Intelligence at the Edge: the Evolution of IP Communications

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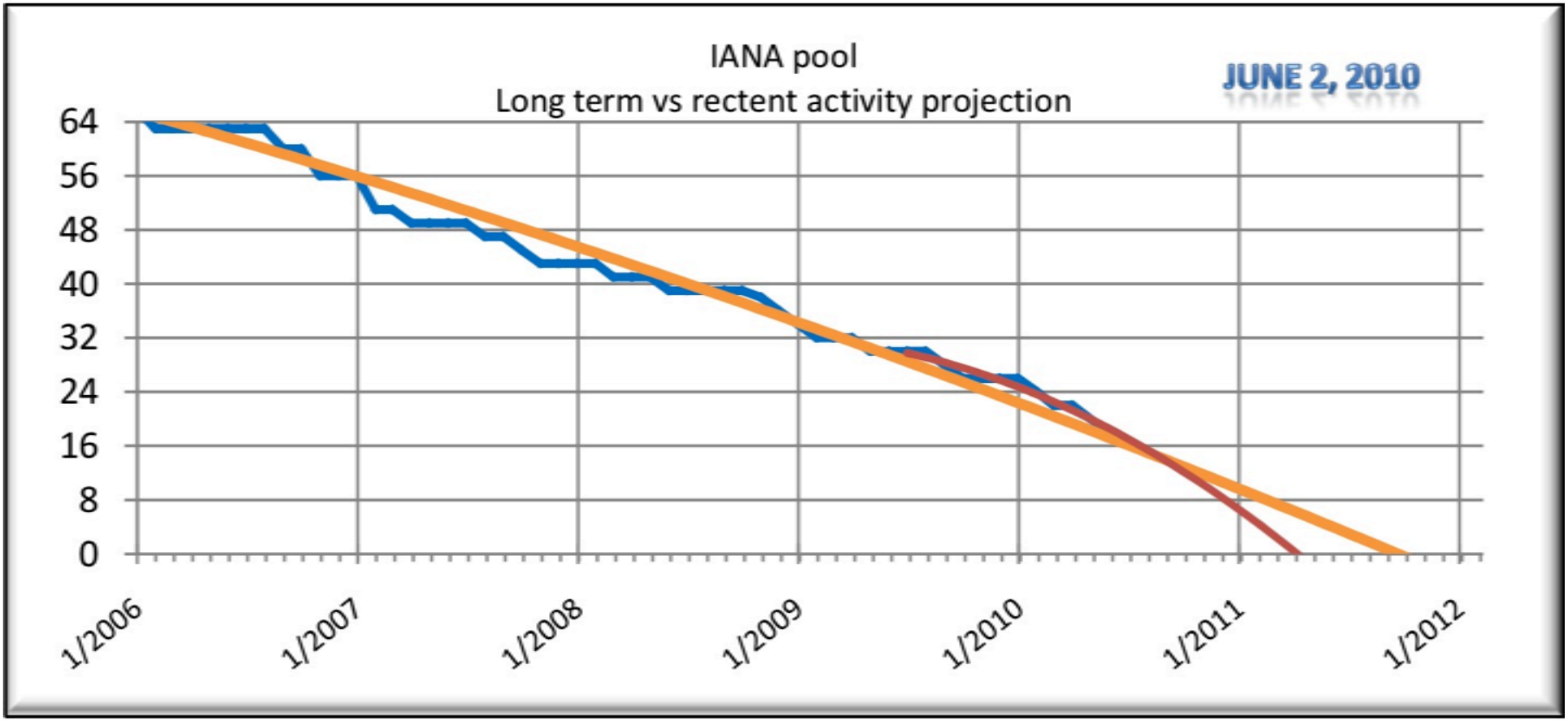
Why IPv6?

Why did the IETF design IPv6?

