An Economic Perspective on the Transition to IPv6

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The Fine Print: I am not a economist in terms of my professional qualifications or by virtue of my work experience. Worse still, I think I fit in to the category of amateur economic dilettante! So most of what I offer here I do so tentatively, as it probably needs a little more rigor and precision in basic economic terms than I am able to provide! Geoff

A “conventional” view of IPv6 transition:

“The minister for communications and information technology does not believe that regulatory intervention is appropriate. Adoption of IPv6 needs to be lead by the private sector. The private sector must recognise that adopting IPv6 is in their own best interests to protect their investment in online capabilities into the future. Issues of advantages and disadvantages, costs, risks, timing, methodology etc, have to be for each enterprise to assess for itself.”

Statement by the New Zealand Minister for Communications
24 August 2009

In other words:

Self interest on the part of consumers and producers will cause the market to sustain the transition to IPv6

This is not an instance of a “market failure”

There is no need for public sector intervention in the operation of the Internet, nor in this transition in particular

Lets explore these assertions with:

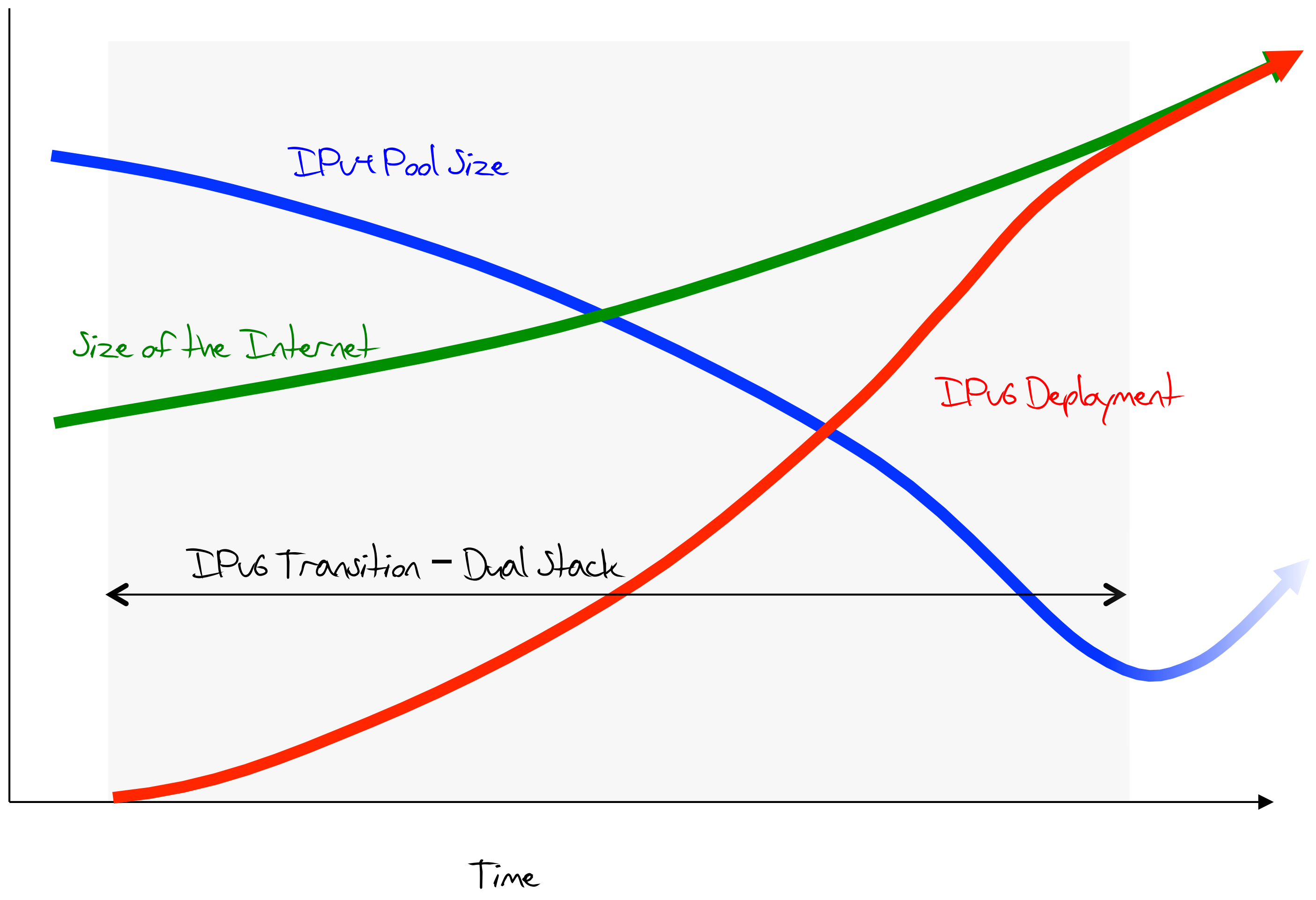
some data

some experience

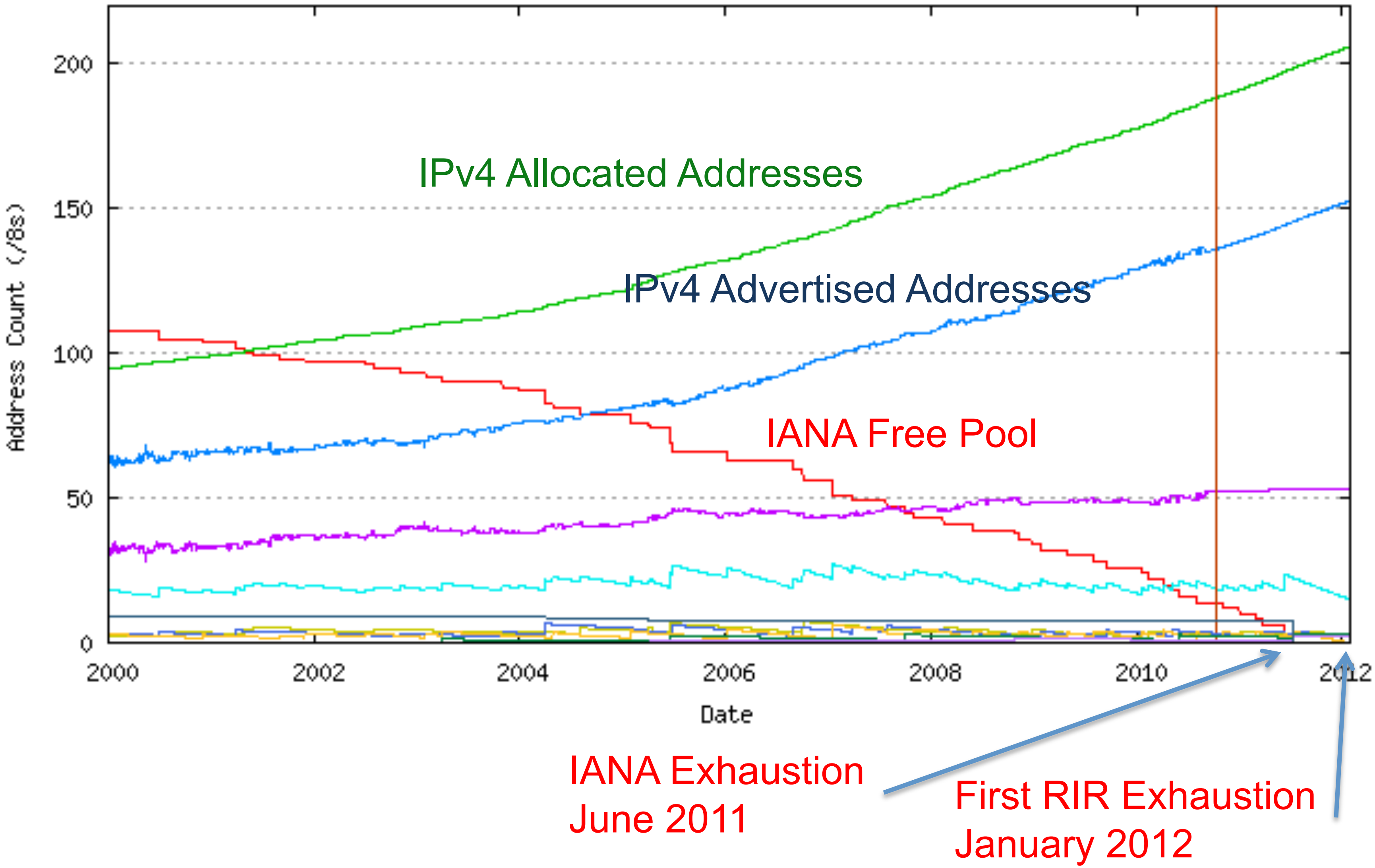
some perspectives

and a little economic theory

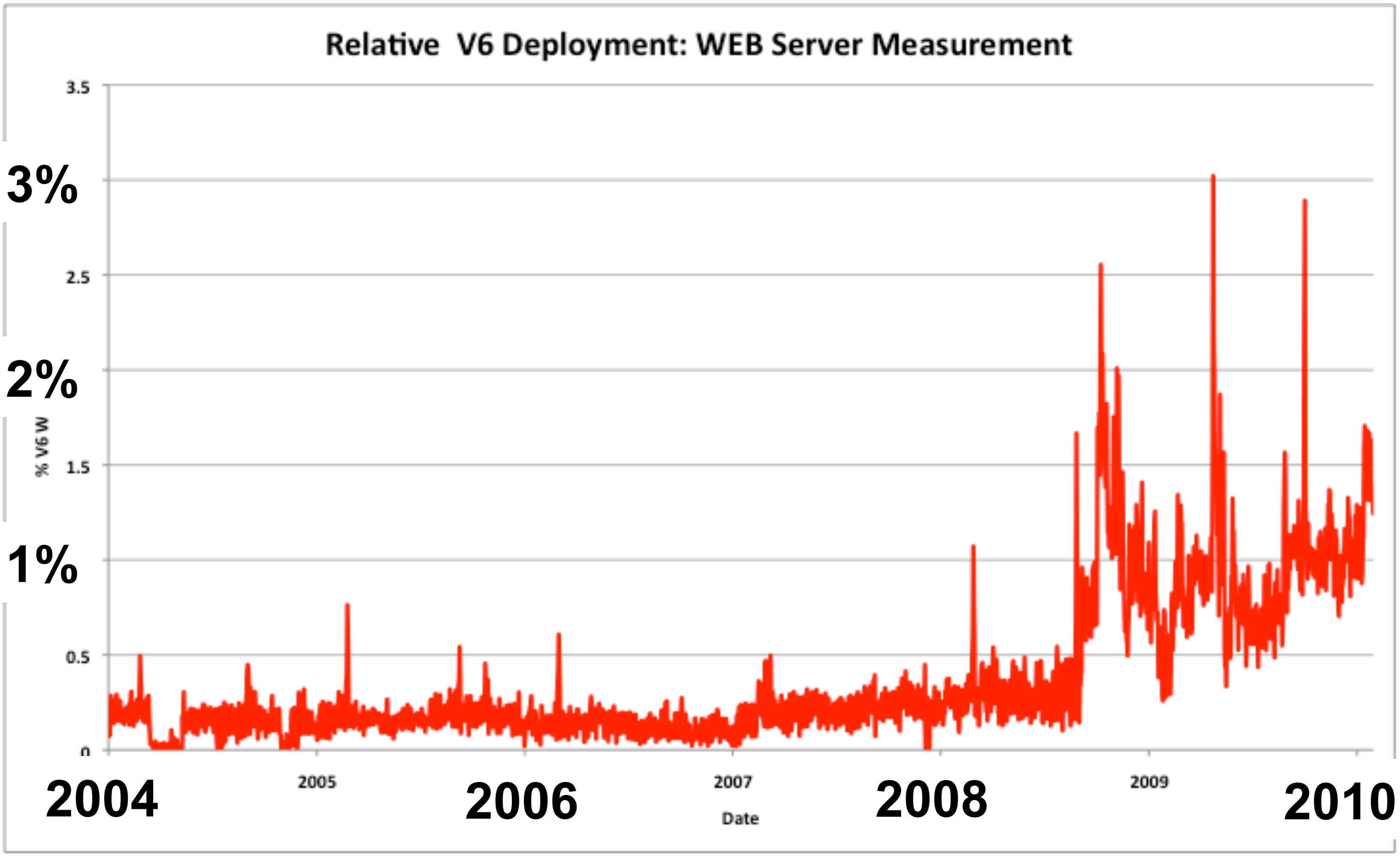
The IPv6 Transition Plan



Obligatory IPv4 Exhaustion Slide

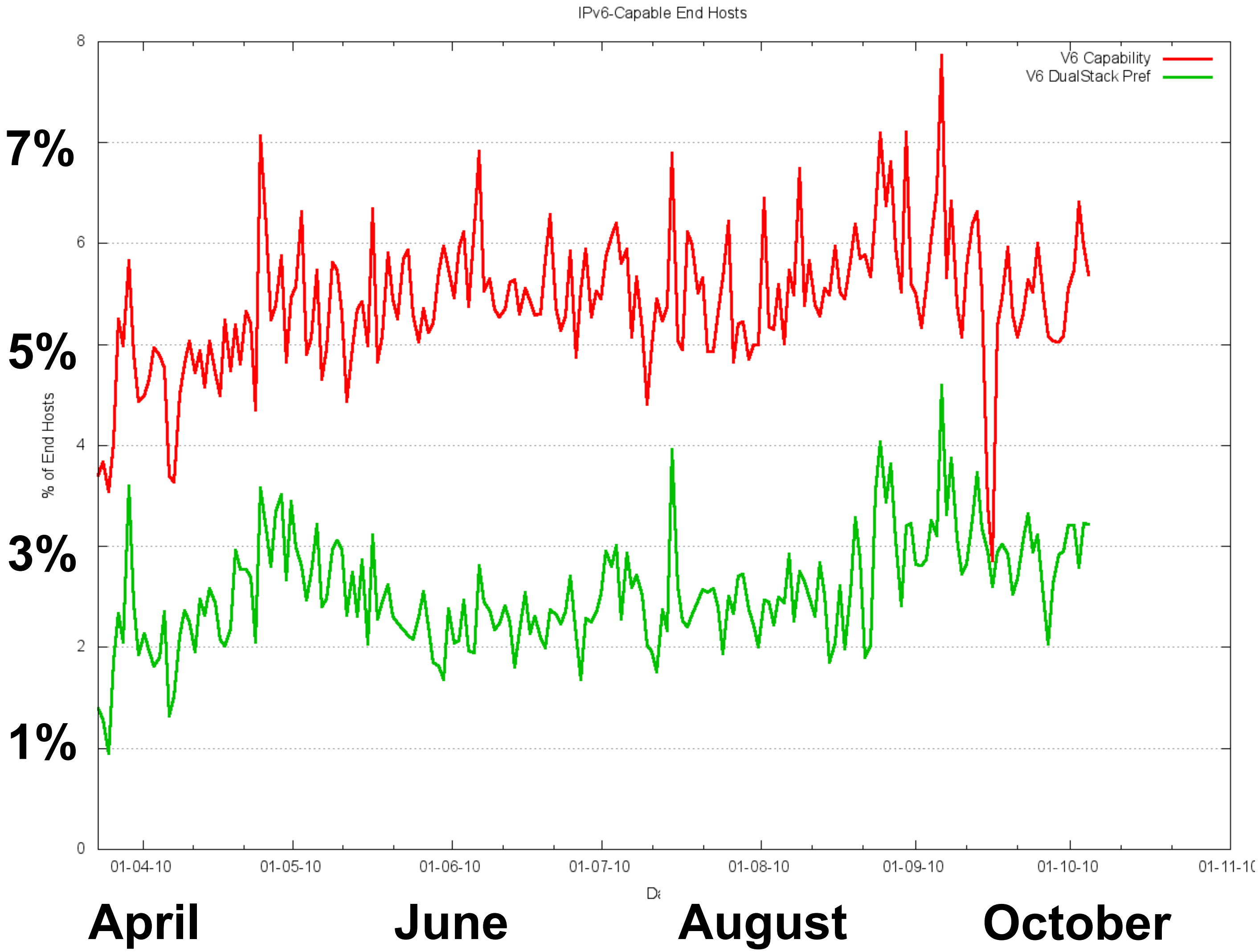


Measured IPv6 Deployment



