Addressing and Routing in 2014

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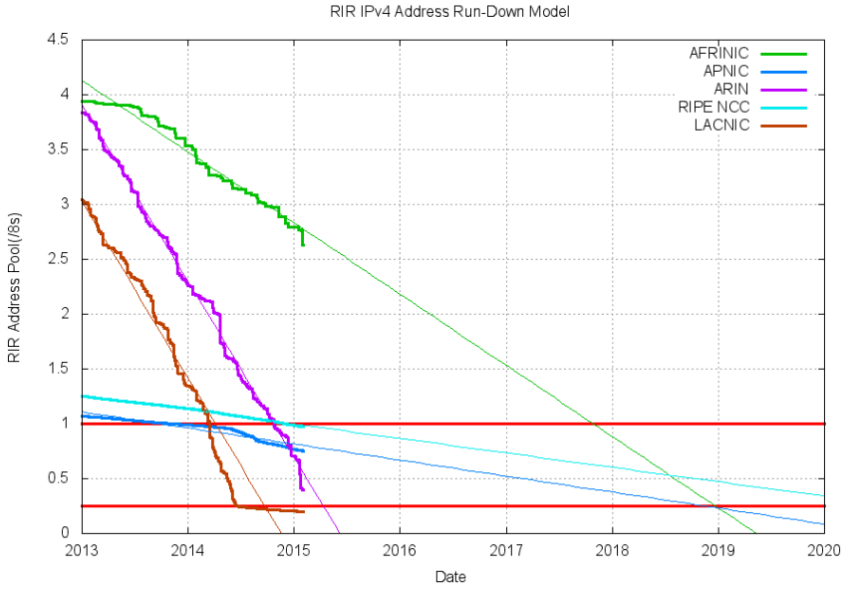
The Addressing View

Addressing V4 Exhaustion

- We have been predicting that the exhaustion of the free pool of IPv4 addresses would eventually happen for the past 25 years
- And, we've now hit bottom!
  - APNIC, RIPE NCC and LACNIC are now empty of general use IPv4 addresses
  - We now have just ARIN and AFRINIC to go – ARIN is expected to run out in the coming weeks

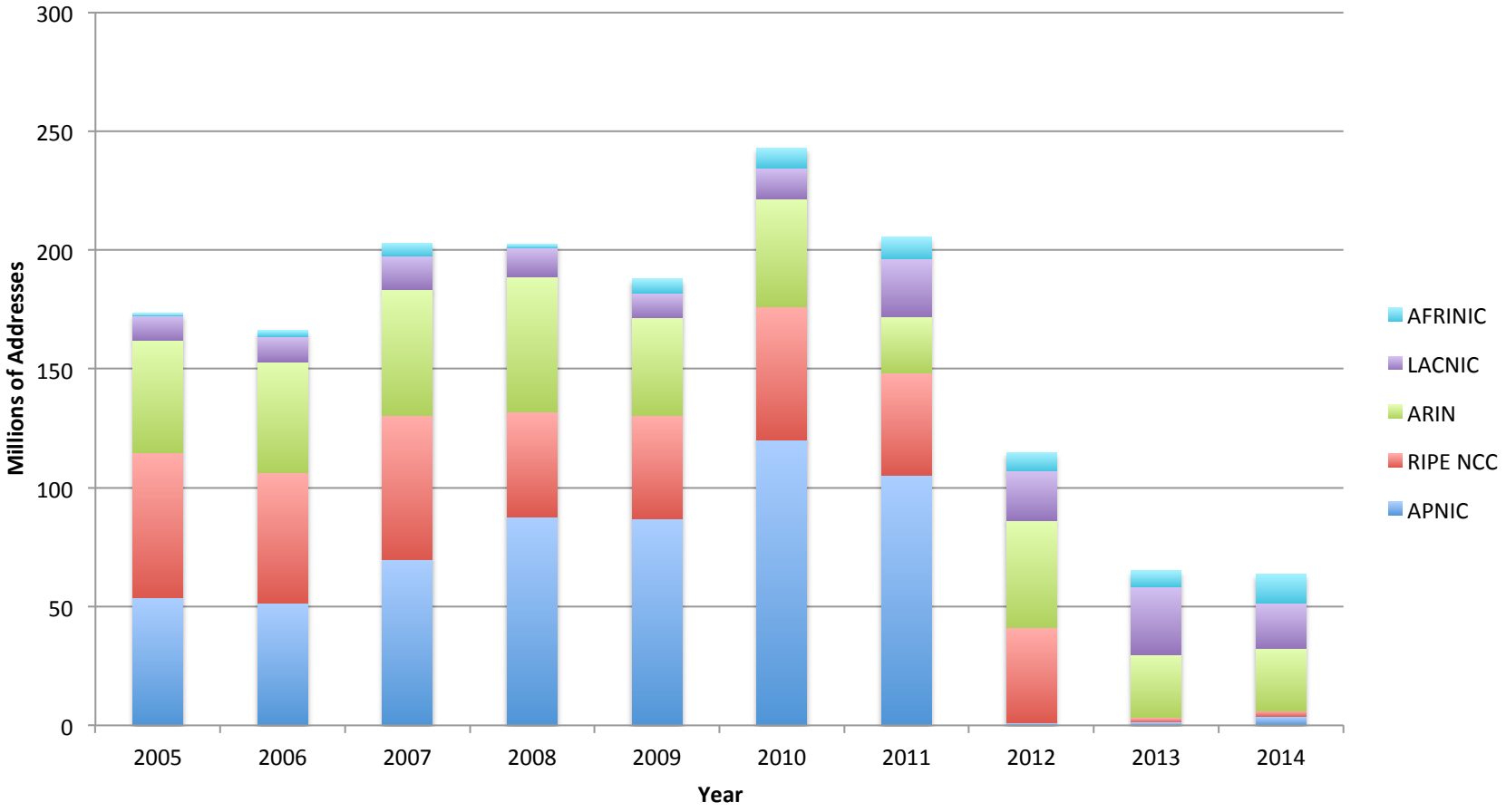
Projected RIR Address Pool Exhaustion Dates:

RIR	Projected Exhaustion Date	Remaining Addresses in RIR Pool (/8s)
APNIC:	**19-Apr-2011** (actual)	0.7520
RIPE NCC:	**14-Sep-2012** (actual)	0.9700
LACNIC:	**10-Jun-2014** (actual)	0.1987
ARIN:	**16-May-2015**	0.3960
AFRINIC:	**23-Jan-2019**	2.6326