- Running out of IPv4 addresses
  - *Except it was 1992 and statistically we expected to run out in 1993-1994*
- Response to the issue:
  - RFC 1550: IP: Next Generation (IPng) White Paper Solicitation
    - Four responses, resulting in IPv6 – RFCs 1883, 1884, 1885, 1886
    - Also, description of GSE and the NIMROD Routing Architecture
  - CIDR deployed by RIRs and incorporated into routing protocols – RFCs 1517, 1518, 1519, 1520, early 1990's
    - Also OSPFv2, IS-IS, BGP, and RIPv2
  - RFC 1918 private addresses, and implementation of Network Address Translation
- IPng ultimately resolved to IPv6.
  - We didn't know it would take 15 years to deploy

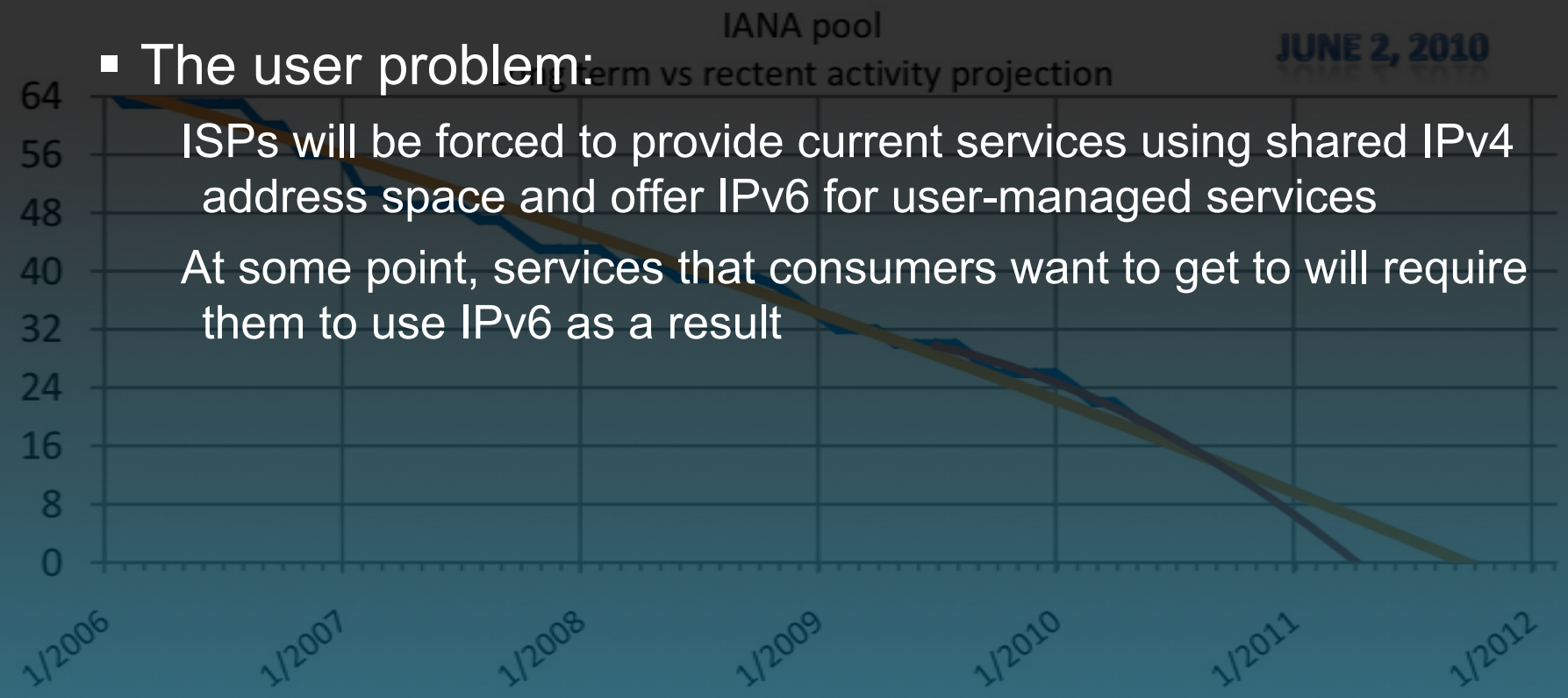
The issue of address depletion

- The ISP problem:
  - The Internet that is deployed will continue to run
  - But it will be harder for ISPs and edge networks to deploy new services and add new customers



