

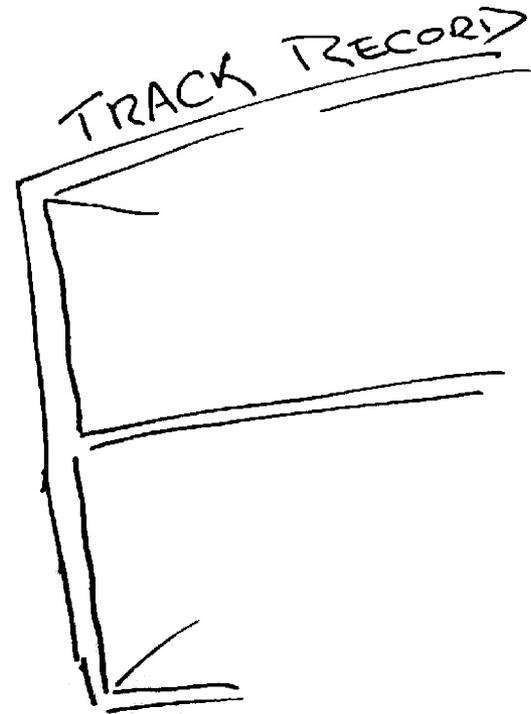
IPv4 Address Exhaustion: A Progress Report

Geoff Huston

APNIC



The mainstream
telecommunications
industry has a
rich history



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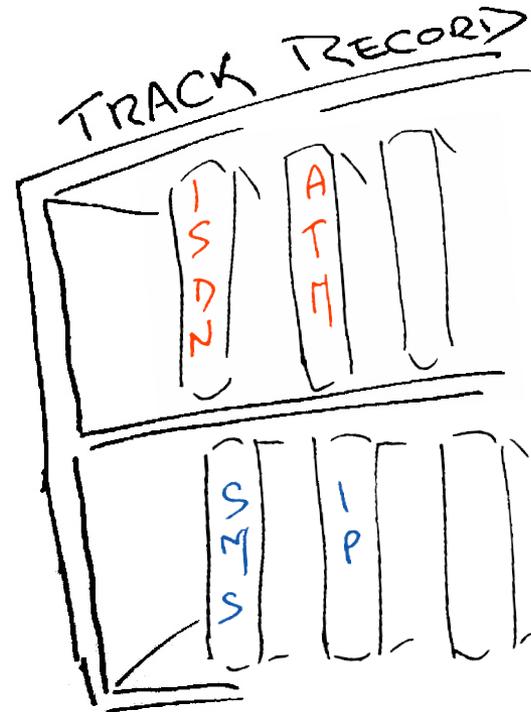
...of making very poor
technology choices



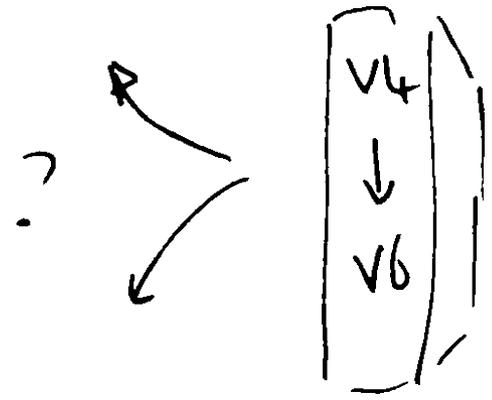
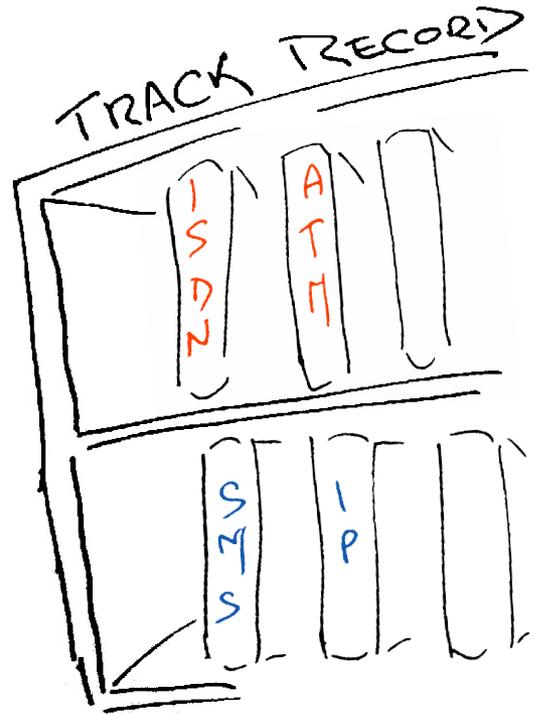
The mainstream
telecommunications
industry has a
rich history

...of making very poor
technology choices

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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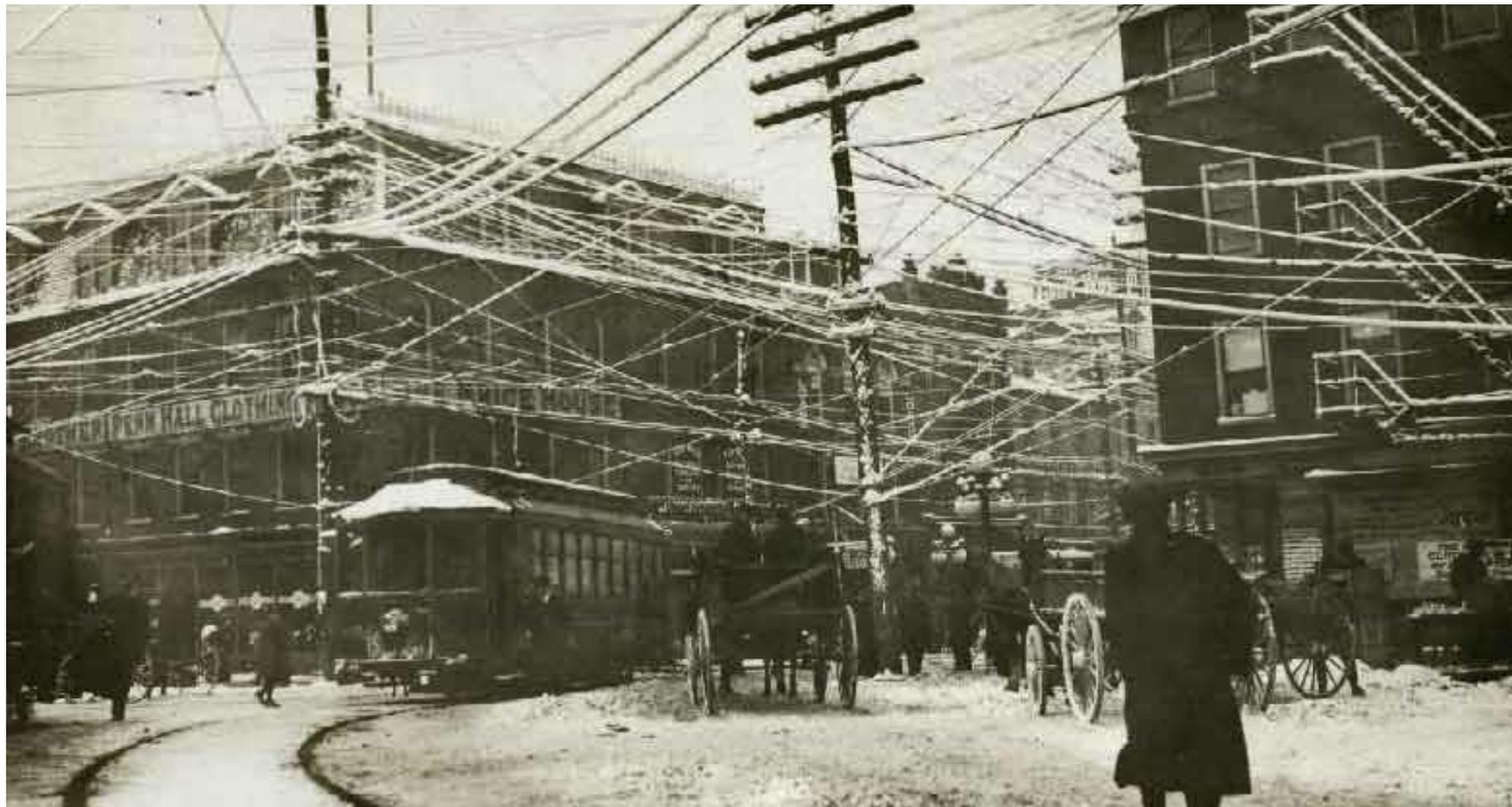
Surely IPv6 will just happen — its just a matter of waiting for the pressure of IPv4 address exhaustion to get to sufficient levels of intensity.

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

The
"inevitability"
of technological
evolution

wires





The
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of technological
evolution

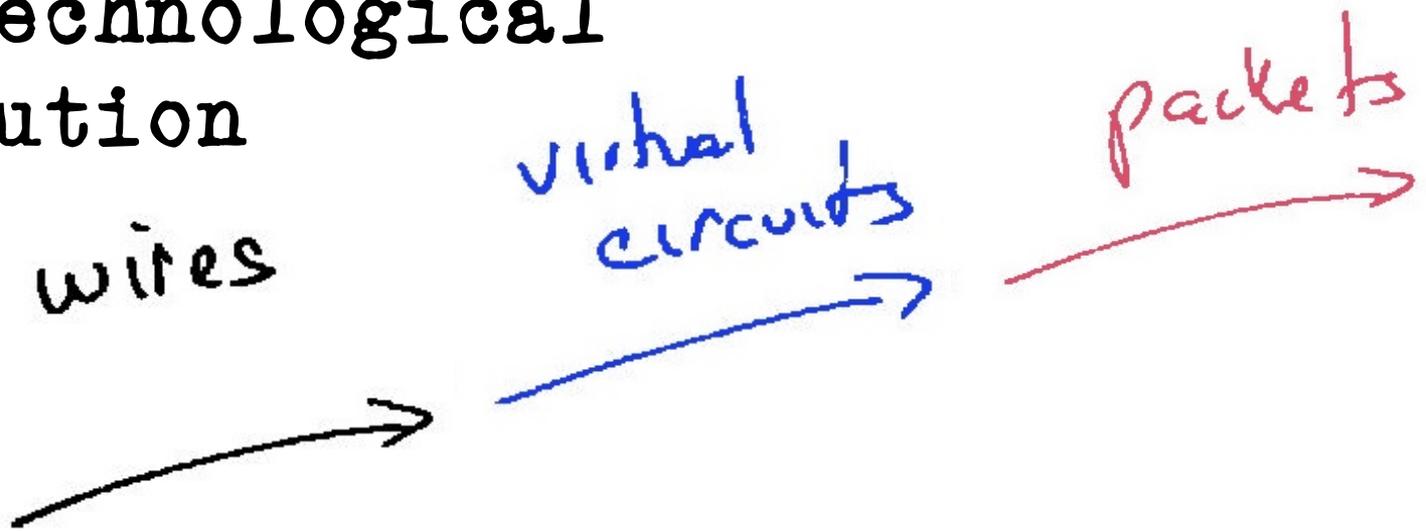
wires

virtual
circuits



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

The
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of technological
evolution