Data from http://www.apnic.net

Measured IPv6 Deployment - 2010

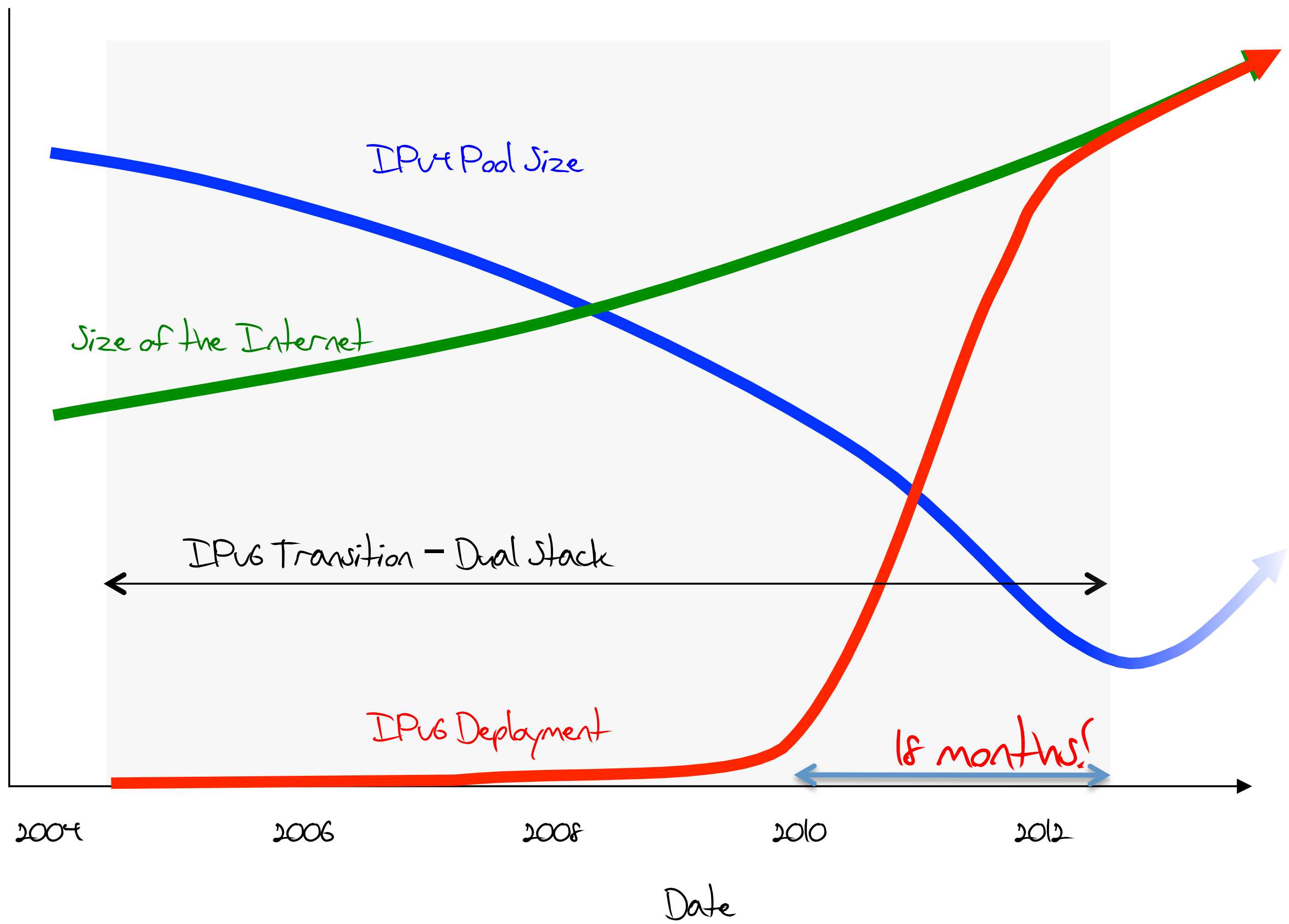


From http://www.potaroo.net/stats/1x1

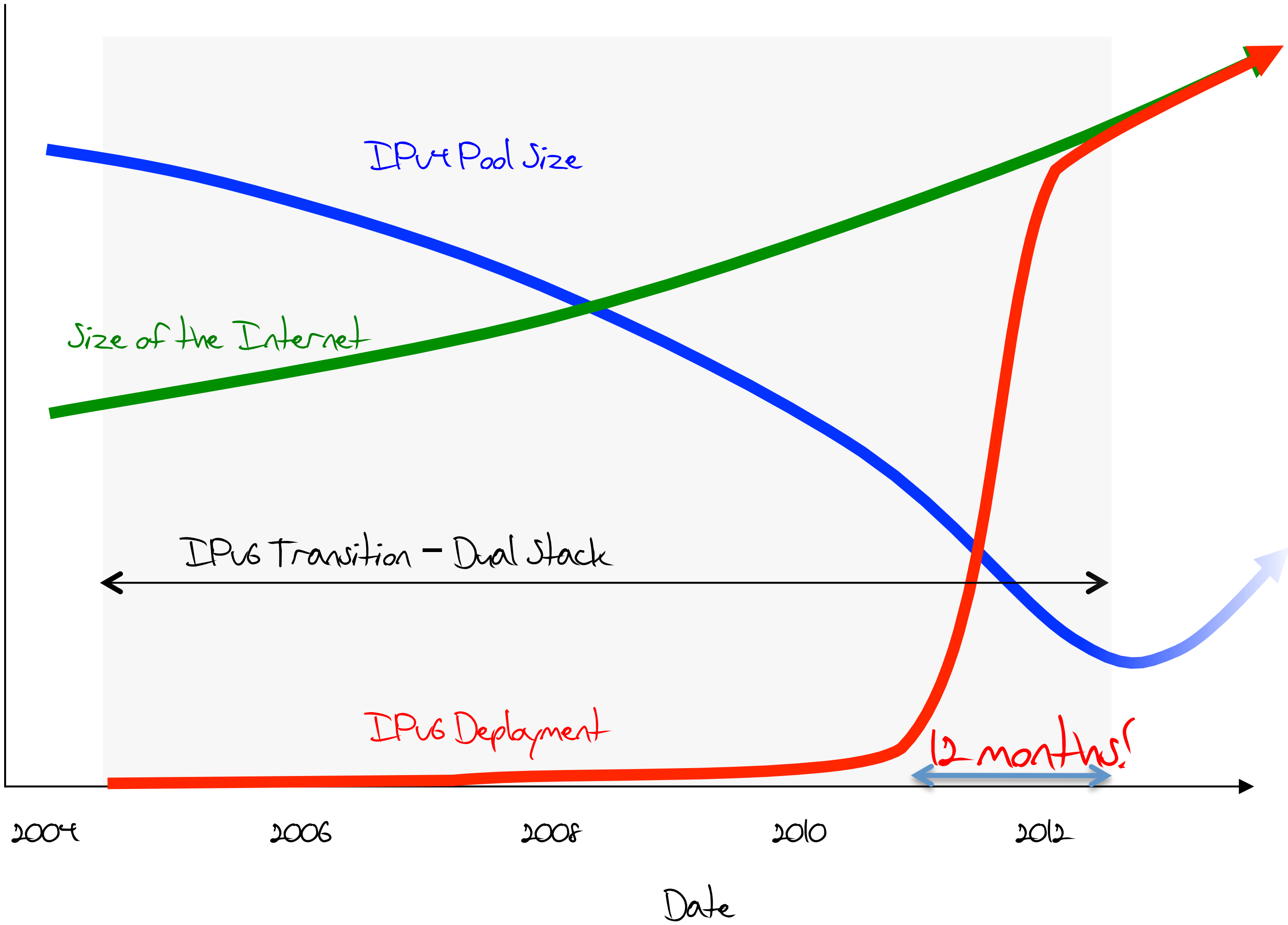
What is this telling us?

- If we want to avoid the “hard edge” of exhaustion of IPv4 addresses we need to complete the transition to IPv6 across most of the network before we run out of the unallocated pool
- We need to get end system and service IPv6 capability up from ~5% of the network today to ~90 % by January 2012

The IPv6 Transition Plan - V2.0



The IPv6 Transition Plan - V2.1



Is this Plan Feasible?

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

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Is this Plan Feasible?

Deploy IPv6 across some 1.7 billion users, with more than a billion end hosts, hundreds of millions of routers, firewalls and middleware units, audit billions of lines of configuration codes and filters, and audit hundreds of millions of ancillary support systems - ***all within the next 360 days***.

What <u>is</u> Feasible?

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What about if we remove the time constraint?

What if we let the unallocated IPv4 address pool run out while we still remain critically dependant on IPv4 in the Internet?

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What about if we remove the time constraint?

What if we let the unallocated IPv4 address pool run out while we still remain critically dependant on IPv4 in the Internet?

Does adding the factor of a fully depleted IPv4 address pool make this transition harder or does it provide additional incentive for industry players?

Added Impetus?