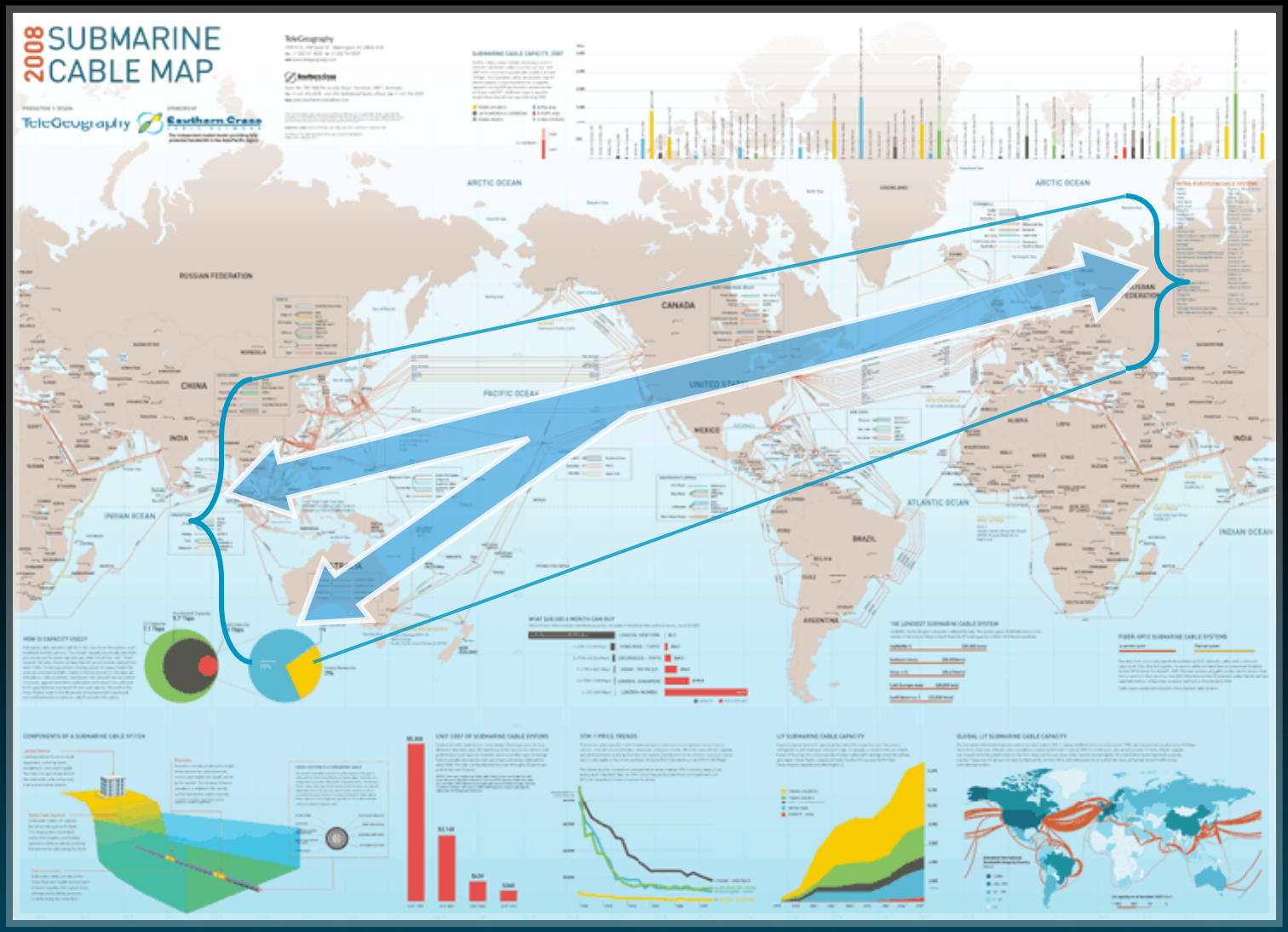
The issue of address depletion

- The ISP problem:
  - The Internet that is deployed will continue to run
  - But it will be harder for ISPs and edge networks to deploy new services and add new customers
- The user problem:
  - ISPs will be forced to provide current services using shared IPv4 address space and offer IPv6 for user-managed services
  - At some point, services that consumers want to get to will require them to use IPv6 as a result



Where Is the Broadband Internet Today?

The Europe/America/East Asia/ANZ Fiber Corridor



Map copyright 2008 TeleGeography

Power, and by Extension, Money, Throughout the World

Today

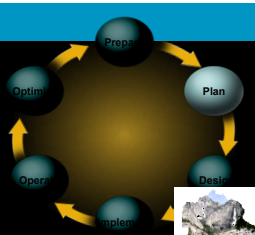
IPv4 Address space throughout the world today

IPv6 penetration and deployment

Who is implementing/adopting IPv6?

- Originally, the research networks and communities
  - Internet II, Renater, CERNET2, TWAREN, AARNET, …
  - Commercial Networks in Japan: NTT, IIJ, KDDI, …
- Large companies, major ISPs, and content providers
  - Facebook, Google, …
  - Comcast, Free.fr, Verizon, AT&T, …
- Governments
- Starting to hear of
  - ISPs losing customers over lack of IPv6 offerings in RFI/RFP responses, which suggests that auditors are driving enterprise customers to require IPv6 service even if they don't buy it today.
  - IPv6-only networks operated by various providers

IPv6 enabled web sites *(growing list at sixy.ch)*



http://[2001:470:d:2ed::1]

OCKELBO

http://[2001:b48:12:1::2]

Sandviken Kommun
http://[2001:b48:10::3]

