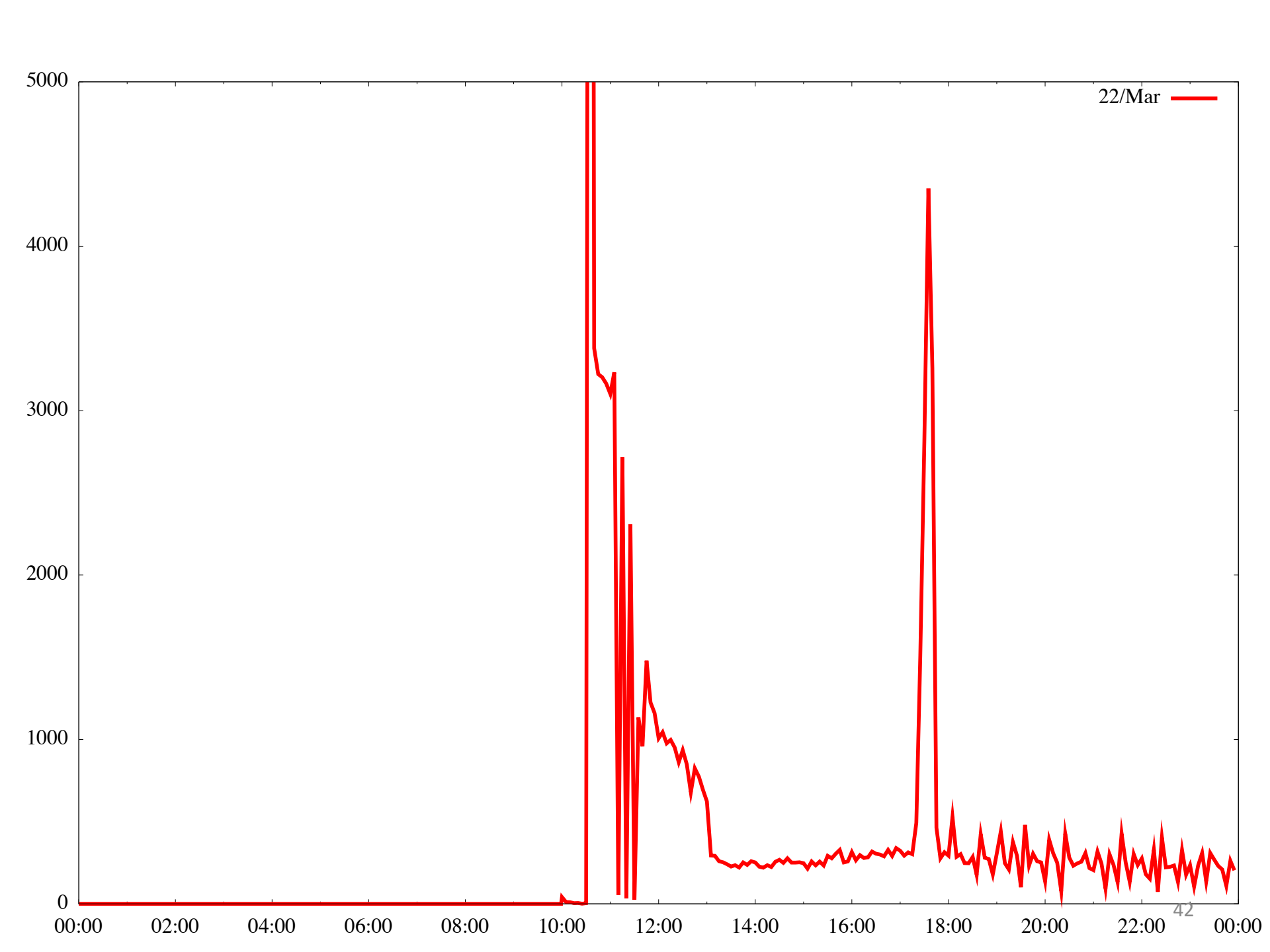
- http://m.t10000.u915111887.s1428434174.i5080.v1111.61bd9.y.dotnxdomain.net/1x1.png

n

- http://n.t10000.u915111887.s1428434174.i5080.v1111.61bda.y.dotnxdomain.net/1x1.png

