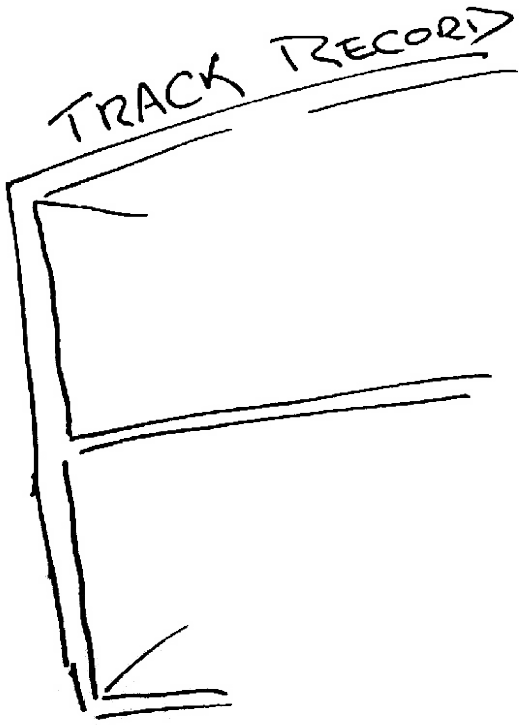
IPv4 Address Exhaustion: A Progress Report

Geoff Huston

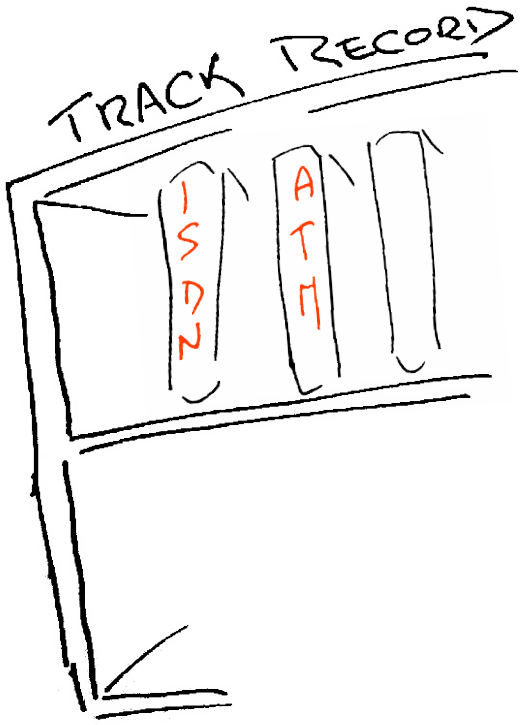
Chief Scientist, APNIC

The mainstream telecommunications industry has a rich history



The mainstream telecommunications industry has a rich history

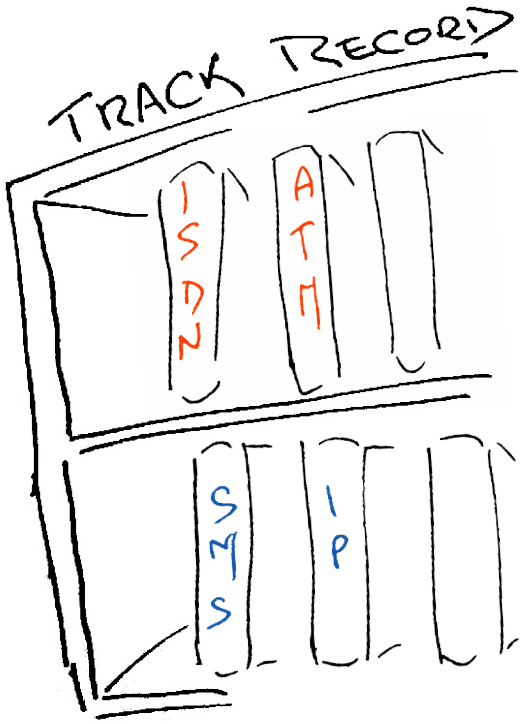
…of making very poor technology choices



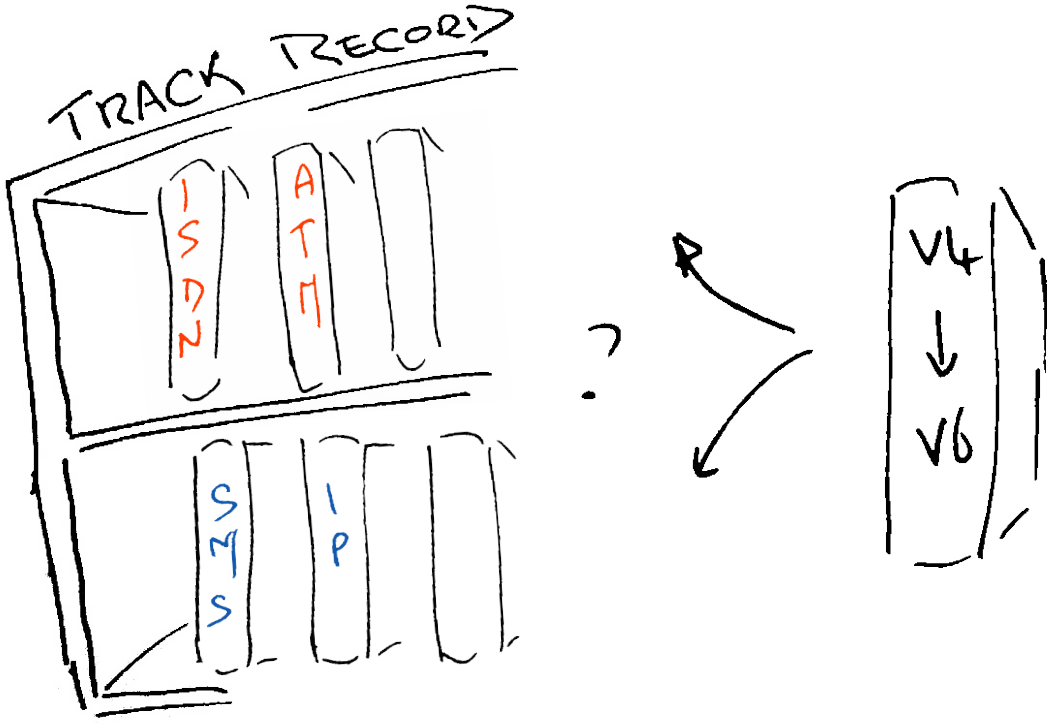
The mainstream telecommunications industry has a rich history

…of making very poor technology guesses

and regularly being taken by surprise!



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



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 ...

The
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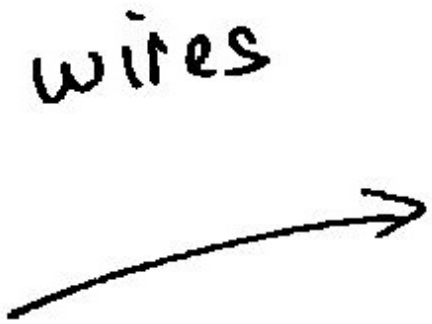
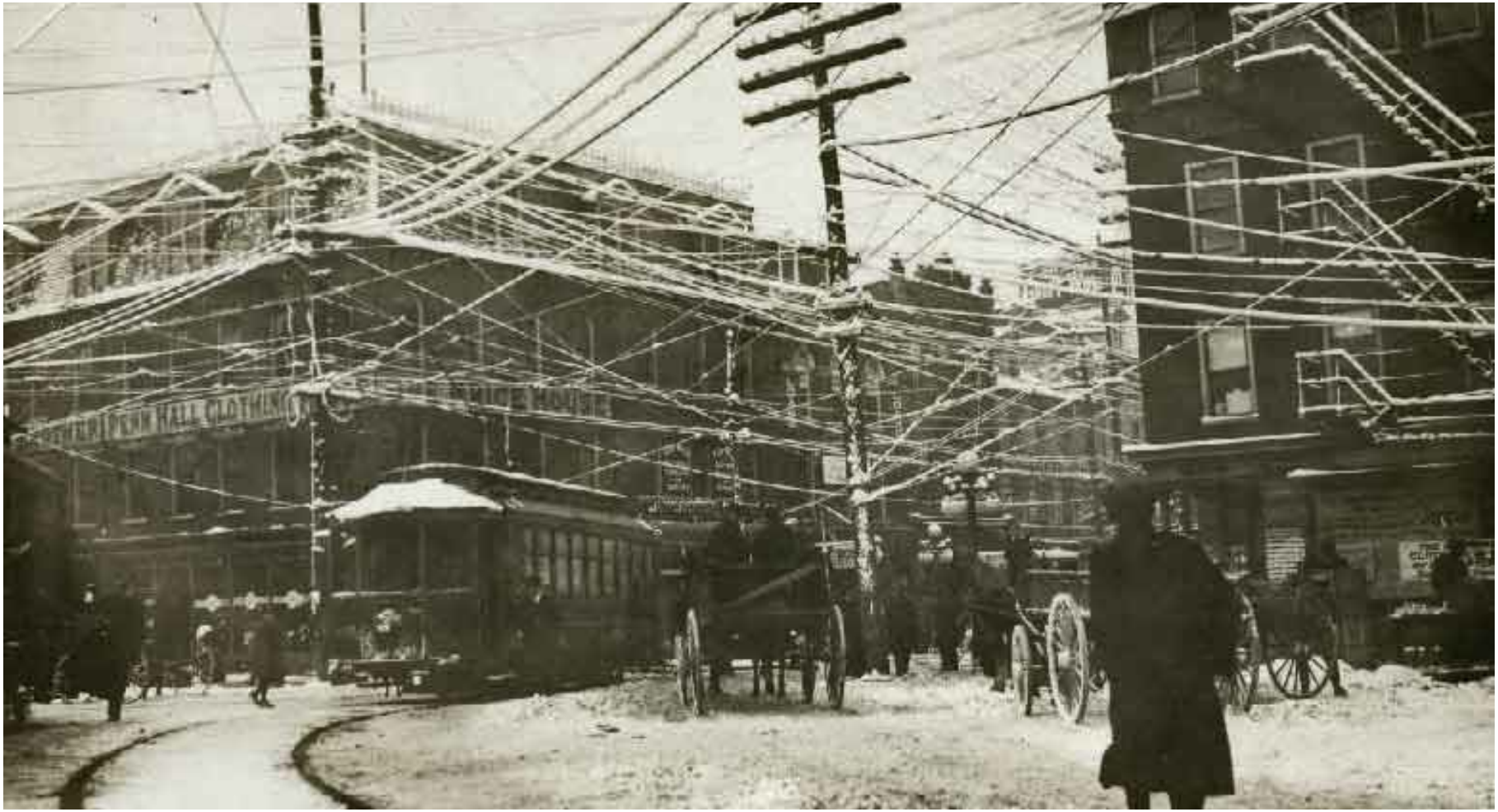
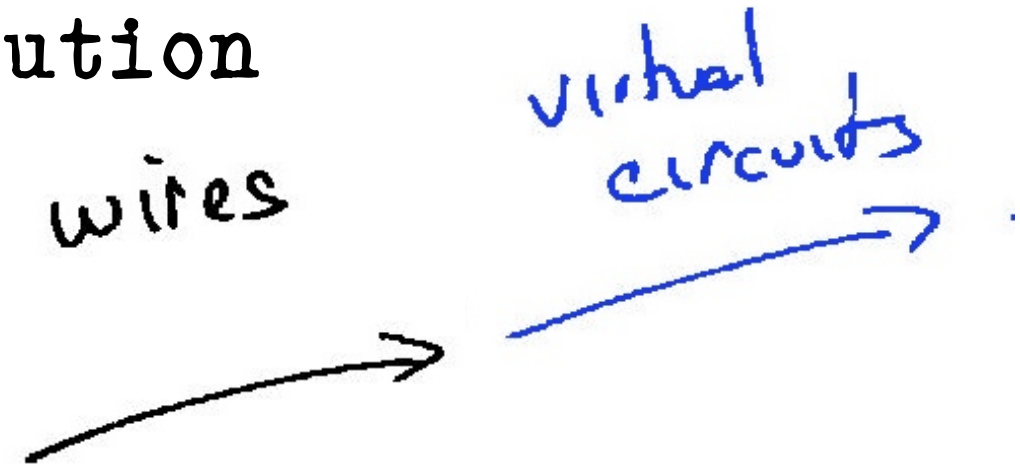
of technological
evolution





The "inevitability" of technological evolution



Well what did you expect? They are VIRTUAL circuits, so a picture was always going to be a challenge!