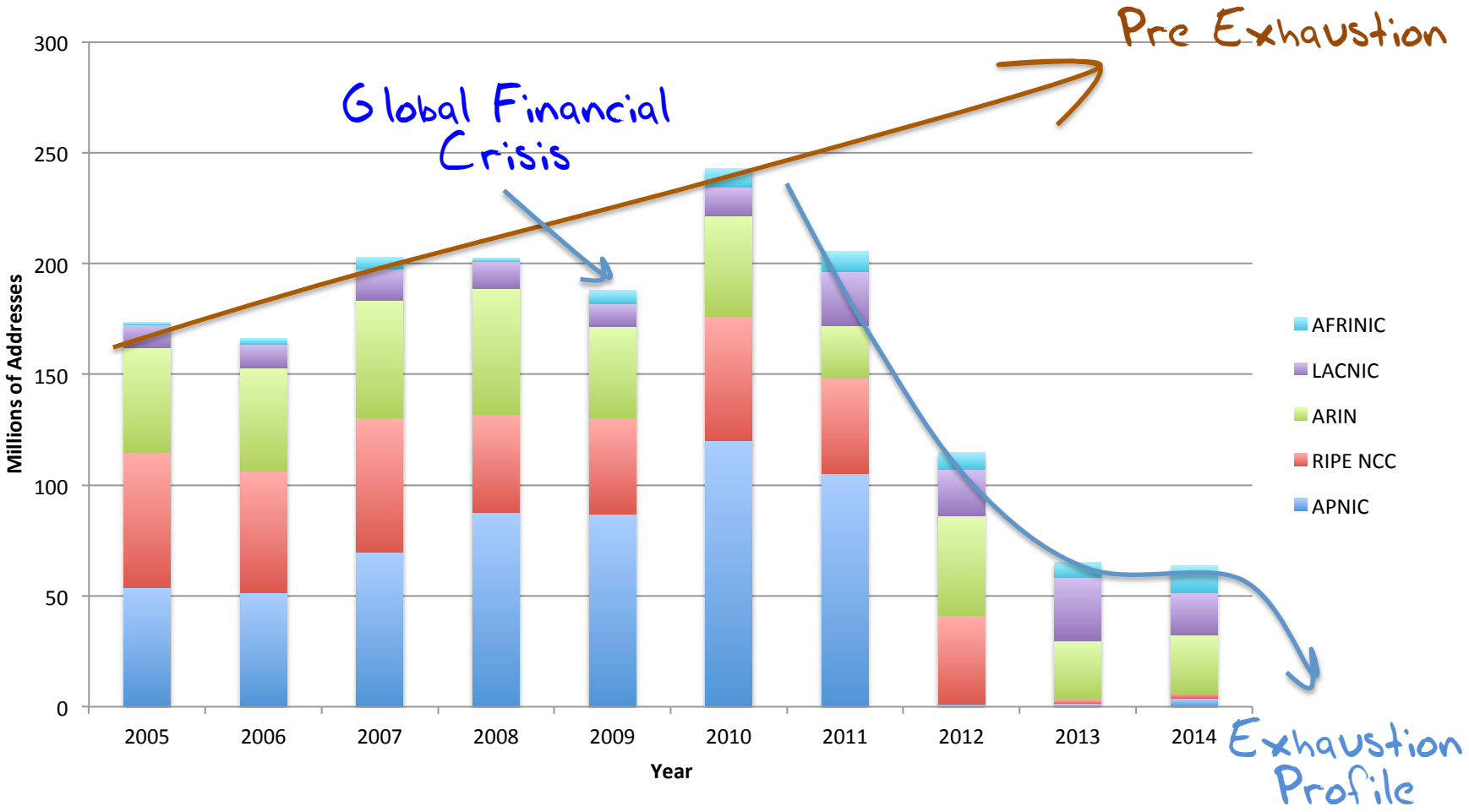


Projection of consumption of Remaining RIR Address Pools

Allocations in the Last Years of IPv4



Allocations in the Last Years of IPv4



Where did the Addresses Go?

Volume of Allocated IPv4 Addresses (using units of millions of /32s) per year

Rank	2010		2011		2012		2013		2014	
1	China	45.2	China	53.1	USA	28.2	USA	25.0	USA	24.5
2	USA	42.3	USA	21.2	Canada	16.7	Brazil	17.4	Brazil	10.9
3	Rep.Korea	25.7	Japan	16.9	Brazil	8.4	Colombia	3.8	Morocco	2.6
4	Japan	10.0	Rep.Korea	7.7	Russia	5.3	Argentina	1.6	Colombia	2.1
5	Australia	9.6	Indonesia	7.1	Iran	4.5	Egypt	1.6	South Africa	1.7
6	India	9.4	Brazil	6.3	Germany	3.4	Canada	1.4	Egypt	1.6
7	UK	8.1	India	6.0	South Africa	3.4	Nigeria	1.2	China	1.5
8	Germany	7.0	France	5.4	Italy	3.3	Chile	1.1	Canada	1.5
9	Russia	6.5	Russia	5.0	Colombia	2.6	Mexico	1.1	Kenya	1.4
10	Brazil	6.3	Germany	4.9	Romania	2.6	Seychelles	1.0	Mexico	1.1

APNIC runs out

RIPE NCC runs out

LACNIC runs out

The IPv4 After-Market: Address Transfers

- There is a considerable residual demand for IPv4 addresses following exhaustion
  - IPv6 is not a direct substitute for the lack of IPv4
- Some of this demand is pushed into using middleware that imposes address sharing (Carrier Grade NATS, Virtual Hosting, etc)
- Where there is no substitute then we turn to the aftermarket
- Some address transfers are “sale” transactions, and they are entered into the address registries
- Some transfers take the form of “leases” where the lease holder’s details are not necessarily entered into the address registry

Address Transfers

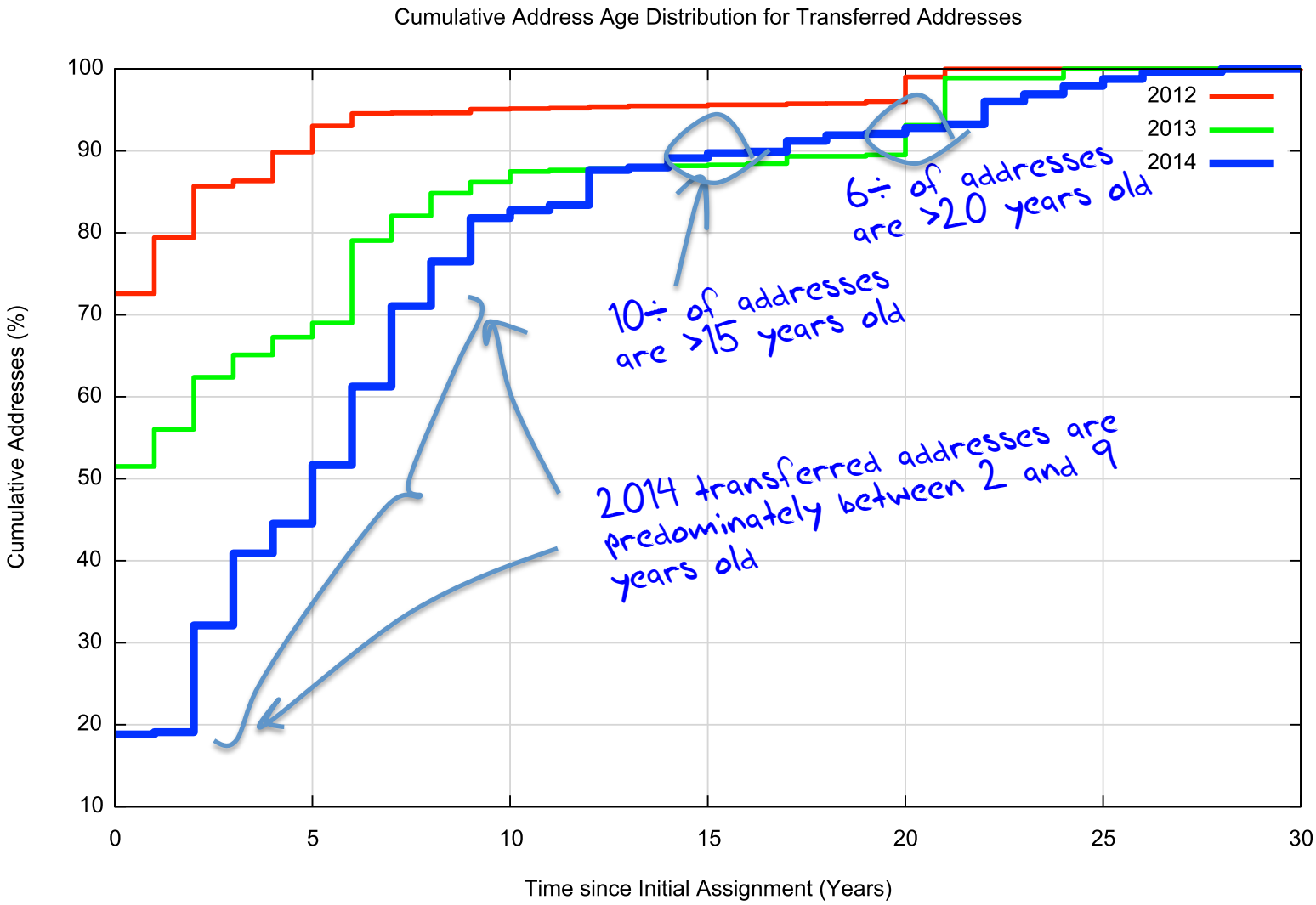
Receiving RIR	2012	2013	2014
ARIN	28	19	42
APNIC	148	152	340
RIPE NCC	9	154	919
Total	**185**	**325**	**1,301**

