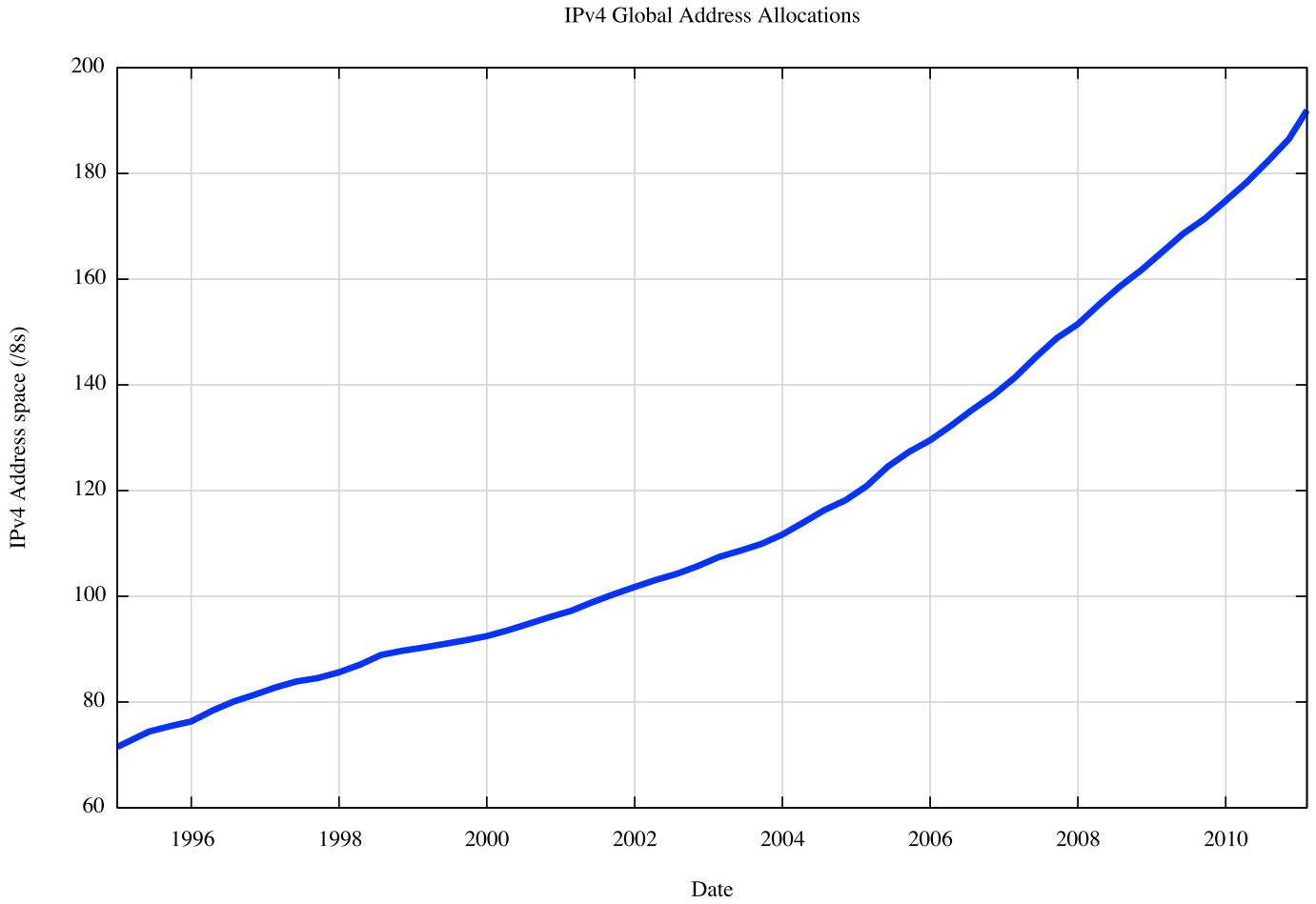
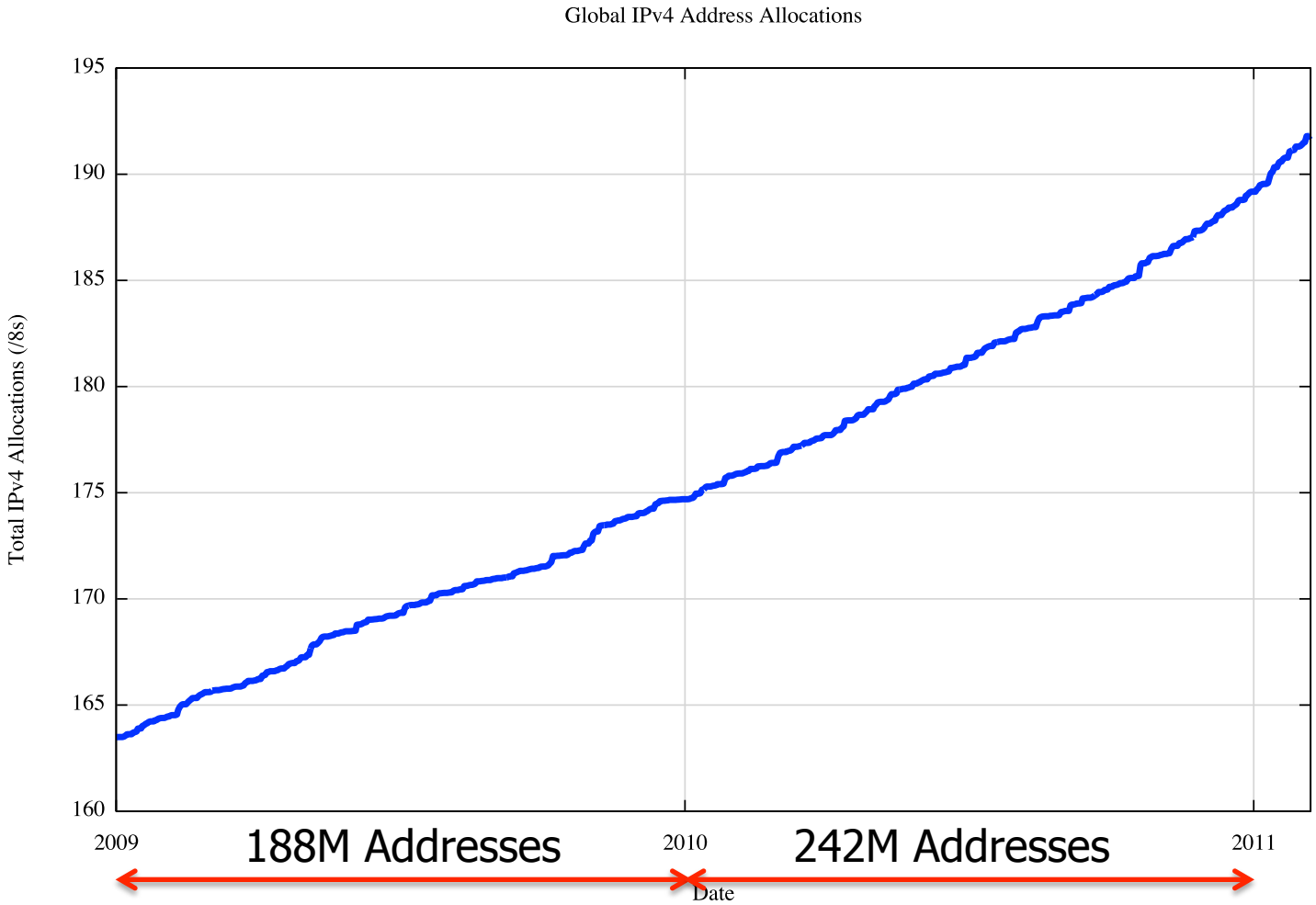

Religion,
Politics and the End of the World
IPVH

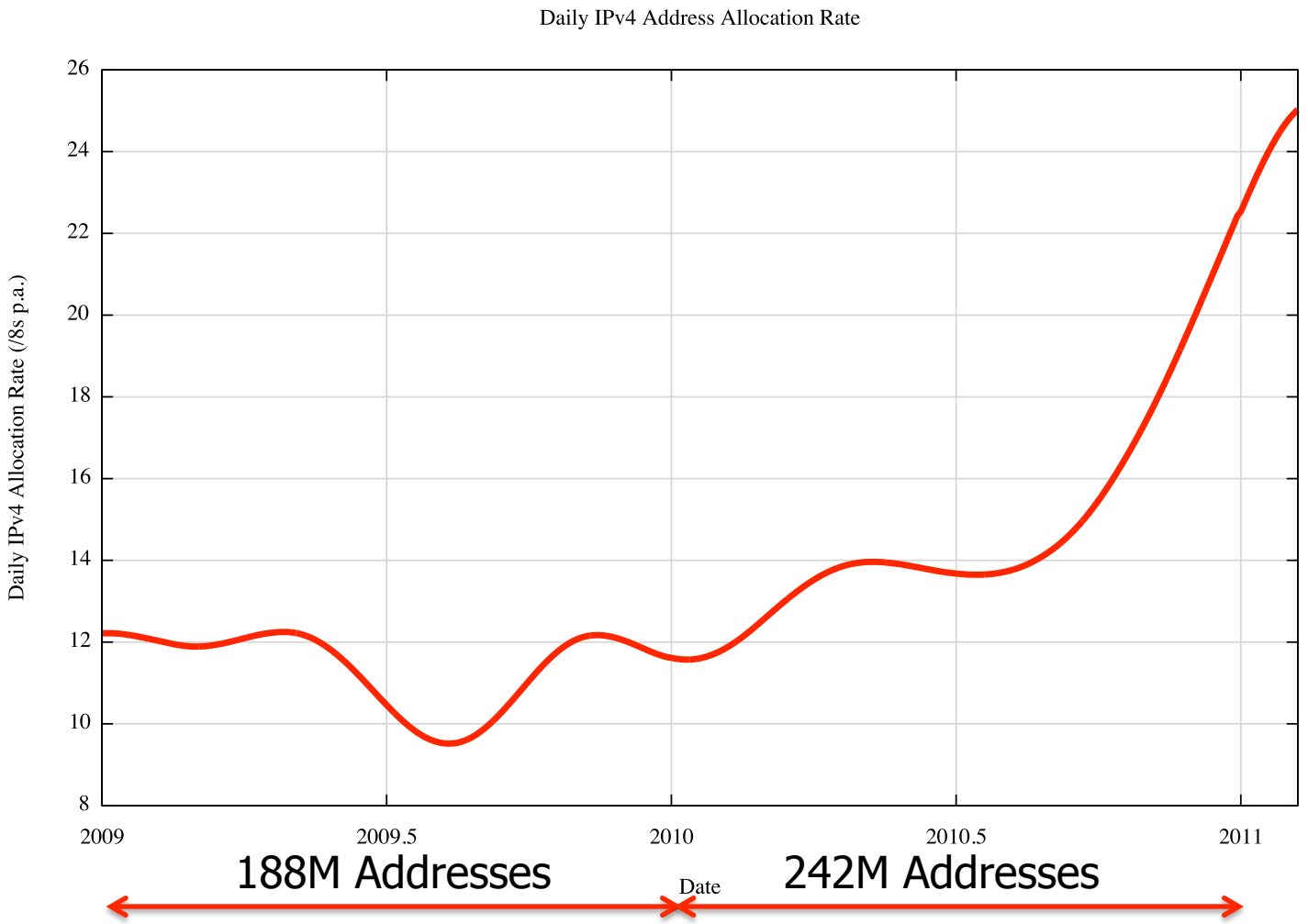
Growth


IPv4 Global Address Allocations
IPv4 Address space (/8s)
200
180
160
140
120
100
80
60
1996
1998
2000
2002
2004
2006
2008
2010
Date

