NAT64, CGN & IPv6 Economics

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AusNOG Melbourne 2012

Agenda

- Problem Statement
- NAT444 (CGN)
- NAT64
- IPv6 Economics

Abstract:
A look at various NAT64 deployment models and what can really be achieved using NAT64 to provide a service or a presence on the Internet. We will also review CGN (NAT44/NAT444) and discuss why NAT will not save those *not* wanting to adopt IPv6 in the long term. Both technologies are seen as impacting the user experience, however if there are no other alternatives what can be done ? Both technologies will be compared using an economic view to determine which would provide the better outcome.

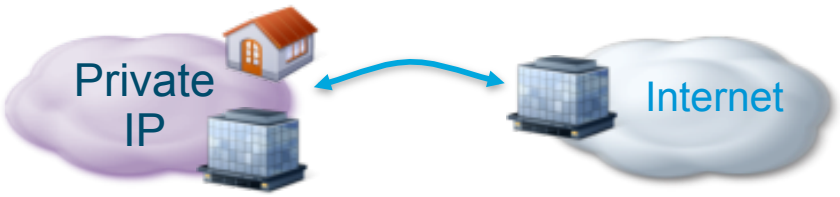
Problem Statement

- You have run out of public IPv4 addresses and are still growing. What do you do ?

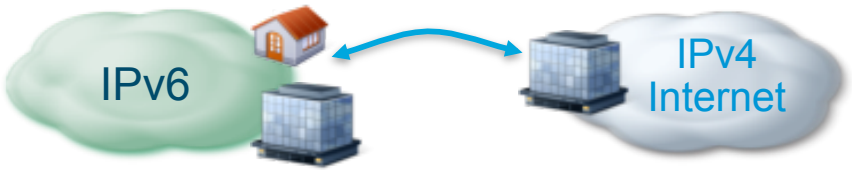
  a) Adopt IPv6 (Dual Stack)
  b) Adopt CGN/NAT444 this IPv6 thing will never take off
  c) If I am going to invest in translation technology, why not just go IPv6 only and use NAT64?
  d) All of the above
  e) None of the above

We look a little further at options b & c

Carrier Grade IPv4 NAT



NAT64 Translation

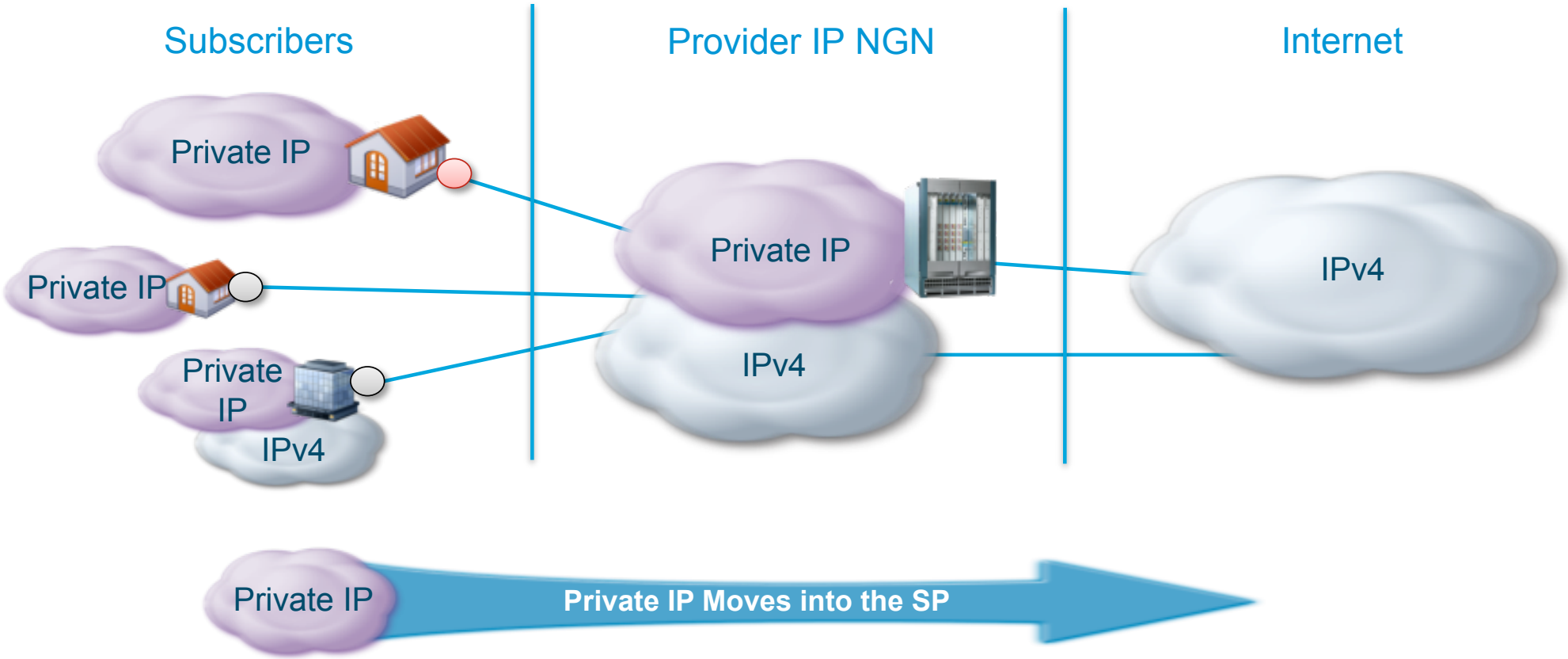


NAT444 / CGN

NAT Terminology

- NAT – Network Address Translation
- NAPT – Network Address and Port Translation
  The ‘router’ in your home
- NAT44 – NA(P)T from IPv4 to IPv4
  The ‘router’ in your home
- Stateful NAT64 – NAPT from IPv6 to IPv4
- Stateless NAT64 – NAT from IPv6 to IPv4
- NAT66 – NAT from IPv6 to IPv6, now known as NPTv6
- “NAT” is often spoken/written instead of “NAPT”
- CGN – Carrier Grade NAT
  Will be used interchangeably with NAT444 in this presentation and we really mean Carrier Grade NAPT

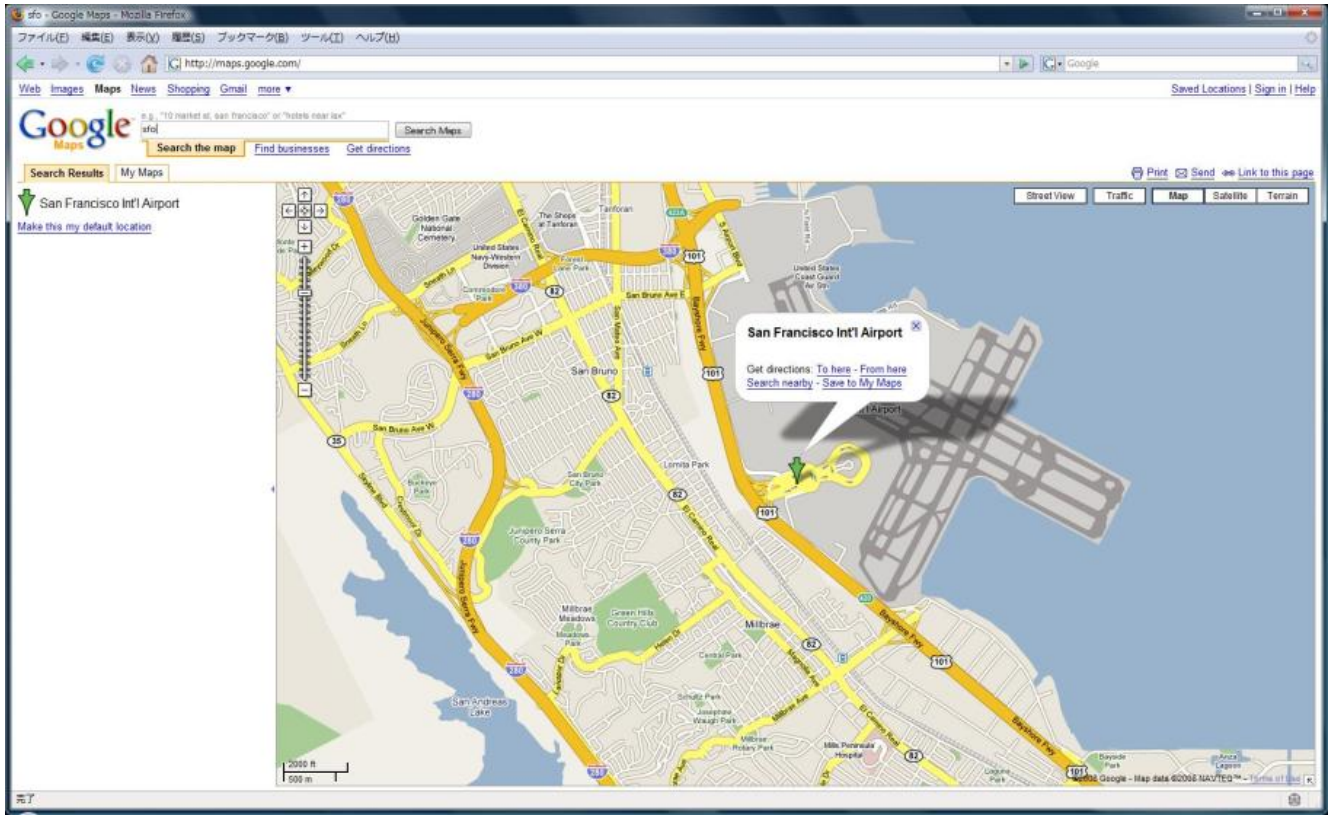
NAT444 = NAT44 + NAT44



Carrier Grade NAT (CGN)

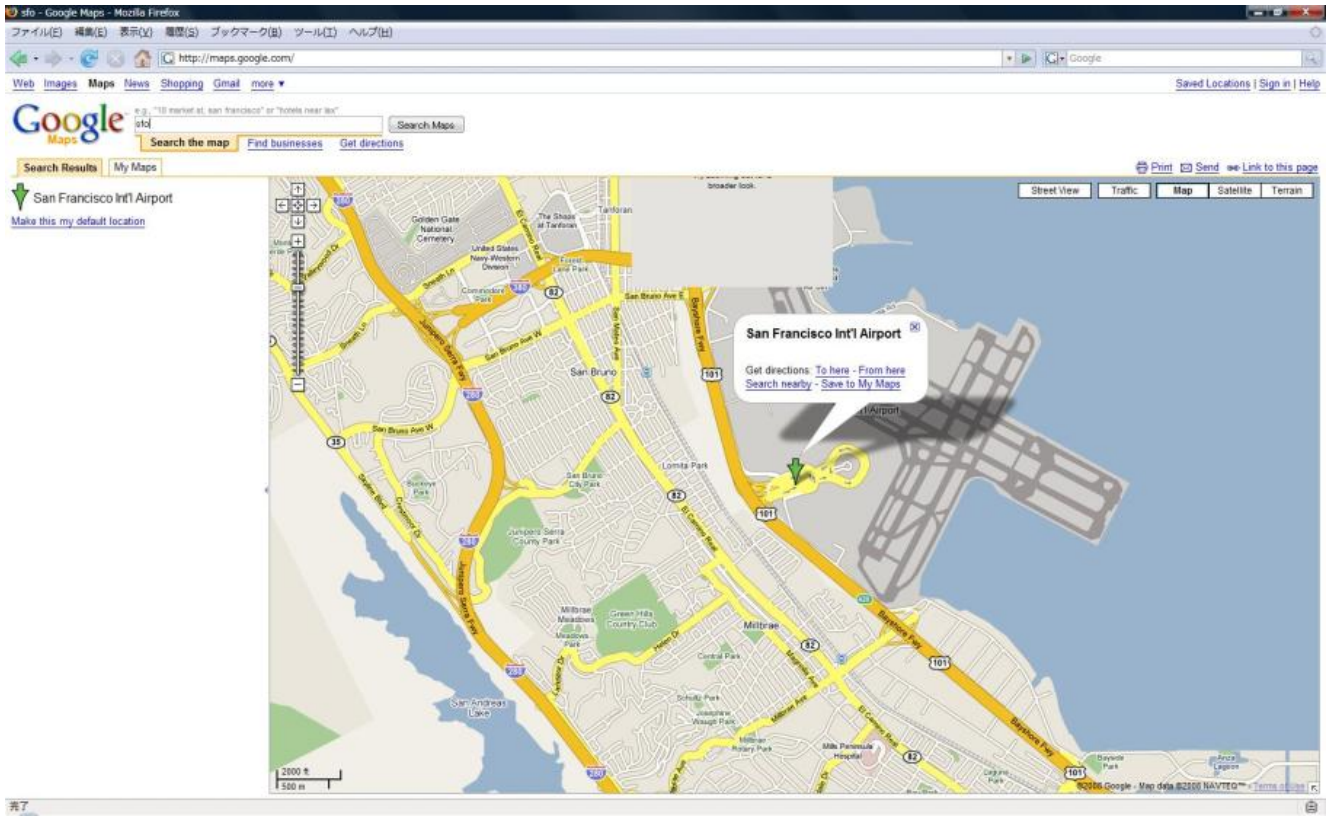
- Essentially, just a big NAPT44
- Can be used with IPv6 adoption technologies such as 6rd & DS-Lite
- Needs per-subscriber TCP/UDP port limits
  - Prevent denying service to other subscribers
  - If too low, can interfere with applications
    - Classic example: Google maps
- Network between subscriber and CGN can be numbered with 100.64.0.0/10
  - RFC6598 IANA Reserved ‘shared transition space’ will avoid complications incurred by using overlapping RFC1918 address space used by clients.