Will the potential pressure from IPv4 address exhaustion provide sufficient pressure for transition?

Or will we need to encounter the reality of a fully depleted environment and take on the additional risk of added elements of supply disruption into the transition scenario?

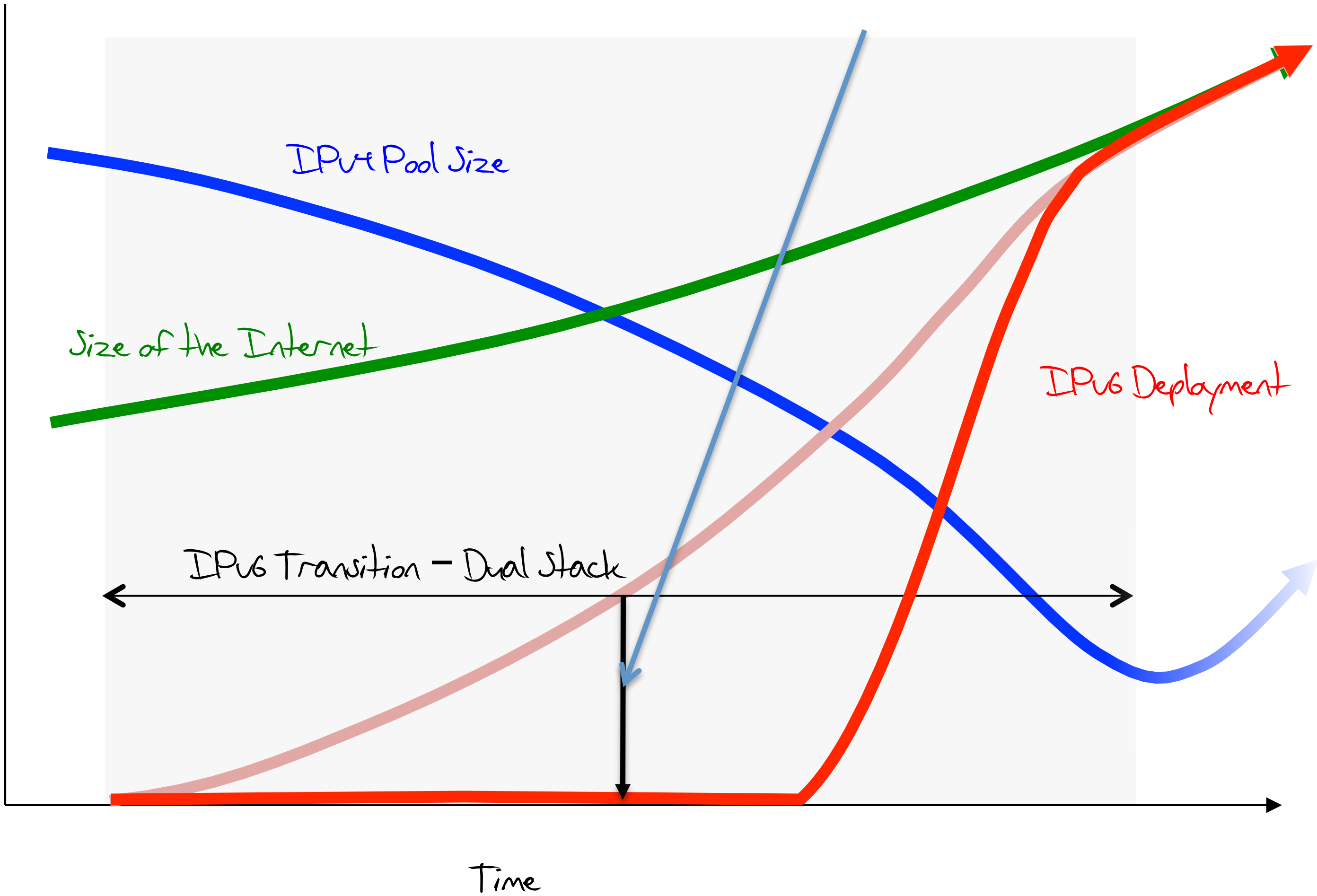
Risk Factors

Investors tend towards *current risk aversion*:

- will chose a lower risk alternative when presented with otherwise equivalent choices
- willing to accept a lower return with a higher degree of certainty
- willing to defer choosing a high risk strategy even if deferral implies higher total cost

The IPv6 Transition Plan
What Happened?

This is a case of Risk Deferral!



Lessons from the Past

If this transition to IPv6 is proving challenging, then how did we ever get the IPv4 Internet up and running in the first place?

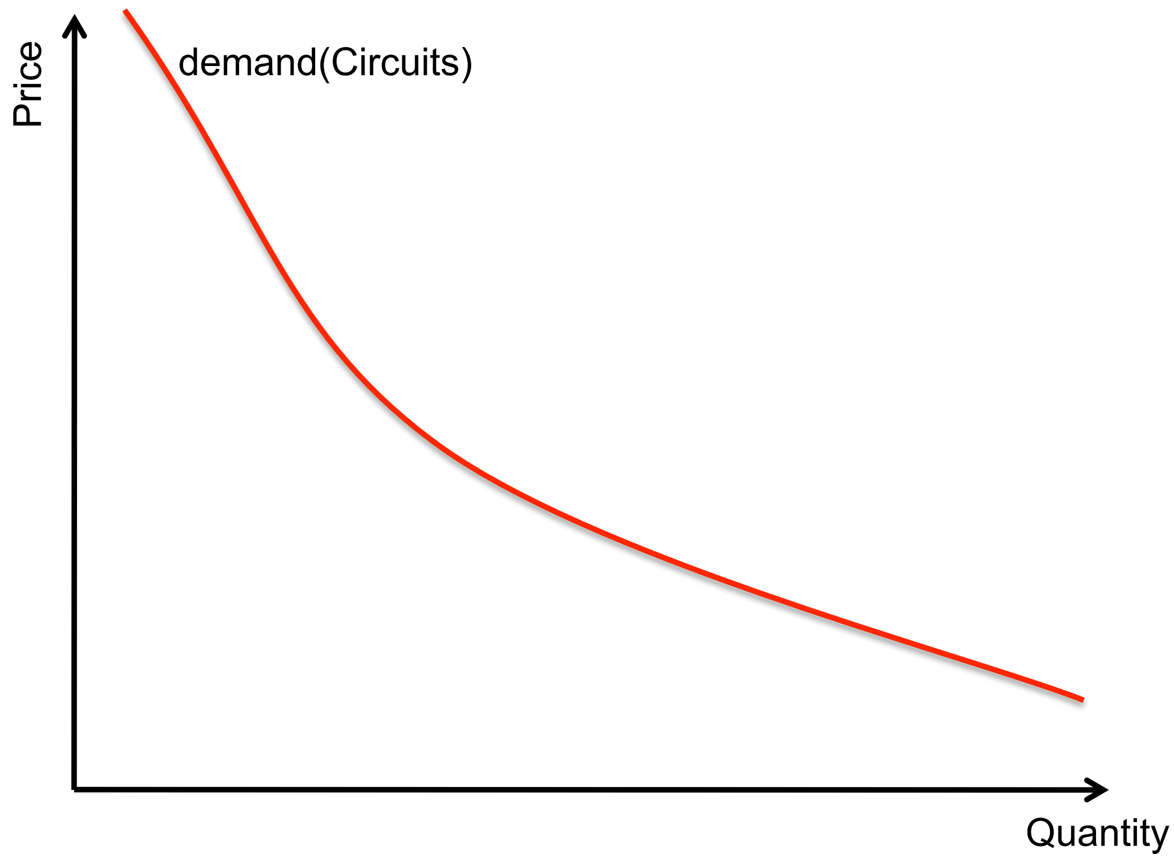
IPv4 Deployment Lessons

Technology: packet switching vs circuit switching

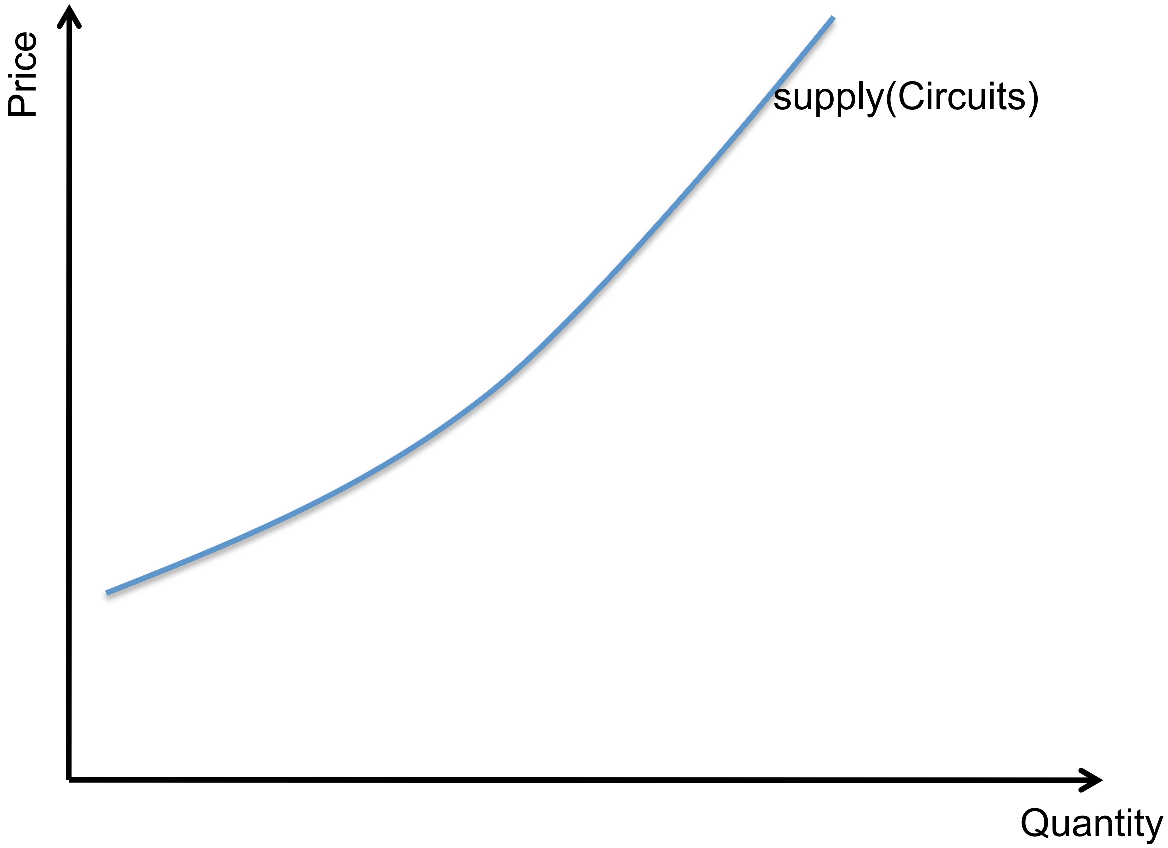
- lower network costs though pushing of functionality and cost to end systems exposed a new demand schedule for communications services