Inexorable Growth



Inexorable Accelerating Growth

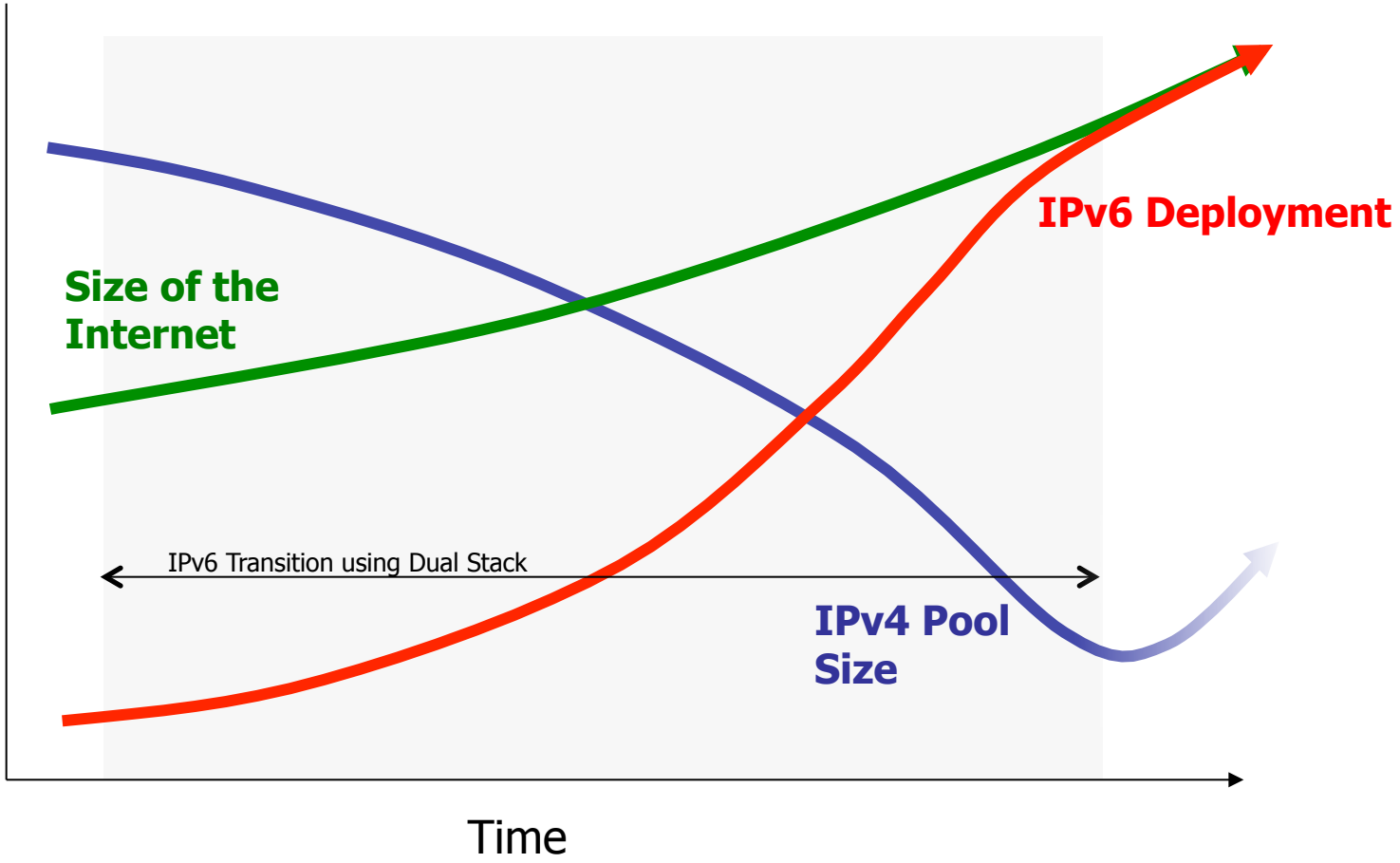


One Year Ago Today

20 April 2011

APNIC was the first of the RIRs to exhaust its IPv4 general use address pool.

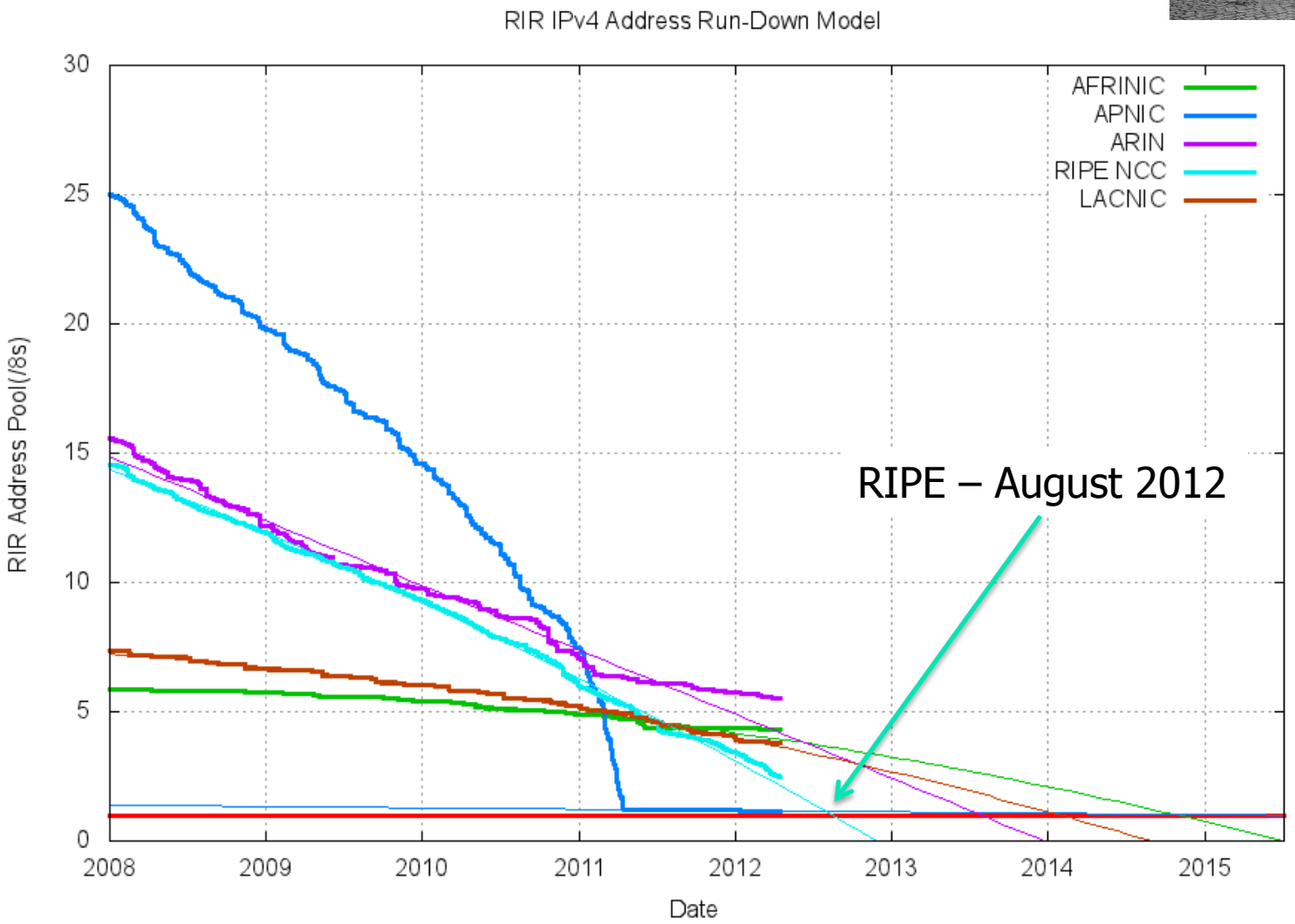
We had a plan …


IPv6 Deployment
Size of the Internet
IPv6 Transition using Dual Stack
IPv4 Pool Size
Time