30 Connections
Impact of NAT port limits

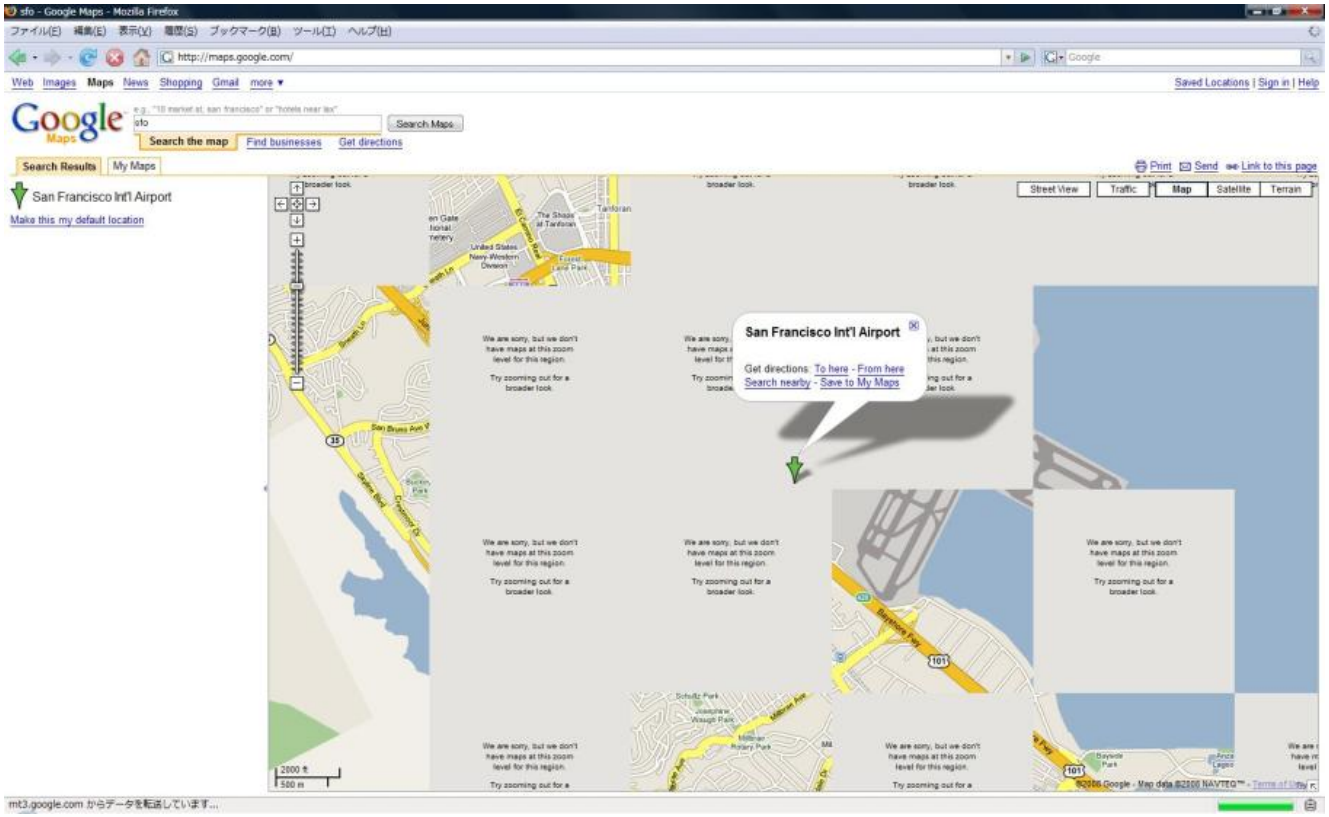


Example/Slides courtesy of NTT, see also:
Hiroshi Esaki: *www2.jp.apan.net/meetings/kaohsiung2009/presentations/ipv6/esaki.ppt*

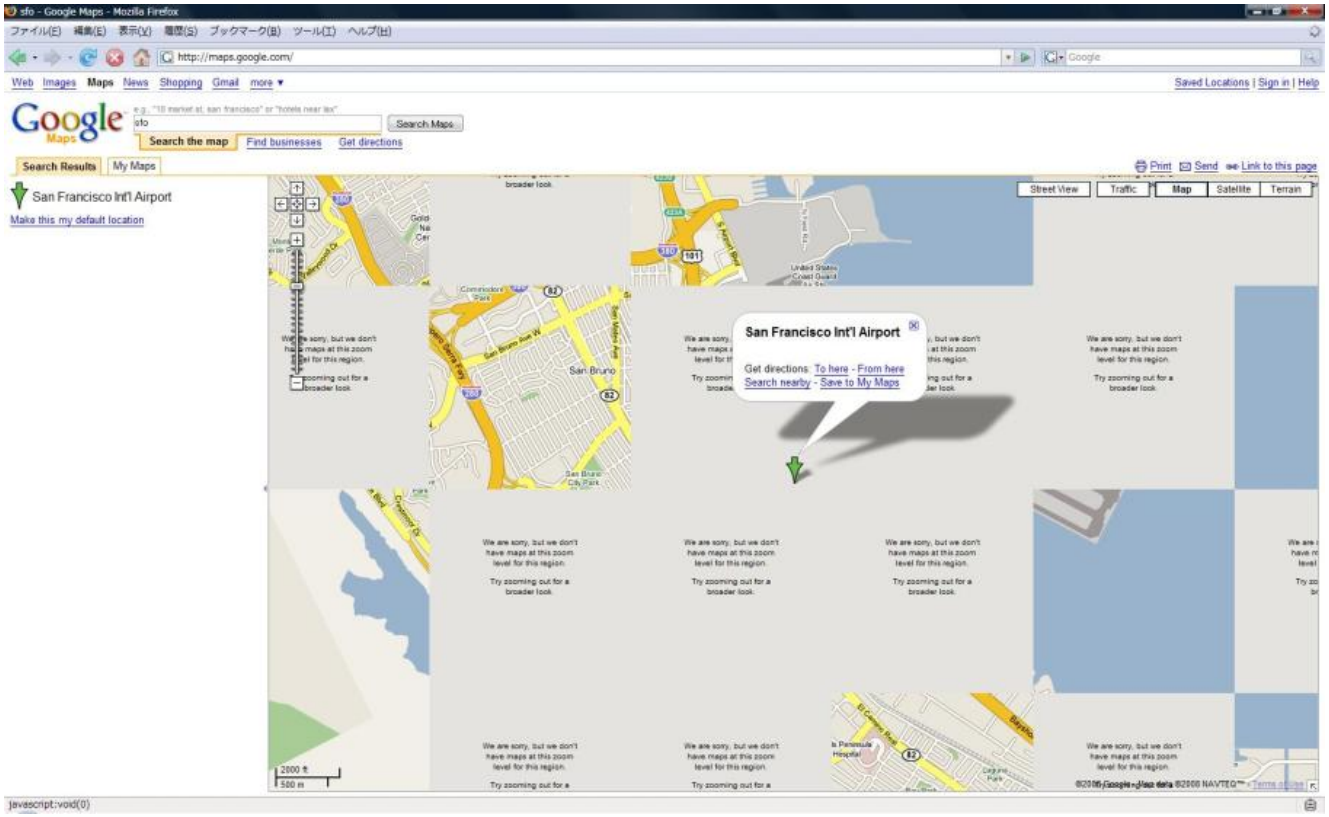
20 Connections



15 Connections



10 Connections



5 Connections

Typical # of Sessions for some Applications

Application	# of TCP sessions
Generic Website	5～10
Yahoo top page	10～20
Google image search	30～60
ニコニコ動画 (Nico Nico Video)	50～80
OCN photo friend	170～200+
iTunes	230～270
iGoogle	80～100
楽天(Rakuten)	50～60
Amazon	90
HMV	100
YouTube	90

Courtesy of NTT, see also:
Hiroshi Esaki: ***www2.jp.apan.net/meetings/kaohsiung2009/presentations/ipv6/esaki.ppt***

Issues with CGN

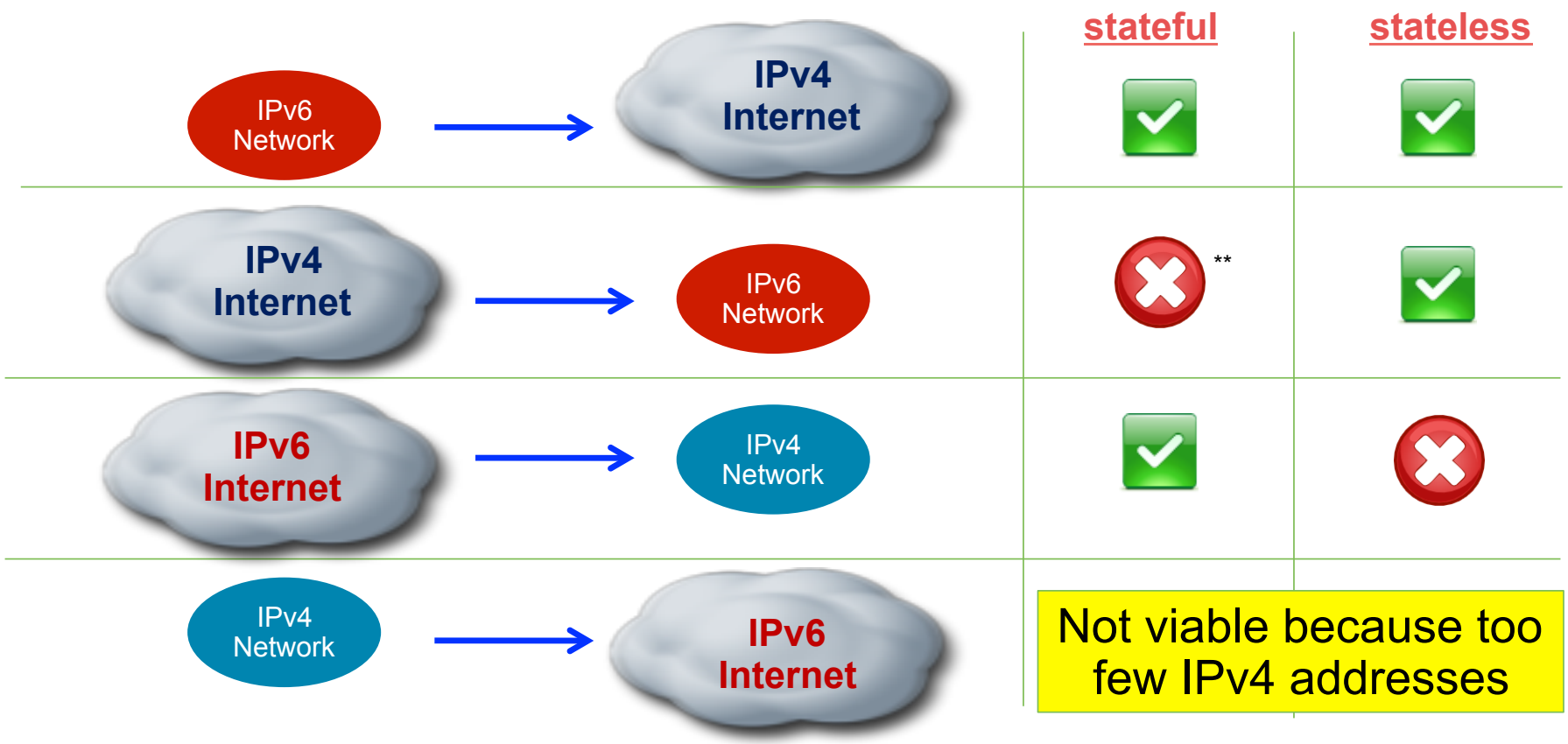
- Application Layer Gateways
  FTP (EPSV, PASV), some CGN solutions have minimal ALG support
- All connections come from translator's Public IPv4 address
  Problems for: Abuse logging, Identity, Geo-location, DOS attacks (tracking & determining)
- All translations will need to be logged
- More application will break as less per-user ports become available
  /24 assuming 60,000 useable ports

# of CGN users	Ratio (Users:IP)	Ports available per user
1,000	4:1	15360
5,000	20:1	3072
10,000	40:1	1536
15,000	60:1	1024
20,000	80:1	768


BUT WHEN SHE TRACED THE KILLER'S IP ADDRESS... IT WAS IN THE 192.168/16 BLOCK!
GASP!

