IPv6 Transition: A Progress Report

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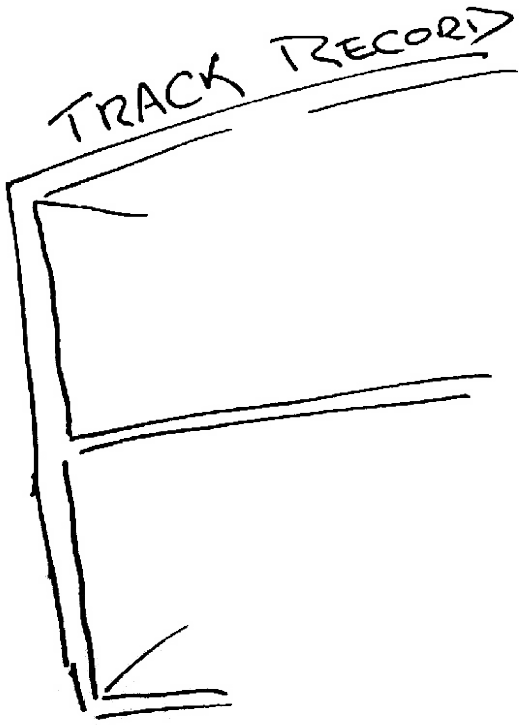
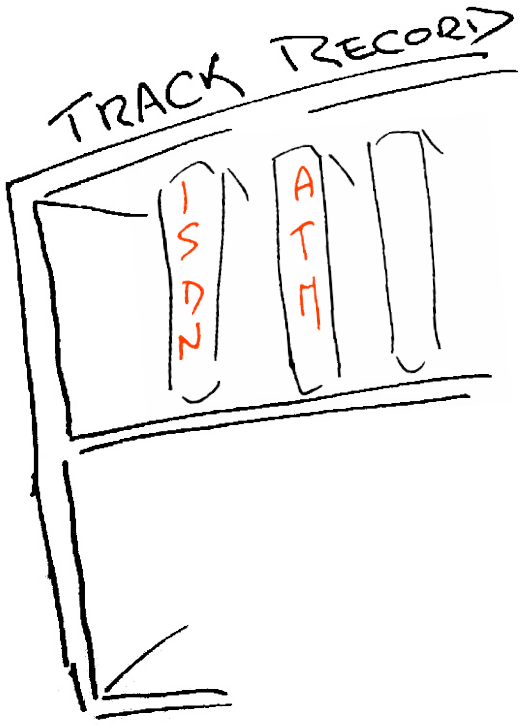
APNIC

The mainstream telecommunications industry has a rich history



The mainstream telecommunications industry has a rich history

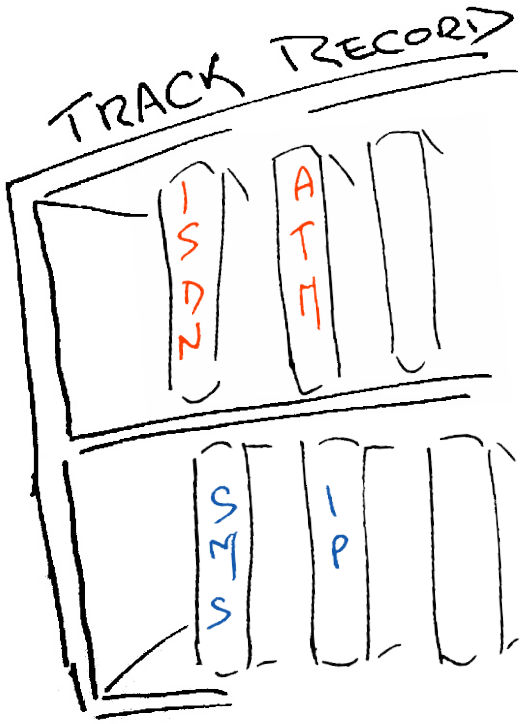
…of making very poor technology choices



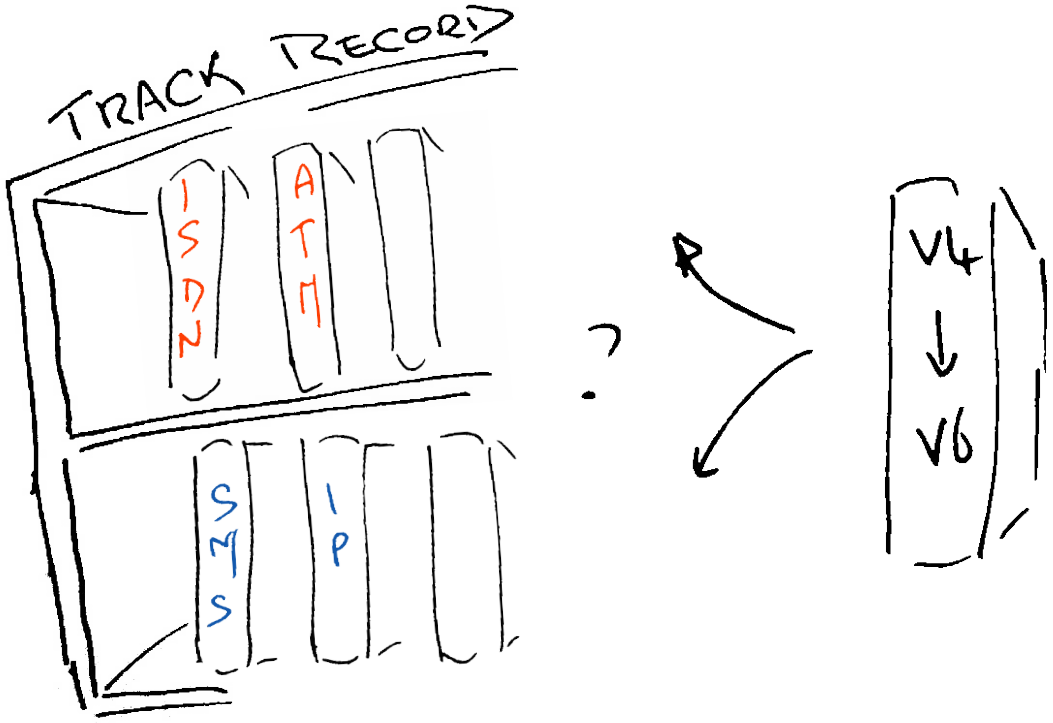
The mainstream telecommunications industry has a rich history

…of making very poor technology guesses

and regularly being taken by surprise!



So, how are we going with the IPv4 to IPv6 transition?



But maybe there's an initial question here:

Do we really need to worry about this?

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Surely IPv6 will just happen – its just a matter of waiting for the pressure of IpV4 address exhaustion to get to sufficient levels of intensity.

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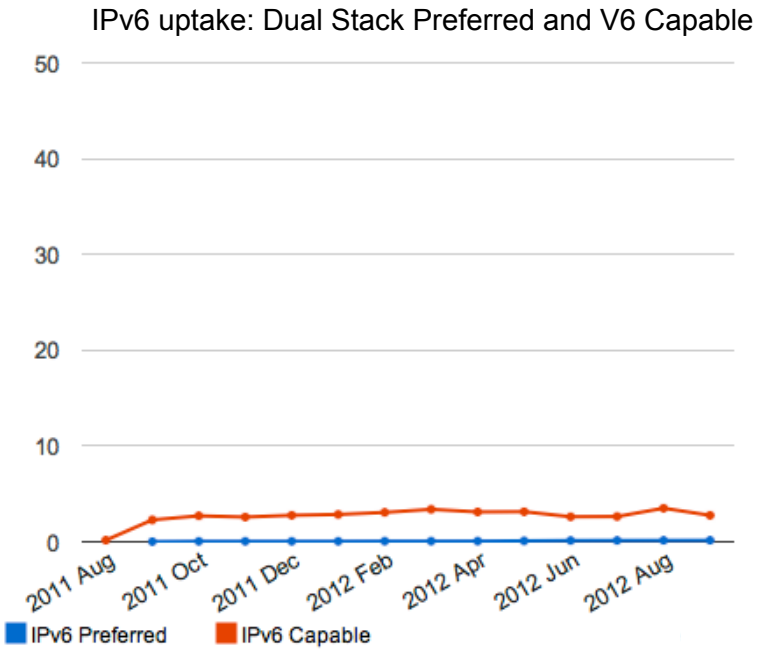
Surely IPv6 will just happen – its just a matter of waiting for the pressure of IpV4 address exhaustion to get to sufficient levels of intensity.

Or maybe not – let's look a bit closer at the situation

IPv6 Uptake

Measured at the level of client capability, the amount of the Internet's user base that currently displays IPv6 capability is less than 1%

More worryingly, the overall trend curves for the entire Internet for Ipv6 adoption have pretty flat for some years now



IPv6 Uptake

There is fair amount of variance here: some countries appear to be well ahead of others in IPv6 deployment....