Number of registered Address transfers per year

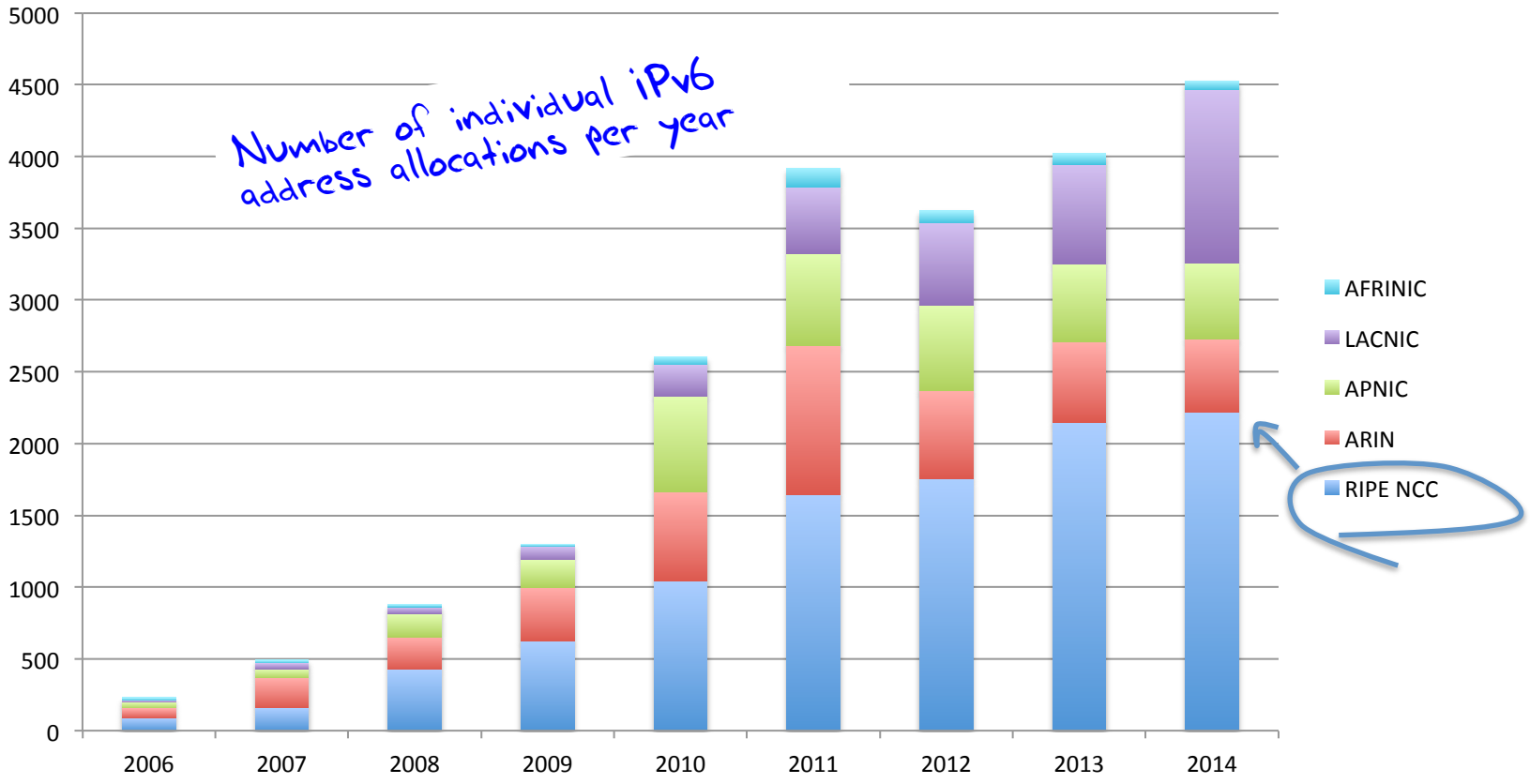
Volume of addresses transferred per year (millions of /32s p.a.)

Receiving RIR	2012	2013	2014
ARIN	4.86	3.90	2.91
APNIC	1.78	1.74	3.71
RIPE NCC	0.06	1.81	9.35
Total	**6.70**	**7.46**	**15.98**

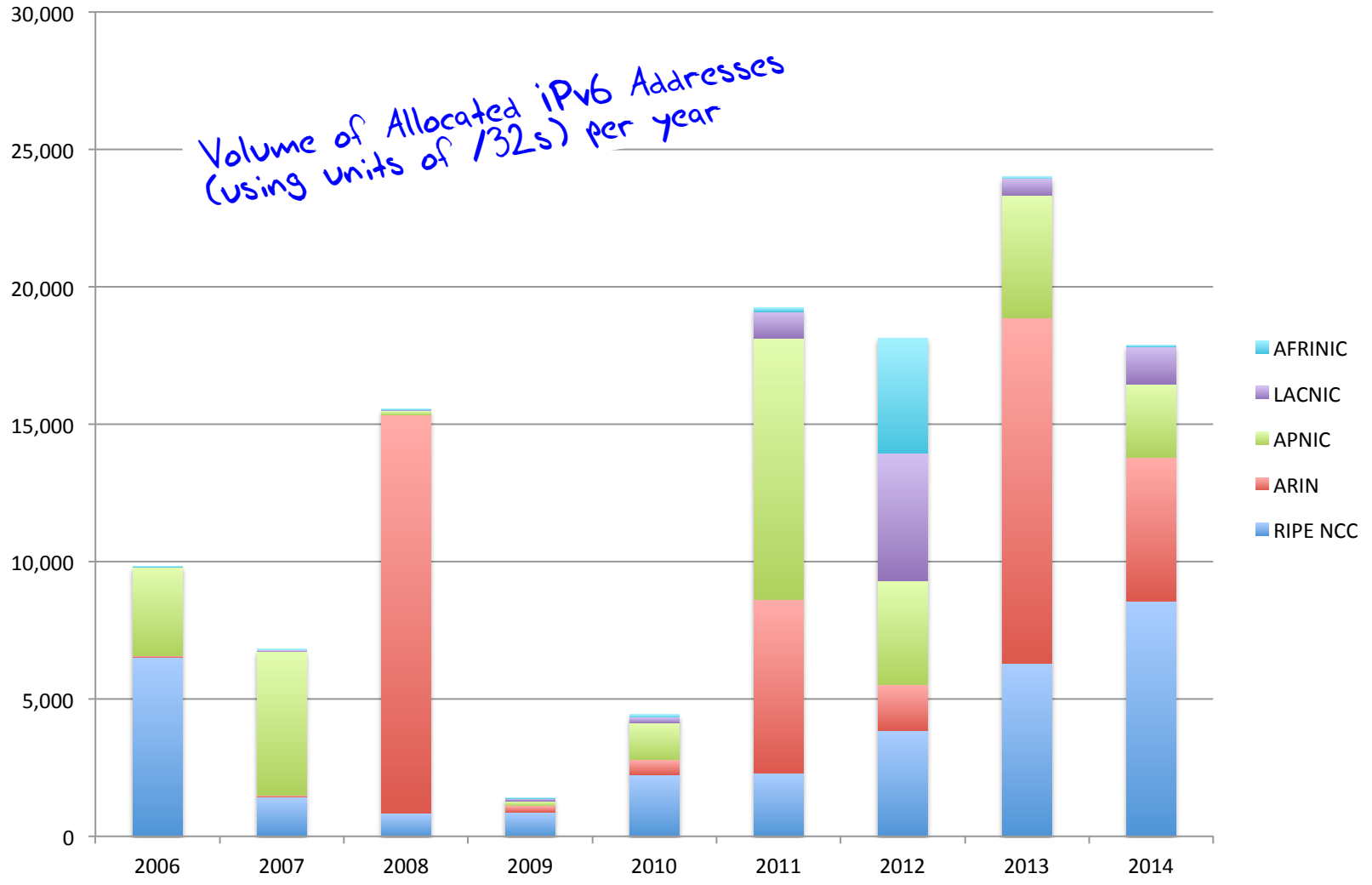
How old are transferred addresses?



IPv6 Allocations



IPv6 Allocated Addresses



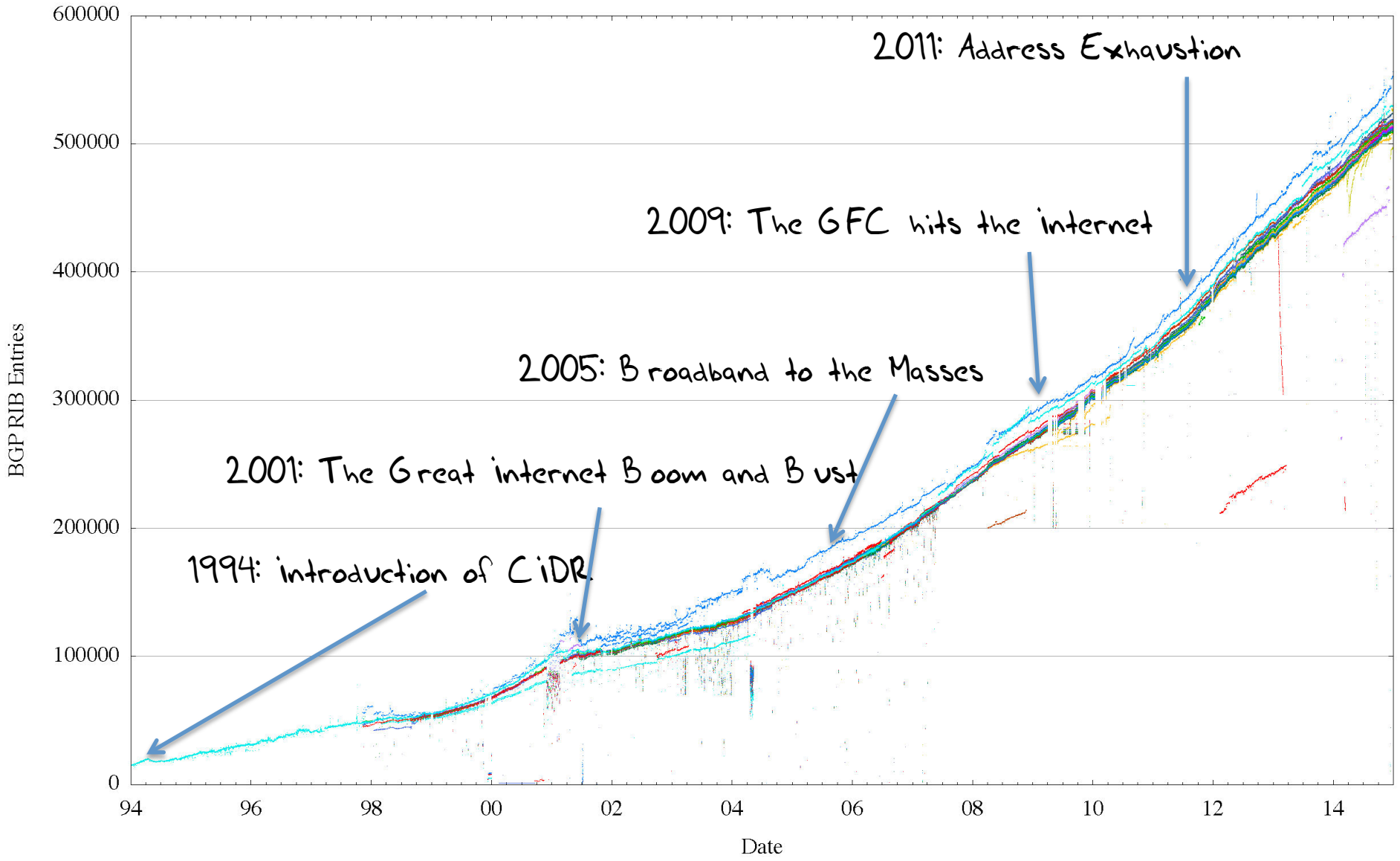
Where did the IPv6 addresses go?