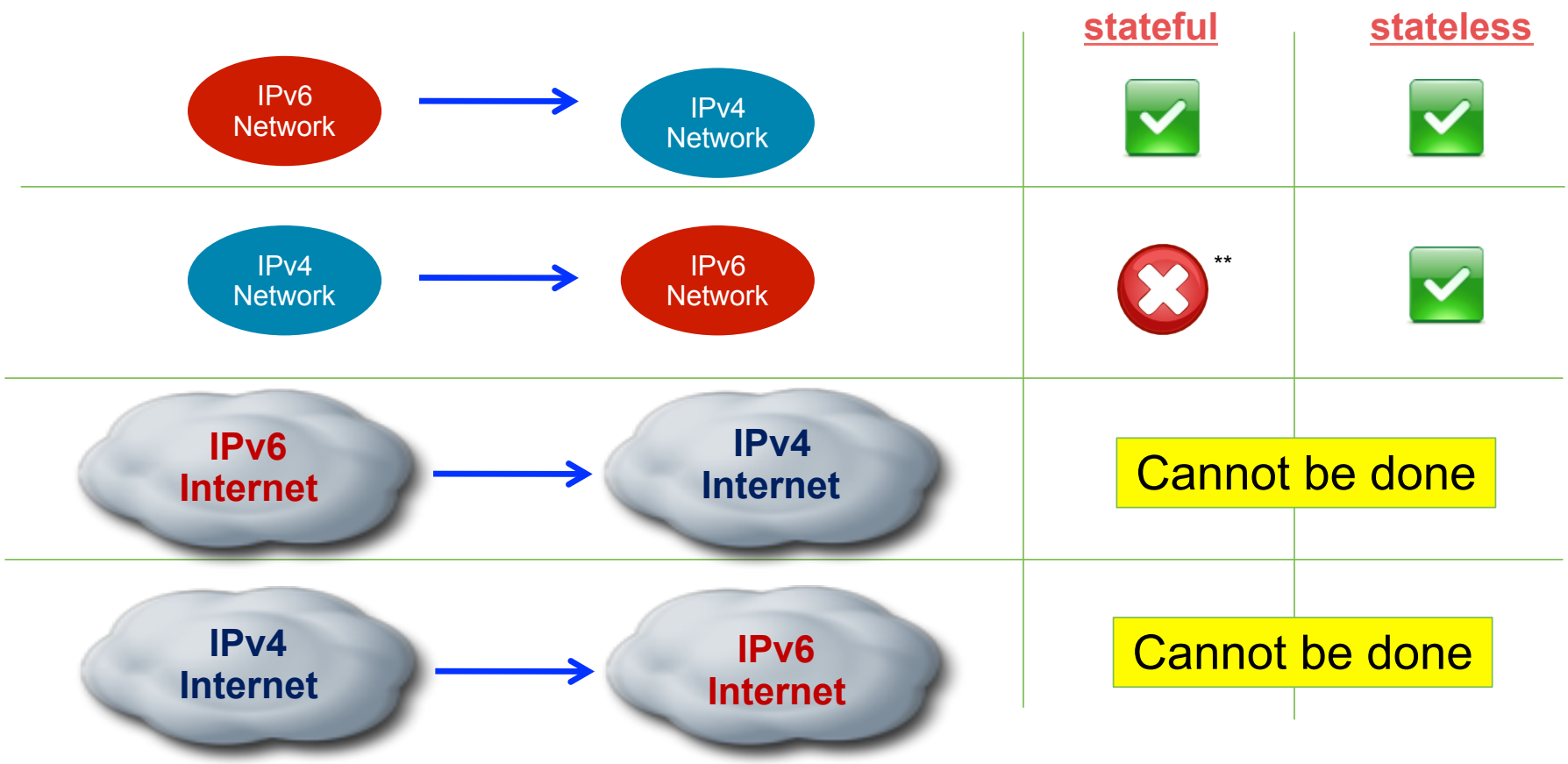
NAT64

IPv4/IPv6 Translation Framework Scenarios



**Possible with nat64 v6v4 static mappings

IPv4/IPv6 Translation Framework Scenarios



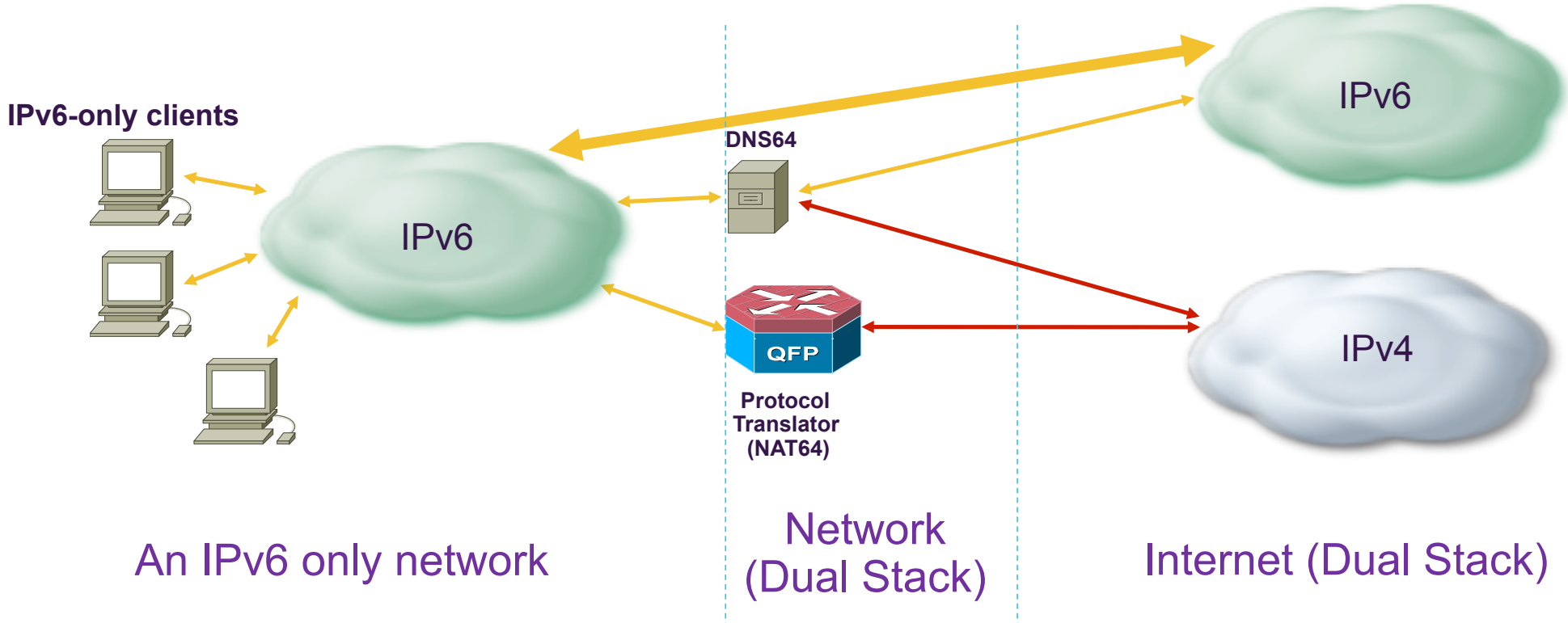
**Possible with nat64 v6v4 static mappings

IPv6/IPv4 Translation: Two Scenarios

- Connecting an IPv6 network to the IPv4 Internet
  - You built an IPv6-only network, and want to access servers on the IPv4 Internet
  - Example: IPv6-only mobile devices

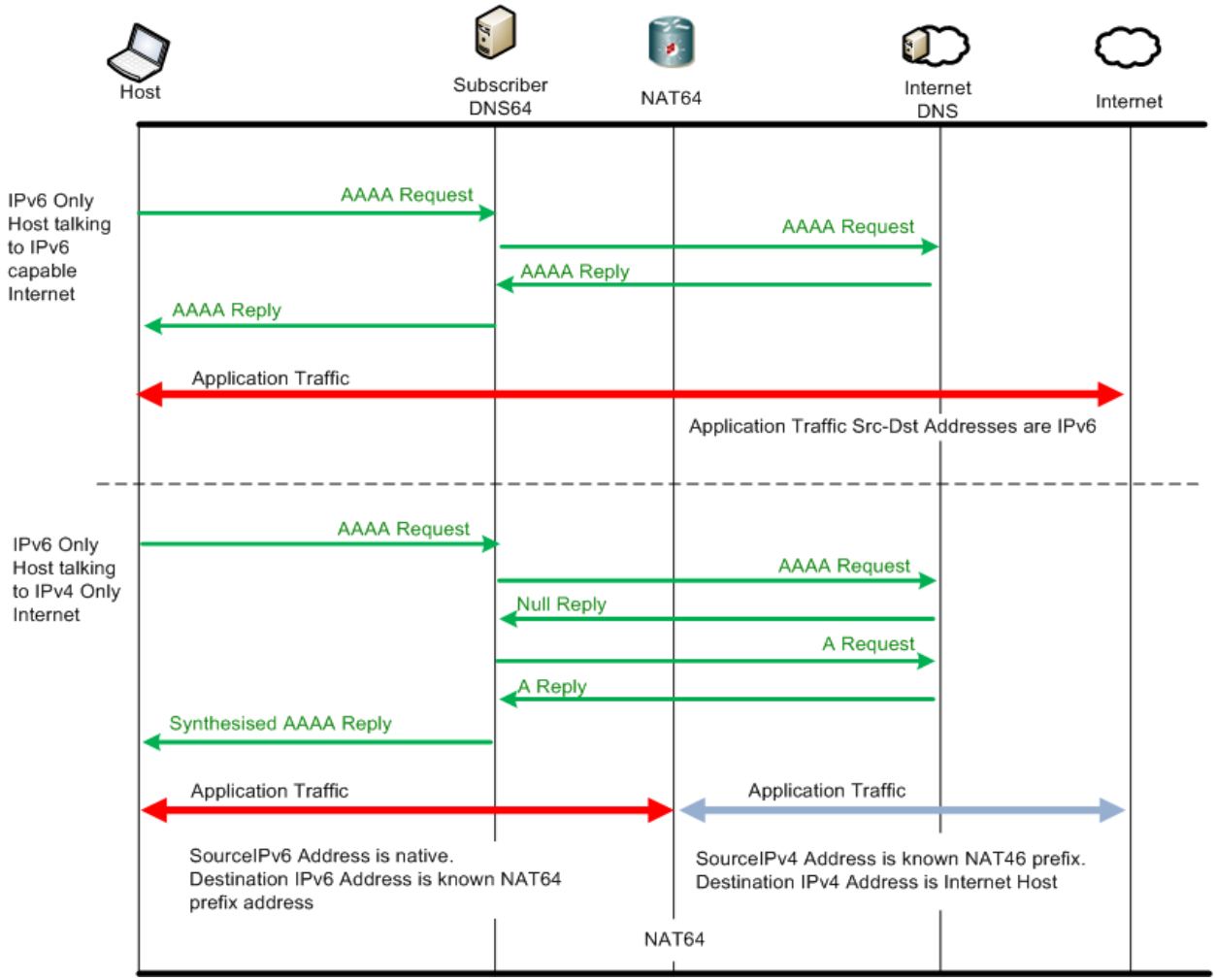
- Connecting the IPv6 Internet to an IPv4 network
  - You have IPv4 servers, and want them available to the IPv6 Internet
  - Example: IPv4-only datacenter (HTTP servers) but are mandated to provide an IPv6 presence.