IPv6 Users by Country

Date: 13 Sep 2012

Index	ISO-3166 Code	Internet Users	V6 Use ratio	V6 Users (Est)	Population	Country
1	RO	8664419	11.18%	968682	22103112	Romania
2	FR	50029950	4.26%	2131275	64805636	France
3	LU	466369	3.09%	14410	510251	Luxembourg
4	JP	100907257	2.40%	2421774	126134072	Japan
5	US	248102536	1.64%	4068881	316861477	United States of America
6	SI	1417840	1.16%	16446	1996959	Slovenia
7	CH	6450040	0.92%	59340	7660381	Switzerland
8	HR	2652722	0.86%	22813	4480951	Croatia
9	SK	4344889	0.80%	34759	5485971	Slovakia
10	NO	4578408	0.78%	35711	4710297	Norway

IPv6 Uptake

There is fair amount of variance here: while others are not as well positioned

IPv6 Users by Country

Date: 13 Sep 2012

Index	ISO-3166 Code	Internet Users	V6 Use ratio	V6 Users (Est)	Population	Country
	KR	40452384	0.01%	4045	48914613	Republic of Korea
	MX	42063891	0.01%	4206	115243539	Mexico
	EC	4153312	0.01%	415	15269532	Ecuador
	RS	4085069	0.01%	408	7268807	Serbia
	AR	28334508	0.01%	2833	42290311	Argentina
	CL	10101727	0.01%	1010	17063729	Chile
	CY	596644	0.01%	59	1142997	Cyprus
	PK	28391823	0.01%	2839	183173056	Pakistan
	UY	1988847	0.02%	397	3545182	Uruguay
	PH	34368582	0.02%	6873	104147221	Philippines
	VE	11169478	0.03%	3350	28134706	Venezuela
	MK	1933904	0.03%	580	3899001	The former Yugoslav Republic of Macedonia
	HK	4922125	0.03%	1476	7164666	Hong Kong Special Administrative Region of China
	IQ	1344734	0.03%	403	31272896	Iraq
	IT	34039140	0.03%	10211	57988314	Italy
	BR	87052766	0.03%	26115	206286176	Brazil

IPv6 Uptake

There is a LOT of uncertainty in the IPv6 transition process at present

Some countries and some sectors are progressing quickly, but much of the Internet appears to be still in a "wait and see" mode

Some actors feel that V6 deployment is something that they should respond to now

Others are still waiting...

IPv6 Uptake

Currently its looking like this transition is becoming an extended hiatus for the Internet

There is no overnight "quick fix" for IPv6 adoption

That implies that EVERYONE will need to support IpV4 access for some years to come

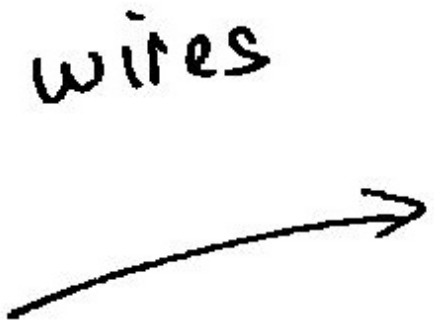
But how we are going to do this, and for how long, is a really tough question

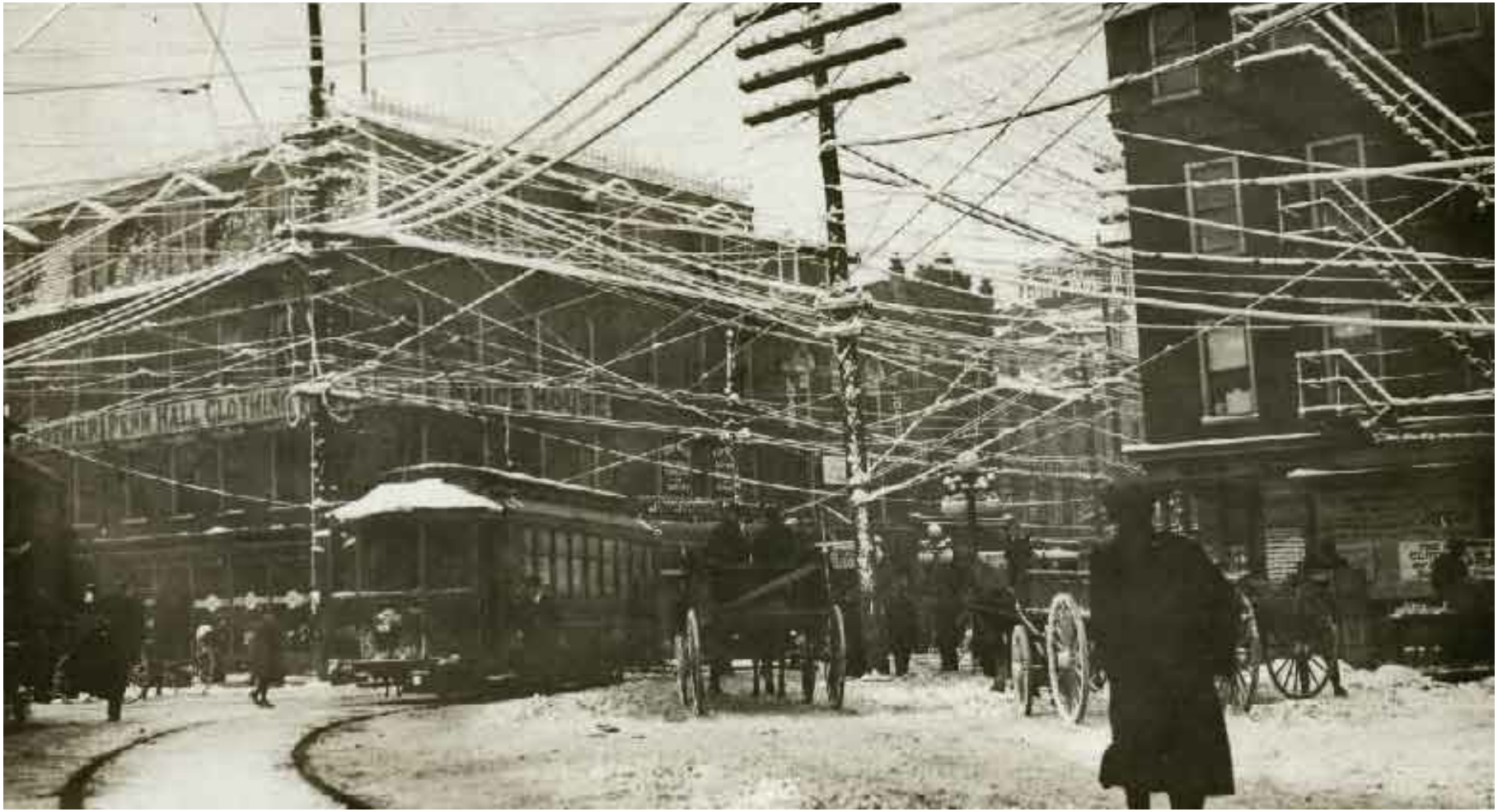
IPv6 Uptake

...But how we are going to support dual stacks, and for how long, is a really tough question

And there are a number of factors that make so much harder, rather than easier...

The
"inevitability"
of technological
evolution





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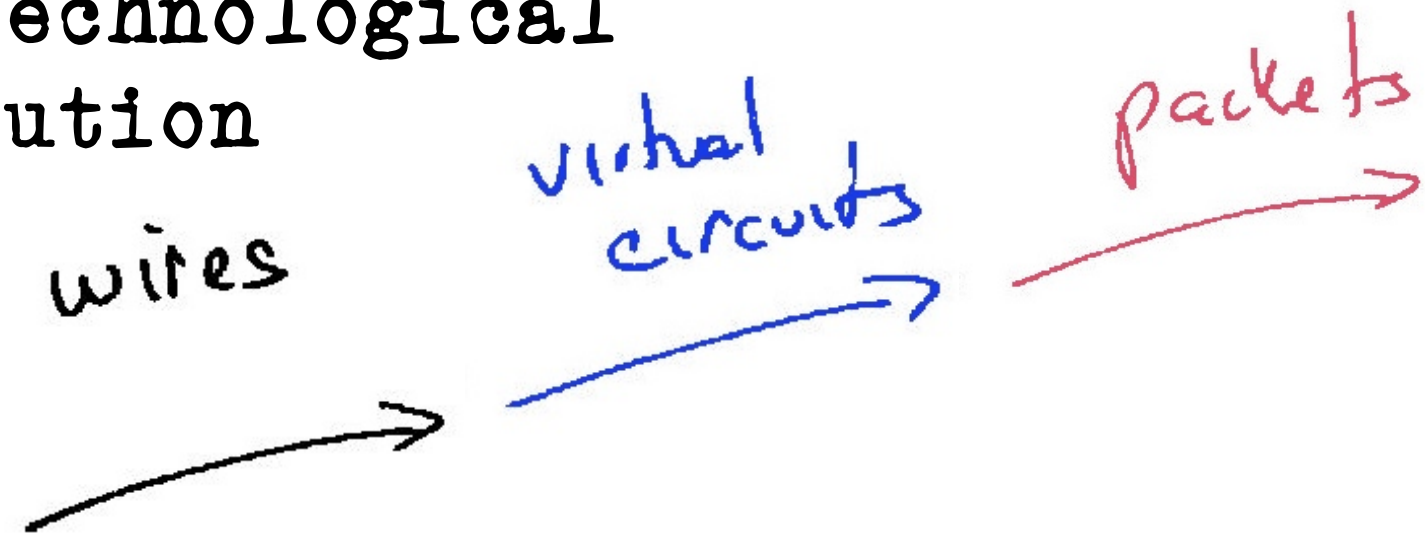

The "inevitability" of technological evolution

Now lets look at something a little more topical to today!