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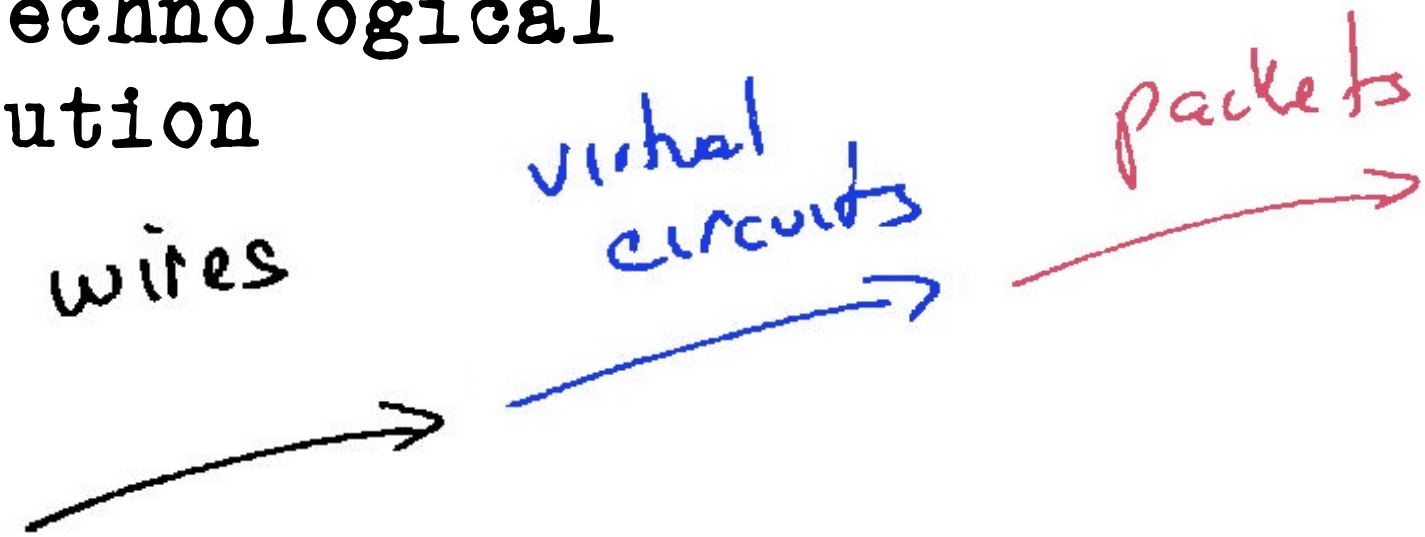

The "inevitability" of technological evolution

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

The
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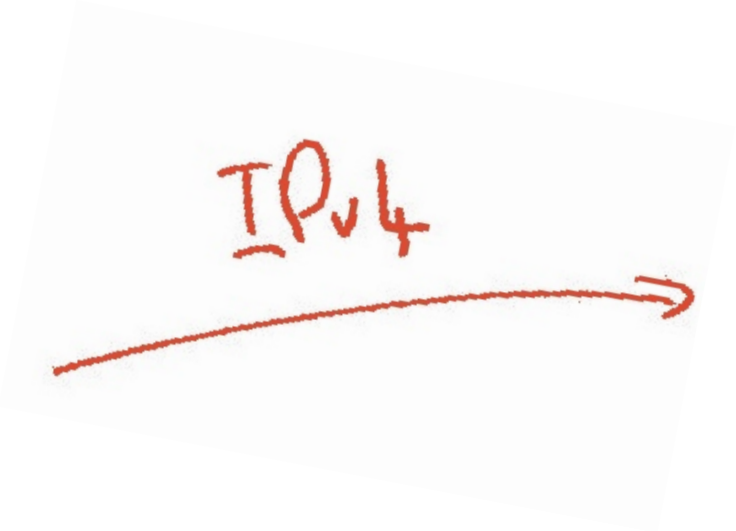

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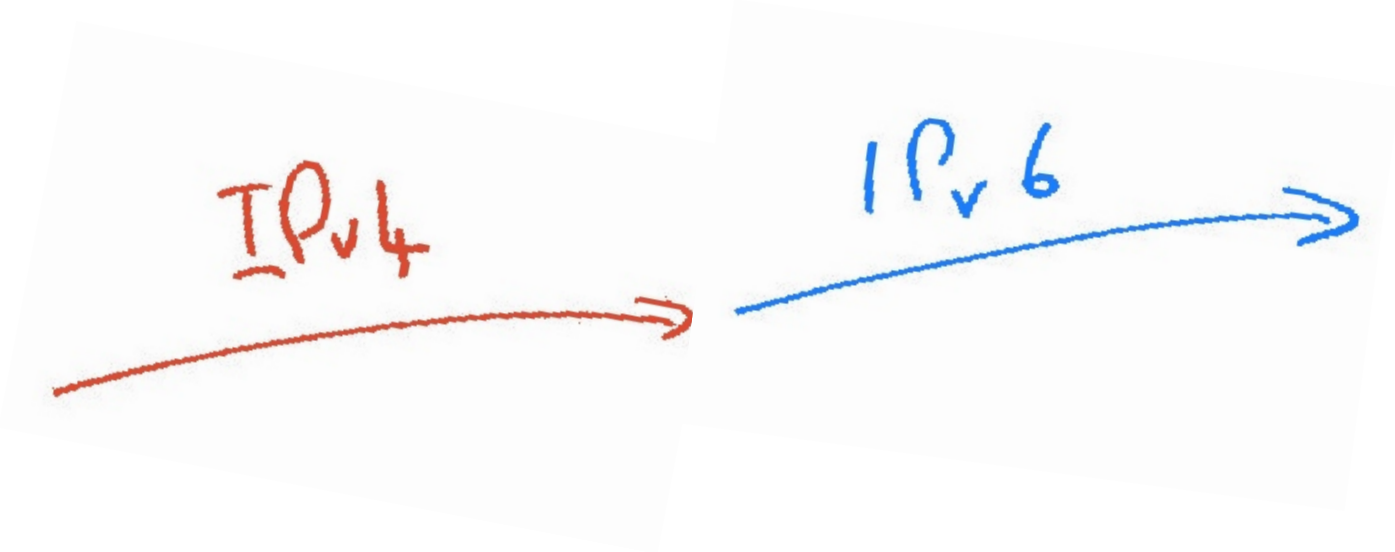
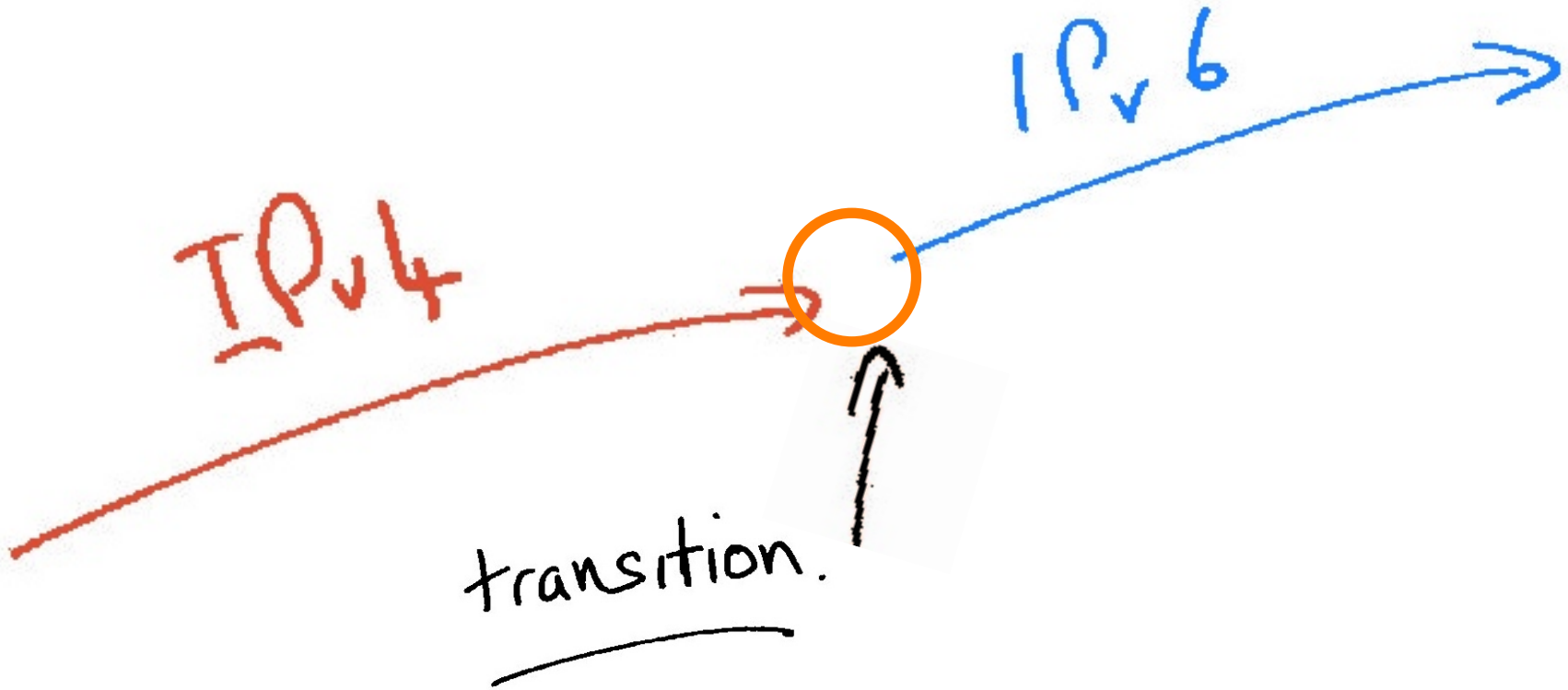
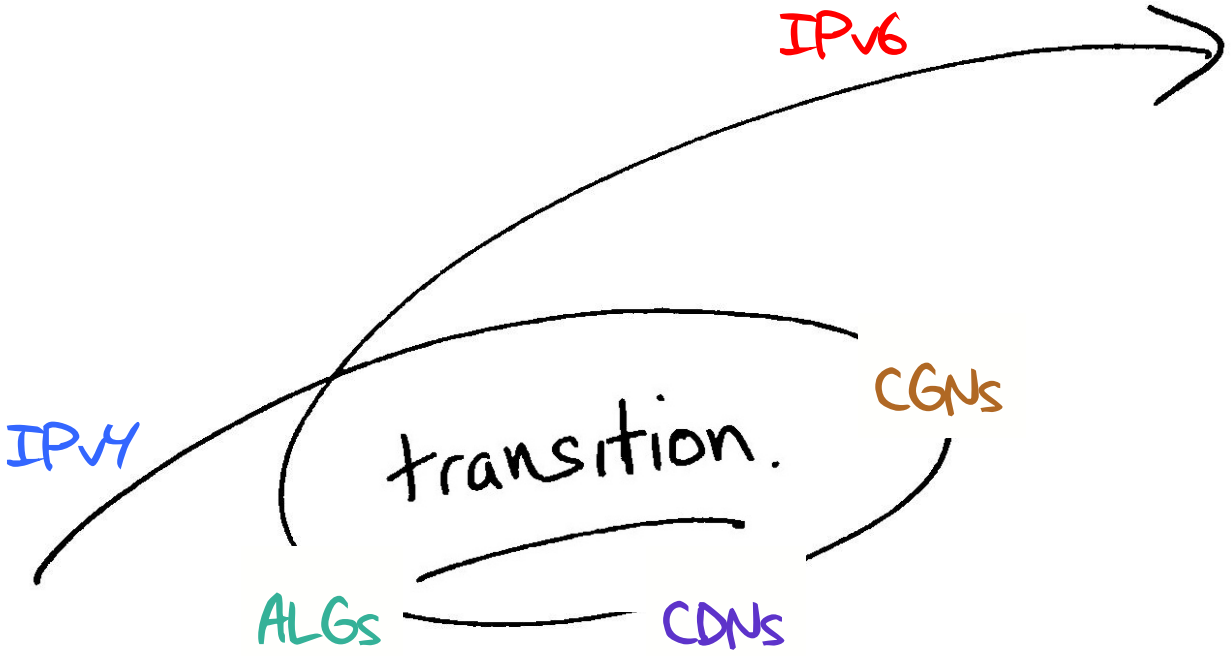