The Demand Schedule

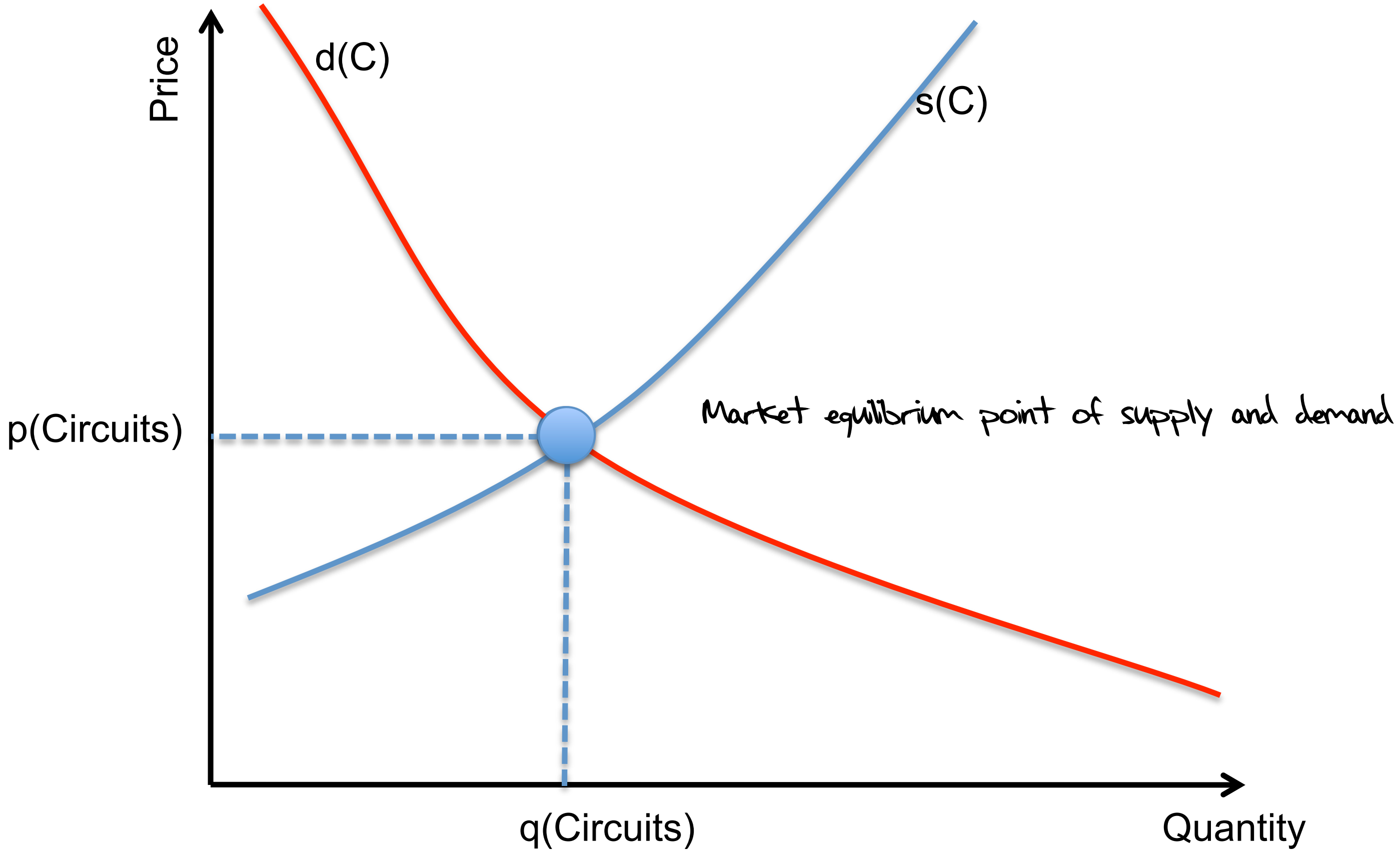
The Demand Schedule: Consumers



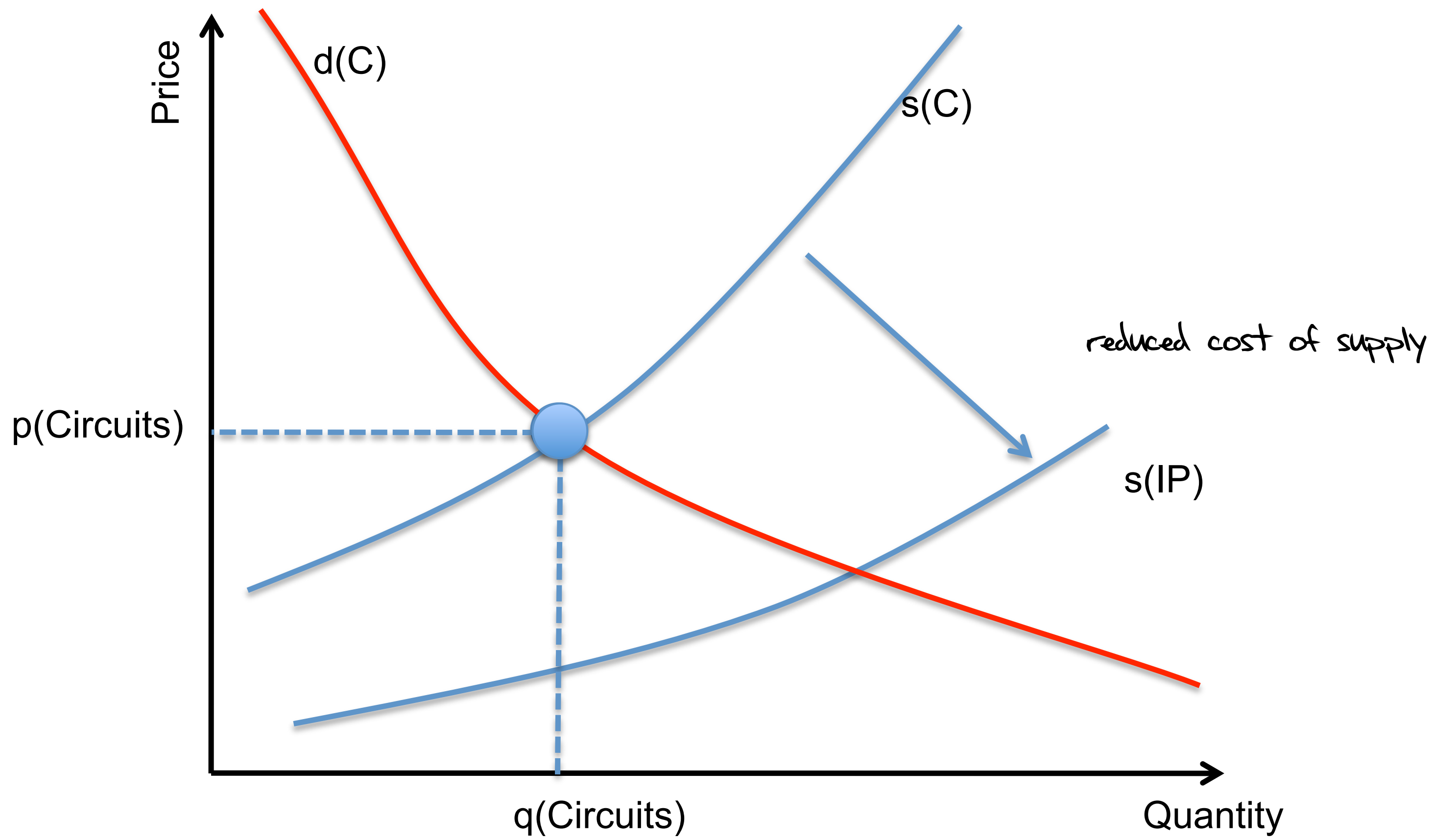
The Demand Schedule: Producers



The Demand Schedule: Equilibrium Point



Circuits to Packets: The Demand Schedule Shift



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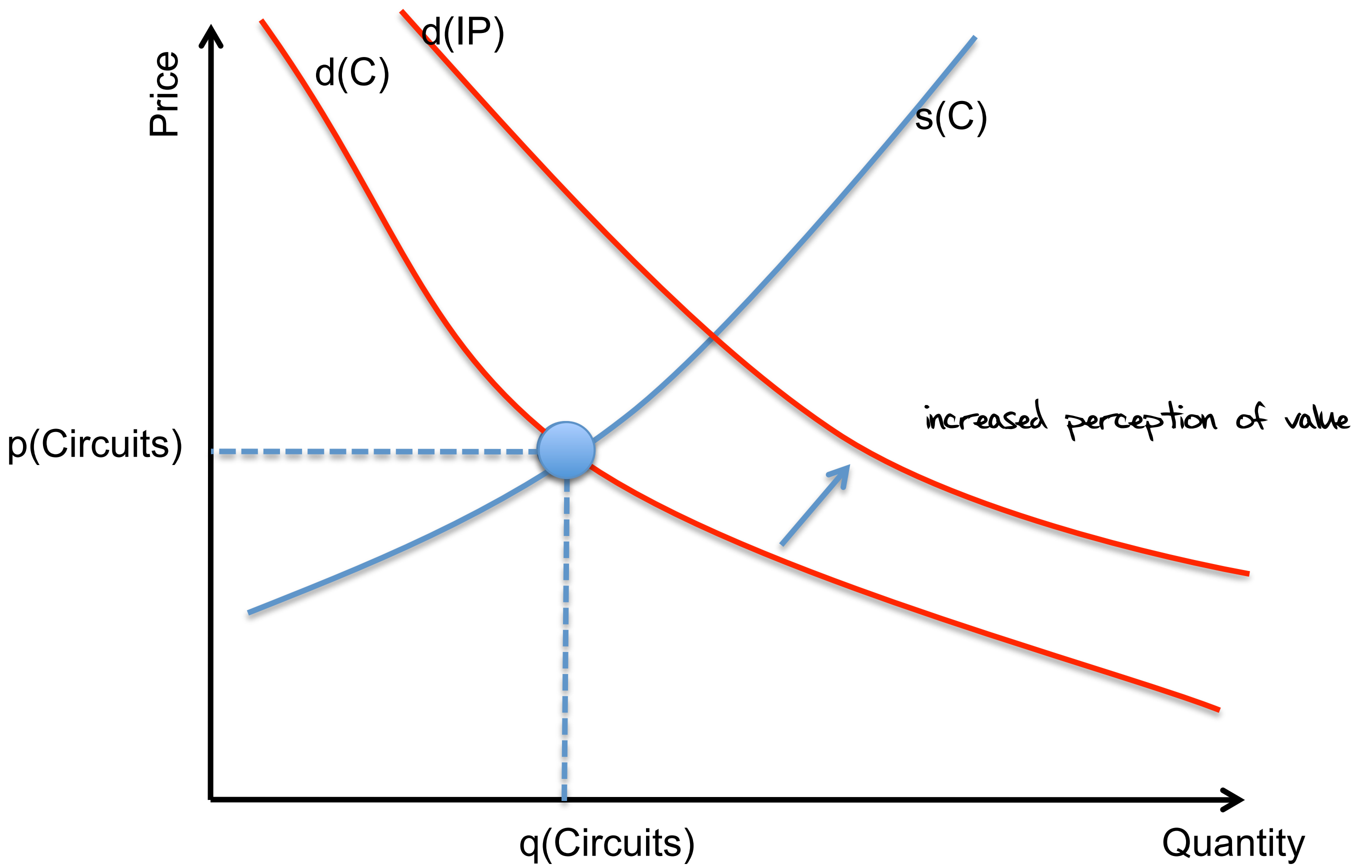

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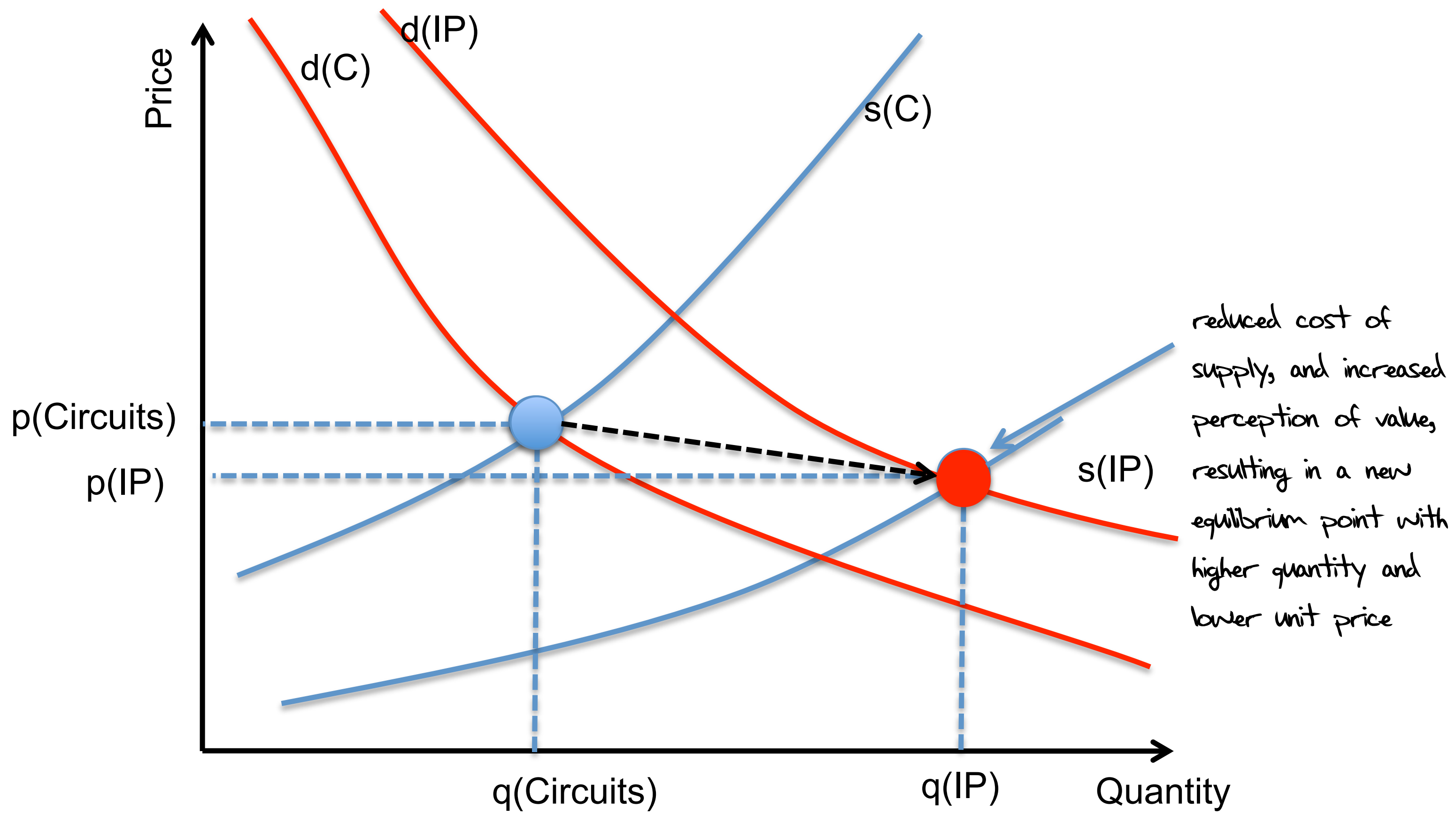

IPv4 Deployment Lessons

Technology: packet switching vs circuit switching

- lower network costs though pushing of functionality and cost to end systems exposed a new demand schedule for communications services

i.e. packet switching was far cheaper than circuit switching. This drop in cost exposed new market opportunities for emergent ISPs

IPv4 Deployment

Business: exposed new market opportunity in a market that was actively shedding many regulatory constraints

- exposed new market opportunities via arbitrage of circuits
  - buy a circuit, resell it as packets
- presence of agile high-risk entrepreneur capital willing to exploit short term market opportunities exposed through this form of arbitrage
- volume-based suppliers initially unable to redeploy capital and process to meet new demand
  - unable to cannibalize existing markets
  - unwilling to make high risk investments

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?