	2010		2011		2012		2013		2014	
1	Germany	654	China	8,997	Argentina	4,177	United States	12,537	United States	4,930
2	Japan	630	United States	6,253	Egypt	4,098	China	4,135	China	2,127
3	United States	504	Spain	667	China	3,136	UK	782	UK	1,090
4	China	339	UK	476	United Sates	1,337	Germany	651	Brazil	863
5	Belgium	270	Brazil	311	Italy	635	Russia	523	Germany	749
6	France	195	Germany	300	Russia	403	Netherlands	463	Netherlands	719
7	Brazil	160	Mexico	261	Germany	399	Brazil	450	Russia	716
8	UK	123	Venezuela	261	UK	356	France	435	France	436
9	Russia	117	Netherlands	241	Canada	323	Italy	339	Italy	410
10	Netherlands	103	Russia	160	Brazil	294	Switzerland	265	Switzerland	369

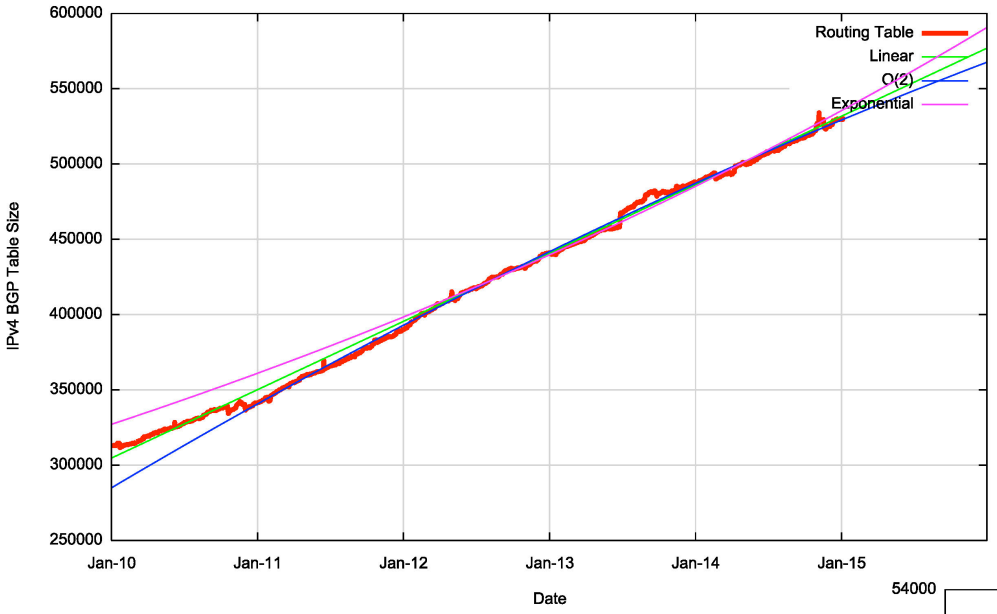
Volume of Allocated IPv6 Addresses (using units of /32s) per country, per year

Looking through the Routing Lens

20 Years of Routing the Internet

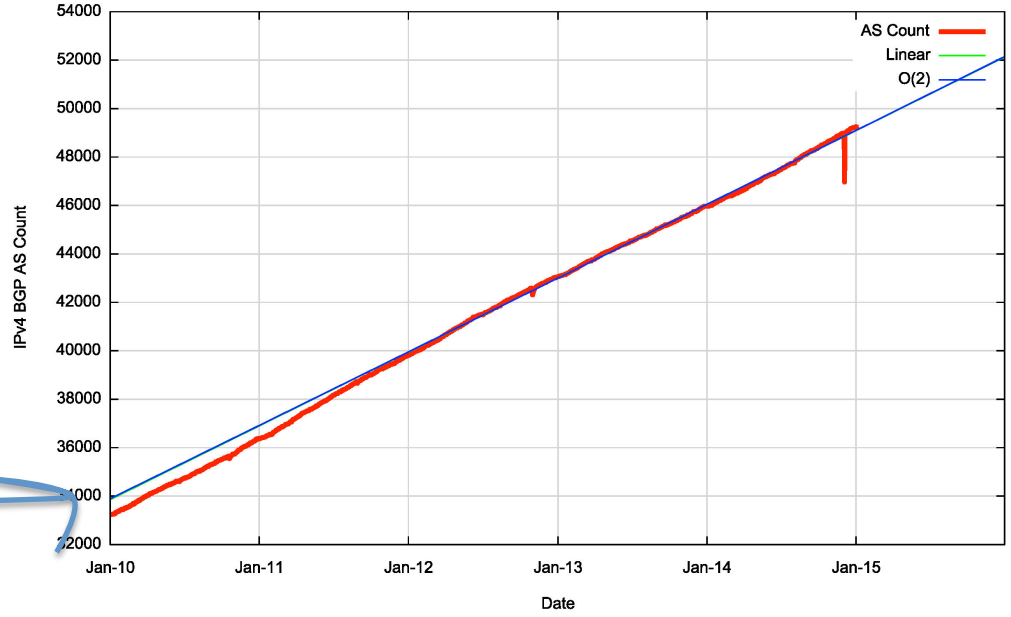


Routing Indicators for IPv4



Routing prefixes - growing by some 45,000 prefixes per year

AS Numbers - growing by some 3,000 ASNs per year



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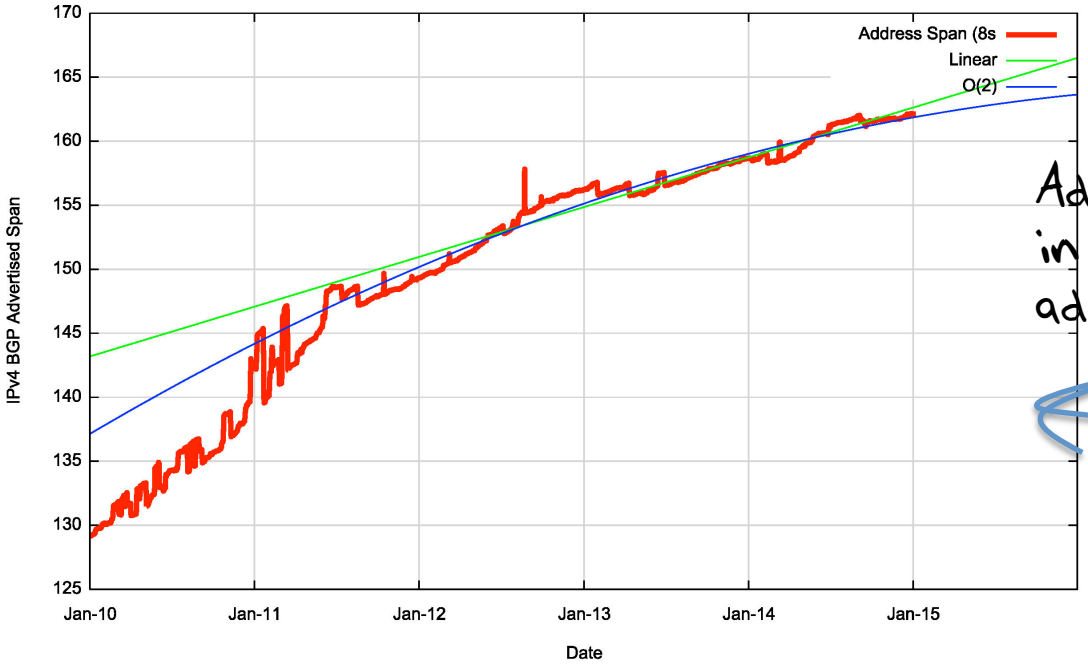
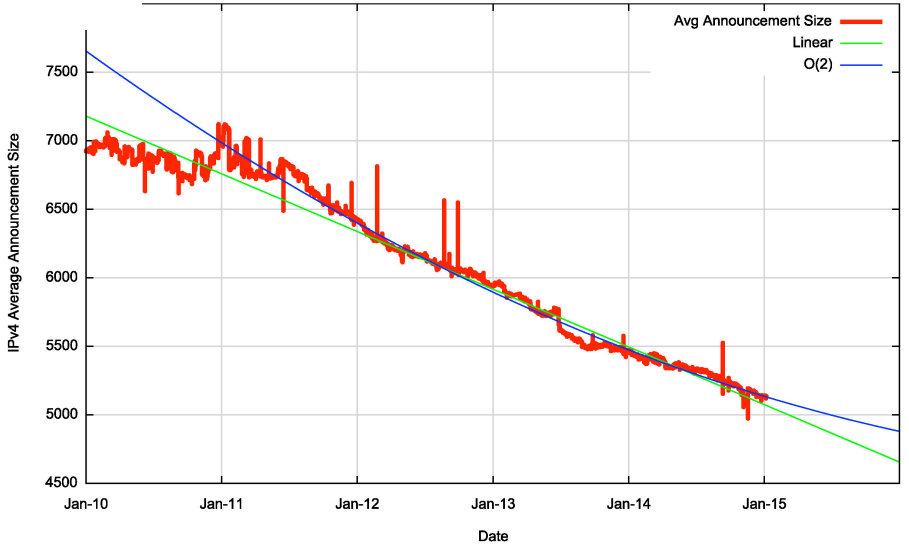