Connecting an IPv6 only network to the IPv4 Internet

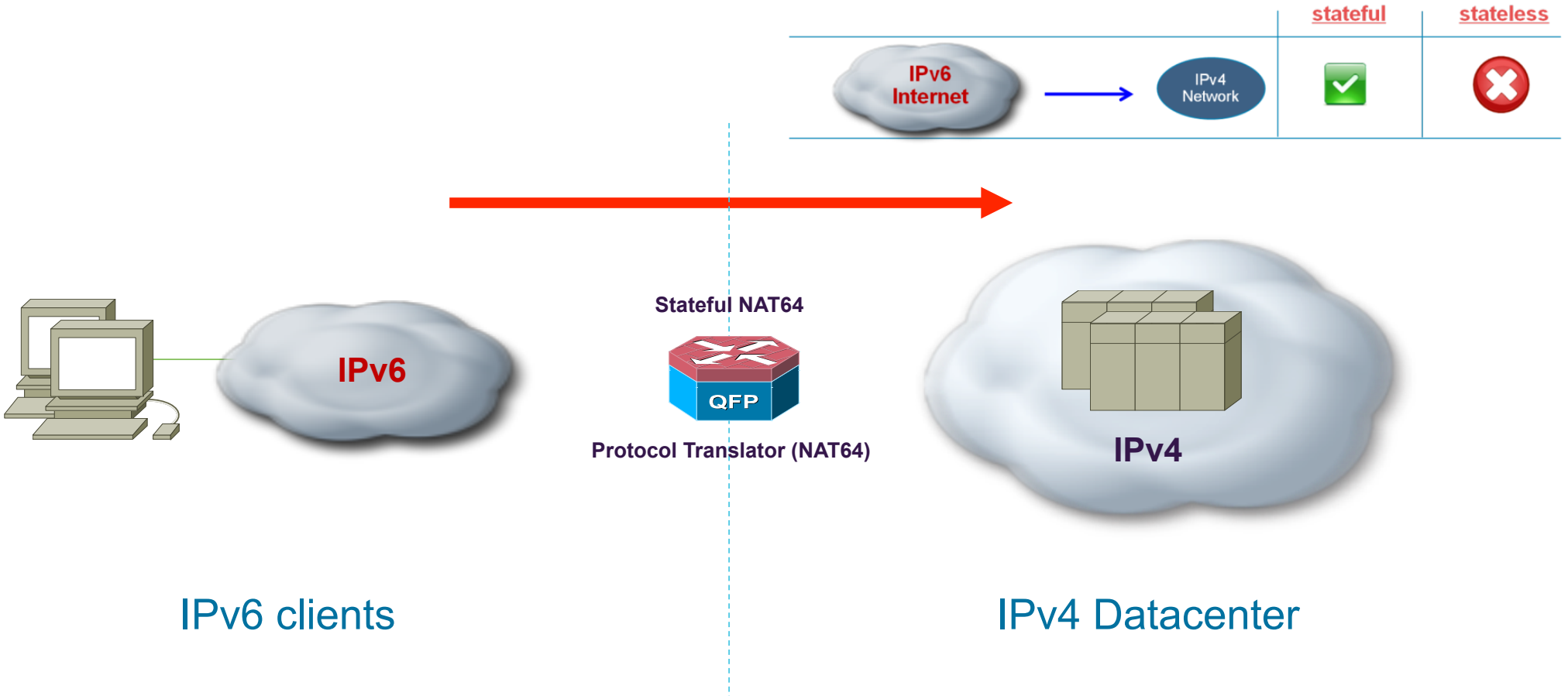


http://www.cisco.com/en/US/prod/collateral/iosswrel/ps6537/ps6553/white_paper_c11-676278.html

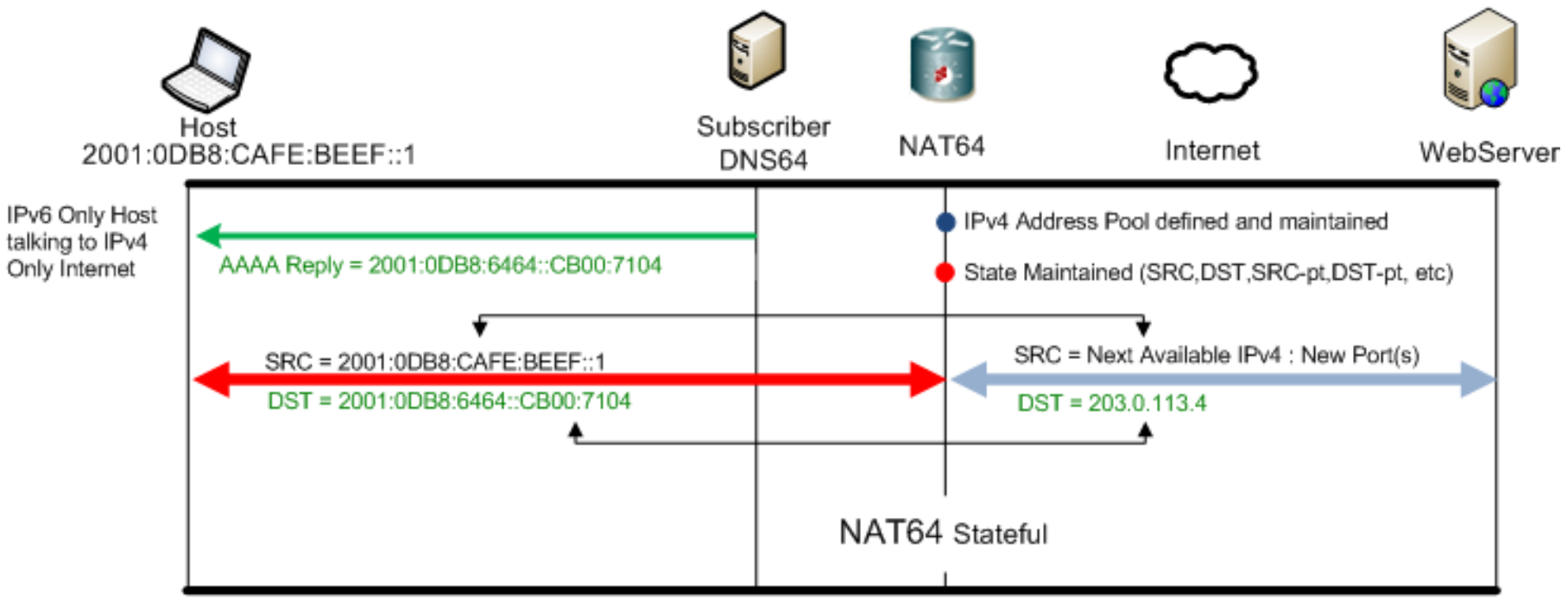
DNS64 flows



IPv6 Into IPv4-Only Datacenter



Stateful NAT64



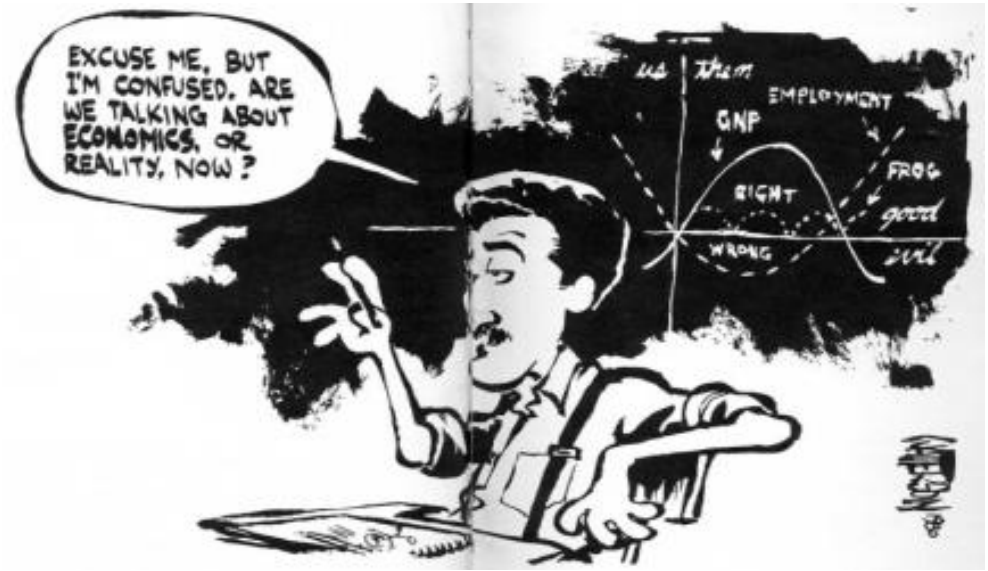
Key:
203.0.113.4 = CB00:7104

Issues with NAT64

- DNS64 works where applications do DNS queries, doesn't work where applications don't.
  - Badly coded application will always be an issue
  - Application that use literals will be an issue (SIP, RTSP, H.323, etc.)
- NAT64 works where there are no payload literals
  - Application that use literals will be an issue (SIP, RTSP, H.323, etc.)
- Stateful NAT64 only supports TCP, UDP & ICMP
- Application Layer Gateway, or application proxy
  - FTP (EPSV, PASV), some NAT64 solutions have minimal ALG support
- All connections come from translator's public IPv4 address
  - Problem for abuse logging, identity, geo-location, DOS attacks (tracking & determining)
  - Lack of 'X-Forwarded-For' header on router based NAT64
- All translations need to be logged
- Same TCP port limitations as in CGN

IPv6 Economics

Realities

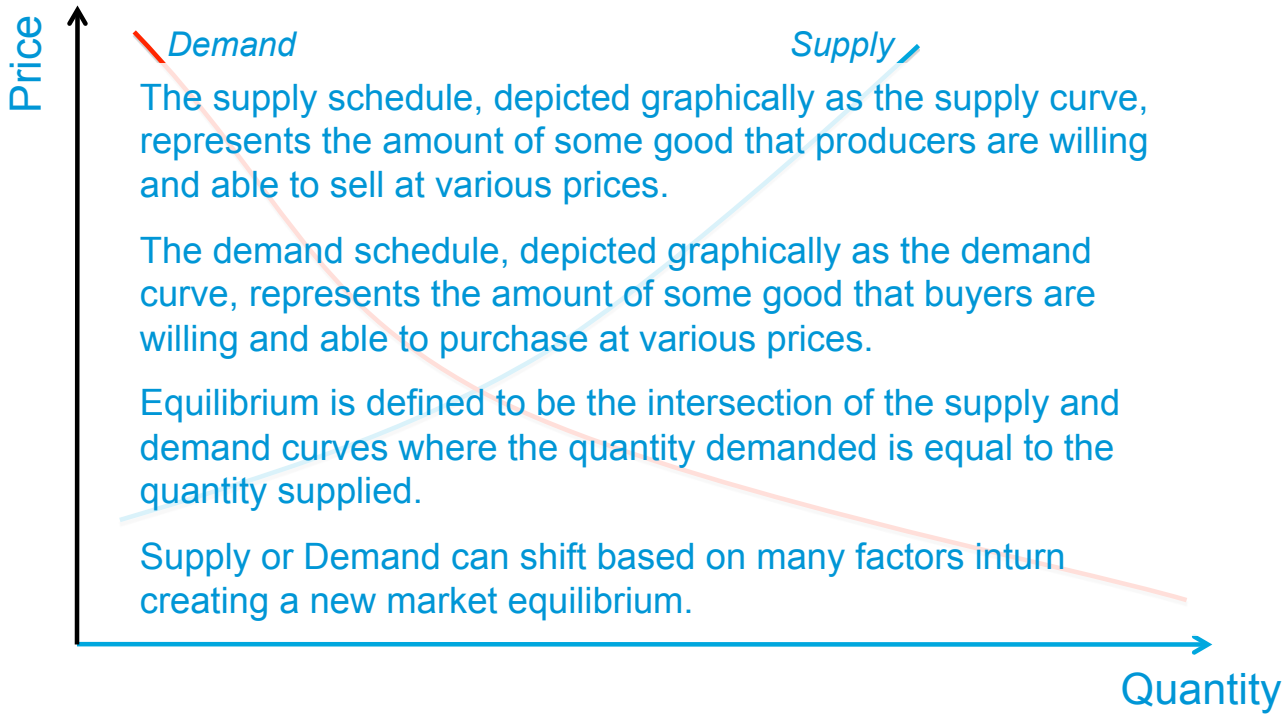


NOTE: I am not an economist.

Citing References

- The following slides have been kindly provided by Geoff Huston (www.potaroo.net), I apologise in advance for any mis-representation.