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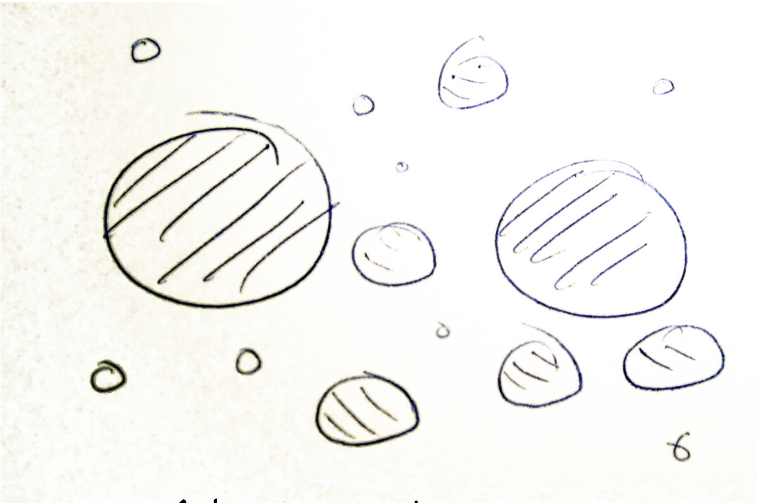
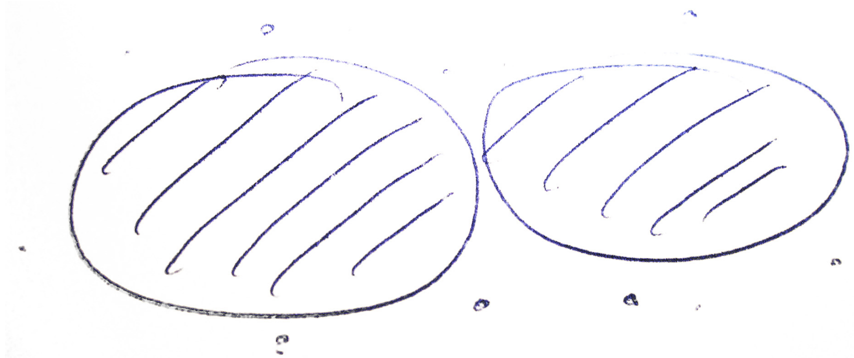
Or is this industry lapsing back into a mode of local monopolies, vertical bundling and strong resistance to further change and innovation?

How "Balanced" is this industry?



A diverse connection
of large and small
ISP enterprises

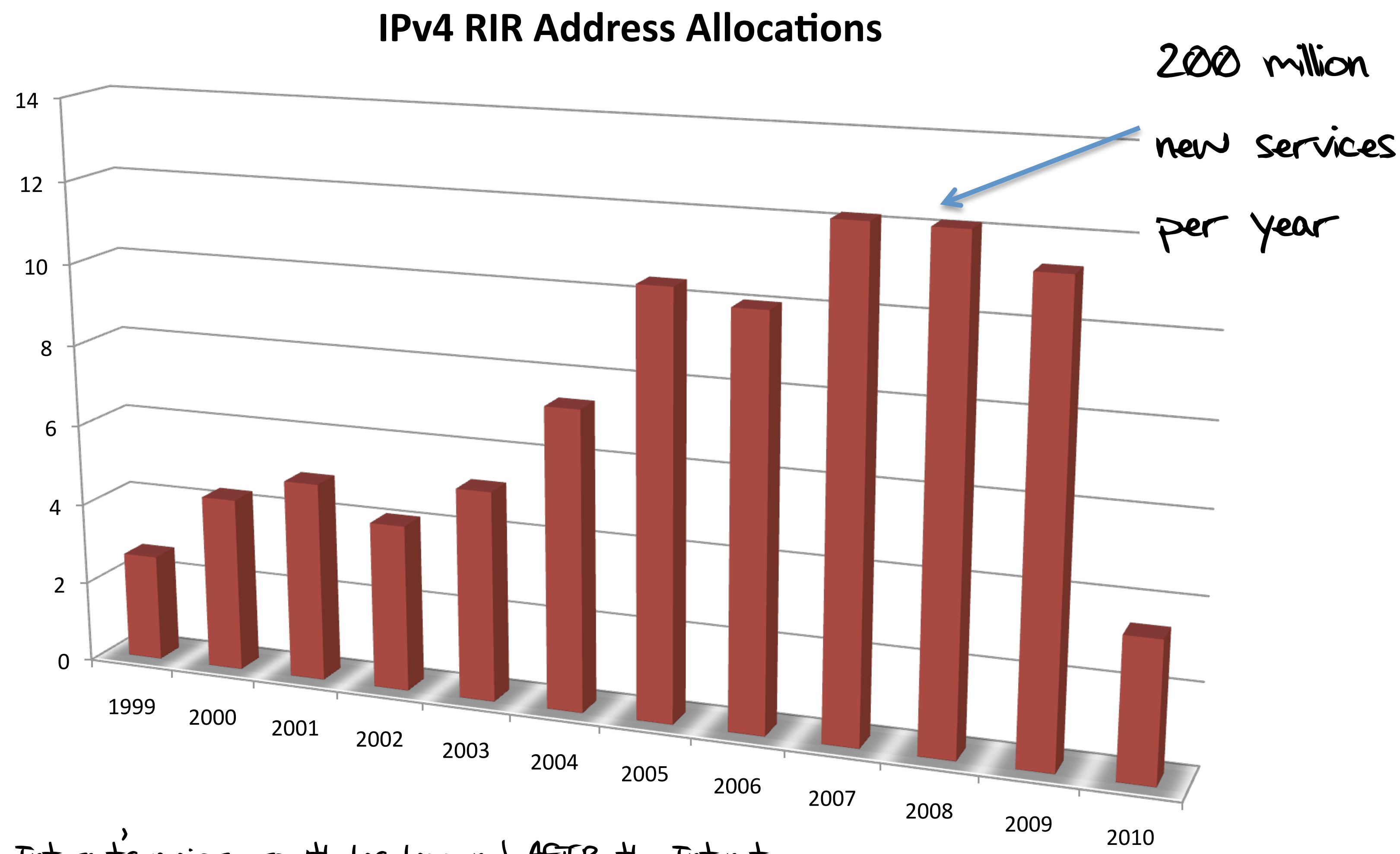
OR



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 2009?

Rank		Company	IPv4 addresses (M)
1	CN	China Mobile Communications Corporation	8.39
2	US	AT&T Internet Services	6.82
3	CN	China TieTong Telecommunications Corporation	4.19
4	CN	Chinanet Guandong Province Network	4.19
5	KR	Korea Telecom	4.19
6	CN	North Star Information Hi.tech Ltd. Co.	4.19
7	JP	NTT Communications Corporation	4.19
8	US	Verizon Internet Services Inc.	3.78
9	US	Sprint Wireless	3.54
10	CN	China Unicom Shandong Province Network	2.10
11	CN	Chinanet Jiangsu Province Network	2.10
12	CN	Chinanet Zhejiang Province Network	2.10
13	FR	LDCOM Networks (France)	2.10
14	IT	Telecom Italia	2.10
15	US	Comcast	1.90

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<u>25%</u> of all the IPv4 addresses allocated in 2009 went to just <u>15</u> ISP enterprises

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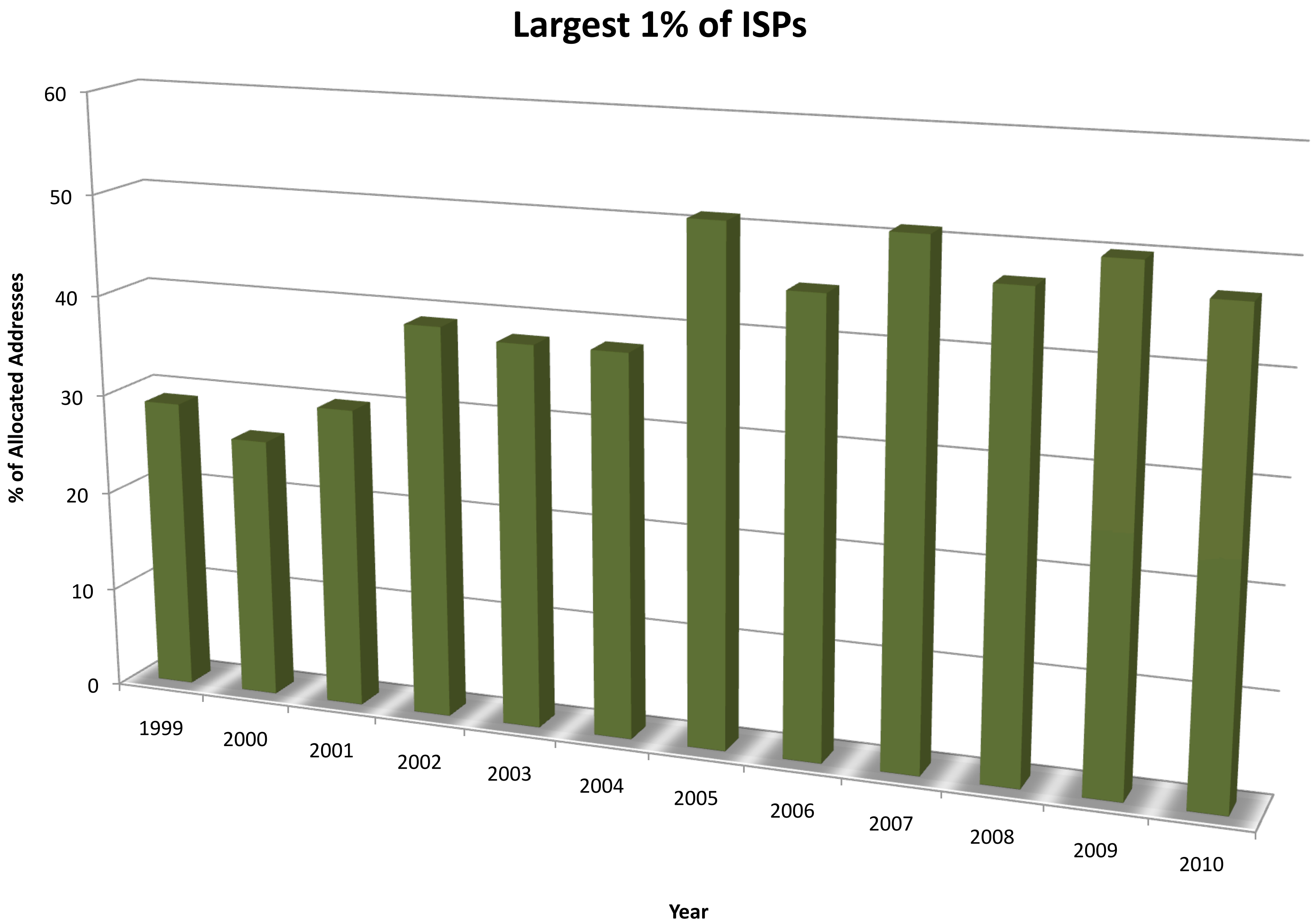

