

# Are we there yet?

iPv6 in 2016

Geoff Huston  
APL 

A question to each of you...



A question to each of you...

How many IPv6 presentations have you sat through?



# A question to each of you...

How many IPv6 presentations have you sat through?

- 20?
- 100?
- 1,000?
- I don't know!



# A reminder

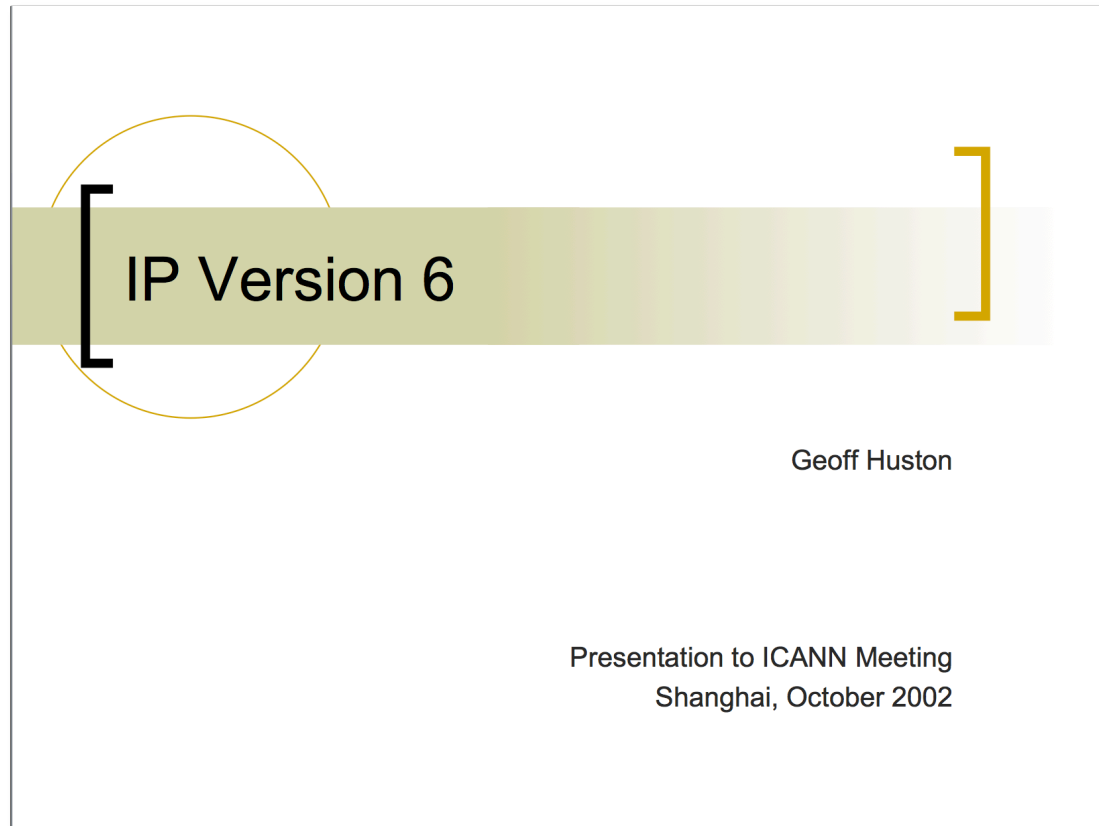
In case you weren't paying attention at the time, here's a few extracts from my archives...



# 14 years ago, in China



# 14 years ago, in China



IP Version 6

Geoff Huston

Presentation to ICANN Meeting  
Shanghai, October 2002

The slide features a central title bar with a light green-to-white gradient. The text 'IP Version 6' is centered within this bar. A thin yellow circle is positioned behind the left side of the bar, and a yellow bracket is on the right. The author's name 'Geoff Huston' is located to the right of the bar. At the bottom center, the event details are listed.



# On IPv6 Myths

## [ IPv6 vs IPv4 ]

- There is no compelling “feature” or aspect of V6 that does not have a functional counterpart in V4.
- Any industry adoption of V6 cannot be based on superior functionality of V6 over V4 as a protocol platform

IPv6 is not brighter, shiner, or more miraculous. It just has more addresses!





# Wavering in the ranks!

## [ The Bottom Line ]

- Its looking like its a NAT vs V6 choice
  - And its not obvious that the market is going to correctly balance the longer term interest against very short term expediency

Moments of doubt and uncertainty!



2005:

“One day man will travel  
faster than a horse can run”

Rene Descarte

If this is all about guessing future requirements, then sometimes we can be both right and incredibly wrong at the same time!



# 2005: Redefining terms of engagement

It looks like the IPv6 future may well be “revolution” where IPv6 is forced into direct competition with existing IPv4+NAT networks

And the primary leverage here is one of “cheaper” and “bigger”, and not necessarily “better”

The emerging realization that IPv6 won't just happen in the same way that IPv4 just happened -- there are other factors at play here.



# 2006:

## Technology - IPv6

- "IP with larger addresses"
- Address space requirements are no longer being easily met by IPv4
- This is an issue for high volume deployments including:
  - Pocket IP devices
  - Consumer devices
- IPv6 appears to offer reasonable technology solutions that preserve IP integrity, reduce middleware dependencies and allow full end-to-end IP functionality for a device-rich world

BUT

Noone wants to pay for widespread IPv6 deployment just yet!



# 2007:

## Maybe it's just deregulation

- Near term business pressures simply support the case for further deferral of IPv6 infrastructure investment
- There is insufficient linkage between the added cost, complexity and fragility of NAT-based applications at the edge and the costs of infrastructure deployment of IPv6 in the middle
  - Deregulated markets are not perfect information markets – pain becomes isolated from potential remedy

It's not just a technology issue – there are business drivers here as well



# 2008:

## New Markets for IPv6?



## The Universe of Tiny Things?

The world of billions of chattering devices unleashing new rivers of gold into the IP industry?

Or is this just the economy? There is no new money and these billions of chattering devices will generate much the same revenue as we have today

So we have to cram all these billions of new devices trillions of new packets into the same money that we have today.

technology leverage will make tomorrow's networks 1,000 times CHEAPER to deliver an IP packet than today's network?

Or have we reached some limit to the economic viability of communications that imply that ever smaller valued transactions can't be sustained over ever larger networks?

Do RFID and Bluetooth provide a different model of communication that is viable in the universe of things, where the identity is global but the communication is strictly limited in scope and

And if you ever are curious enough to enlarge this slide to see if there is text all the way down the page you will have got yourself to this point, where it becomes obvious that I've got nothing more to say and I want to fill up the bottom of the slide with tiny text.



# 2008

This is the time of the **“IPv4 exhaustion is coming. What are we going to do?”** presentations.