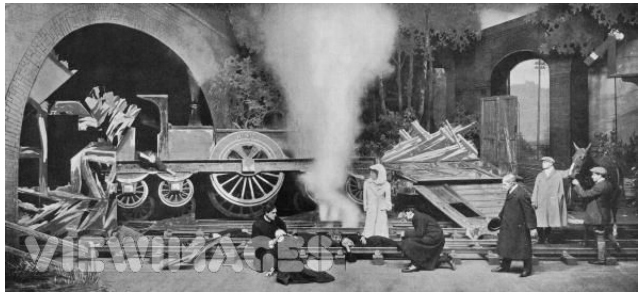
The Theory

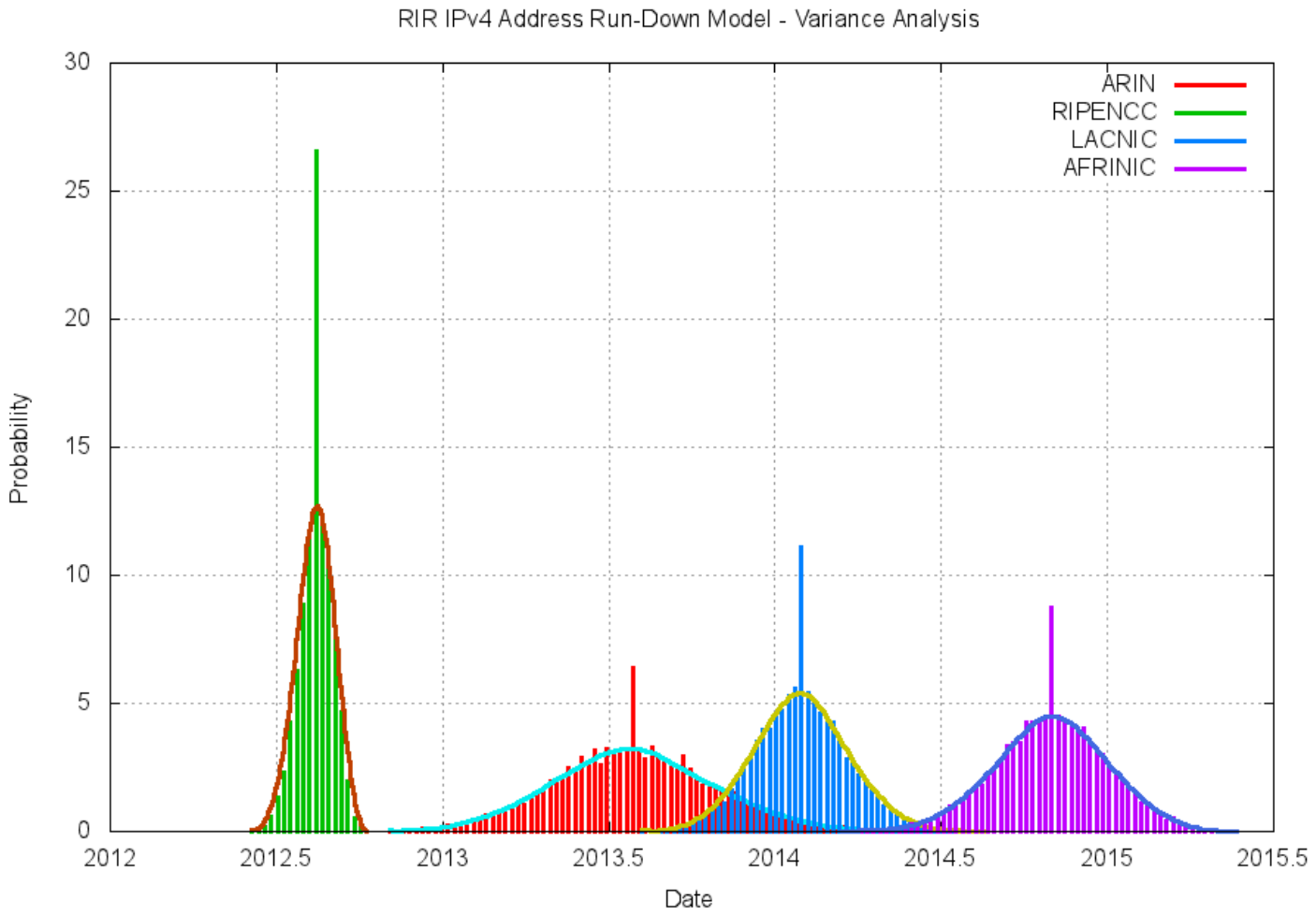
- The idea was that we would never "run out" of IPv4 addresses
- Industry would see the impending depletion and gradually and seamlessly fold IPv6 into their products and services
- We would be an all-IPv6 Internet before we ever had to use the last IPv4 address
- And no customer would see any change during the entire process

Modelling IPv4 Exhaustion



Variance Analysis





What then?

- Some possible scenarios to sustain a growth rate of 300M new network clients services every year:
  - Persist in IPv4 networks using more NATs
  - Address markets for redistributing IPv4
  - IPv6
  - Head off in a different direction entirely!

IPv4 NATs Today

- Today NATS are largely an externalized cost for ISPs
  - Customers buy and operate NATS
  - Applications are tuned to single-level NAT traversal
  - Static public addresses typically attract a tariff premium in the retail market
    - For retail customers, IP addresses already have a market price!

The "Just Add More NATs" Option

- Demand for increasing NAT "intensity"
  - Shift ISP infrastructure to private address realms
  - Multi-level NAT deployments both at the customer edge and within the ISP network
    - This poses issues in terms of application discovery and adaptation to NAT behaviours
- Market cost for public IPv4 addresses will increase to reflect realities of scarcity and higher exploitative value

NAT Futures

- NATs represent just more of the same
  - NATs are already extensively deployed today
- But maybe not…
  - More intense use of NATs will alter the network's current architectural model, as ports become the next scarce shared resource
  - Applications must change to reflect an ever smaller aperture through which the Internet can be seen and used
  - Increasing cost will be pushed back to consumers as price escalation

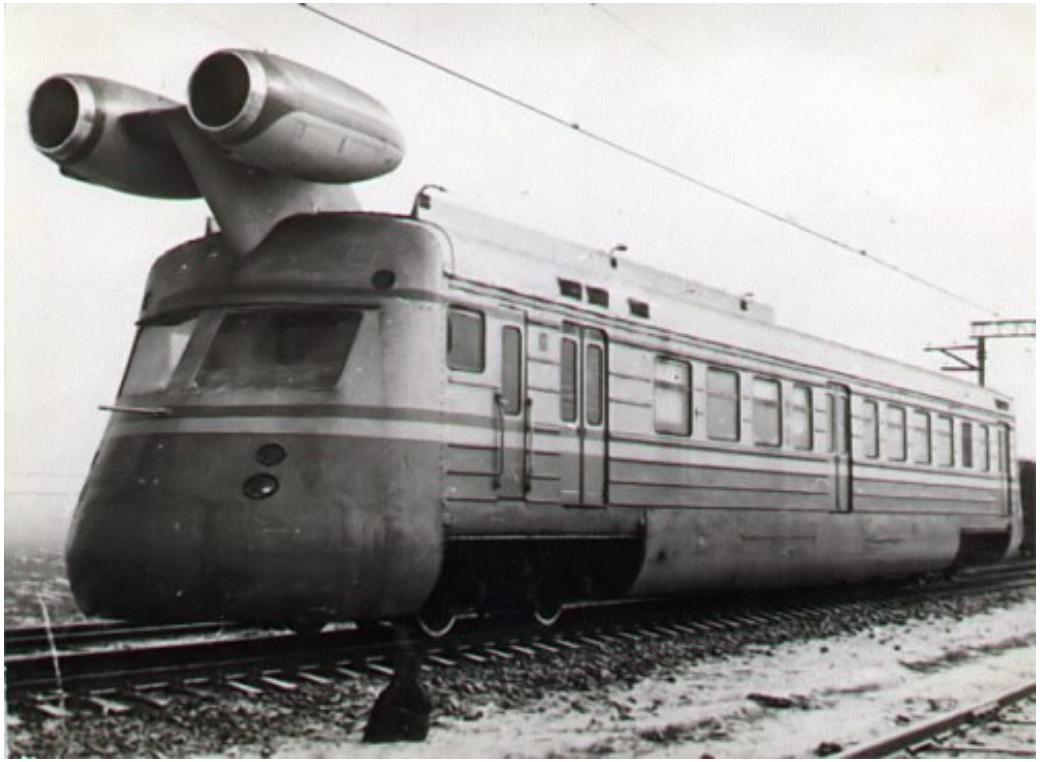
NAT Futures

- How far can NATs scale?
  - Not well known, but the unit cost increases with volume
  - What are the critical resources here?
    - NAT binding capacity and state maintenance
    - NAT packet throughput
    - Private address pool sizes
    - Application complexity
    - Public Address availability and cost

NAT Futures

- Do we need to go a few steps further with NATs?
  - NAT + DNS ALG to allow bi-directional NAT behaviours ?
  - Full shift to ALGs, with massive impact on the content industry ?
- In the escalating complexity curve, when does IPv6 get to look like a long term cheaper outcome?

The Other Option: IPv6



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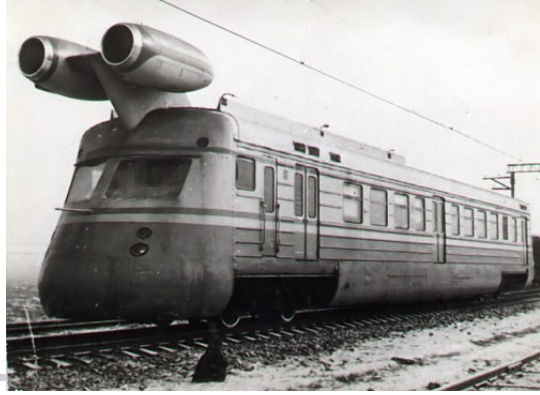
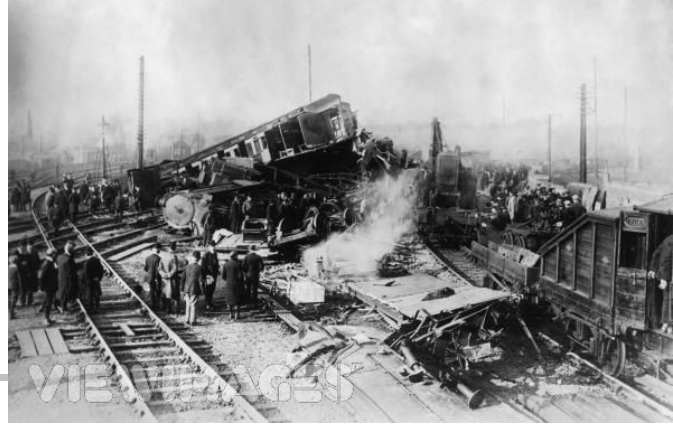
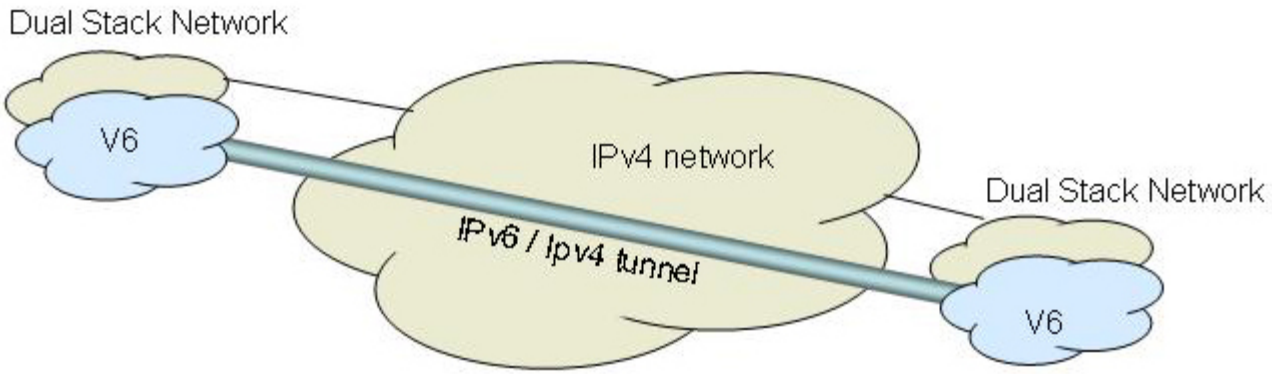