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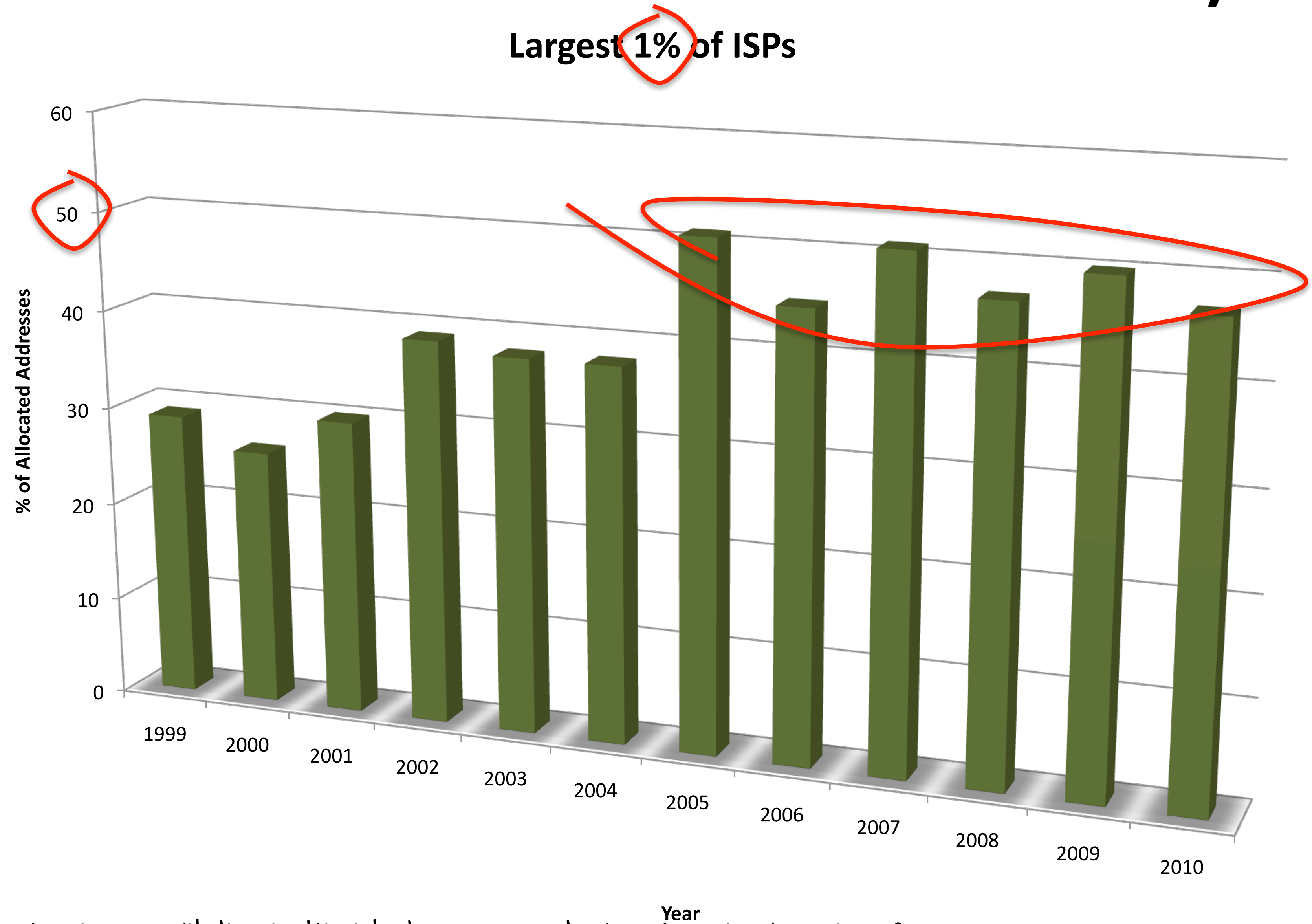

Massive consolidation in this industry appears to have been in place since 2005

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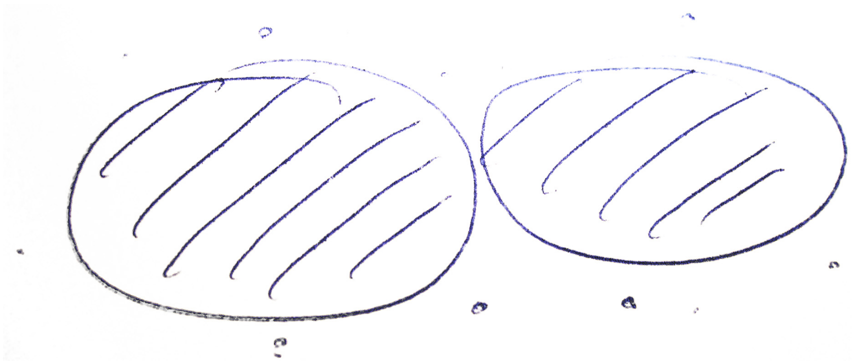

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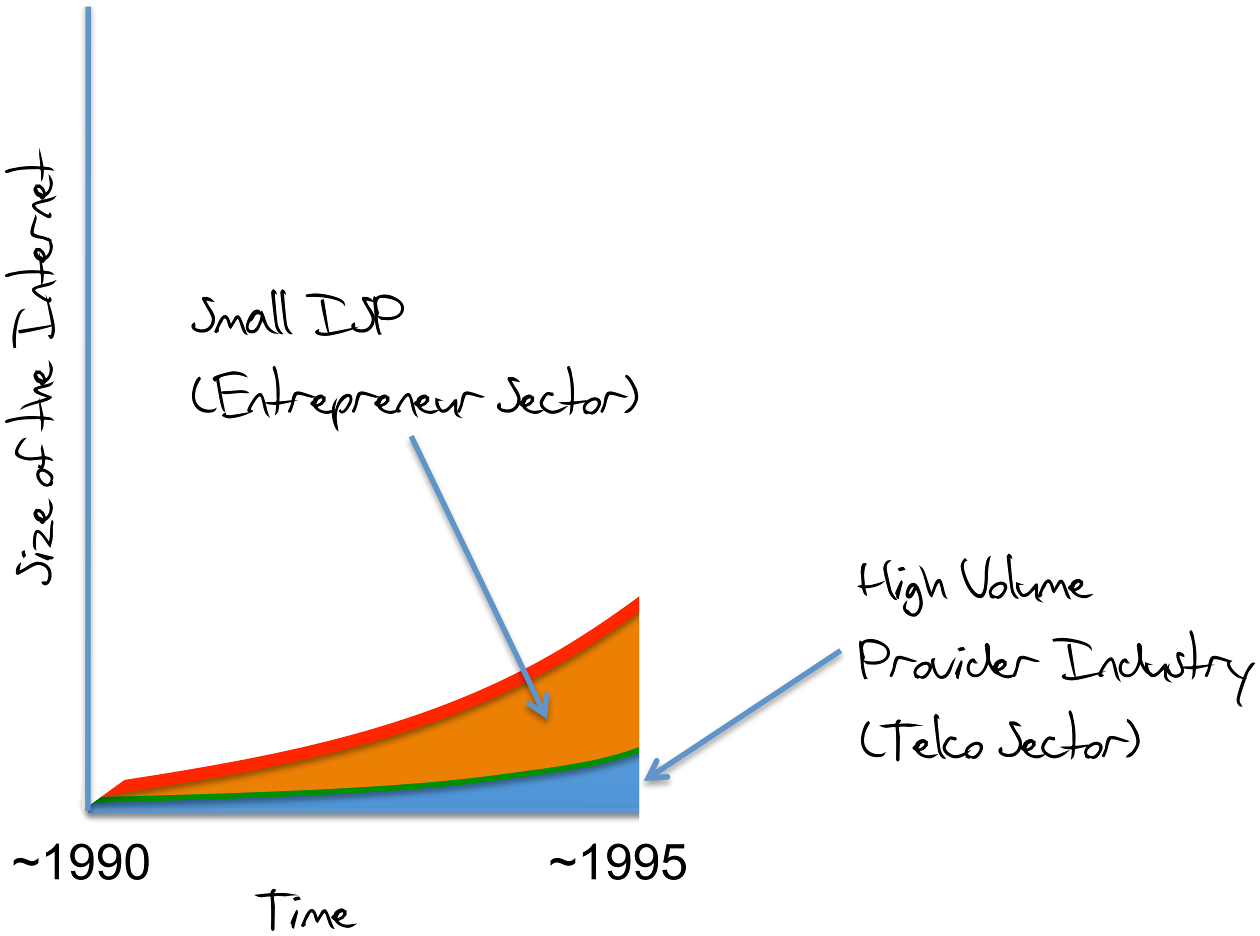

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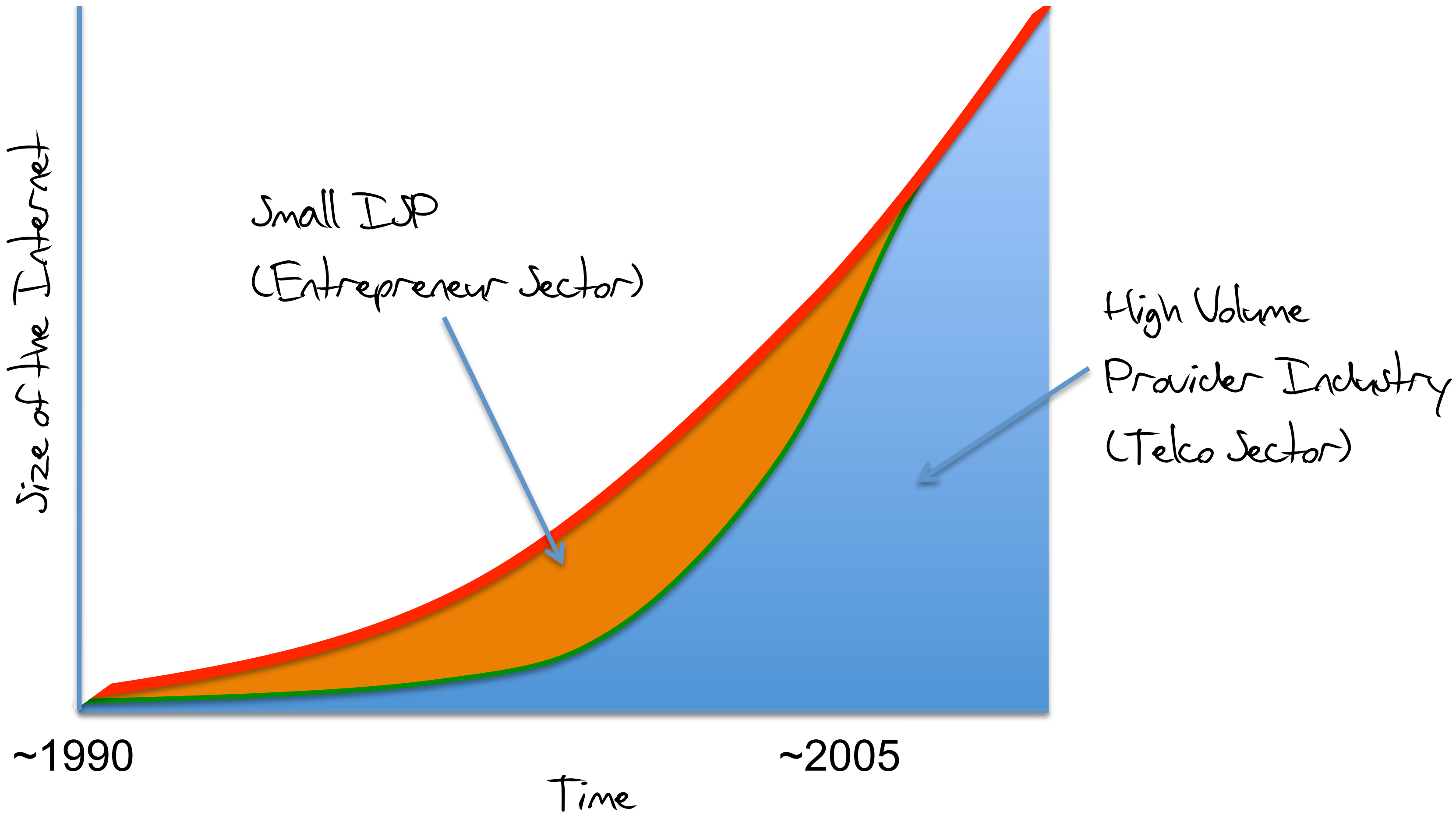
- volume-based suppliers initially unable to redeploy capital and process to meet new demand
  - unable to cannibalize existing markets
  - unwilling to make high risk investments
- the maturing market represented an opportunity for large scale investment that could operate on even lower cost bases through economies of scale

IPv4 Deployment Now



Back to IPv6 Transition…

What about IPv6 Transition?