The
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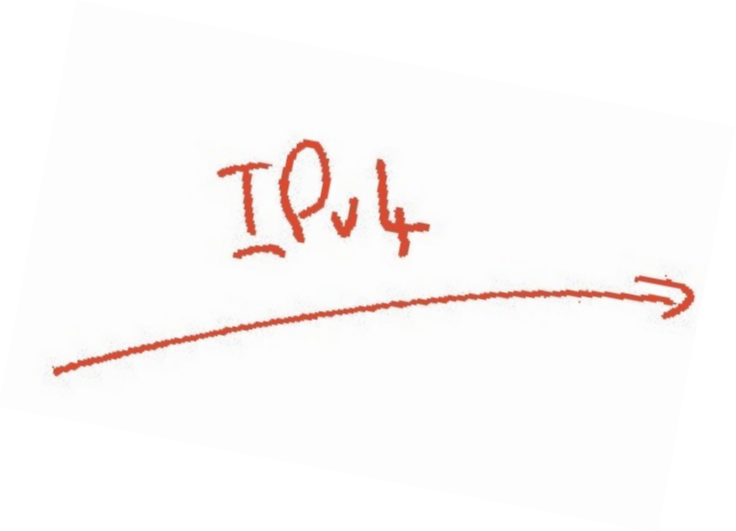
evolution?



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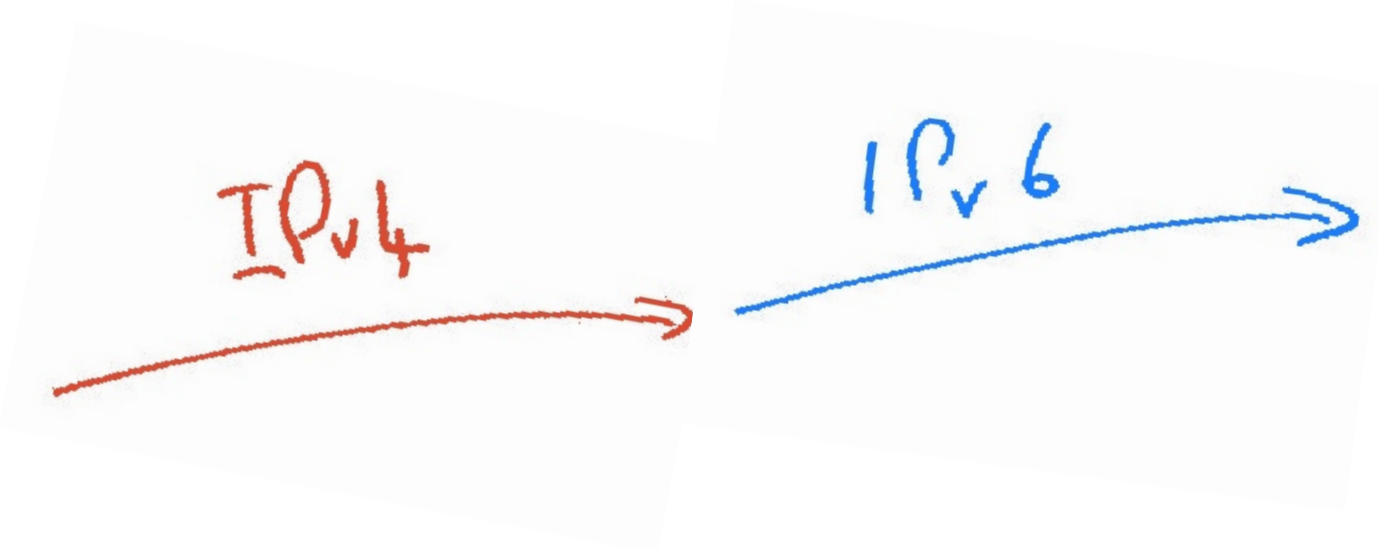
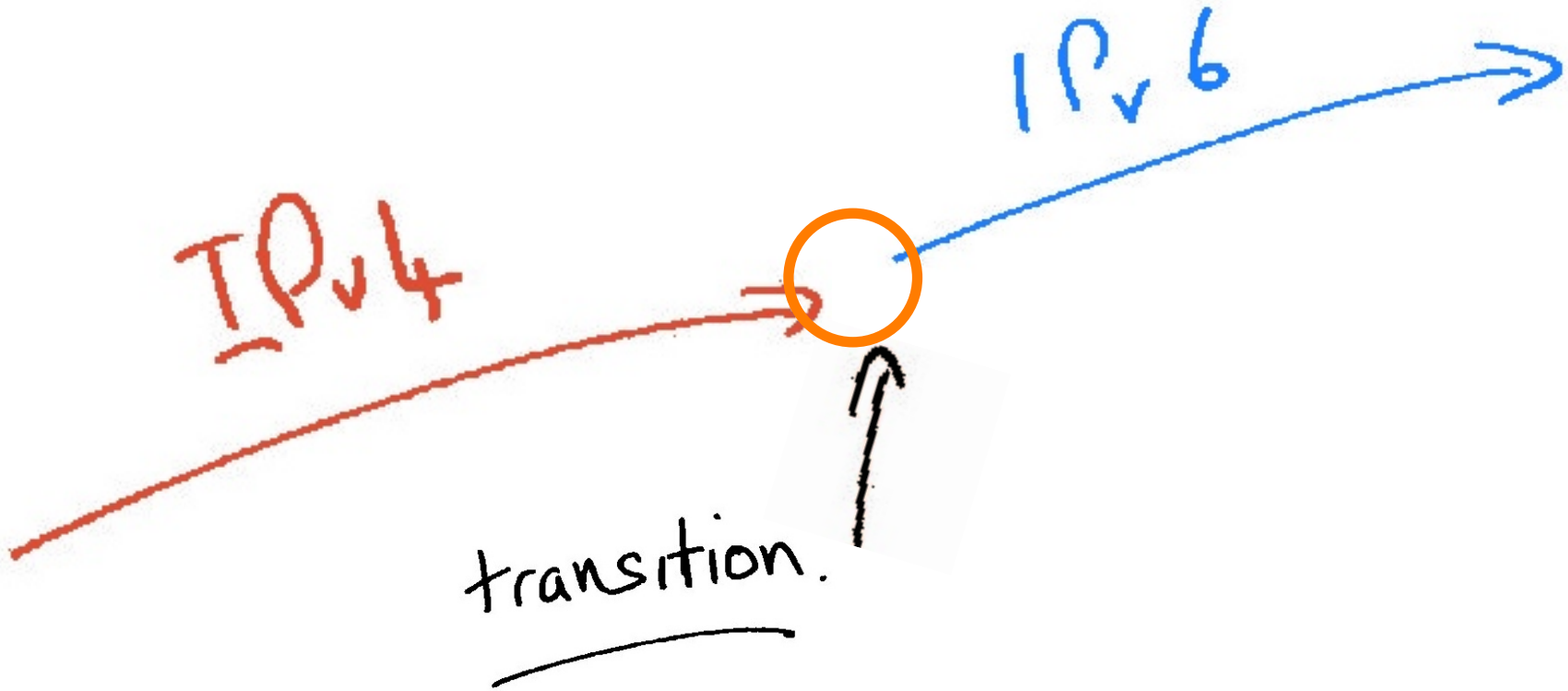


The challenge often lies in managing the transition from one technology to another