Address Exhaustion is now visible in the extent of advertised address space

So the average size of a routing advertisement is getting smaller



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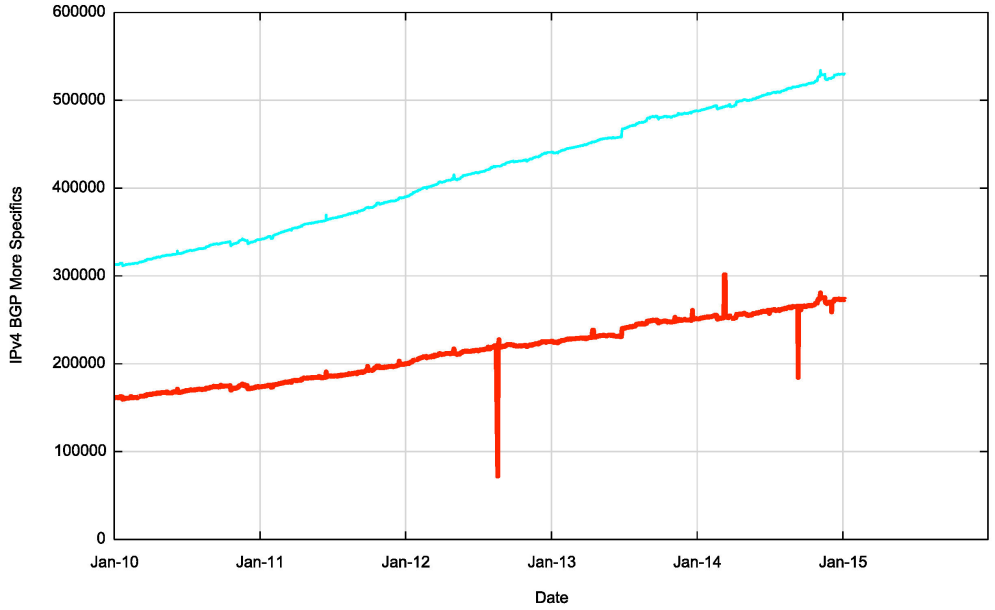
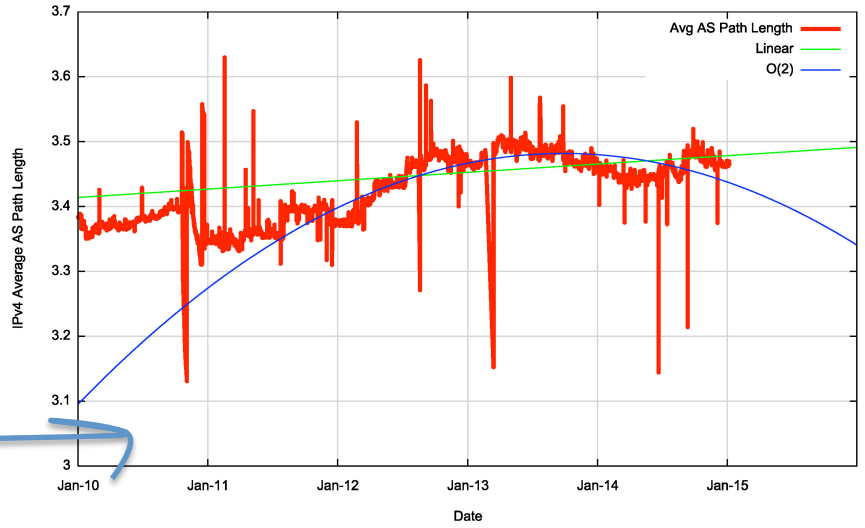


More Specifics are still taking up one half of the routing table

The "shape" of inter-AS interconnection appears to be steady, as the Average AS Path length has been held steady through the year

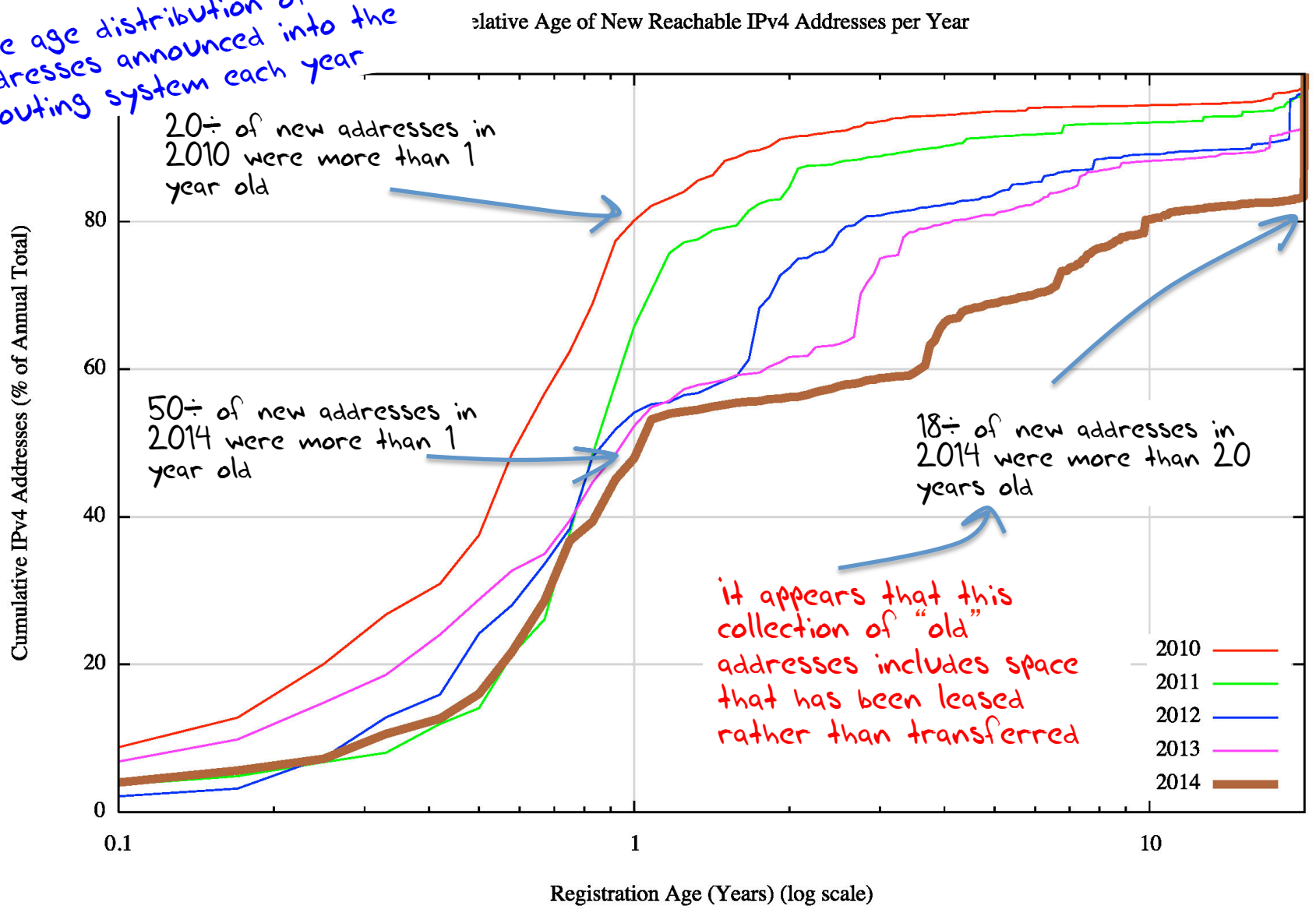


How can the IPv4 network continue to grow when we are running out of IPv4 addresses?