Results

- http://t10000.u915111887.s1428434174.i5080.v1111.61bd9.results.h.labs.apnic.net/1x1.png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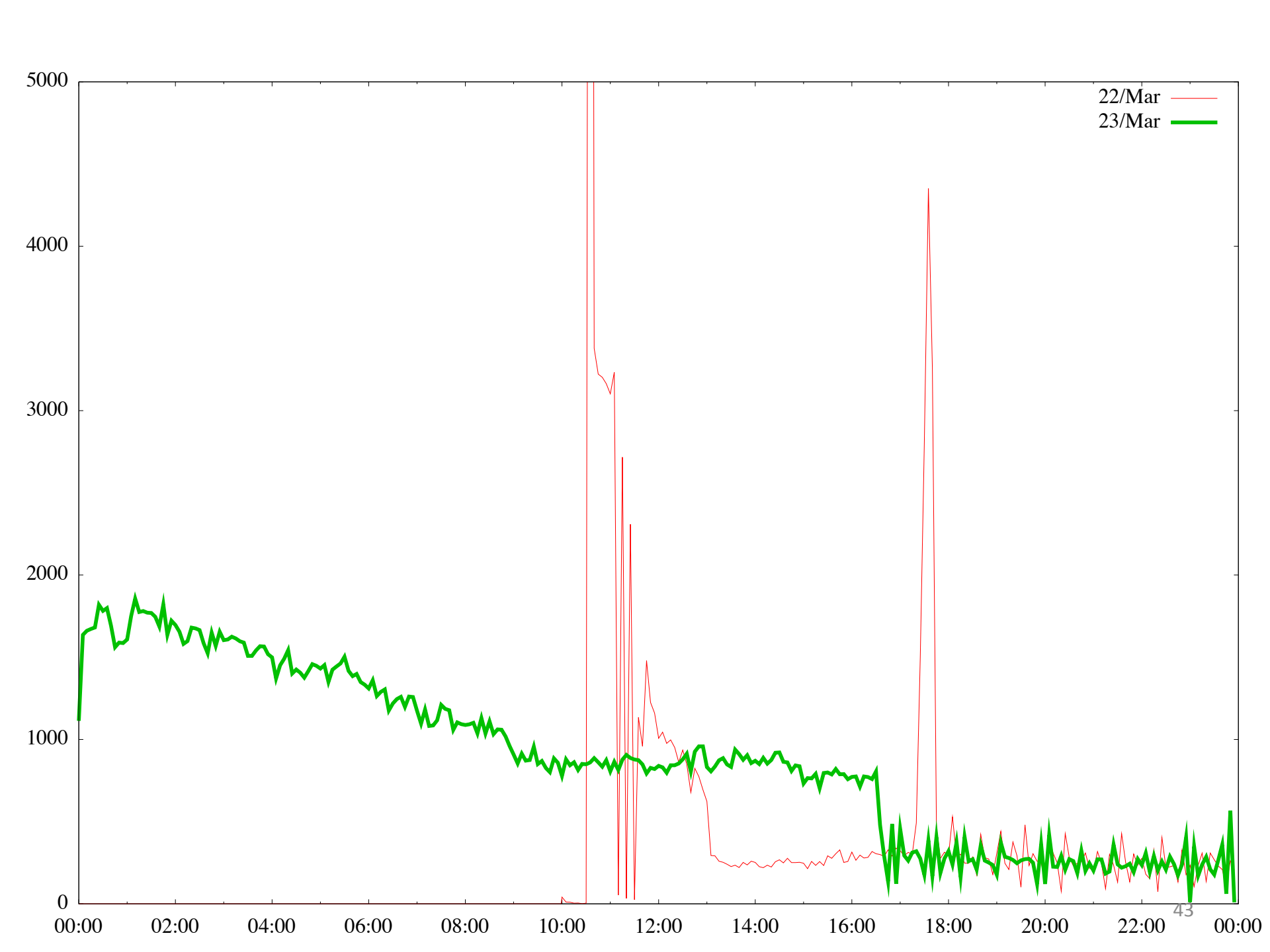
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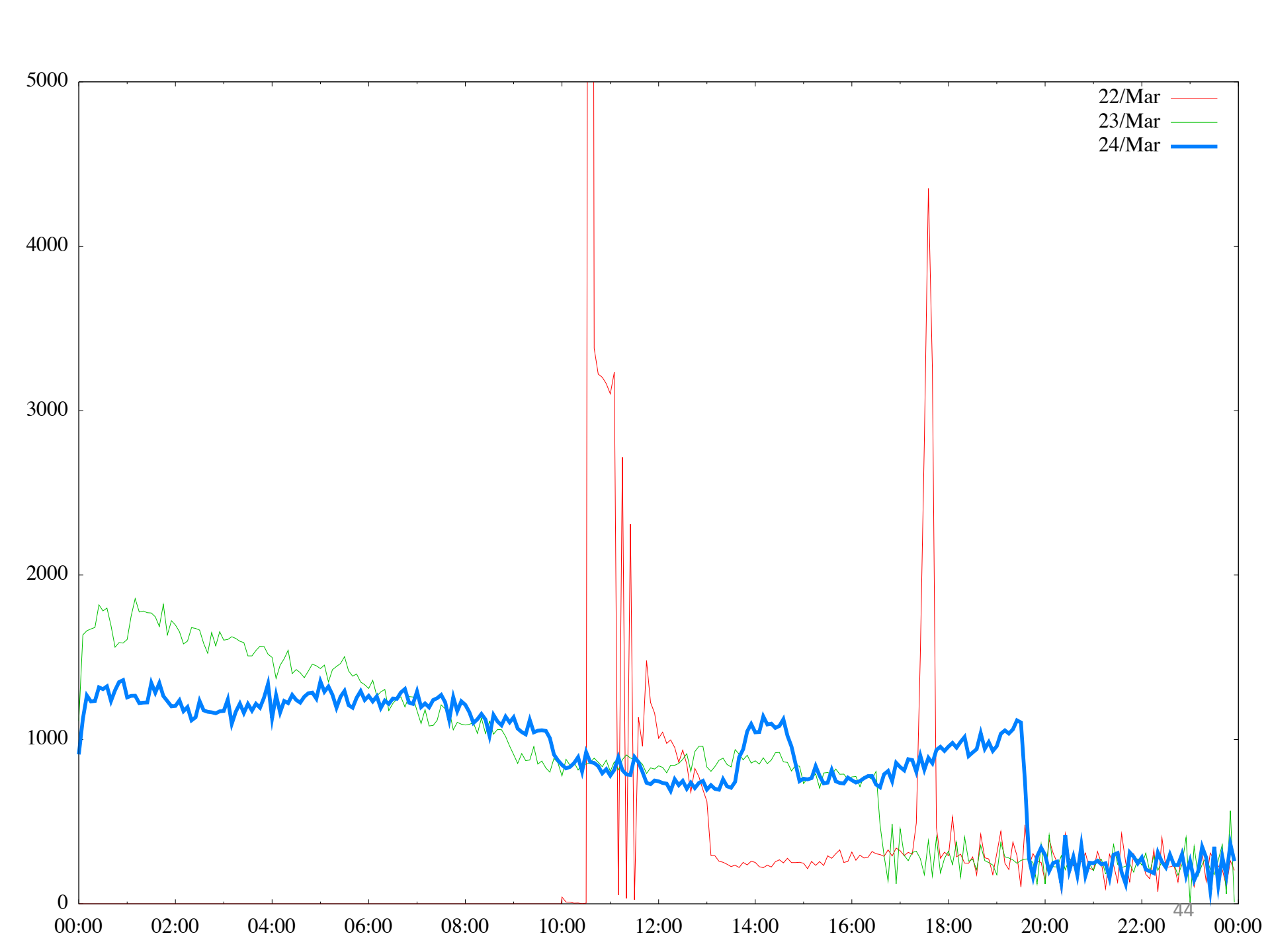
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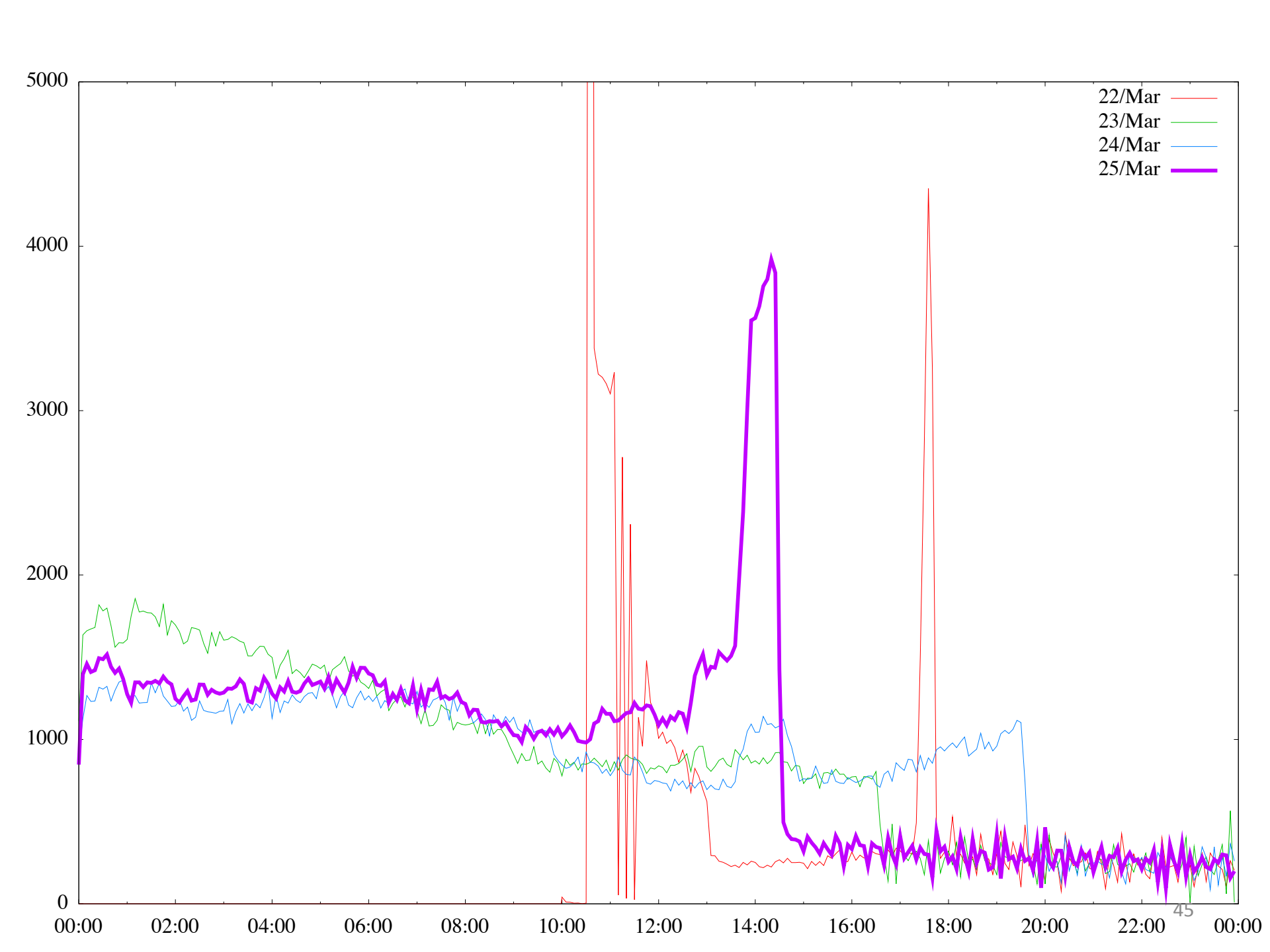
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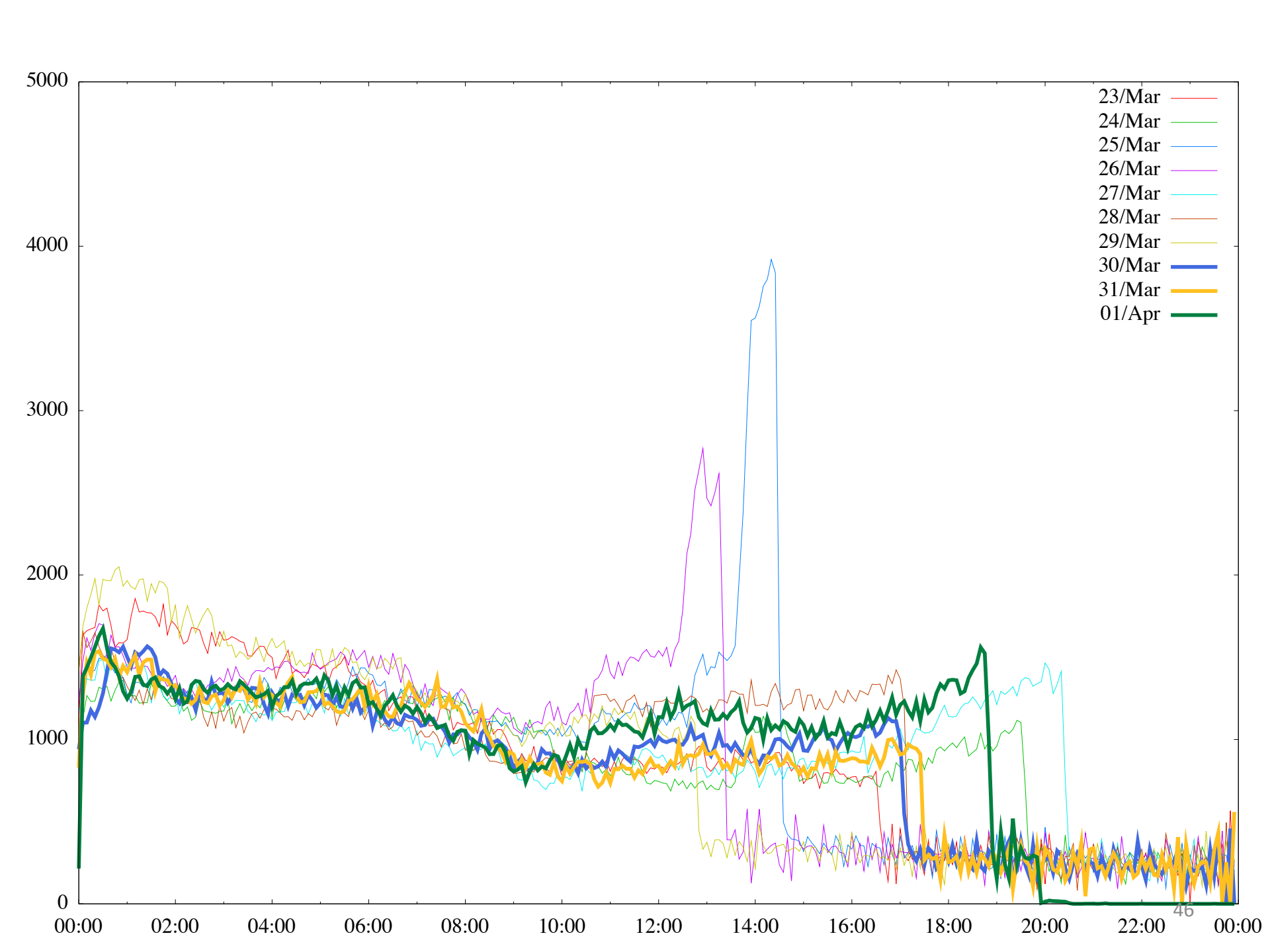
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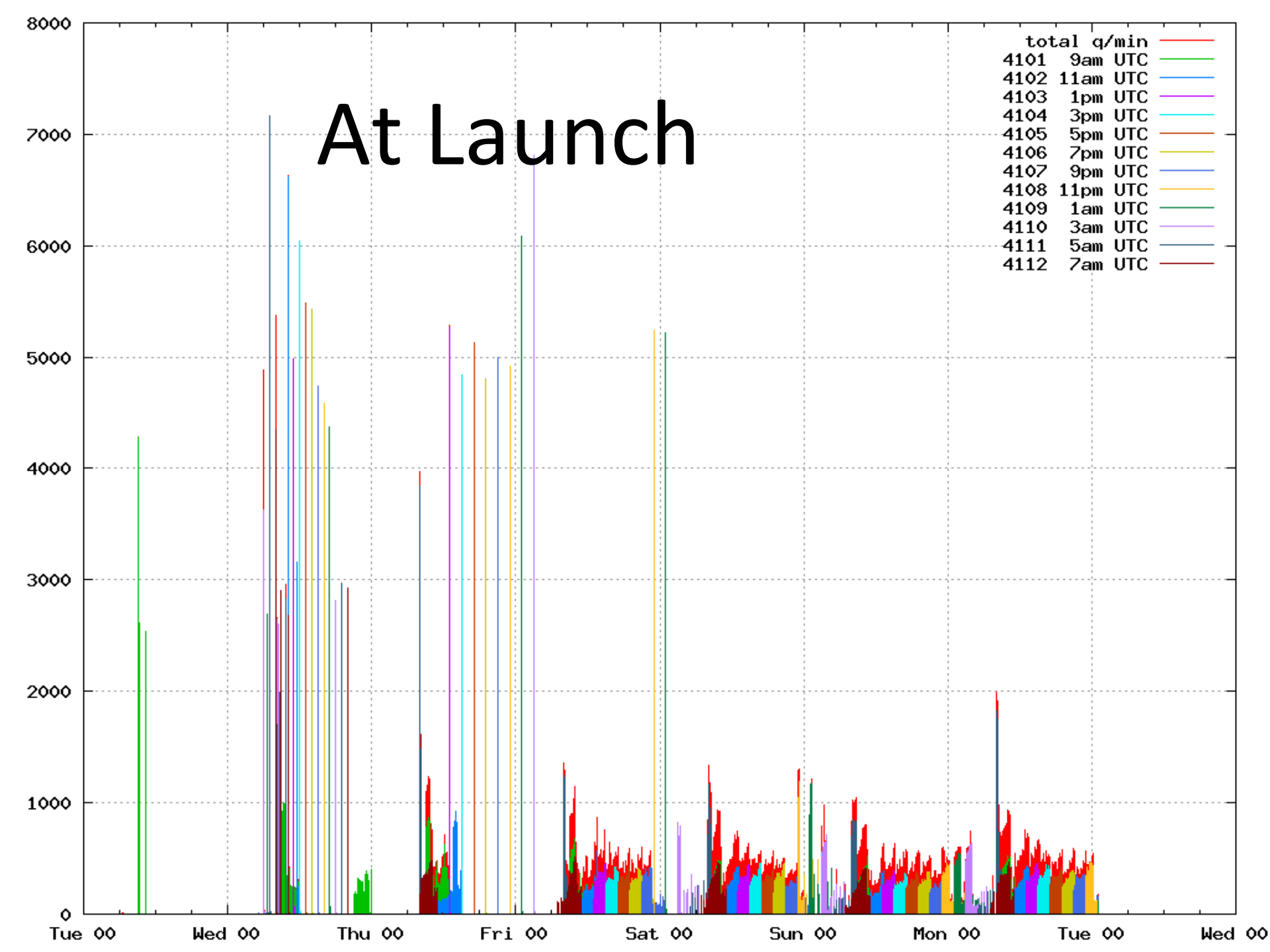
At Launch
total q/min
4101 9am UTC
4102 11am UTC
4103 1pm UTC
4104 3pm UTC
4105 5pm UTC
4106 7pm UTC
4107 9pm UTC
4108 11pm UTC
4109 1am UTC
4110 3am UTC
4111 5am UTC
4112 7am UTC
8000
7000
6000
5000
4000
3000
2000
1000
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Sun 00
Mon 00
Tue 00
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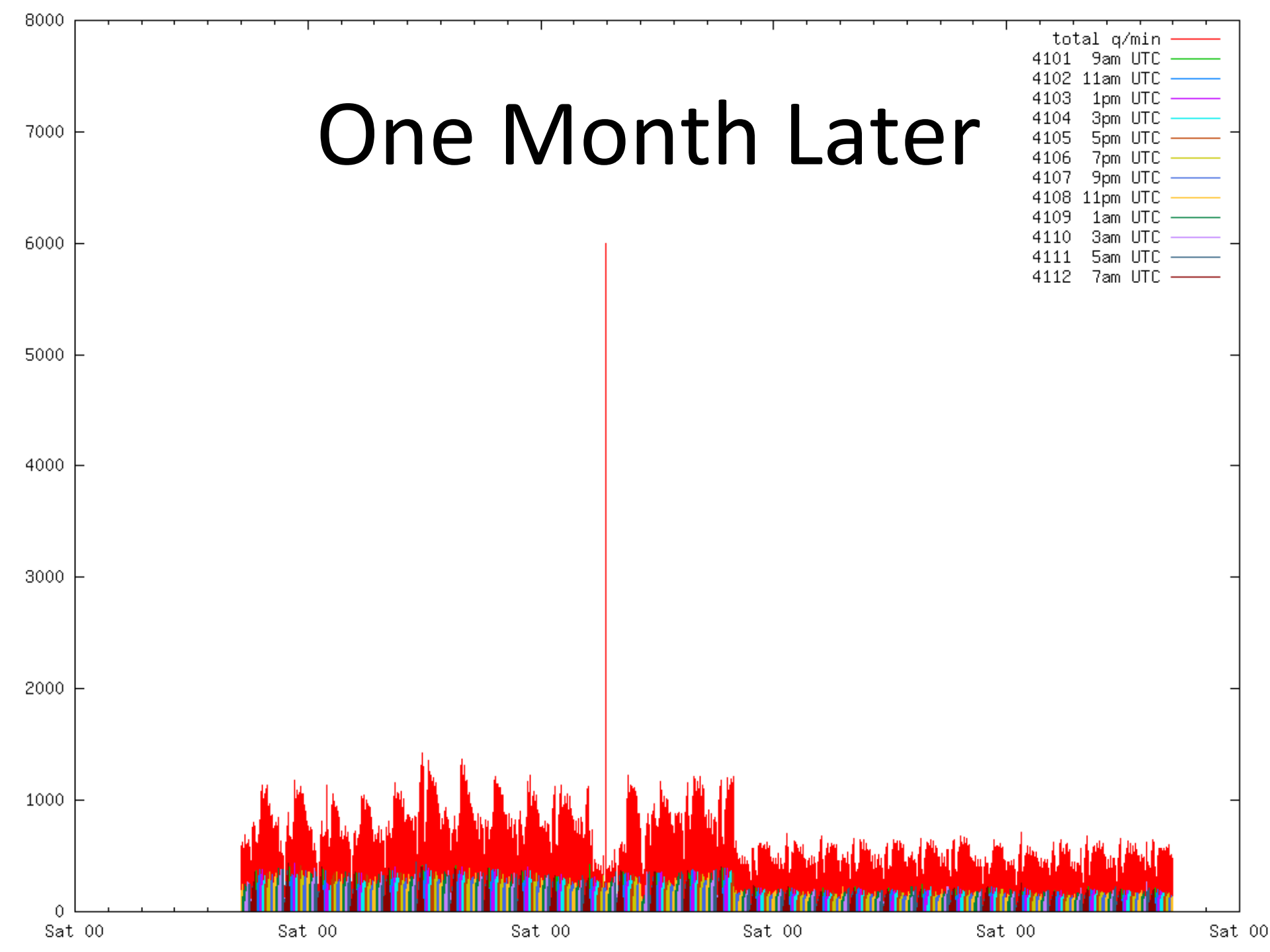
One Month Later
total q/min
4101 9am UTC
4102 11am UTC
4103 1pm UTC
4104 3pm UTC
4105 5pm UTC
4106 7pm UTC
4107 9pm UTC
4108 11pm UTC
4109 1am UTC
4110 3am UTC
4111 5am UTC
4112 7am UTC
8000
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Sat 00

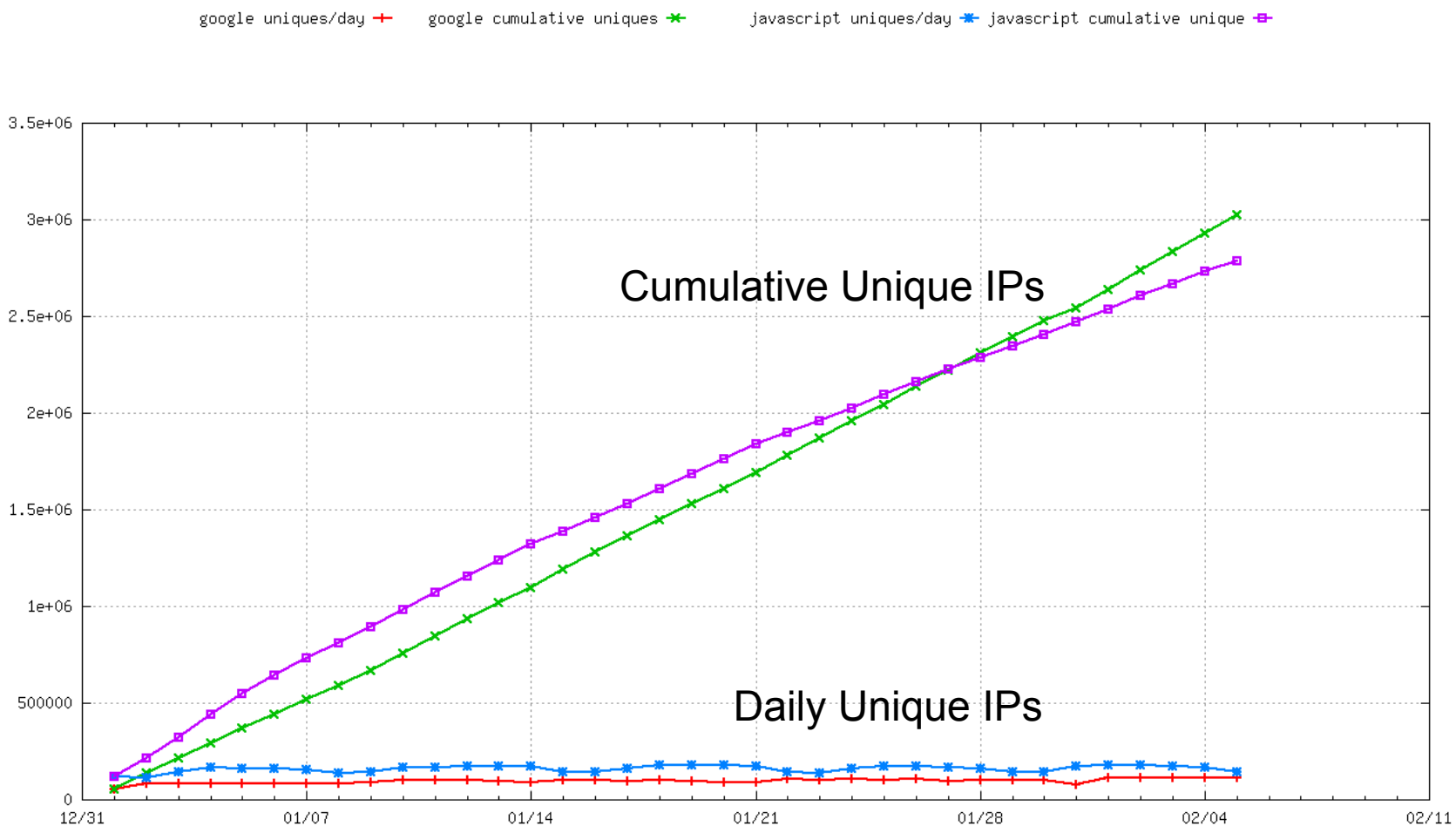
The effects of placement time

- Time of day influences who google can present to
- We now run multiple adverts in bands of time to try and ensure we get better coverage in every economies peak time of use
- We may have to work harder to get more data for emerging Internet economies, Africa, Oceania, parts of Asia, South America
- G20 is ok. It's the rest of the world that's a worry

Unique IPS?