Economics 101
The Supply Demand Schedule



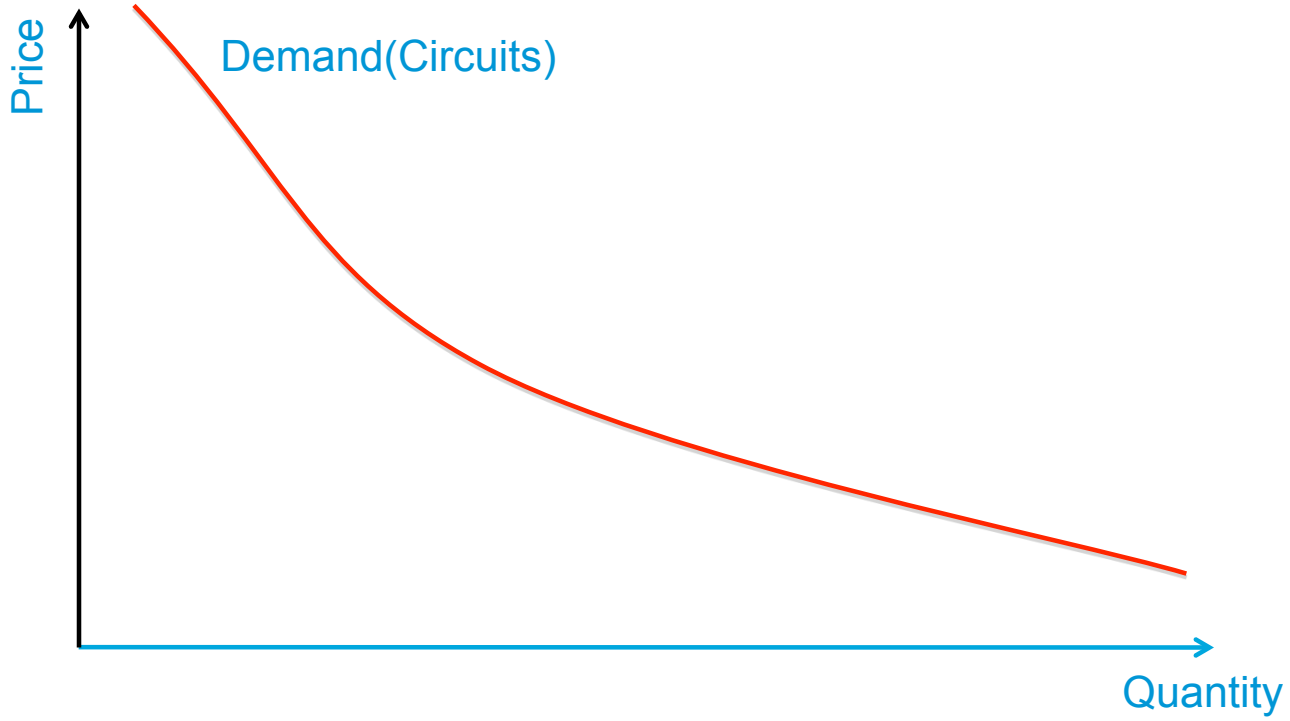
The supply schedule, depicted graphically as the supply curve, represents the amount of some good that producers are willing and able to sell at various prices.

The demand schedule, depicted graphically as the demand curve, represents the amount of some good that buyers are willing and able to purchase at various prices.

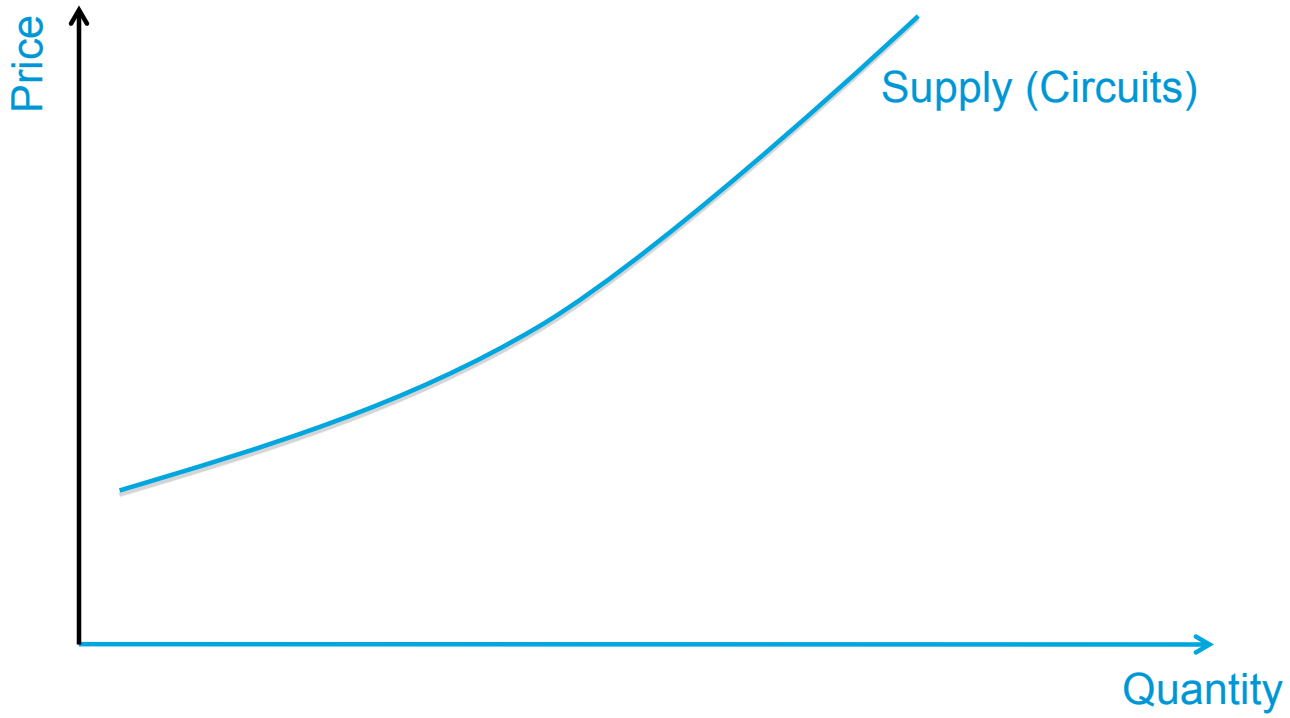
Equilibrium is defined to be the intersection of the supply and demand curves where the quantity demanded is equal to the quantity supplied.

Supply or Demand can shift based on many factors inturn creating a new market equilibrium.