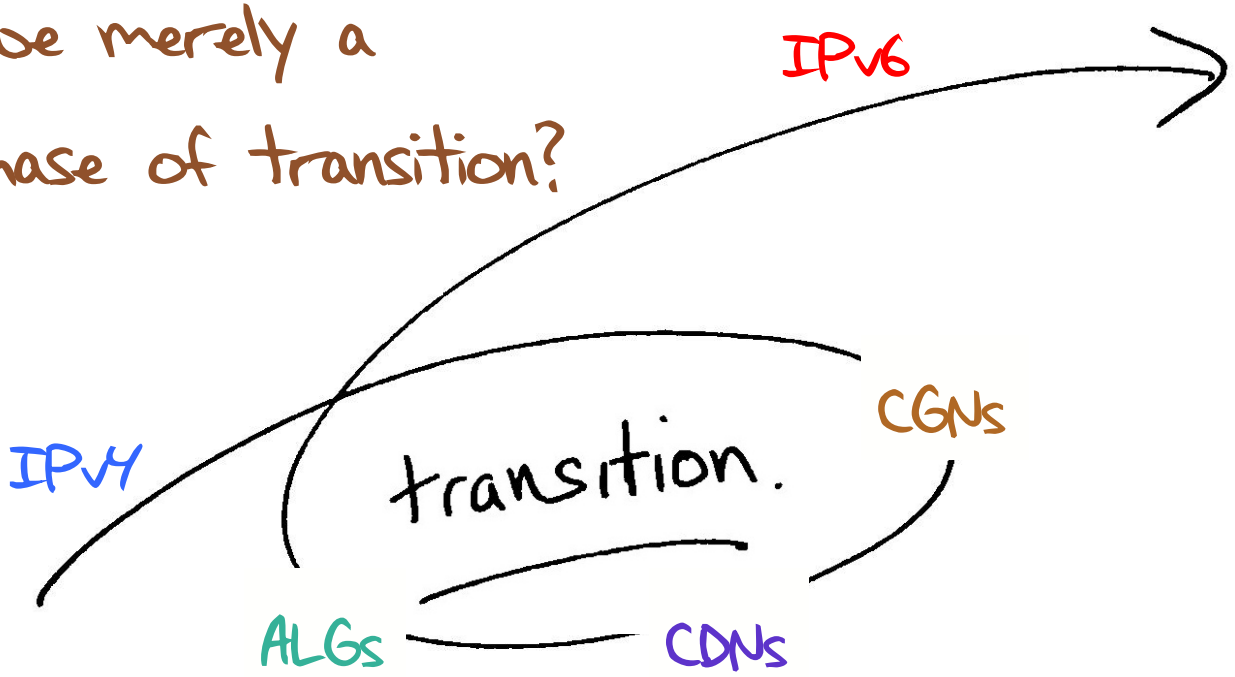
The challenge often lies in managing the transition from one technology to another



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



But will this be merely a temporary phase of transition?



Transition requires the network owner to undertake capital investment in network service infrastructure to support IPv4 address sharing/rationing.

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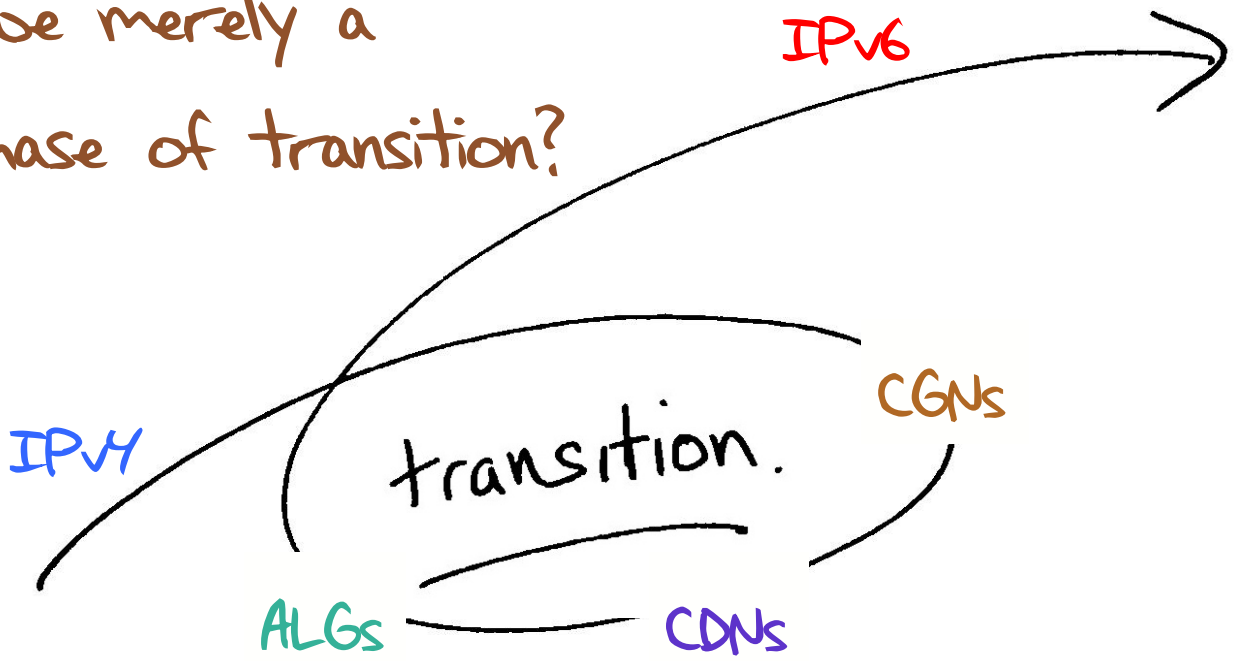

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What lengths will the network owner then go to to protect the value of this additional investment by locking itself into this "transitional" service model for an extended/indefinite period?

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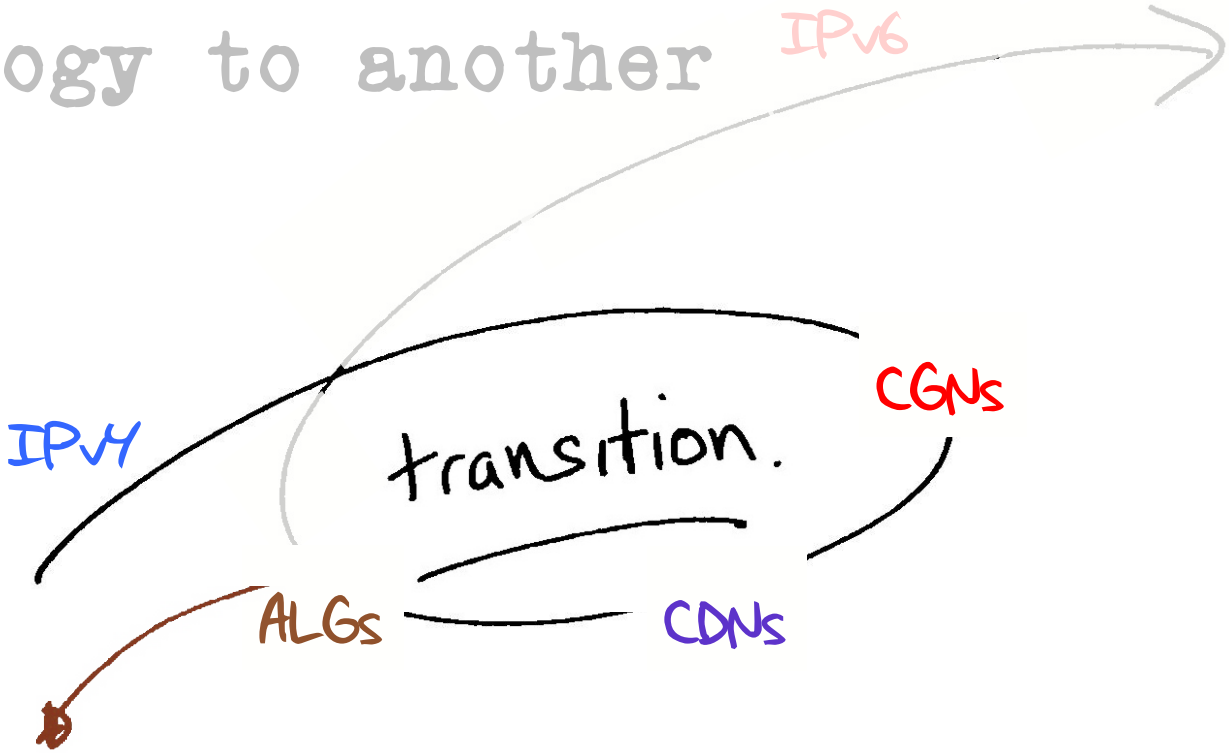
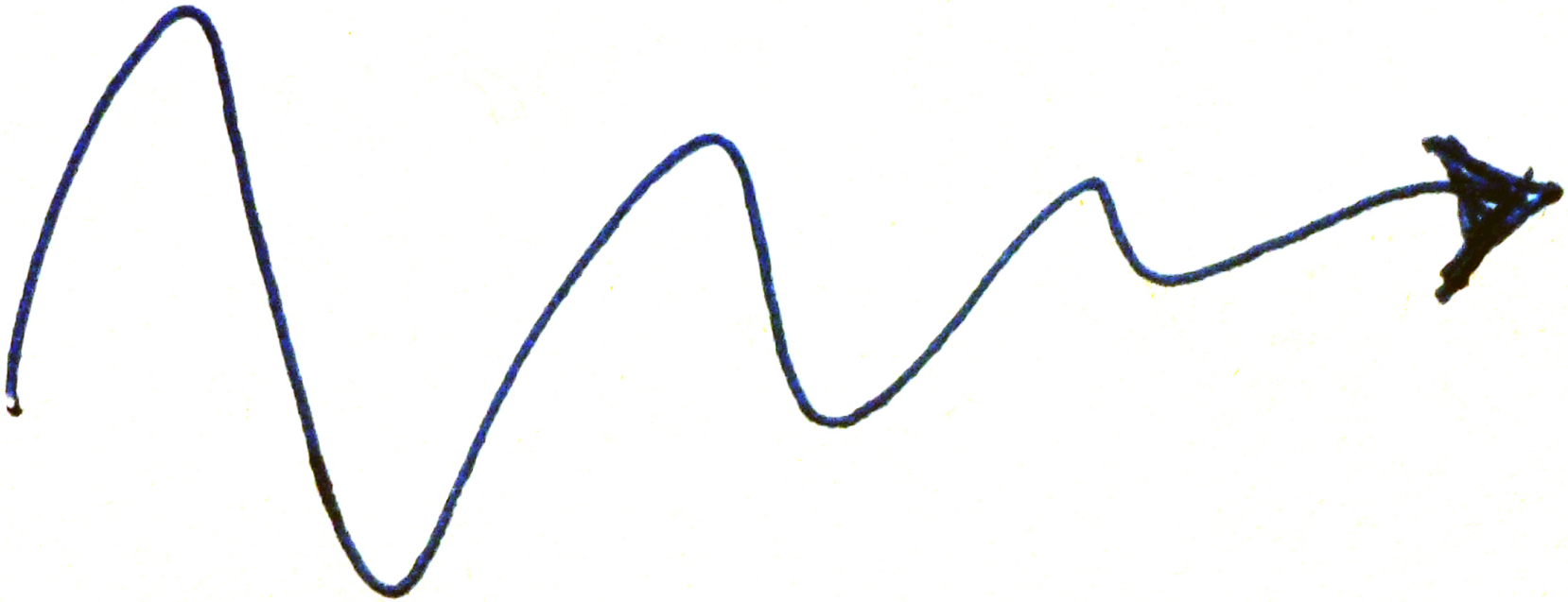


The risk in this transition phase is that the Internet heads off in a completely different direction!