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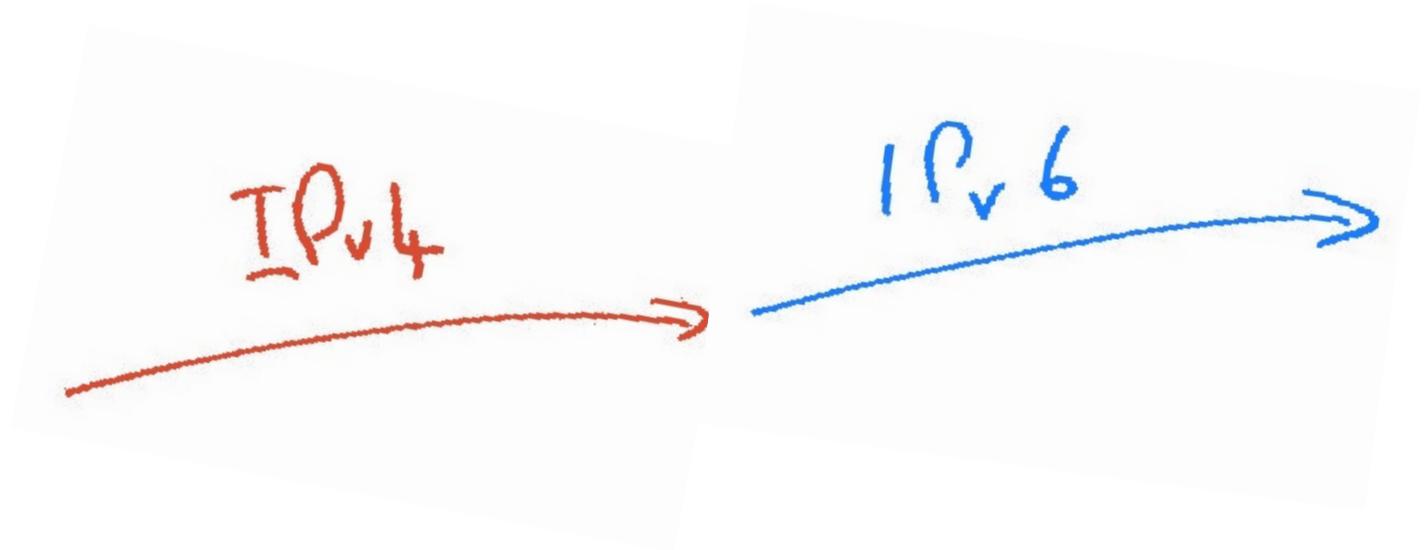
Now lets look at something a little
more topical to today!

The
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evolution?

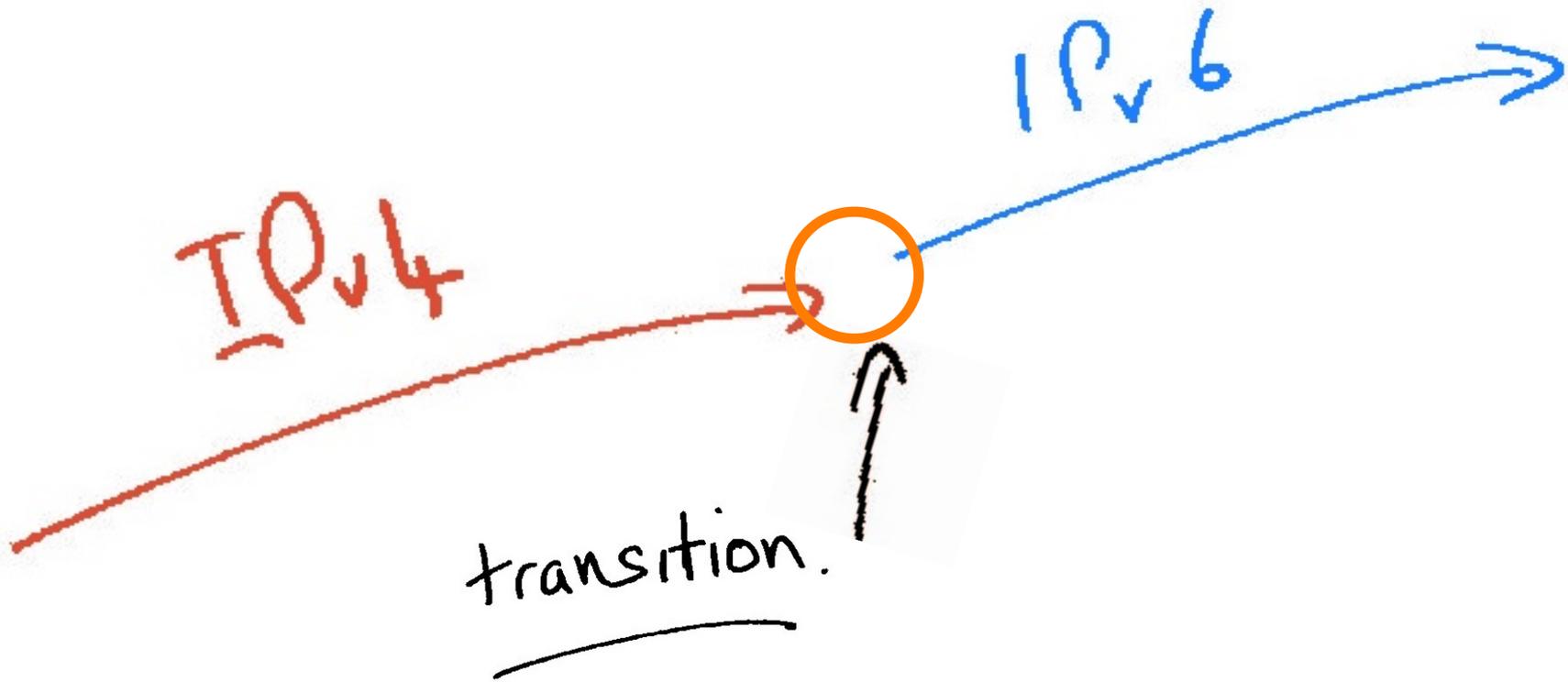
IPv4



The
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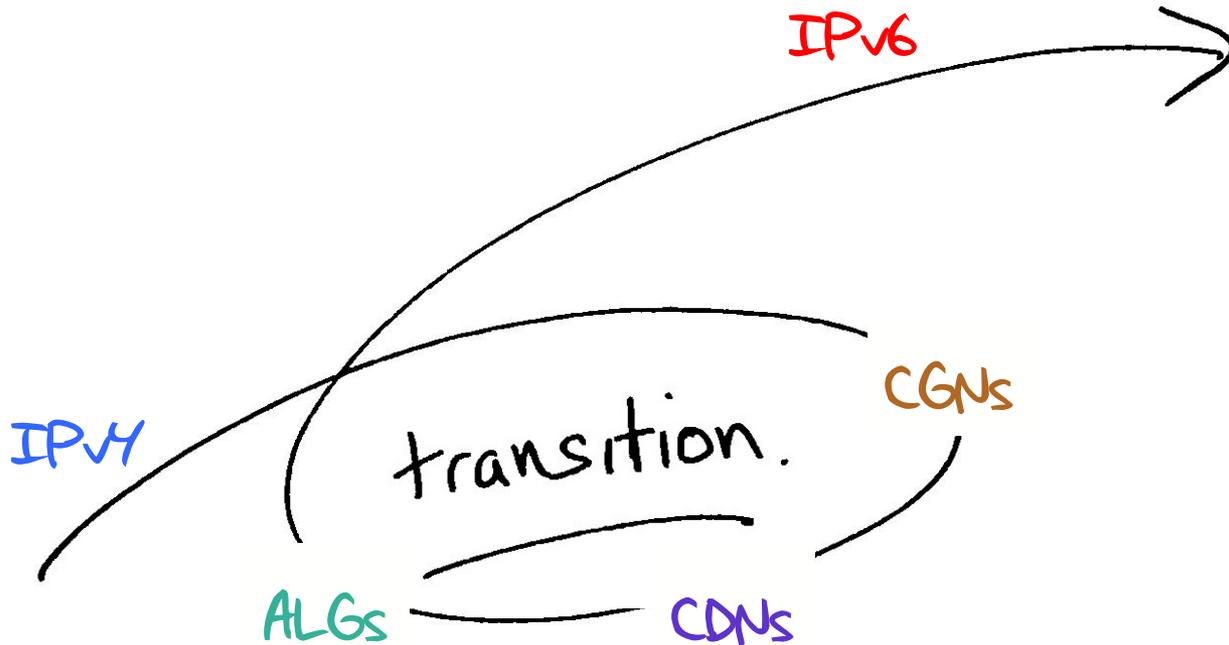
The challenge often
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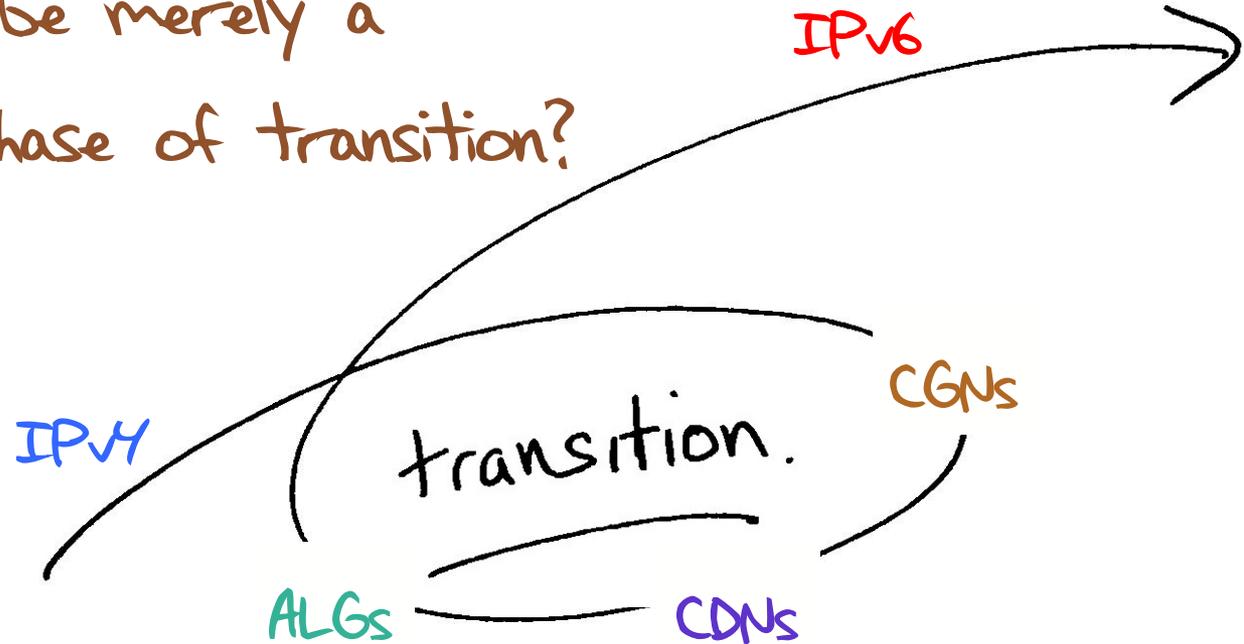
Transitional Degrees of Difficulty

- +1 preserve transport protocol semantics
- +2 not backward compatible
- +2 end-to-end protocol
- +5 no service disruption
- +10 we exhausted IPv4!!

