

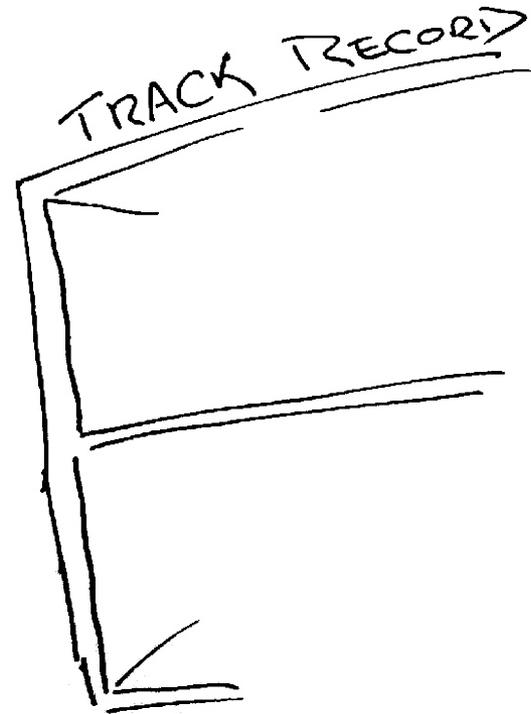
# IPv4 Address Exhaustion: A Progress Report

Geoff Huston

Chief Scientist, APNIC

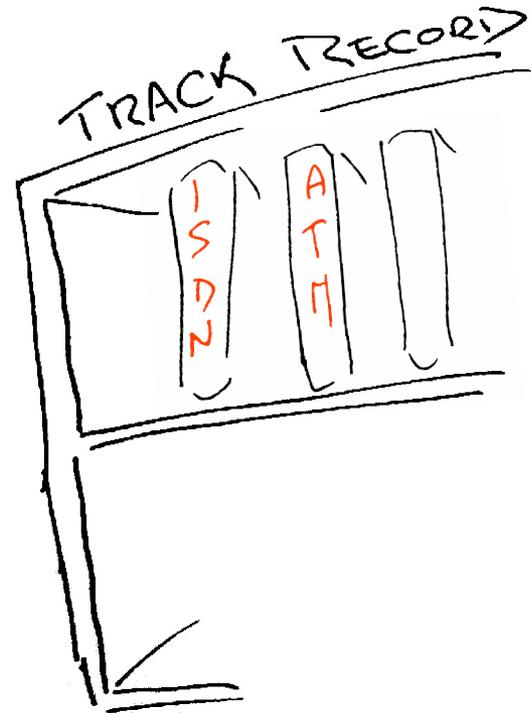


The mainstream  
telecommunications  
industry has a  
rich history



The mainstream  
telecommunications  
industry has a  
rich history

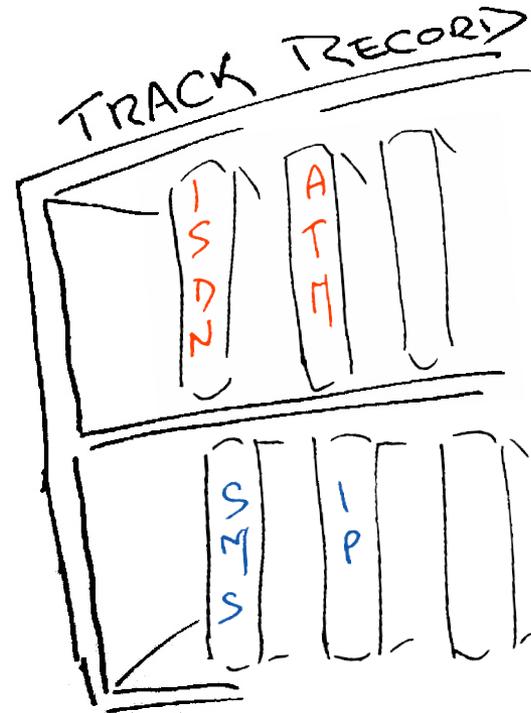
...of making very poor  
technology choices



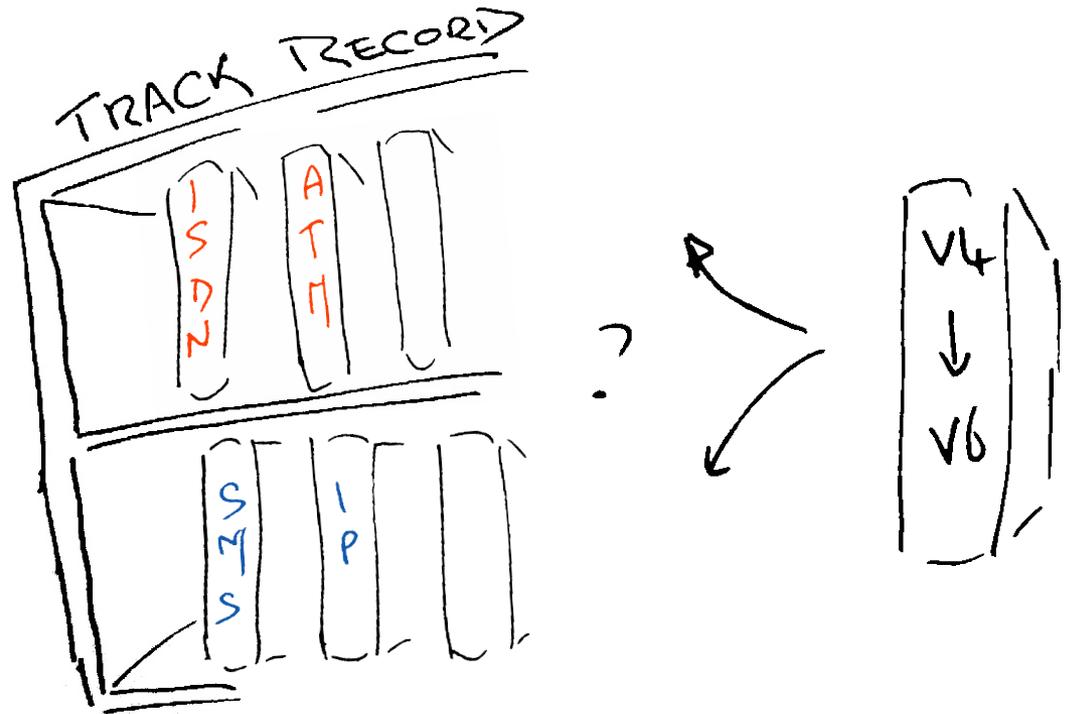
The mainstream  
telecommunications  
industry has a  
rich history

...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?

Do we really need to worry about this?

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.

Do we really need to worry about this?

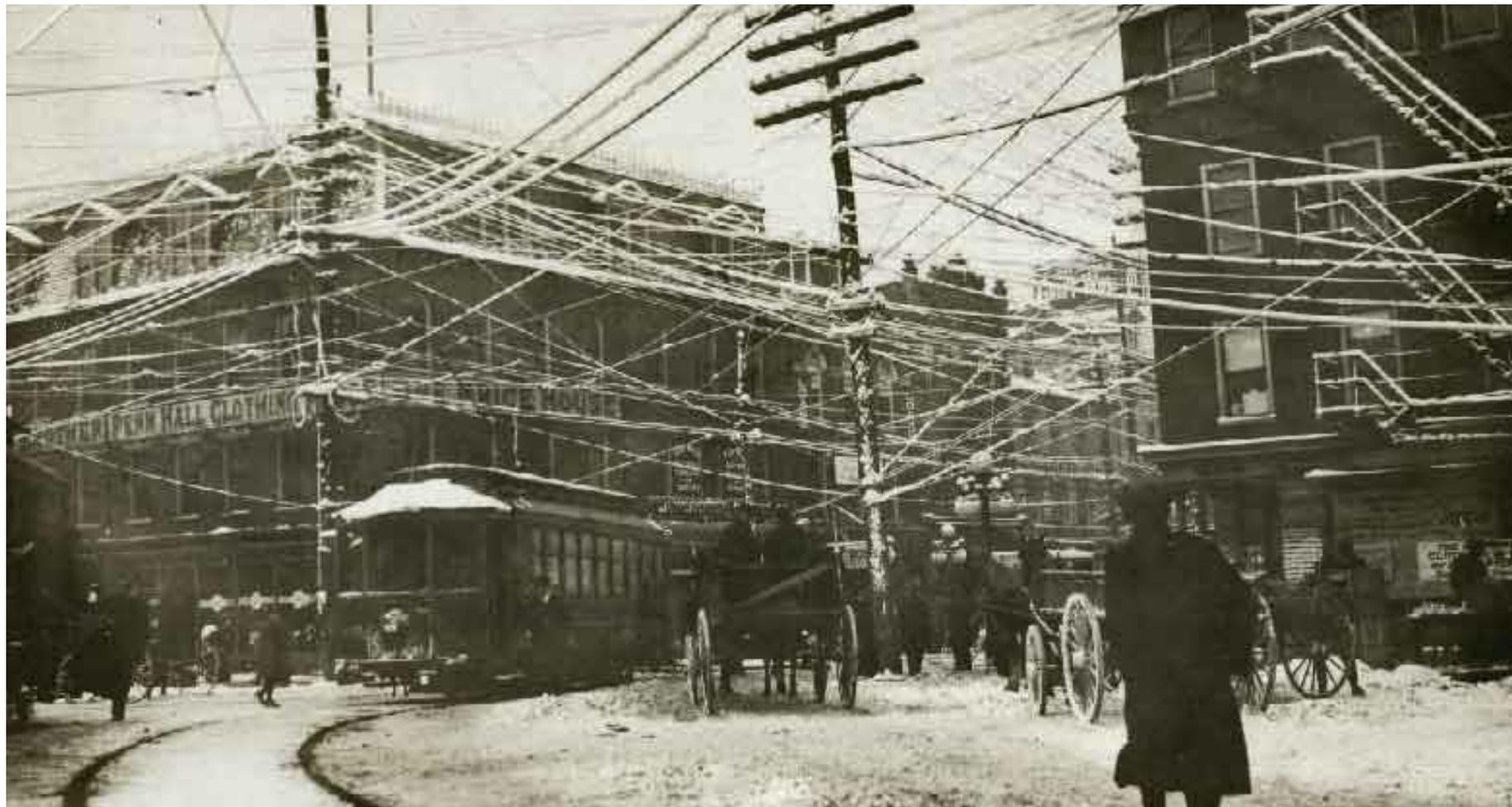
Surely IPv6 will just happen — its just a matter of waiting for the pressure of IPv4 address exhaustion to get to sufficient levels of intensity.