HD

Helsingborg Dagblad
http://[2001:2040:2000::6]

SOUTHWEST GREENS
GRASS SOLUTIONS

http://[2001:470:1:1d::d8da:84ea]

http://[2001:470:0:e6::4a52:2717]

keenspot COMICS

http://[2001:470:1:3a::13]

The Comedy Corner

http://[2001:440:fff9:100:202:b3ff:fea4:a44e]

Google

Google Search | I'm Feeling Lucky

清華新闻网
News.tsinghua.edu.cn

http://[2001:da8:200:200::4:28]

http://[2001:252:0:1::2008:6]

GovHK香港政府一站通

http://[2406:0:6a:4::167]

comcast

http://[2001:558:1004:9:69:252:76:96]

Limelight NETWORKS

http://[2607:f4e8:12:fffe:230:48ff:fe96:f99e]

NETFLIX

http://[2620:0:ef0:13::20]

facebook

http://[2620:0:1cfe:face:b00c::3]

AXCELX
"Business Services that Excel"

http://[2001:4830:20e0:1::5]

AussieHQ
Making the web work for you.

http://[2405:5000:1:2::99]

FDC SERVERS

http://[2001:49f0:1000::3]

SOFTLAYER™

http://[2607:f0d0:1000:11:1::2]

LOOPIA

http://[2a02:250::6]

BLACKNIGHT SOLUTIONS

http://[2a01:a8:0:5::26]

FreeBSD

http://[2001:4f8:fff6::21]

WIRESHARK

http://[2607:f0d0:3001:62:1::53]

NTP POOL PROJECT

http://[2607:f238:2::51]

FXnetworks

http://[2402:6000:200:100::4]

Internode

http://[2001:44b8:8020:f501:250:56ff:feb3:6633]

NTT Communications

http://[2001:218:2001:3005::8a]

HURRICANE ELECTRIC
INTERNET SERVICES

http://[2001:470:0:64::2]

free

http://[2a01:e0c:1:1599::1]

BAHNHOF

http://[2001:9b0:1:104:230:48ff:fe56:31ae]

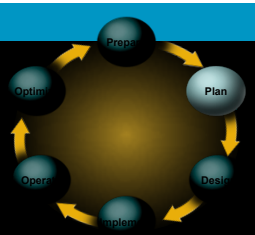
6IX Euro6IX

http://[2a01:48:1:0:2e0:81ff:fe05:4658]

SixXS

http://[2001:838:1:1:210:dcff:fe20:7c7c]

What trouble can I get into?