A digression...

How "real" is this risk?



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How "real" is this risk?

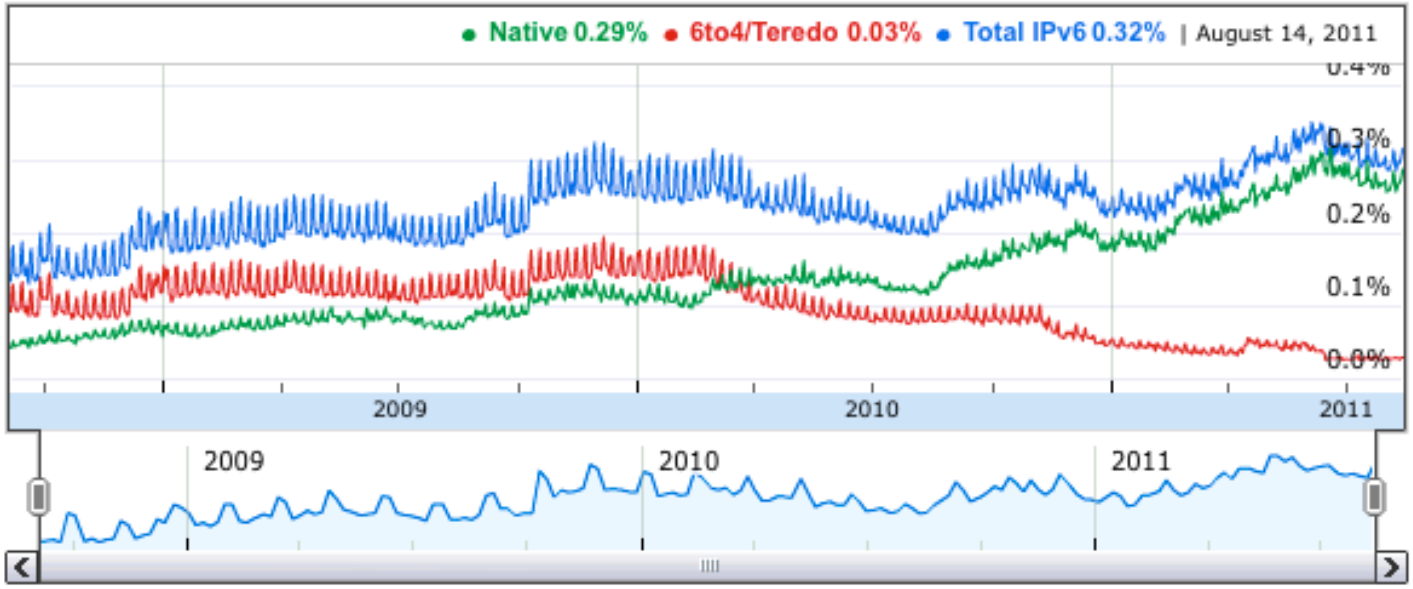
Is this industry seriously prepared to contemplate an IPv4 forever strategy?

Some Measurements

39% of the IPv4 transit networks appear to be dual stack capable

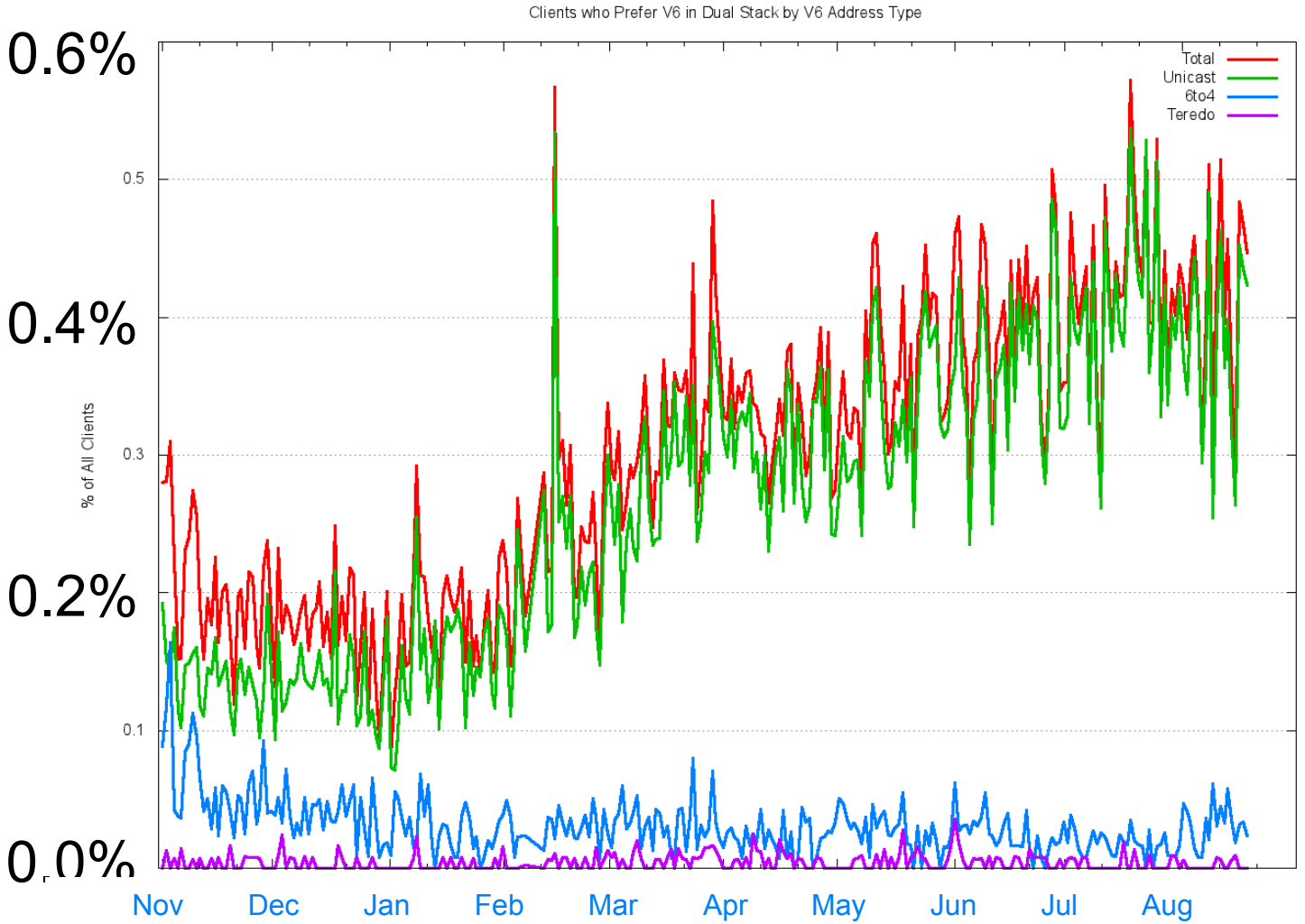
~50% of the Internet's end devices have an installed IPv6 stack

IPv6 capability, as seen by Google



http://www.google.com/intl/en/ipv6/statistics/

IPv6 capability, as seen by APNIC



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39% of the IPv4 transit networks appear to be dual stack capable

48% of the Internet's end devices have an installed IPv6 stack that can be tickled into life

0.3% of the Internet's end devices have native IPv6 delivered to them

Some Measurements

- 39% of the IPv4 transit networks appear to be dual stack capable
- ~50% of the Internet's end devices have an installed IPv6 stack
- 0.3% of the Internet's end devices have native IPv6 delivered to them

Where's the problem here?

The last mile access service business is not doing IPv6 because:

A) they are stupid
B) they are lazy
C) they are uninformed
D) they are broke
E) they operate in an economic and business regime that makes provisioning IPv6 an unattractive investment option for them

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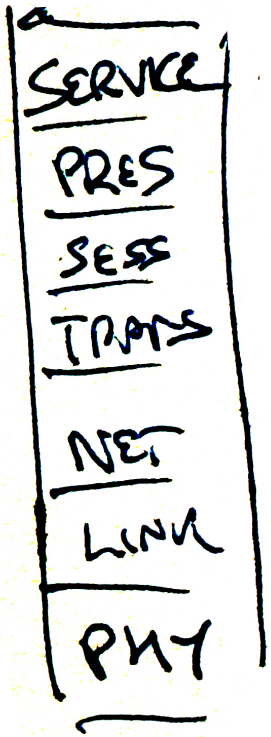
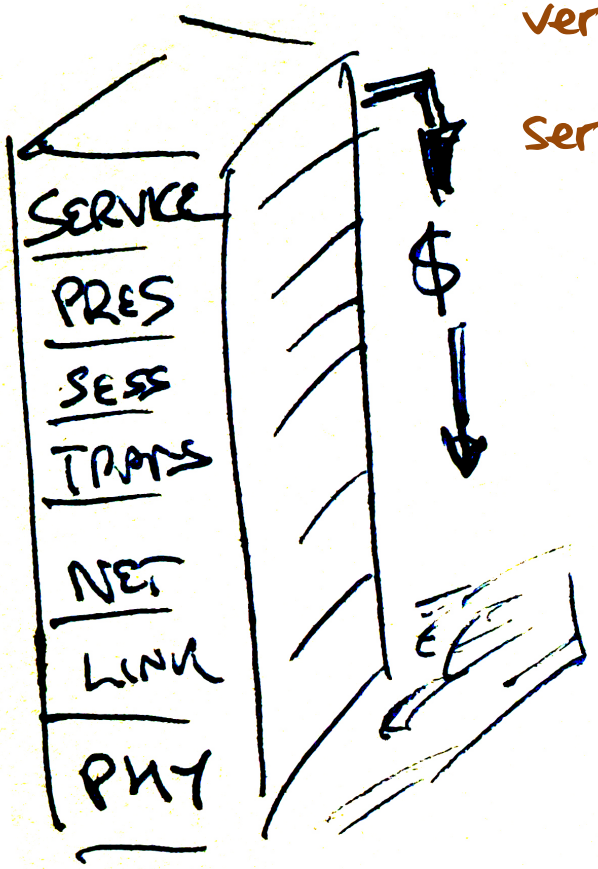
Why is IPv6 such an unattractive business proposition for Carriage Providers?