We are now recycling old addresses back into the routing system

IPv4 Address Reuse

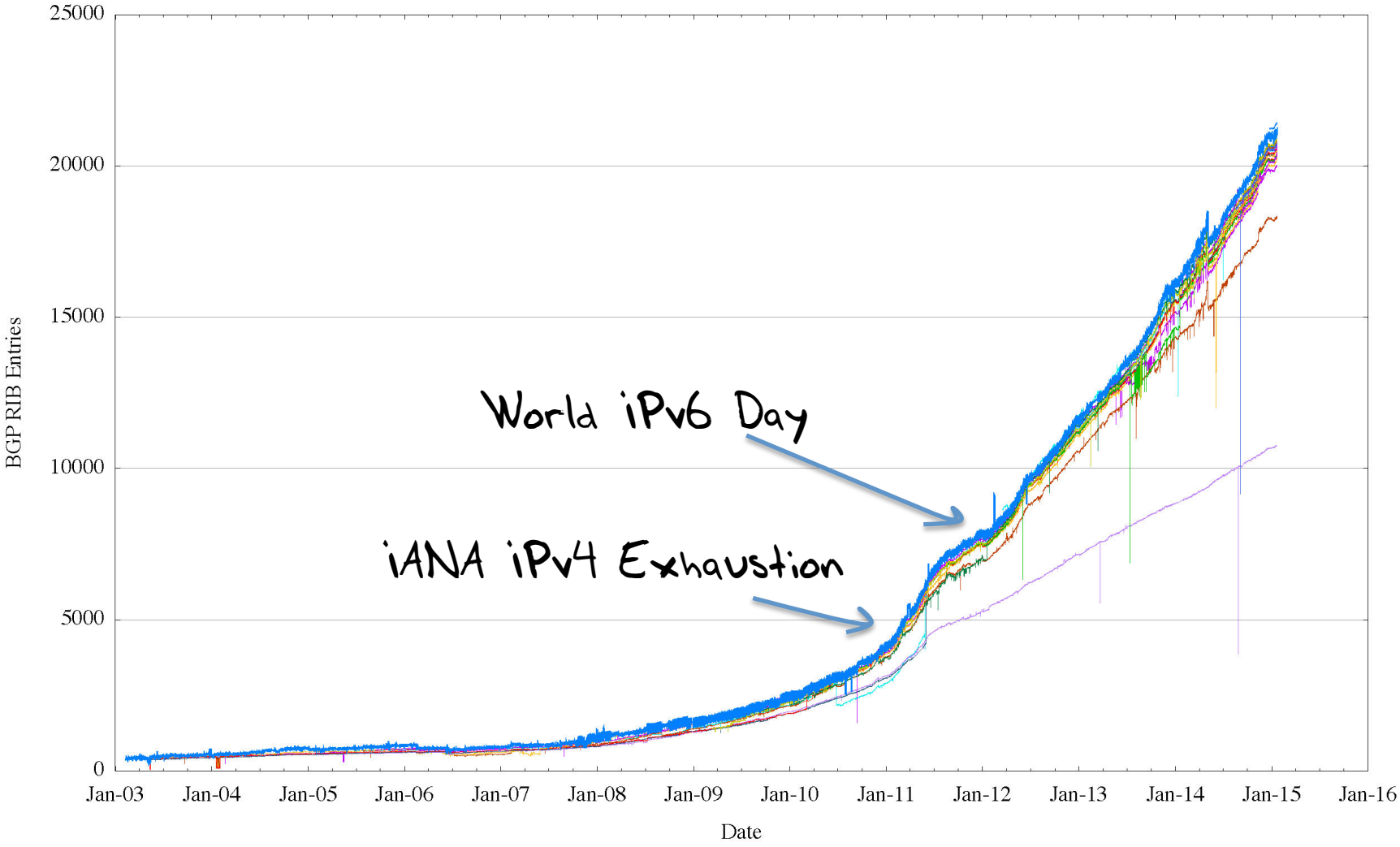
The age distribution of new addresses announced into the 'routing system each year



IPv4 in 2014 - Growth is Slowing

- Overall IPv4 Internet growth in terms of BGP is at a rate of some **~9%-10% p.a.**
- Address span growing far more slowly than the table size
- The rate of growth of the IPv4 Internet is slowing down
  - Address shortages
  - Masking by NAT deployments and transfers
  - Saturation of critical market sectors
  - Transition uncertainty

The Route Views view of IPv6



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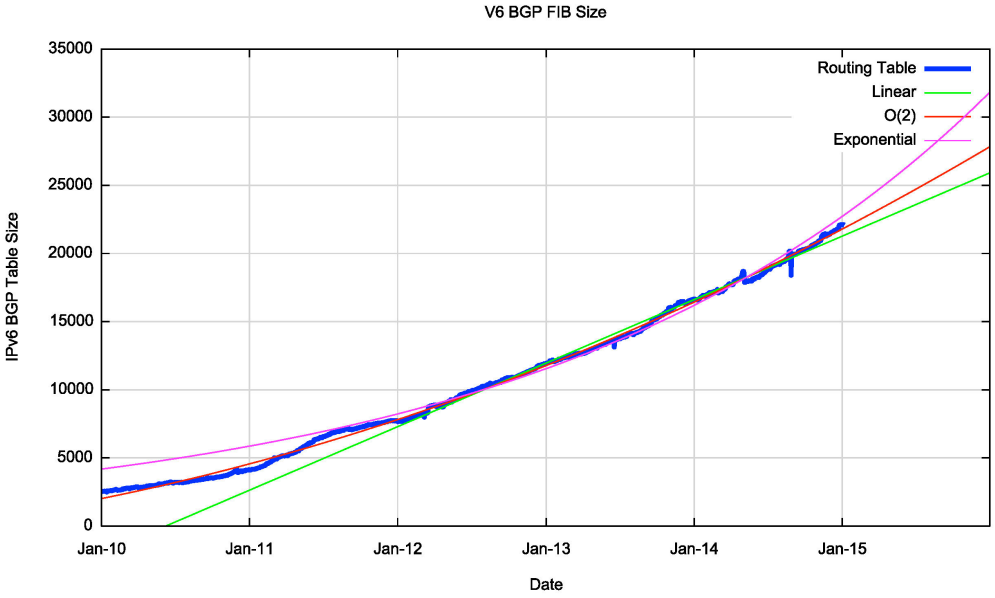
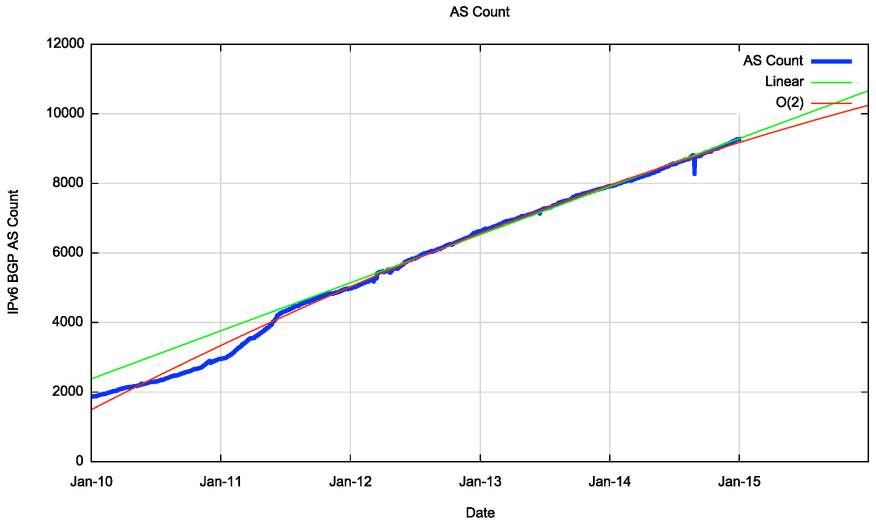


Routing prefixes - growing by some 6,000 prefixes per year

AS Numbers- growing by some 1,600 prefixes per year (which is half the V4 growth)