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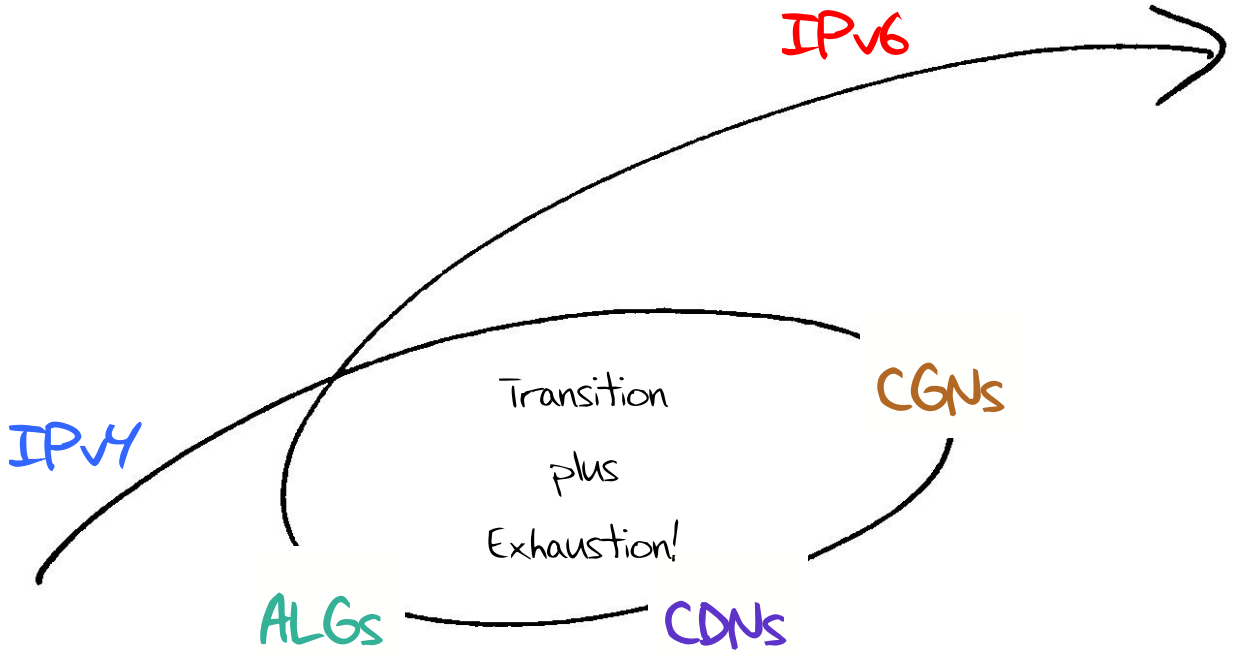
To get from "here" to "there" requires an excursion through an environment of CGNs, CDNs, ALGs and similar middleware 'solutions' to IPv4 address exhaustion



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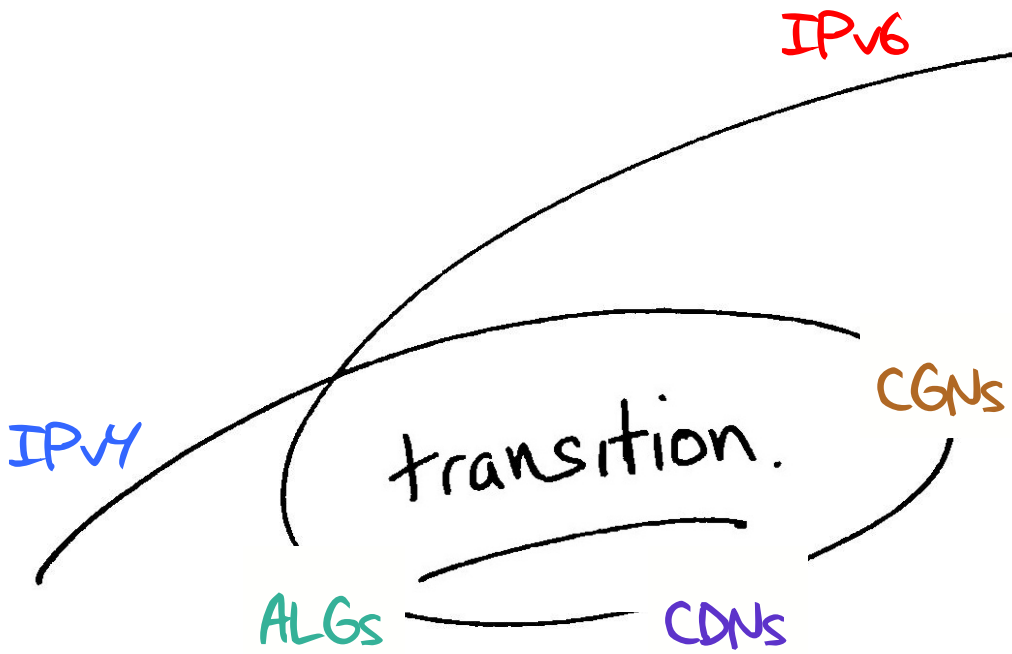
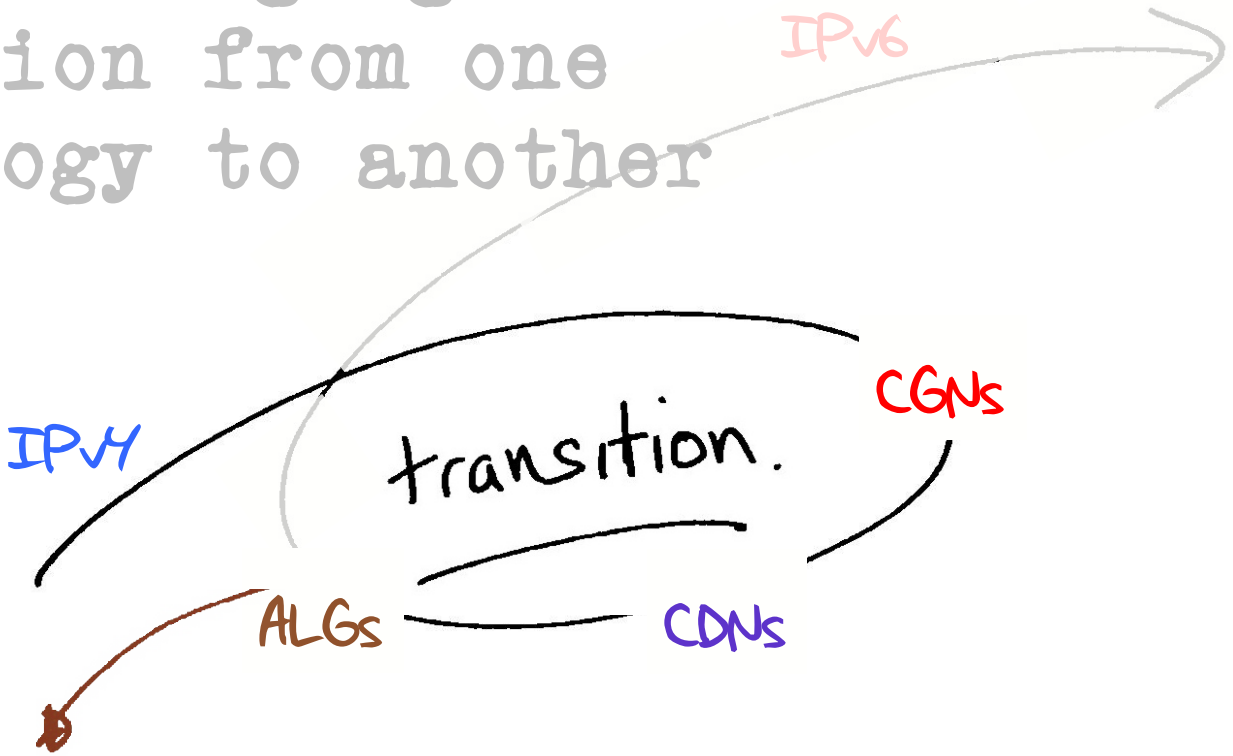


Transition requires the network owner to undertake capital investment in network service infrastructure. What lengths will the network owner then go to to protect the value of this additional investment by locking itself into this "transitional" service model for an extended/indefinite period?

The challenge often lies in managing the transition from one technology to another



The risk in this transition phase is that the Internet heads off in a completely different direction!

Can we "manage" this transition?

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To ensure that the industry maintains a collective focus on IPv6 as the objective of this exercise!

How can we "manage" this transition?

To ensure that the industry maintains a collective focus on IPv6 as the objective of this exercise!

And to ensure that we do not get distracted by attempting to optimize what were intended to be temporary measures

Challenges:

1. This is a deregulated and highly competitive environment

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It is NOT a case of a single "either/or" decision

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There are many different players

Each with their own perspective

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There are many different players

Each with their own perspective

And all potential approaches will be explored!

Challenges:

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   There is no plan, just the interplay of various market pressures