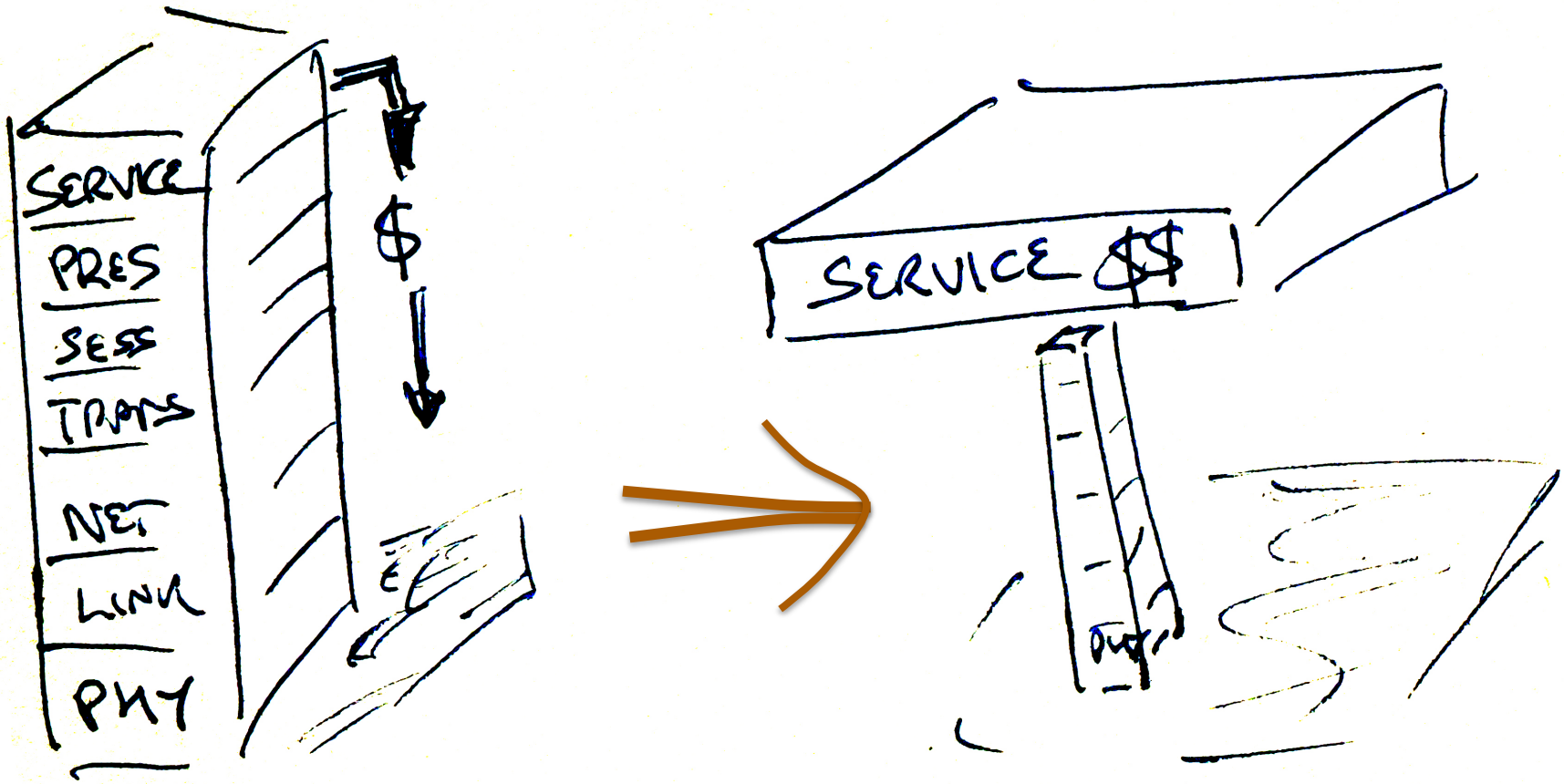
Back to networking basics....



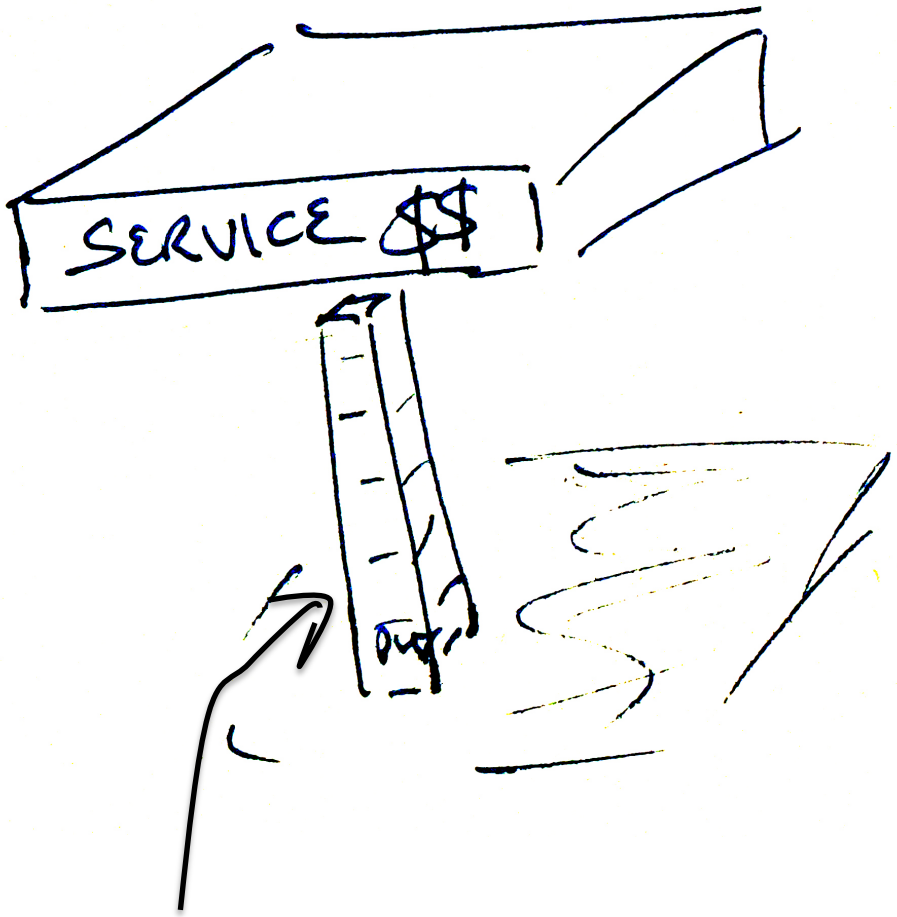
Telco nostalgia...

The historical vertically integrated service architecture





Devolution of the integrated service architecture through an open IP service architecture and deregulation

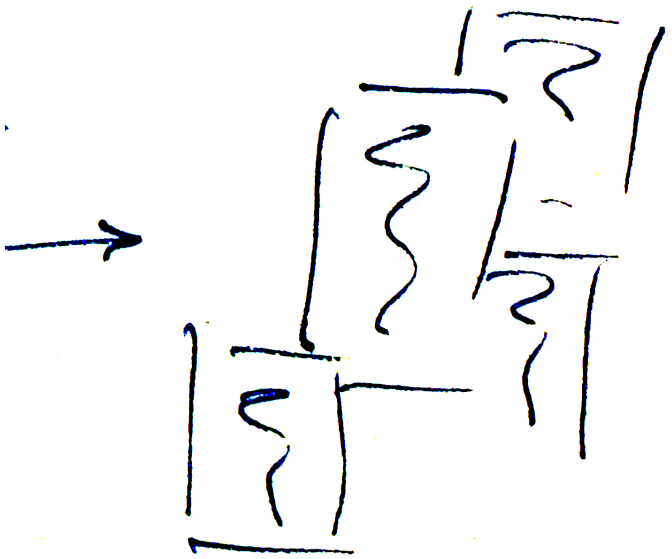


Devolution of the integrated service architecture

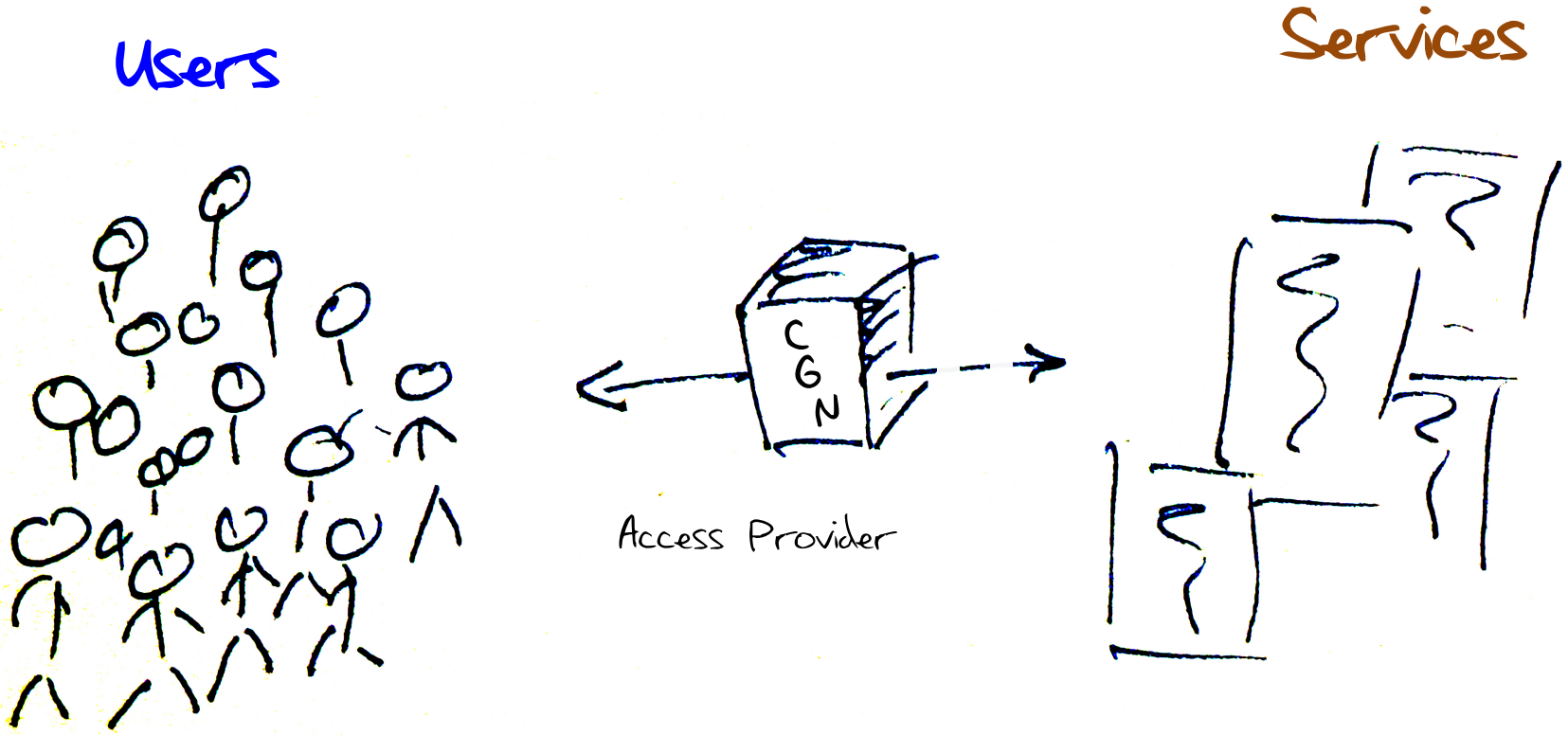
Where's the money to invest in new network services?