- Transition to IPv6
  - IPv6 is not backward compatible with IPv4 on the wire
  - So the plan is that we need to run some form of a “dual stack” transition process
    - Either dual stack in the host, or dual stack via protocol translating proxies

Dual Stack Transition to IPv6

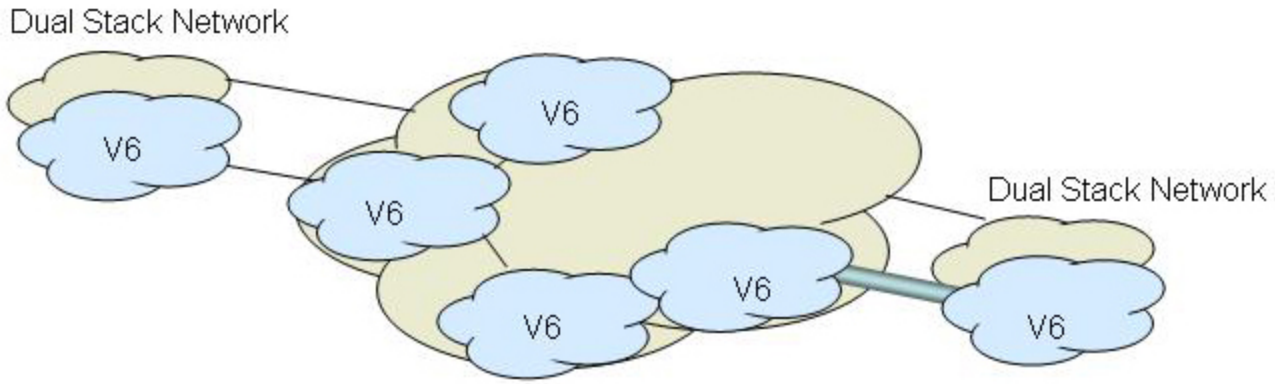




Theology– Phase 1

- "Initial" Dual Stack deployment:
  Dual stack networks with V6 / V4 connectivity
  Dual Stack hosts attempt V6 connection, and use V4 as a fallback

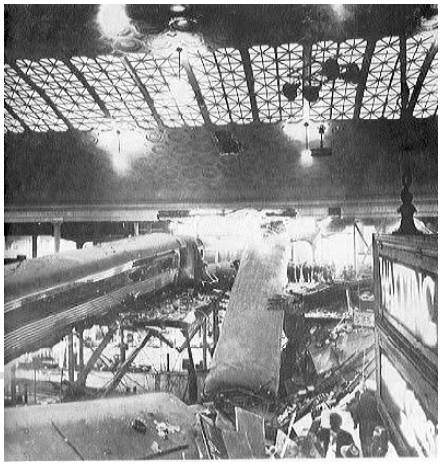
Dual Stack Transition to IPv6

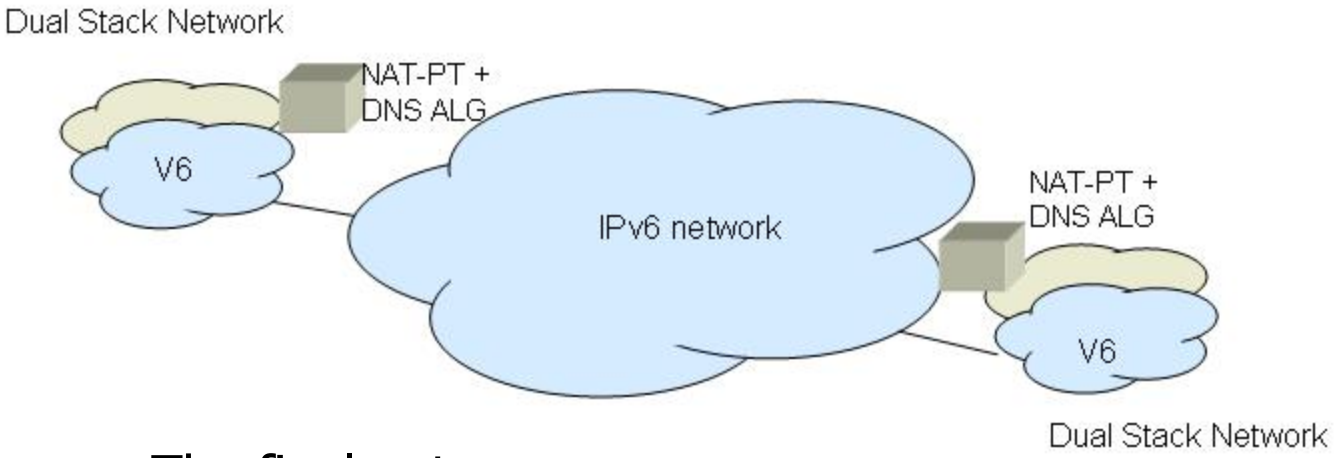


Theology – Phase 2

- “Intermediate”
  - Older V4 only networks are retro-fitted with dual stack V6 support

Dual Stack Transition to IPv6

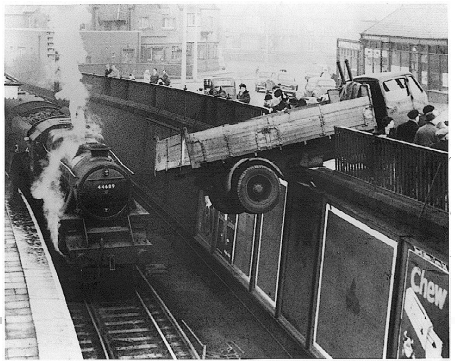




Theology - The final outcome

- "Completion"
  - V4 shutdown occurs in a number of networks
  - Connectivity with the residual V4 islands via DNS ALG + NAT-Protocol Translation
  - Outside the residual legacy deployments the network is single protocol V6

Dual Stack Assumptions

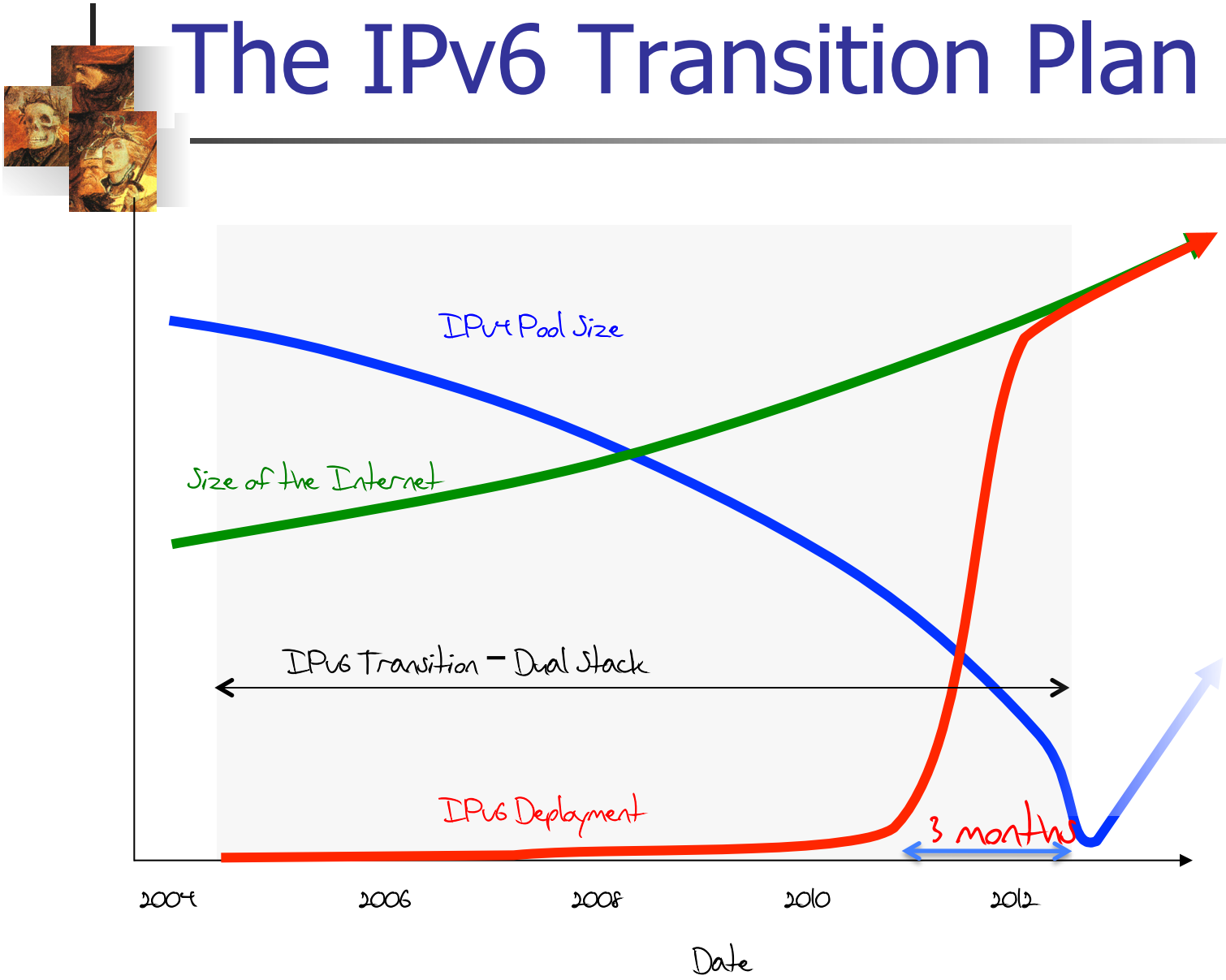


- That we could drive the entire transition to IPv6 while there were still ample IPv4 addresses to sustain the entire network and its growth
- Transition would take some (optimistically) small number of years to complete
- Transition would be driven by individual local decisions to deploy dual stack support
- The *entire* transition would complete *before* the IPv4 unallocated pool was exhausted

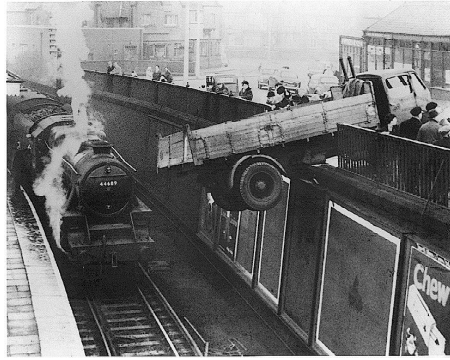
Oops!

We were meant to have completed the transition to IPv6 BEFORE we completely exhausted the supply channels of IPv4 addresses

The IPv6 Transition Plan - V2



Is this Plan Feasible?



Deploy IPv6 across some 1.7 billion users, with more than a billion end hosts.