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

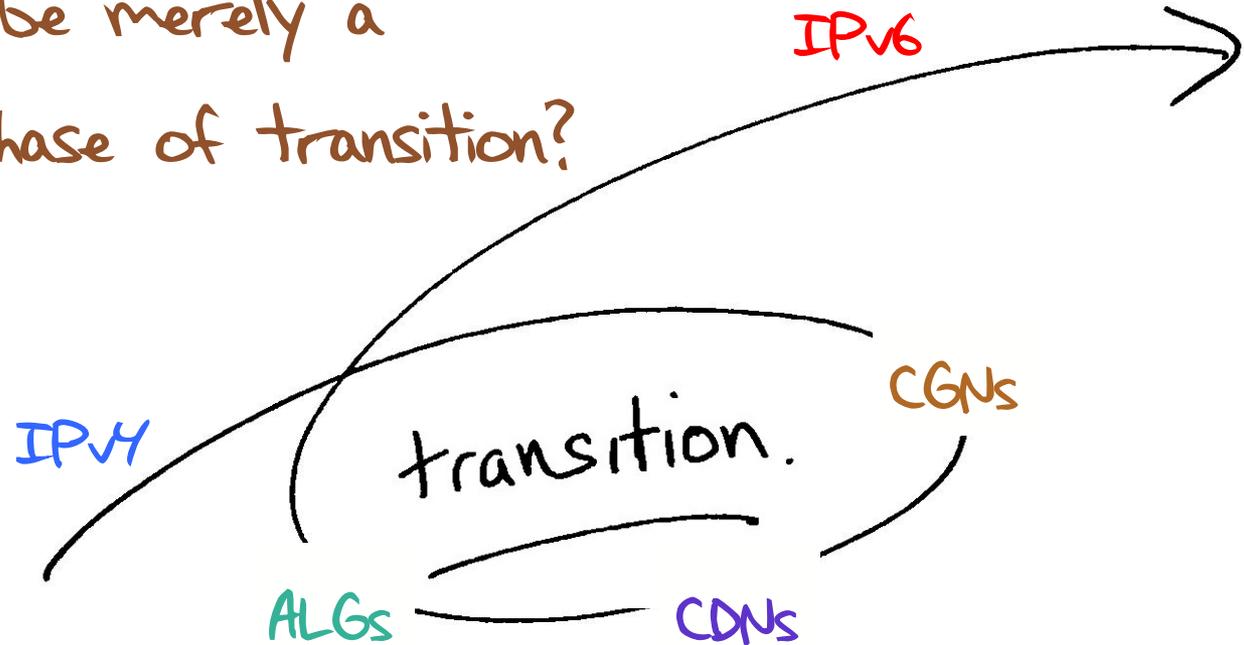


But will this be merely a temporary phase of transition?



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

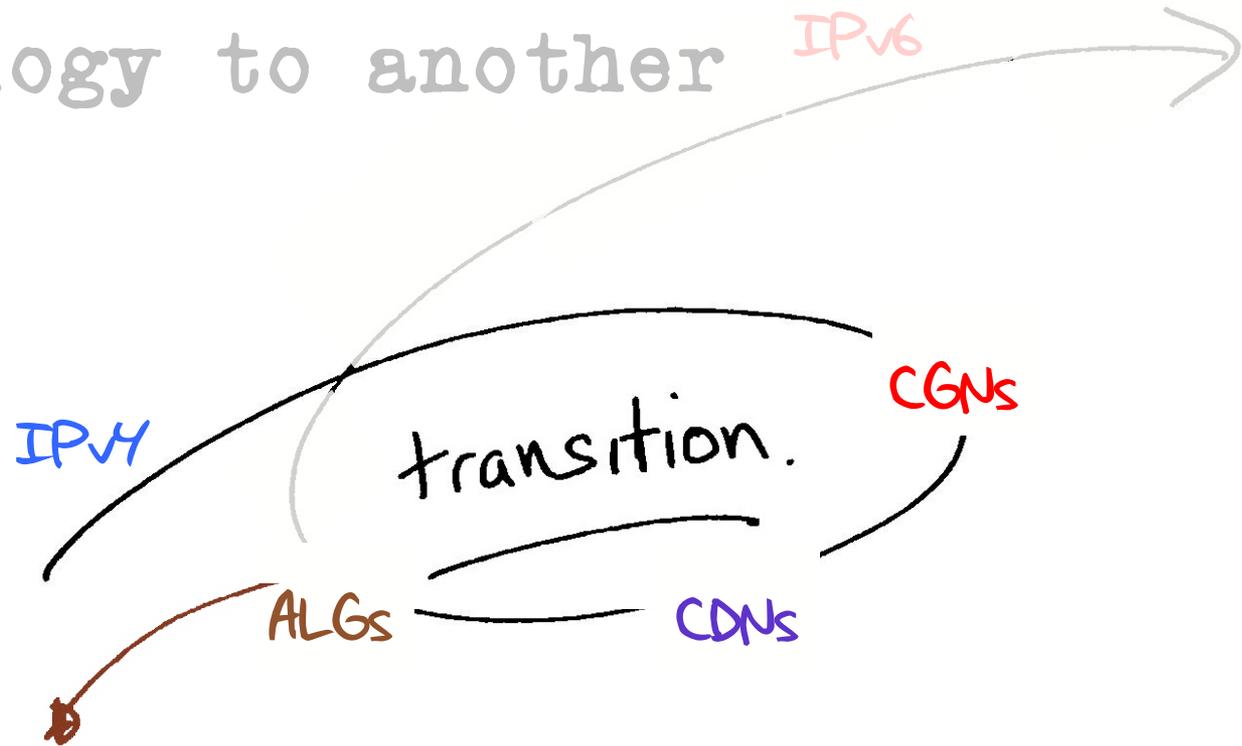
But will this be merely a temporary phase of transition?



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

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?

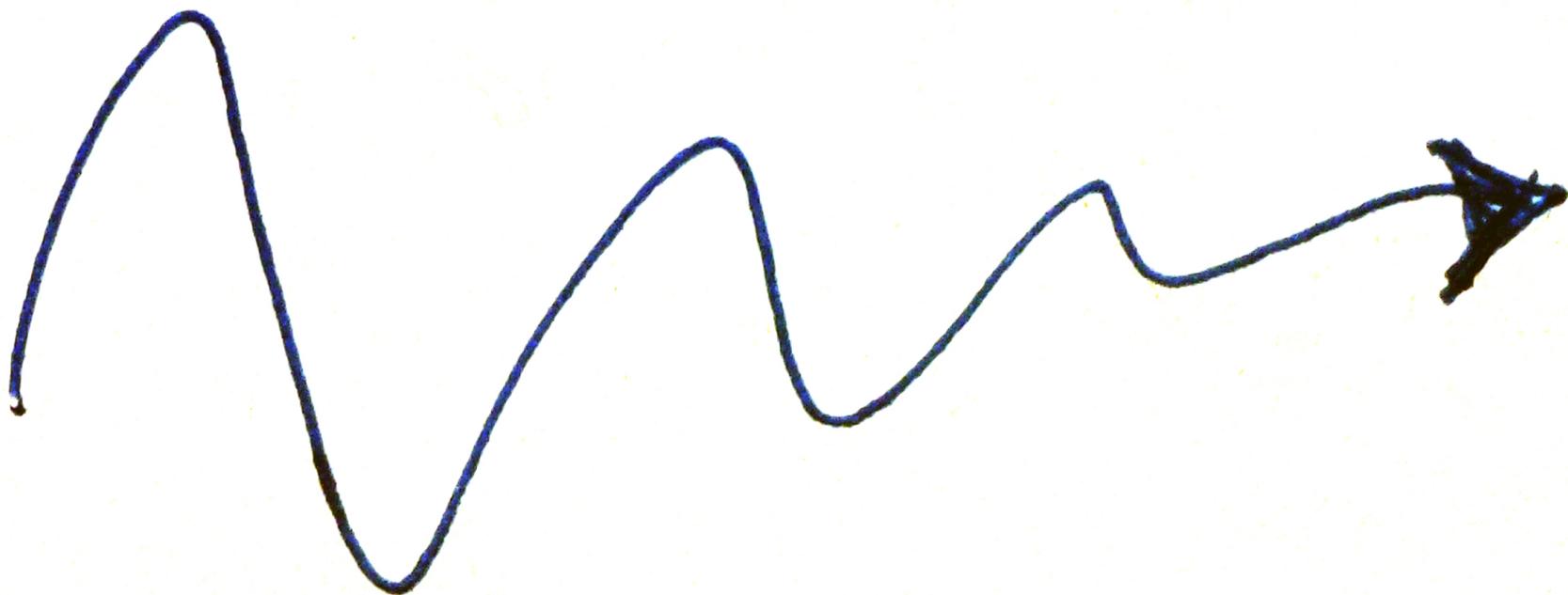
The challenge often lies in managing the transition from one technology to another



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

A digression...

How "real" is this
risk?