- Collect list of unique IP addresses seen
  - Per day
  - Since inception
- Plot to see behaviours of system
  - Do we see ‘same eyeballs’ all the time?

Lots of Unique IP’S



Success!

- 350,000 rising to 1million samples/day
- Large dataset, cross index DNS, IPv4, IPv6
  - Tag by economy, ASN, v4/v6 relationships, capability
- Graphs, Tables, Presentations, Reports

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- Large dataset, cross index DNS, IPv4, IPv6
  - Tag by economy, ASN, v4/v6 relationships, capability
- Graphs, Tables, Presentations, Reports
- ….Lets drill a bit “deeper”

…but where are these IP’s ?

…but where are these IP's ?

Economy	Count	Economy	Count
CN	100,449	TW	22,238
TR	72,220	PH	20,065
BR	51,311	PH	19,046
TH	33,996	EG	17,293
IN	28,755	UA	17,092
US	26,585	PJ	16,712
VN	26,340	RU	15,435
AR	25,145	FR	15,151
ID	23,079	ES	15,125
MX	22,494	RO	14,796

Wait a minute…

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Whats the ITU Ranking by # users?

Economy	Internet Pop	Economy	Internet Pop
CN	535175571	MX	46255178
US	225700819	KR	41568044
IN	128274827	EG	33430342
JP	100388570	IT	33269399
BR	92633032	TR	32827609
RU	69779393	VN	32581444
DE	67128189	ES	31916641
GB	54332971	CA	29609196
NG	51283648	PH	29219781
FR	50415364	ID	28232026

Whats the ITU Ranking by # users?

At least we Agree they Are top 20

Economy	Our ranking	Economy	Our Ranking
CN	1	MX	10
US	6	KR	(22)
IN	5	EG	14
JP	12	IT	(26)
BR	3	TR	2
RU	17	VN	7
DE	(41)	ES	19
GB	(39)	CA	(40)
NG	(105)	PH	13
FR	18	ID	9

Whats the ITU Ranking by # users?

Economy	Our ranking	Economy	Our Ranking
CN	1	MX	10
US	6	KR	(22)
IN	5	EG	14
JP	12	IT	(26)
BR	3	TR	2
RU	17	VN	7
DE	(41)	ES	19
GB	(39)	CA	(40)
NG	(105)	PH	13
FR	18	ID	9

Whats the ITU Ranking by # users?

The only
One we
Got right

Economy	Our ranking	Economy	Our Ranking
CN	1	MX	10
US	6	KR	(22)
IN	5	EG	14
JP	12	IT	(26)
BR	3	TR	2
RU	17	VN	7
DE	(41)	ES	19
GB	(39)	CA	(40)
NG	(105)	PH	13
FR	18	ID	9

Ad display skew

- We have a severe problem with ad skew by economy
  - Adverts are presented where google can find unique eyeballs
  - Unique eyeballs do not equate well to economic ranking by ITU user counts, internet capacity
- But we can adjust for this.
  - Factor our % counts for regional, world totals

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- We have a severe problem with ad skew by economy
  - Adverts are presented where google can find unique eyeballs
  - Unique eyeballs do not equate well to economic ranking by ITU user counts, internet capacity
- But we can adjust for this.
  - Factor our % counts for regional, world totals
- Q: is anyone else doing this?

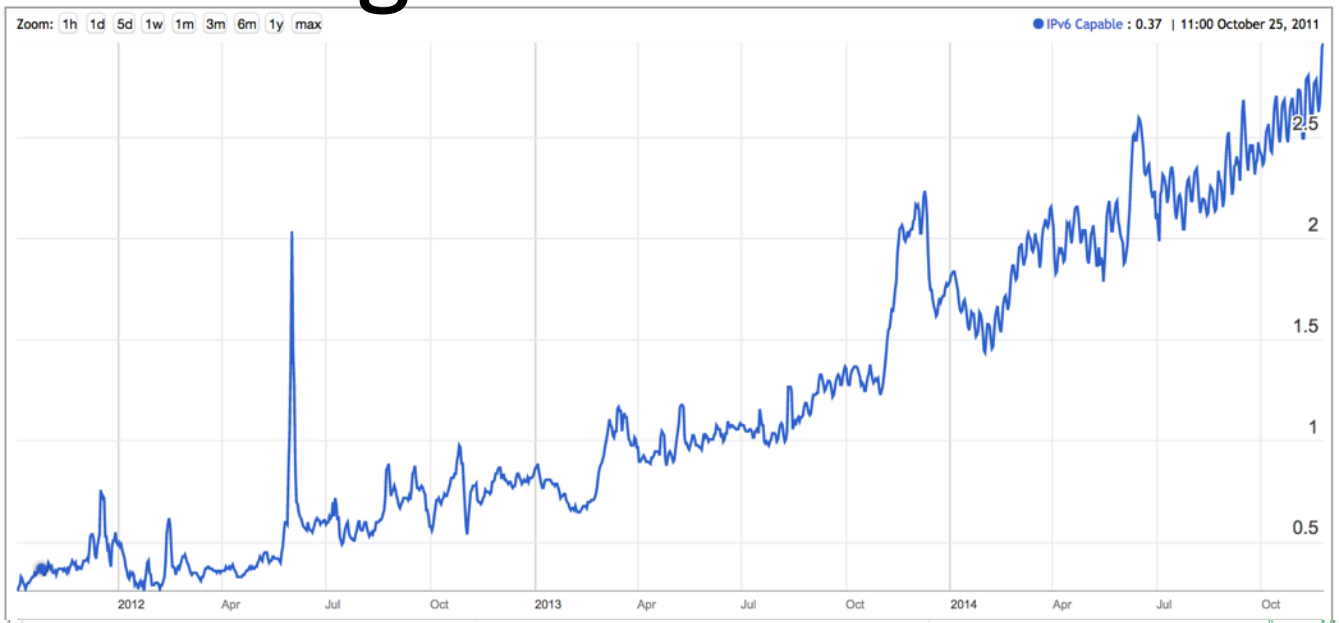
Is anyone else doing ‘adjusted’ counts

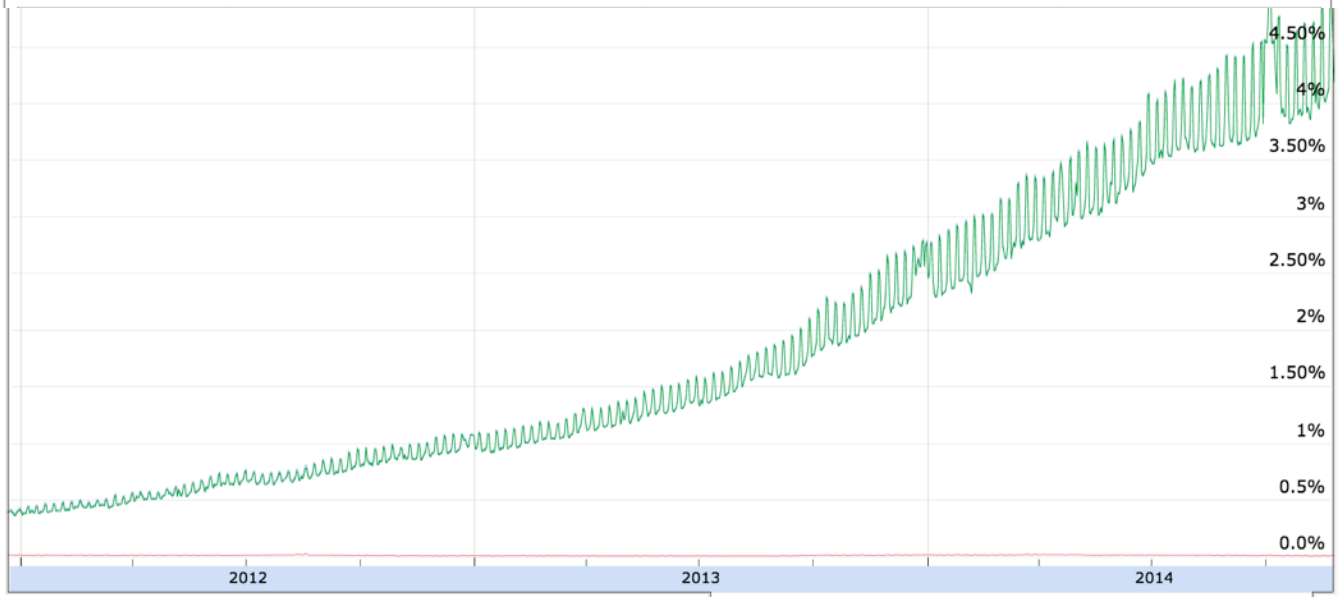
- Our data for ‘world’ is adjusted by ITU internet population.
  - For UN subregions, as well as world figures
- We record 1% - 2% lower world IPv6 uptake than other figures
- We do not think the other measures have adjusted for sample bias, or take account of the population effects of measurement
- We tend to have good agreement per-economy with other measurements (google, akamai)

APNIC vs Google World IPv6

Consistent trend
But we measure world
At 2% lower than Google

(we believe artifacts in the APNIC graph are a function of smaller sample size, methodology & changes over the life of our Experiment)





The Problem of ASN

- Some people run a mesh of ASN to manage complex routing architectures
- Eg Time Warner / Roadrunner
  - Large US Cable provider
- 12 ASN visible in BGP, across v4, v6
  - We've seen nine of them

Time Warner / Roadrunner

ASN	AutNum	V4 Prefix in BGP	V6 Prefix in BGP	Seen in 1x1
3456	TW-CABLE	27	1	4
7843	TWCABLE-BACKBONE	311	6	16
10796	SC-RR	861	2	802
11351	RR-NYSREGION	220	2	471
11426	SC-RR	295	1	494
11427	SC-RR	208	2	445
11955	SC-RR	14	-	19
12271	SC-RR	213	1	541
14065	ADELPHIA	4	1	-
20001	ROADRUNNER-WEST	210	3	817
20231	ROADRUNNER-CENTRAL	1	1	-
27476	TWCME (maine)	1	-	-

How do we ascribe IPv6?

- If we aggregate v6 capability across entire set of ASN, we ignore engineering
  - TW network engineers confirm it's a rollout progressing by region
- If we aggregate by TW/RR, how do we account for the other 17 ASN in their registration (they actually have 29 ASN)
  - Old acquisitions, not visible in BGP?

ASN	Network	Econ Of ASN	# econ	Economylist
174	COGENT-174 - Cogent Communications	US	10	CA,58,DE,10,ES,86,EU,19,FR,61,GB,57,GY,25,IE,24,TR,9,US,3196
702	Verizon Business	US	16	AT,1,BE,102,CH,13,DE,220,DK,6,ES,38,FI,53,FR,199,GB,316,GR,8,IE,80,IT,25,NL,149,PT,2,SE,6,US,31
3209	VODANET Vodafone GmbH	DE	3	DE,13740,EU,3,US,232
3292	TDC TDC A/S	DK	5	DK,11221,FI,93,NO,204,SE,542,US,13
3549	LVLT-3549 - Level 3 Communications.	US	12	AR,6102,BR,1200,CL,86,DE,1,EC,220,FR,1,GB,221,MX,3,NL,27,PE,15,US,2821,VE,226
4755	TATACOMM-AS TATA formerly VSNL	IN	5	AU,5,FR,16,IN,15217,SE,152,US,10
5432	BELGACOM-SKYNET-AS BELGACOM S.A.	BE	5	BE,13454,GB,10,KE,9,NL,293,SE,9
5483	HTC-AS Magyar Telekom Plc.	HU	3	HU,45919,IT,10,RO,61
6830	LGI-UPC Liberty Global Operations B.V.	AT	11	AT,7932,CH,3733,CZ,17652,DE,4,EU,3,HU,29255,IE,5087,NL,7142,PL,20302,RO,22948,SK,4137
6866	CYTA-NETWORK Cyprus Telecommunications	CY	2	CY,19095,GR,5724
6939	HURRICANE - Hurricane Electric Inc.	US	14	BR,1,CA,105,CZ,4,DE,3,GB,2,IN,3,KR,1,KZ,1,LV,1,NL,1,RU,1,TW,1,US,6170,na,9
8075	Microsoft Corporation	US	3	BR,137,GB,8,US,13756
8167	Brasil Telecom S/A	BR	2	BO,12,BR,49975
8220	COLT COLT Technology Services Group	GB	12	AT,44,BE,30,CH,120,DE,388,DK,3,ES,370,FR,199,GB,914,IE,6,IT,285,PT,115,US,21
8359	MTS MTS OJSC	RU	3	CZ,15,RU,35316,UA,528
8926	MOLDTELECOM-AS Moldtelecom SA	MD	3	EU,121,MD,10798,RO,14498
9050	RTD ROMTELECOM S.A	RO	2	IR,100,RO,58976

ASN in more than one Economy

- Some ASN are genuinely international
  - But some of their competitors run multiple ASN
- Comparing like-with-like requires extra information
- Some of these cases are because of inadequate tracking of resource relocations in registry processes
  - This can only get worse with address transfers

Data Integration

- U<unique> + s<time> gives us unique collation key
- Can now correlate tcpdump, weblog, dns
- DNS resolver IP now associated to client
  - Can inform “who uses whom” for DNS Services
  - Can test client capability in DNSSEC
  - Map client usage of google public DNS, openDNS
- Results line gives client view of timing
  - Can compare to tcpdump, web/dns log times
- Map to economy, iso3166 region, AS number
  - RIR databases, Maxmind, BGP (origin-as)

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- Map to economy, iso3166 region, AS number
  - RIR databases, Maxmind, BGP (origin-as)

This has issues

Sources of Economy data

- What does RIR economy of assignment mean?
- What does maxmind economy of use mean?
- What do we do about international services?
  - Maxmind identifies VPN tunnel endpoint addresses
  - Maxmind identifies what it thinks is international address deployment
- Quality of RIR/NIR economy data is mixed
  - Under transfers, this is only getting worse

Other Error bars

- We can't directly measure most mobile devices in the google flash mechanism (because flash isn't being run on these handsets)
  - Mitigation: we are re-developing into HTML5 (javascript) which will work on all modern devices including phones.
- We can't directly measure anyone with adblock enabled in the flash measurement (because .. Its an *advert*!)
  - There is no real mitigation but on the upside we now respect the "do not track" flags and have a compliant private identifying information policy

Other Error bars

- We can't directly measure end users who have ACLs blocking youtube (the predominant ad placement website) in the flash measurement.
  - These are 'low side' effects: we undercount in flash,a nd we feel confident we are a low-side count compared to some more optimistic measures.
  - We have good convergeance with many other measures being done by google, Akamai of their perceptions of end-user capability. The variances lie in economies with low sample counts, or high rates of mobile device internet.