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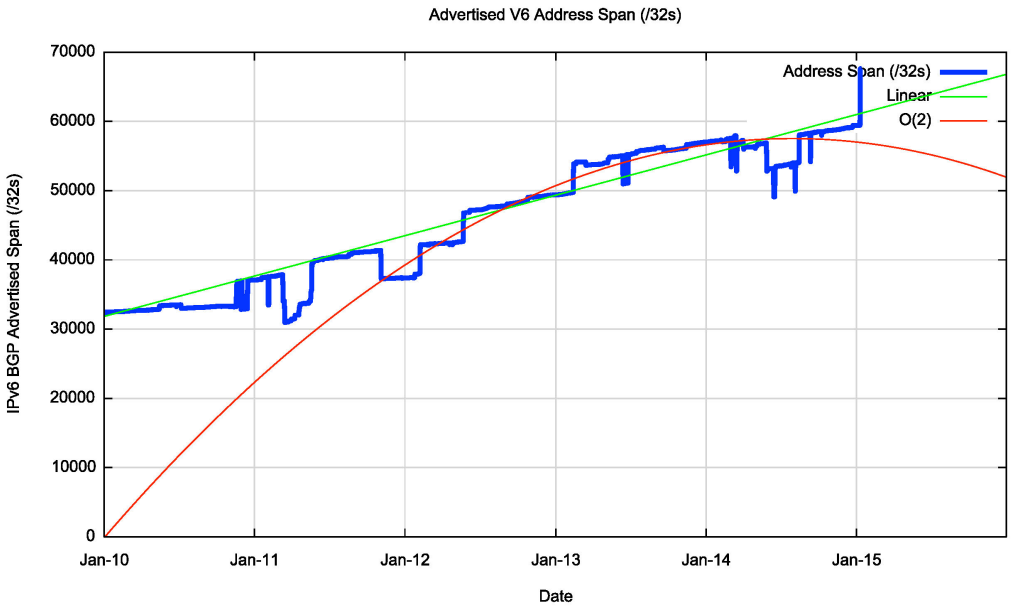
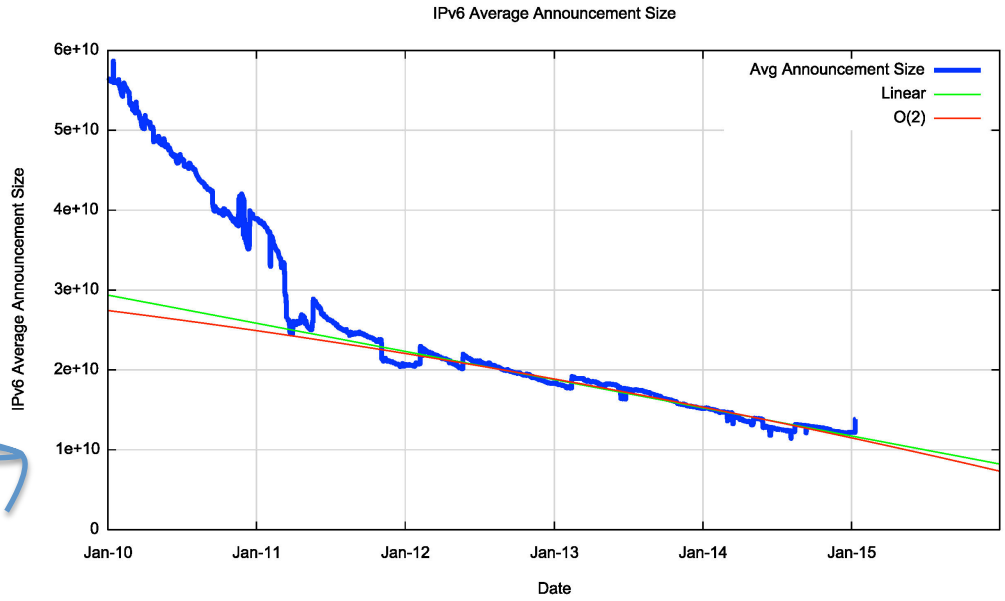


Address consumption is happening at a constant rate, and not growing year by year

The average size of a routing advertisement is getting smaller



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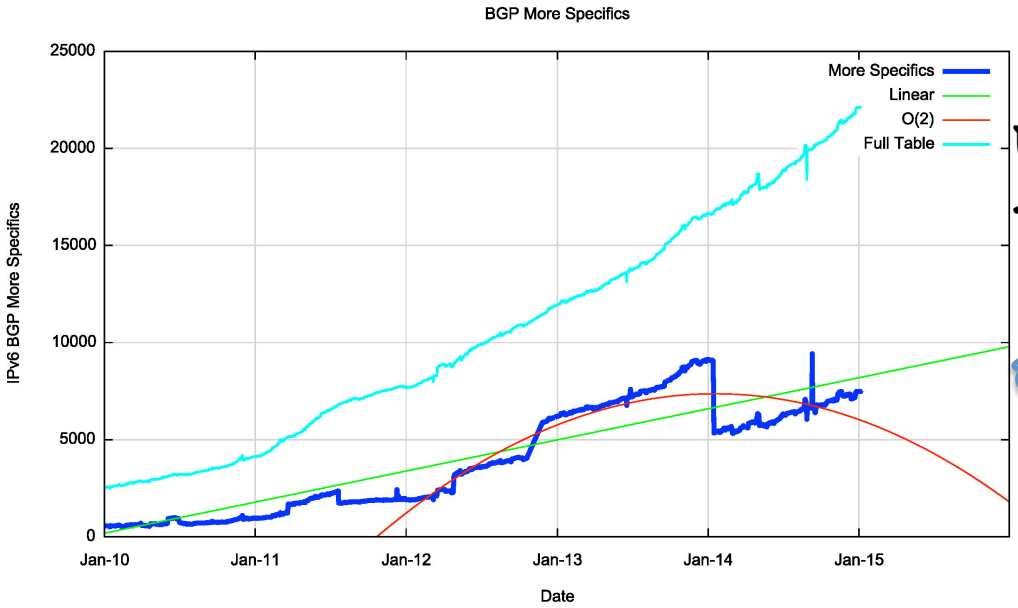

More Specifics now take up one third of the routing table

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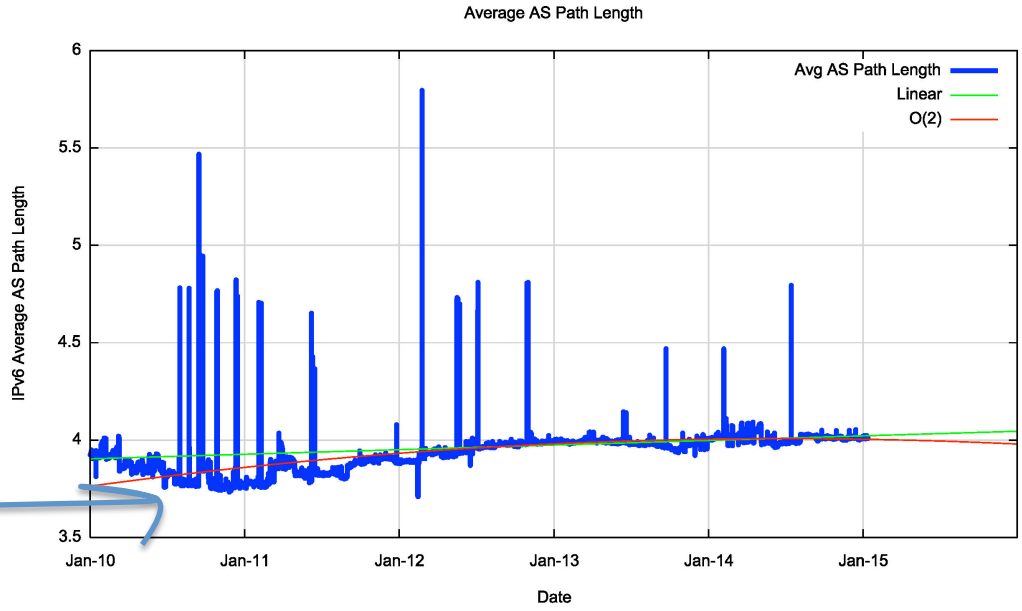


IPv6 in 2013

- Overall IPv6 Internet growth in terms of BGP is **20% - 40 % p.a.**
  - 2012 growth rate was ~ 90%.

If these relative growth rates persist then the IPv6 network would span the same network domain as IPv4 in ~16 years time