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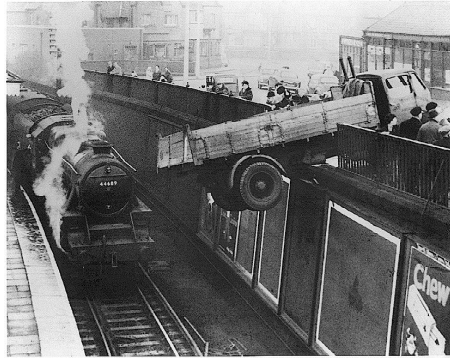

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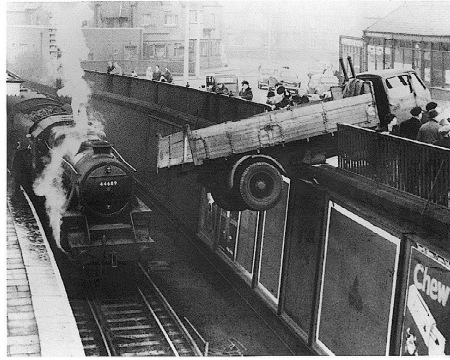

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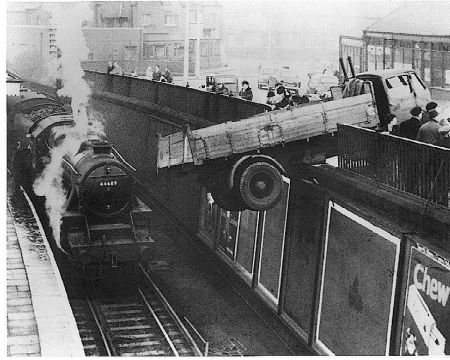

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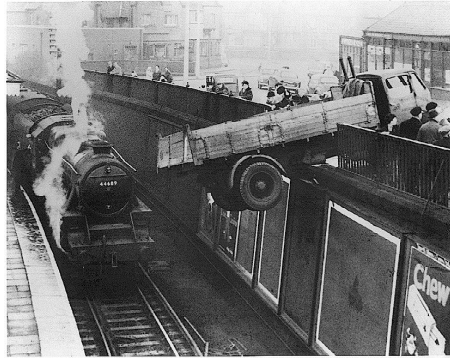
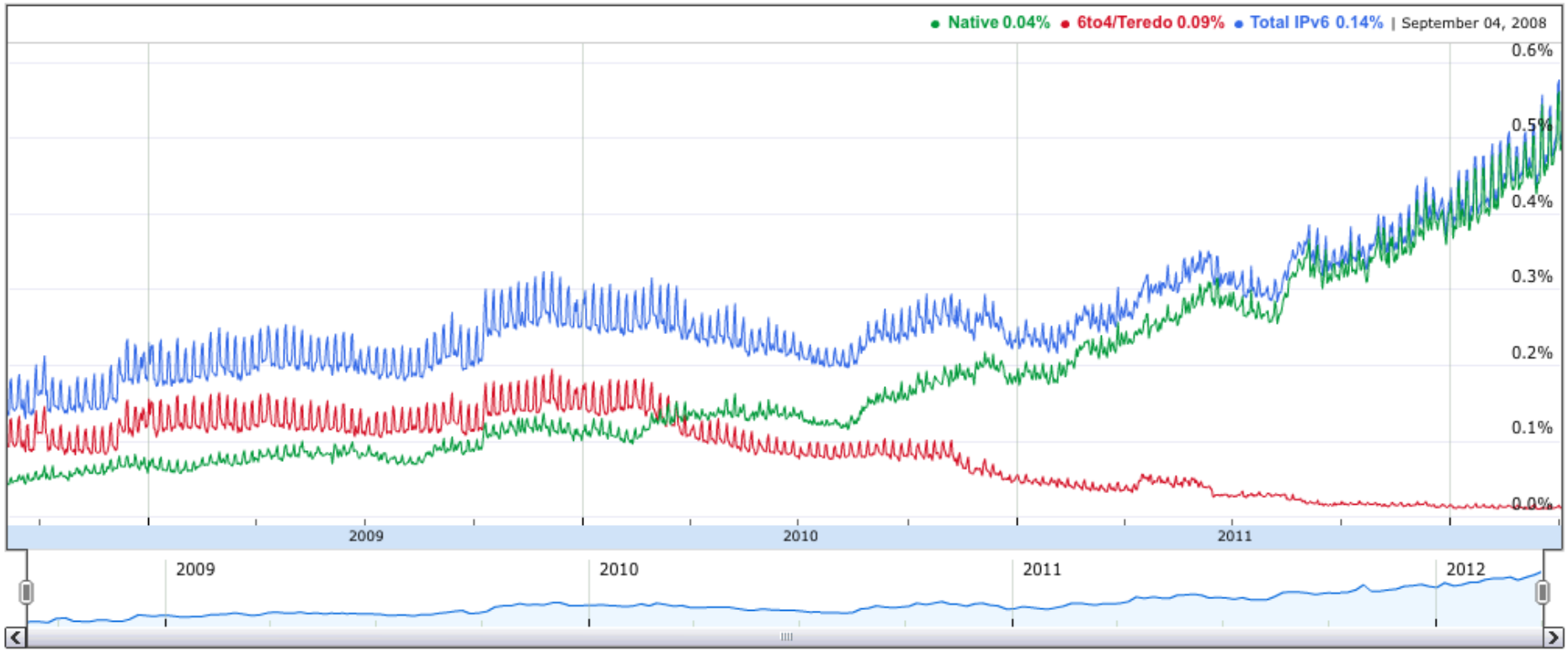


Deploy IPv6 across some 1.7 billion users, with more than a billion end hosts, and upgrade hundreds of millions of routers, firewalls and middleware units, and audit billions of lines of configuration codes and filters, and audit hundreds of millions of ancillary support systems -

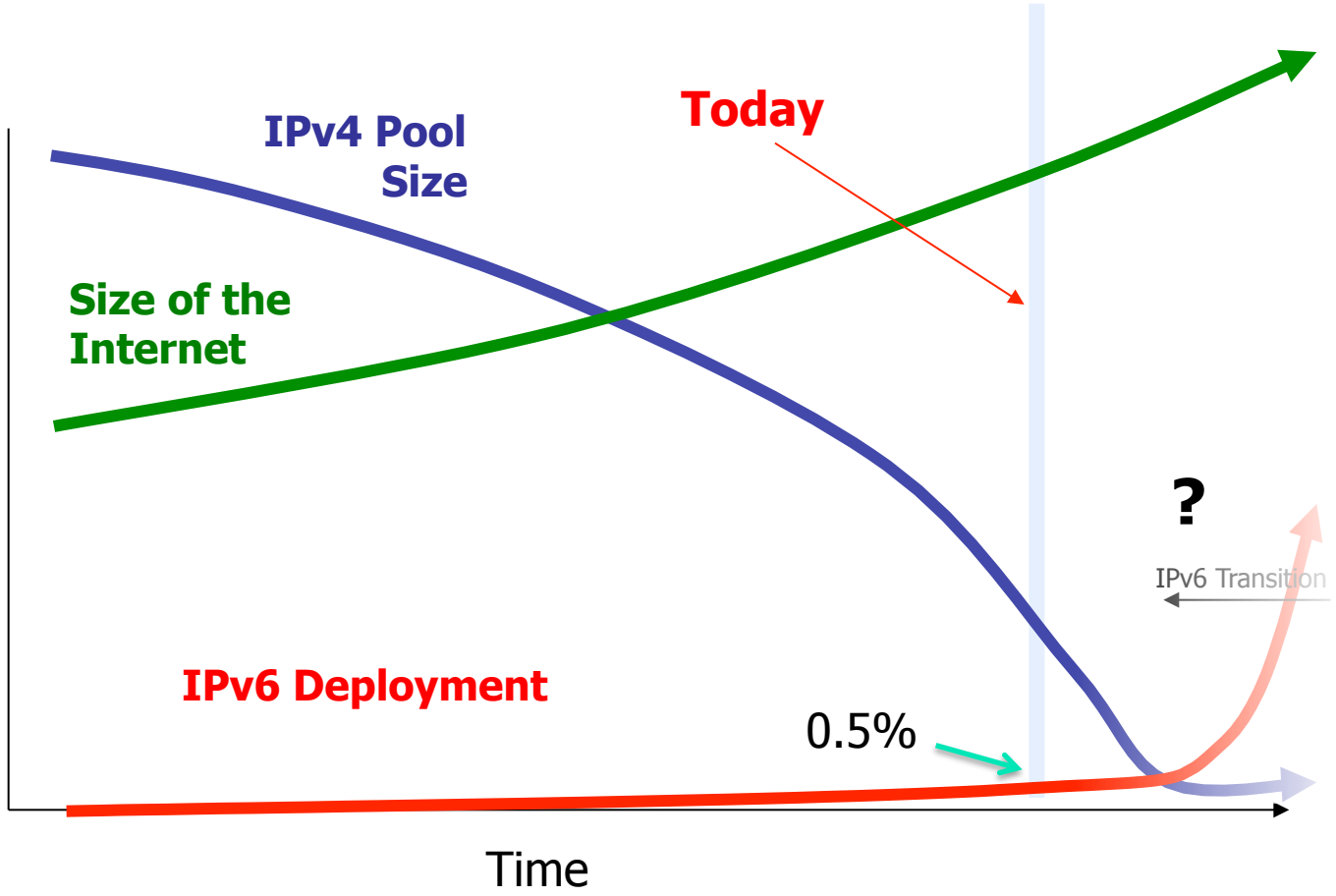
all within the next 100 days!

Where are we with IPv6 deployment?



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

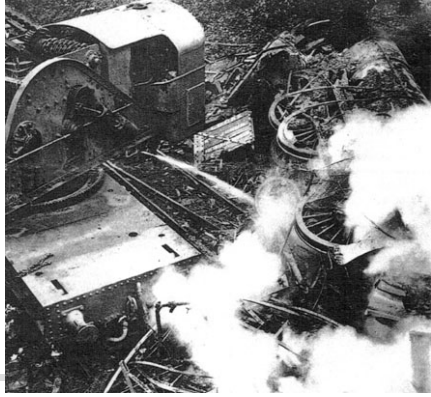
What's the revised plan?