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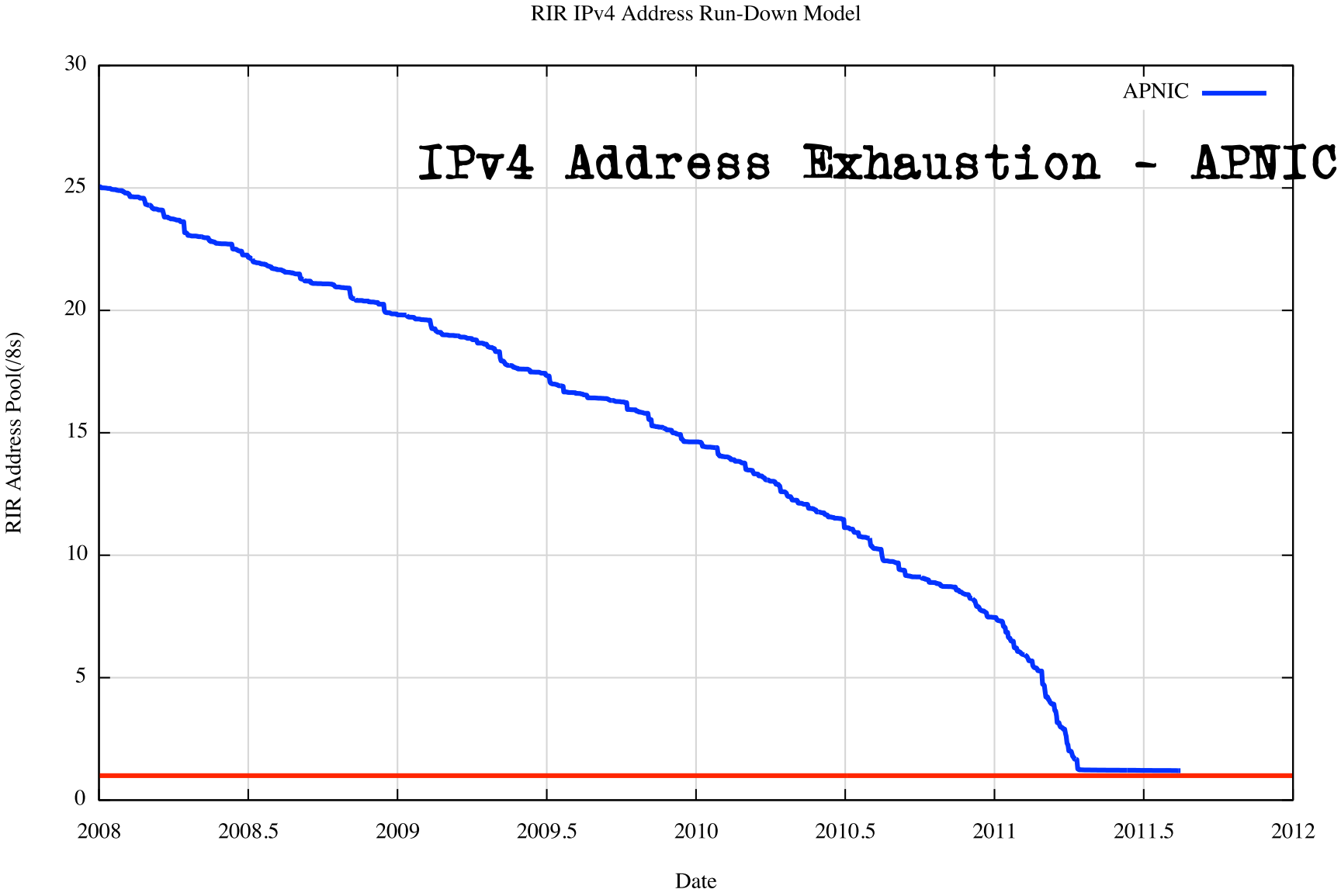
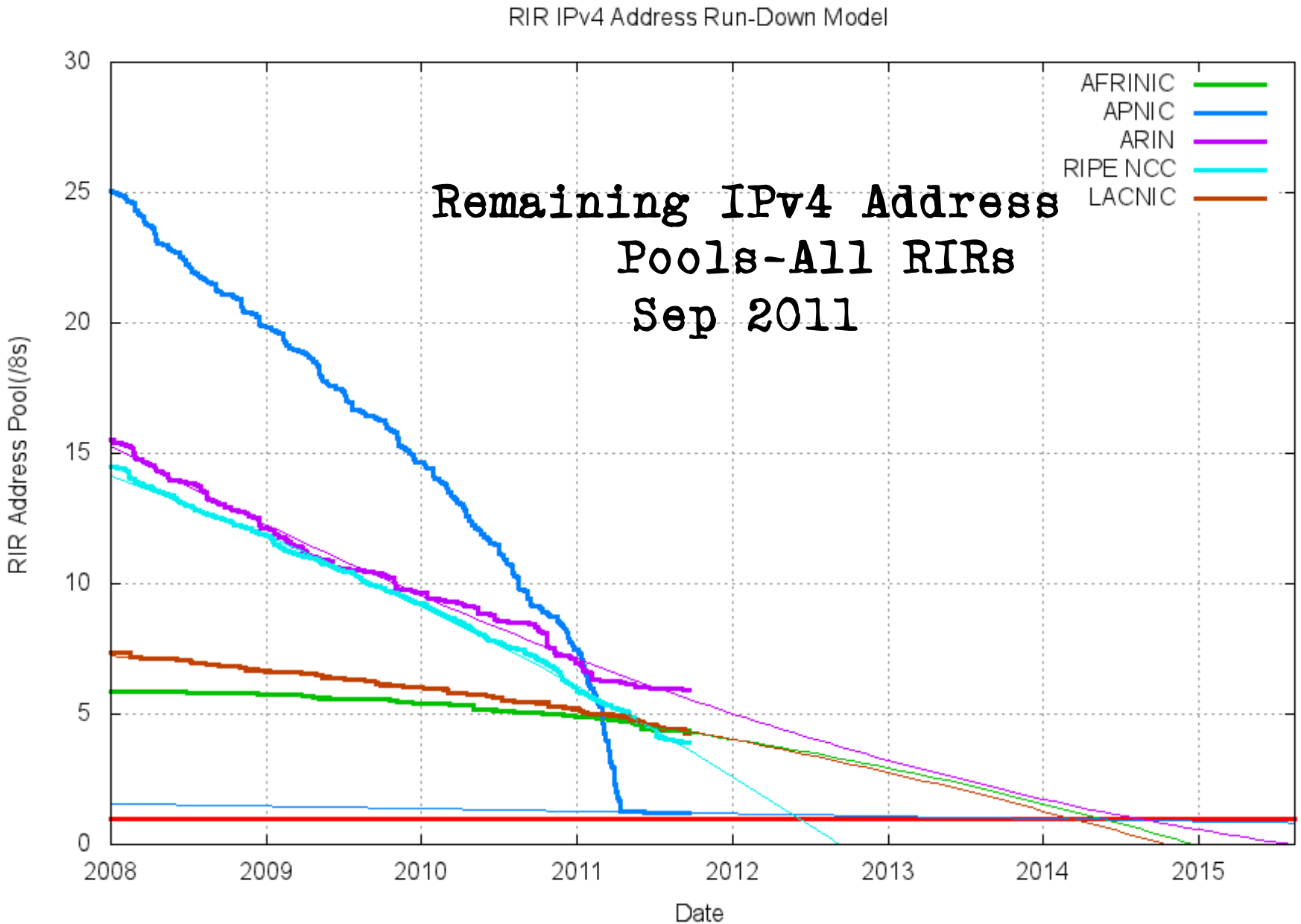
2. Varying IPv4 Address Exhaustion Timelines


RIR IPv4 Address Run-Down Model
IPv4 Address Exhaustion - APNIC
APNIC
RIR Address Pool(/8s)
Date
30
25
20
15
10
5
0
2008
2008.5
2009
2009.5
2010
2010.5
2011
2011.5
2012