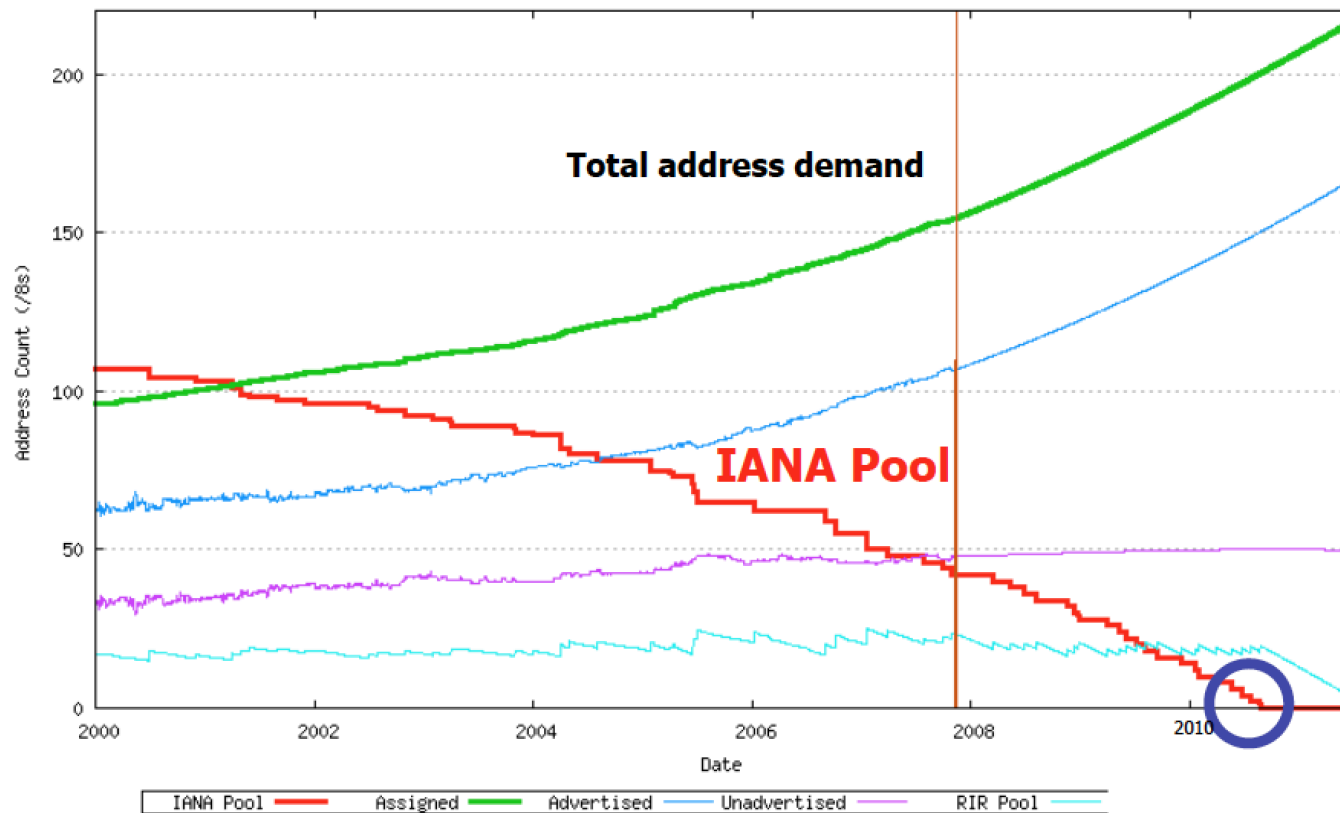
Lets dive into one of them for a few slides from 2008...



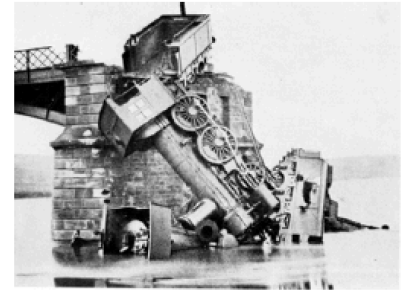
Ooops!



Data Prediction



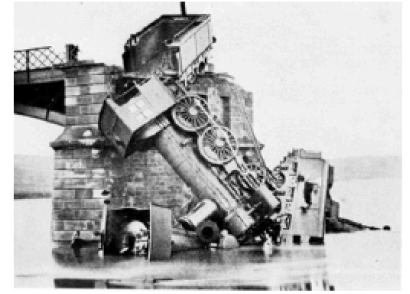




That's 5<sup>th</sup> February 2011

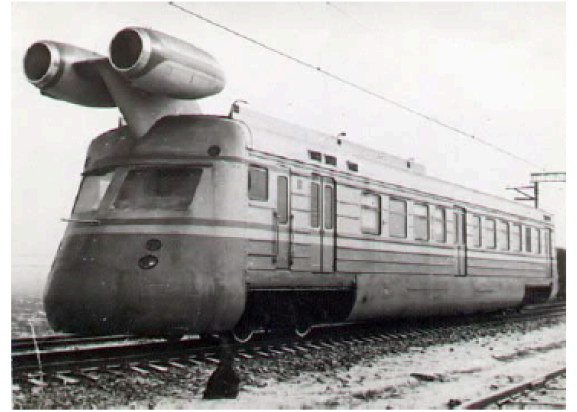
<http://ipv4.potaroo.net>





what then?