- The javascript measurement is prone to distortions from repeat visits. We try to account for this.
  - This is a 'high side' effect: we can over count in javascript

Other Problems

- We are having to move to HTML5, https: to meet AUP from google
  - Work in progress
  - Higher implementation costs server-side
    - TCP sessions slower (crypto) bigger (more state)
    - Sign-on-the-fly costs to get *.dom.ain wildcards (SAN)
- We are captured by a single source of adverts
  - Good evidence that Google are an ‘honest broker’
  - Investigating alternative placement channels
    - May pick up developing internet economies better

Whats actually happening out there?

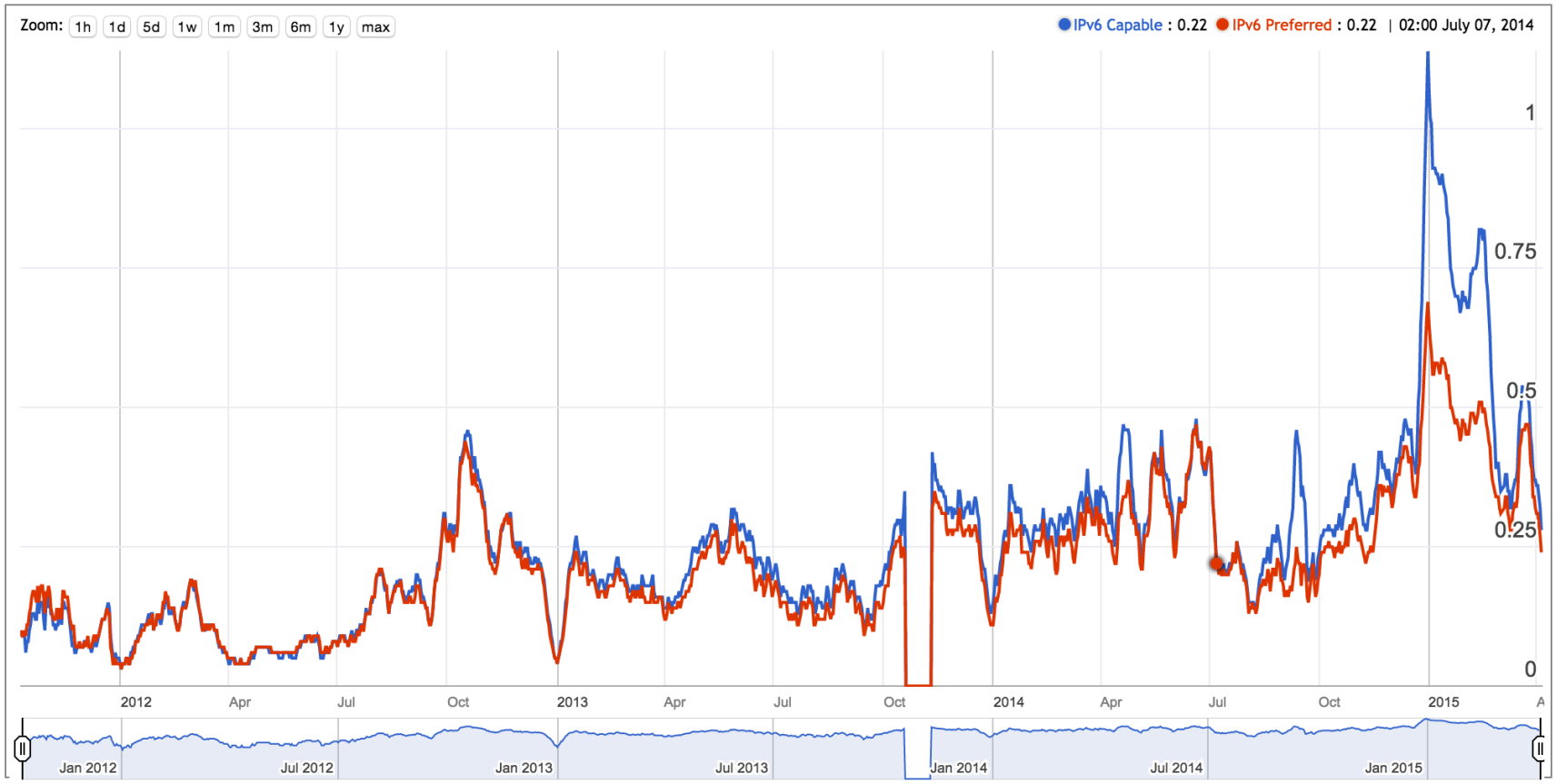
- http://stats.labs.apnic.net/ipv6
  - Breakdowns by UN Region
  - AS per ASN
  - Sortable tables
  - Google Chart API
  - *(We stole the L&F from Erik Vynke)*

Whats actually happening out there?

- We see at least four trends in IPv6 uptake

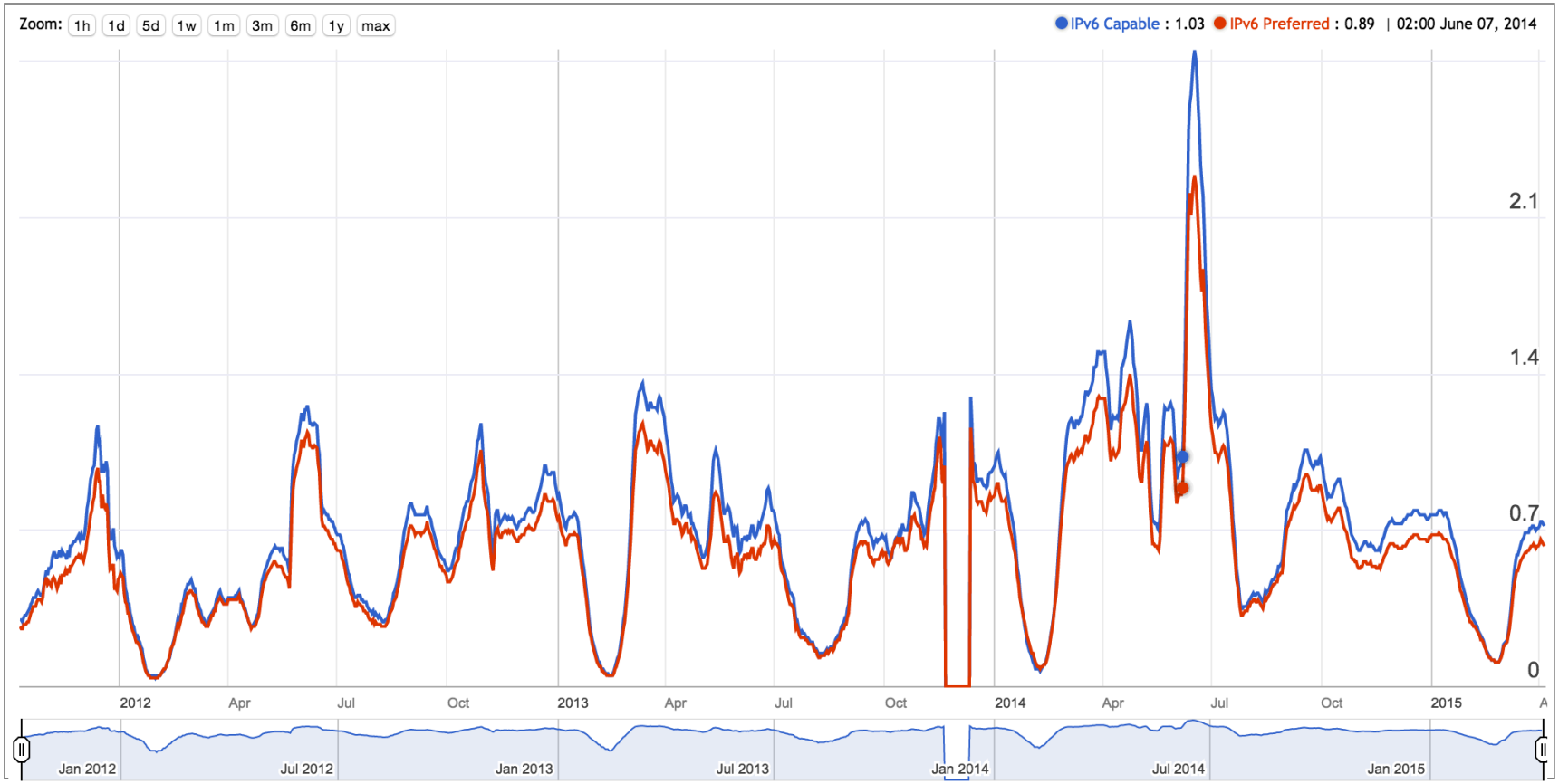
1. Its not happening at all (UK outside of JANET)
2. Its happening but we can't measure it properly
   - 'Great Firewall of China'
   - Mobile devices (watch this space)
3. It happened, but peaked early (FR)
4. Its real (US,DE,MY,BE) and the sky's the limit

GB Its not happening



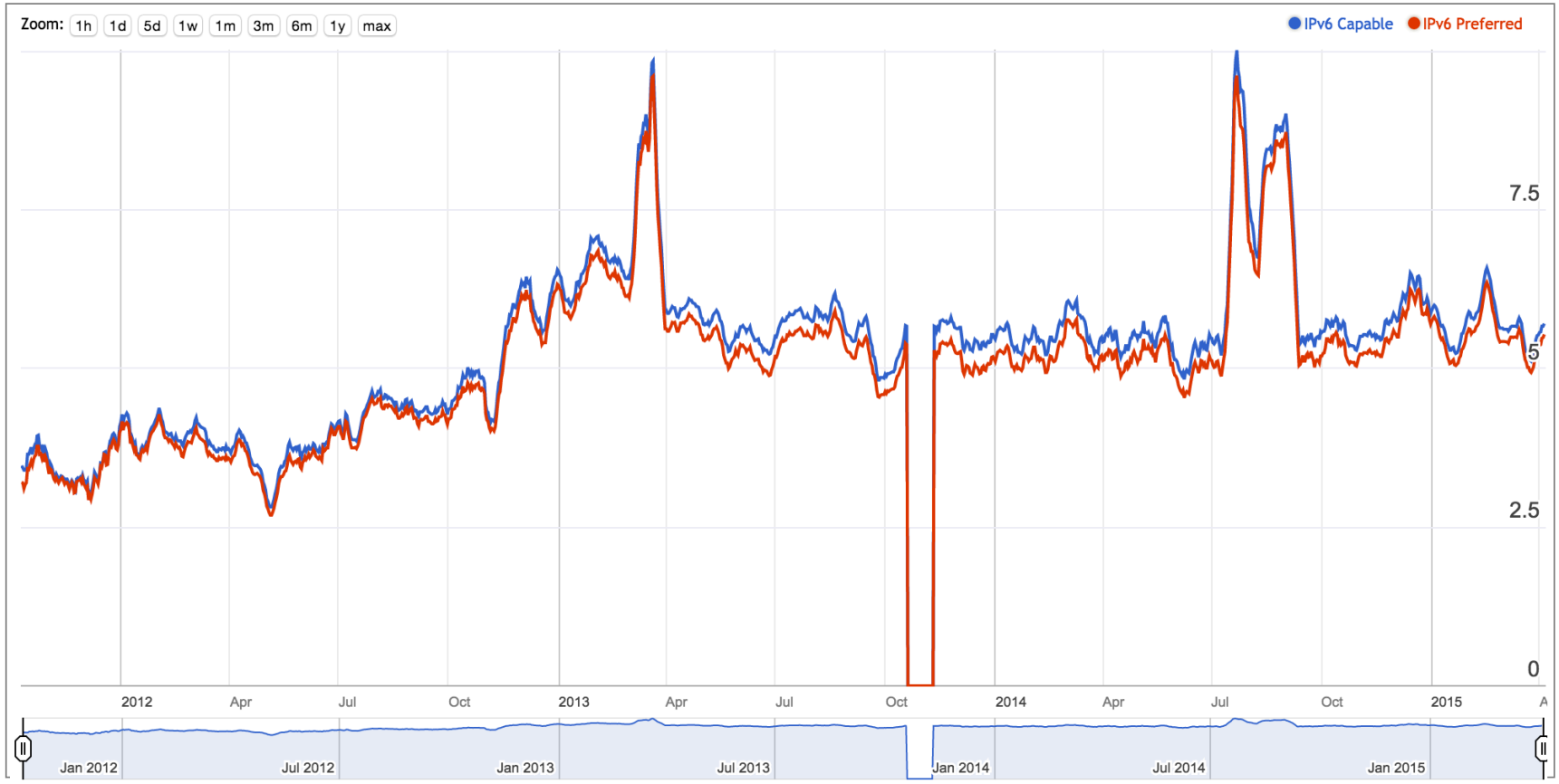
http://stats.labs.apnic.net/ipv6/GB?c=GB&x=1&p=1&r=1&w=10

CN We can’t measure properly



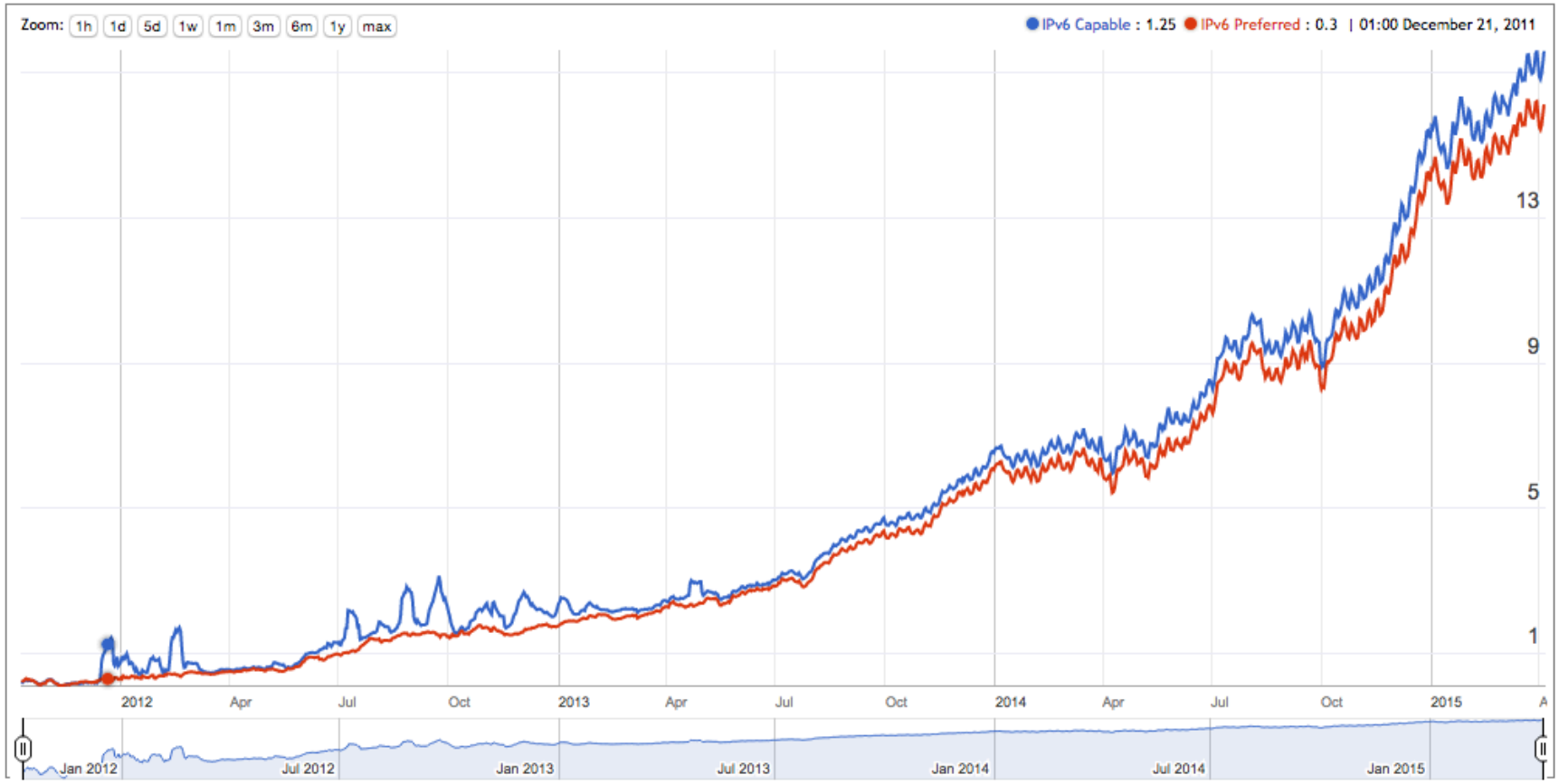
http://stats.labs.apnic.net/ipv6/CN?c=CN&x=1&p=1&r=1&w=10