Dual Stack

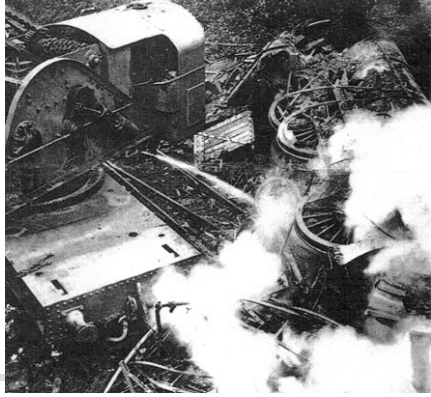
- Dual Stack transition is not a “or” proposition
  - Its not a case of IPv4 today, IPv6 tomorrow
- Dual Stack transition is an “and” proposition
  - It’s a case of IPv4 AND IPv6
  - Double the fun and triple the cost?
- But we don’t know for how long
  - So we need to stretch IPv4 out to encompass tomorrow’s Internet, and the day after, and …

Implications



- Whether its just IPv4 NATs OR transition to IPv6 …
  - IPv4 addresses will continue to be in demand far beyond the date of exhaustion of the unallocated pool
    - In the transition environment, all new and expanding network deployments will need IPv4 service access and addresses for as long as we are in this dual track transition

Implications

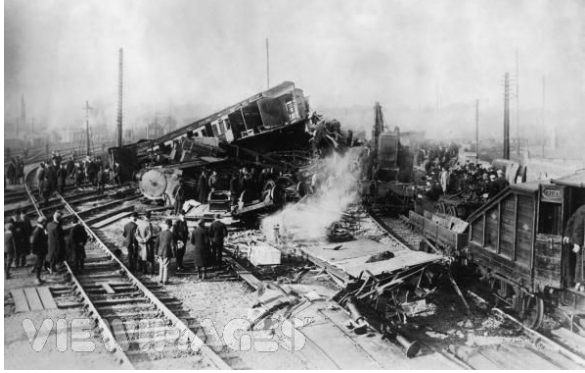


- Whether its just IPv4 NATs OR transition to IPv6 …
  - But the address distribution process is no longer directly controlled through today's address allocation policies
    - that IPv4 address pool in the sky is running out!
    - the mechanisms of management of the IPv4 address distribution and registration function will necessarily change

Making IPv4 Last Longer

- Its not the IPv4 address pool that's fully consumed
  - It's the unallocated address pool that's been consumed
  - 20% of the address space is not advertised in global routing
  - widespread use of NATs would yield improved address utilization efficiencies
- So we could "buy" some deviant Second Life for IPv4
  - But it won't be life as we've known it!
  - It will be predicated on the operation of a market in IPv4 addresses
  - And such a market in addresses will not necessarily be open, accessible, efficient, regulated or even uniformly visible
    - This prospect is more than a little worrisome

Making IPv4 Last Longer



- Some ideas I've observed so far:
  - Encourage NAT deployment
  - Larger Private Use Address Pool
  - Policies of rationing the remaining IPv4 space
  - Undertake efforts of IPv4 Reclamation
  - Deregulate Address Transfers
  - Regulate Address Transfers
  - Facilitate Address Markets
  - Resist Address Markets

Making IPv4 Last Longer


The Wreck of Maine Central Train No. 13, Oakland
(W.H. Bunting)

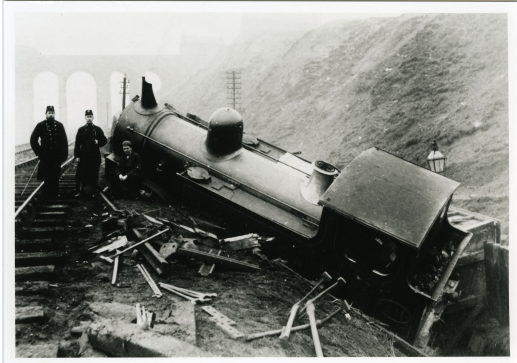
- For how long?
- For what cumulative address demand?
- For what level of fairness of access?
- At what cost?
- For whom?
- To what end?
- What if we actually achieve something different?
  - How would the Law of Unintended Consequences apply here?
  - Would this negate the entire “IPv6 is the solution” philosophy?

Who are "we" anyway?

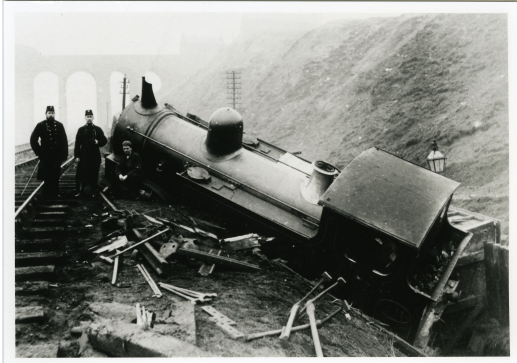
The Internet has often been portrayed as the "poster child" for deregulation in the telecommunications sector in the 1990's.

The rapid proliferation of new services, the creation of new markets, and the intense level of competition in every aspect of the Internet is seen as a successful outcome of this policy of deliberate disengagement by the regulator.

But is this still true today?

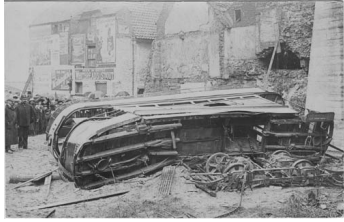


Do we still see intense competition in this industry? Is there still strong impetus for innovation and entrepreneurial enterprise? Will this propel the transition to IPv6?

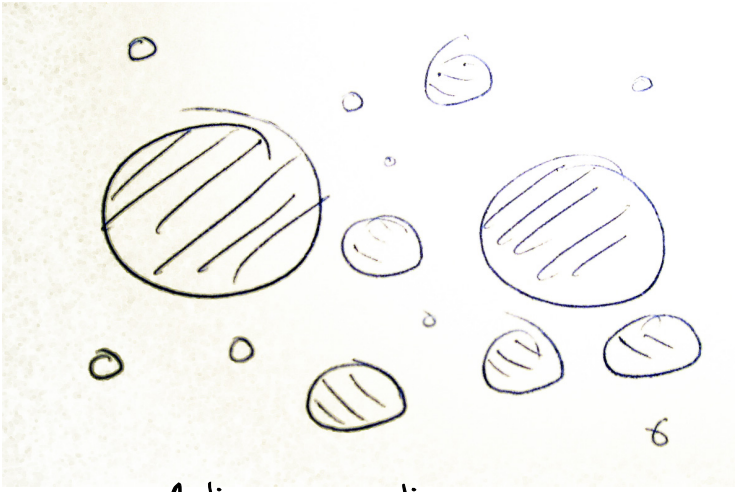


Do we still see intense competition in this industry? Is there still strong impetus for innovation and entrepreneurial enterprise? Will this propel the transition to IPv6?

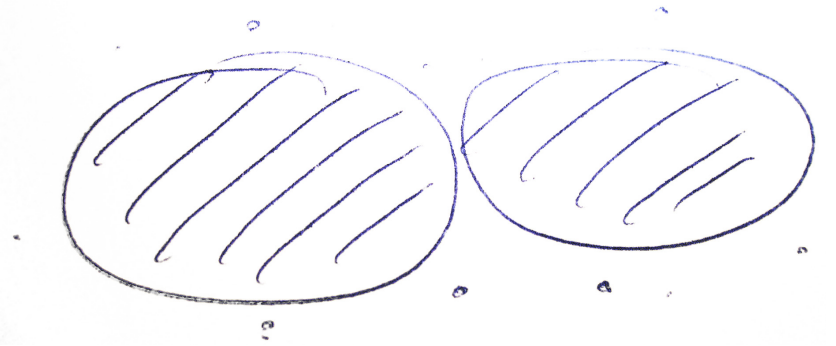
Or is this industry lapsing back into a mode of local monopolies, vertical bundling and strong resistance to further change and innovation?



How "Balanced" is this industry?



OR

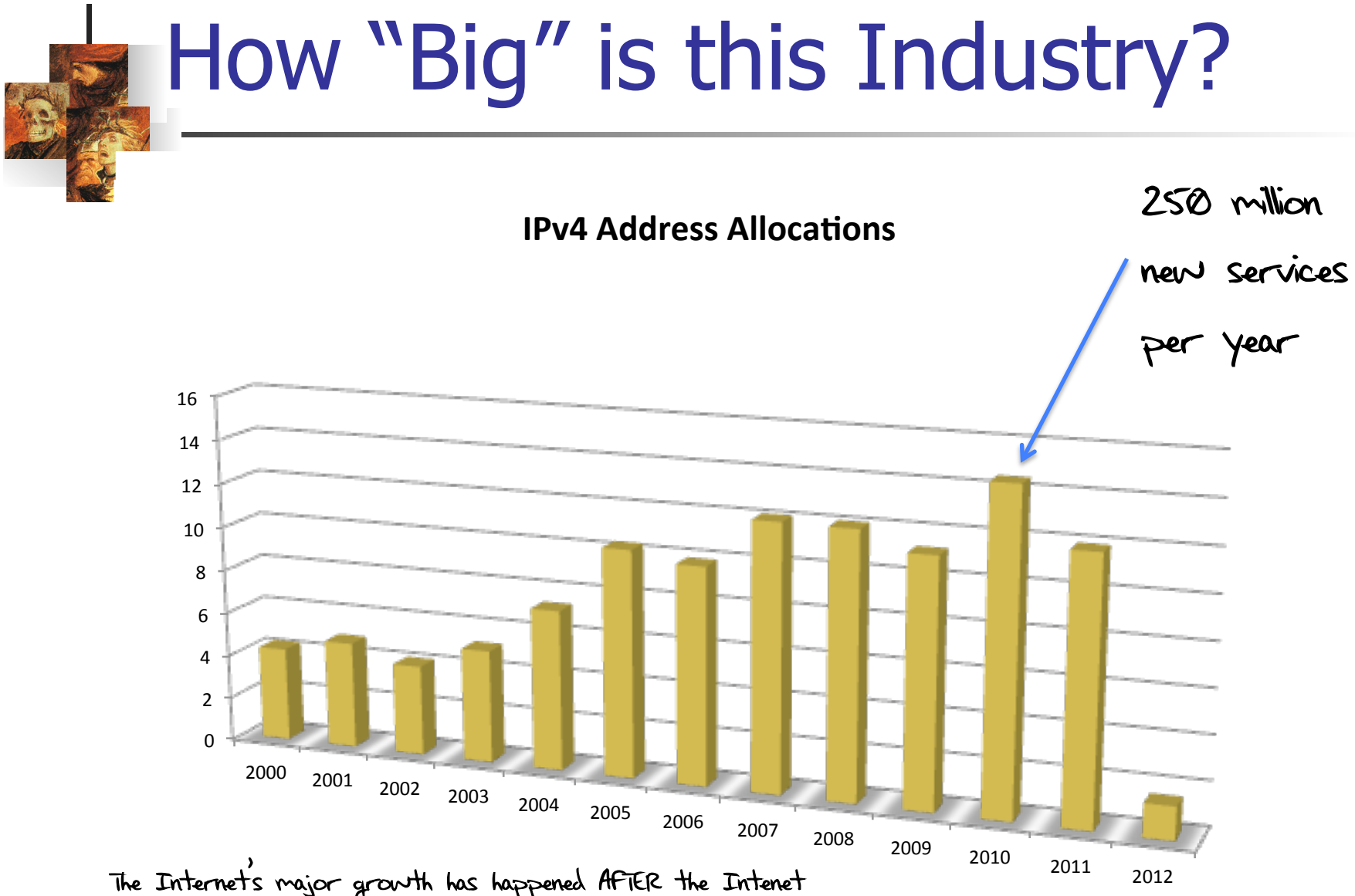


A diverse connection of large and small ISP enterprises

A small number of very large enterprises and some very small independent players left hanging on for the ride

What can IPv4 address allocation data tell us about this industry?