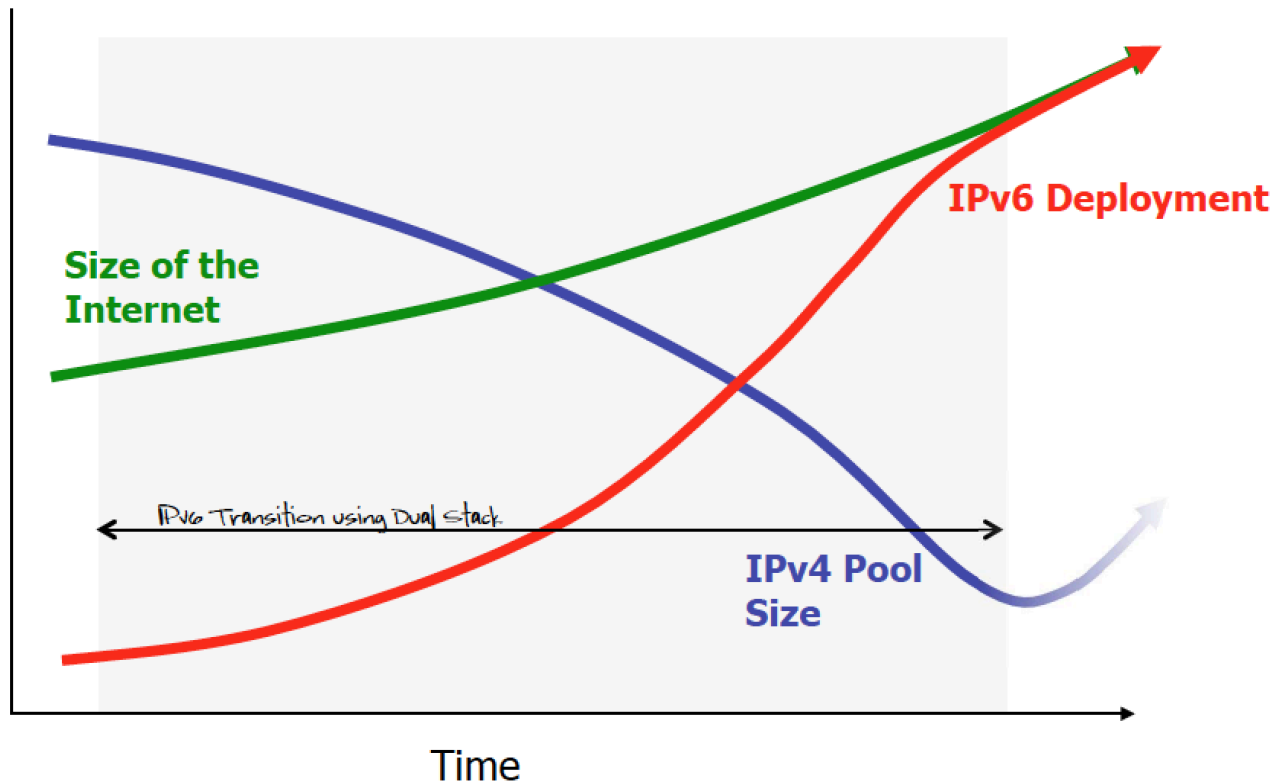




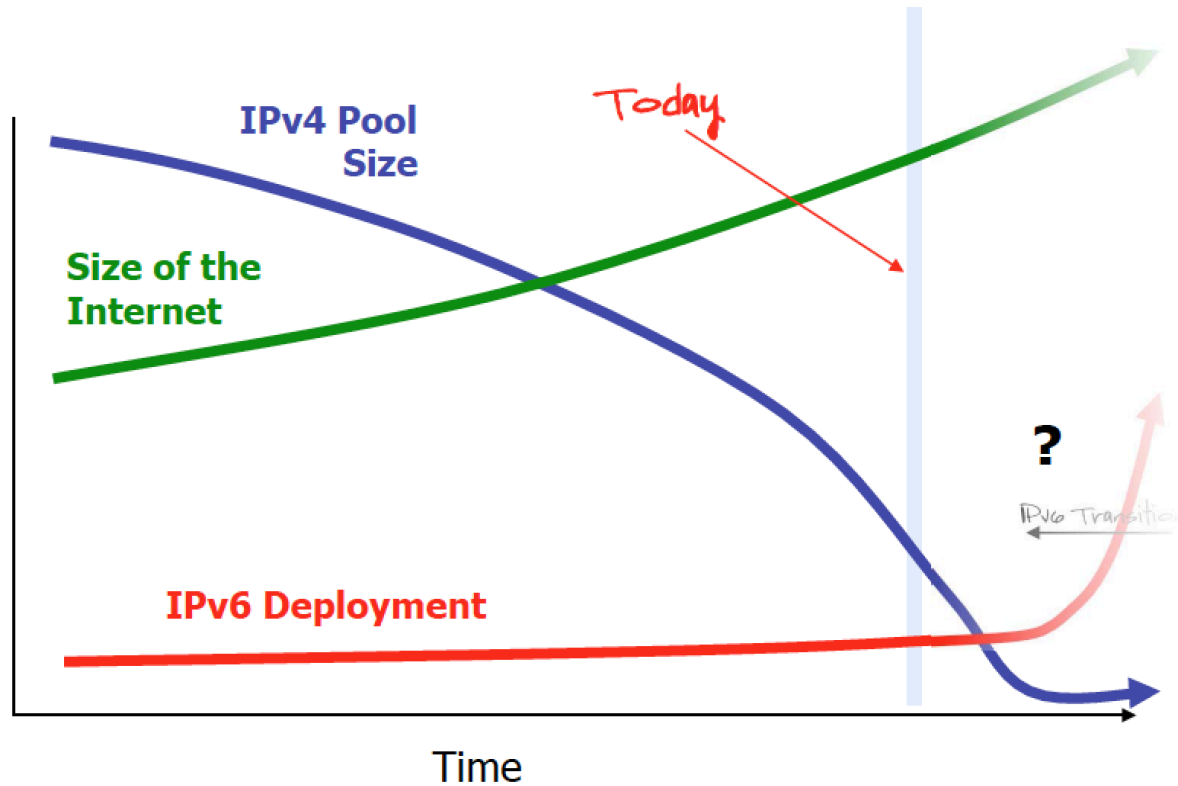
IPV6!



We had this plan ...



what's the revised plan?



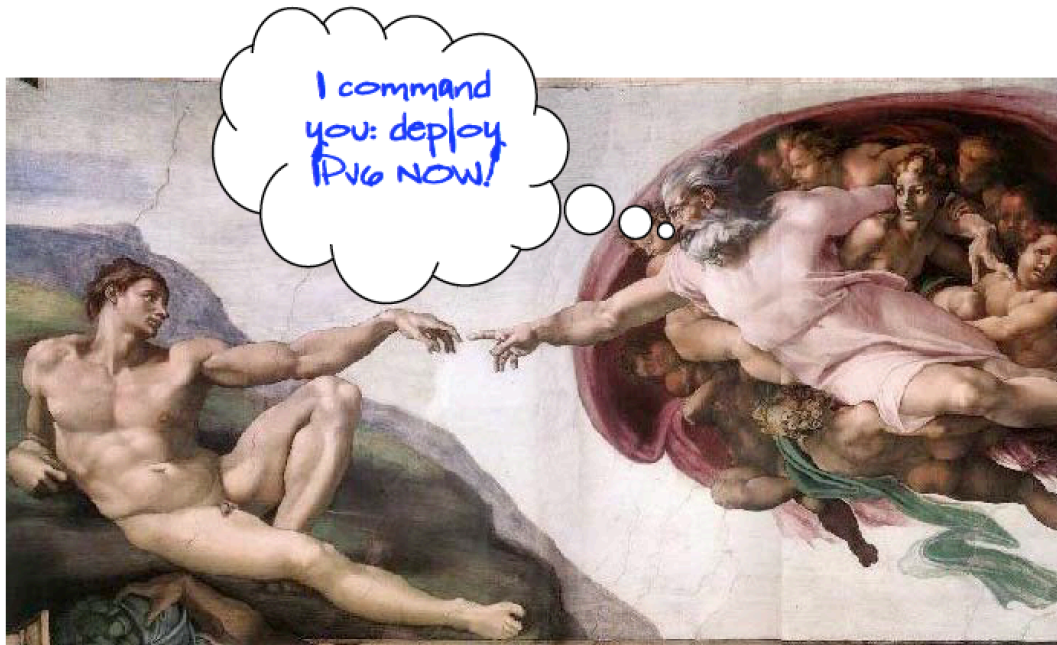
If IPv6 is the answer then...



Plan A: its time to move!

The global internet adopts IPv6 universally  
before **January 2009** and completely quits all  
use of IPv4 well before address pool  
exhaustion occurs





If IPv6 is the answer then..

**Plan A: its time to move!**

The global Internet, with more than 1.7 billion users, a similar population of end hosts, and hundreds of millions of routers, firewalls, and billions of lines of configuration codes, and hundreds of millions of ancillary support systems, where only a very small proportion are IPv6 aware, , are all upgraded and fielded to work with IPv6 **in the next 120 days**, and then completely quits all use of IPv4 in **10 days later**.

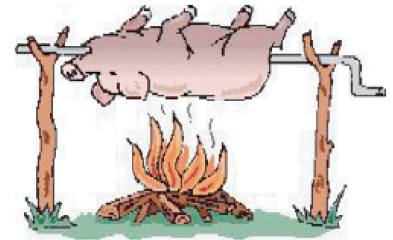






Really.





BIG and FAST don't go together!



If IPv6 is the answer then...