FR Peaked early



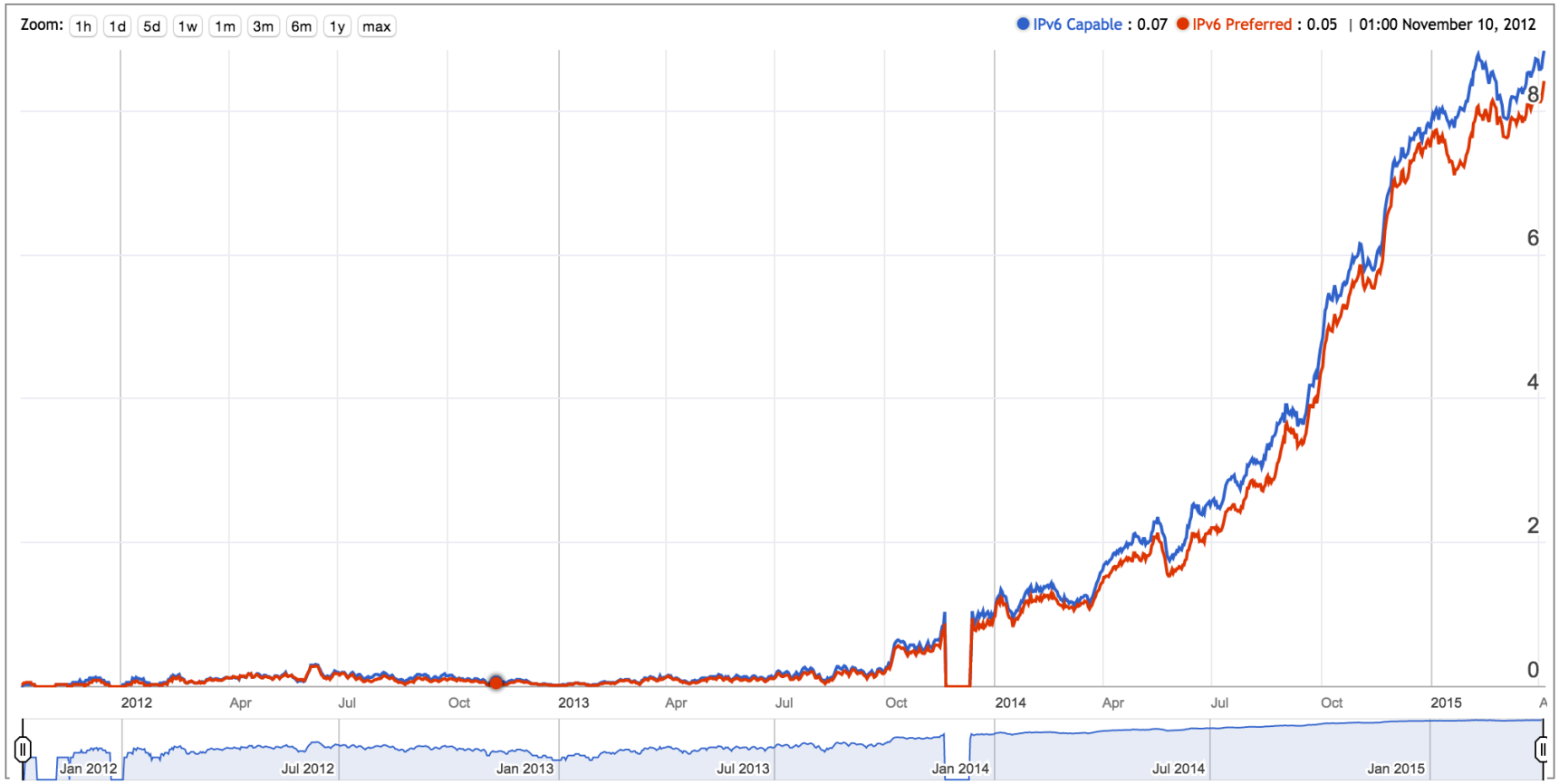
http://stats.labs.apnic.net/ipv6/FR?c=FR&x=1&p=1&r=1&w=10

US It’s on!



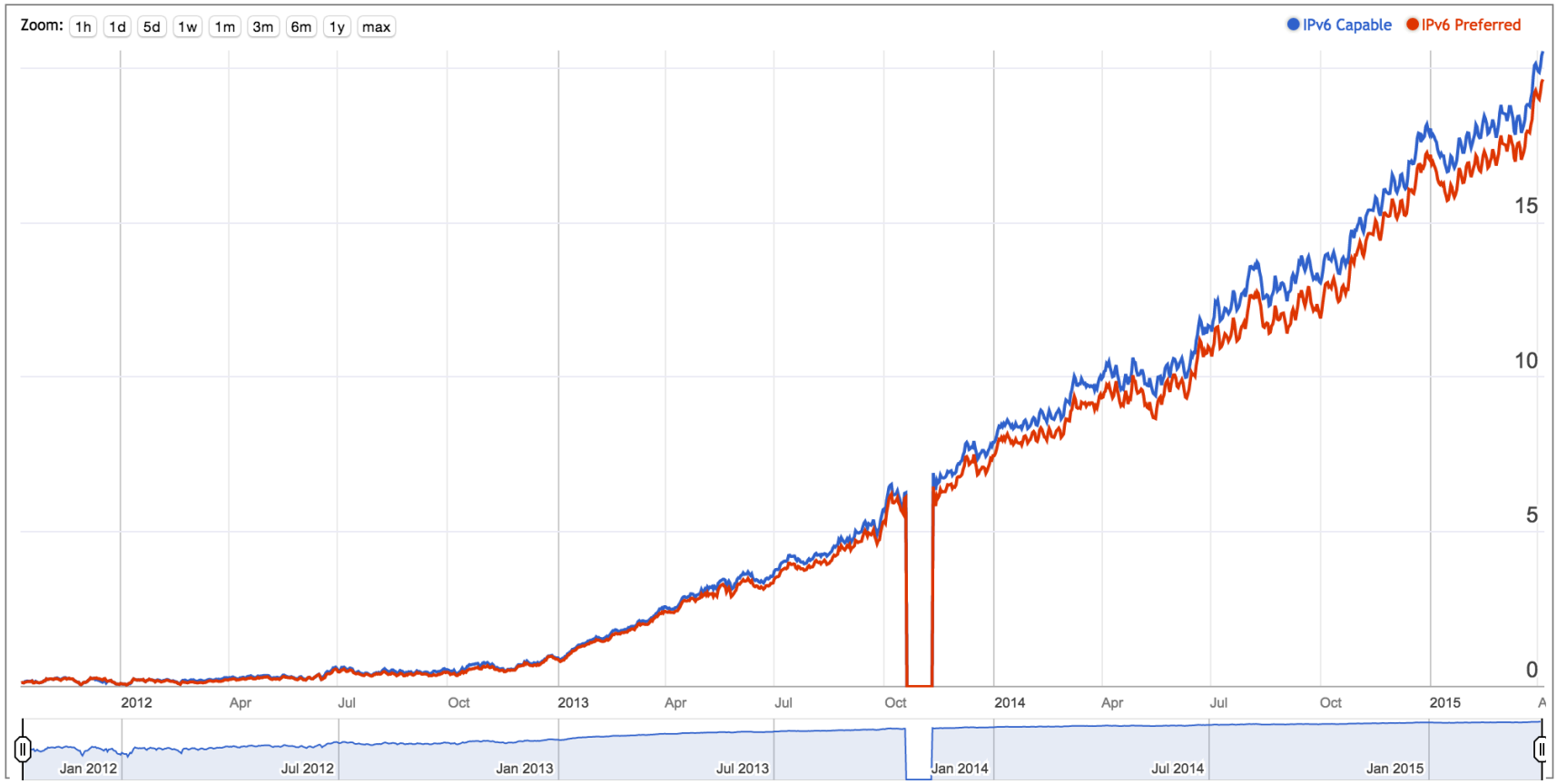
http://stats.labs.apnic.net/ipv6/US?c=US&x=1&p=1&r=1&w=10

MY It's on!



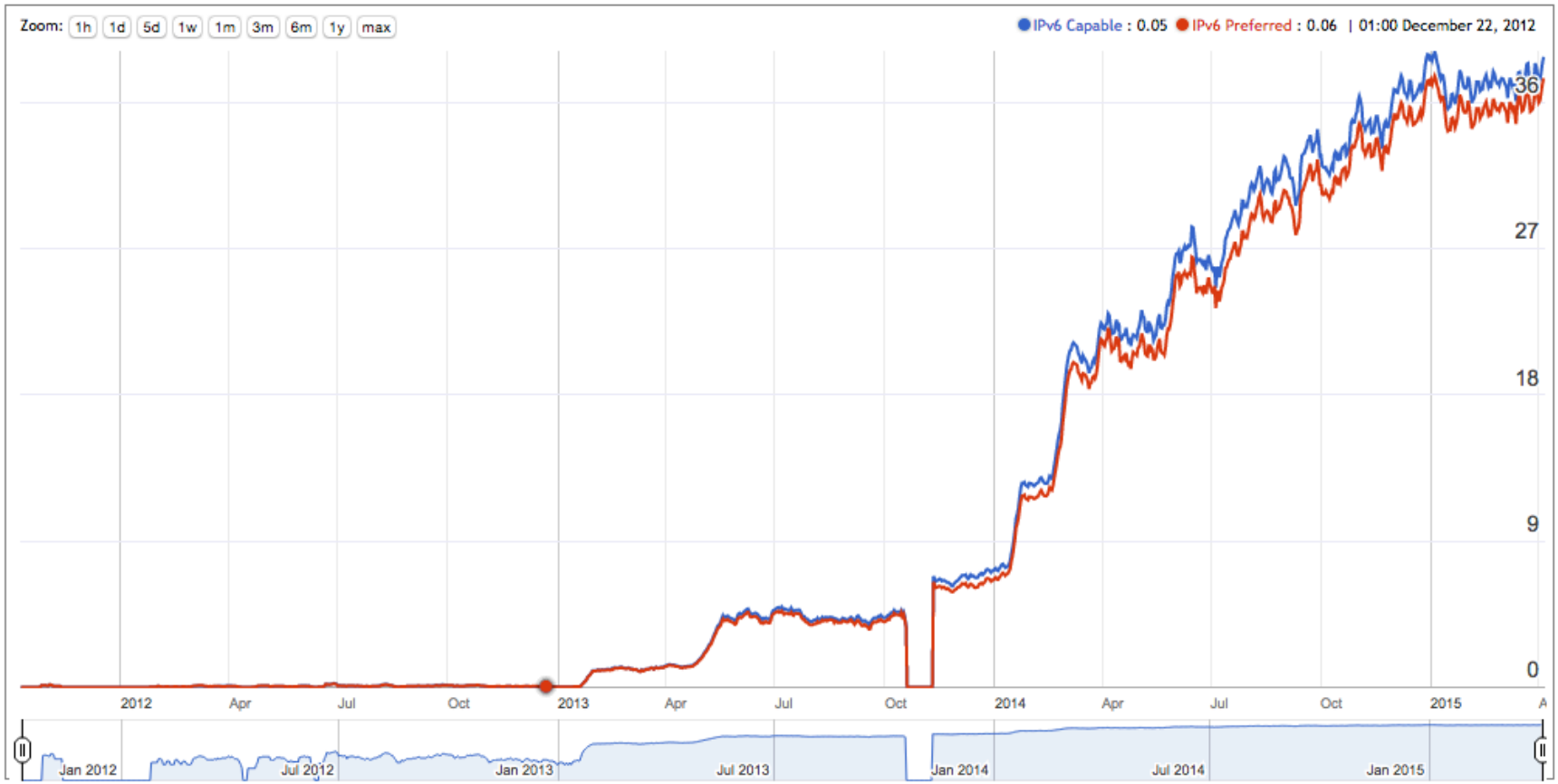
http://stats.labs.apnic.net/ipv6/MY?c=MY&x=1&p=1&r=1&w=10

DE It’s on!