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

The  
"inevitability"  
of technological  
evolution

wires





The  
"inevitability"  
of technological  
evolution

wires

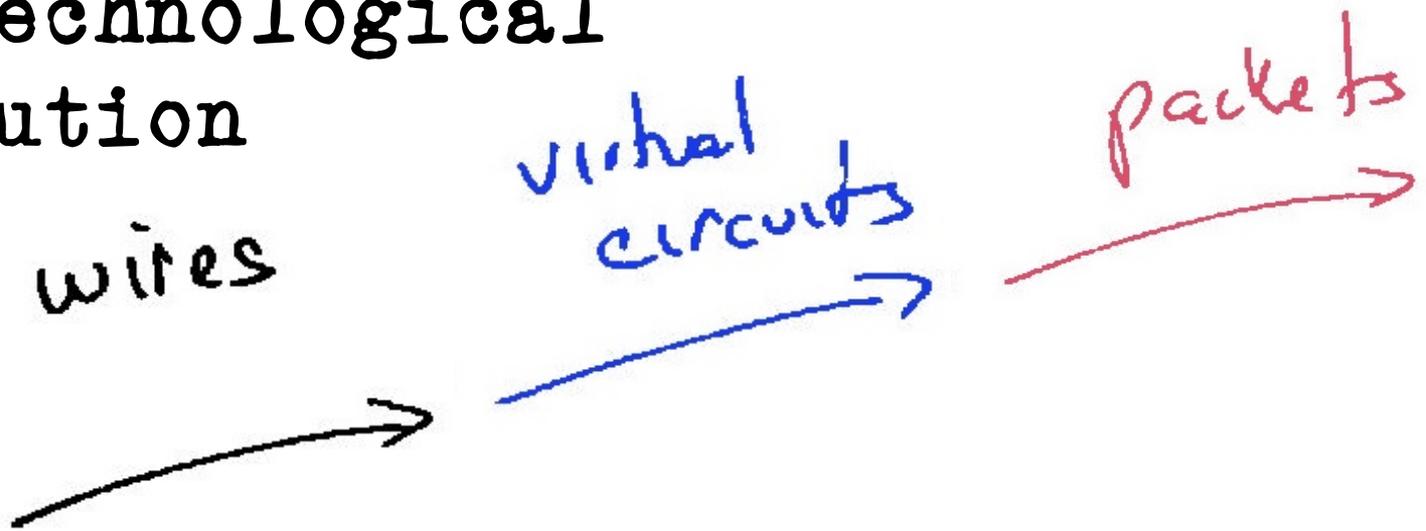
virtual  
circuits





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

The  
"inevitability"  
of technological  
evolution



The  
"inevitability"  
of technological  
evolution

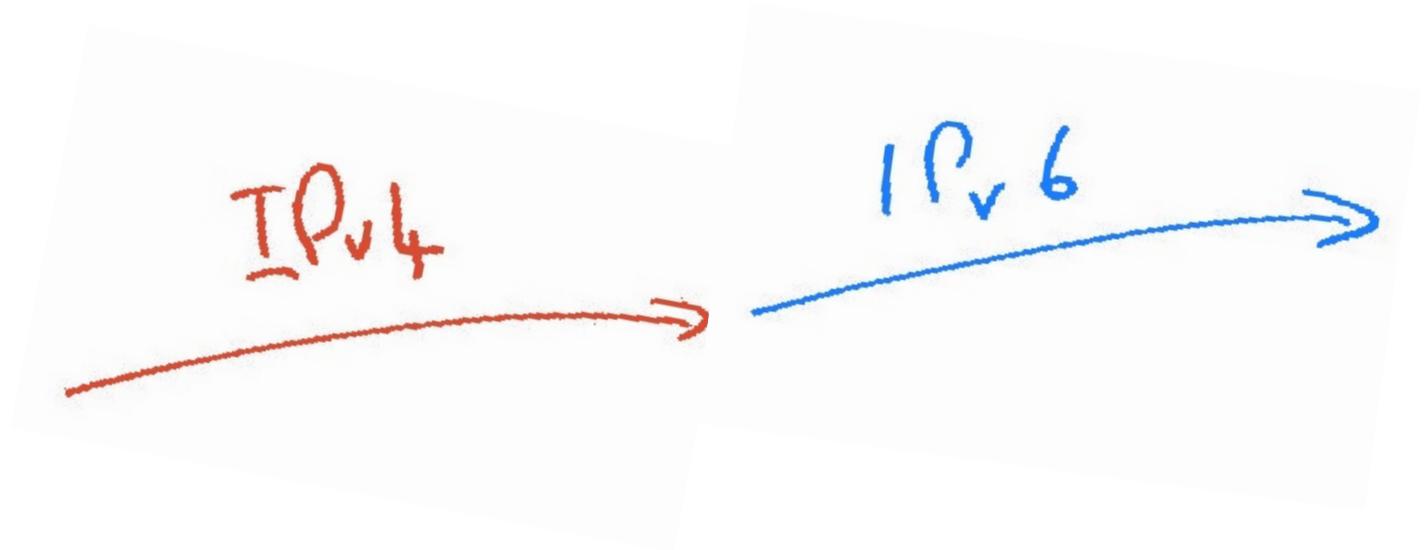
Now lets look at something a little  
more topical to today!

The  
"inevitability"  
of technological  
evolution?

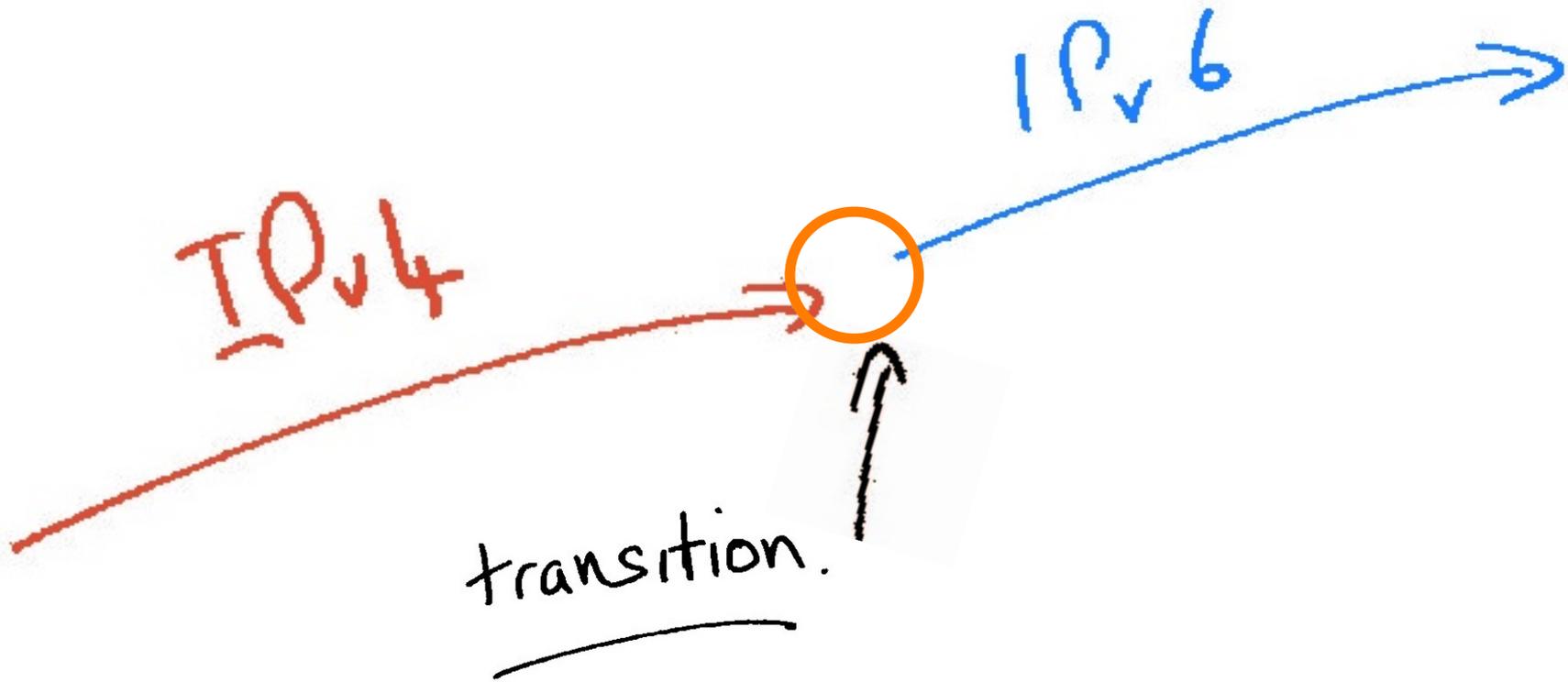
IPv4



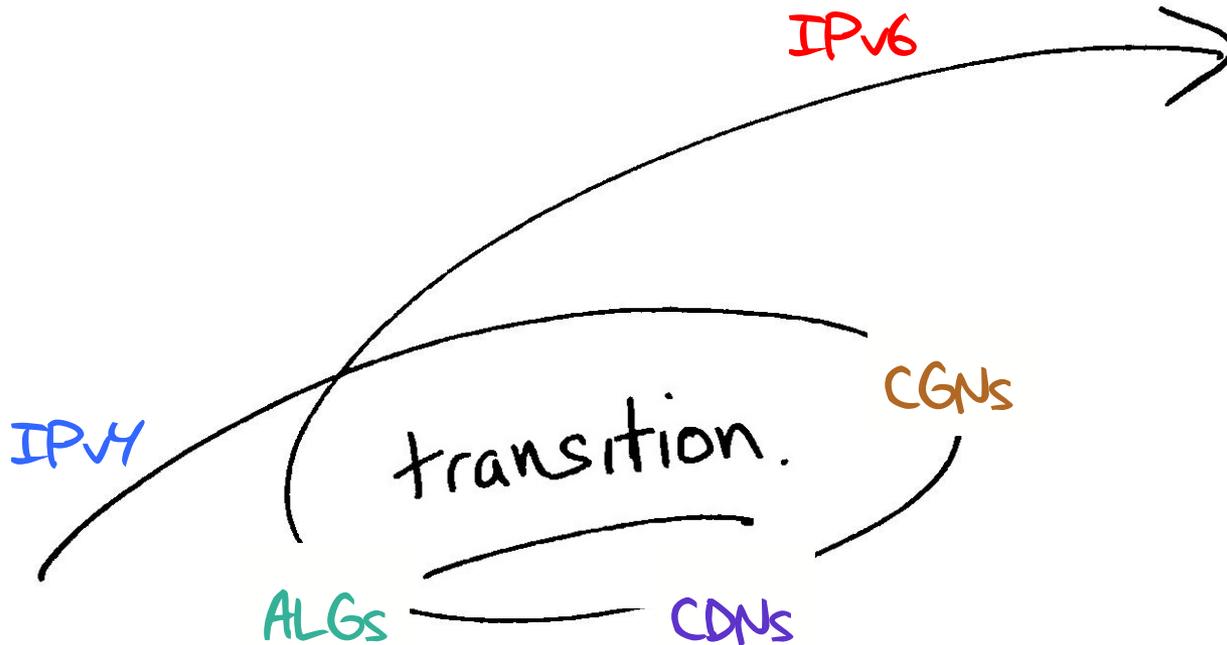
The  
"inevitability"  
of technological  
evolution?