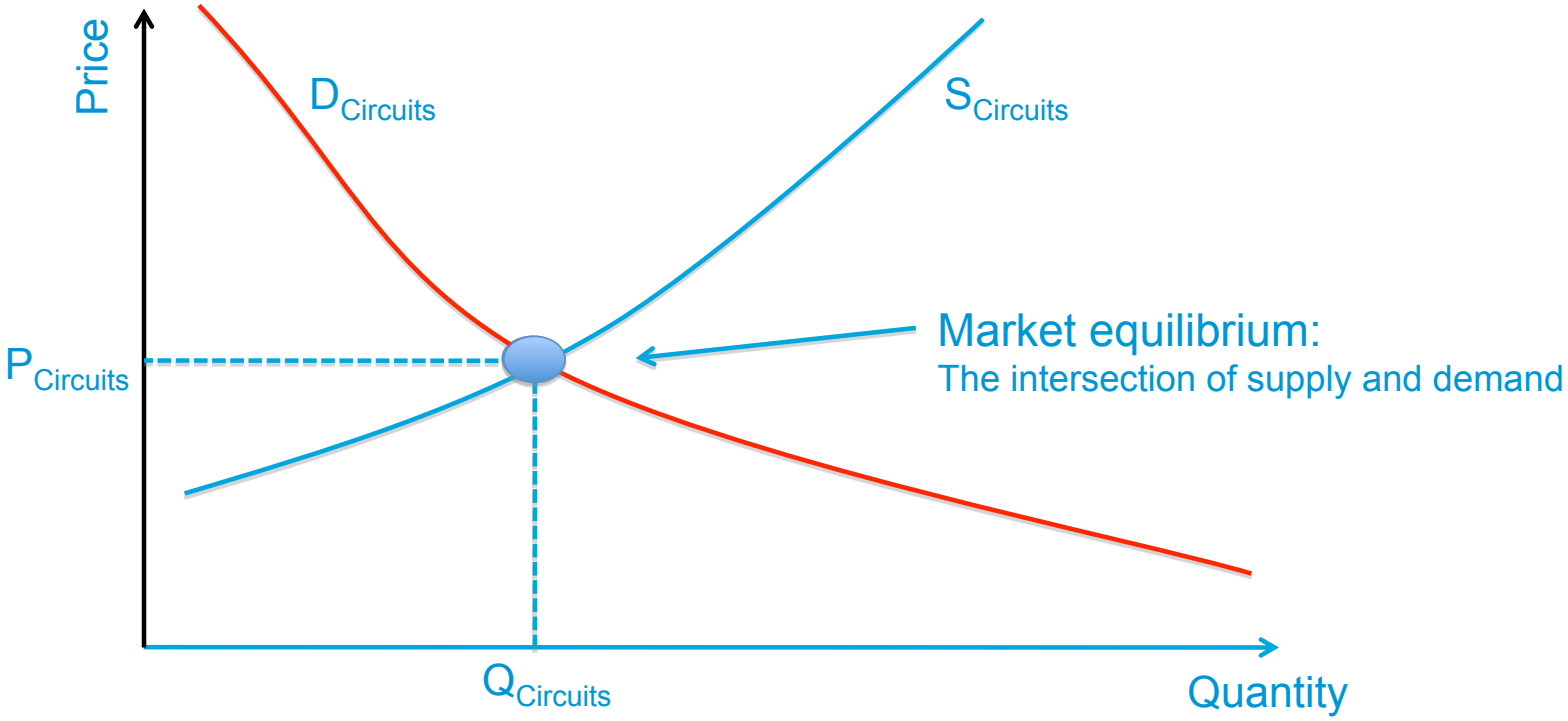
The Demand Schedule
Consumers



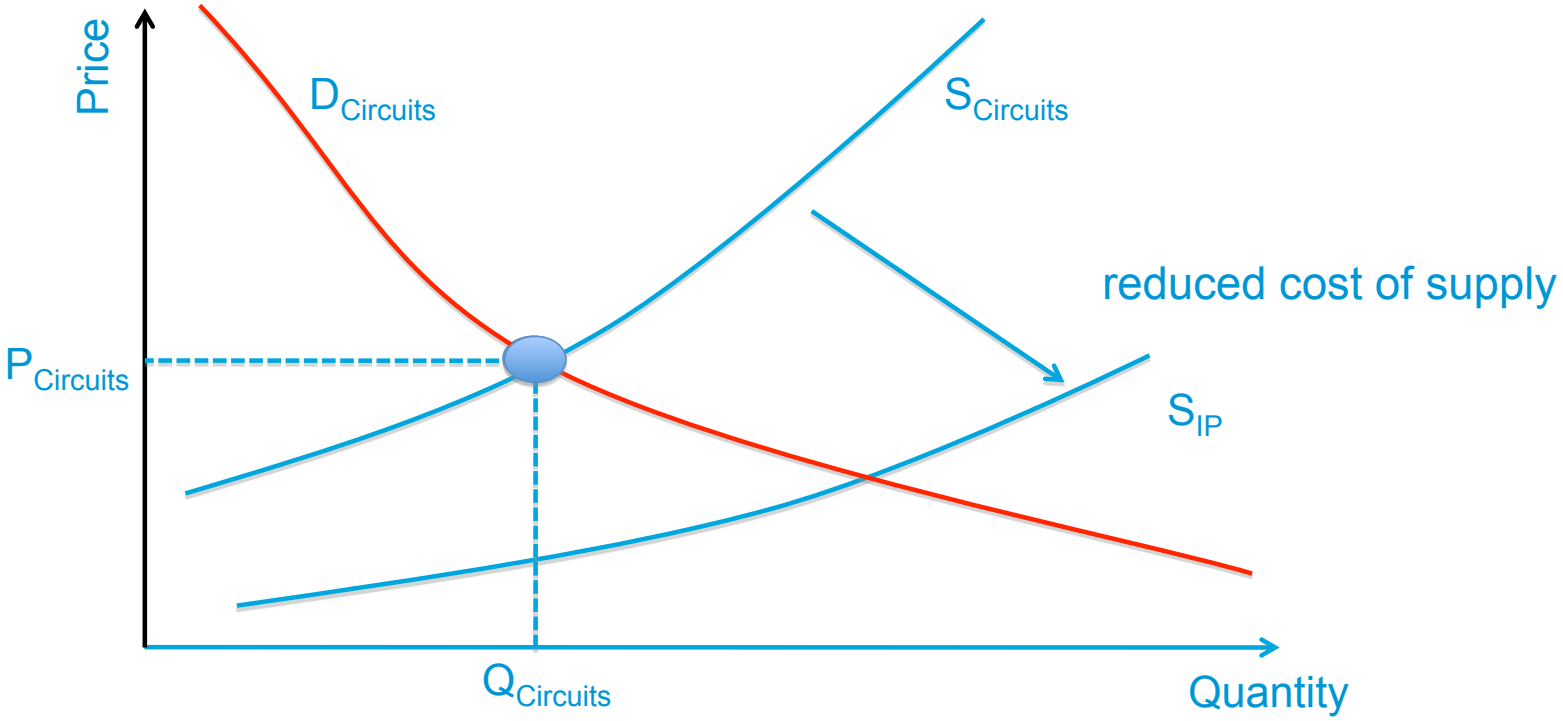
The Supply Schedule
Producers



The Supply Demand Schedule
Equilibrium Point

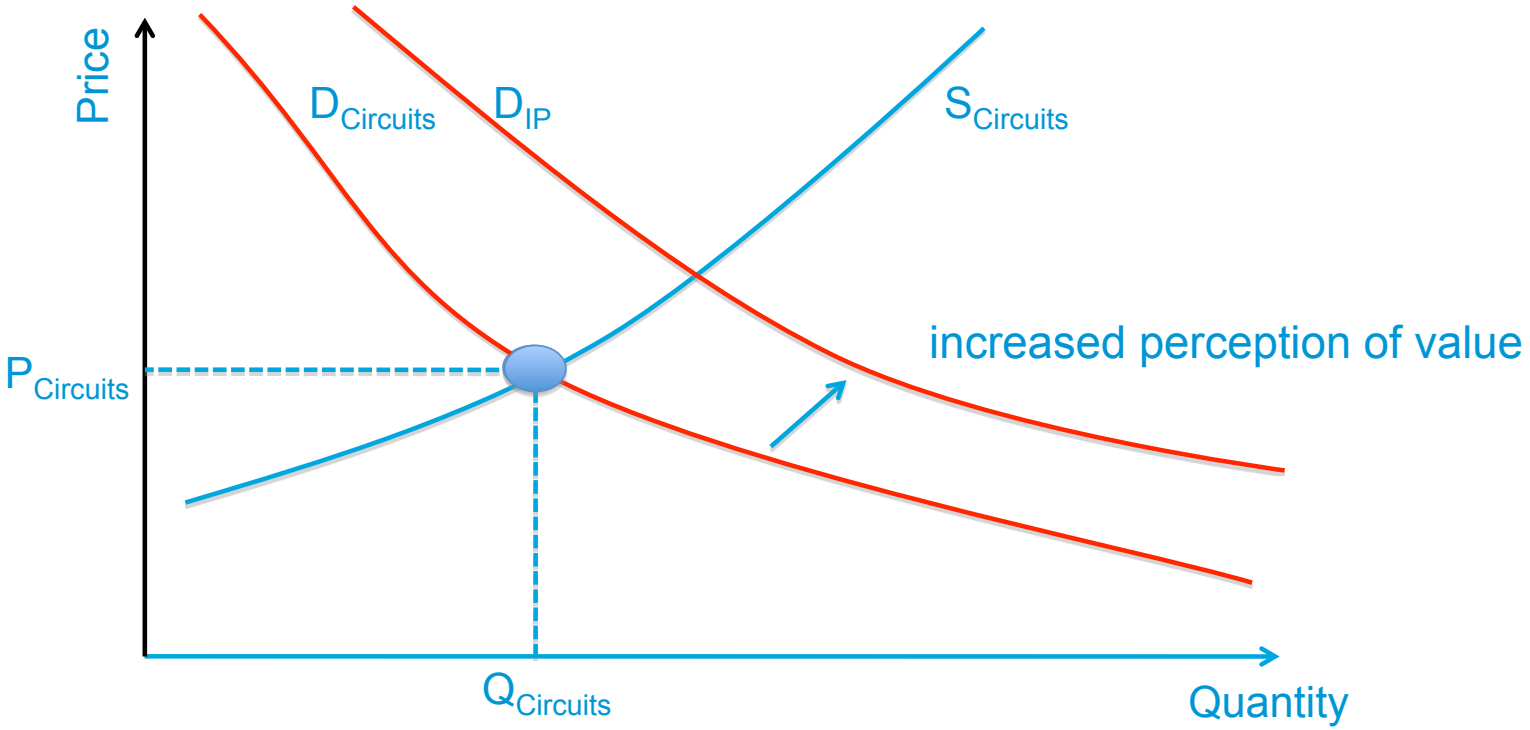


The Supply Schedule Shift
Circuits to Packets Supply



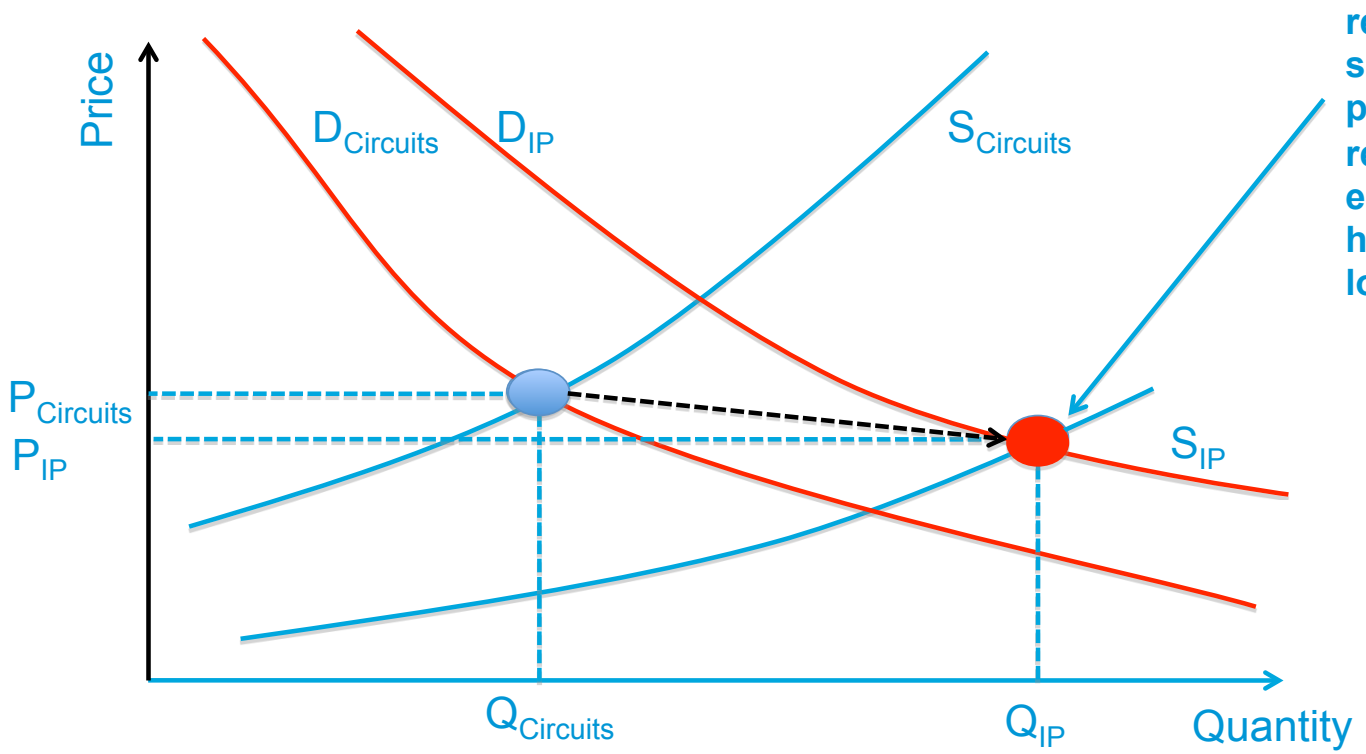
The Demand Schedule Shift

Circuits to Packets Demand



The Supply Demand Schedule

Circuits to Packets the new equilibrium



reduced cost of supply, and increased perception of value, resulting in a new equilibrium point with higher quantity and lower unit price

IPv6 vs. IPv4

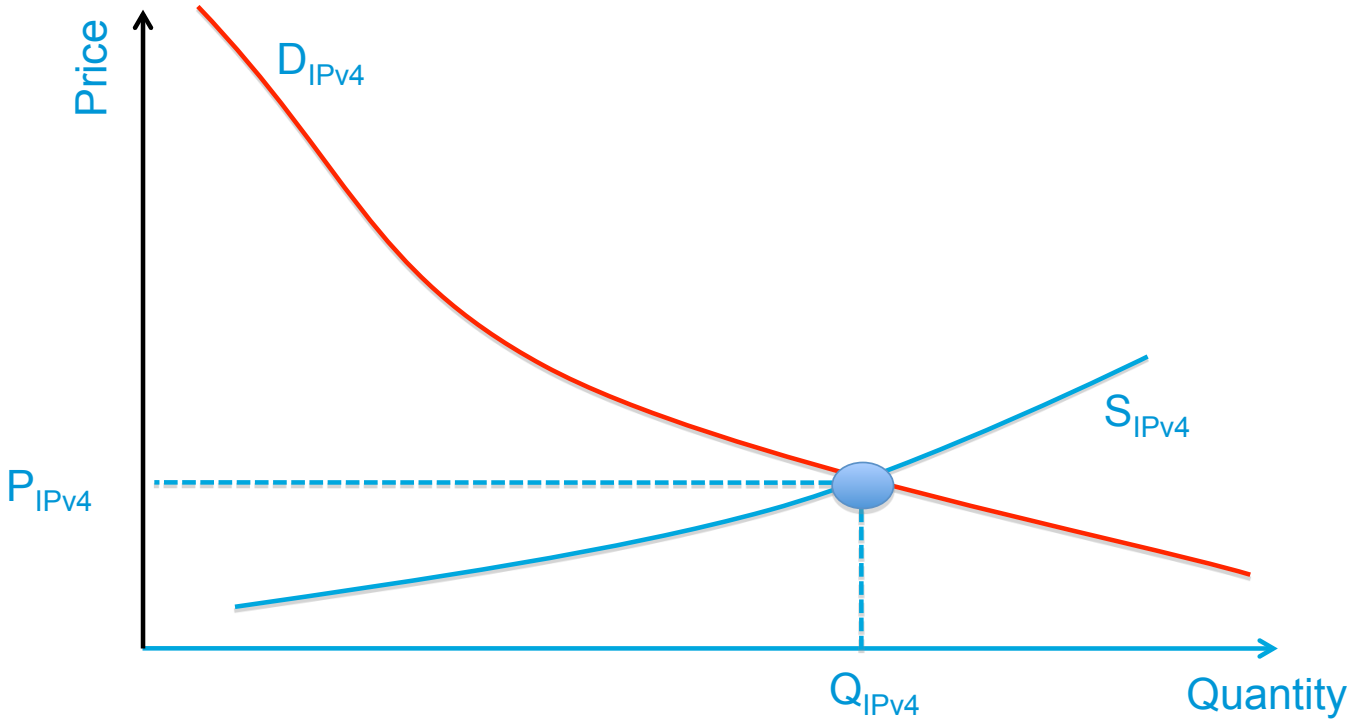
Are there any *competitive differentiators*?

- Is the $cost_{v4}$ = $cost_{v6}$?
  - No, there is a cost associated with implementing IPv6
- Is the $functionality_{v4}$ = $functionality_{v6}$?
  - Yes, they are both transports, so no difference

Also:

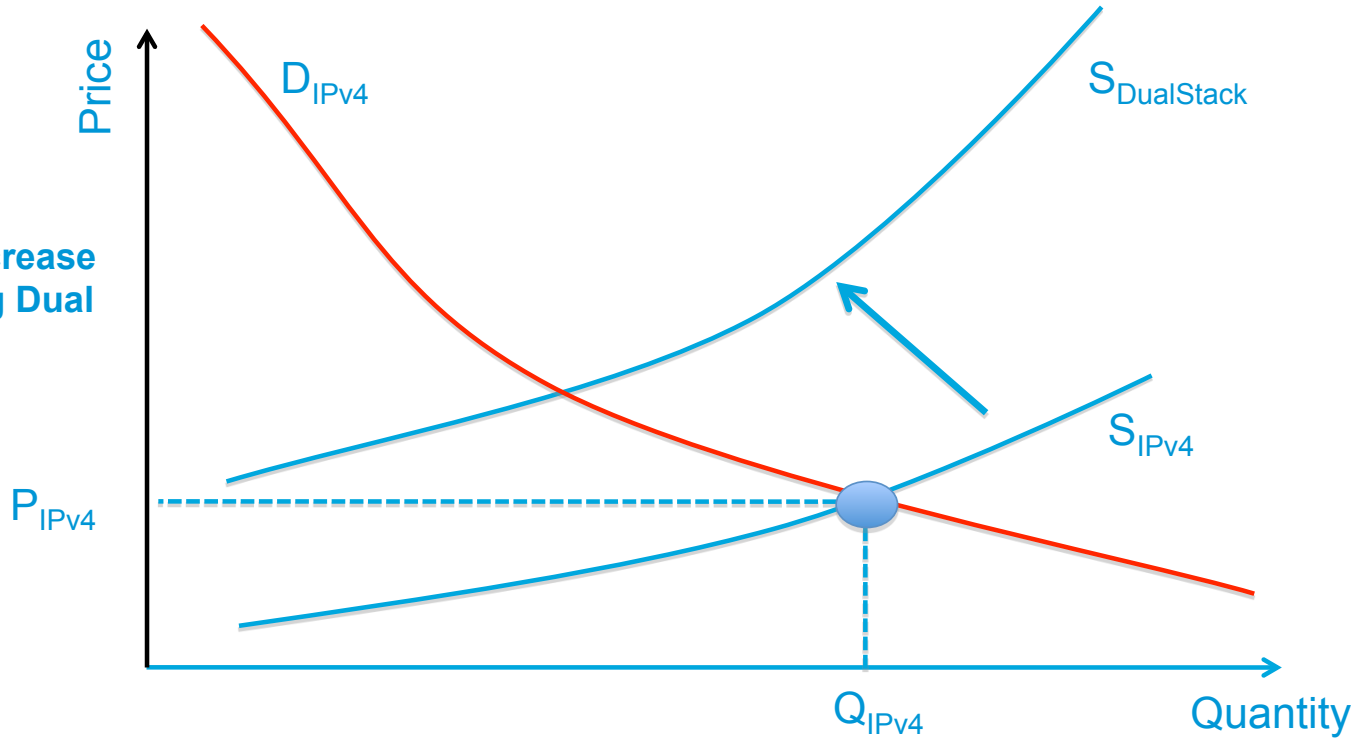
- no inherent consumer-visible difference or demand
- hard to monetise IPv6
- adoption enables hedging by the provider against *future risk*