## Plan B: Dual Stack

Leisurely IPv6 deployment

and

Persist with IPv4 networks using more NATs



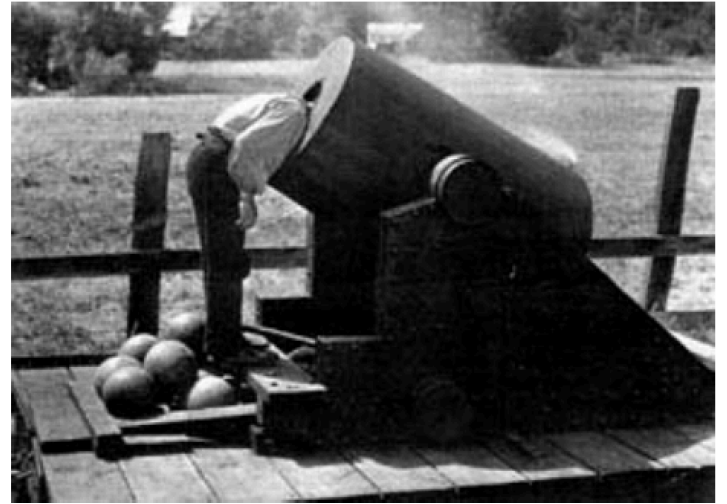
If IPv6 is the answer then...



## Plan B: Dual Stack

Make IPv4 work using more intense levels of NAT deployment in new products and services for as long as the existing deployed networks continue to use IPv4  
This may take a decade or two





Its just not looking very good is it?



why are we here?

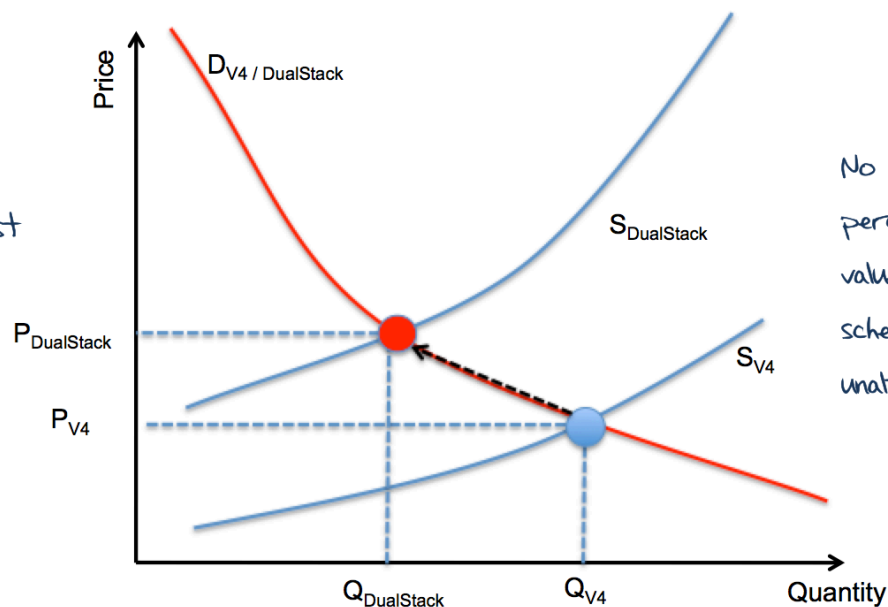




# 2010 – Invoking Economics!

## IPv4 to Dual Stack: The Demand Schedule Shift

Supply side cost  
increase due to  
Dual Stack  
operation



No change in  
perception of  
value, so demand  
schedule is  
unaltered

Equilibrium point is at a lower quantity if Dual Stack supply costs are passed on to customers





# 2010 – invoking economics!

Is this a bit like the economics of climate change?

Right now individual short term interests are leading the Internet towards collective long term sub-optimal outcomes

At some point very soon the Internet will need some external impetus to restate short term interests to align with common longer term objectives

If we want IPv6 to happen we might need a large kick in the rear to get us there!



Which brings us to...



6 June 2012



# World IPv6 Launch

“This time it’s forever”

Urging service providers to turn on IPv6, and leave it on.

Reach out to network, access and content providers to start moving in public on IPv6 services

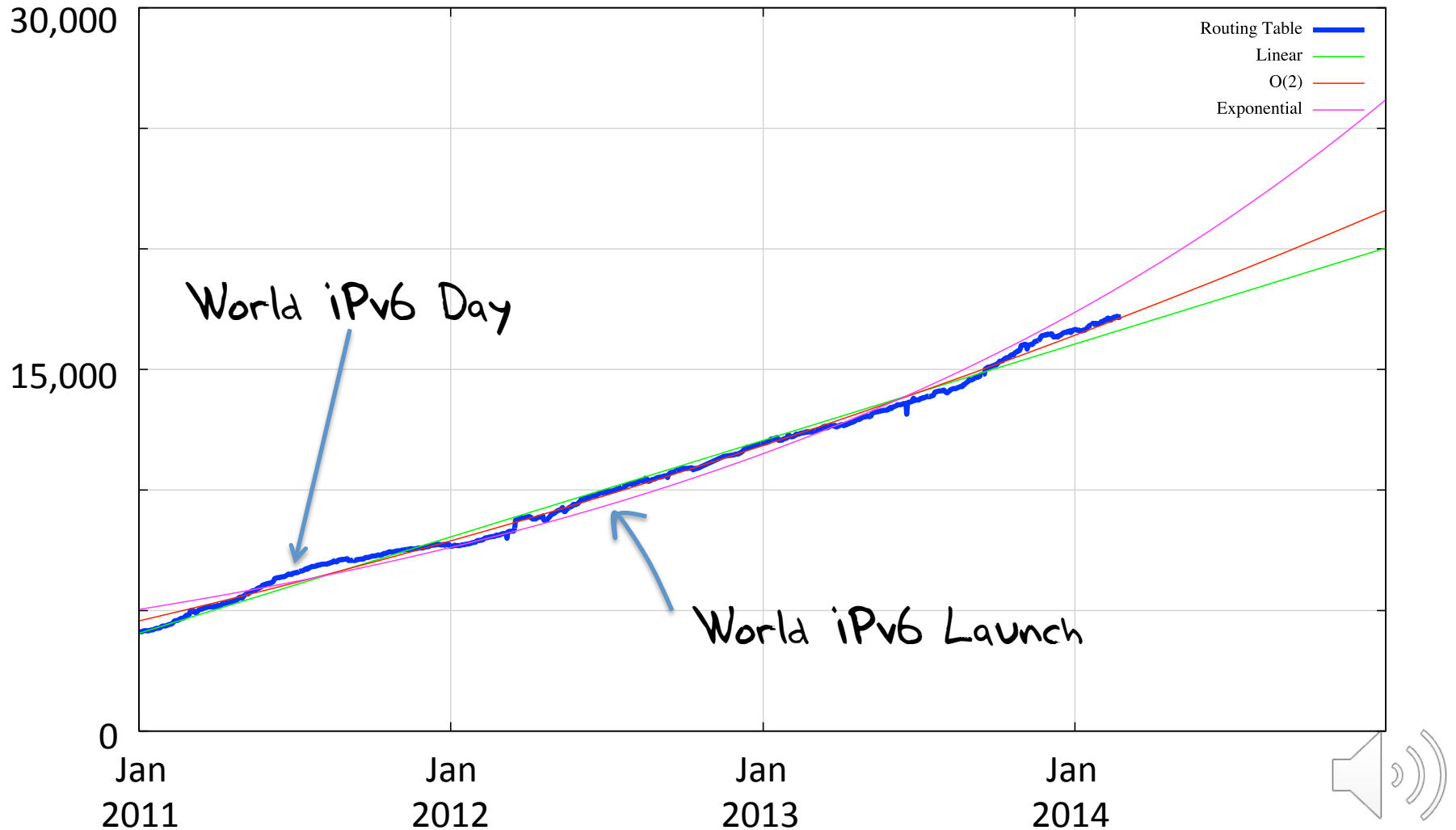


Did it work?