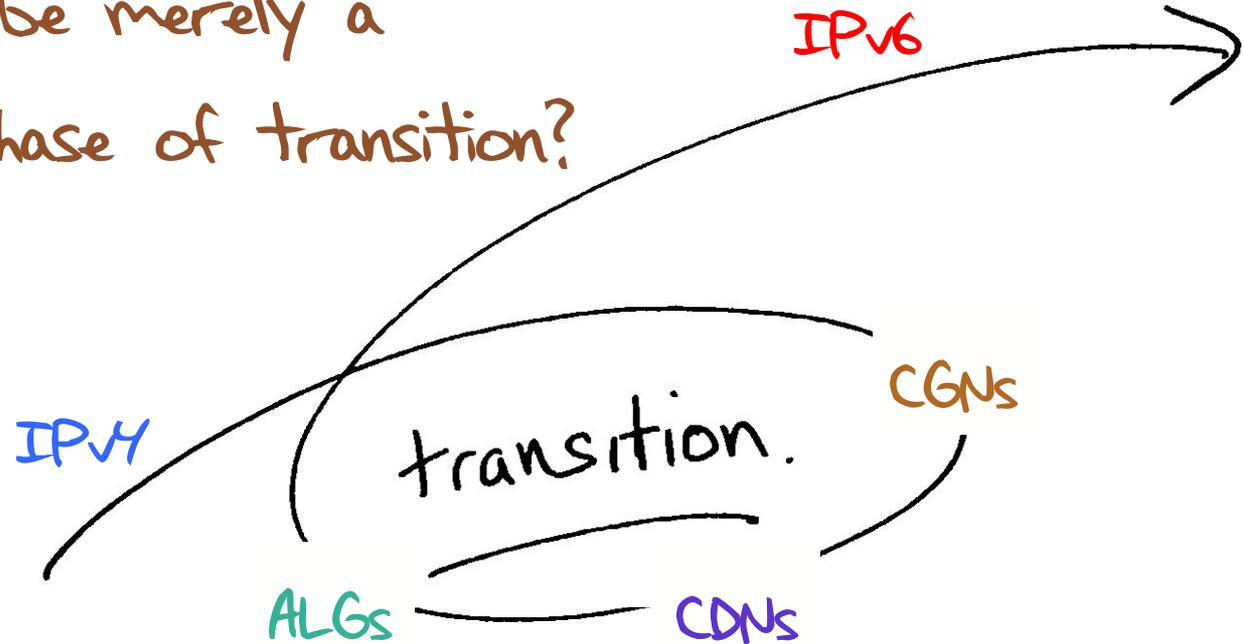
The challenge often  
lies in managing the  
transition from one  
technology to another



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

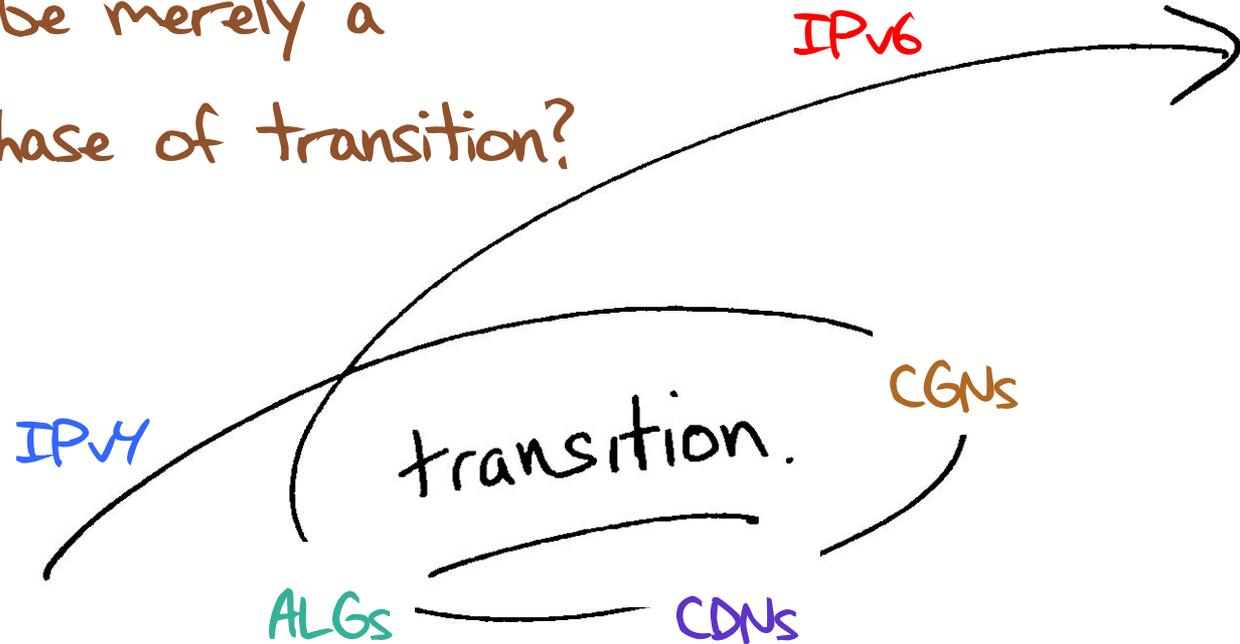


But will this be merely a temporary phase of transition?



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

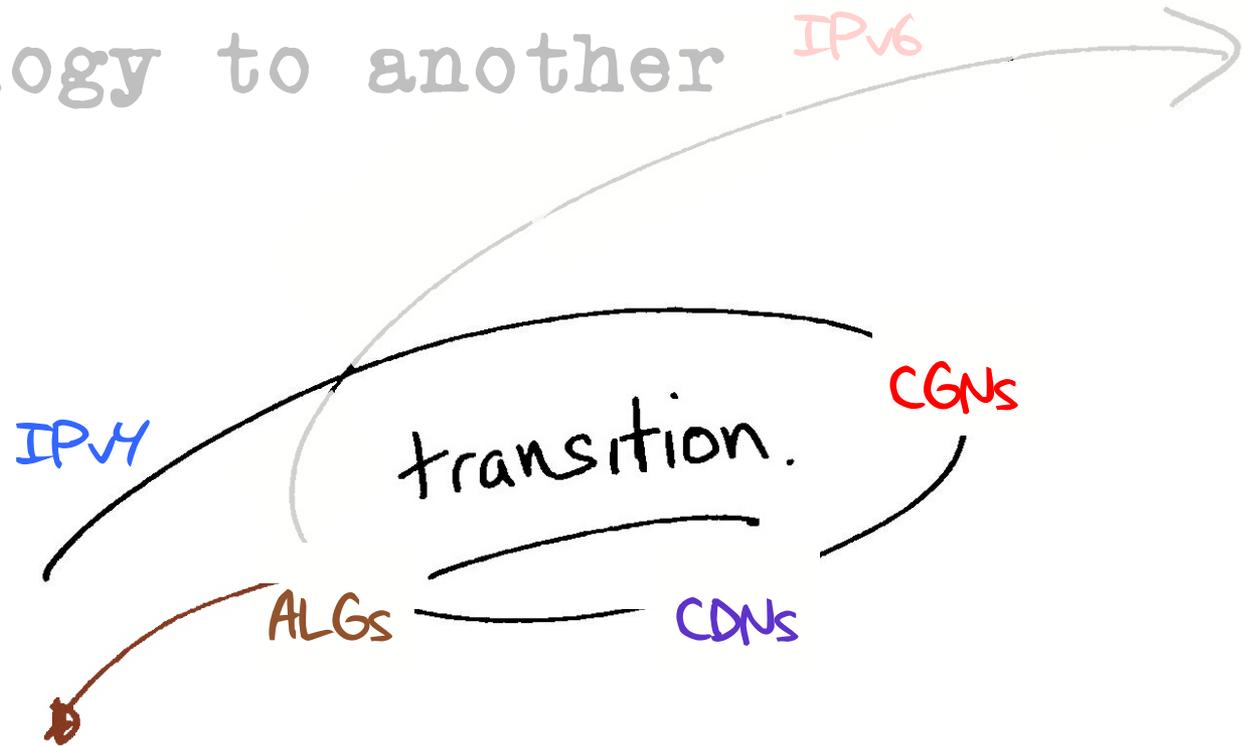
But will this be merely a temporary phase of transition?



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?