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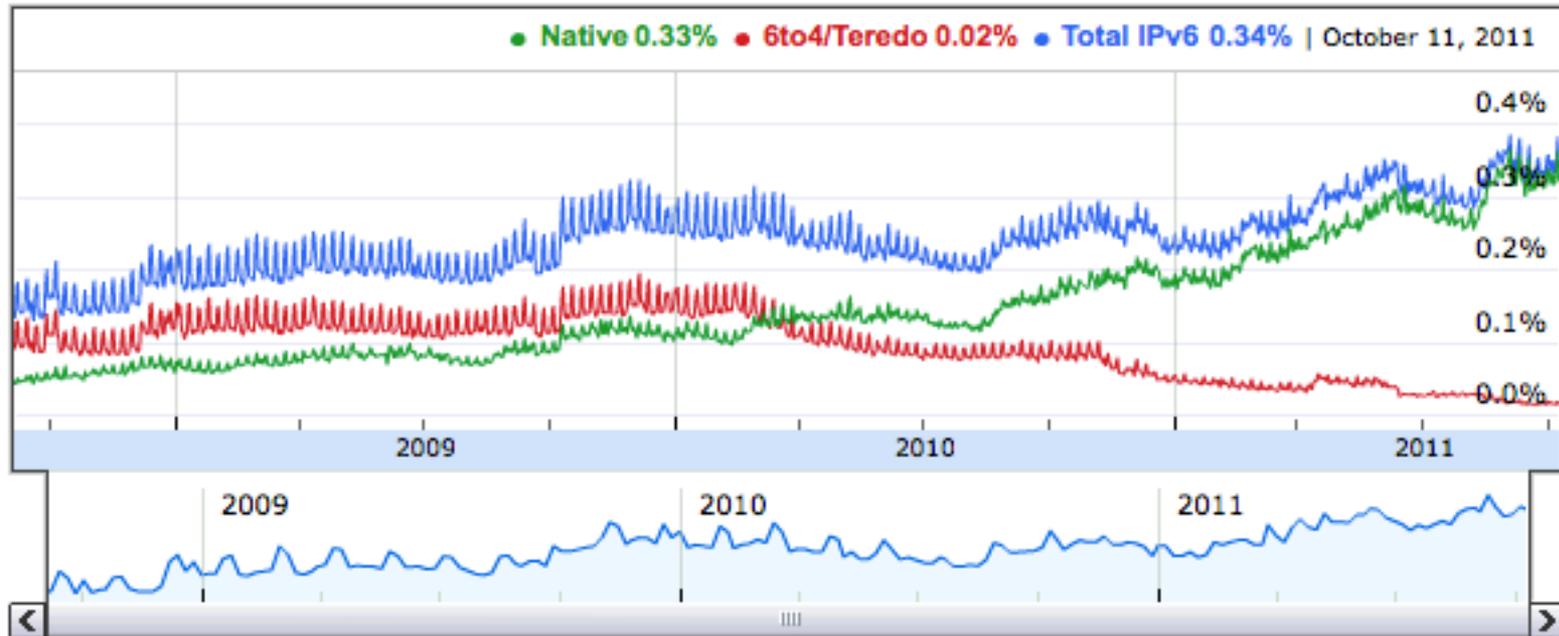
Is this industry seriously prepared to contemplate an
IPV4 forever strategy?

Some Measurements

39% of the Internet's transit networks appear to be dual stack capable

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

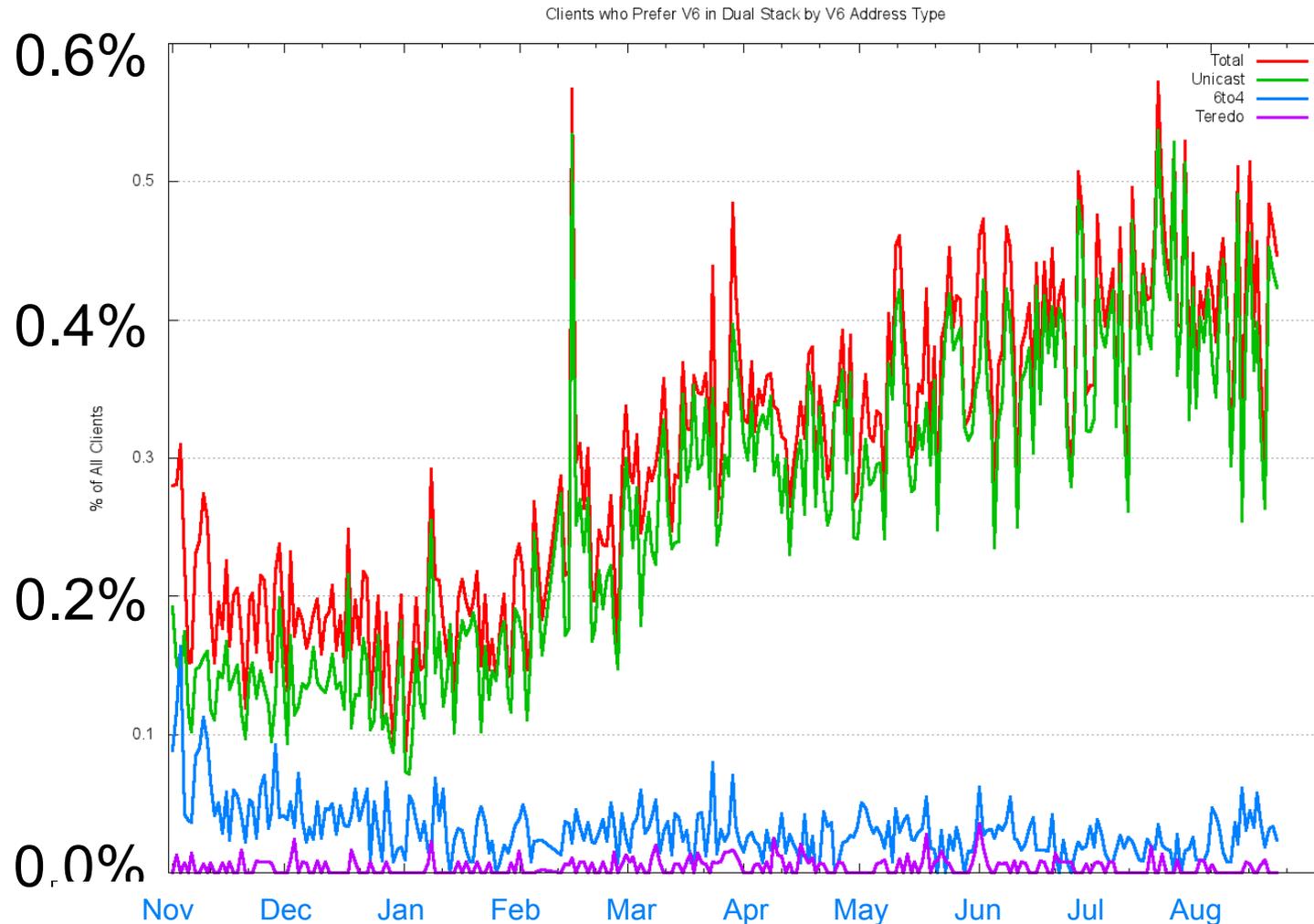
End-to-end IPv6 capability, as seen by Google



©2011 Google

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

End-to-end IPv6 capability, as seen by APNIC



Some Measurements

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

0.4% 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

48% of the Internet's end devices have an installed IPv6 stack
Where's the problem here?

0.4% of the Internet's end devices have native IPv6 delivered to them

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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Hint!

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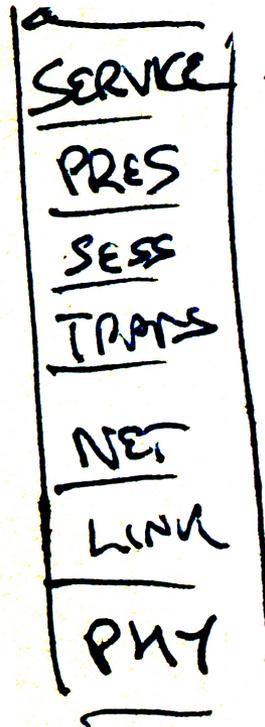
D) they are broke

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

They operate in an economic and business regime that makes

provisioning IPv6 an unattractive investment option for them

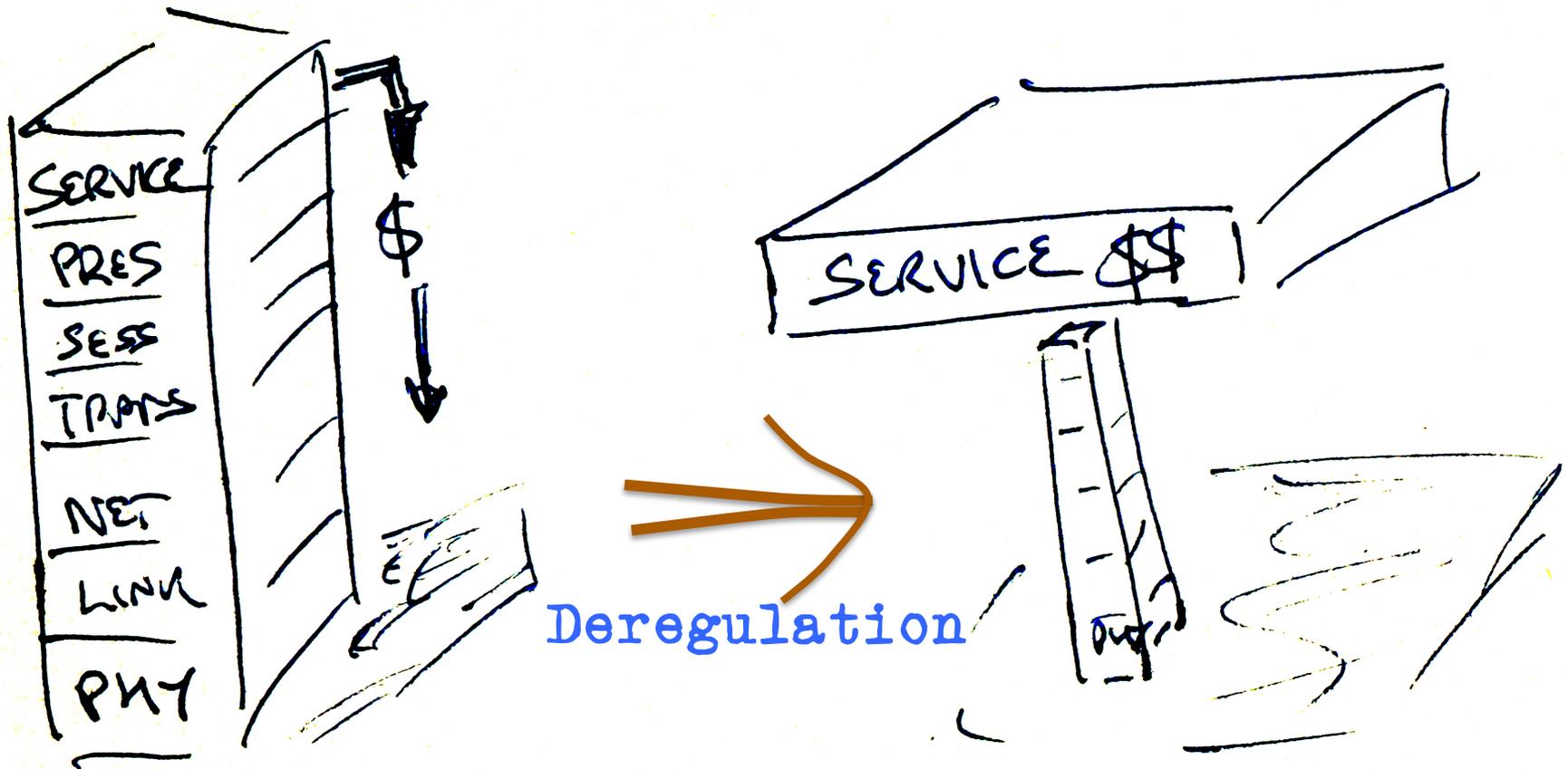
Back to networking basics....