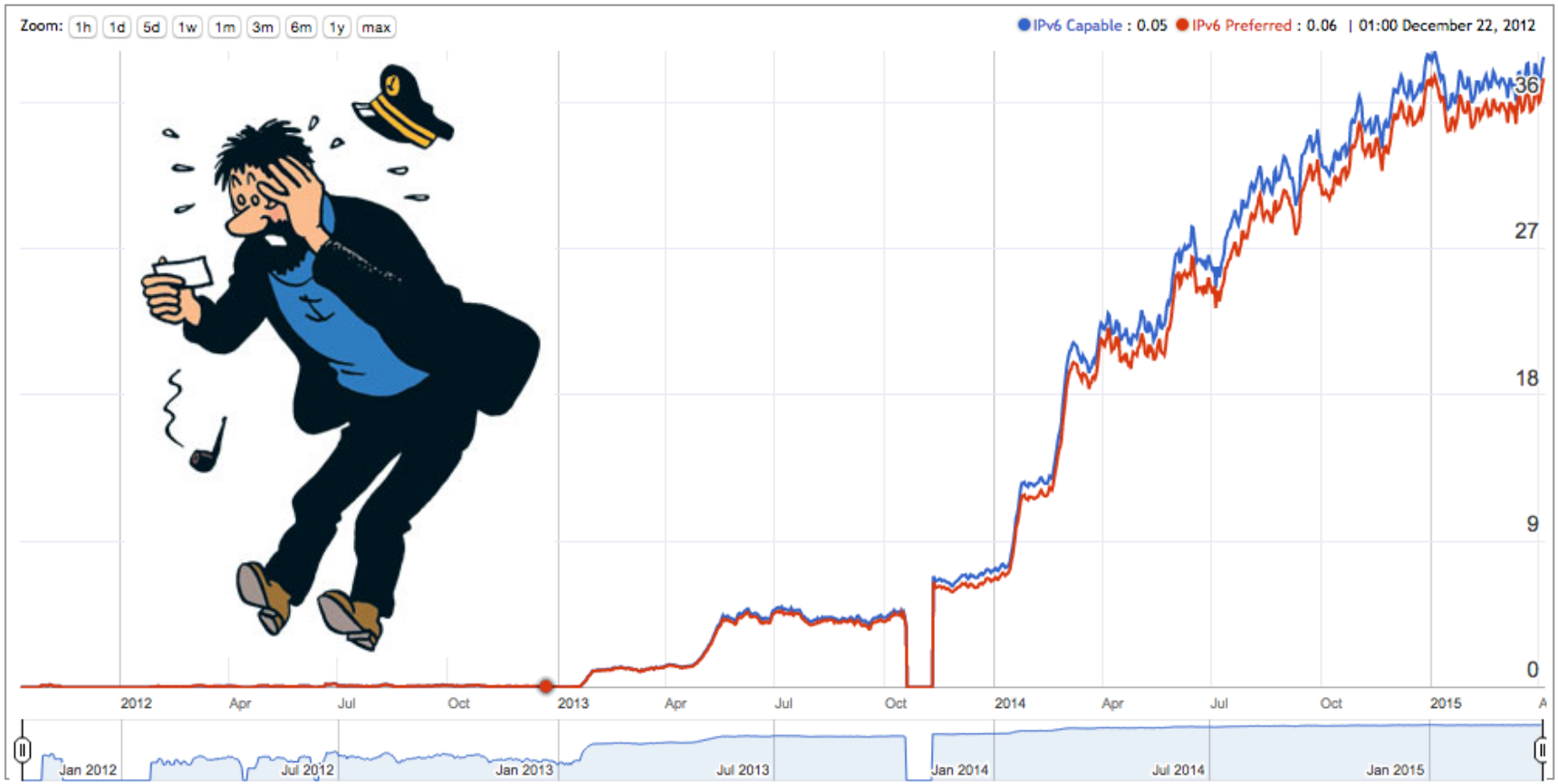
http://stats.labs.apnic.net/ipv6/DE?c=DE&x=1&p=1&r=1&w=10

BE It’s on!



http://stats.labs.apnic.net/ipv6/BE?c=BE&x=1&p=1&r=1&w=10

BE Tonnerre du Brest!!



http://stats.labs.apnic.net/ipv6/BE?c=BE&x=1&p=1&r=1&w=10

Whats actually happening out there?

- Drill down into an Economy, show the per-AS state.

Belgian IPv6 capability by ASN

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS5432	BELGACOM-SKYNET-AS BELGACOM S.A.	21.13%	20.15%	62129
AS6848	TELENET-AS Telenet N.V.	60.20%	57.92%	45029
AS12392	ASBRUTELE Brutele SC	66.11%	63.99%	17180
AS2611	BELNET BELNET	8.64%	8.28%	3321
AS47377	MES Mobistar SA	0.03%	0.03%	3204
AS9031	EDPNET EDPNET	1.07%	1.07%	845
AS25147	SOFIANET Ecoplast OOD	0.00%	0.00%	508
AS29587	SCHEDOM-AS Schedom Vof	0.00%	0.00%	453
AS9208	WIN WIN Autonomous System	0.00%	0.00%	350
AS48517	DESTINY-BACKBONE Destiny N.V	0.00%	0.00%	300

UK IPv6 Capability by ASN

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS15395	Rackspace Ltd.	38.03%	35.21%	71
AS20712	AS20712 Andrews Arnold Ltd	36.04%	35.14%	111
AS8943	JUMP Jump Networks Ltd.	17.54%	17.54%	57
AS15830	TELECITY-LON TELECITYGROUP INTERNATIONAL LIMITED	11.73%	10.92%	1108
AS202109	DIGITALOCEAN-ASN-2 Digital Ocean, Inc.	9.75%	0.00%	513
AS198864	QMW-AC-UK Queen Mary and Westfield College, University of London	6.02%	6.02%	133
AS62217	VOOSERVERS VooServers Ltd	5.88%	3.92%	51
AS786	JANET JISC Collections And Janet Limited	5.20%	4.78%	15370
AS58305	ZENIVA Zeniva Limited	4.23%	2.82%	71
AS12496	IDNET Infinity Developments Limited	3.66%	3.66%	82
AS39326	GOSCOMB-AS Goscomb Technologies Limited	2.87%	2.05%	244
AS29550	SIMPLYTRANSIT Simply Transit Ltd	2.41%	1.81%	166
AS31708	COREIX-UK-AS Coreix Ltd	2.08%	0.00%	96
AS42689	CABLECOM-AS Cablecom Networking Limited	2.02%	2.05%	3319
AS6067	ONYX Onyx Group	2.00%	2.00%	50
AS251	KAIAGLOBAL-AS Kaia Global Networks Ltd.	1.63%	0.77%	1042
AS35289	VERITAS-SOFTWARE Symantec Limited	1.49%	0.00%	67
AS1273	CW Cable and Wireless Worldwide plc	1.39%	1.34%	2092
AS42831	UKSERVERS-AS UK Dedicated Servers Limited	1.35%	0.00%	148
AS12703	PULSANT-AS Pulsant (Scotland) Ltd	1.22%	1.22%	82
AS25577	C4L-AS Connexions4London Ltd	1.06%	1.06%	94
AS20860	IOMART-AS Iomart	1.03%	0.17%	585
AS12519	FASTNETUK FastNet International Ltd	0.98%	0.98%	102
AS57230	ARIAWEBCO-AS Aria Web Development LLC	0.80%	0.00%	125
AS25180	EXPONENTIAL-E-AS Exponential-e Ltd	0.78%	0.78%	1149

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AS25180	EXPONENTIAL-E-AS Exponential-e Ltd	0.78%	0.78%	1149

HMMM. Lets sort this by Sample-Count….

Whats actually happening out there?

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS5089	NTL Virgin Media Limited	0.02%	0.03%	103564
AS2856	BT-UK-AS BT Public Internet Service	0.02%	0.00%	91170
AS5607	BSKYB-BROADBAND-AS British Sky Broadcasting Limited	0.04%	0.04%	76003
AS13285	OPALTELECOM-AS TalkTalk Communications Limited	0.01%	0.01%	37817
AS12576	ORANGE-PCS Orange Personal Communications Services	0.01%	0.01%	15789
AS786	JANET JISC Collections And Janet Limited	5.20%	4.78%	15370
AS9105	TISCALI-UK Tiscali UK	0.00%	0.00%	14581
AS6871	PLUSNET PlusNet PLC	0.03%	0.03%	10930
AS8220	COLT COLT Technology Services Group Limited	0.28%	0.26%	9212
AS43234	TT-AOLUK-AS TalkTalk Communications Limited	0.00%	0.00%	8264
AS35662	REDSTATION Redstation Limited	0.27%	0.25%	4811
AS60339	H3GUK Hutchison 3G UK Limited	0.00%	0.00%	3683
AS21321	ARETI-AS Areti Internet Ltd.	0.54%	0.16%	3673
AS42689	CABLECOM-AS Cablecom Networking Limited	2.02%	2.05%	3319
AS41230	ASK4 Ask4 Limited	0.00%	0.00%	2583
AS8928	INTEROUTE Interoute Communications Limited	0.04%	0.04%	2430
AS5400	BT British Telecommunications plc	0.04%	0.04%	2240
AS1273	CW Cable and Wireless Worldwide plc	1.39%	1.34%	2092
AS12390	KINGSTON-UK-AS KCOM Group Public Limited Company	0.00%	0.00%	2079
AS30969	ZOL-AS Zimbabwe OnLine (Private) Ltd.	0.00%	0.00%	1813
AS13037	ZEN-AS Zen Internet Ltd	0.13%	0.13%	1509
AS29302	HSI-EUROPE Hosting Services Inc	0.07%	0.07%	1375
AS25180	EXPONENTIAL-E-AS Exponential-e Ltd	0.78%	0.78%	1149
AS15830	TELECITY-LON TELECITYGROUP INTERNATIONAL LIMITED	11.73%	10.92%	1108
AS4589	EASYNET Easynet Global Services	0.09%	0.09%	1078

Whats actually happening out there?

- Hmm. So.. If we rank by sample size, and we get an approximation of market share by random sample, then what if we back-apply this to the ITU data on Internet users, and the World Population stats?
- Geoff makes:
  - http://stats.labs.apnic.net/cgi-bin/aspop?c=US

Whats actually happening out there?

Visible ASNs: Customer Populations (Est.)

Rank	ASN	AS Name	CC	Users (est.)	% of country	% of Internet	Samples
1	AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	US	43483629	19.24	1.8885	580917
2	AS7018	ATT-INTERNET4 - ATT Services, Inc.	US	21760565	9.63	0.945	290709
3	AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business	US	16938732	7.5	0.7356	226292
4	AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	US	9212136	4.08	0.4001	123069
5	AS20115	CHARTER-NET-HKY-NC - Charter Communications	US	8323476	3.68	0.3615	111197
6	AS209	ASN-QWEST - Qwest Communications Company, LLC	US	6351163	2.81	0.2758	84848
7	AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	US	5450377	2.41	0.2367	72814
8	AS6128	CABLE-NET-1 - Cablevision Systems Corp.	US	5348502	2.37	0.2323	71453
9	AS10796	SCRR-10796 - Time Warner Cable Internet LLC	US	5176339	2.29	0.2248	69153
10	AS3549	LVLT-3549 - Level 3 Communications, Inc.	US	4454527	1.97	0.1935	59510
11	AS11351	RR-NYSREGION-ASN-01 - Time Warner Cable Internet LLC	US	3389962	1.5	0.1472	45288
12	AS11427	SCRR-11427 - Time Warner Cable Internet LLC	US	3292278	1.46	0.143	43983
13	AS11426	SCRR-11426 - Time Warner Cable Internet LLC	US	3228578	1.43	0.1402	43132
14	AS12271	SCRR-12271 - Time Warner Cable Internet LLC	US	3100279	1.37	0.1346	41418
15	AS33363	BHN-TAMPA - BRIGHT HOUSE NETWORKS, LLC	US	3047657	1.35	0.1324	40715
16	AS6939	HURRICANE - Hurricane Electric, Inc.	US	2731850	1.21	0.1186	36496
17	AS5650	FRONTIER-FRTR - Frontier Communications of America, Inc.	US	2424277	1.07	0.1053	32387
18	AS7029	WINDSTREAM - Windstream Communications Inc	US	2352044	1.04	0.1021	31422
19	AS19108	SUDDENLINK-COMMUNICATIONS - Suddenlink Communications	US	1800748	0.8	0.0782	24057
20	AS6389	BELLSOUTH-NET-BLK - BellSouth.net Inc.	US	1758980	0.78	0.0764	23499

Whats actually happening out there?

Visible ASNs: Customer Populations (Est.)

Rank	ASN	AS Name	CC	Users (est.)	% of country	% of Internet	Samples
1	AS1221	ASN-TELSTRA Telstra Pty Ltd	AU	6361492	33.62	0.2763	80572
2	AS7545	TPG-INTERNET-AP TPG Telecom Limited	AU	3058446	16.16	0.1328	38737
3	AS4804	MPX-AS Microplex PTY LTD	AU	2616934	13.83	0.1137	33145
4	AS4739	INTERNODE-AS Internode Pty Ltd	AU	1319244	6.97	0.0573	16709
5	AS4802	ASN-IINET iiNet Limited	AU	900471	4.76	0.0391	11405
6	AS38285	M2TELECOMMUNICATIONS-AU M2 Telecommunications Group Ltd	AU	764276	4.04	0.0332	9680
7	AS9443	INTERNETPRIMUS-AS-AP Primus Telecommunications	AU	382769	2.02	0.0166	4848
8	AS10143	EXETEL-AS-AP Exetel Pty Ltd	AU	245152	1.3	0.0106	3105
9	AS7575	AARNET-AS-AP Australian Academic and Reasearch Network (AARNet)	AU	223992	1.18	0.0097	2837
10	AS2764	AAPT AAPT Limited	AU	156881	0.83	0.0068	1987
11	AS18291	VFAU-NET-AS VODAFONE AUSTRALIA PTY LIMITED Public Autonomous System Number	AU	129011	0.68	0.0056	1634
12	AS9822	AMNET-AU-AP Amnet IT Services Pty Ltd	AU	104851	0.55	0.0046	1328
13	AS7583	MESSAGELABS-AP MessageLabs - Now Part of Symantec	AU	104219	0.55	0.0045	1320
14	AS7474	OPTUSCOM-AS01-AU SingTel Optus Pty Ltd	AU	103350	0.55	0.0045	1309
15	AS38657	WAWB-AS-AP WAWB Pty Ltd	AU	70663	0.37	0.0031	895
16	AS7718	TRANSACT-SDN-AS TransACT Capital Communications Pty Limited	AU	69163	0.37	0.003	876
17	AS7598	WEBSENSE-HOSTED-APAC Websense Hosted Security - AsiaPac region	AU	68848	0.36	0.003	872
18	AS24093	BIGAIR-AP BIGAIR. Multihoming ASN	AU	60399	0.32	0.0026	765
19	AS133125	PUBLICISGROUPE-AS-AP PG Lion ReSources Aust Pty Ltd	AU	59294	0.31	0.0026	751
20	AS24313	NSW-DET-AS NSW Department of Education and Training	AU	54794	0.29	0.0024	694

…and now DNSSEC

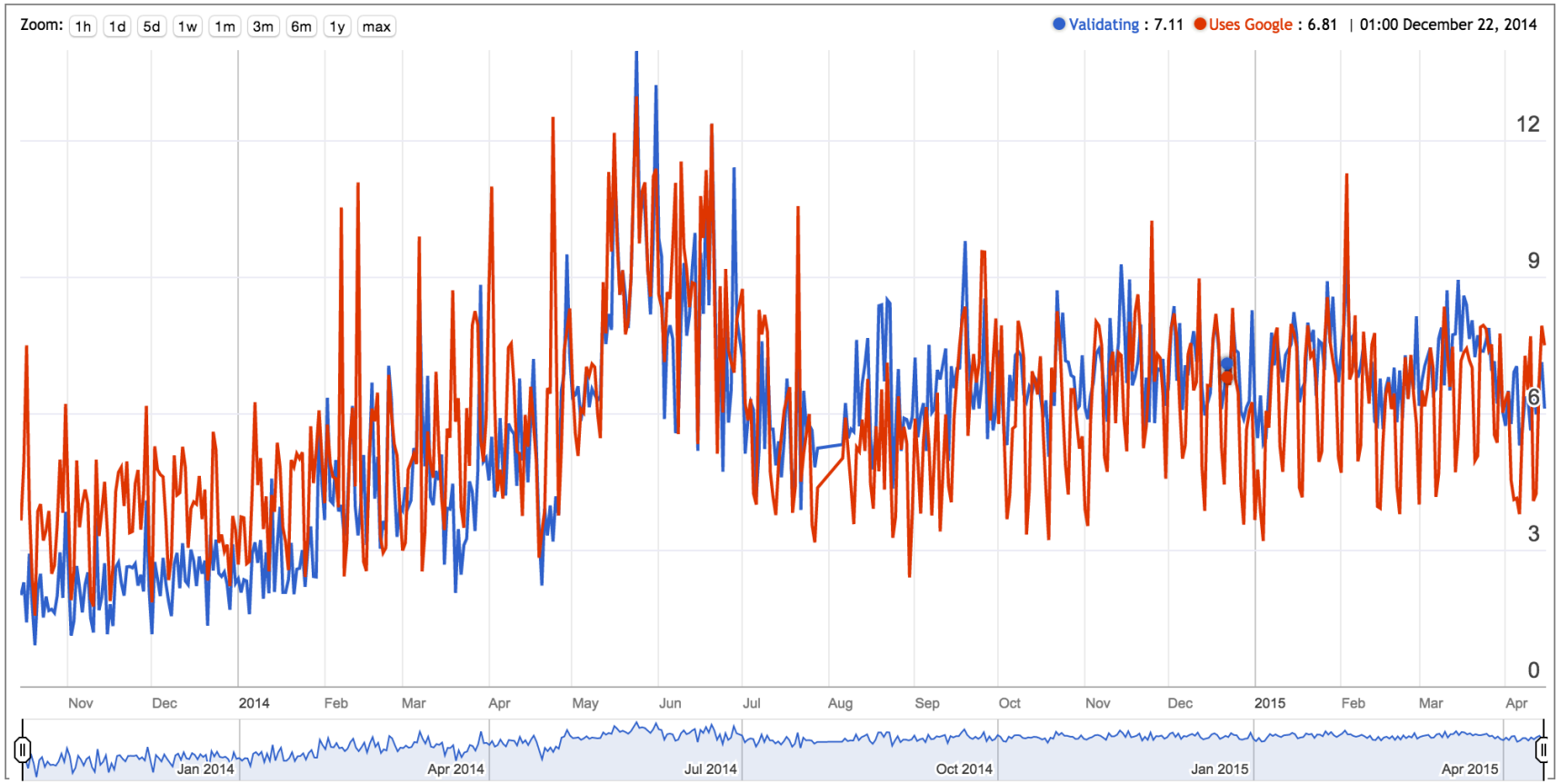
…and now DNSSEC

- http://stats.labs.apnic.net/dnssec/NL

- Present users with DNSSEC signed names
  - Well signed (can be validated)
  - Badly signed (provably invalid)