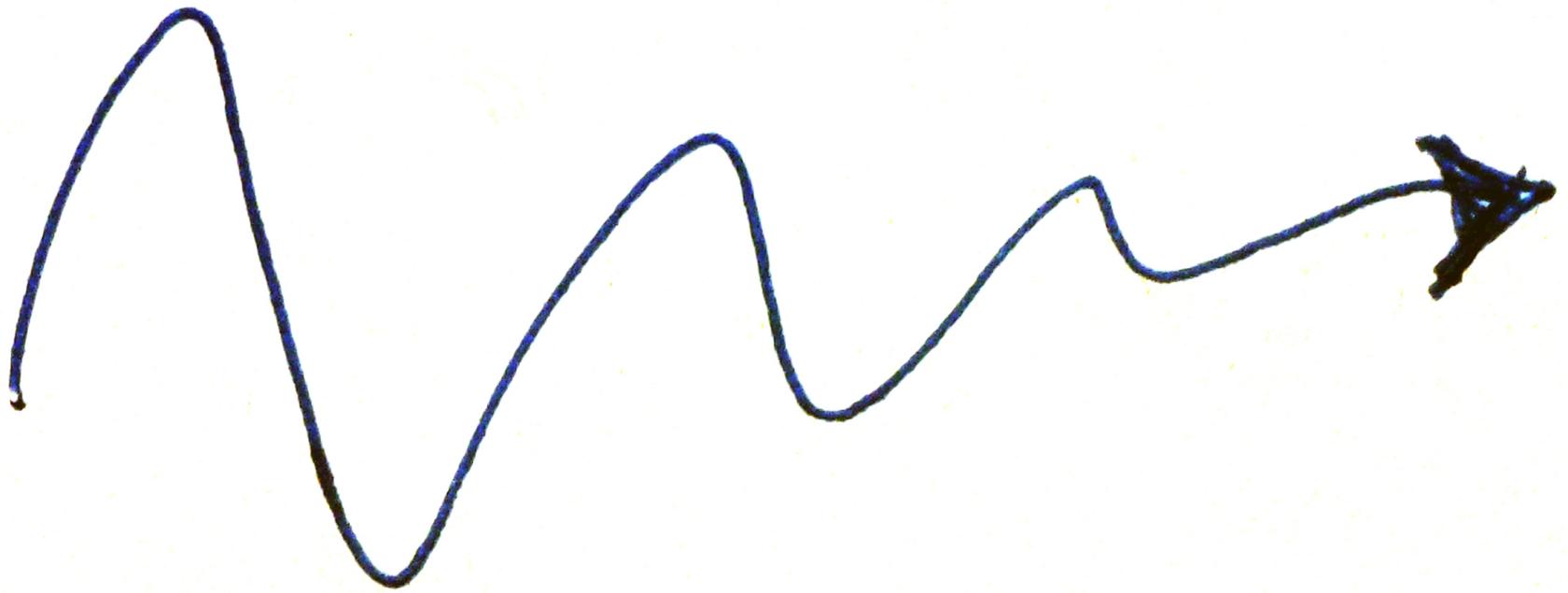
The challenge often lies in managing the transition from one technology to another



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

A digression...

How "real" is this  
risk?



A digression...

How "real" is this  
risk?

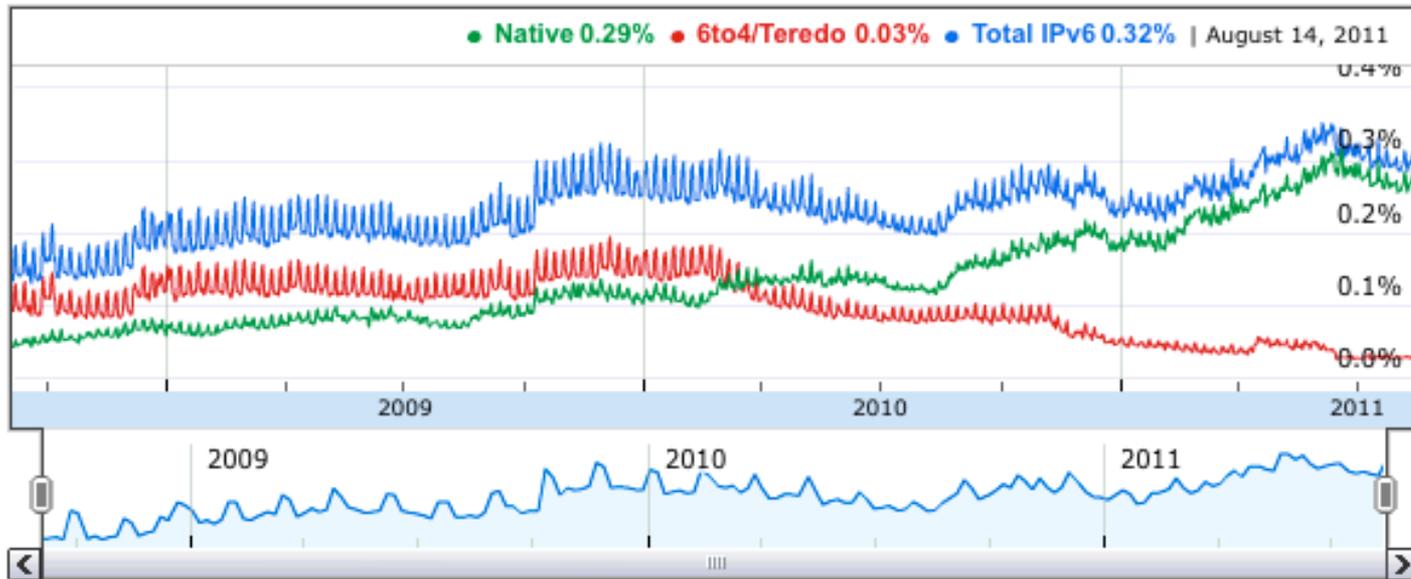
Is this industry seriously prepared to contemplate an  
IPv4 forever strategy?

# 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

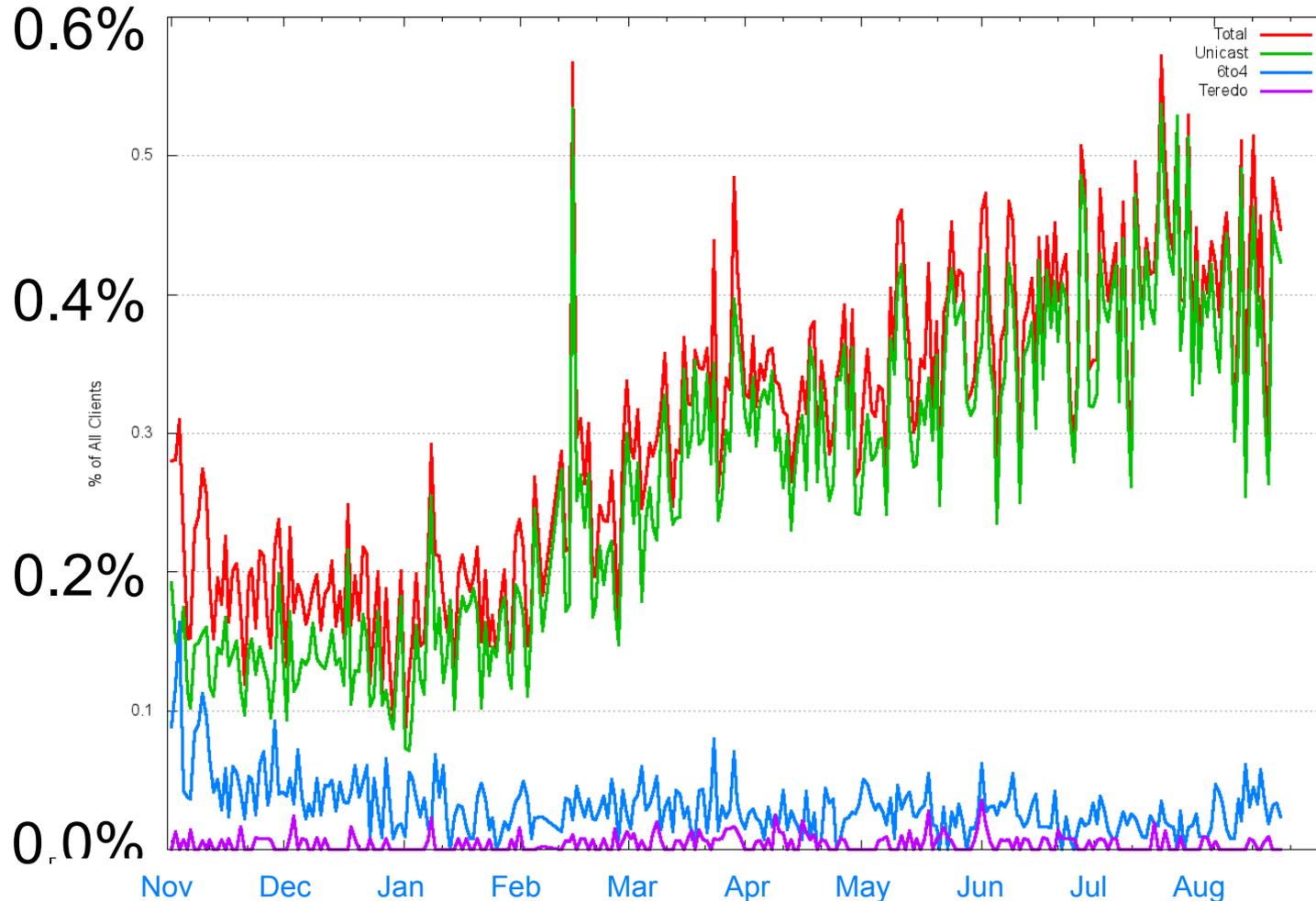


©2011 Google

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

# IPv6 capability, as seen by APNIC

Clients who Prefer V6 in Dual Stack by V6 Address Type



# 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

0.3% 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

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

Hint!