# IPv6 BGP Prefix Count

V6 BGP FIB Size



Not really.



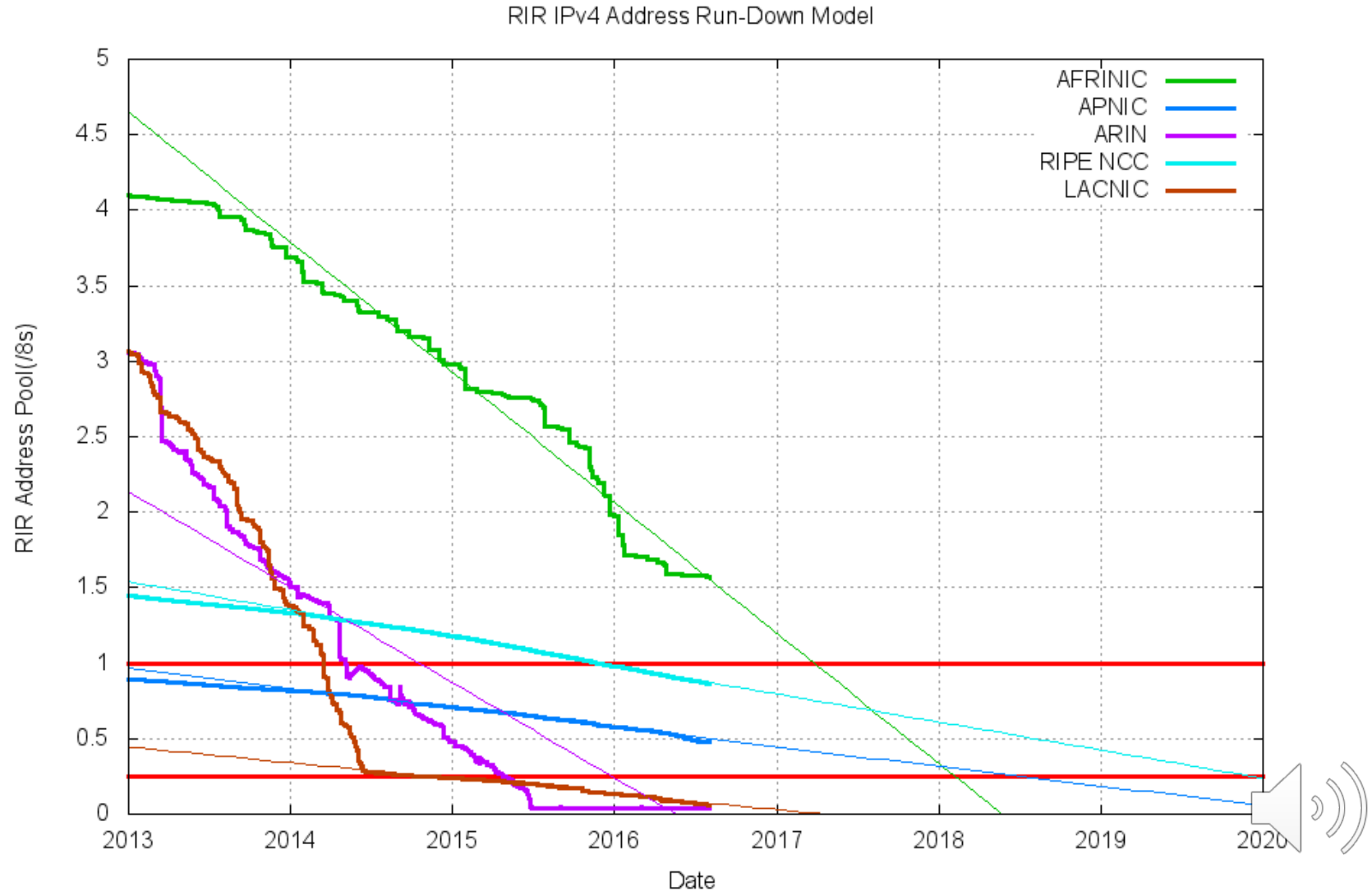
# Where are we today?

- Originally we thought that the Internet would avoid complete IPv4 exhaustion and adopt IPv6 before that date
  - This has not happened

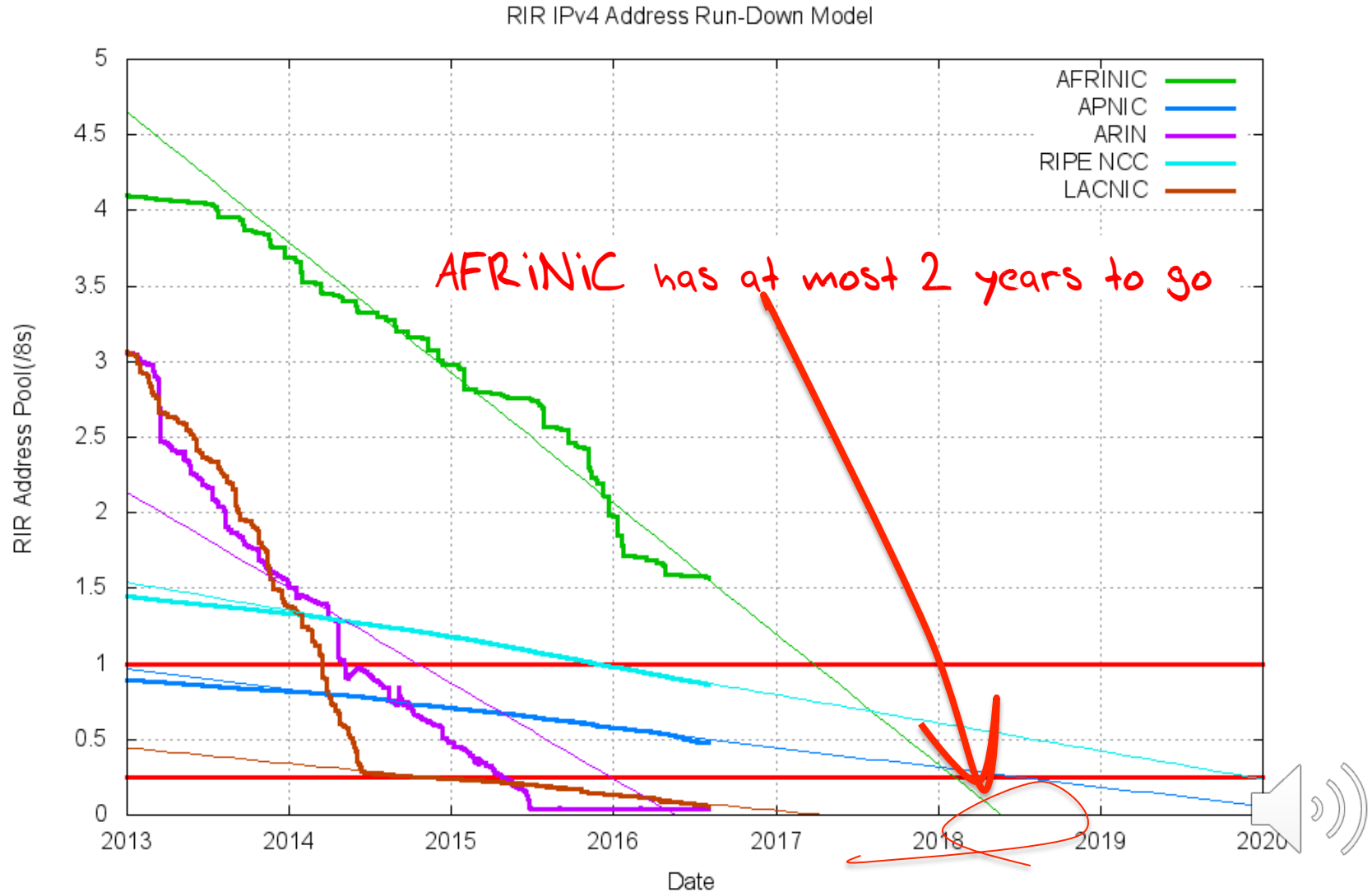




# The RIR IPv4 Address Pools



# The RIR IPv4 Address Pools



# So its time ...

- NATs will work for a while
  - But not forever
- And after a while
  - all that we can do it head towards IPv6
  - We have no alternatives left to try