RIR IPv4 Address Run-Down Model
Remaining IPv4 Address Pools-All RIRs Sep 2011
AFRINIC
APNIC
ARIN
RIPE NCC
LACNIC
RIR Address Pool(/8s)
Date
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5
10
15
20
25
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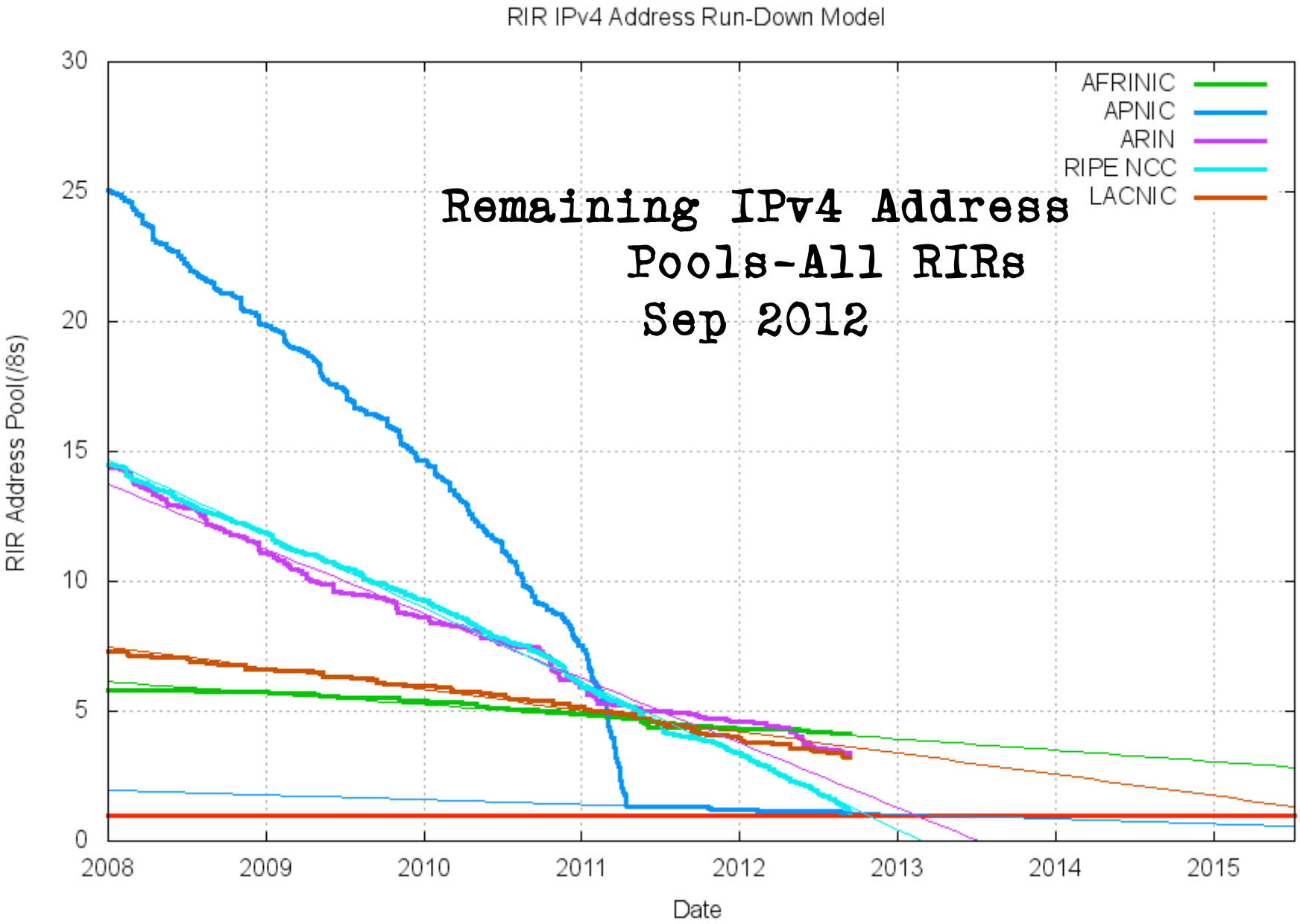
2008
2009
2010
2011
2012
2013
2014
2015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AFRINIC
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Date
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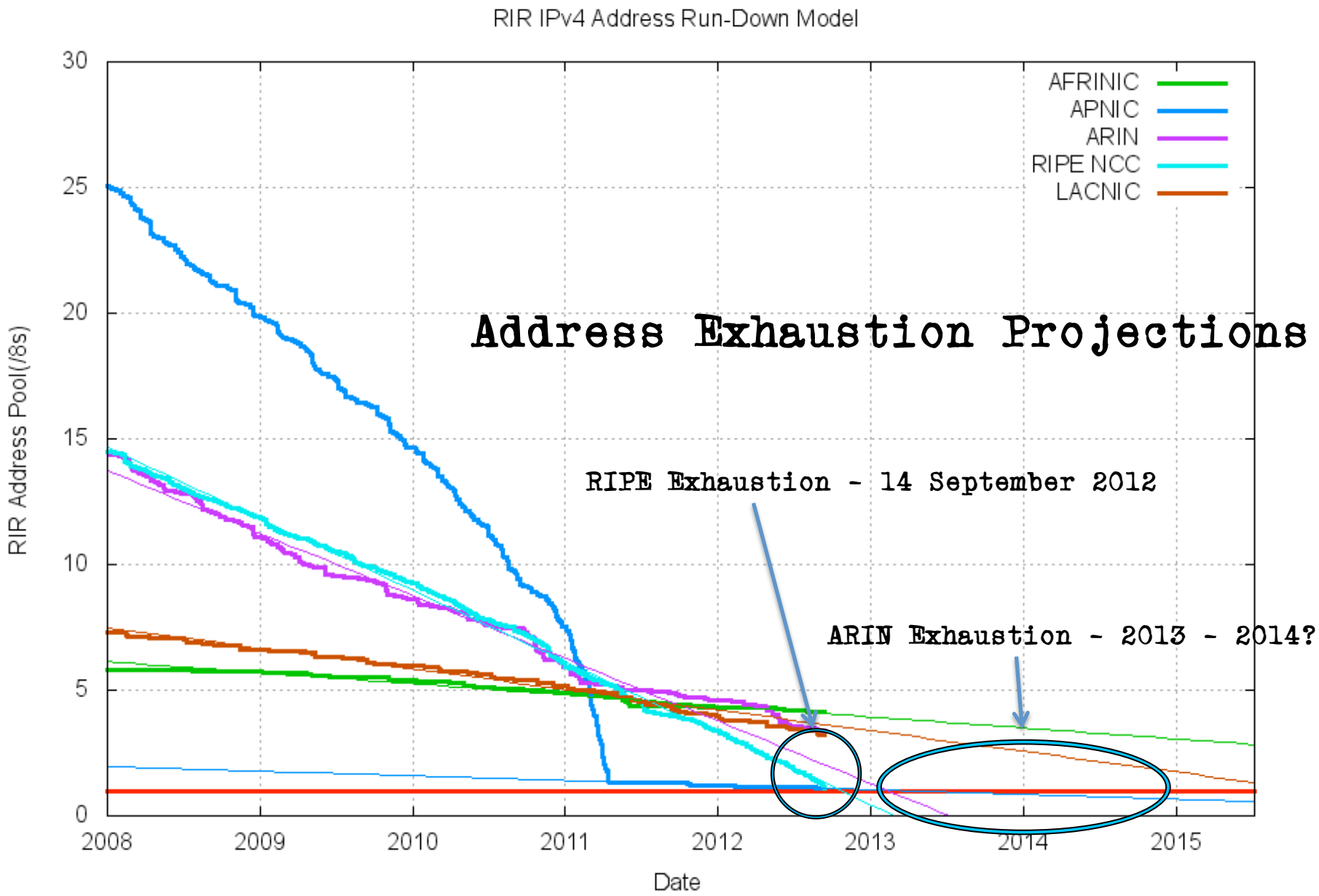
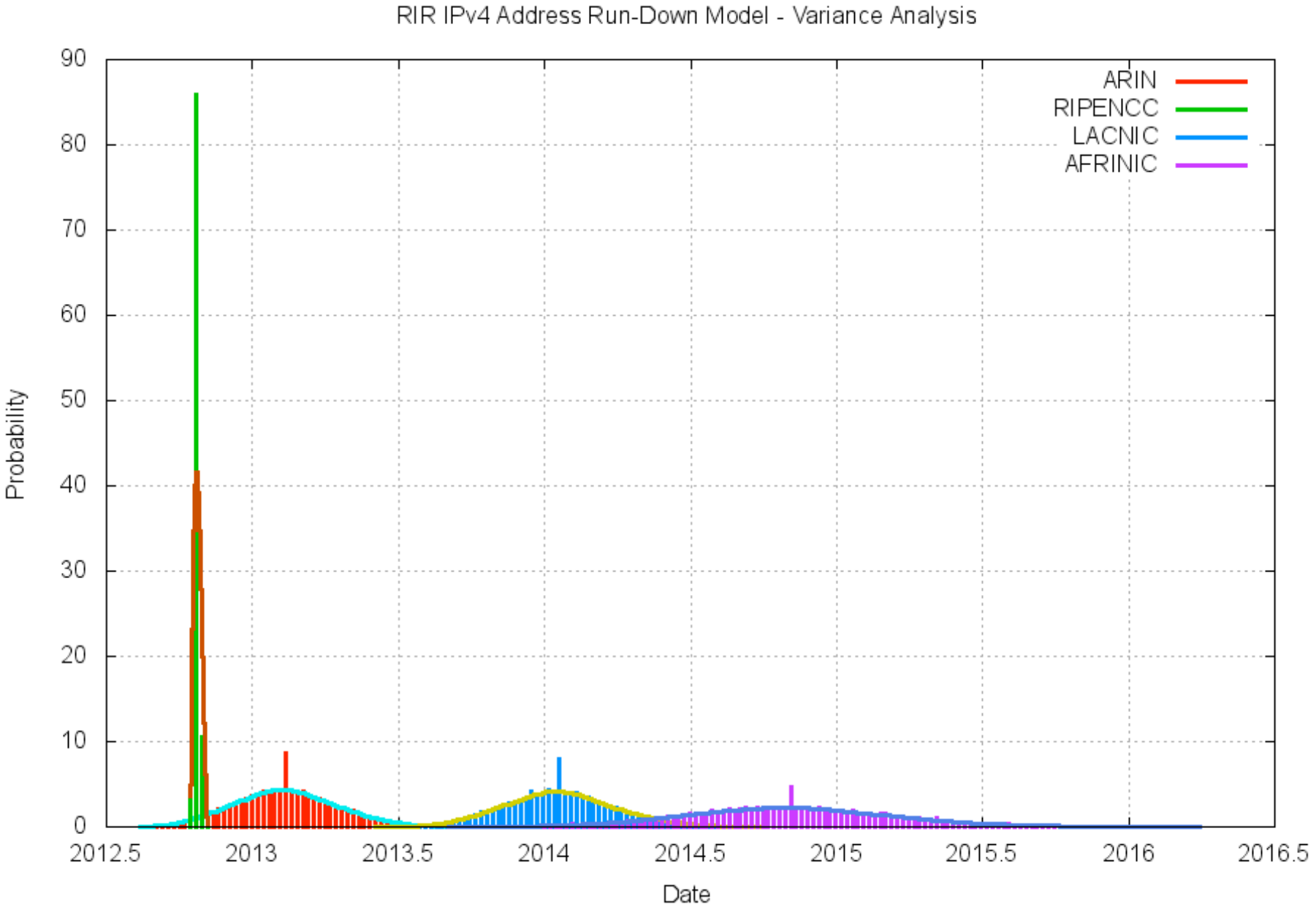