Will the same technology, cost and regulatory factors that drove the deployment of the IPv4 Internet also drive this industry through the transition from IPv4 to IPv6?

IPv6 vs IPv4

Are there *competitive differentiators*?

✗ $cost_4 = cost_6$

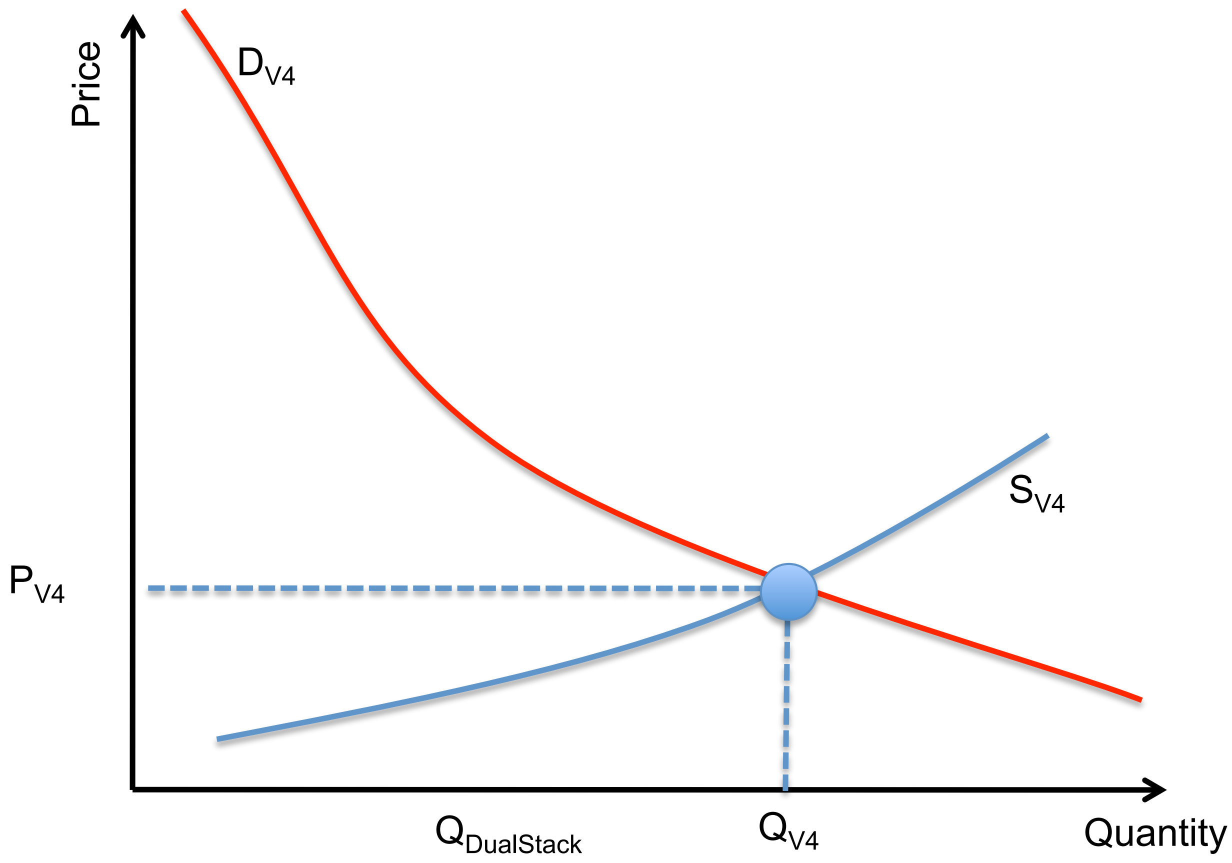
✗ $functionality_4 = functionality_6$

no inherent consumer-visible difference

no visible consumer demand

no visible competitive differentiators other than *future risk*

IPv4 to Dual Stack: The Demand Schedule Shift



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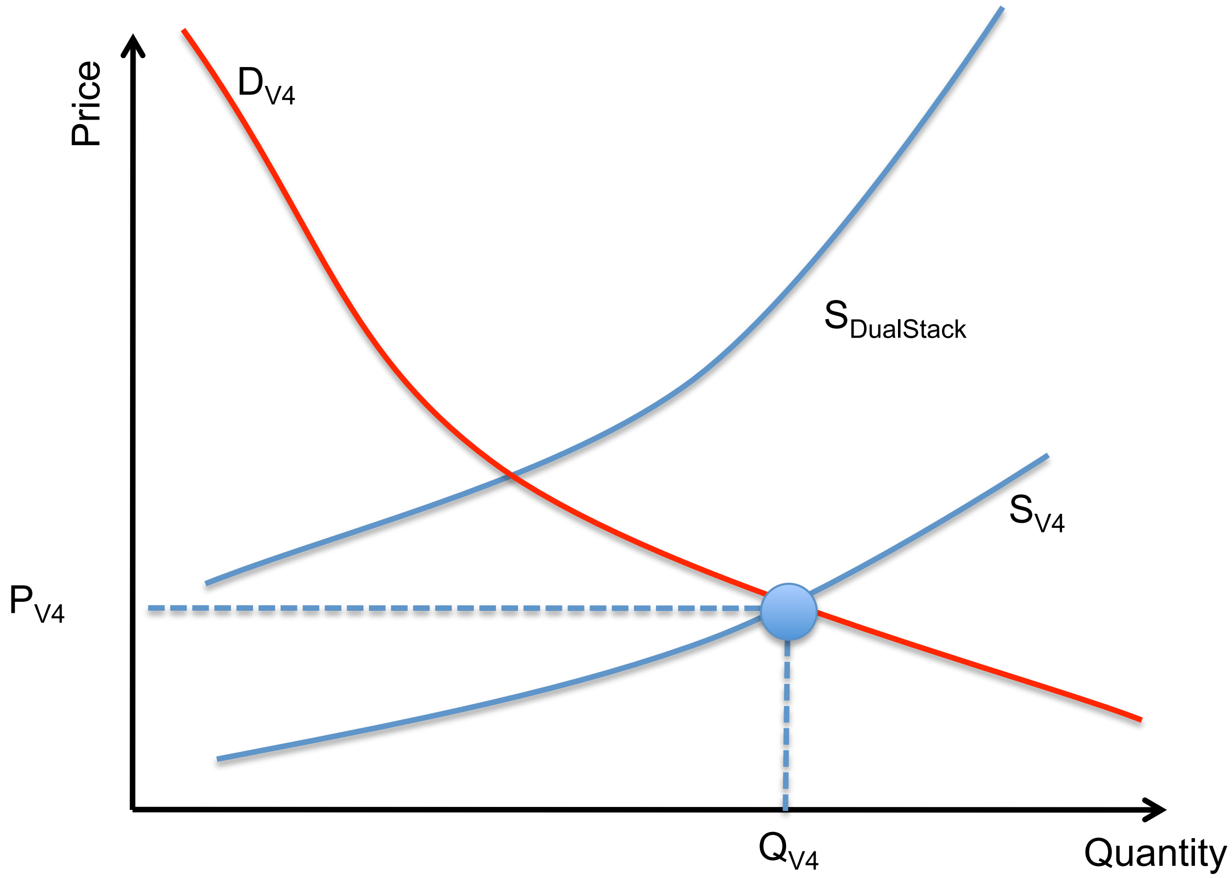
Supply side cost increase due to Dual Stack operation



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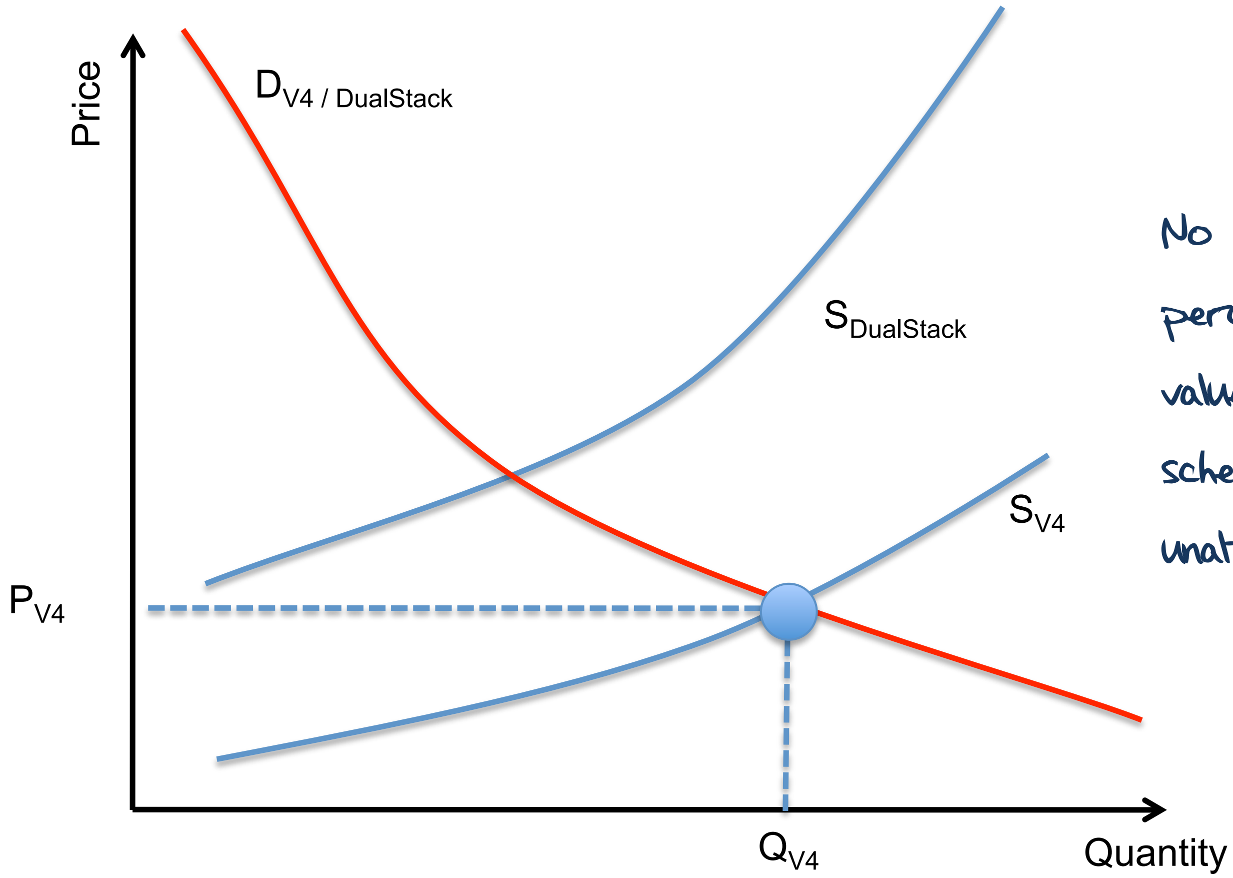