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

A) they are stupid

B) they are lazy

C) they are uninformed

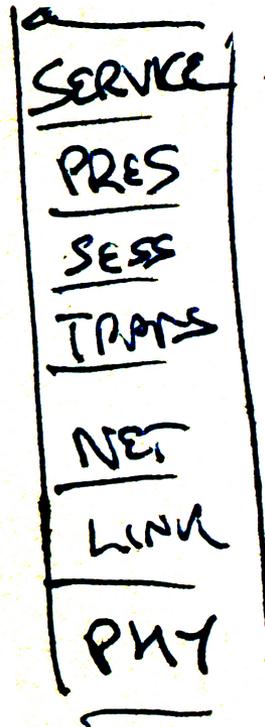
D) they are broke

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

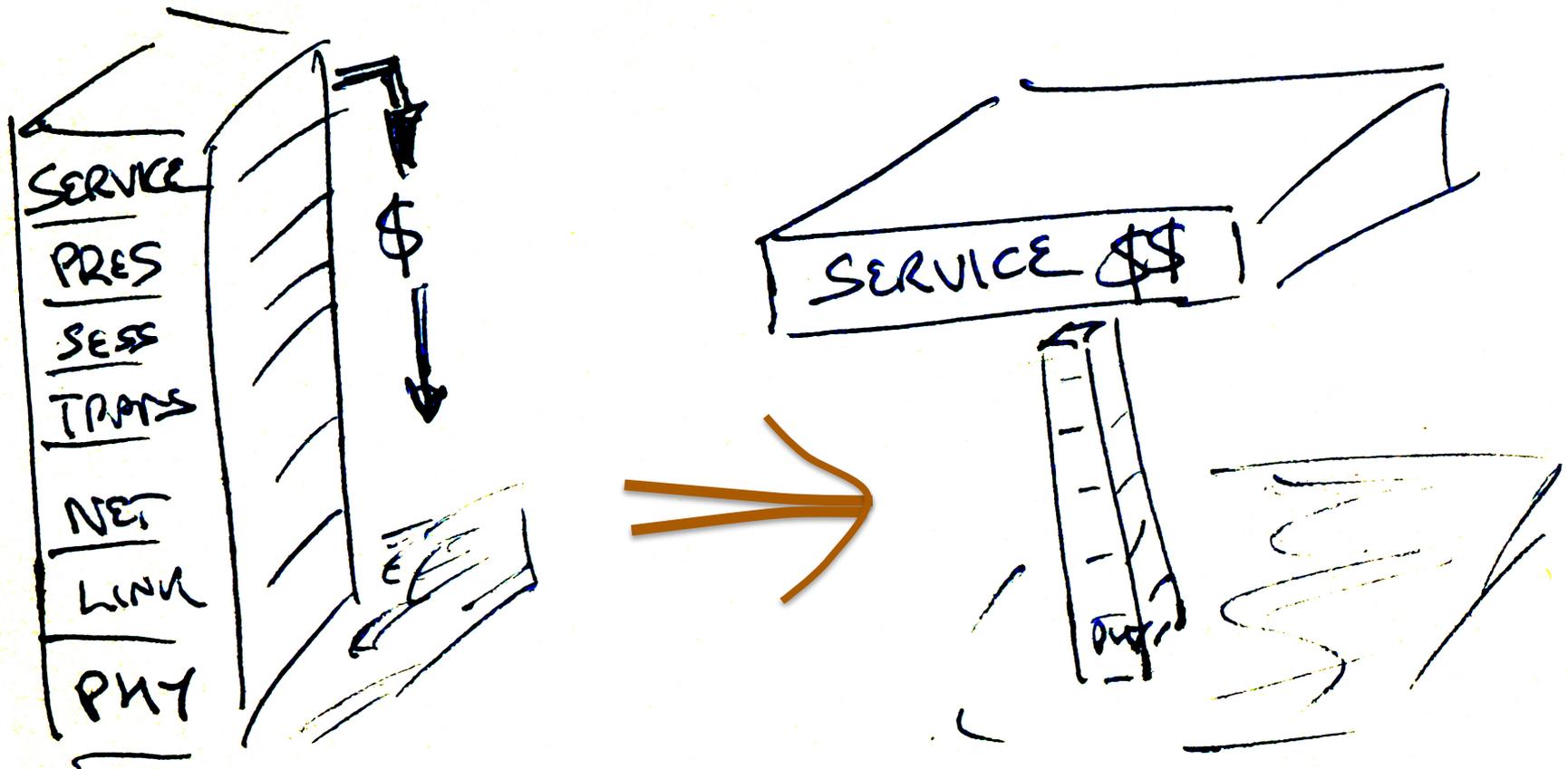
Back to networking basics....



# Telco nostalgia...

The historical  
vertically integrated  
service architecture

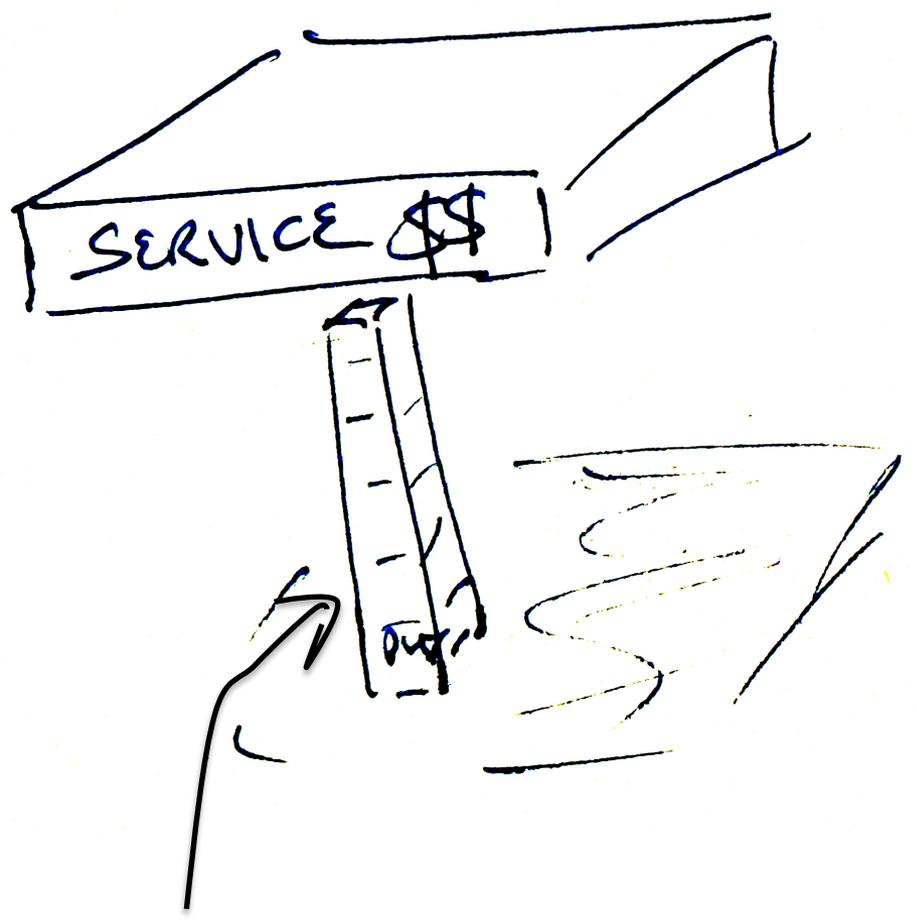




Devolution of the integrated service architecture through an open IP service architecture and deregulation



Devolution of the integrated service architecture

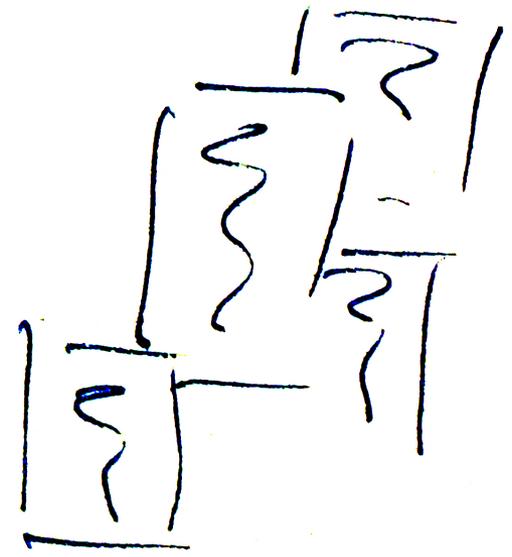


Where's the money to invest in new network services?

Users



Services



Access Provider

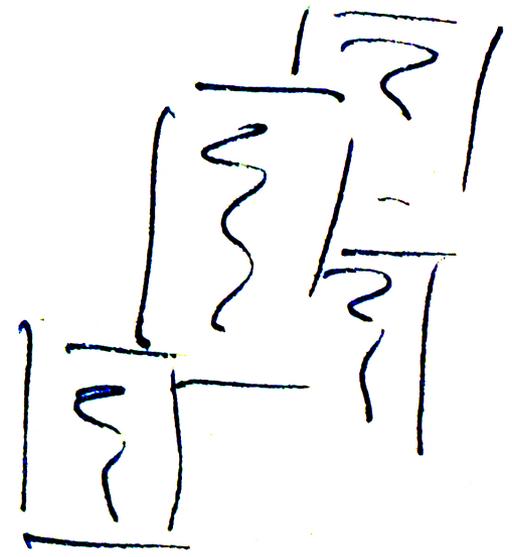


# Users



Access Provider

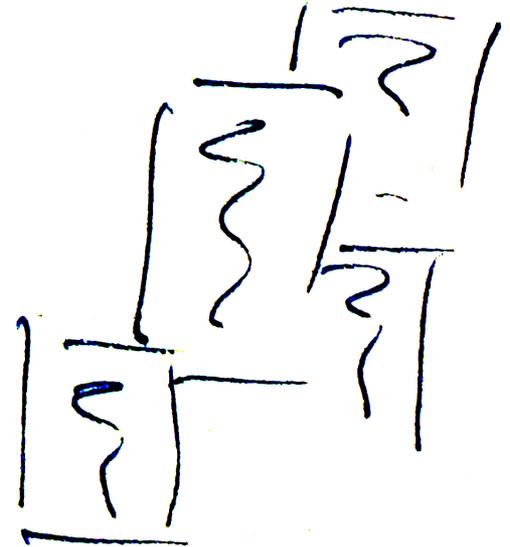
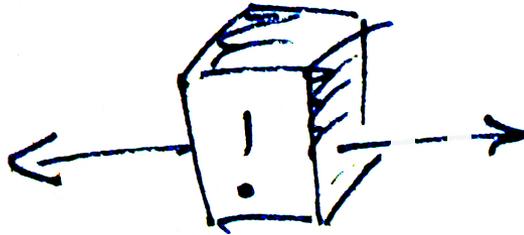
# Services



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?

How can we "manage" this transition?

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

How can we "manage" this transition?

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

How can we "manage" this transition?

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

And 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.

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

# Challenges:

1. This is a deregulated and highly competitive environment

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



# Challenges:

1. This is a deregulated and highly competitive environment

There are many different players  
Each with their own perspective



# Challenges:

1. This is a deregulated and highly competitive environment

There are many different players  
Each with their own perspective



And all potential approaches will be explored!

# Challenges:

1. This is a deregulated and highly competitive environment

There is no plan!