Telco nostalgia...

The historical
vertically integrated
service architecture

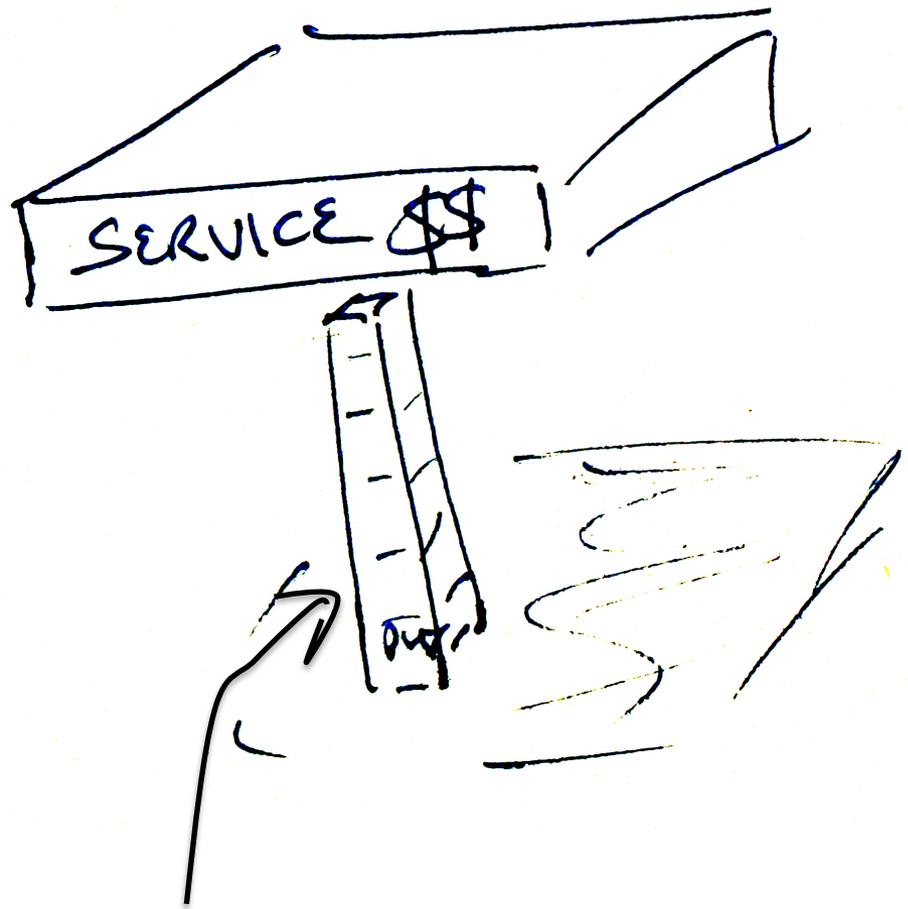




Devolution of the integrated service architecture through an open IP service architecture and deregulation

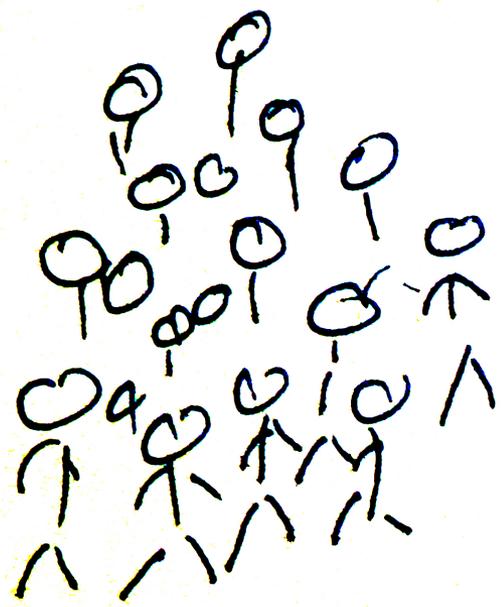


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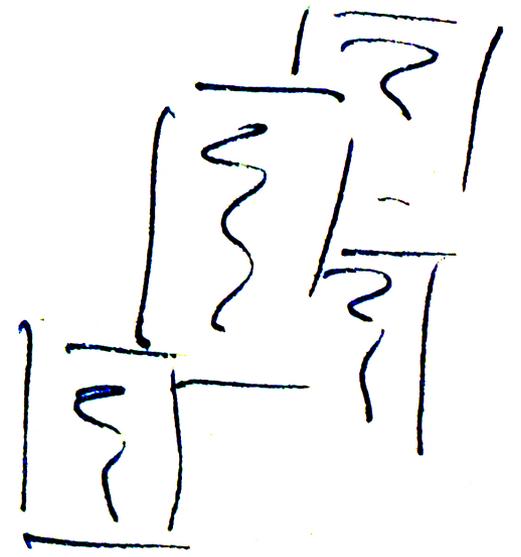


Where's the money to invest
in new network services?

Users



Services



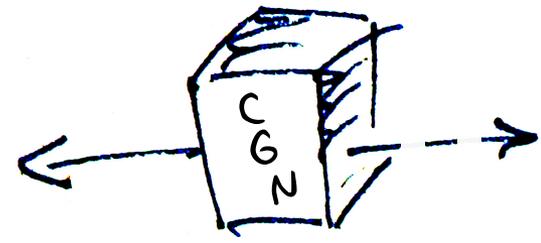
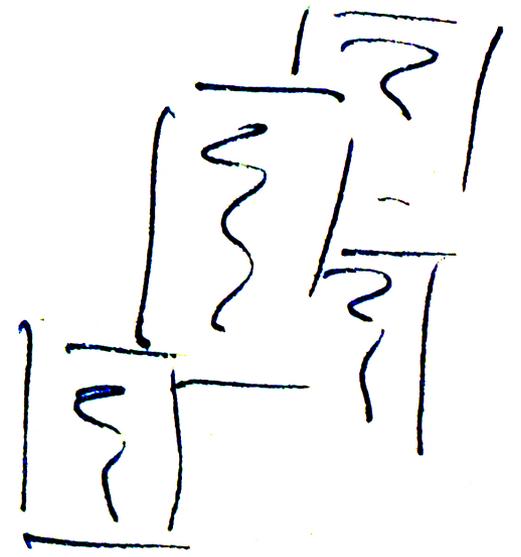
Access Provider



Users



Services



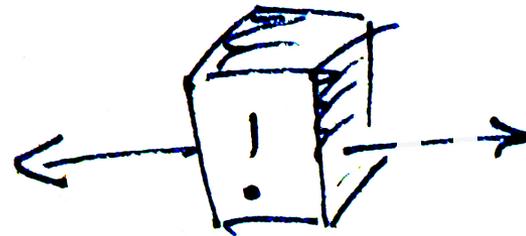
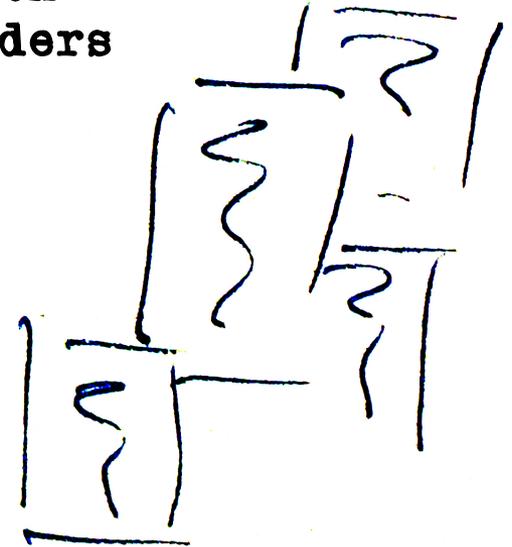
Access Provider

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



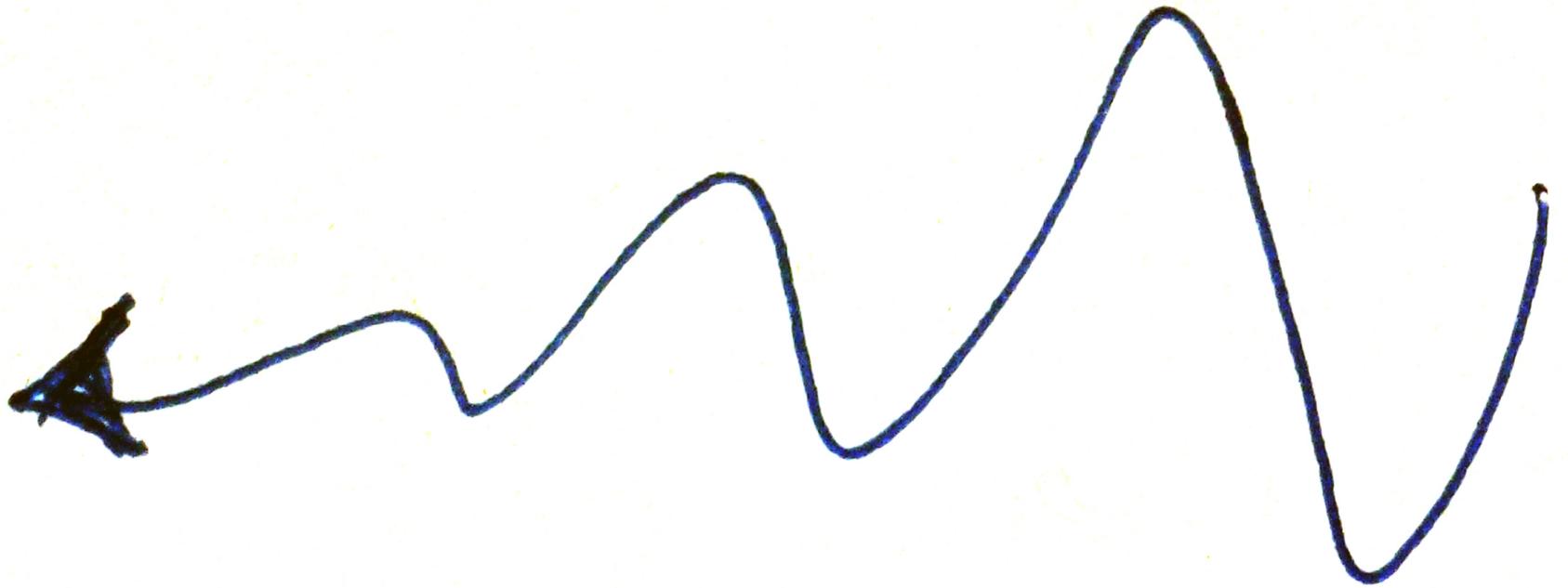
Access Provider



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

How can we "manage" this transition?