How "Big" is this Industry?



The Internet's major growth has happened AFTER the Intenet "boom" of 1999 to 2001

Who got all those addresses in 2011?

Rank	Economy	Organization	Addresses(M)	
1	Japan	NTT Communications Corporation	8.39	*
2	China	China Mobile Communications Corporation	8.39	*
3	Brazil	Comite Gestor da Internet no Brasil (Brasil NIR)	6.29	
4	Indonesia	PT Telekomunikasi Selular Indonesia	6.29	*
5	Japan	KDDI Corporation	4.19	
6	United States	AT&T Mobility LLC	4.19	*
7	United States	AT&T Internet Services	4.19	
8	France	Bouygues Telecom	4.19	*
9	Germany	Telekom Deutschland Mobile	2.1	*
10	China	CHINANET Zhejiang Province Network	2.1	
11	China	China TieTong Telecommunications Corporation	2.1	
12	Pakistan	Pakistan Telecommuication	2.1	*
13	China	China Unicom Shandong province network	2.1	
14	Morocco	Maroc Telecom	2.1	*
15	India	Bharti Airtel Limited	2.1	*
16	Vietnam	Viettel Corporation	2.1	
17	Mexico	Uninet S.A. de C.V., Mexico	2.1	
18	Egypt	TE Data, Egypt	2.1	
		Total	**67.11**	

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1	Japan	NTT Communications Corporation	8.39	*
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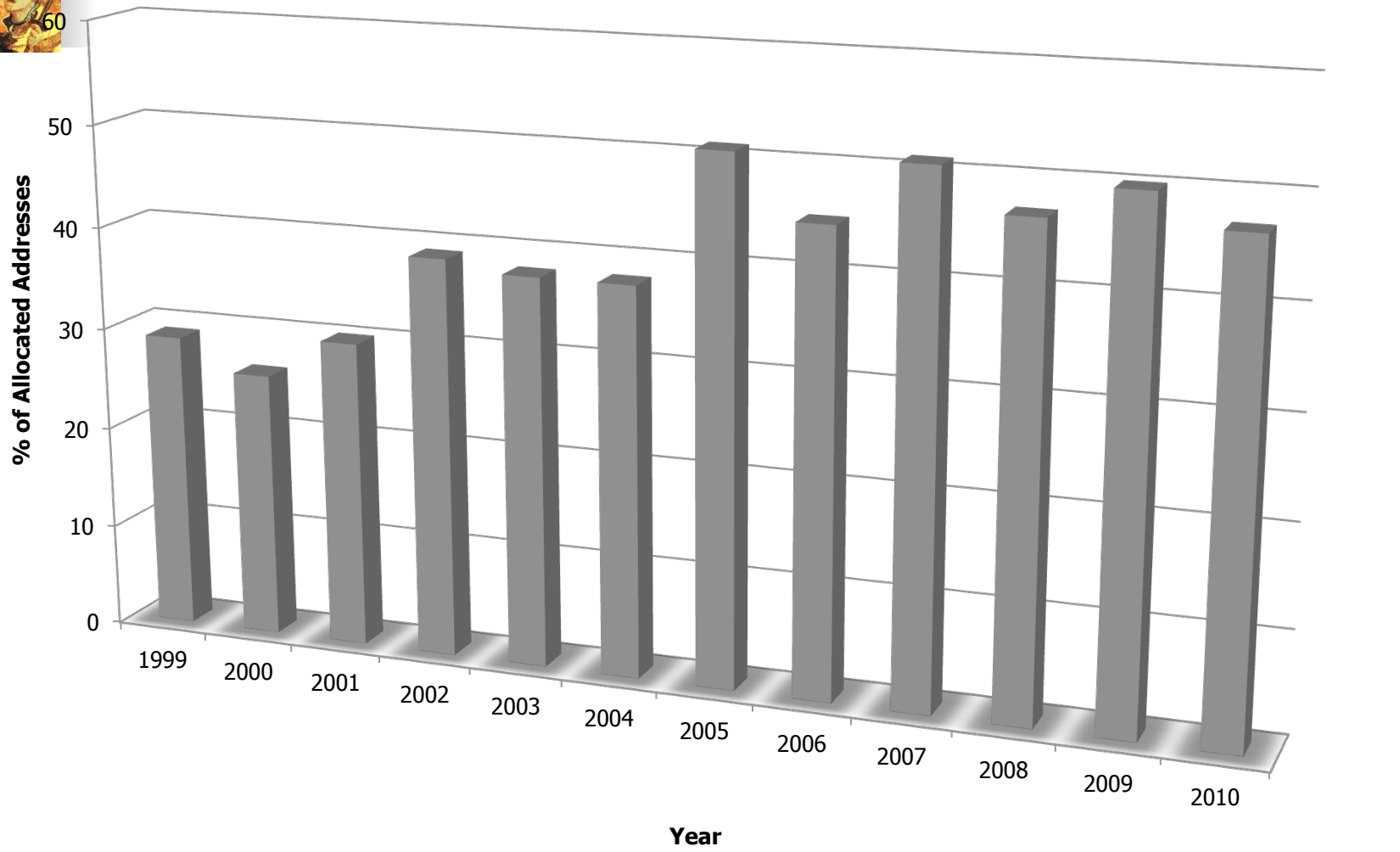
7	United States	AT&T Internet Services	4.19	
8	France	Bouygues Telecom	4.19	*
9	Germany	Telekom Deutschland Mobile	2.1	*
10	China	CHINANET Zhejiang Province Network	2.1	
11	China	China TieTong Telecommunications Corporation	2.1	
12	Pakistan	Pakistan Telecommuication	2.1	*
13	China	China Unicom Shandong province network	2.1	
14	Morocco	Maroc Telecom	2.1	*
15	India	Bharti Airtel Limited	2.1	*
16	Vietnam	Viettel Corporation	2.1	
17	Mexico	Uninet S.A. de C.V., Mexico	2.1	
18	Egypt	TE Data, Egypt	2.1	
		Total	**67.11**	

30% of all the IPv4 addresses allocated in 2011 went to just 18 ISP enterprises

How "Balanced" is this Industry?



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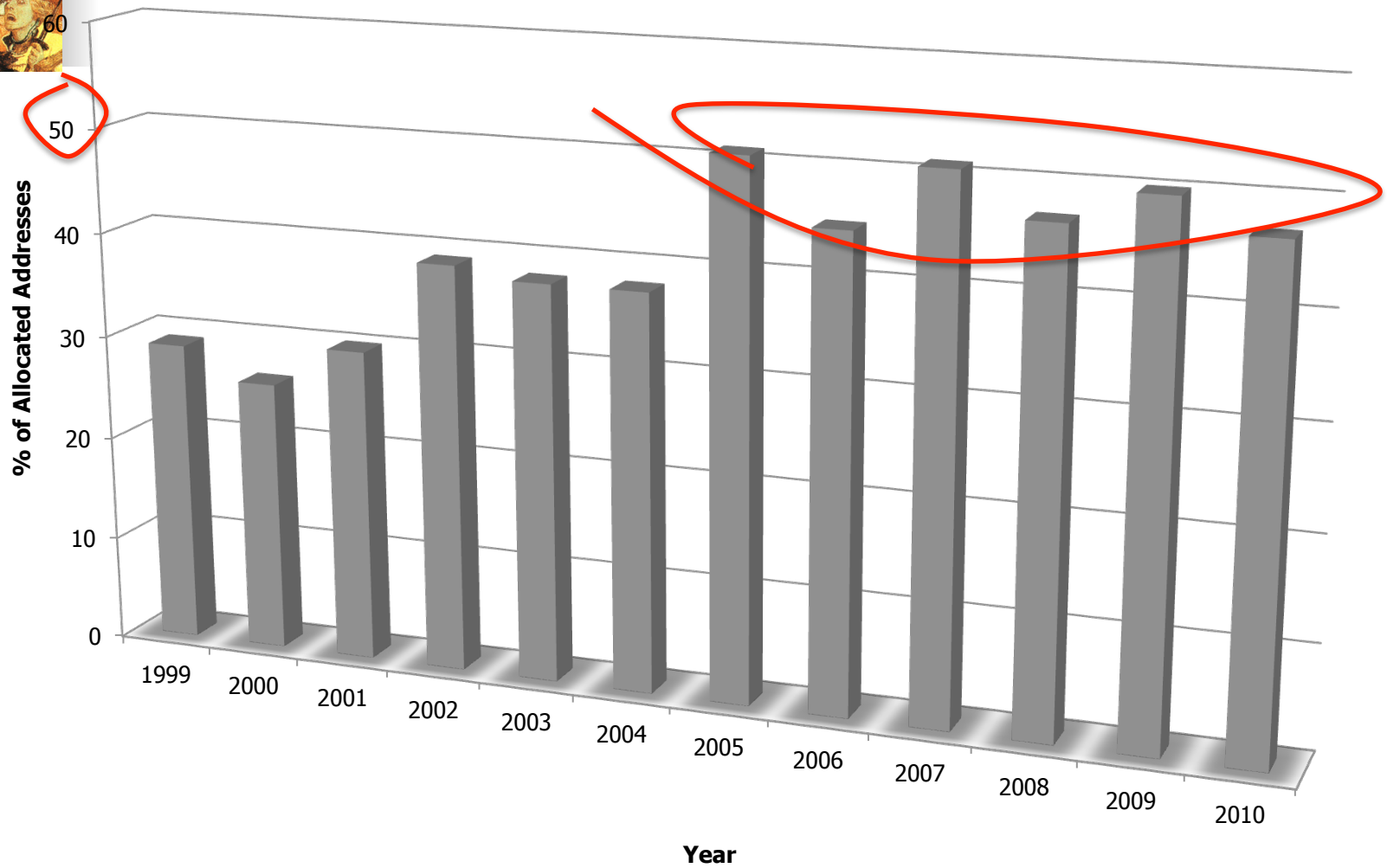
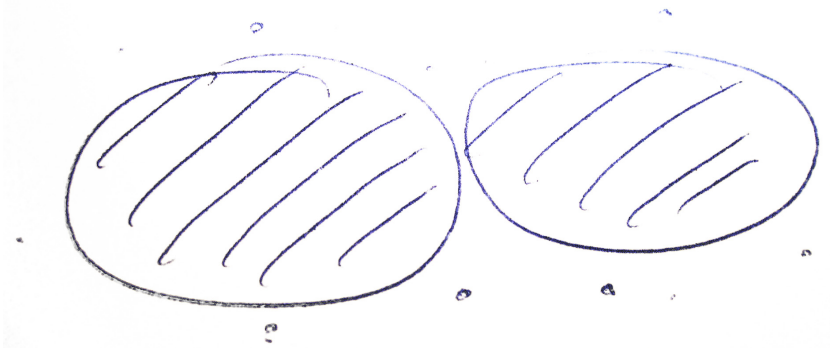