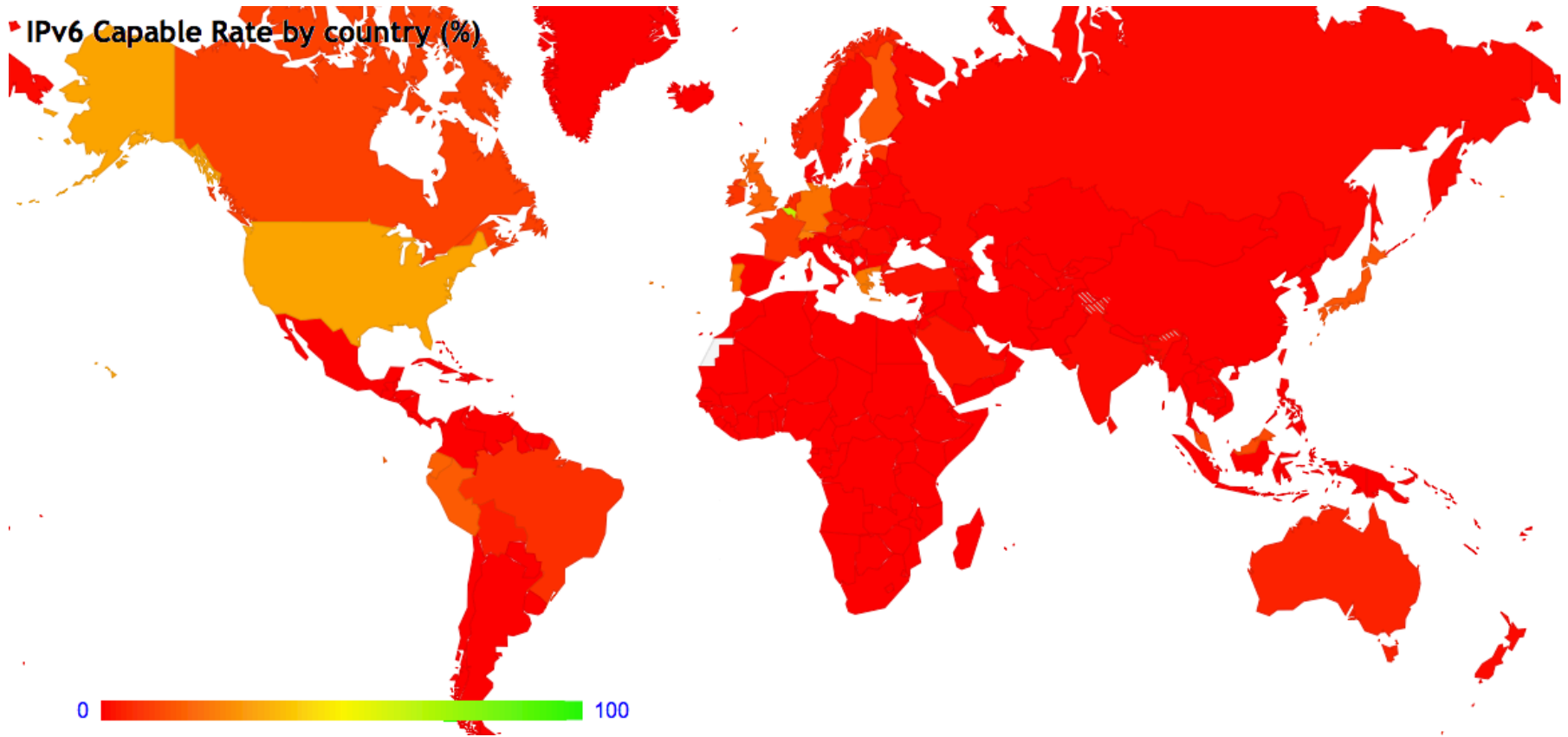


# Networks are special

- Large scale distributed networks are different
- Individual networks need to keep in sync with all of their peer networks
  - If a network heads down its own path it is then isolated
  - Isolated networks have little residual value
- To keep in sync we need to understand what everyone else is doing



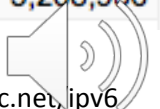
# What is everyone doing in IPv6?



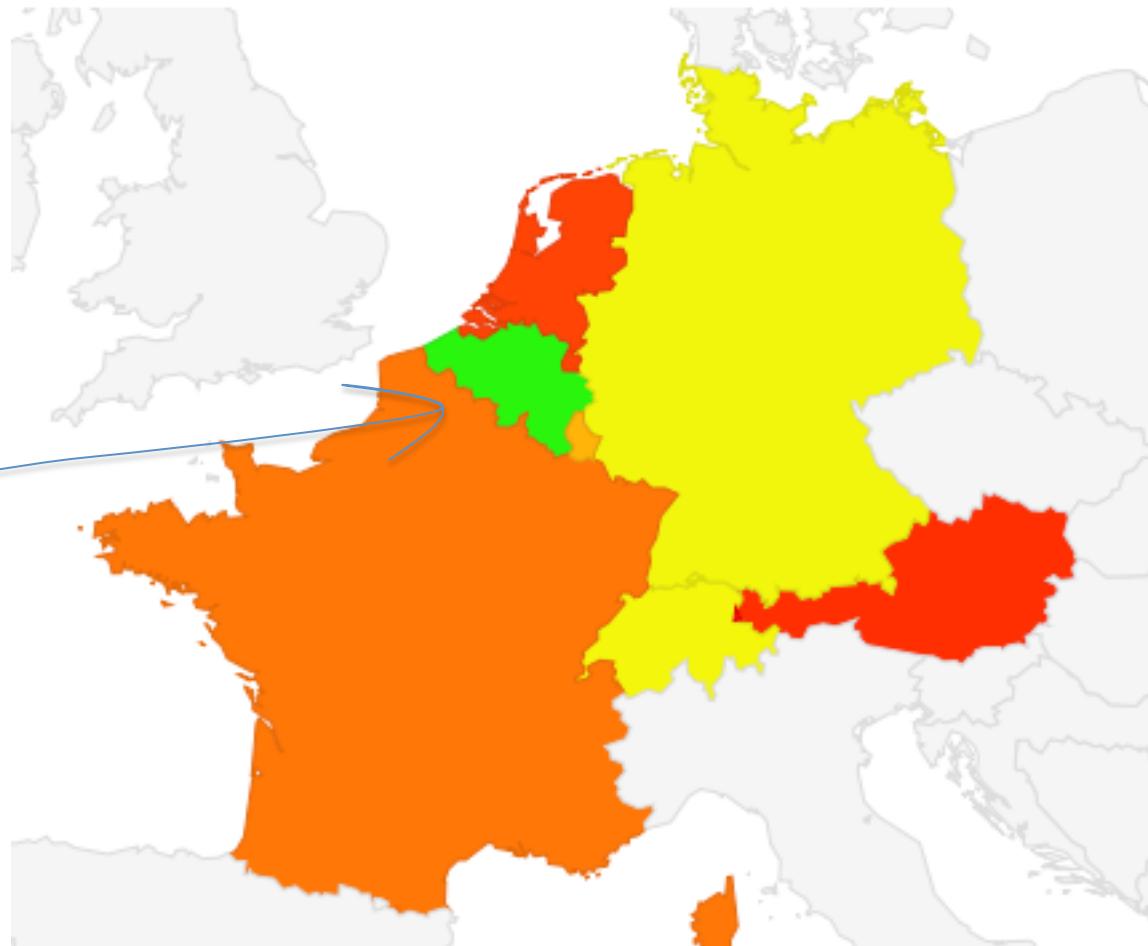
# What is everyone doing in IPv6?