To ensure that the industry maintains a collective focus on IPv6

This was always the objective of this exercise!
going to be a very hard question to try and answer!

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

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The data on IPv6 uptake 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.

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The data on IPv6 uptake 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~~ geological!

How can we "manage" this transition?

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



Challenges:

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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!

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

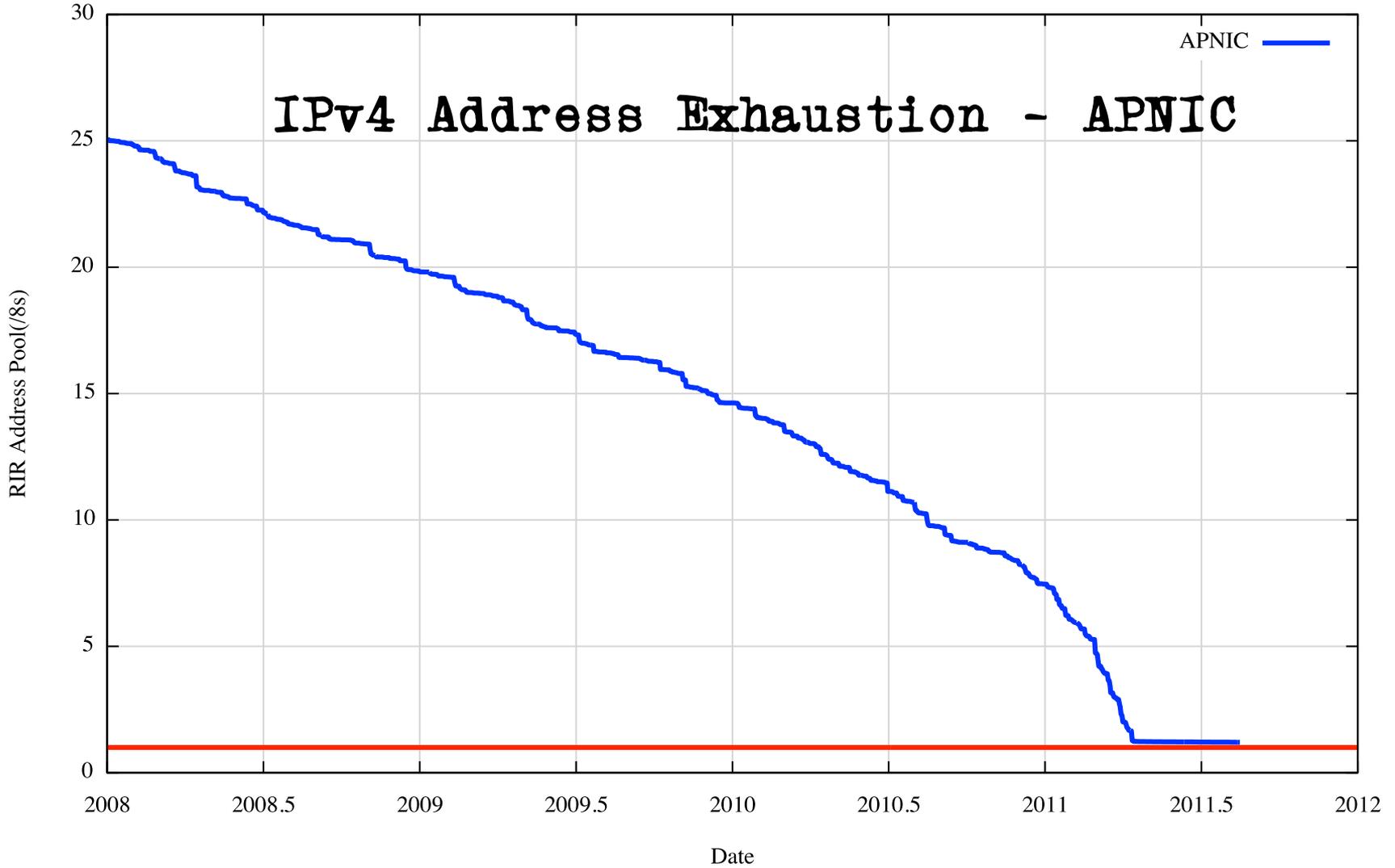
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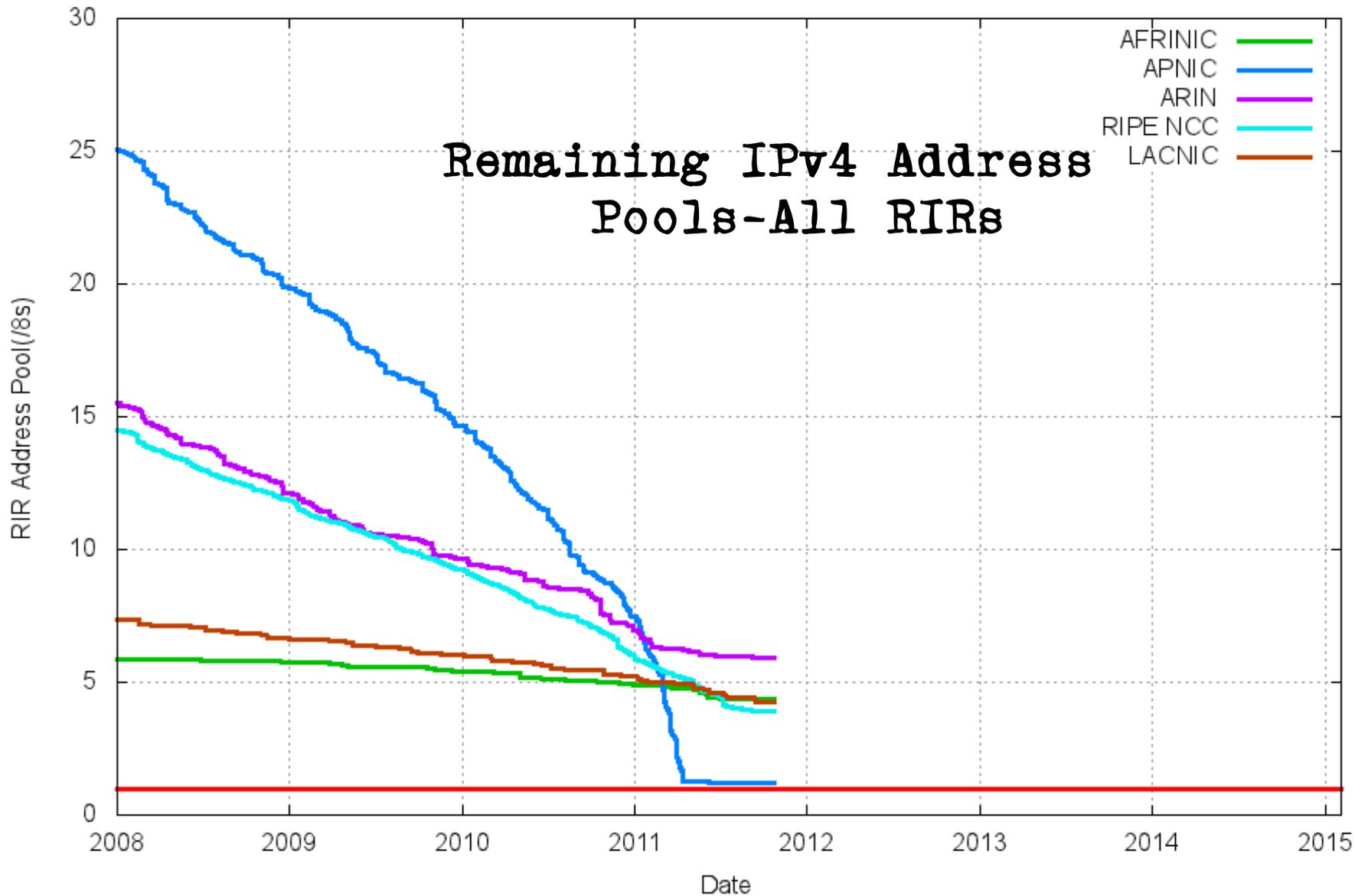
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2. Varying IPv4 Address Exhaustion Timelines