- If they go to the badly signed, they aren't validating, or include non-validating resolvers in their configuration
- If they fetch DNS "DS" and "DNSKEY" records of the zone, we know they are trying to validate
  - Requires a large (500,000) space of zones, to avoid cache hits inside the TTL of the zone fetch of DS/DNSKEY
  - Moving to random unique sign-on-the-fly zones

…and now DNSSEC



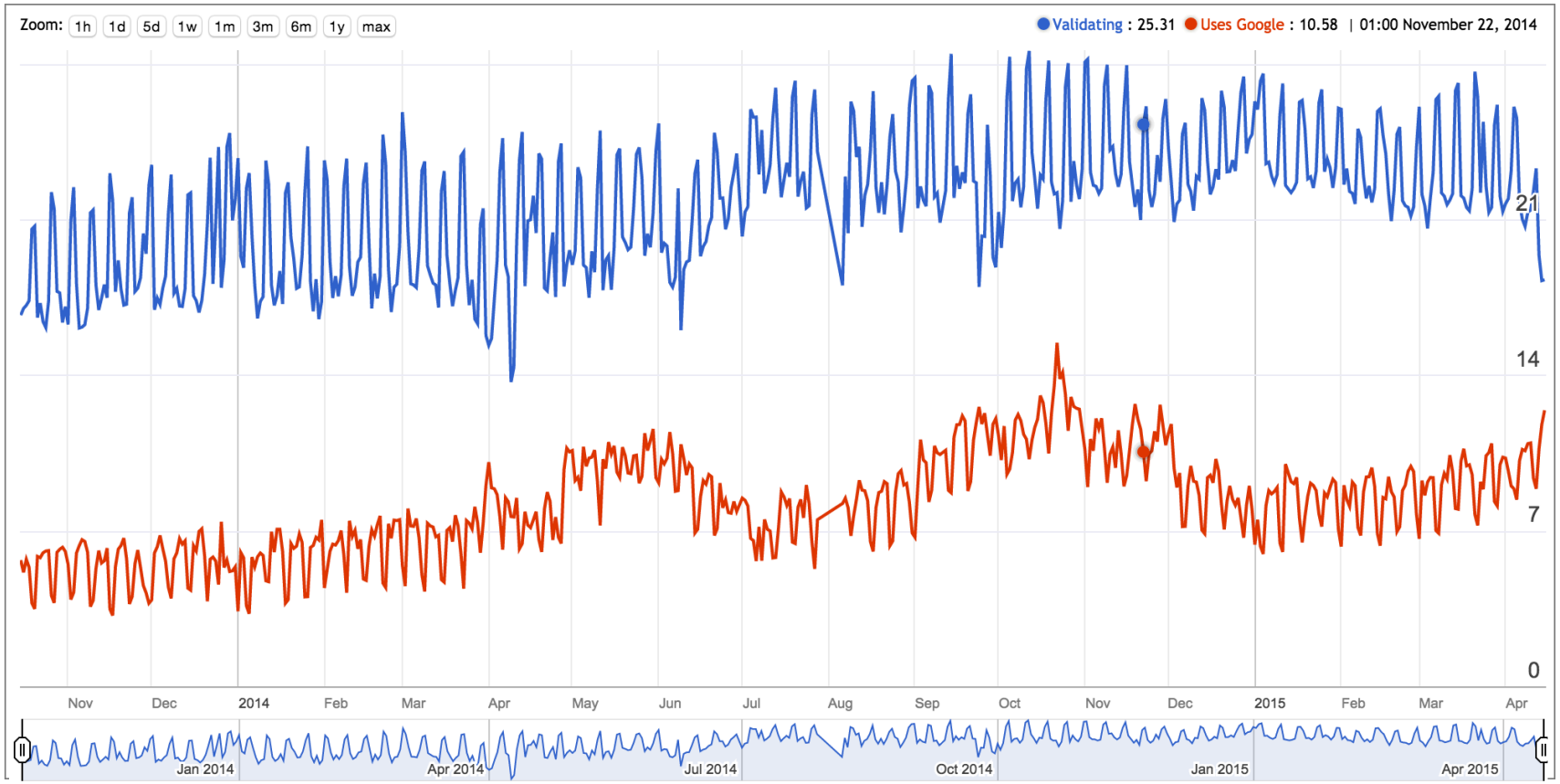
DNSSEC for the UK

ASN	AS Name	DNSSEC Validates	Uses Google PDNS	Samples
AS56460	O2-WIFI-AS Telefonica UK Limited	98.41%	9.52%	63
AS42689	CABLECOM-AS Cablecom Networking Limited	90.96%	2.00%	2645
AS34931	AWARESOFT Awareness Software Limited	89.00%	100.00%	100
AS197520	UNIONCOM UnionCOM Ltd	88.18%	96.28%	296
AS29009	UKBROADBAND-AS UK Wireless Broadband Network	87.96%	6.48%	108
AS251	KAIAGLOBAL-AS Kaia Global Networks Ltd.	87.78%	1.24%	966
AS50648	UAINET-AS PE UAinet	87.25%	2.50%	839
AS6871	PLUSNET PlusNet PLC	86.08%	3.66%	9022
AS62059	CONWAYBB16-AS Turbo Leisure Ltd	80.00%	92.86%	70
AS20712	AS20712 Andrews Arnold Ltd	75.00%	17.50%	80
AS42705	TALIA Talia provides VSAT network and hosting services worldwide.	65.91%	30.30%	132
AS31290	MURPHX-UK-AS Daisy Communications Ltd	57.46%	37.46%	590
AS2830	MCI-DUAL-HOMED-CUSTOMERS Verizon Nederland B.V.	53.01%	23.99%	813
AS49158	WIFINITY Wifinity Ltd	51.72%	70.11%	87
AS15412	FLAG-AS Flag Telecom Global Internet AS	50.00%	78.57%	294
AS8468	ENTANET ENTANET International Limited	47.37%	40.18%	570
AS29550	SIMPLYTRANSIT Simply Transit Ltd	46.38%	85.51%	138
AS39356	AVANTI-UK-AS Avanti Broadband Ltd.	46.10%	52.93%	410
AS44611	TALKINTERNET Talk Internet	43.84%	60.27%	73
AS5413	AS5413 Daisy Communications Ltd	43.11%	25.74%	610
AS35017	SWIFTWAY-AS Swiftway Sp. z o.o.	41.28%	62.39%	109
AS58305	ZENIVA Zeniva Limited	38.96%	98.70%	77
AS8513	SKYVISION SkyVision Global Networks Ltd	34.00%	63.02%	603
AS12519	FASTNETUK FastNet International Ltd	32.63%	55.79%	95
AS57230	ARIAWEBCO-AS Aria Web Development LLC	31.52%	72.83%	92
AS29669	GEMEDICAL GE Medical Systems Societe en Commandite Simple	29.87%	1.30%	77
AS42973	MANCHESTERMETRONET Metronet (UK) Limited	29.67%	38.46%	182
AS24916	ORBITAL-ASN OrbitalNet Ltd	26.26%	37.37%	99
AS35662	REDSTATION Redstation Limited	26.02%	34.39%	4150
AS44369	EMBC-EMPSN-AS emPSN Services Limited	25.00%	17.50%	80
AS15830	TELECITY-LON TELECITYGROUP INTERNATIONAL LIMITED	23.45%	7.32%	1544

DNSSEC for the UK

ASN	AS Name	DNSSEC Validates	Uses Google PDNS	Samples
AS5089	NTL Virgin Media Limited	2.58%	3.25%	85418
AS2856	BT-UK-AS BT Public Internet Service	2.13%	3.84%	75187
AS5607	BSKYB-BROADBAND-AS British Sky Broadcasting Limited	0.97%	1.16%	62615
AS13285	OPALTELECOM-AS TalkTalk Communications Limited	1.45%	1.72%	30988
AS12576	ORANGE-PCS Orange Personal Communications Services	1.09%	1.60%	12967
AS9105	TISCALI-UK Tiscali UK	1.82%	2.35%	11957
AS786	JANET JISC Collections And Janet Limited	13.85%	7.87%	11839
AS6871	PLUSNET PlusNet PLC	86.08%	3.66%	9022
AS8220	COLT COLT Technology Services Group Limited	7.00%	25.64%	8199
AS43234	TT-AOLUK-AS TalkTalk Communications Limited	1.03%	1.46%	6920
AS35662	REDSTATION Redstation Limited	26.02%	34.39%	4150
AS21321	ARETI-AS Areti Internet Ltd.	0.03%	1.00%	3505
AS60339	H3GUK Hutchison 3G UK Limited	2.13%	4.42%	3097
AS42689	CABLECOM-AS Cablecom Networking Limited	90.96%	2.00%	2645
AS5400	BT British Telecommunications plc	15.10%	21.48%	2239
AS8928	INTEROUTE Interoute Communications Limited	13.49%	28.87%	2165
AS41230	ASK4 Ask4 Limited	1.57%	2.67%	1907
AS1273	CW Cable and Wireless Worldwide plc	2.95%	8.52%	1796
AS44444	WEBSENSE-HOSTED-EMEA-AS Websense Hosted Security Network	0.79%	9.84%	1768
AS29302	HSI-EUROPE Hosting Services Inc	8.39%	13.13%	1729
AS12390	KINGSTON-UK-AS KCOM Group Public Limited Company	2.72%	4.46%	1728
AS30969	ZOL-AS Zimbabwe OnLine (Private) Ltd.	6.72%	18.72%	1651
AS15830	TELECITY-LON TELECITYGROUP INTERNATIONAL LIMITED	23.45%	7.32%	1544
AS35788	WEBSENSE-HOSTED-AMER-AS Websense Hosted Security Network	3.34%	16.36%	1528
AS13037	ZEN-AS Zen Internet Ltd	7.97%	20.15%	1092
AS251	KAIAGLOBAL-AS Kaia Global Networks Ltd.	87.78%	1.24%	966
AS25180	EXPONENTIAL-E-AS Exponential-e Ltd	10.82%	35.07%	961
AS13213	UK2NET-AS UK2 - Ltd	16.33%	24.97%	949
AS15421	Internap European Autonomous System	1.12%	6.17%	891
AS4589	EASYNET Easynet Global Services	12.43%	29.69%	869
AS21345	SYMANTEC-EU MessageLabs Limited	0.81%	9.15%	863