CC	Country	IPv6 Capable	IPv6 Preferred	Samples
BE	Belgium, Western Europe, Europe	55.51%	53.22%	1,915,221
US	United States of America, Northern America, Americas	32.88%	30.27%	78,938,328
DE	Germany, Western Europe, Europe	29.72%	26.51%	1,554,668
CH	Switzerland, Western Europe, Europe	29.39%	27.90%	1,228,366
GR	Greece, Southern Europe, Europe	28.20%	27.65%	5,224,545
PT	Portugal, Southern Europe, Europe	26.68%	25.89%	5,268,936



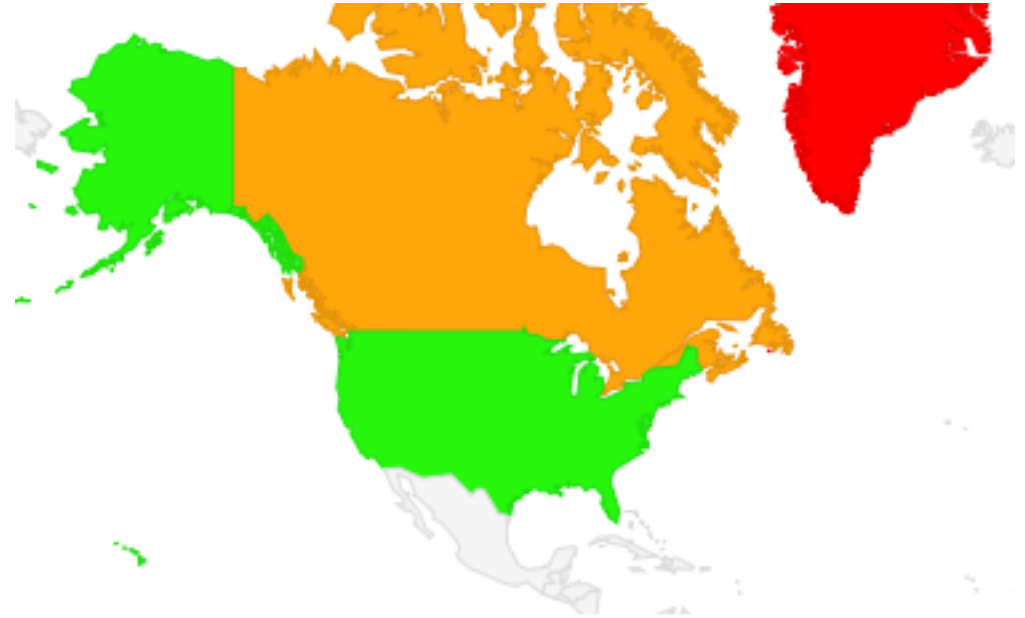
# Belgium



ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples ▼
AS5432	BELGACOM-SKYNET-AS Proximus NV	46.56%	44.34%	788,560
AS6848	TELENET-AS Telenet N.V.	71.68%	68.80%	731,978
AS12392	ASBRUTELE Brutele SC	74.99%	72.96%	198,174
AS47377	MES Mobistar SA	0.18%	0.06%	43,461
AS21502	ASN-NUMERICABLE NC Numericable S.A.	0.00%	0.00%	36,698