Users

Services



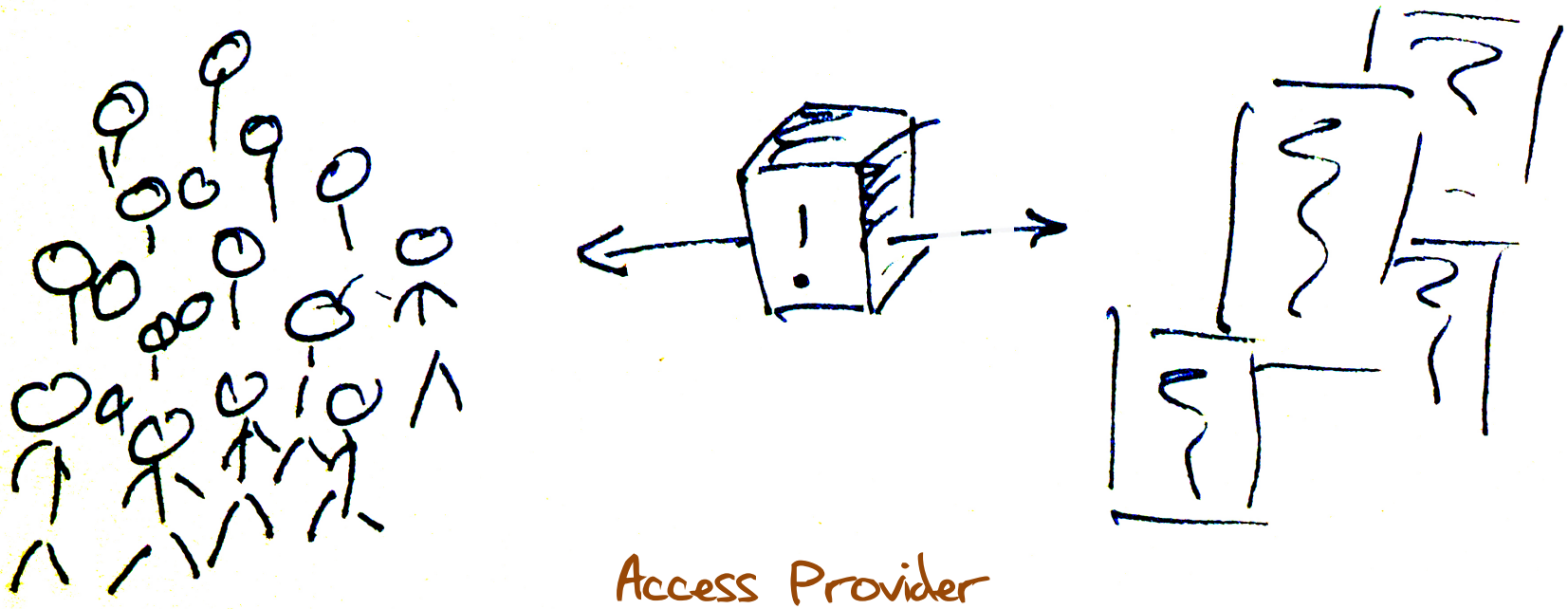
Access Provider


Users
Services
C
G
N
Access Provider

CGNs and ALGs and similar IPv4 rationing middleware devices provide control points in the IPv4 network that allow monetary extraction from both consumers and content providers

Users

Services



A digression...

How "real" is this risk?

Is this industry seriously prepared to contemplate an IPV4 forever strategy?

Yes – it's a possibility!

How 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!

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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

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This was always going to be a very hard question to try and answer!

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And the data on IPv6 update so far suggests that we are still not managing this at all well. Progress at the customer edge of the network with IPv6 access is glacial.

How can we "manage" this transition?

This was always going to be a very hard question to try and answer!

And at the moment we seem to be making the task even harder, not easier, by adding even more challenges into the path we need to follow!

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!

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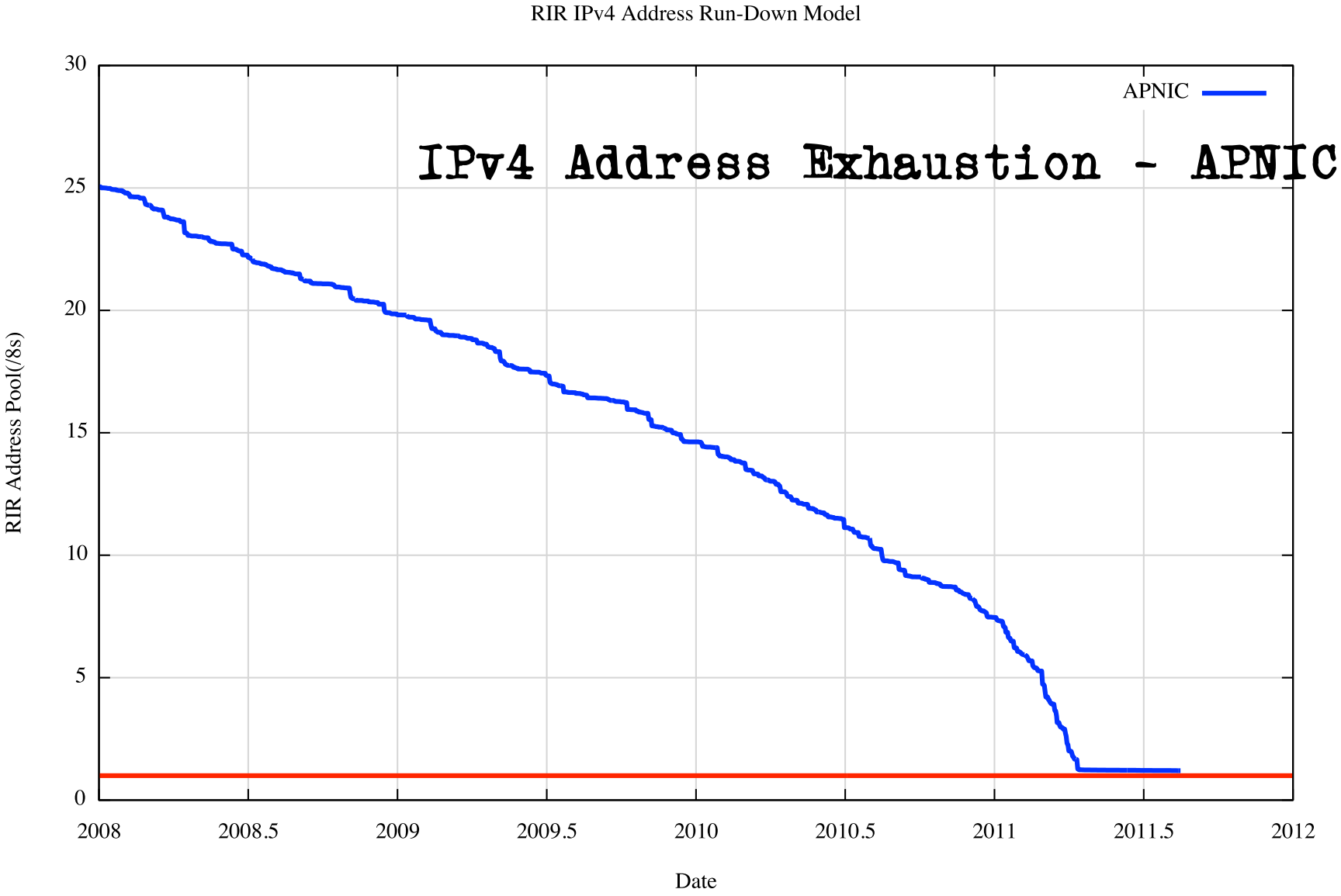
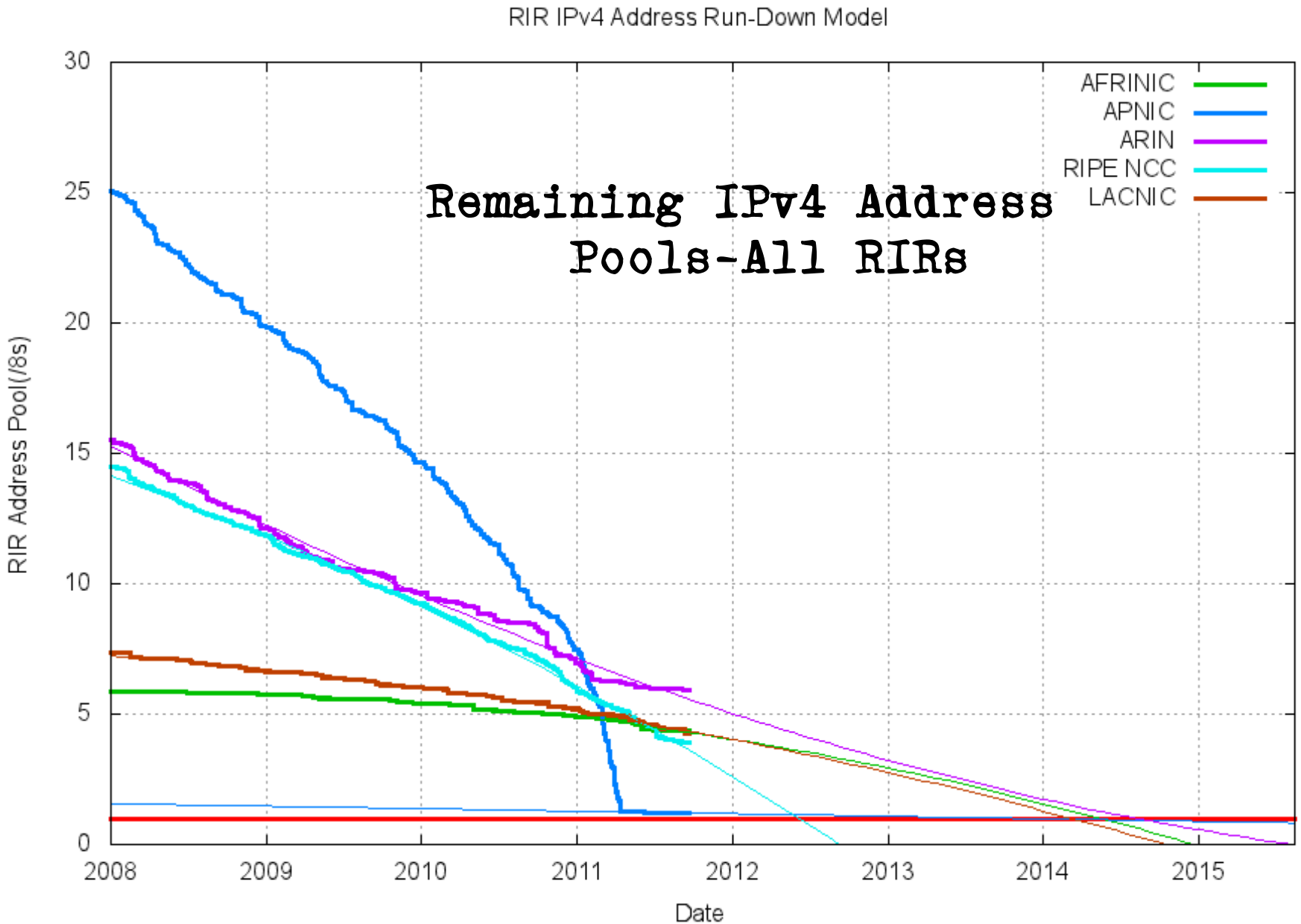
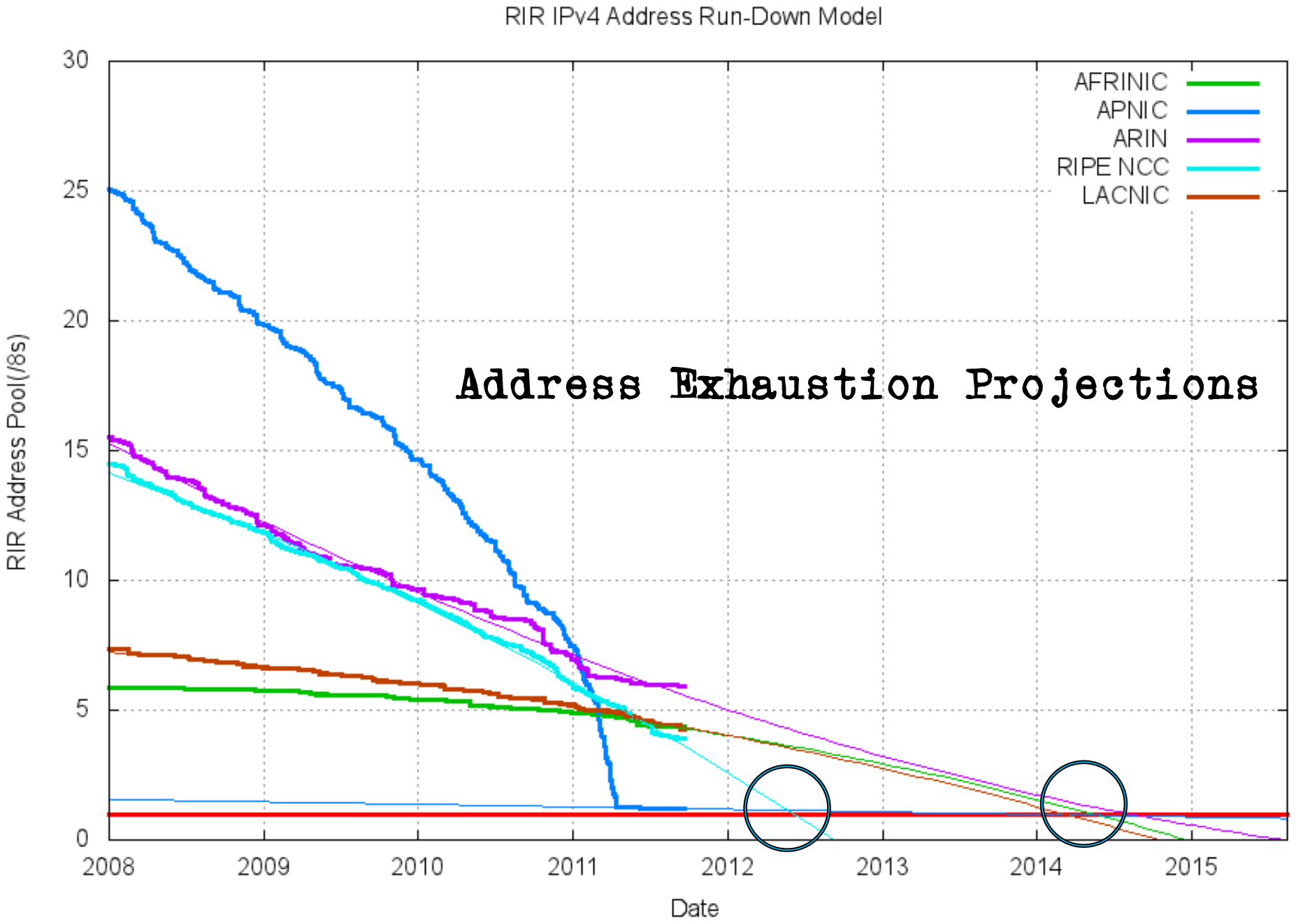
2. Varying IPv4 Address Exhaustion Timelines