# Challenges:

1. This is a deregulated and highly competitive environment

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

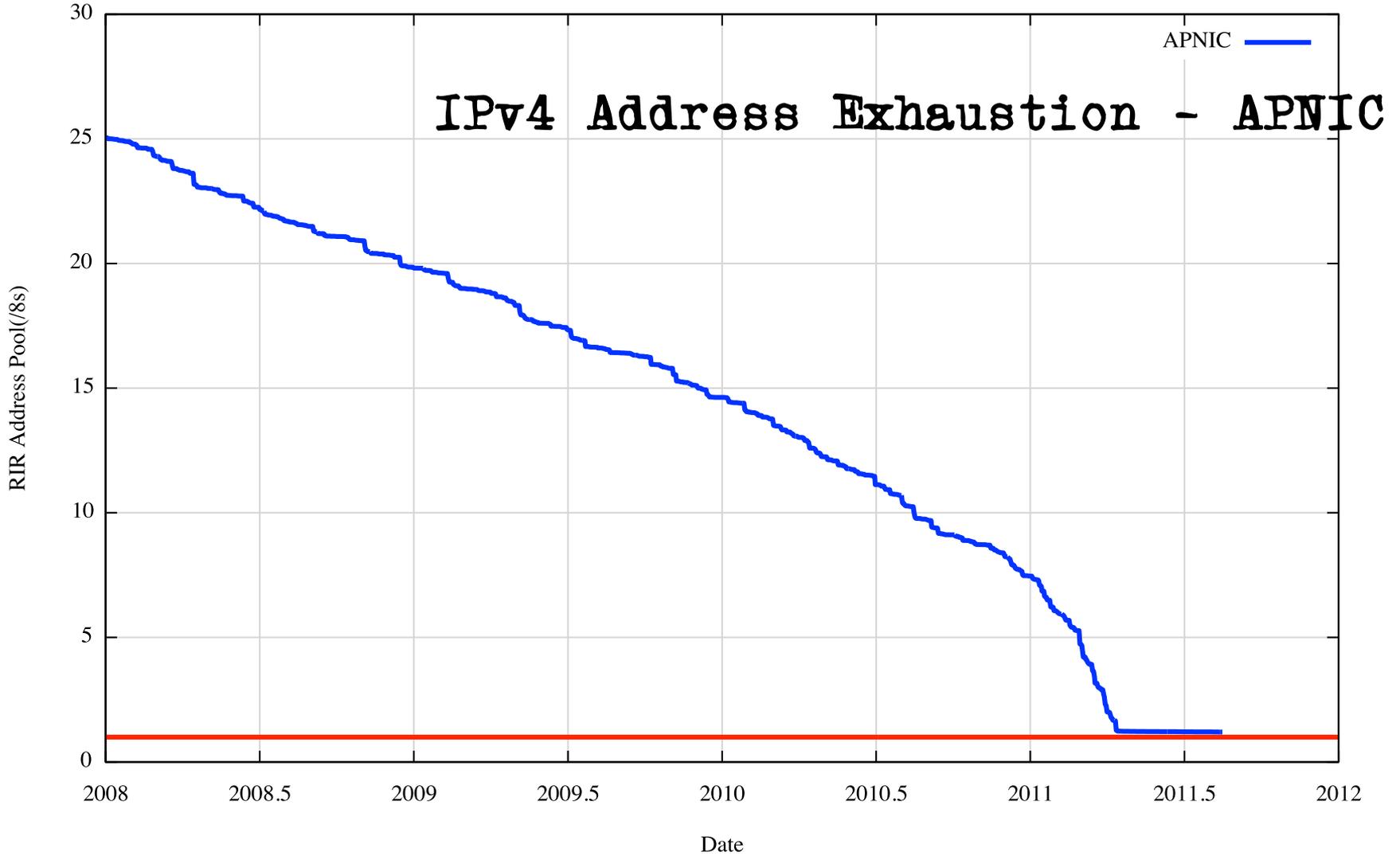
# Challenges:

1. This is a deregulated and highly competitive environment

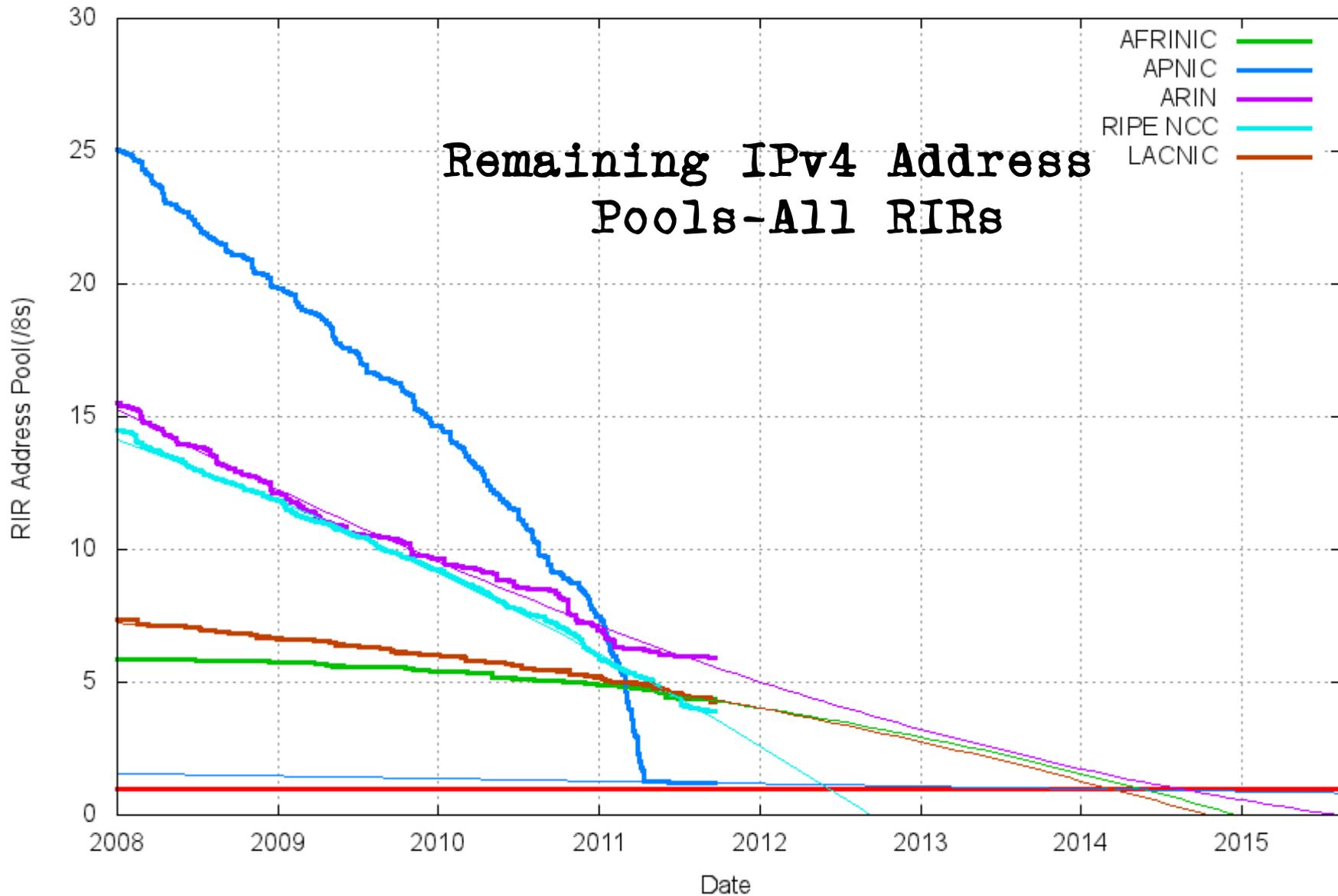
There is no plan, just the interplay of various market pressures