No change in perception of value, so demand schedule is unaltered

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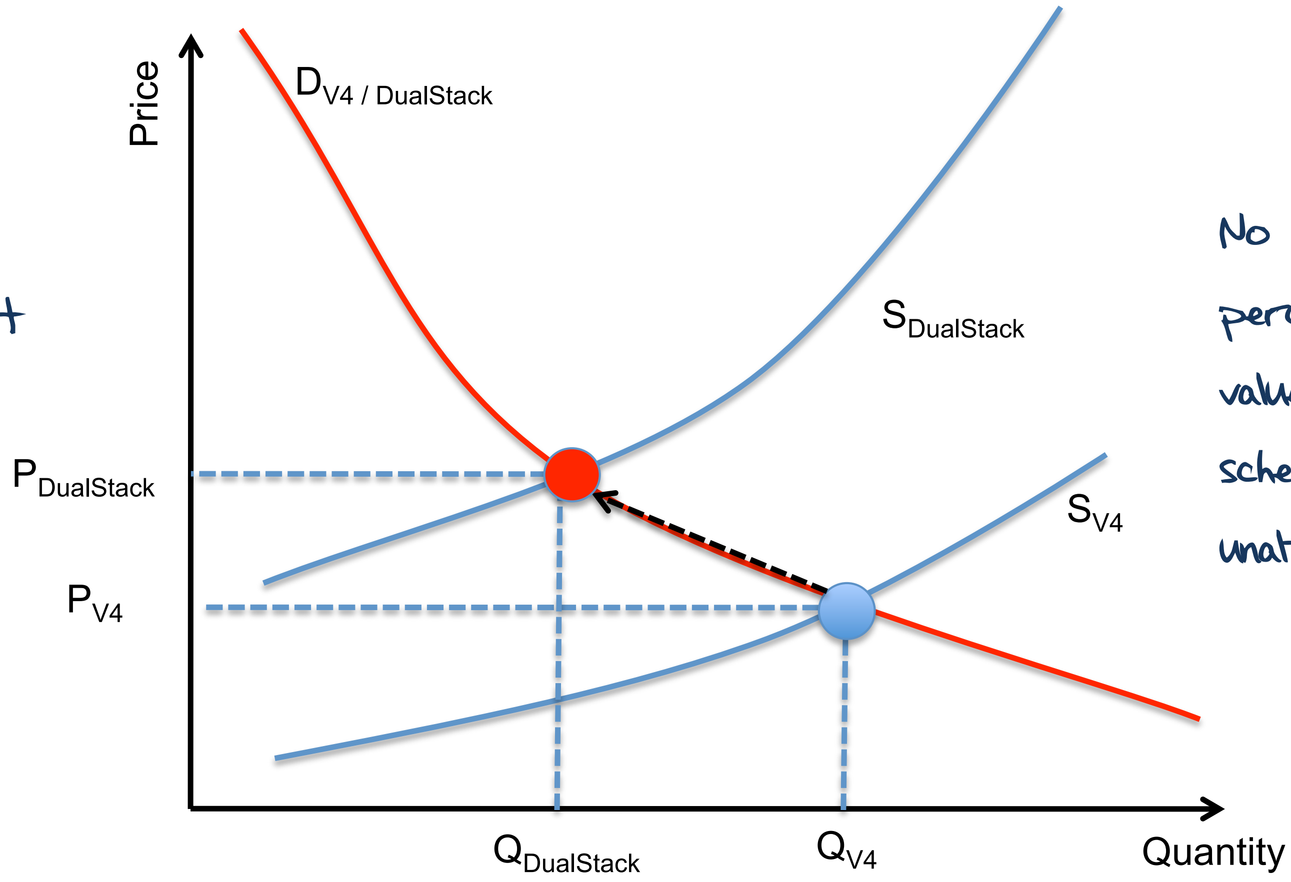


No change in perception of value, so demand schedule is unaltered

Equilibrium point is at a lower quantity if Dual Stack supply costs are passed on to customers

“Market Failure”

Wikinomics:

“In economics, a market failure exists when the production or use of goods and services by the market is not efficient. That is, there exists another outcome where market participants' overall gains from the new outcome outweigh their losses (even if some participants lose under the new arrangement). Market failures can be viewed as scenarios where individuals' pursuit of pure self-interest leads to results that are not efficient – that can be improved upon from the societal point-of-view. The first known use of the term by economists was in 1958, but the concept has been traced back to the Victorian philosopher Henry Sidgwick.”

http://en.wikipedia.org/wiki/Market_failure

The Transition to IPv6

Alternatively, is this transition an instance of a *market failure*?

Individual self-interest leads to inefficient supply outcomes, as self-interest does not lead the installed based of consumers and suppliers to underwrite the cost of dual stack operation within the transition

IPv6 Transition as a Public Good?

Is the transition to IPv6 is *non-excludable* and *non-rivalrous?*

In which case this transition issue parallels that of a *public good*

- With an implication that conventional market dynamics in a deregulated environment will not lead to this transition being undertaken
- And a corollary that if this transition is considered to be necessary or essential then some form of public good solution needs to be considered

Public Good "solutions"

There are a number of conventional approaches to the distribution of a *public good:*

- Assurance contracts
- Coasian solutions
- Government enterprise provisioning
- Tariffs
- Subsidies
- Taxation remedies
- Regulatory impost

Regulatory Impost

- A regulatory constraint is placed on the ISP carrier licence holders that IPv6 services are to be provided by a given deadline
  - as has happened with digital television in many regulatory regimes.
- This regulatory constraint acts a form of a *assurance contract*, where all providers are in effect bound to produce a particular solution

Government Purchase Contracts

- Where the public sector collectively require the provision in IPv6 in all their service contracts.
- This is a form of a *coasian solution* where a group of potential beneficiaries pool together their willingness to pay for the public good.
  - We have seen this approach in the past with the Government OSI Profiles (GOSIP) of the late 1980's when the approach proved ineffectual.
  - There is no assurance that such collective actions on the part of the public sector have sufficient mass and momentum to create a broader sustainable market that will impel the private sector to undertake the transition.

Subsidies and Incentives

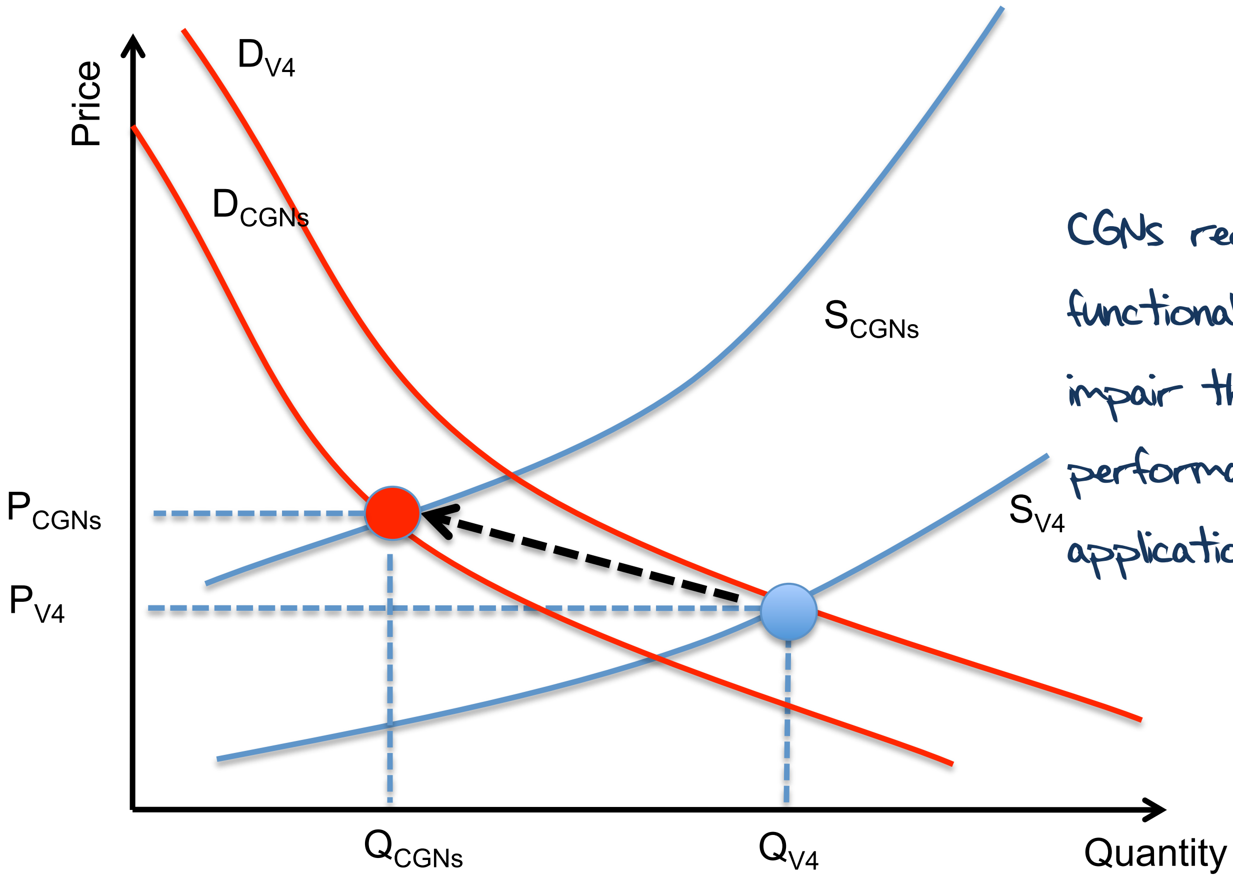
- Where the production of the good is subsidised in some fashion by public funds
  - This can be in the form of direct payments to service providers, or in the form of vouchers to consumers which can be redeemed only in exchange for the supply of a specified service.
- Related incentive measures include the use of taxation incentives related to infrastructure investment, where the investment in a certain class of infrastructure or in a certain sector can be provided with advantaged taxation treatment.

Public Provision

- Where the service is provided by a publically-owned enterprise.
- The funding for such an enterprise can be provided by government-backed investment bonds, or directly from public revenues, and operating losses are underwritten by the public purse.
  - This measure was used for most national telephone service providers for a significant part of the twentieth century, so it is not exactly a completely foreign concept for this industry.

Post-Exhaustion: Adding CGNs to IPv4

Supply side cost increase due to Dual Stack operation

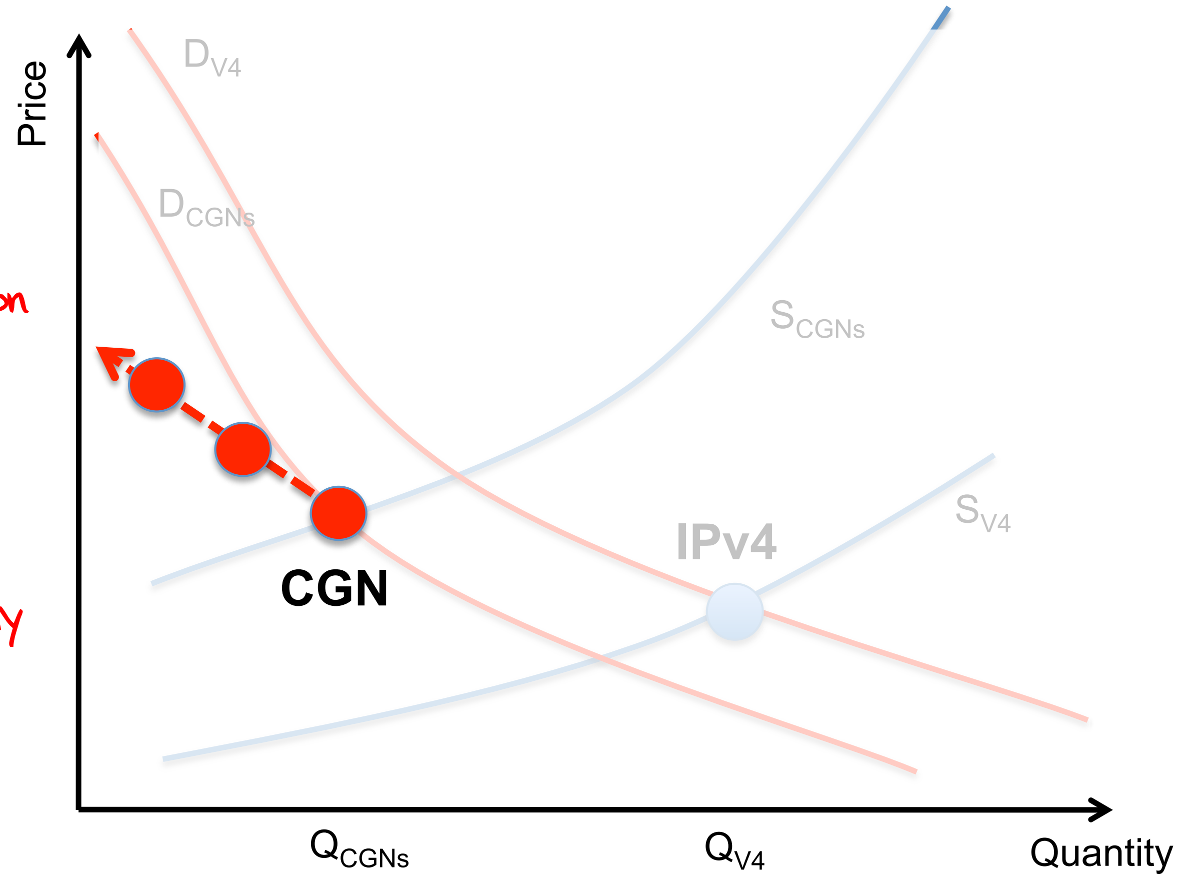


CGNs reduce functionality and impair the performance of some applications

CGNs represent higher cost and lower value for customers

IPv4/CGNs + Dual Stack
The Demand Schedule Shift over Time

As NAT compression becomes more intense the IPv4 CGN approach become decreasingly viable



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?

Your Thoughts?

Thank You