RIR IPv4 Address Run-Down Model
RIR Address Pool(/8s)
Date
AFRINIC
APNIC
ARIN
RIPE NCC
LACNIC
Address Exhaustion Projections
RIPE Exhaustion - 14 September 2012
ARIN Exhaustion - 2013 - 2014?
0
5
10
15
20
25
30
2008
2009
2010
2011
2012
2013
2014
2015

Exhaustion Predictions

RIR	Predicted Exhaustion Date *	Remaining Address Pool (14 Sep 2012)
APNIC	19 April 2011 (actual)	0.91
RIPE NCC	14 September 2012 (actual)	1.05 /8s
ARIN	24 August 2013	3.36 /8s
LACNIC	16 May 2014	3.22 /8s
AFRINIC	8 Aug 2014	4.14 /8s

** Here "exhaustion" is defined as the point when the RIR's remaining pool falls to 1 /8*


RIR IPv4 Address Run-Down Model - Variance Analysis
ARIN
RIPENCC
LACNIC
AFRINIC
Probability
Date
0
10
20
30
40
50
60
70
80
90
2012.5
2013
2013.5
2014
2014.5
2015
2015.5
2016
2016.5

Challenges:

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   There is no plan, just the interplay of various market pressures

2. Varying IPv4 Address Exhaustion Timelines
   Differing time lines create differing pressures in the market

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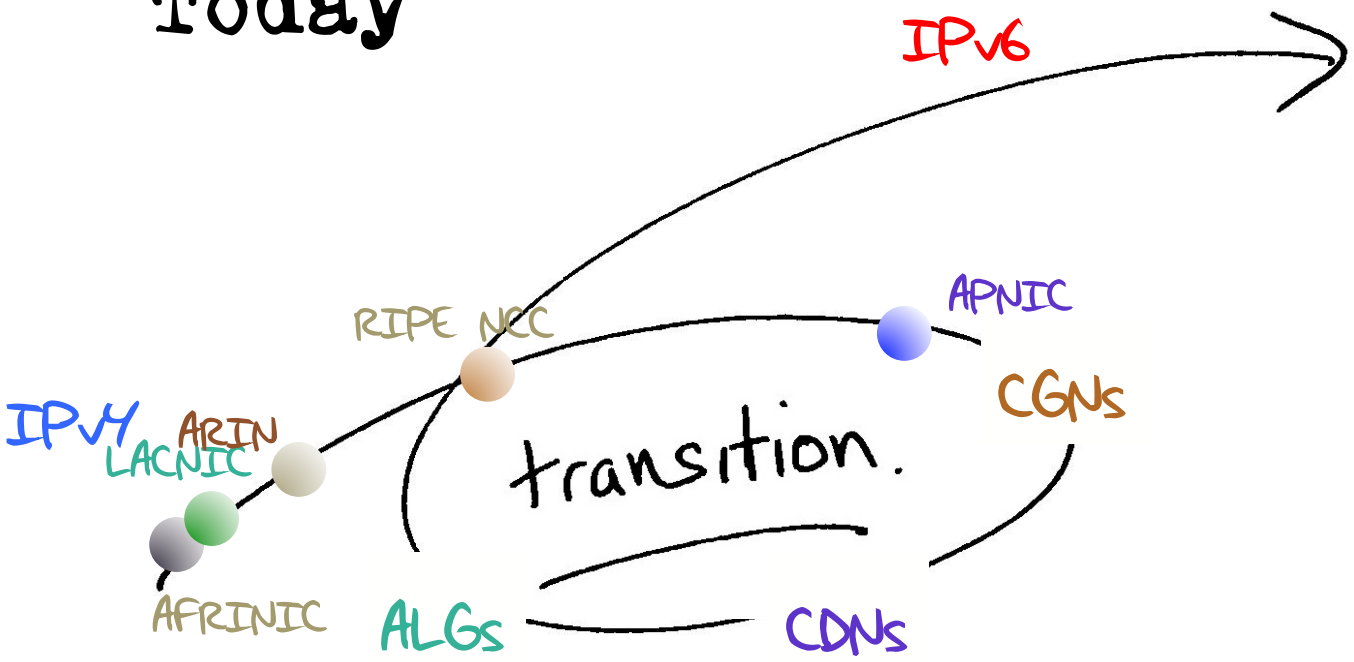
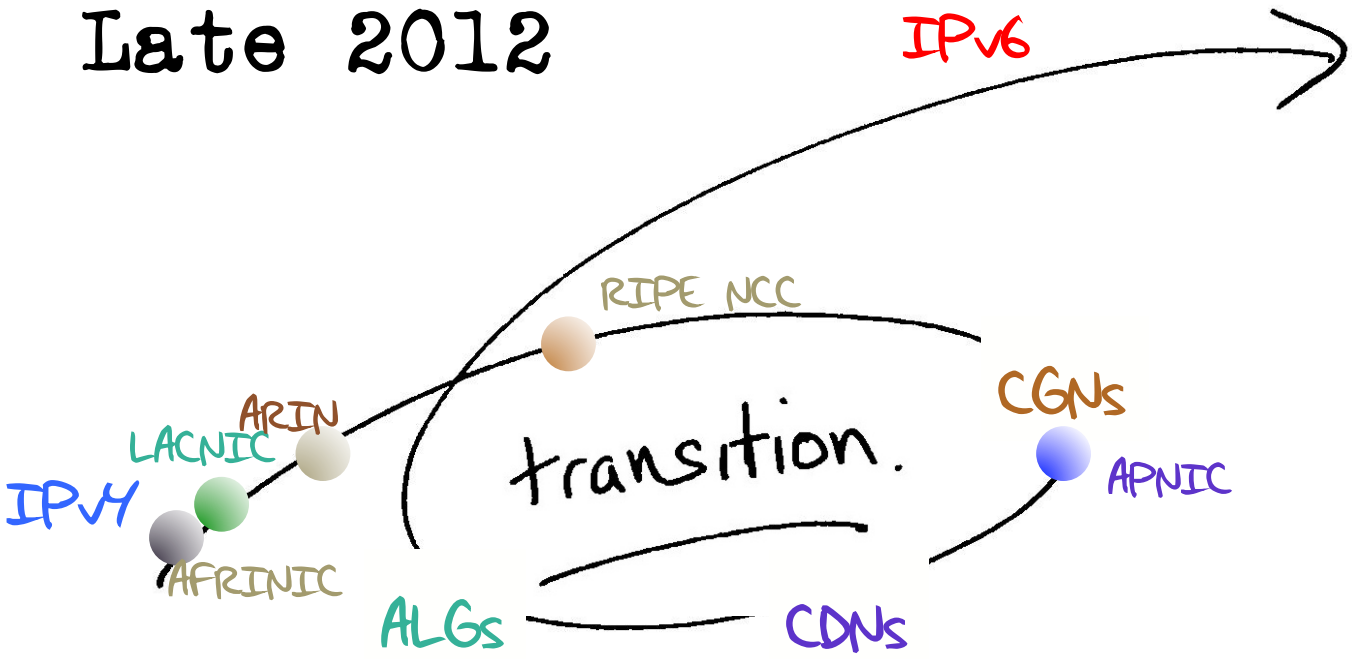
3. Regional Diversity

Today


IPv6
RIPE NCC
APNIC
CGNs
IPv4
ARIN
LACNIC
transition.
AFRINIC
ALGs
CDNs

Late 2012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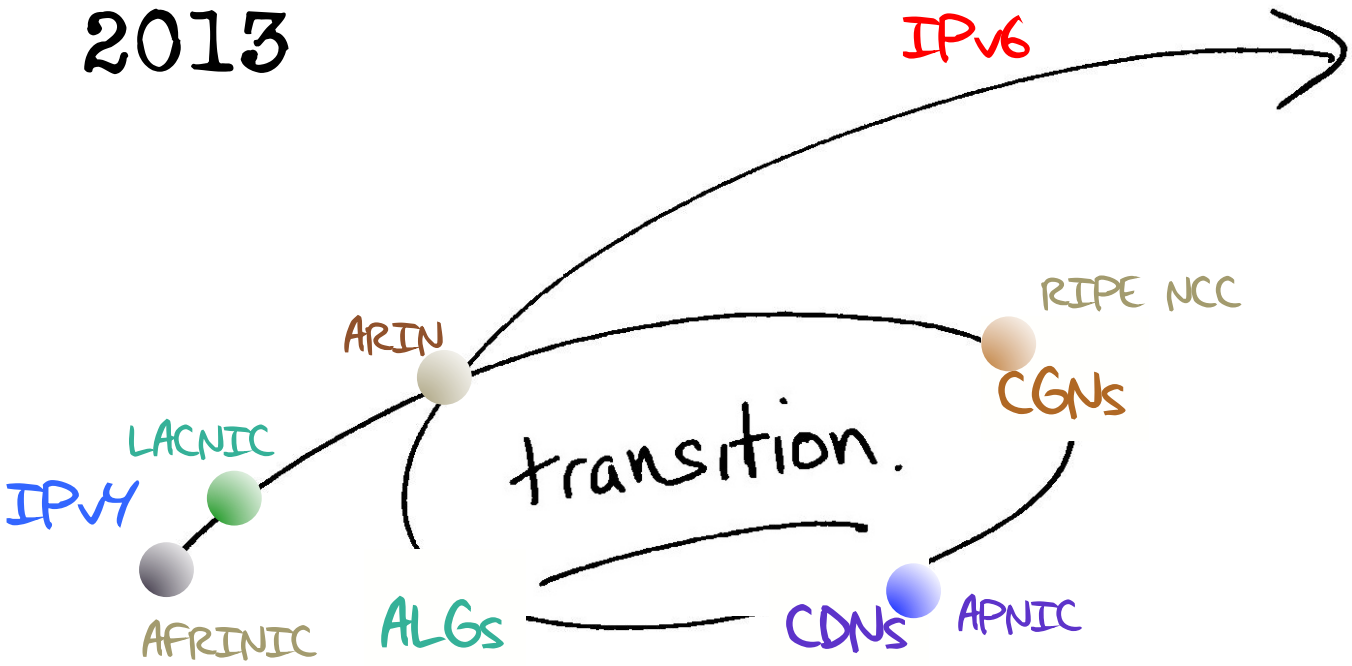
2013
IPv6
RIPE NCC
ARIN
CGNs
LACNIC
IPv4
transition.
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ALGs
CDNs
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By 2014 it is possible that different regions of the world will be experiencing very different market pressures for the provision of Internet services, due to differing transitional pressures from IPv4 exhaustion