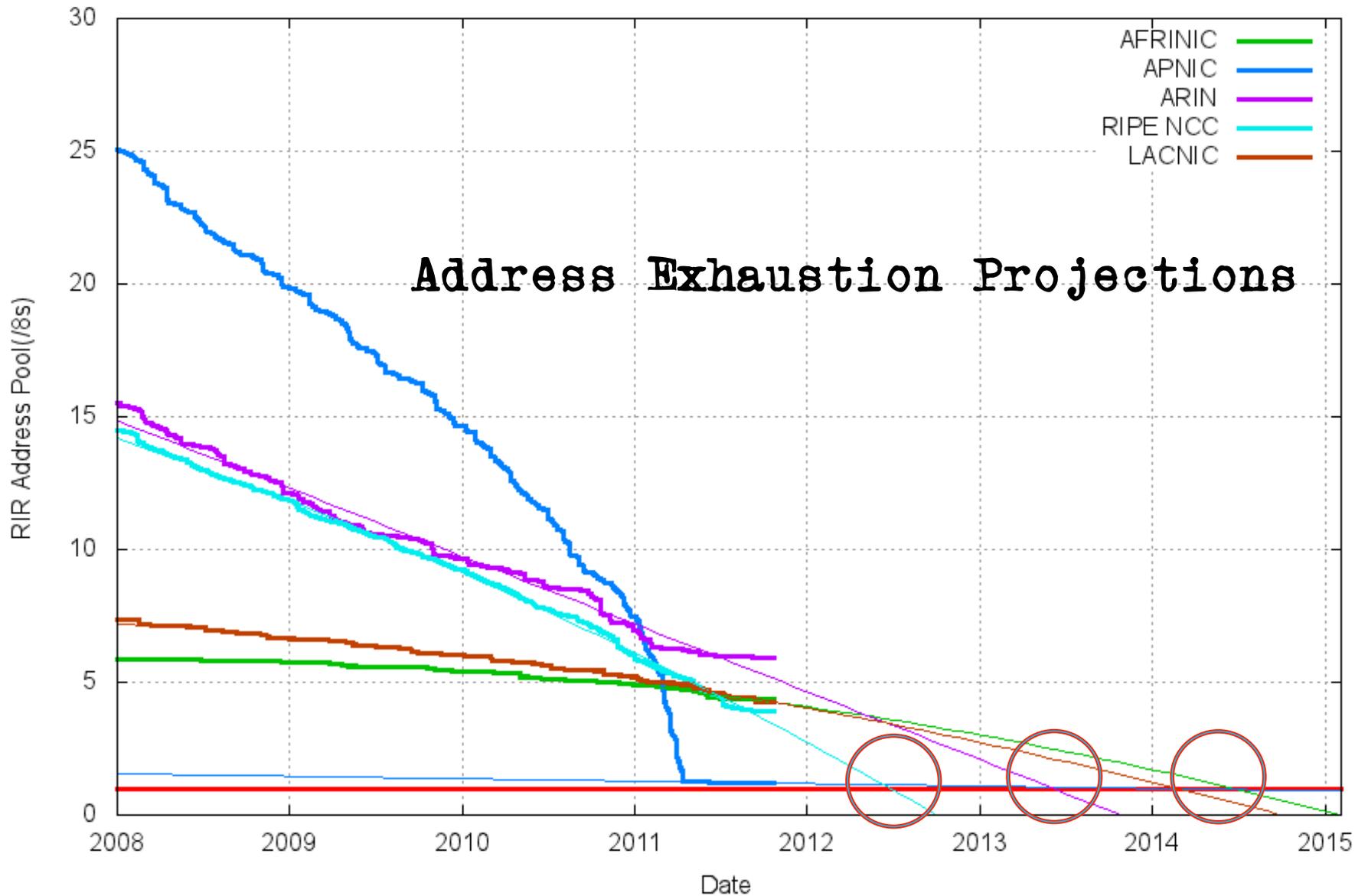
RIR IPv4 Address Run-Down Model



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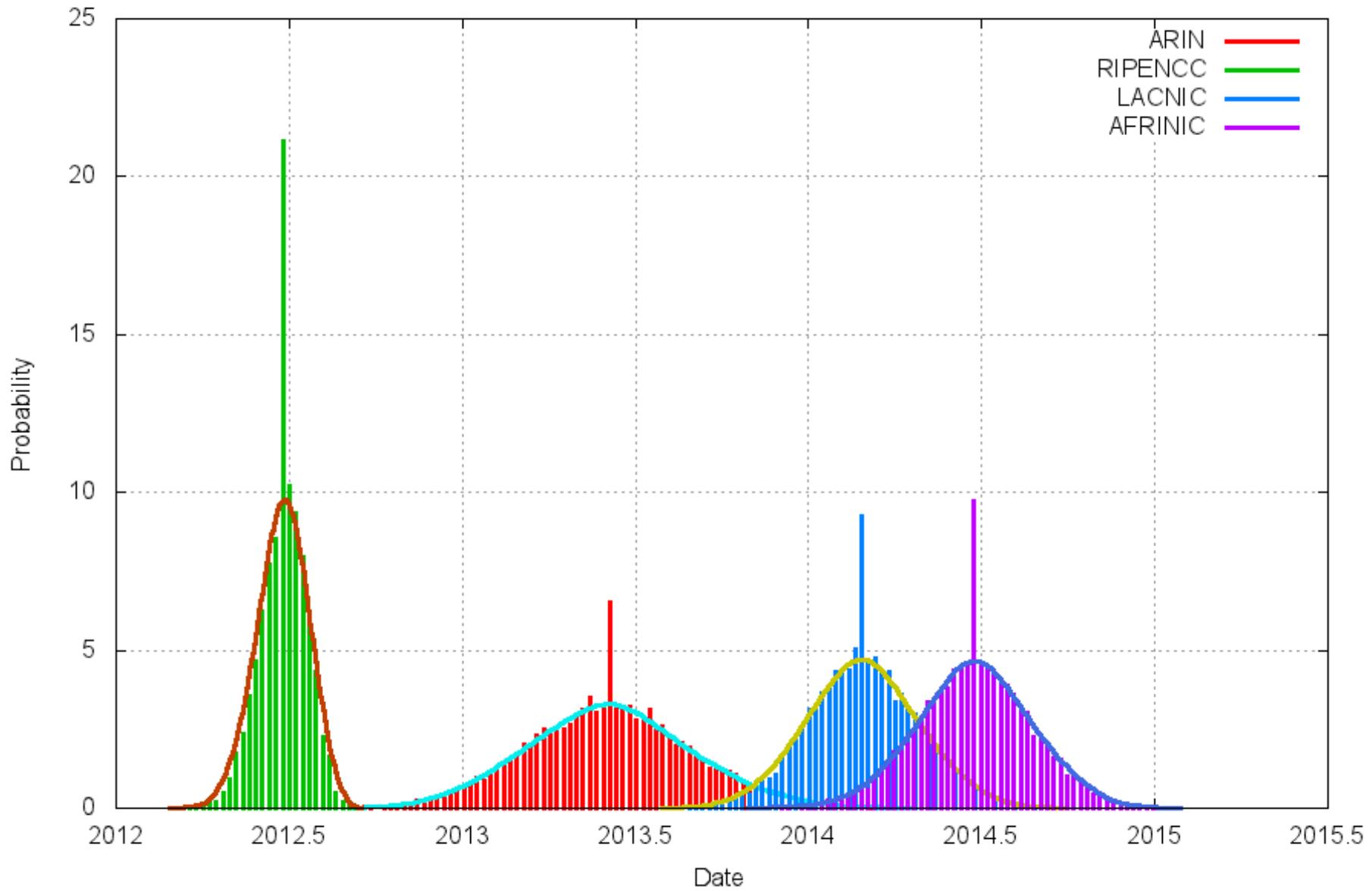


Exhaustion Predictions

RIR	Predicted Exhaustion Date *	Remaining Address Pool (24 Oct 2011)
APNIC	19 April 2011 (actual)	1.20 /8s (0.3 /8s rsvd)
RIPE NCC	23 June 2012	3.91 /8s
ARIN	4 June 2013	5.91 /8s
LACNIC	25 February 2014	4.27 /8s
AFRINIC	23 June 2014	4.38 /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



So what?

Reality Acceptance

Reality Acceptance

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

Or not

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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2. Varying IPv4 Address Exhaustion Timelines

There is a credibility problem!

Challenges:

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There is a credibility problem: This industry has a hard time believing reality over the comforts of denial

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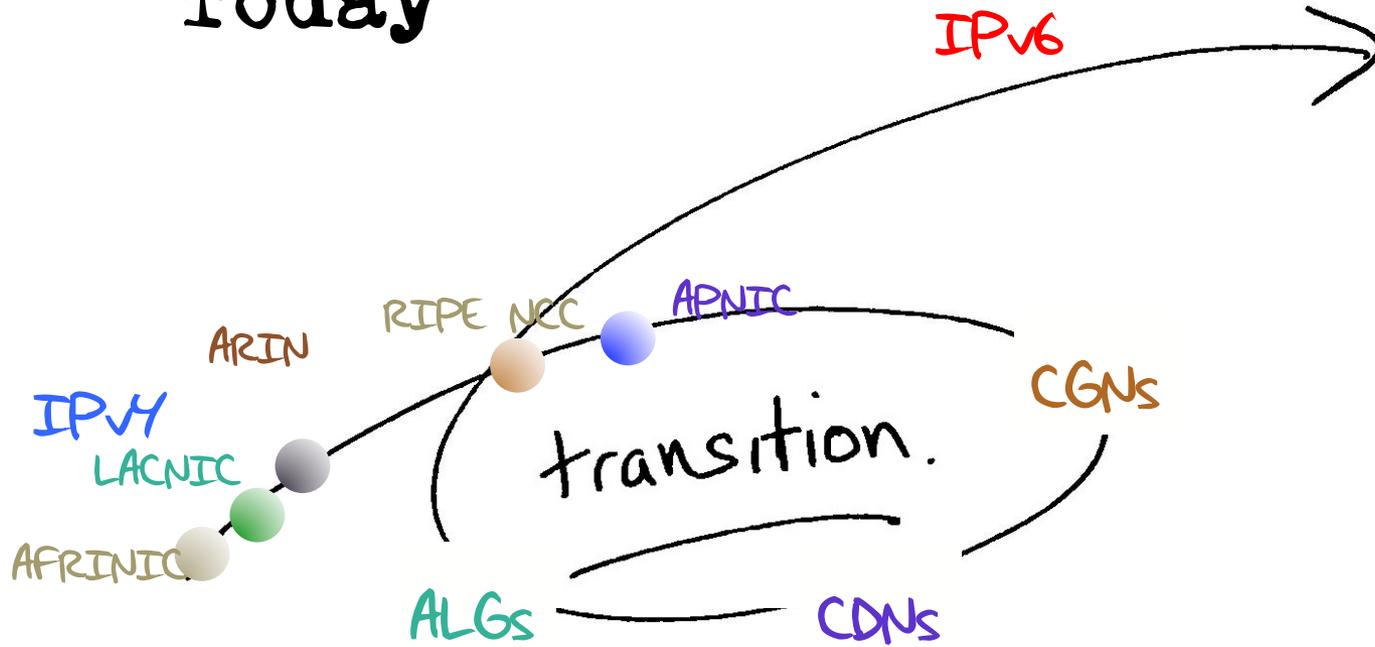
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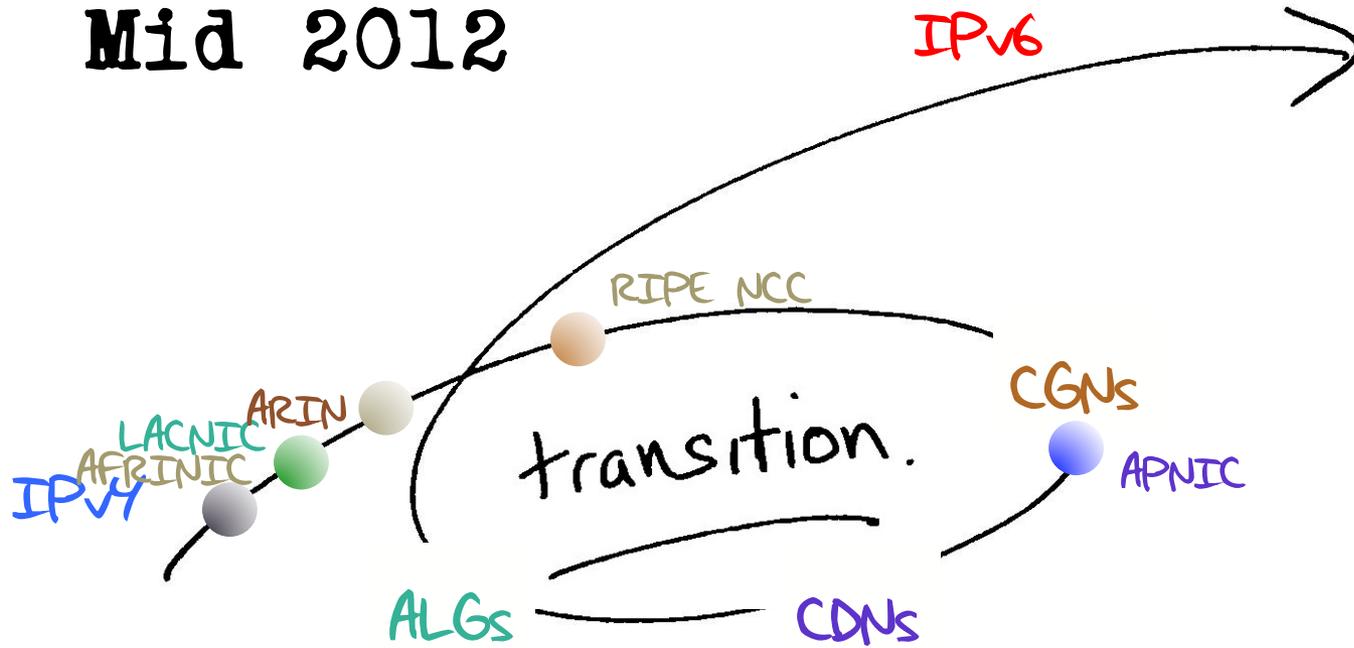
3. Regional Diversity