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

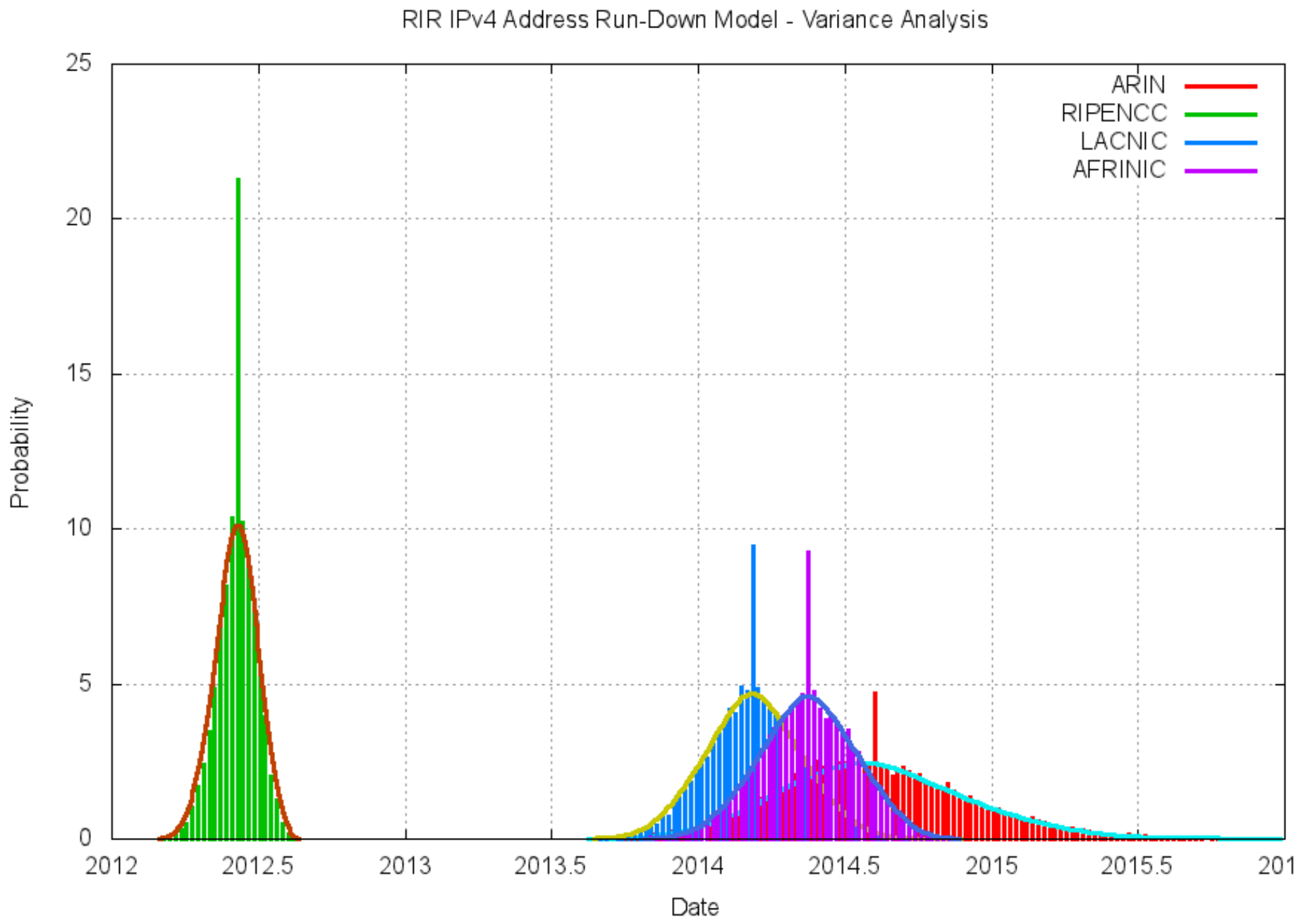

RIR IPv4 Address Run-Down Model
Remaining IPv4 Address Pools-All RIRs
AFRINIC
APNIC
ARIN
RIPE NCC
LACNIC
RIR Address Pool(/8s)
Date
0
5
10
15
20
25
30
2008
2009
2010
2011
2012
2013
2014
2015


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

Exhaustion Predictions

RIR	Predicted Exhaustion Date *	Remaining Address Pool (2 Oct 2011)
APNIC	19 April 2011 (actual)	1.20 /8s (0.3 /8s rsvd)
RIPE NCC	9 June 2012	3.91 /8s
LACNIC	1 March 2014	4.27 /8s
AFRINIC	28 May 2014	4.38 /8s
ARIN	9 Oct 2014	5.91 /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
5
10
15
20
25
2012
2012.5
2013
2013.5
2014
2014.5
2015
2015.5
2016

So what?

Reality Acceptance

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Or not

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Is IPv4 address exhaustion a "here and now" problem or a "some time in the future" problem?

Reality Acceptance

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Is IPv4 address exhaustion a "here and now" problem or a "some time in the future" problem?

Well, that depends on where you happen to be! If it hasn't happened to you yet, then denial is still an option!

Reality Acceptance

Or not

Is IPv4 address exhaustion a "here and now" problem or a "some time in the future" problem?

It's not happening until its happening to me!

Challenges:

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

2. Varying IPv4 Address Exhaustion Timelines
   There is a credibility problem!

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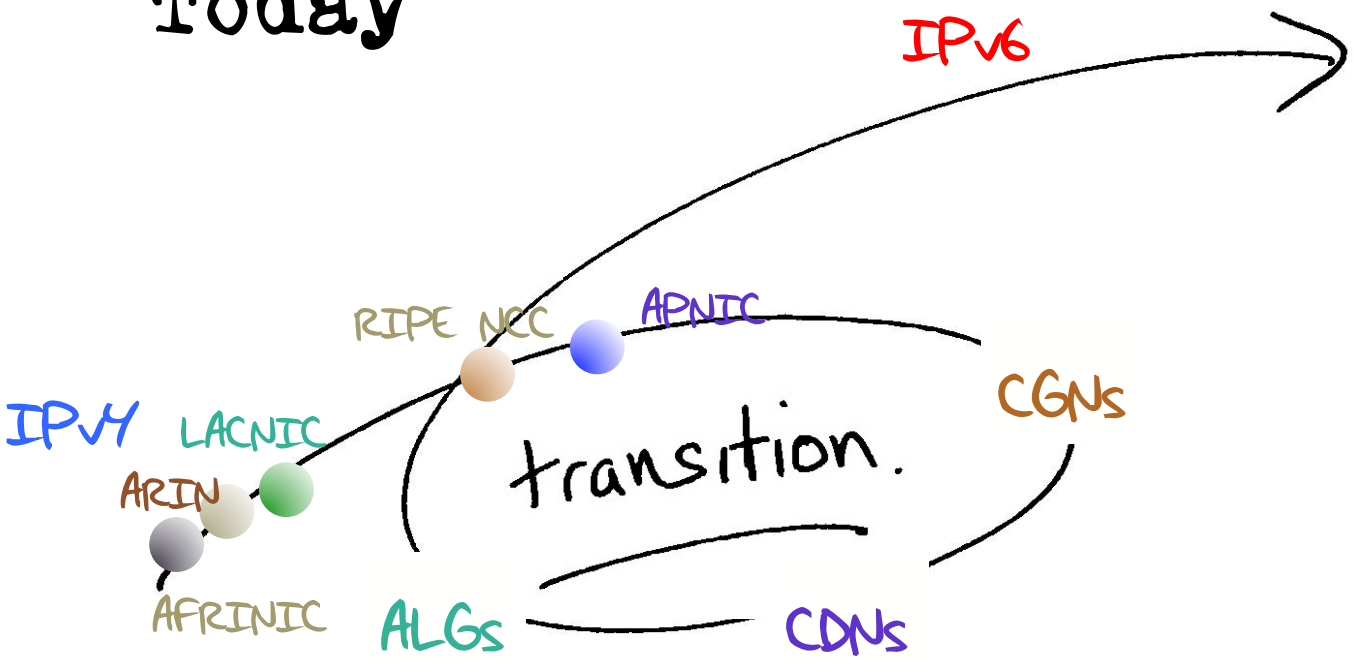
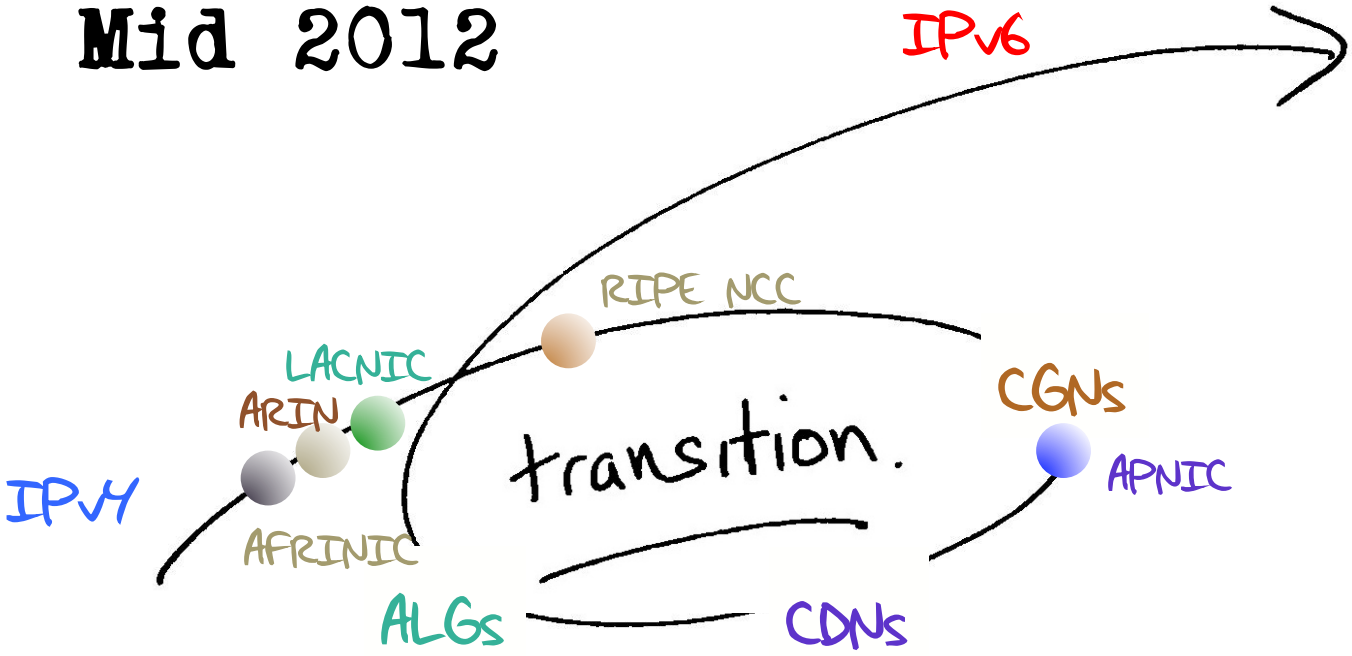
3. Regional Diversity