2. Varying IPv4 Address Exhaustion Timelines

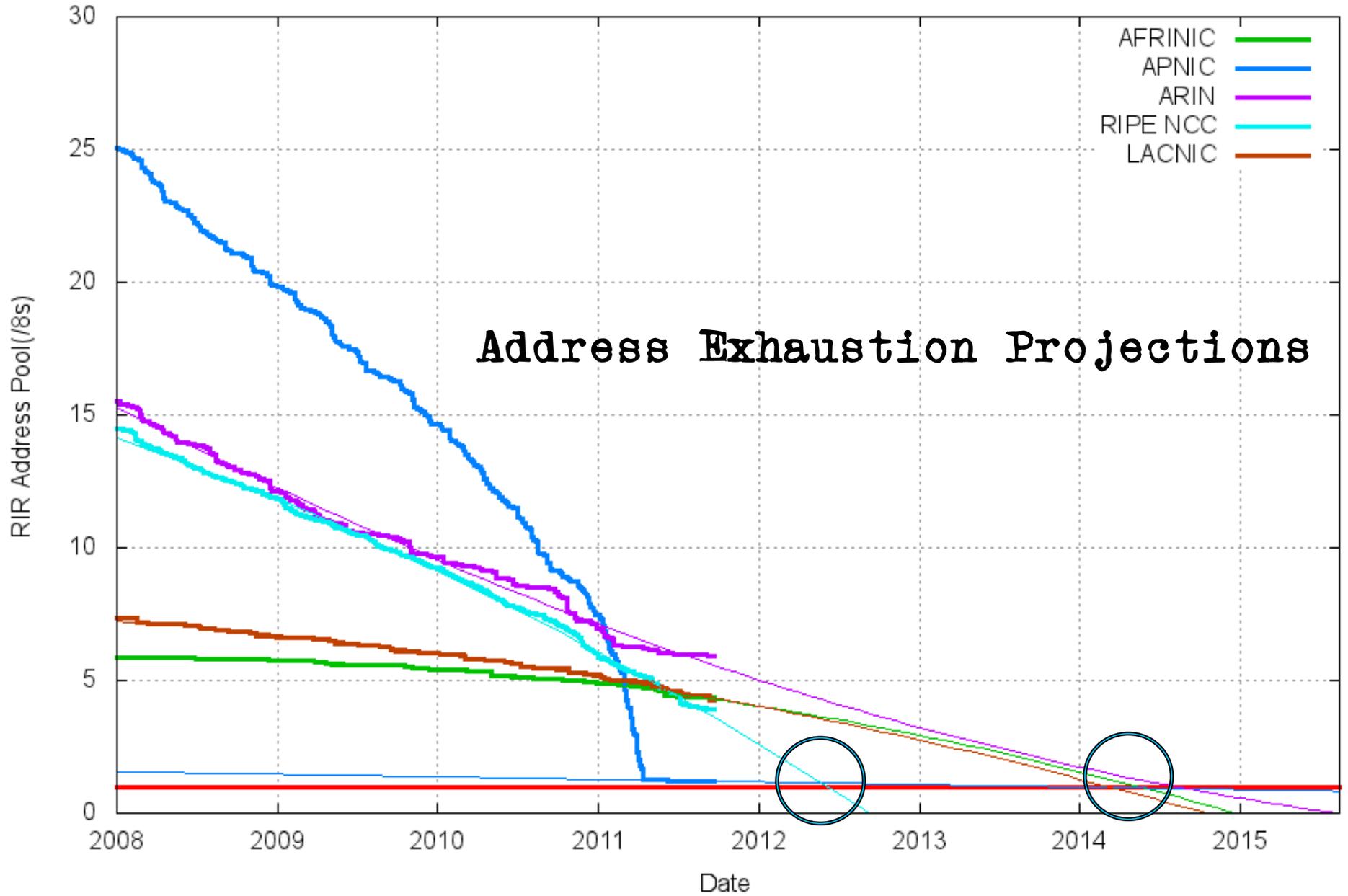
RIR IPv4 Address Run-Down Model



RIR IPv4 Address Run-Down Model



RIR IPv4 Address Run-Down Model

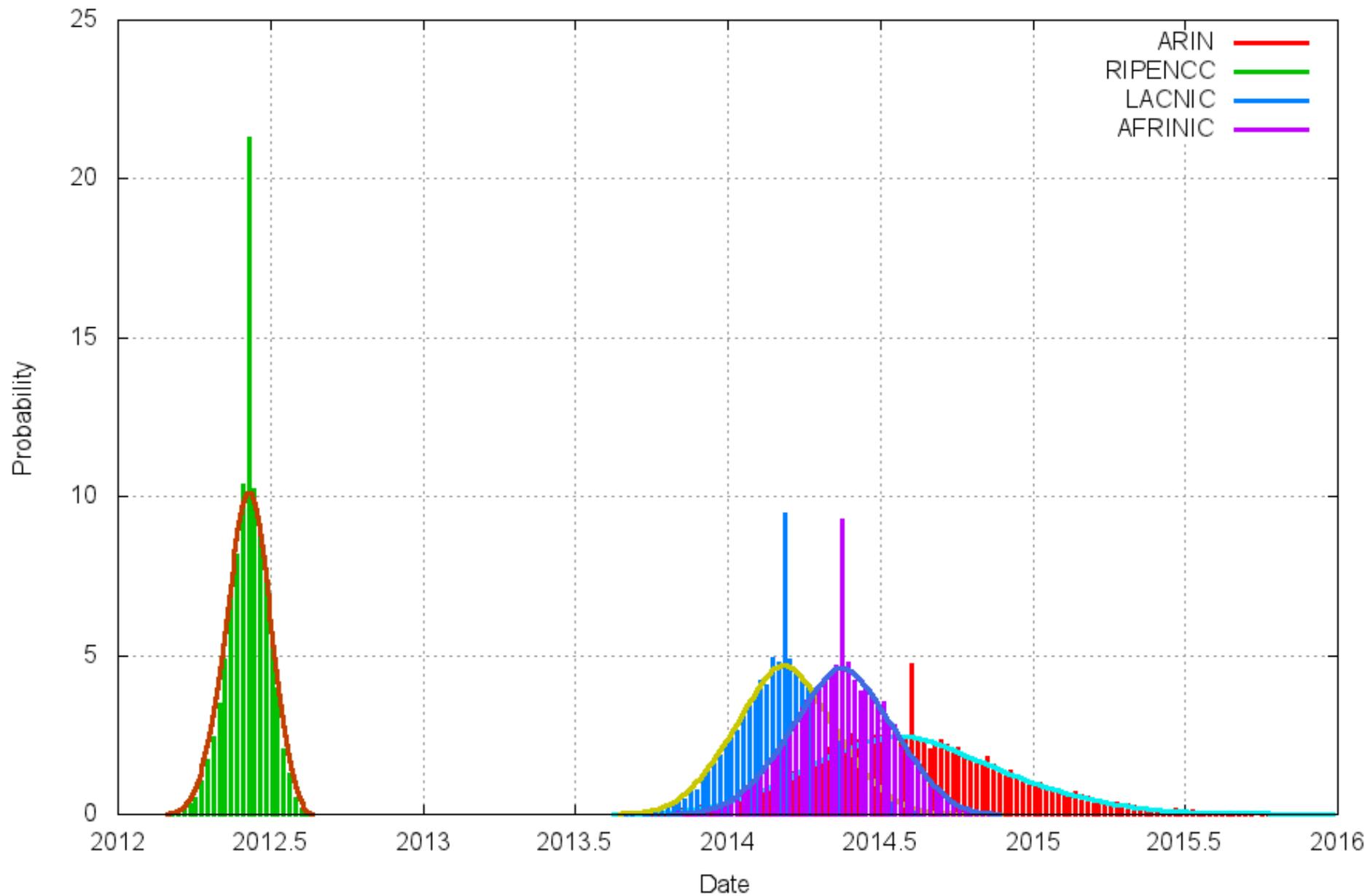


# Exhaustion Predictions

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



**So what?**

# Reality Acceptance

# Reality Acceptance

Or not

# Reality Acceptance

Or not

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:

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

There is a credibility problem!

# 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

There is a credibility problem: This industry has a hard time believing reality over its own mythology

# Challenges:

1. This is a deregulated and highly competitive environment

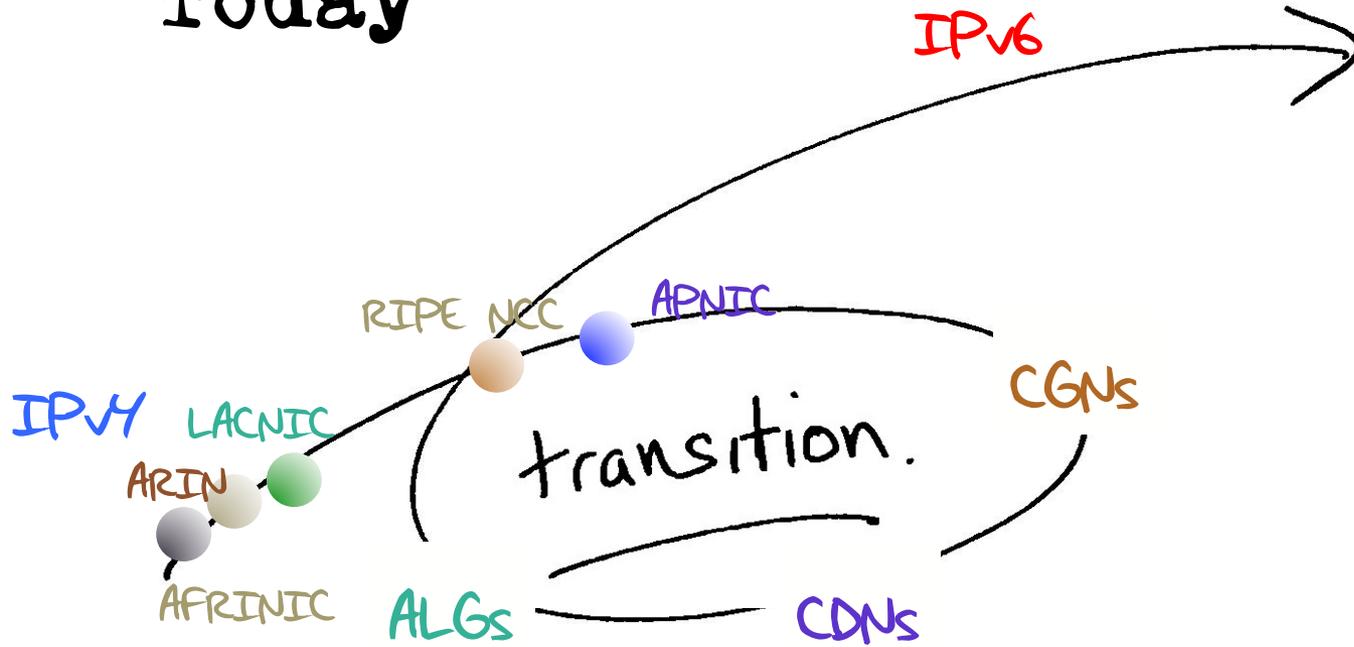
There is no plan, just the interplay of various market pressures

2. Varying IPv4 Address Exhaustion Timelines

There is a credibility problem: This industry has a hard time believing reality over its own mythology