Today



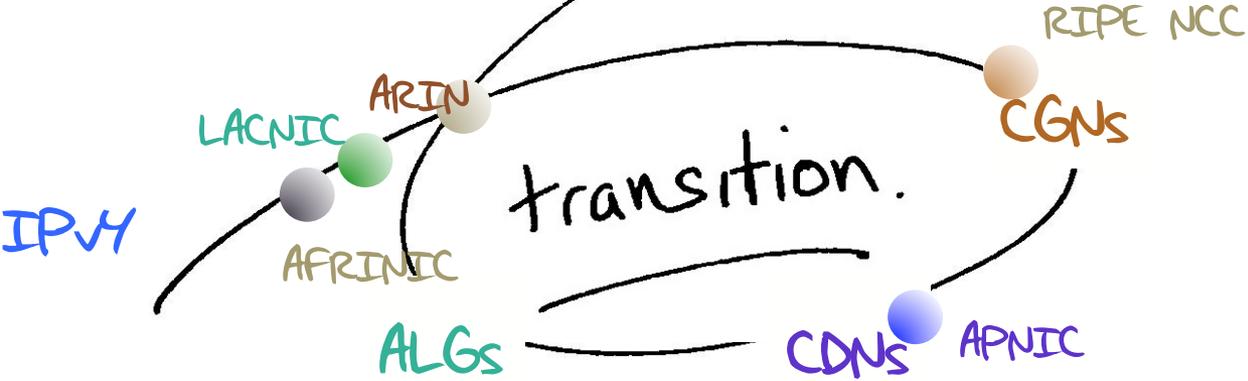
Mid 2012

IPv6



2013

IPv6



By 2013 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?

By 2013 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

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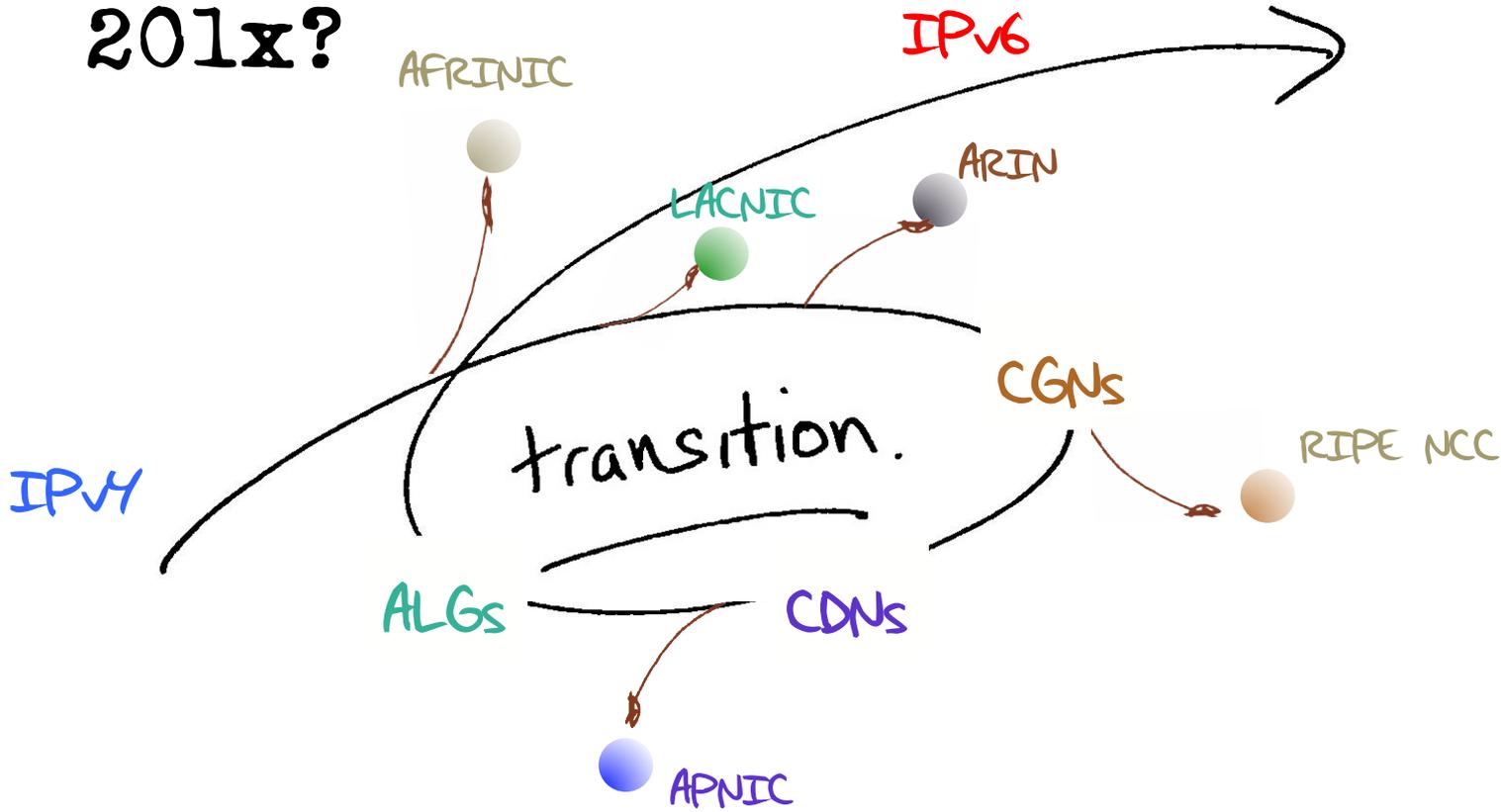
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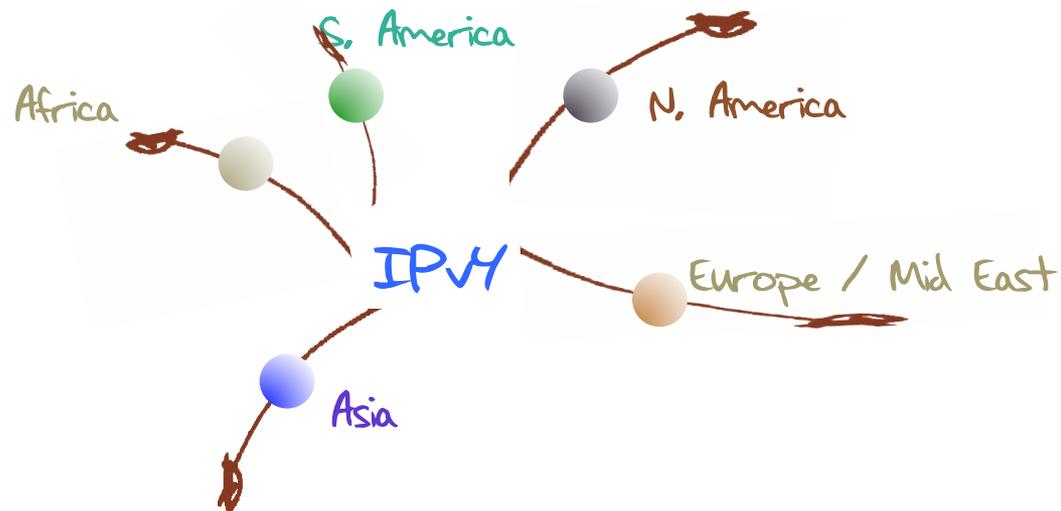
Are we still committed to the plans we had 5 years ago? How about our 10 year old plans?

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

201x?



20xx?



Challenges:

1. This is a deregulated and highly competitive environment

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

2. Varying IPv4 Address Exhaustion Timelines

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3. Regional Diversity

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 might work,

But even though I don't have an answer here, I have some thoughts to offer about this issue of pulling the Internet through 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, nor "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!