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What's the level of risk that the differing environments of transition lead to significantly different outcomes in each region?

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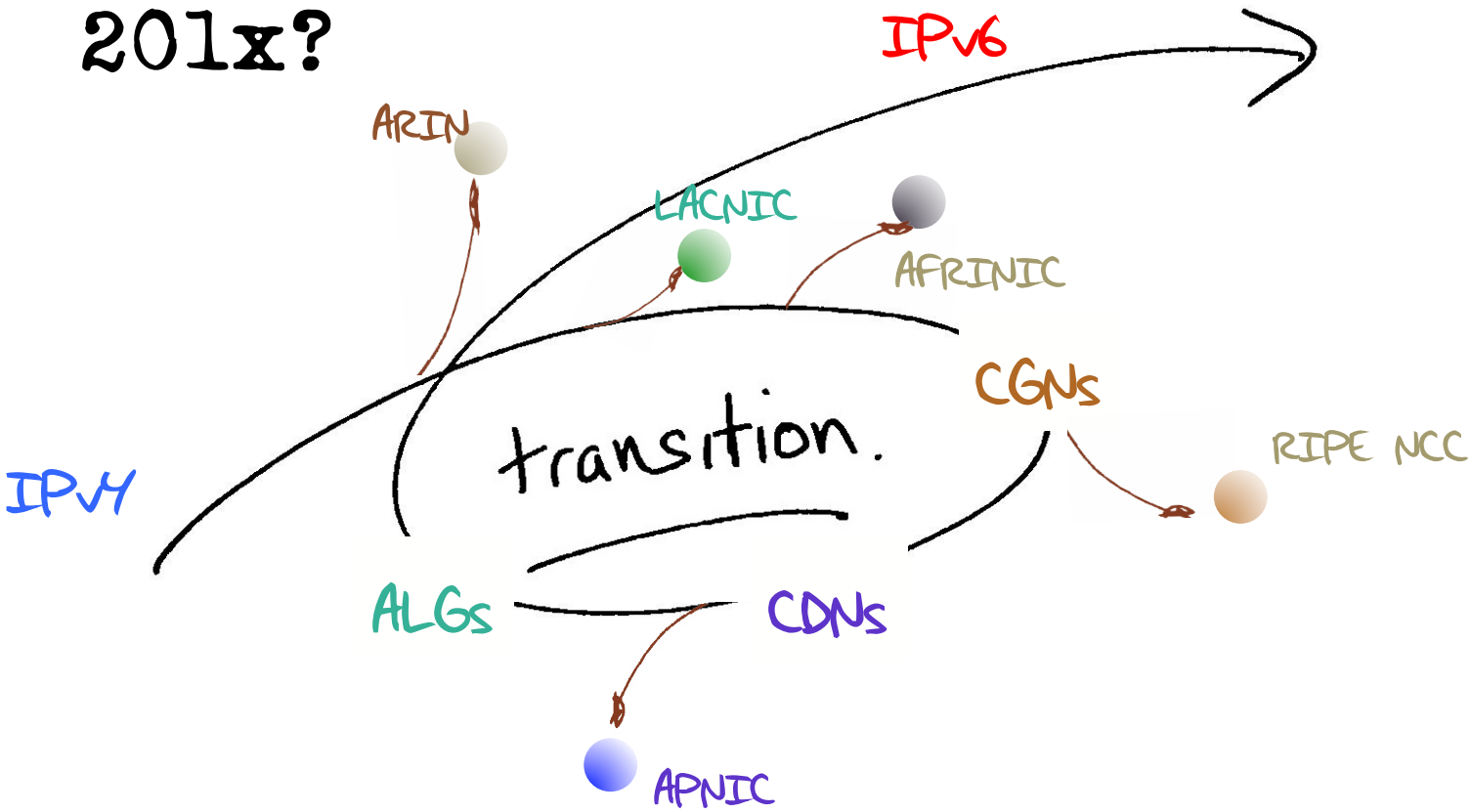
Will we continue to maintain coherency of a single Internet through this transition?

What's the level of risk that the differing environments of transition lead to significantly different outcomes in each region?

The Risk of the Long Term Plan

The longer the period of transition, the higher the risk of completely losing the plot and heading into other directions!


201x?
IPv6
ARIN
LACNIC
AFRINIC
CGNs
transition.
IPv4
RIPE NCC
ALGs
CDNs
APNIC

Challenges:

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   There is no plan, just the interplay of various market pressures

2. Varying IPv4 Address Exhaustion Timelines
   Differing time lines create differing pressures in the market

3. Regional Diversity
   One network architecture is not an assured outcome!

What does this mean for the Internet?

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We are going to see a LOT of transition middleware being deployed!

What does this mean for LEAs?

We are going to see a LOT of transition middleware being deployed!

And we are going to see a significant diversity in what that middleware does

What does this mean for LEAs?

LEAs have traditionally focused on the NETWORK as the point of interception and tracing:

They are used to a consistent model to trace activity:

- get an IP address and a time range
- trace back based on these two values to uncover a set of network transactions

What does this mean for LEAs?

In a world of densely deployed CGNs and ALGS then the IP address loses coherent meaning in terms of end party identification.

These traceback approaches won't work any more!

What does this mean for LEAs?

In a world of densely deployed CGNs and ALGS then the IP address loses coherent meaning in terms of end party identification

And instead of shifting to a single "new" model of IP address use, we are going to see widespread diversity in the use of transition mechanisms and NATs in carrier networks

What does this mean for LEAs?

The risk we are running at the moment is that in the near future there will no longer be a single consistent model of how an IP network manages IPv4 and IPv6 addresses

Which implies that there will no longer be a useful single model of how to perform traceback on the network

What does this mean for LEAs?

What's the likely response from LEAs and regulators?

One likely response is to augment the record keeping rules for ISPs:

"record _absolutely everything_, and keep the records for decades"

What does this mean for ISPs?

What are the new record keeping rules?

In order to map a "external" IP address and time to a subscriber as part of a traceback exercise then:

* for every active middleware element you now need to hold the _precise_ time and the _precise_ tranforms that were applied to a packet flow
- and you need to be able to cross-match these records accurately

What does this mean for ISPs?

What are the new record keeping rules?

How many different sets of rules are required for each CGN / dual stack transition model being used?

And are these record keeping practices affordable?

(granularity of the records is shifting from "session" records to "transition" and even individual packet records in this diverse model)

Are they even practical within today's technology capability?

Is this scaleable?

Is it even useful any more?

Traceback in tommorrow's Internet?

The traceback toolkit:

- precise time, source and dest IP addrs, protocol and port information
- Access to all ISP middleware logs
- CDN SP logs
- Network and Middleware deployment maps
- V6 Transition technology map used by the ISP
- A thorough understanding of vendor's equipment behaviour for various applications
- A thorough understanding of application behaviours

Making it hard...

The V6 transition was challenging enough

The combination of V4 exhaustion and V6 transition is far harder

The combination of varying exhaustion times, widespread confusion, diverse agendas, diverse pressures, V4 exhaustion and V6 transition is now amazingly challenging

Making it very hard...

The problem we are facing is that we are heading away from a single service architecture in our IP networks

Different providers are seeing different pressures and opportunities, and are using different technology solutions in their networks

And the longer we sit in this "exhaustion + transitioning" world, the greater the diversity and internal complexity of service networks that will be deployed

Even harder?

All this will make the entire record and trace problem for ISPs and LEAs far harder than it is at present!

At some point along this path of escalating network complexity and diversity its likely that our networks will be simply be unable to track individual use in any coherent manner

If this is where the Internet is heading, then from an LEA perspective the tracking and tracing story is looking pretty bad

In which case we really need to understand if there is a Plan B because what we are doing now may simply not work any longer!

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Thank You