Today


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

Mid 2012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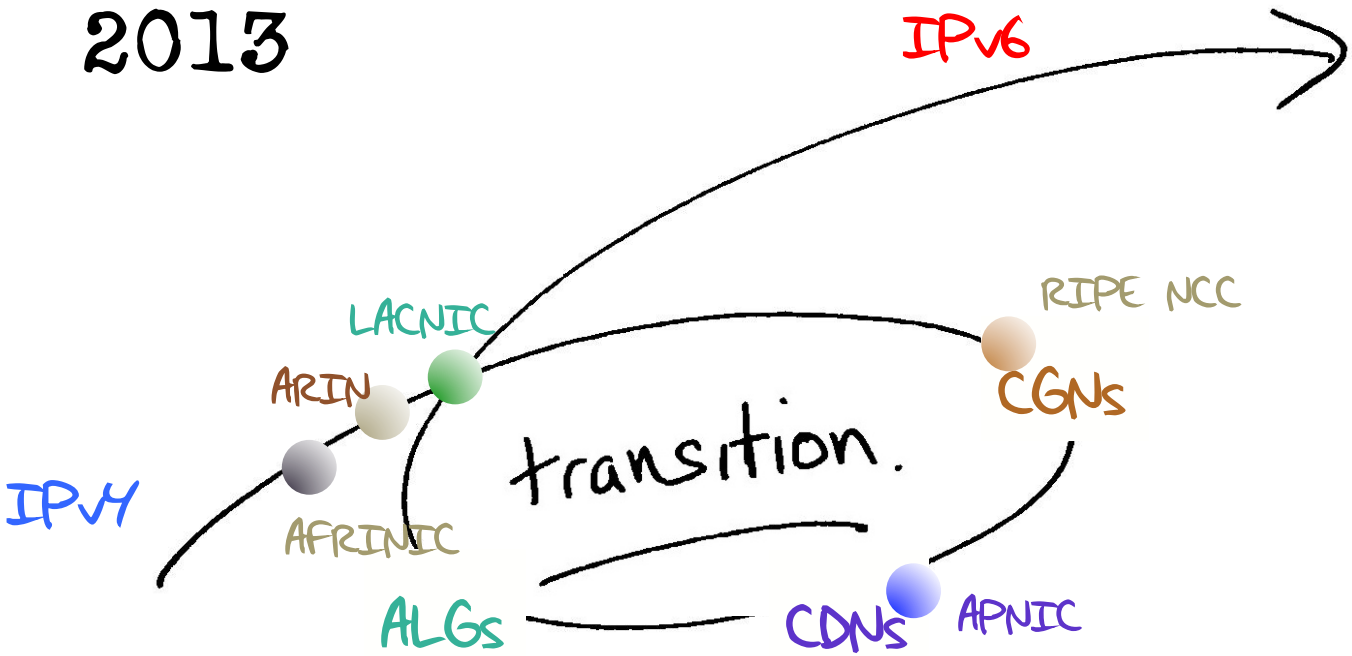
2013
IPv6
LACNIC
RIPE NCC
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CGNs
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What's the level of risk that the differing environments of transition lead to significantly different outcomes in each region?

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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 Myth of the Long Term Plan

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"Transition will take many years...

5 years, maybe 10 years, maybe longer"

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Are we still firmly committed to the plans we had 5 years ago?

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How about our 10 year old plans?

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"Transition will take many years...

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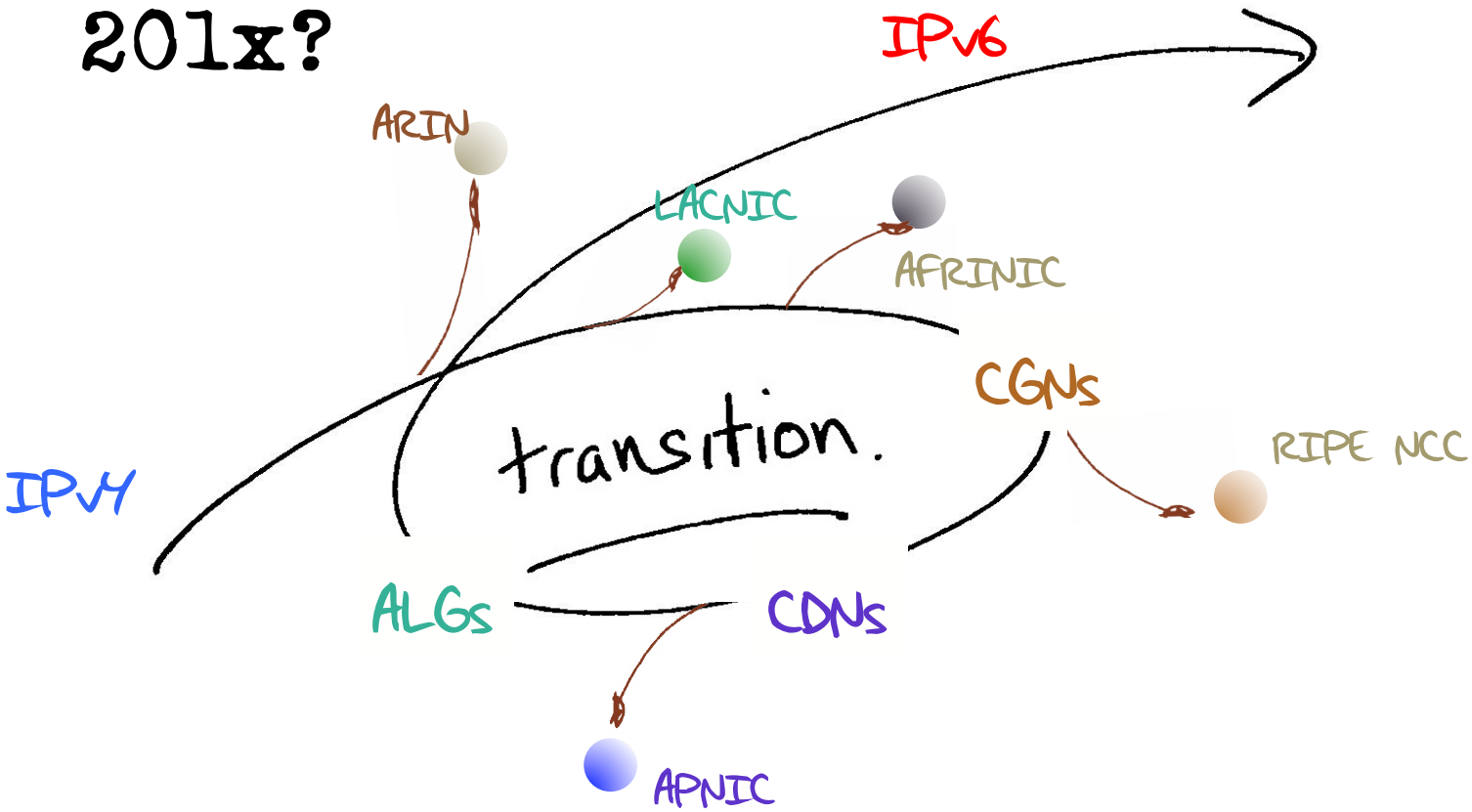
Are we still committed to the plans we had 5 years ago? How about our 10 year old plans?

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
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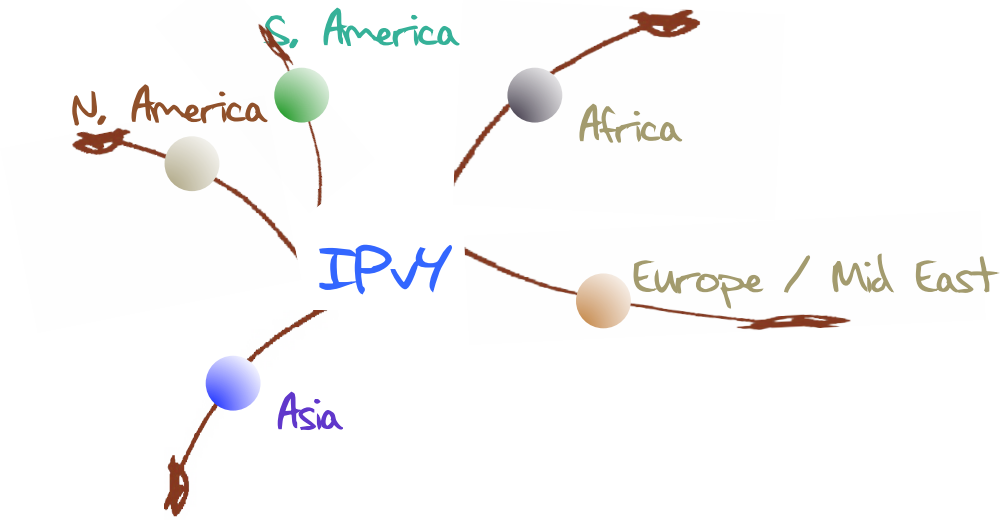
IPv4
RIPE NCC
ALGs
CDNs
APNIC

20xx?



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   One network is not an assured outcome!

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3. Regional Diversity
   One network is not an assured outcome: Market pressures during an extended transition may push the Internet along different paths in each region

if what we are after as an open and accessible platform for further network growth and innovation

then the public interest in a continuing open and accessible network needs to be expressed within the dynamics of market pressures.

Today's question is:

How can we do this?

How can we help the Internet through this transition?

How can we help the Internet through this transition?

Or at least, how can we avoid making it any worse than it is now?

Yes, that was intentionally left blank!

I really don't know what will work,

And as far as I can see, nor does anyone else!

But even though I don't have an answer here, I have some thoughts to offer about this issue of pulling the Internet though this transition

Three thoughts...

Firstly

If we want one working Internet at the end of all this, then keep an eye on the larger picture

Think about what is our common interest here

and try to find ways for local interests to converge

with our common interest in a single cohesive network

that remains open, neutral, and accessible

Secondly

Addresses should be used in working networks, not hoarded or "safeguarded"

Scarcity generates pain and uncertainty

Extended scarcity prolongs the pain and increases the unpredictability of the entire transition process

No matter how hard we may want it to be otherwise, "scarcity" and "fairness" are not synonyms!

Finally...

Bring it on! A rapid onset of exhaustion and a rapid transition represents the best chance of achieving an IPv6 network as an outcome

The more time we spend investing time, money and effort in deploying IPv4 address extension mechanisms, the greater the pain to our customers, and the higher the risk that we will lose track of the intended temporary nature of transition and the greater the chances that we will forget about IPv6 as the objective!

Thank You!