The Supply Demand Schedule
Baseline - Existing IPv4



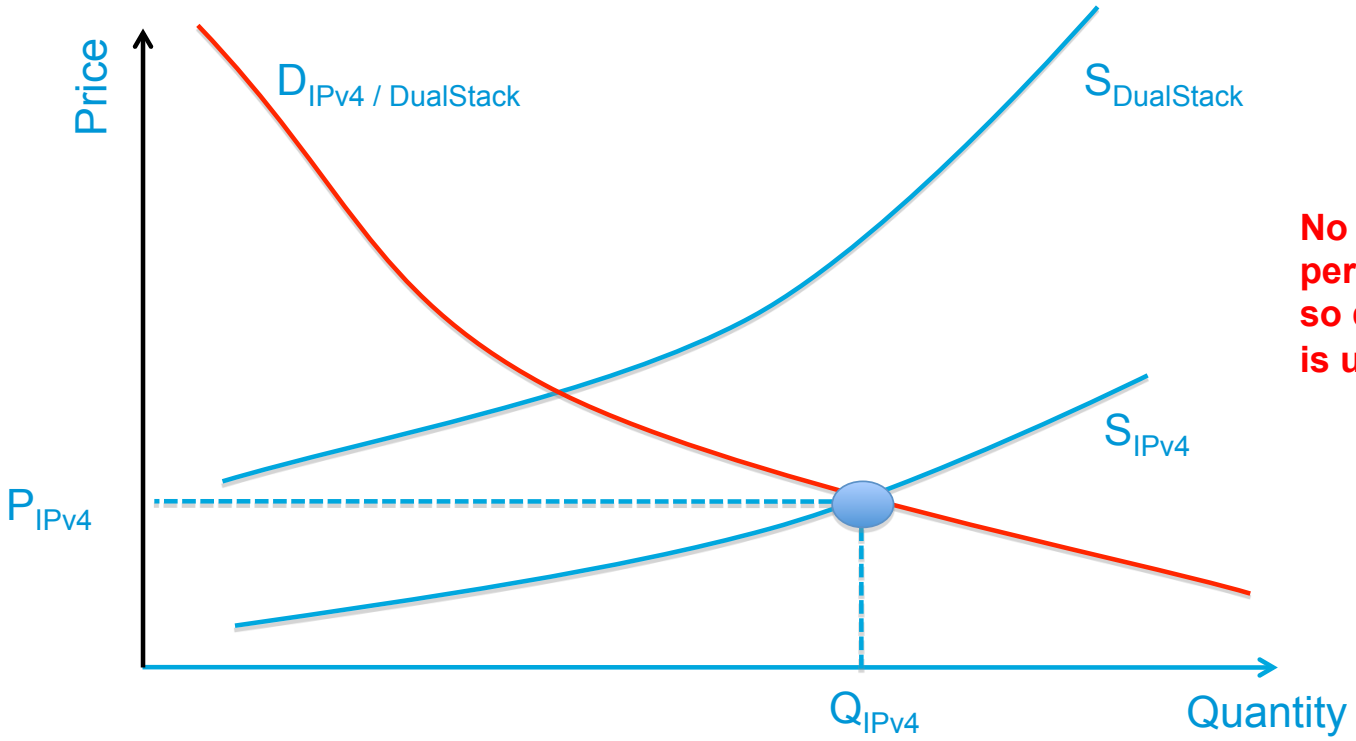
The Supply Schedule Shift
Adopting Dual Stack Supply

Supply side cost increase due to implementing Dual Stack operation



The Demand Schedule Shift

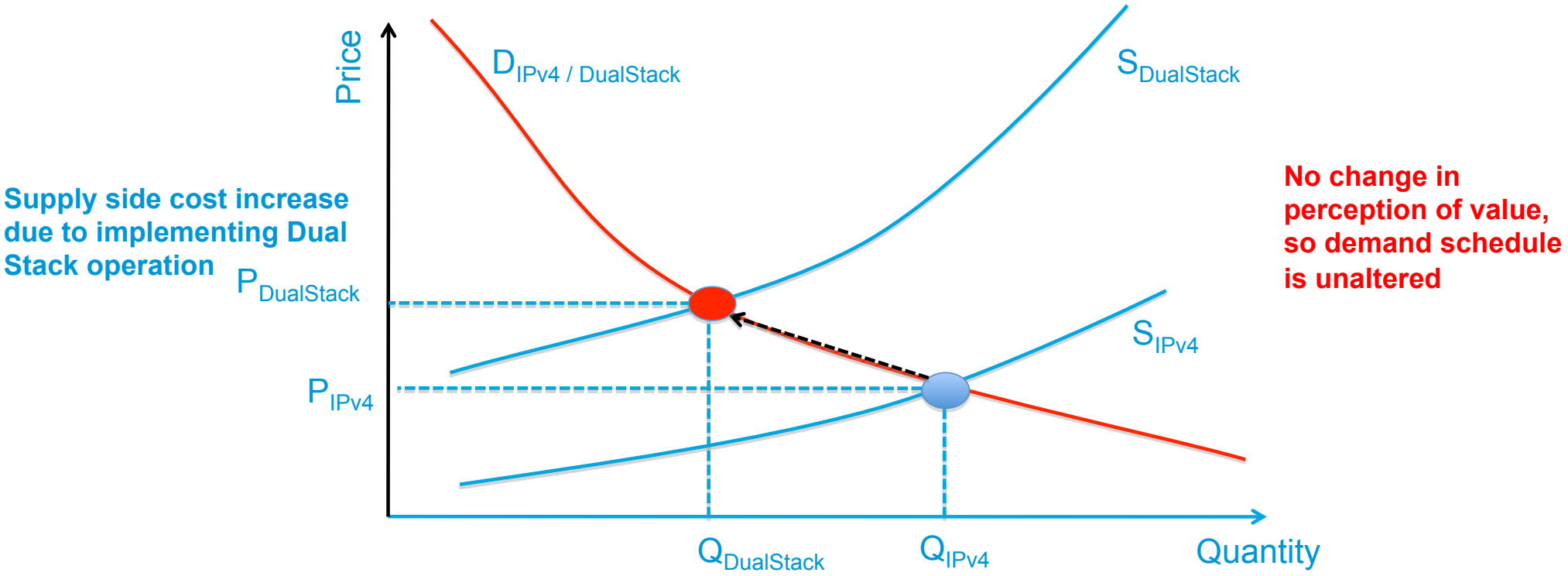
Adopting Dual Stack Demand



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

The Supply Demand Schedule

Adopting Dual Stack the new equilibrium

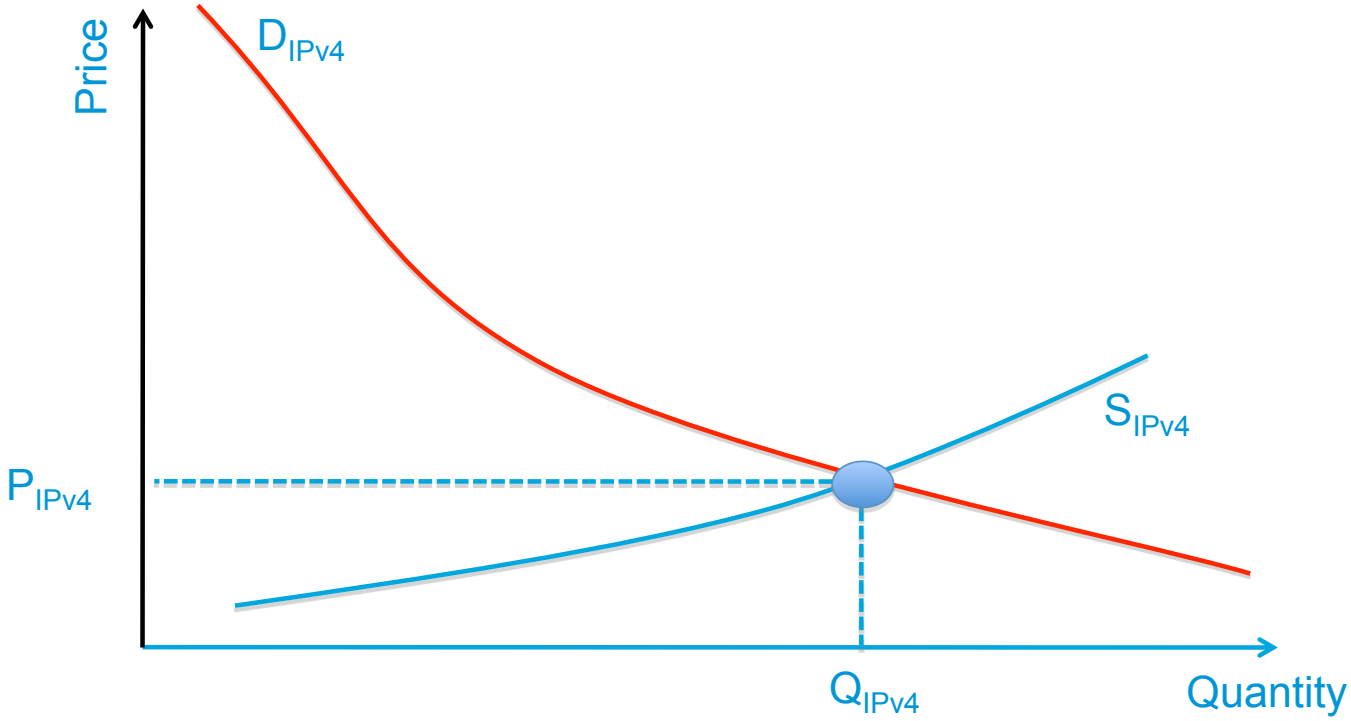


- **Equilibrium point is at a lower quantity if Dual Stack supply costs are passed on to customers**

What About IPv4 Exhaustion?

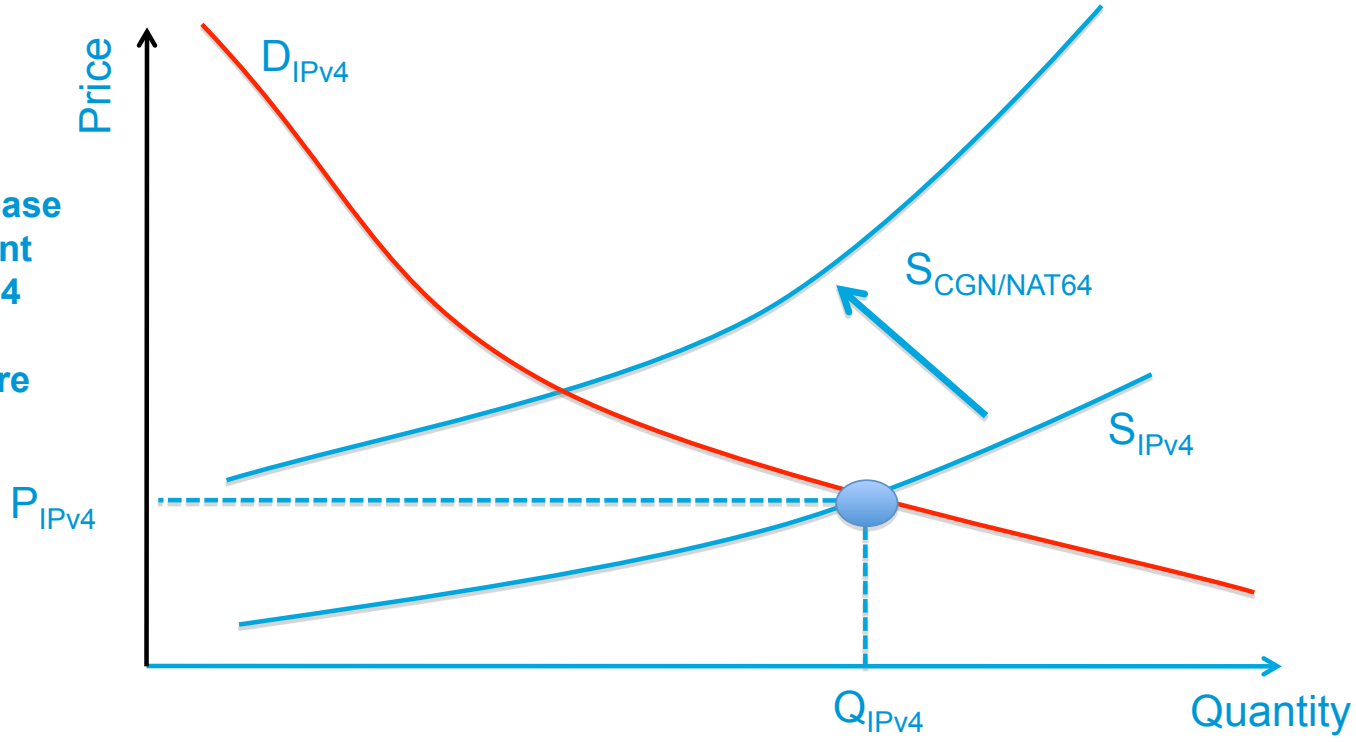
- Does IPv4 address exhaustion change this picture?
- What are the economic implications of service providers adding NAT444 or NAT64 as a service offering ?
- Should we drive deeper NAT444 solutions ?

