IPv4 Address Exhaustion:
A Progress Report

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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 — it’s 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 – it’s 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
Well what did you expect? They are VIRTUAL circuits, so a picture was always going to be a challenge!
The "inevitability" of technological evolution

wires → virtual circuits → packets
The "inevitability" of technological evolution

Now let's look at something a little more topical to today!
The "inevitability" of technological evolution?
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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.

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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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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?

But will this be merely a temporary phase of transition?
The challenge often lies in managing the transition from one technology to another.

IPv4

IPv6

CGNs

ALGs

CDNs

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

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

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
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!
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
IPv4 Address Exhaustion - APNIC
Remaining IPv4 Address Pools—All RIRs
Address Exhaustion Projections
## Exhaustion Predictions

<table>
<thead>
<tr>
<th>RIR</th>
<th>Predicted Exhaustion Date *</th>
<th>Remaining Address Pool (2 Oct 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APNIC</td>
<td>19 April 2011 (actual)</td>
<td>1.20 /8s (0.3 /8s rsvd)</td>
</tr>
<tr>
<td>RIPE NCC</td>
<td>9 June 2012</td>
<td>3.91 /8s</td>
</tr>
<tr>
<td>LACNIC</td>
<td>1 March 2014</td>
<td>4.27 /8s</td>
</tr>
<tr>
<td>AFRINIC</td>
<td>28 May 2014</td>
<td>4.38 /8s</td>
</tr>
<tr>
<td>ARIN</td>
<td>9 Oct 2014</td>
<td>5.91 /8s</td>
</tr>
</tbody>
</table>

* Here “exhaustion” is defined as the point when the RIR’s remaining pool falls to 1 /8
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 it's happening to me!
Challenges:

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   There is a credibility problem!
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2. Varying IPv4 Address Exhaustion Timelines
   There is a credibility problem: This industry has a hard time believing reality over its own mythology
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3. Regional Diversity
Today

IPv4
IPv6
CGNs
ALGs
CDNs
APNIC
RIPE NCC
LACNIC
ARIN
AFRINIC

transition.
IPv4
IPv6
transition.

IPv4 connections:
- LACNIC
- ARIN
- AFRINIC
- ALGs
- CDNs

IPv6 connections:
- RIPE NCC
- CGNs
- APNIC

Mid 2012
2013 transition.
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?
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Will we continue to maintain coherency of a single Internet through this transition?

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The Myth of the Long Term Plan
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5 years, maybe 10 years, maybe longer”
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How about our 10 year old plans?
The Myth of the Long Term Plan

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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?

IPv4

IPv6

transition.

ARIN

LACNIC

AFRINIC

CGNs

RIPE NCC

APNIC

ALGs

CDNs
20xx?

IPv4

IPv6

Asia

Europe / Mid East

Africa

N. America

S. America
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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 IPv6 is 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

Scarcity generates pain and uncertainty

Hoarding exacerbates scarcity in both its intensity and duration

Extended scarcity prolongs the pain and increases the unpredictability of the entire transition process
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!
Of course, there is another perspective on this transition to IPv6...
IPv4 as a Strategy

or how address shortage will provide control over services again

MEAT & GREED

Because Meat and Malbec is simply not enough
Services generate value

• Users do not care about the network, they care about services
  • voice, games, music, movies, and other entertainment
  • self-ordering fridges, automotive intelligence, and other device2device or device2human interaction
Prior to the Internet

- Telecom operators provided the services and controlled the value chain and its revenue
- high stability, high margins, stockholder value
- successful innovations: telephony, fax, minitel, 800 and 900 number based services
Internet is a virus?! 

- Internet caught us by surprise:
  - Customers connected to Internet Service Providers via modems over telephony infrastructure
  - Applications where offered without our permission
  - Turned the intelligent telephony network into a dumb transport service
Connectivity vs. Service

• Providing television, internet and voice over the same infrastructure provides some value added revenue

• But content is provided more and more by Internet Services

  • Telephony moves to voip (Skype)

  • Television moves to YouTube
Why did this work?

• The open end-to-end model:
  • Network Layer and Application Layer evolved independently
  • Connected devices could interact without changes to the network
Breaking Openness

• Internet depended on the endless supply of free IP addresses

• Resources are not free:
  • People did not pay for additional addresses
  • rational economic behavior forces intelligence towards the core

• Imagine what we could have done when we had monetized on NATs from the start
Why is IPv4 Shortage Good For Us?

• Allows us to introduce an additional control point through which we can gain control over the services

• End user hosts will not be able to connect to the Internet directly

• Technology called Carrier Grade NAT (CGN)
Properties of Carrier NAT Architecture

• Turns one limited resource (addresses) into another (ports)

• We can relate the number of ports a customer has available to services

• Results in the possibility of tiered services and variable billing
Experience limited because of global resource limits

Partner Service Platform

CGN

Internet Platform

unencumbered view
In addition

- Some services are extremely difficult to operate over NAT. e.g.:
  - Voice over IP (SKYPE)
  - Bit Torrent
  - Running services
The result

- Incentive for Application Service Providers to partner with us
- Guaranteed Quality of Service
- Revenue sharing to keep CGN and network up to par with their needs
Risks

- Potential Regulatory Pressure
  - IPv4 for new entrants
  - Net Neutrality
  - IPv6 ‘as public good’
IPv4 and new entrants

- IPv4 is a scarce resource: 2012 no IPv4 available from the RIRs
  - Market Entrance is a regulatory concern
- We will return IPv4 addresses
  - Goodwill with regulators
- We’ll be moving to CGNs anyway
Net Neutrality

• The CGN based architecture cannot be neutral any longer because the address-scarcity cannot be fixed by investments or market competition

• External services move inside our network

• or only have limited ports: bad user experience
IPv6 trials

• Offering IPv6 leads to failure:
  • No application and CPE support
  • Worse user experience: customers will allow us to stay conservative and slowly move to CNGs

• Expensive to participate in

• But a demonstration of good will
Conclusion

- IPv4 based CGNs to cope with address exhaustion as a positive long term incentive
- CGNs will allow us to generate revenue from services again
Thank You!

Because Meat and Malbec is simply not enough

Consultants
Because Meat and Malbec is simply not enough