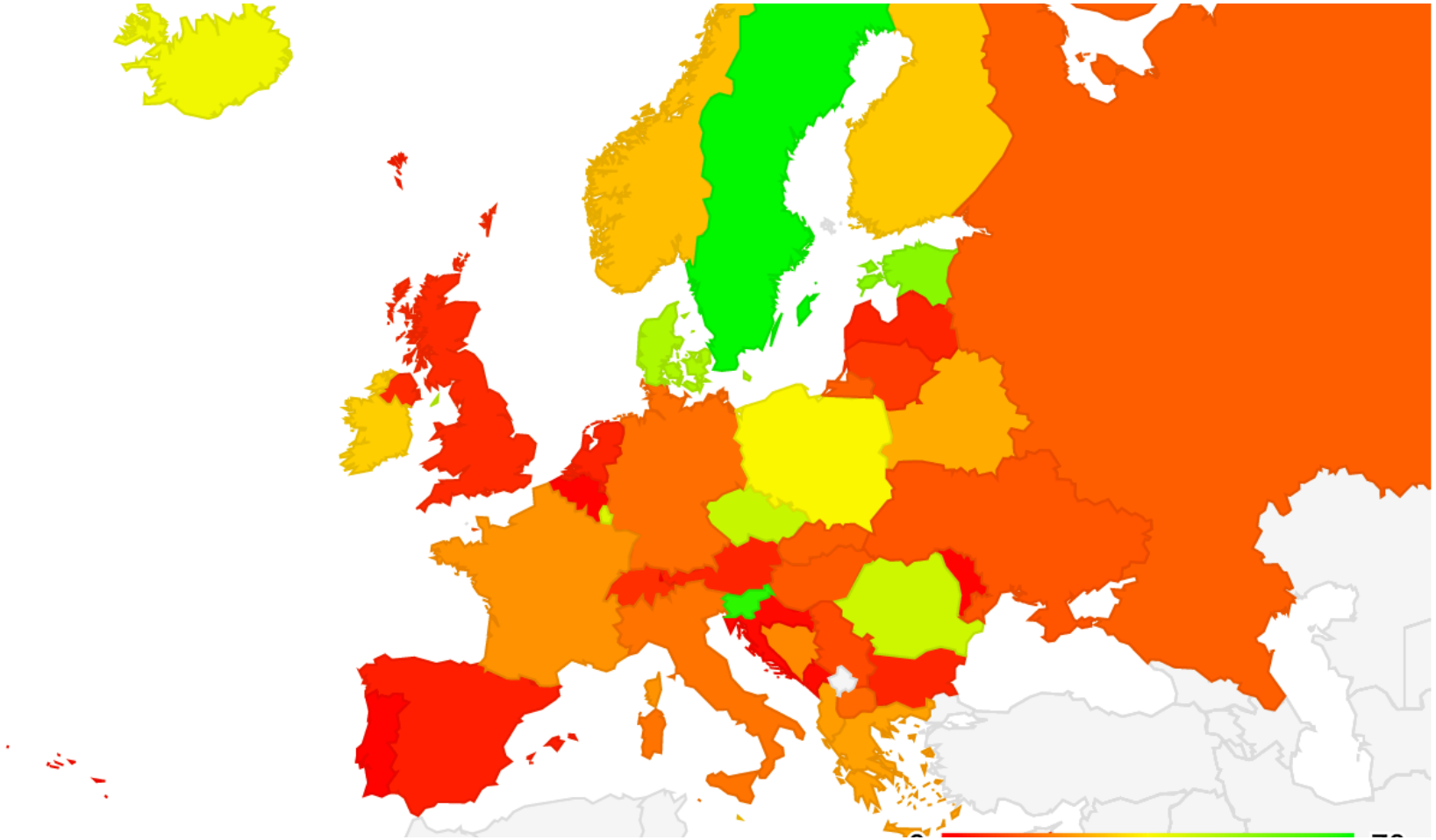
DNSSEC for the US



DNSSEC for the US

ASN	AS Name	DNSSEC Validates	Uses Google PDNS	Samples
AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	85.07%	4.13%	381565
AS7018	ATT-INTERNET4 - ATT Services, Inc.	2.12%	3.74%	196187
AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business	2.03%	3.29%	142570
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	2.67%	4.99%	81756
AS20115	CHARTER-NET-HKY-NC - Charter Communications	3.53%	5.60%	73617
AS209	CENTURYLINK-US-LEGACY-QWEST - Qwest Communications Company, LLC	3.07%	5.45%	56946
AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	3.14%	4.80%	49013
AS3549	LVLT-3549 - Level 3 Communications, Inc.	20.49%	42.94%	46741
AS10796	SCRR-10796 - Time Warner Cable Internet LLC	3.30%	4.53%	46004
AS6128	CABLE-NET-1 - Cablevision Systems Corp.	83.00%	3.91%	42728
AS11427	SCRR-11427 - Time Warner Cable Internet LLC	3.71%	5.54%	31821
AS11426	SCRR-11426 - Time Warner Cable Internet LLC	3.95%	4.19%	28352
AS11351	RR-NYSREGION-ASN-01 - Time Warner Cable Internet LLC	2.68%	3.93%	28300
AS33363	BHN-TAMPA - BRIGHT HOUSE NETWORKS, LLC	2.93%	3.95%	24785
AS12271	SCRR-12271 - Time Warner Cable Internet LLC	4.10%	4.75%	24038
AS6939	HURRICANE - Hurricane Electric, Inc.	7.12%	64.12%	22468
AS5650	FRONTIER-FRTR - Frontier Communications of America, Inc.	2.73%	4.47%	21345
AS7029	WINDSTREAM - Windstream Communications Inc	4.95%	11.41%	20322
AS15169	GOOGLE - Google Inc.	0.95%	99.95%	18112
AS19108	SUDDENLINK-COMMUNICATIONS - Suddenlink Communications	5.85%	7.69%	17017
AS30036	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom Communications Corp	3.45%	5.75%	14693
AS6389	BELLSOUTH-NET-BLK - BellSouth.net Inc.	2.12%	4.23%	13277
AS14618	AMAZON-AES - Amazon.com, Inc.	0.29%	1.10%	11542
AS18747	IFX18747 - IFX Corporation	18.46%	34.35%	11367
AS174	COGENT-174 - Cogent Communications	20.79%	35.64%	10825
AS12083	WOW-INTERNET - WideOpenWest Finance LLC	3.08%	4.95%	10765
AS23520	COLUMBUS-NETWORKS - Columbus Networks USA, Inc.	11.97%	38.49%	10208
AS22561	CENTURYLINK-LEGACY-LIGHTCORE - CenturyTel Internet Holdings, Inc.	3.16%	4.33%	9846
AS25605	SCANSAFE - Cisco Systems Ironport Division	2.50%	16.59%	8878
AS4323	TWTC - tw telecom holdings, inc.	6.49%	26.32%	8398

DNSSEC for Europe



DNSSEC for Europe

CC	Country	DNSSEC Validates	Uses Google PDNS	Samples	Weight	Weighted Samples
SE	Sweden, Northern Europe, Europe	69.31%	6.97%	95753	1.67	159518
SI	Slovenia, Southern Europe, Europe	65.74%	6.92%	107638	0.24	26277
EE	Estonia, Northern Europe, Europe	53.17%	4.54%	45374	0.39	17811
DK	Denmark, Northern Europe, Europe	47.37%	7.53%	49021	1.9	93030
CZ	Czech Republic, Eastern Europe, Europe	43.81%	16.34%	288727	0.48	138791
RO	Romania, Eastern Europe, Europe	42.41%	7.67%	983077	0.19	186937
LU	Luxembourg, Western Europe, Europe	39.92%	6.10%	10430	0.85	8844
IS	Iceland, Northern Europe, Europe	37.05%	4.99%	10419	0.54	5637
PL	Poland, Eastern Europe, Europe	35.20%	12.05%	677073	0.64	431862
IE	Ireland, Northern Europe, Europe	29.80%	8.84%	83610	0.77	64222
FI	Finland, Northern Europe, Europe	28.44%	3.03%	71230	1.22	86808
MT	Malta, Southern Europe, Europe	27.55%	4.18%	28763	0.18	5163
NO	Norway, Northern Europe, Europe	27.17%	4.22%	56469	1.5	84744
GI	Gibraltar, Southern Europe, Europe	26.86%	57.79%	1374	0.26	361
BY	Belarus, Eastern Europe, Europe	24.17%	6.94%	202868	0.43	87345
GR	Greece, Southern Europe, Europe	22.80%	2.61%	515920	0.22	115890
AL	Albania, Southern Europe, Europe	22.54%	24.14%	100943	0.33	33353
FR	France, Western Europe, Europe	20.89%	3.43%	842037	1.12	939967
BA	Bosnia and Herzegovina, Southern Europe, Europe	19.44%	11.96%	264206	0.17	45091
IT	Italy, Southern Europe, Europe	16.58%	20.04%	607289	1.02	621995
DE	Germany, Western Europe, Europe	15.66%	4.99%	318091	3.89	1237312
MK	The former Yugoslav Republic of Macedonia, Southern Europe, Europe	15.15%	10.60%	105130	0.2	20827
RU	Russian Federation, Eastern Europe, Europe	13.66%	10.52%	1631046	0.93	1517925
SK	Slovakia, Eastern Europe, Europe	13.54%	16.05%	141950	0.53	74947
HU	Hungary, Eastern Europe, Europe	12.83%	6.04%	469059	0.27	125144

What kinds of questions?

- Dualstack
  - Provide a DNS name backed by IPv4, IPv6
    - Which does the client use to fetch? Indicates dualstack preference, can be influenced by 'happy eyeballs'
    - Can correlate to the RTT of simultaneously opened IPv4 and IPv6 connections in TCPdump, with weblog of the one which goes to completion
- V6 only
  - Provide a DNS name with only AAAA record
    - If client doesn't fetch, highly indicative of no IPv6
- IPv6 Literal
  - Bypasses gethostbyname() limits in IPv6 (windows) and can force out more IPv6 capable hosts behind tunnels
- RTT comparisons
  - Use first 'syn' bit time in tcpdump, compare IPv4, IPv6

What kinds of questions?

- DNS on IPv6
  - Nameserver behind 1x1 experiment
    - hosted on dualstack, IPv6 only
    - What transport DNS uses is disjoint from client DNS capability
- DNSSEC enabled
  - Create DNS zones will dnssec signed, badly signed zones
    - Test who will follow into a badly signed DNS label
    - DNSSEC already at 20% worldwide
  - Test new DNSSEC algorithms
    - EC-DSA (75% unsupported)
- Test large DNS packets
  - Failover to TCP, effects of 512 byte firewall rules on DNS UDP

What kinds of questions?

- IP prefix reachability
  - Home 1x1, dns on prefix under test
  - Track reachability of clients under different BGP policy
    - Presence/absence of Internet Routing Registry Object
    - Use of Routing PKI attestations
  - Used to test unallocated ‘dirty’ IPv4 address blocks during final address policy initiation

Conclusions

- APNIC believes it can reliably measure end-user IPv6 and DNS capability independently of the ISP, both within an economy, and inter-economy
- We believe we have insights into market share, and other intra-economy behaviours not otherwise measured
- We're committed to a long-term measurement and will continue to present data, results

- http://stats.labs.apnic.net/ (DNSSEC and IPv6)

- Explore the data!

Conclusions

- We are aware of systematic bias in our system
  - We can't measure mobile devices adequately
  - We over sample some economies
  - We under sample interesting economies in the developing internet
  - We can't measure into firewalled economies yet
- We think we have some simple adjustments
  - For sample skew, and population estimates
  - But a lot more work is needed

Informing Address Policy

- Wide-scale deployment of IPv6 exists
  - There is no obvious shortage of IPv6 addresses by economy, or ISP
  - There appears to be good global coverage
  - Most people are within 1 or 2 ASN of Native IPv6
  - Most ISPs have IPv6 in their core
- The problem is in the CPE
  - Deploying IPv6 into the customer net is expensive
  - We may need regulatory (incentives?) involvement

Informing Address Policy

- Uniform behaviour is vanishing from the net
  - Segmenting by capital investment opportunities, economic conditions
  - Effects of national policy (firewalls, filters)
  - Re-monopolization risks in the CGN (vertical market capture)
- We don’t want a 2-tier internet
  - We’re probably faced with an n-tier internet
  - Dual Stack IPv4/IPv6 presents issues

Informing Address Policy

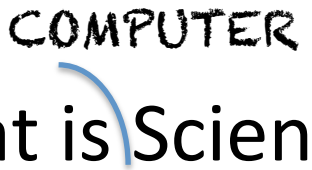
- Wide-scale deployment of CGN exists
  - Its cheap (relatively) and effective
  - Vendors want to sell the boxes
  - Unlike IPv6, few end user visible consequences
    - Except its not end-to-end clean
- We're just about to hit ARIN run-out
  - What the IPv4 future looks like isn't clear

A word for our sponsors

- Thanks to
  - the Internet Society
  - Google
  - ISC
  - RIPE NCC
  - Comcast

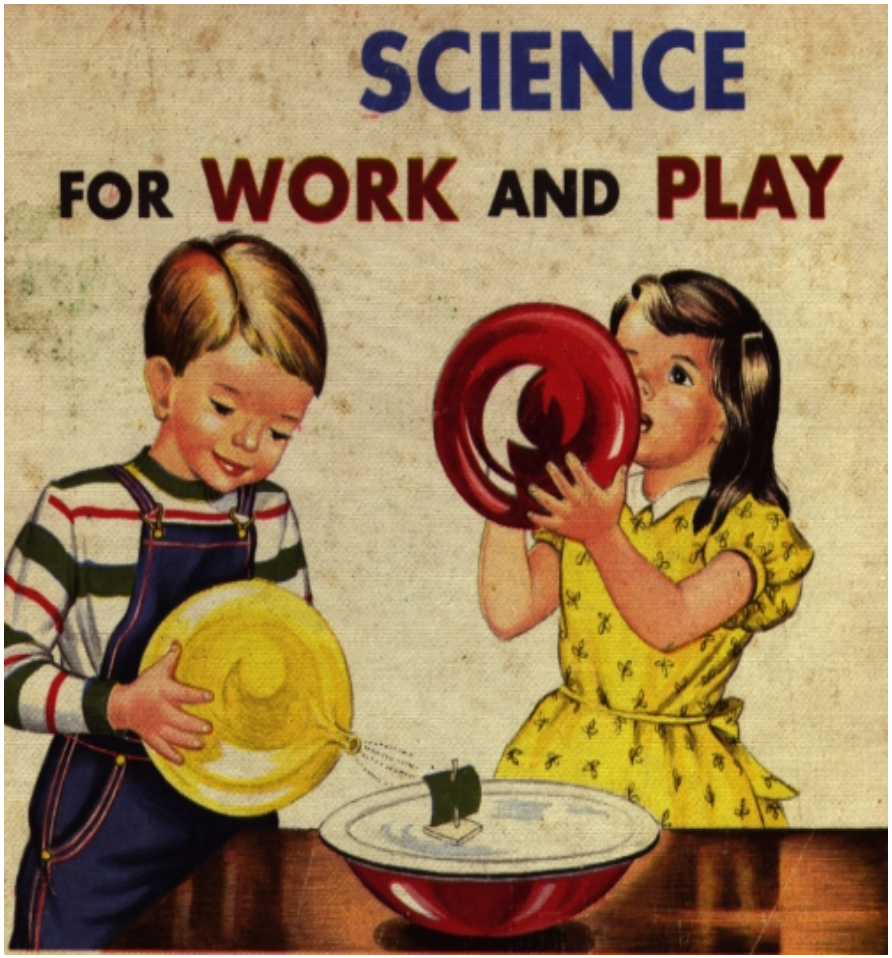
- For funding, platform support, collaboration

APNIC Research & Development



What is Science for?

APNIC Research & Development



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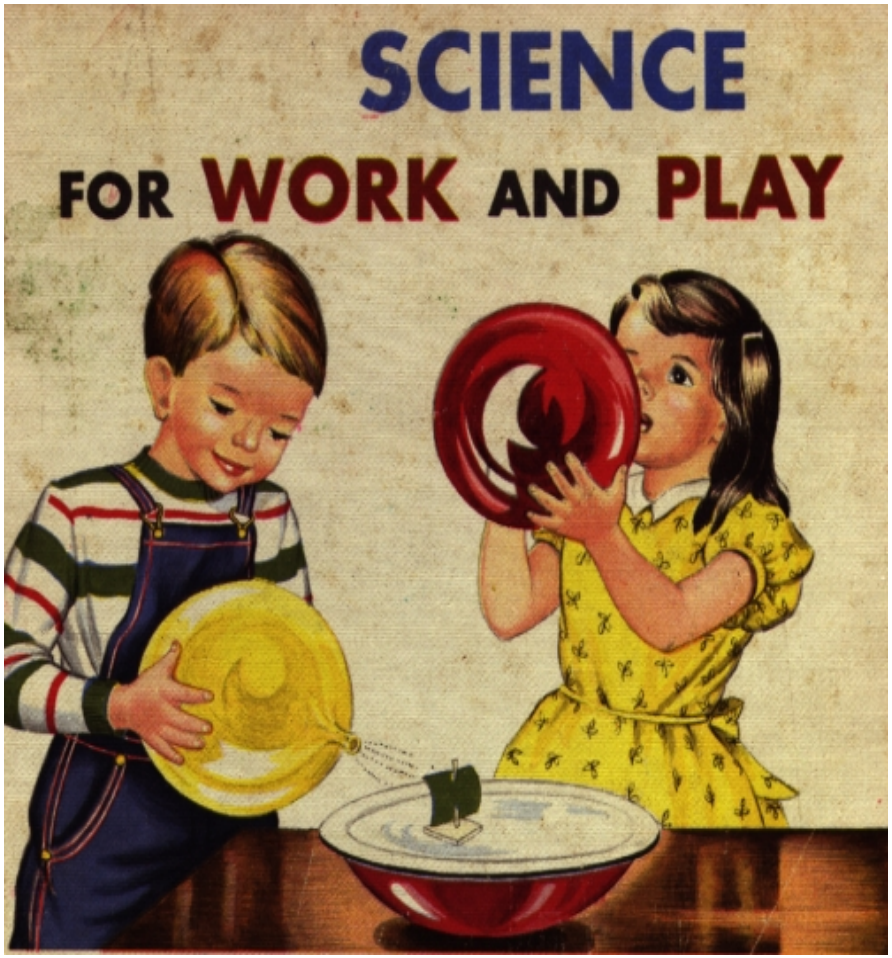

WAIT!!!

WAIT!!!

WAIT!!!

Cryptech needs you!

- http://cryptech.is/funding
- Independently designed, audited FPGA for a complete Hardware Security Module (HSM)
- Test units now built using ‘novena’ board
- Strong source of randomness has been tested
- Potting, tamper/hardening WIP
- But funding is low…