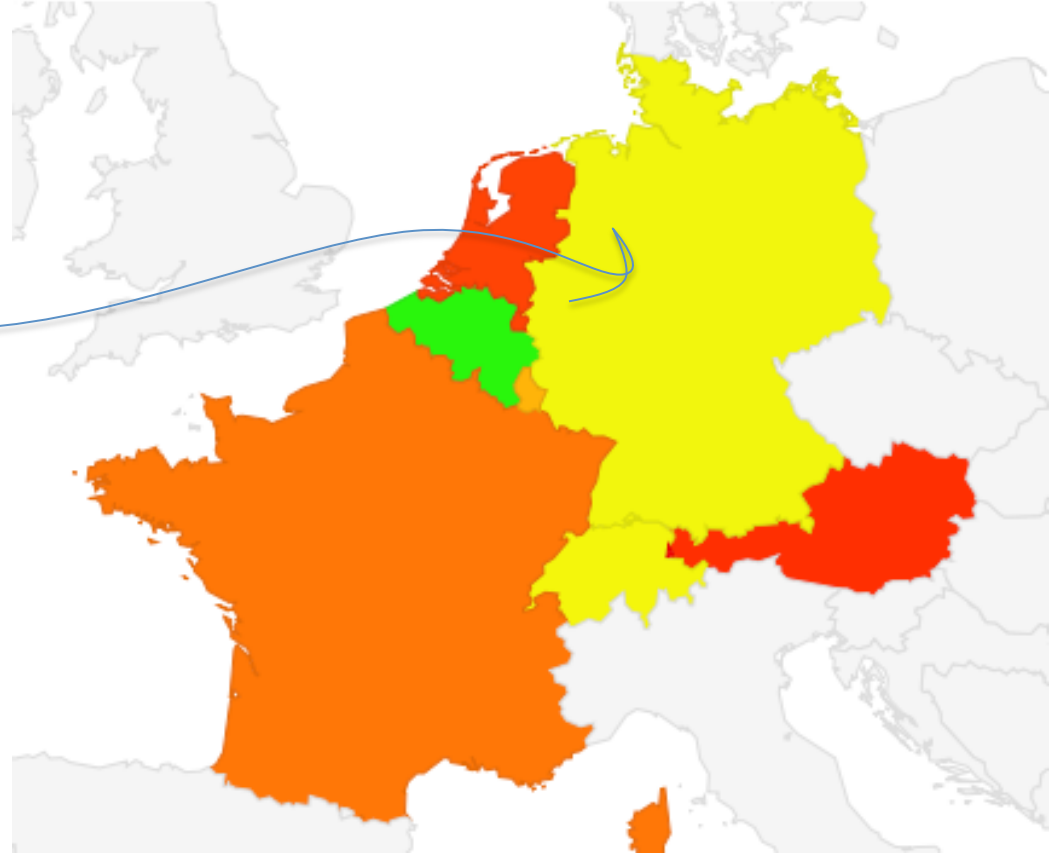
# United States



ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples ▼
AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	63.58%	59.24%	15,018,049
AS7018	ATT-INTERNET4 - ATT Services, Inc.	82.18%	75.24%	8,733,815
AS701	UUNET - MCI Communications Services, Inc. dba Verizon Business	0.17%	0.02%	4,421,927
AS20115	CHARTER-NET-HKY-NC - Charter Communications	0.12%	0.02%	3,518,064
AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc.	26.85%	25.05%	3,293,274
AS22394	CELLCO - Cellco Partnership DBA Verizon Wireless	89.64%	82.16%	2,487,117
AS209	CENTURYLINK-US-LEGACY-QWEST - Qwest Communications Company, LLC	0.15%	0.08%	2,338,251
AS20057	ATT-MOBILITY-LLC-AS20057 - ATT Mobility LLC	10.74%	10.57%	2,318,700
AS20001	ROADRUNNER-WEST - Time Warner Cable Internet LLC	45.31%	41.84%	2,066,142
AS5650	FRONTIER-FRTR - Frontier Communications of America, Inc.	0.11%	0.01%	2,015,253
AS10796	SCRR-10796 - Time Warner Cable Internet LLC	23.02%	21.64%	1,992,576
AS6128	CABLE-NET-1 - Cablevision Systems Corp.	0.11%	0.01%	1,880,000
AS21928	T-MOBILE-AS21928 - T-Mobile USA, Inc.	57.51%	56.31%	1,724,200
AS11427	SCRR-11427 - Time Warner Cable Internet LLC	43.50%	40.42%	1,326,276



# Germany



ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples ▼
AS3320	DTAG Deutsche Telekom AG	50.79%	49.13%	411,241
AS3209	VODANET Vodafone GmbH	0.11%	0.05%	134,969
AS31334	KABELDEUTSCHLAND-AS Vodafone Kabel Deutschland GmbH	68.72%	65.13%	90,406
AS24940	HETZNER-AS Hetzner Online GmbH	3.12%	2.58%	88,719
AS6805	TDDE-ASN1 Telefonica Germany GmbH Co.OHG	0.44%	0.34%	80,936
AS28753	LEASEWEB-DE Leaseweb Deutschland GmbH	41.98%	0.82%	73,377
AS200185	XANDMAIL-ASN X AND MAIL SA	0.00%	0.00%	64,241
AS6830	LGI-UPC Liberty Global Operations B.V.	49.94%	46.90%	61,345



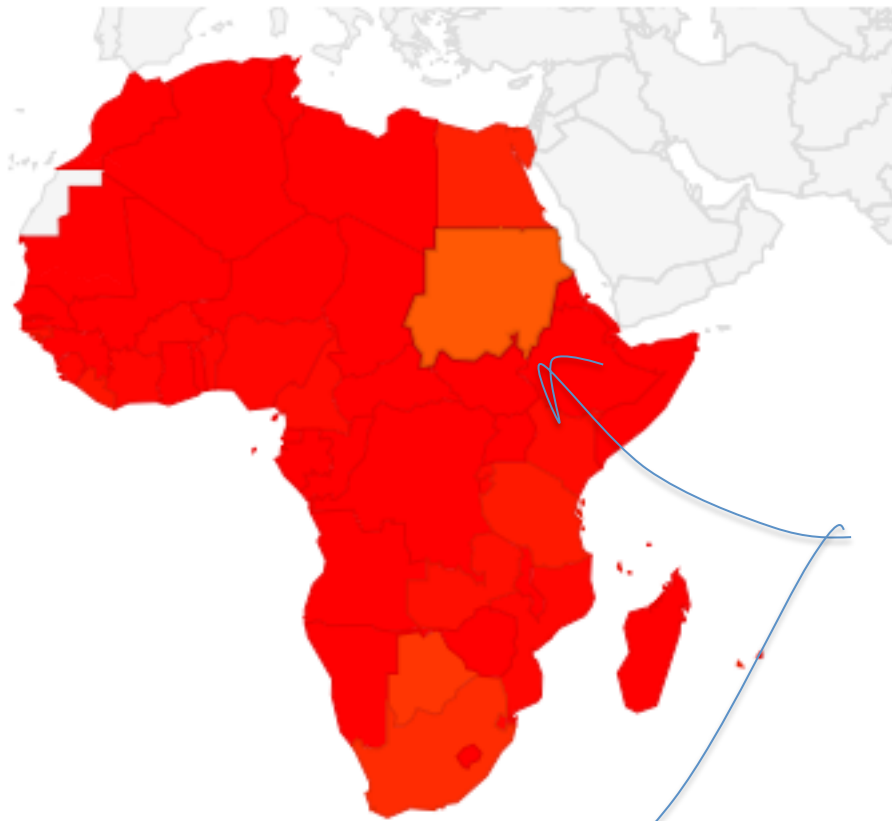
# Sudan

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samples
AS37197	SUDREN	29.63%	26.21%	4,620
AS15706	Sudatel	0.08%	0.07%	242,255
AS33788	KANARTEL	0.01%	0.00%	42,933
AS36998	SDN-MOBITEL	0.01%	0.00%	428,220
AS36972	MTNSD	0.00%	0.00%	178,438
AS36892	IPTECH	0.00%	0.00%	788
AS37211	MAX-NET-FOR-INTERNET-SERVICES	0.00%	0.00%	4,726
AS0	Reserved (ietf)	0	0	5
AS37594	MTNSS	0	0	4
AS54334	ROYA - Roya Hosting LLC	0	0	2

AS 37197 – SUDREN has deployed IPv6 – noone else!



# Africa



SUDAN is #1 for IPv6 in Africa!

CC	Country	IPv6 Capable	IPv6 Preferred	Samples
SD	Sudan, Northern Africa, Africa	0.18%	0.15%	901,991
BW	Botswana, Southern Africa, Africa	0.11%	0.10%	147,523
ZA	South Africa, Southern Africa, Africa	0.09%	0.08%	370,892
EG	Egypt, Northern Africa, Africa	0.07%	0.06%	18,314,521
RE	Reunion, Eastern Africa, Africa	0.07%	0.02%	610,565
TZ	United Republic of Tanzania, Eastern Africa, Africa	0.05%	0.04%	376,016
LR	Liberia, Western Africa, Africa	0.04%	0.00%	47,808
GW	Guinea-Bissau, Western Africa, Africa	0.03%	0.01%	9,941
KM	Comoros, Eastern Africa, Africa	0.03%	0.01%	6,789
ZM	Zambia, Eastern Africa, Africa	0.03%	0.00%	170,087



# What are we seeing?

IPv6 deployment is not happening everywhere.

IPv6 is not happening all at once.

But it IS happening.



# What are we seeing?

What we appear to be seeing are concentrated areas of quite intense IPv6 activity.



# Is IPv6 still “A Waiting Game”?

So far what we have heard from many industry actors about IPv6 is:

“I’m waiting for others. I’ll jump when they jump.”



# Is IPv6 still “A Waiting Game”?

In the past year we have seen a number of major commercial network service operators, primarily in the United States, Japan, Germany, France, and Switzerland launch programs that integrate IPv6 services into their mass market retail offerings.



# Is IPv6 still “A Waiting Game”?

Is this effort by a few large scale service providers enough to break out of the general waiting game?





# Is IPv6 still “A Waiting Game”?

Is this effort by a few large scale service providers enough to break out of the general waiting game?

I'd like to think so!



# A question to each of you...

How many IPv6 presentations have you sat through?

21?

101?

1,001?

I don't know - I was asleep by the end!



Thank You!