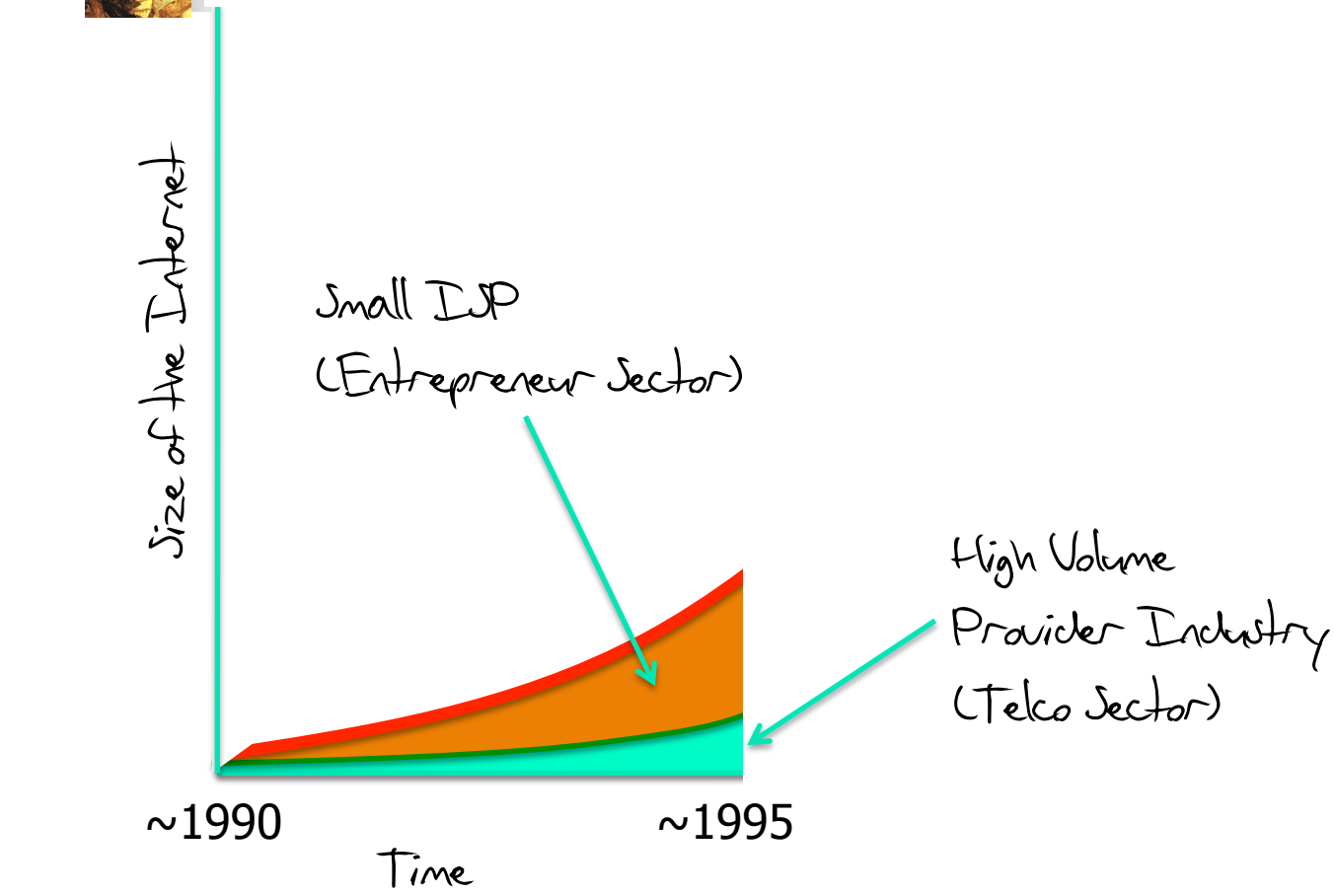
Massive consolidation in this industry appears to have been in place since 2005

How "Balanced" is this industry?

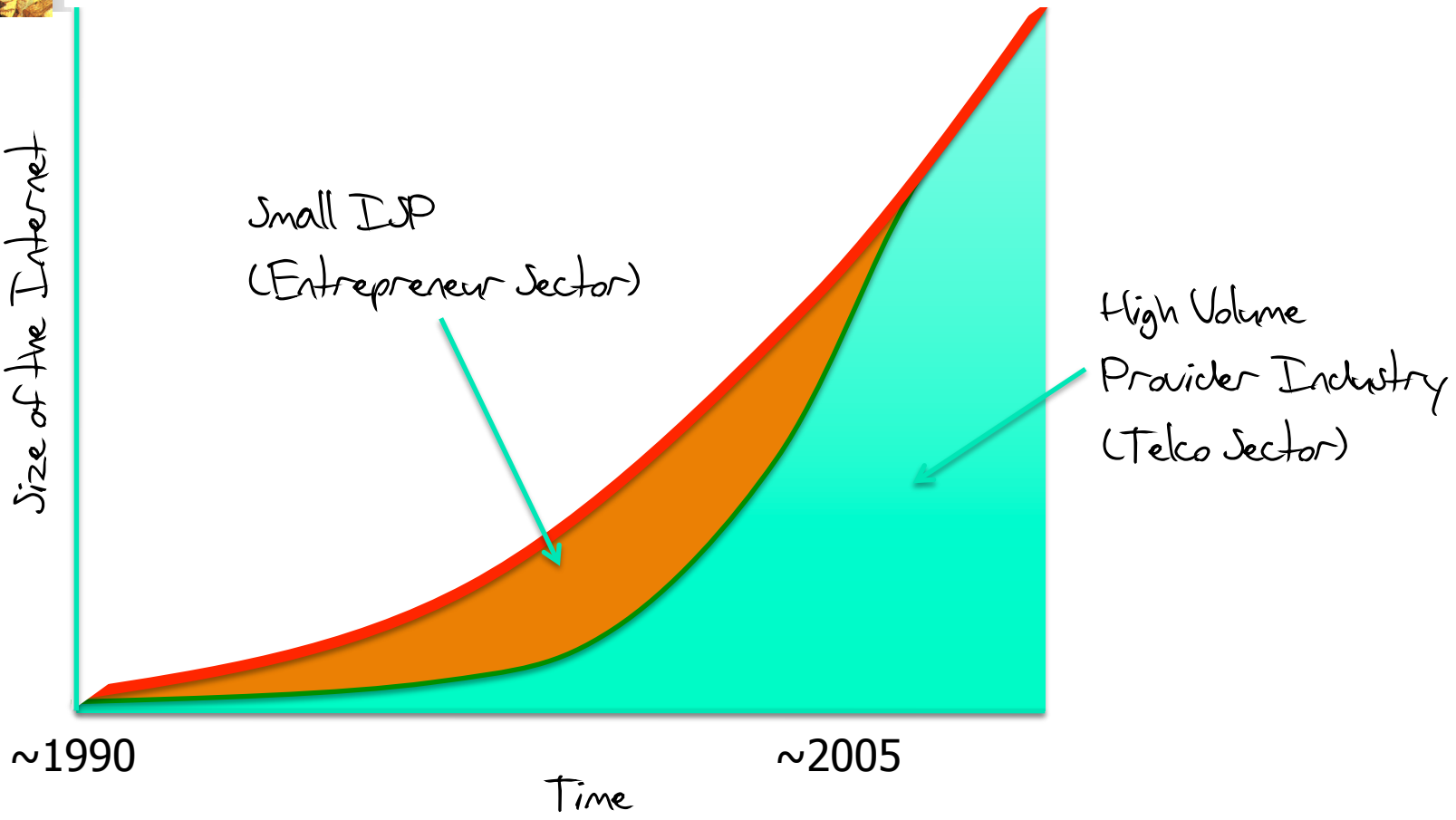


A small number of very large enterprises and some very small independent players left hanging on for the ride

IPv4 Deployment Then



IPv4 Deployment Now



What's the problem?

Can a large volume-based industry with complex and lengthy supply chains who are no longer reliant on innovation but efficiency of production and operation on a massive scale now change its direction from IPv4 to IPv6 in an agile fashion?

What is Happening Here?

- Given that Dual Stack requires IPv4, and IPv4 is the critically scarce good here, are we wedging ourselves?
- Are there alternate directions for this industry that represent lower risk and/or increased opportunities for the larger class of actors?
- What factors will determine the common direction of providers and consumers?
- Is IPv6 a stable point of relative compromise between individual aspirations?
- Or will this offer new opportunities for market sector dominance and control by a small subset of this industry?

What could be useful right now

- Understanding of the implications of various options at an economic and public policy level
- Appreciation of our limitations and strengths as a global deregulated industry attempting to preserve a single coherent networked outcome
- Understanding of the larger audience and the broader context in which these processes are playing out and the risks we run if this does not proceed as planned
- Understanding that some transitions are not ‘natural’ for a deregulated industry. Some painful transitions were only undertaken in response to regulatory fiat
  - Think analogue to digital spectrum shift as a recent example

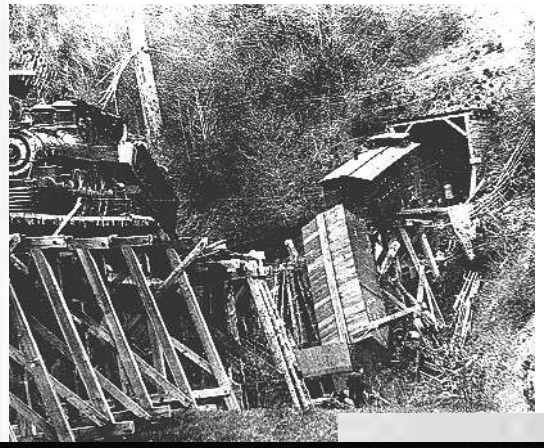
Implications

It is likely that there will be some disruptive aspects of this situation that will impact the entire industry

- The original IPv6 transition plan is a business failure
- Resolution of this failure is now going to be tough
- This will probably not be seamless nor costless

And will probably involve various forms of regulatory intervention, no matter what direction we might take from here

Thank You

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