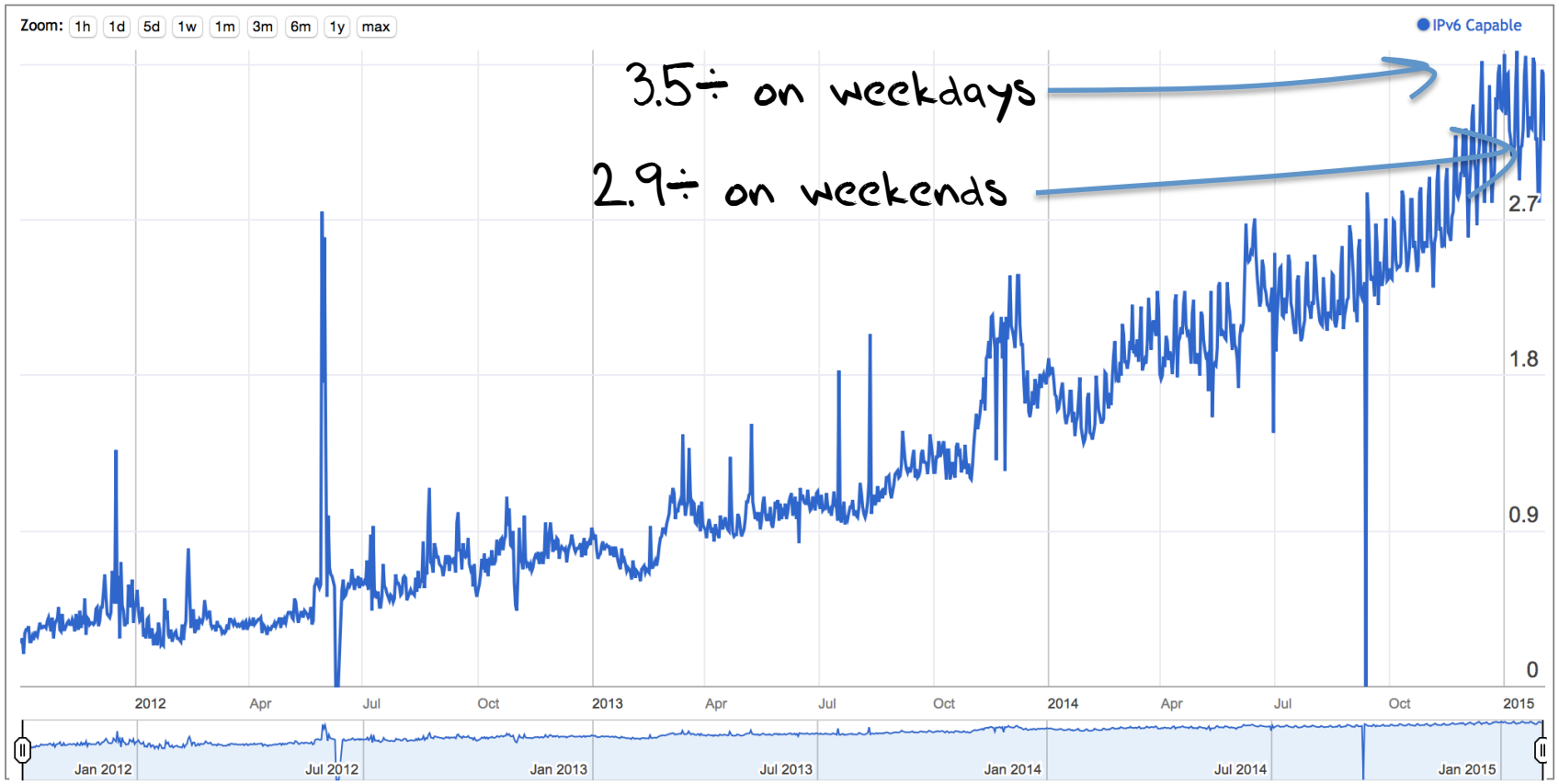
So we are all now taking up using V6?

So we are all now taking up using V6?

Yes, and No!

How many IPv6 users are there today?

IPv6 Country Deployment

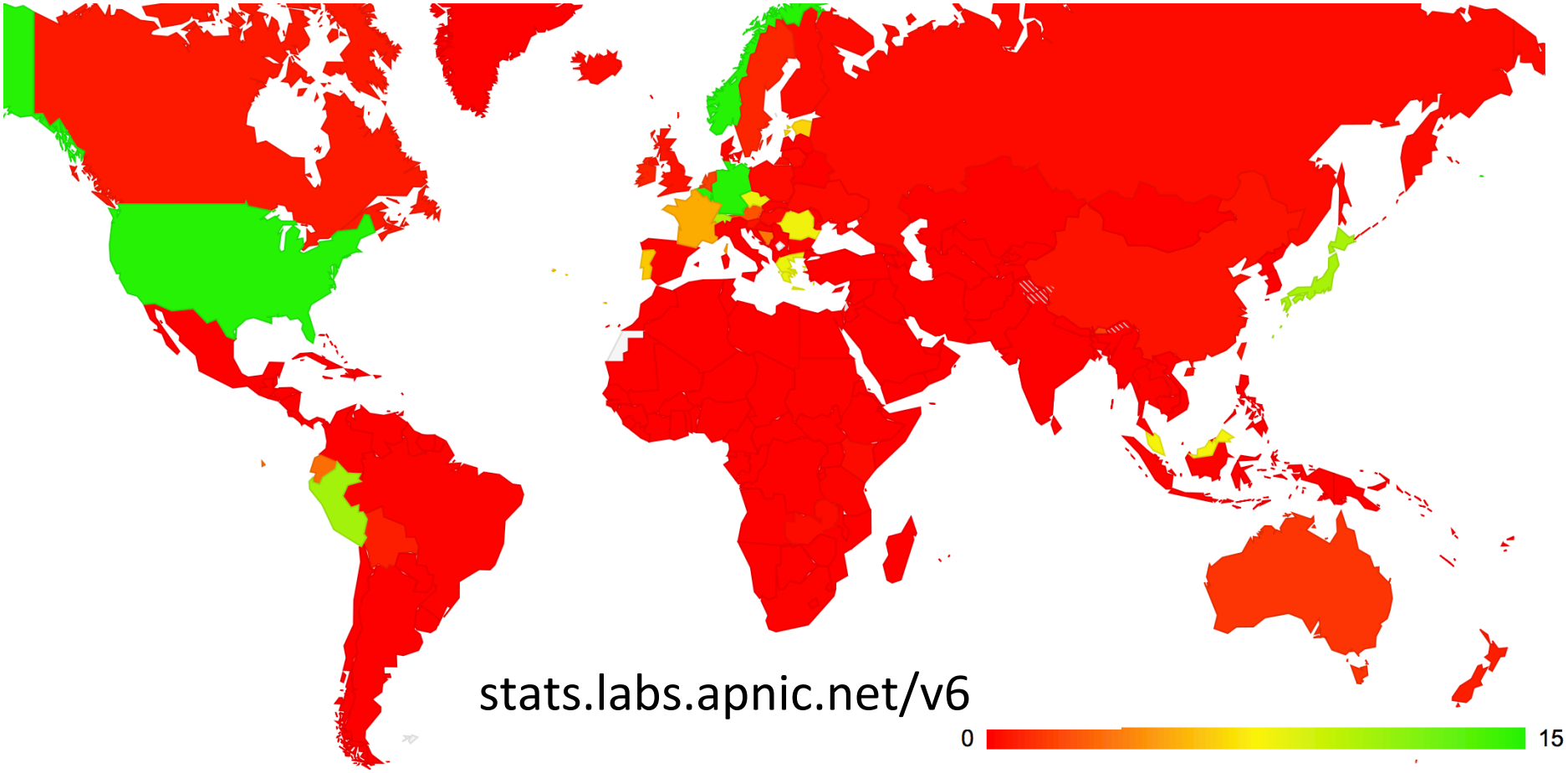


CC	Country	IPv6 Capable
BE	Belgium, Western Europe, Europe	36.79%
DE	Germany, Western Europe, Europe	16.96%
LU	Luxembourg, Western Europe, Europe	15.10%
US	United States of America, Northern America, Americas	14.40%
NO	Norway, Northern Europe, Europe	14.21%
CH	Switzerland, Western Europe, Europe	11.23%
EU	European Union, Western Europe, Europe	10.74%
JP	Japan, Eastern Asia, Asia	10.16%
PE	Peru, South America, Americas	9.58%
CZ	Czech Republic, Eastern Europe, Europe	9.20%
RO	Romania, Eastern Europe, Europe	8.48%
MY	Malaysia, South-Eastern Asia, Asia	7.54%
GR	Greece, Southern Europe, Europe	7.41%
FR	France, Western Europe, Europe	5.79%
PT	Portugal, Southern Europe, Europe	5.71%
EE	Estonia, Northern Europe, Europe	5.44%
SG	Singapore, South-Eastern Asia, Asia	4.71%
BA	Bosnia and Herzegovina, Southern Europe, Europe	3.38%
EC	Ecuador, South America, Americas	2.99%
AT	Austria, Western Europe, Europe	2.73%
NL	Netherlands, Western Europe, Europe	2.33%
BT	Bhutan, Southern Asia, Asia	1.86%
AU	Australia, Australia and New Zealand, Oceania	1.55%
SE	Sweden, Northern Europe, Europe	1.33%
IE	Ireland, Northern Europe, Europe	1.26%
NZ	New Zealand, Australia and New Zealand, Oceania	0.88%
CA	Canada, Northern America, Americas	0.87%
TW	Taiwan, Eastern Asia, Asia	0.81%
BO	Bolivia, South America, Americas	0.74%
CN	China, Eastern Asia, Asia	0.68%
GB	United Kingdom of Great Britain and Northern Ireland, Northern Europe, Europe	0.64%
VU	Vanuatu, Melanesia, Oceania	0.64%
SI	Slovenia, Southern Europe, Europe	0.56%
FI	Finland, Northern Europe, Europe	0.53%
RU	Russian Federation, Eastern Europe, Europe	0.52%
AX	Aland Islands, Northern Europe, Europe	0.46%
PL	Poland, Eastern Europe, Europe	0.40%
HK	Hong Kong Special Administrative Region of China, Eastern Asia, Asia	0.35%
UA	Ukraine, Eastern Europe, Europe	0.32%
SK	Slovakia, Eastern Europe, Europe	0.28%

Who is moving along with IPv6

Who isn't

The IPv6 World Map



Thank You