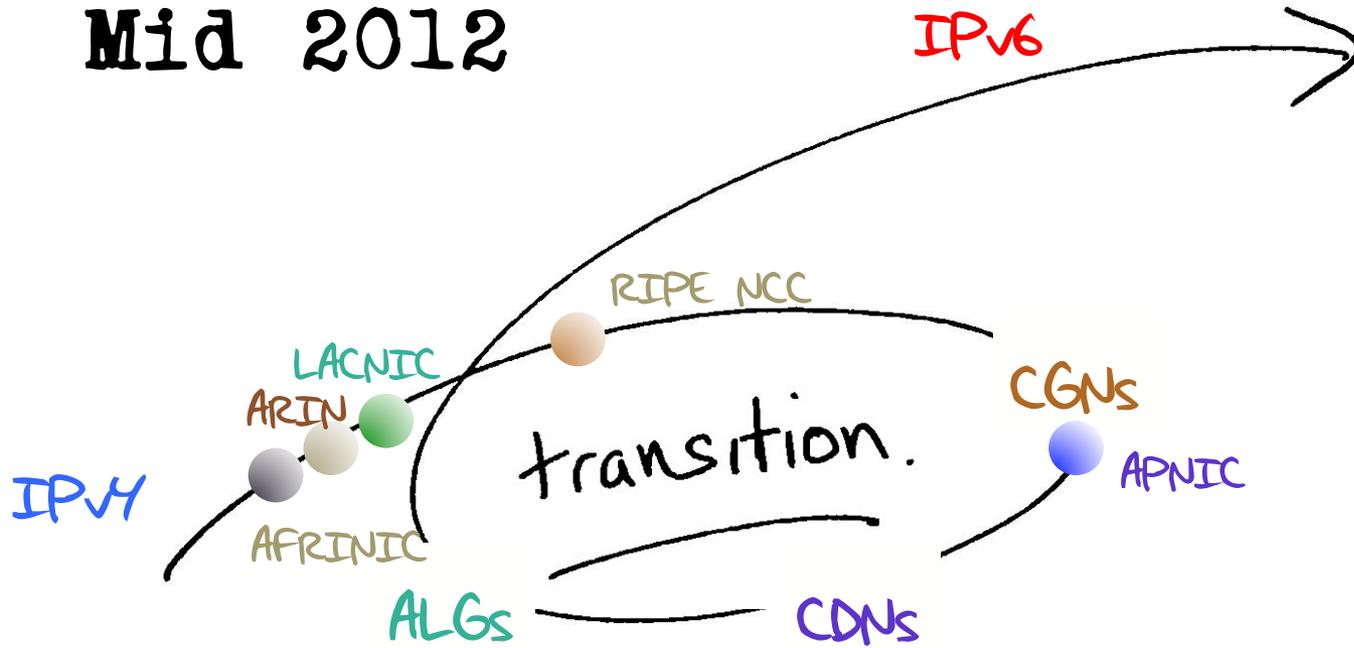
3. Regional Diversity

Today



Mid 2012

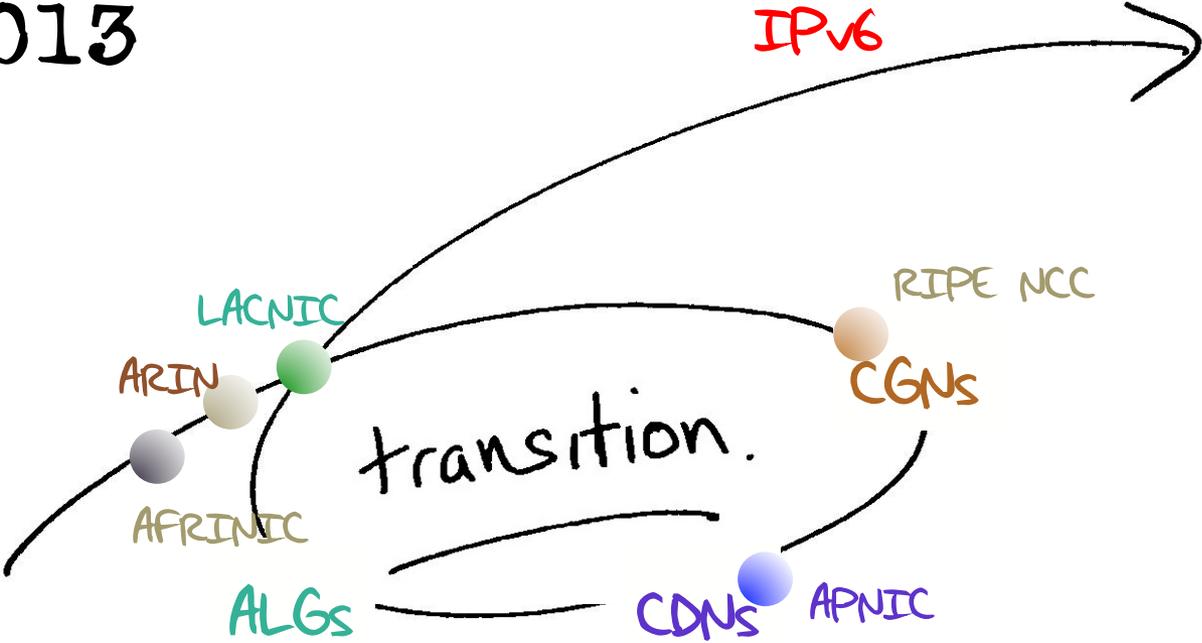
IPv6



2013

IPv6

IPv4



ARIN

LACNIC

AFRINIC

ALGs

RIPE NCC

CGNs

transition.

CDNs

APNIC

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

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

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

# The Myth of the Long Term Plan

"Transition will take many years...

5 years, maybe 10 years, maybe longer"

# The Myth of the Long Term Plan

"Transition will take many years...

5 years, maybe 10 years, maybe longer"

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

# The Myth of the Long Term Plan

“Transition will take many years...

5 years, maybe 10 years, maybe longer”

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

How about our 10 year old plans?

# The Myth of the Long Term Plan

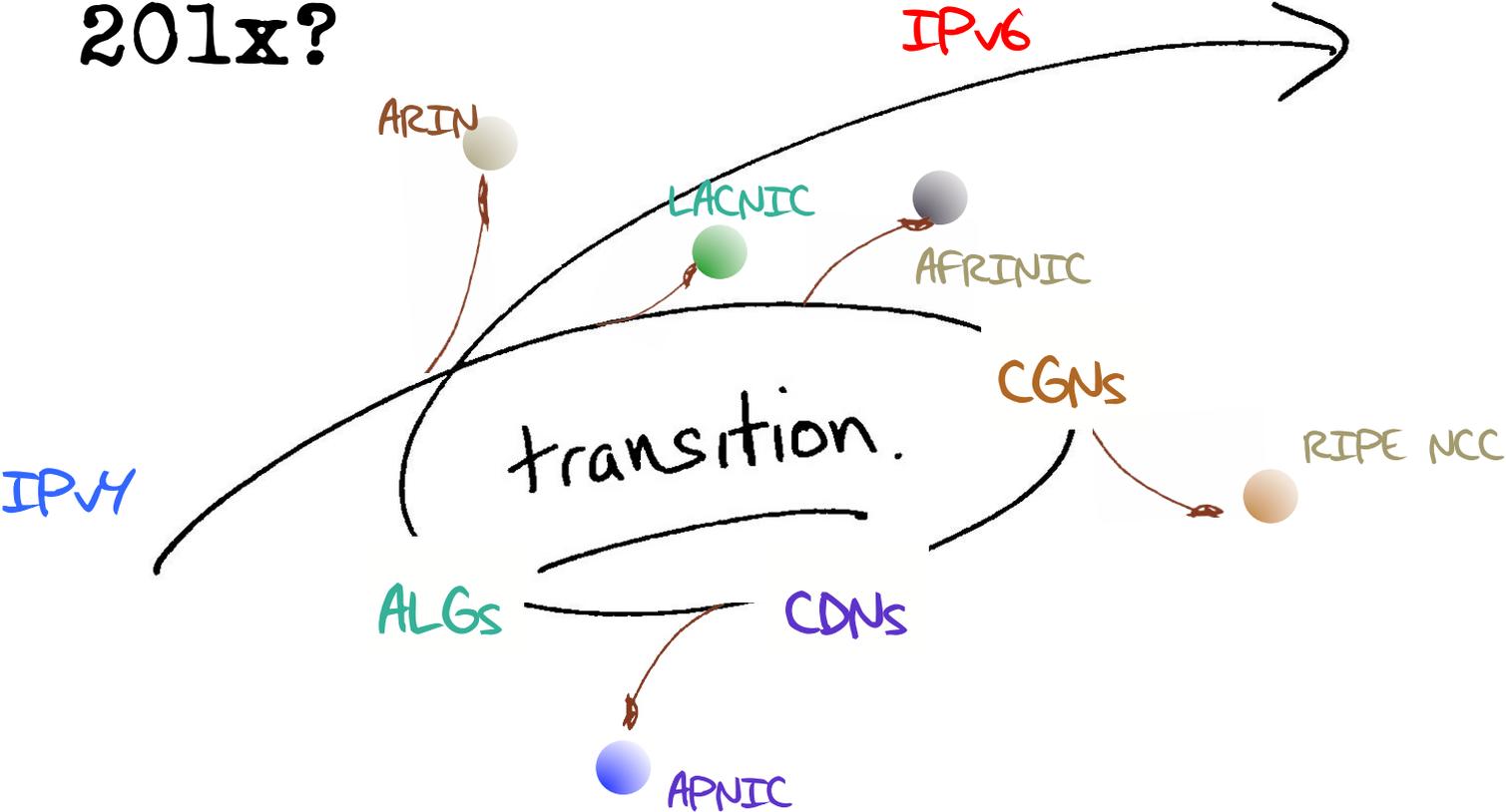
“Transition will take many years...

5 years, maybe 10 years, maybe longer”

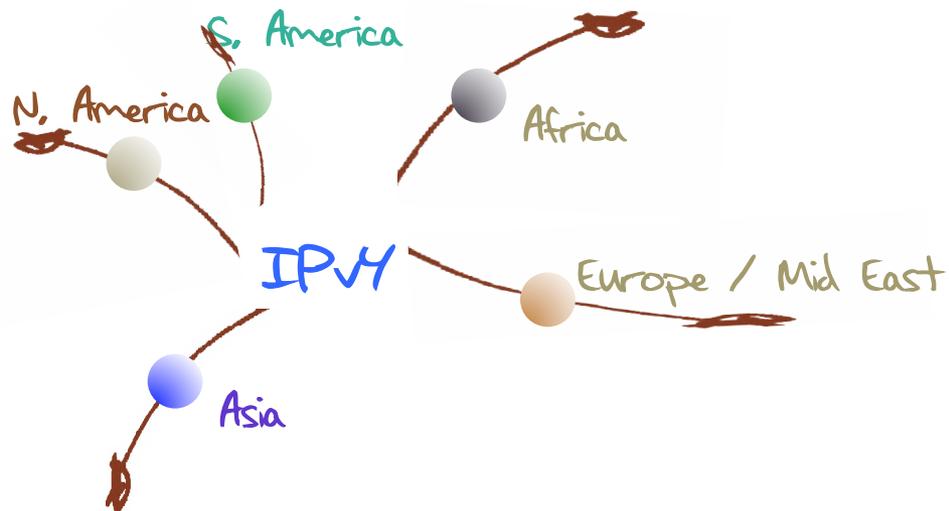
Are we still committed to the plans we had 5 years ago? How about our 10 year old plans?

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

There is a credibility problem: This industry has a hard time believing reality over its own mythology

3. Regional Diversity

One network is not an assured outcome!

# 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

There is a credibility problem: This industry has a hard time believing reality over its own mythology

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 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 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!