The Supply Demand Schedule
Baseline - Existing IPv4

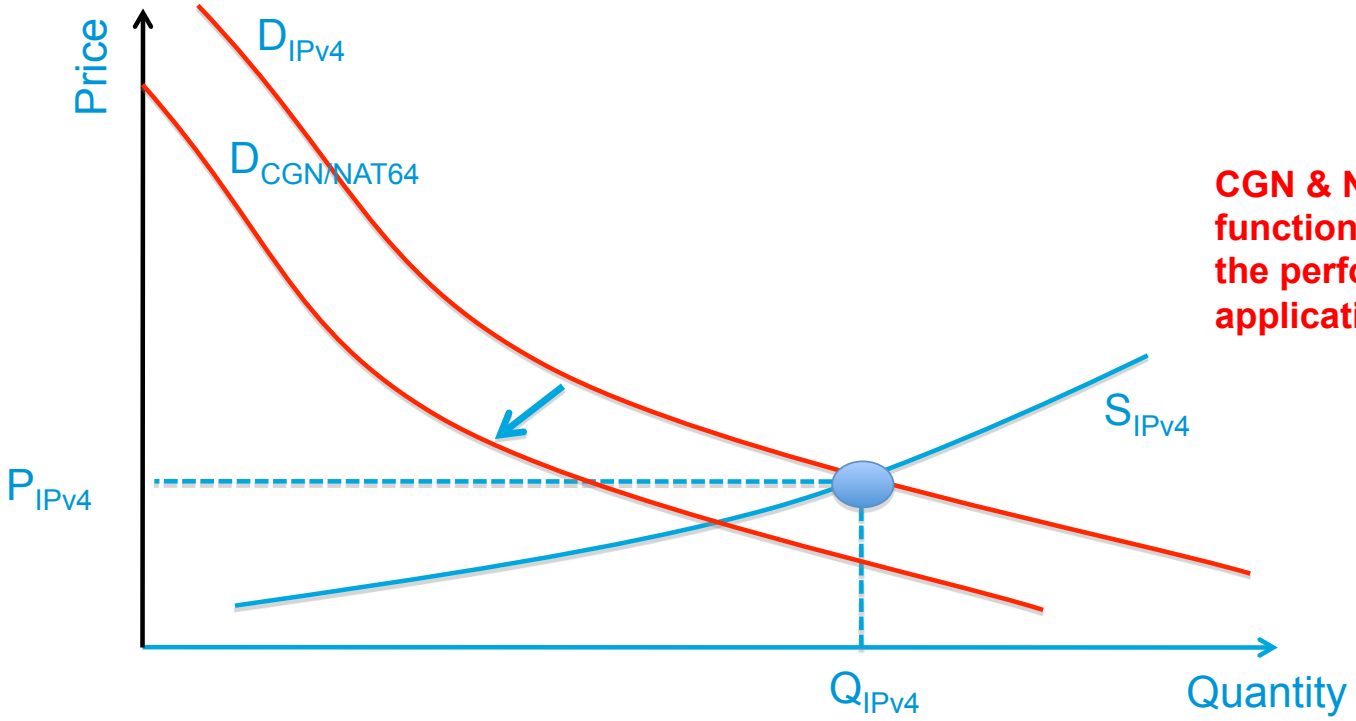


The Supply Schedule Shift
Adding CGN / NAT64 Supply

Supply side cost increase due to SP's requirement to deploy a CGN/NAT64 solution within the network's infrastructure



The Demand Schedule Shift
Adding CGN / NAT64 Demand

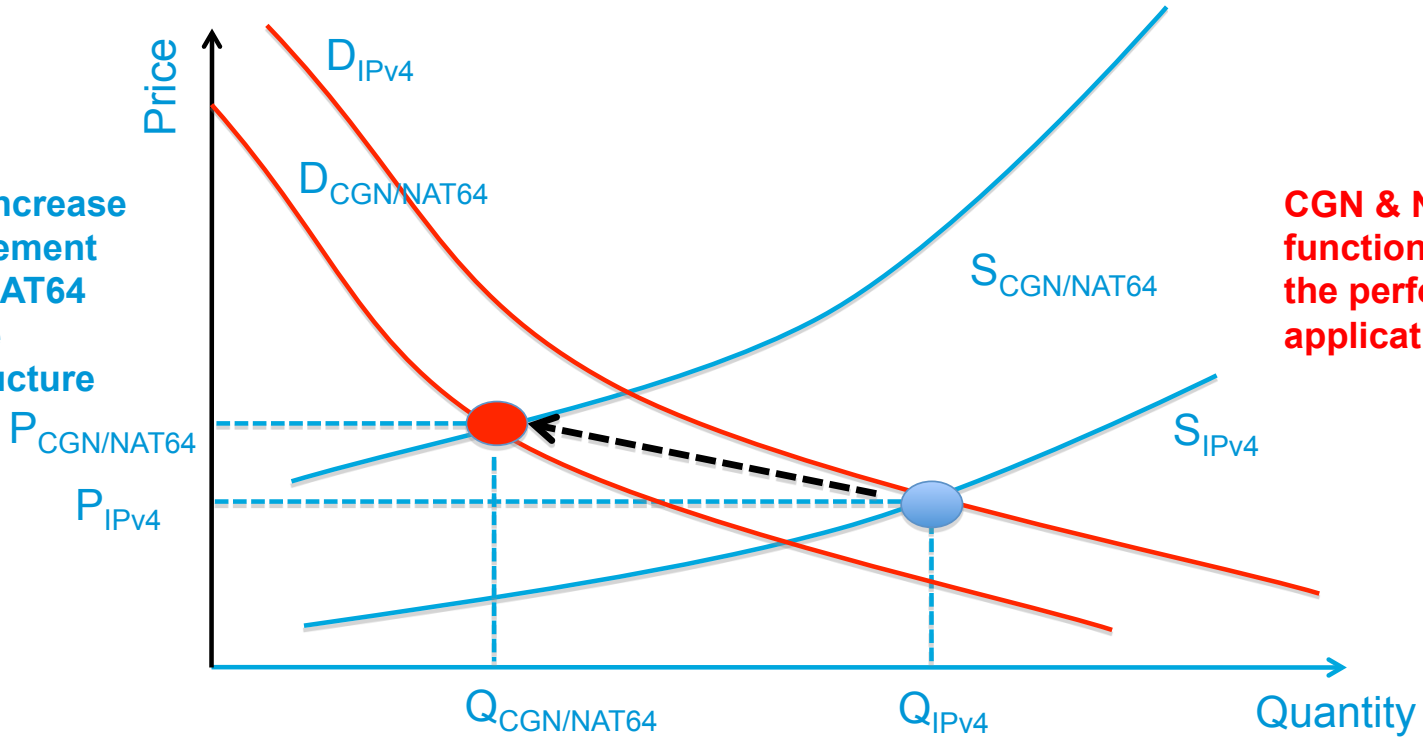


CGN & NAT64 reduces functionality and impairs the performance of some applications

The Supply Demand Schedule

Adding CGN / NAT64 the new equilibrium

Supply side cost increase due to SP's requirement to deploy a CGN/NAT64 solution within the network's infrastructure



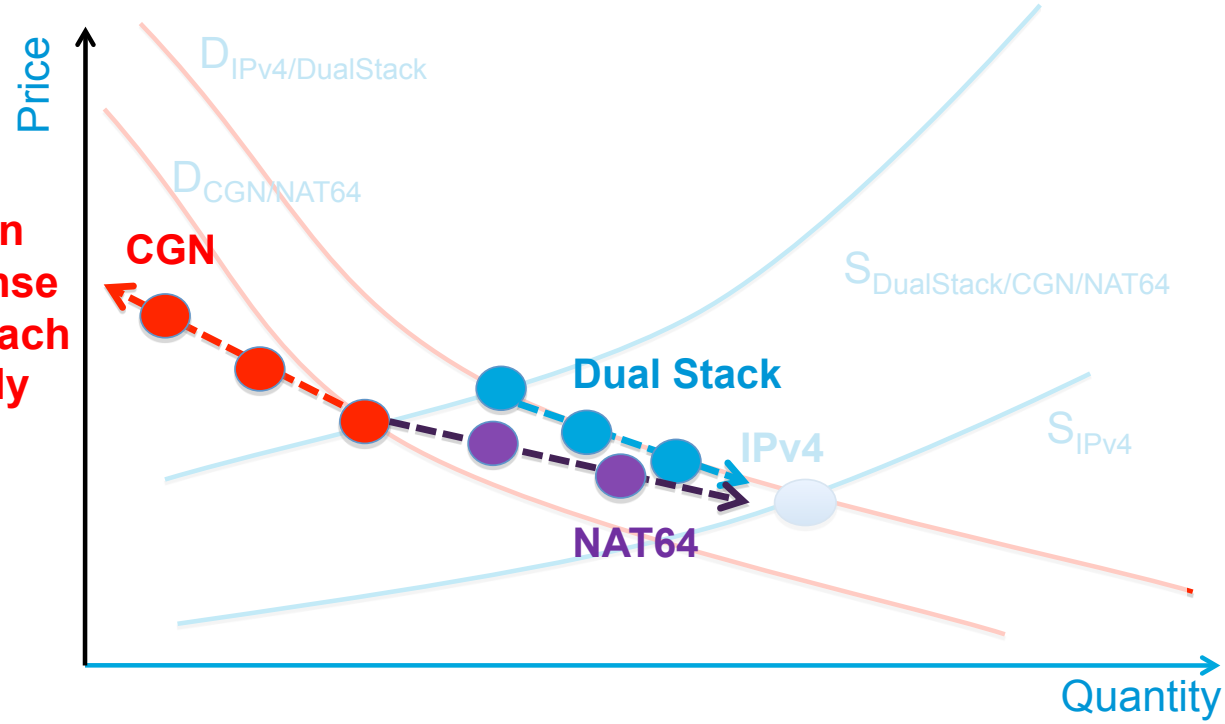
CGN & NAT64 reduces functionality and impairs the performance of some applications

- Equilibrium point of CGN & NAT64 represent higher cost and lower value for customers
- Even if costs are not passed on, cannot escape perceived change in service & issues

The Schedule Shift over Time

CGN, NAT64 or Dual Stack?

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



As Dual Stack becomes more prevalent economies of scale push down costs

As more native IPv6 is deployed NAT64 becomes less of a requirement. NAT64 services trend towards Dual Stack

Conclusion

- The market will go through a transitional phase before stability is reached
  - Should consumers pay more for the same, or a lesser service than they get today ?
- Dual Stack is the better long term option (This should be your goal)
- Translation is evil, though some are a bit more evil than others
  - Pick your translation technology carefully. Only apply it where you must.
- CGN/NAT444 is a short term fix that buys you the time to do an IPv6 deployment
  - Long term CGN/NAT444 deployments will only get worse and more expensive over time.
- NAT64 is a hybrid of both CGN/NAT444 and Dual Stack, though becomes better over time as more native IPv6 becomes available and there is less dependency on NAT64
  - NAT64 is painful now, though gets better and cheaper over time
- Good Luck

Thank you.