Business Challenges

- Avoid natural tendency to ignore IPv4 complexity as ‘cost of doing business’ while highlighting explicit costs to add IPv6.
- IPv6 can lead to less complex, easier to manage, implementation and operations

  Enables greater ROI over time from emerging and new business apps
- Natural evolution to improve operations, productivity, and service

  Could just replace 1:1, but ask:

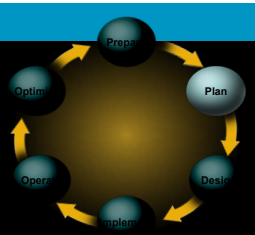
‘Where does the network need to be in 3-5 years?’

‘Which applications and services will be expected?’

(mobility, virtual presence, …)

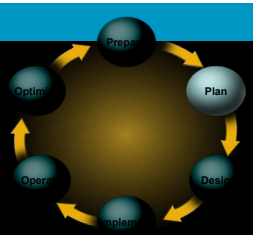
Business Risks

- Staff training – reducing perceived service level
- Network management tools – scripts and commercial products ignoring the IPv6 deployment
- Awareness – Microsoft will tunnel unless there is native service
- Applications – not providing IPv6 support before IPv4 is missing from part of the network or a partner
- Multi-homing – Global address allocation policy for enterprise deployments
- Traffic patterns – old wan traffic models dominated by client/server apps, new by peer-to-peer collaboration tools
- Timing – deployment being forced in short order by a partner interaction rather than planned and orderly over time



Business - Costs

- The largest cost for most network managers will be training.
  - Related but different protocol.
- Another major cost will be retooling custom apps and scripts.
  - Frequent coding shortcuts assume an address will always be 32 bits.
- Is IPv6 deployment an opportunity to integrate other engineering changes that have not been large enough to justify by themselves?
  - What costs will be attributed to IPv6 vs. general evolution?



Adoption Spectrum

- Mostly or completely past the “why?” phase
- Assessment (e2e)
- Weeding out vendors (features and $)
- Focus on training and filling gaps

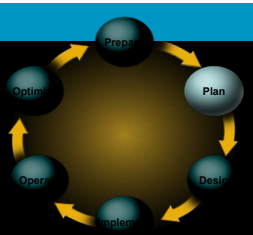
Kicking the tires

Pilot/Early Deployment

Production/ Looking for parity and beyond

- Is it real?
- Do I need to deploy everywhere?
- Equipment status?
- SP support?
- Addressing
- What does it cost?

- Still fighting vendors
- Content and wide-scale app deployment
- Review operational cost of 2 stacks
- Competitive/Strategic advantages of new environment



IPv6 Deployment strategy

Train the architects

Protocol differences create an operational experience vacuum

Develop addressing plan

use any initial /32 for infrastructure or labs ; get a real block for customers

customer prefix delegation on nibble boundary to align with ptr authority

Enable core & PE routers

dual-stack, with tunneling where necessary to align with life-cycle

Enable support services

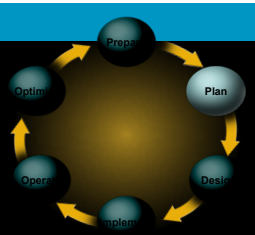
dual-stack the servers, populate DNS AAAA, configure AAA, deploy management and monitoring tools

Establish peering

encourage content sites to deploy to minimize the need for IPv4/IPv6 nat

Enable customers

tunnel over legacy distribution media where necessary

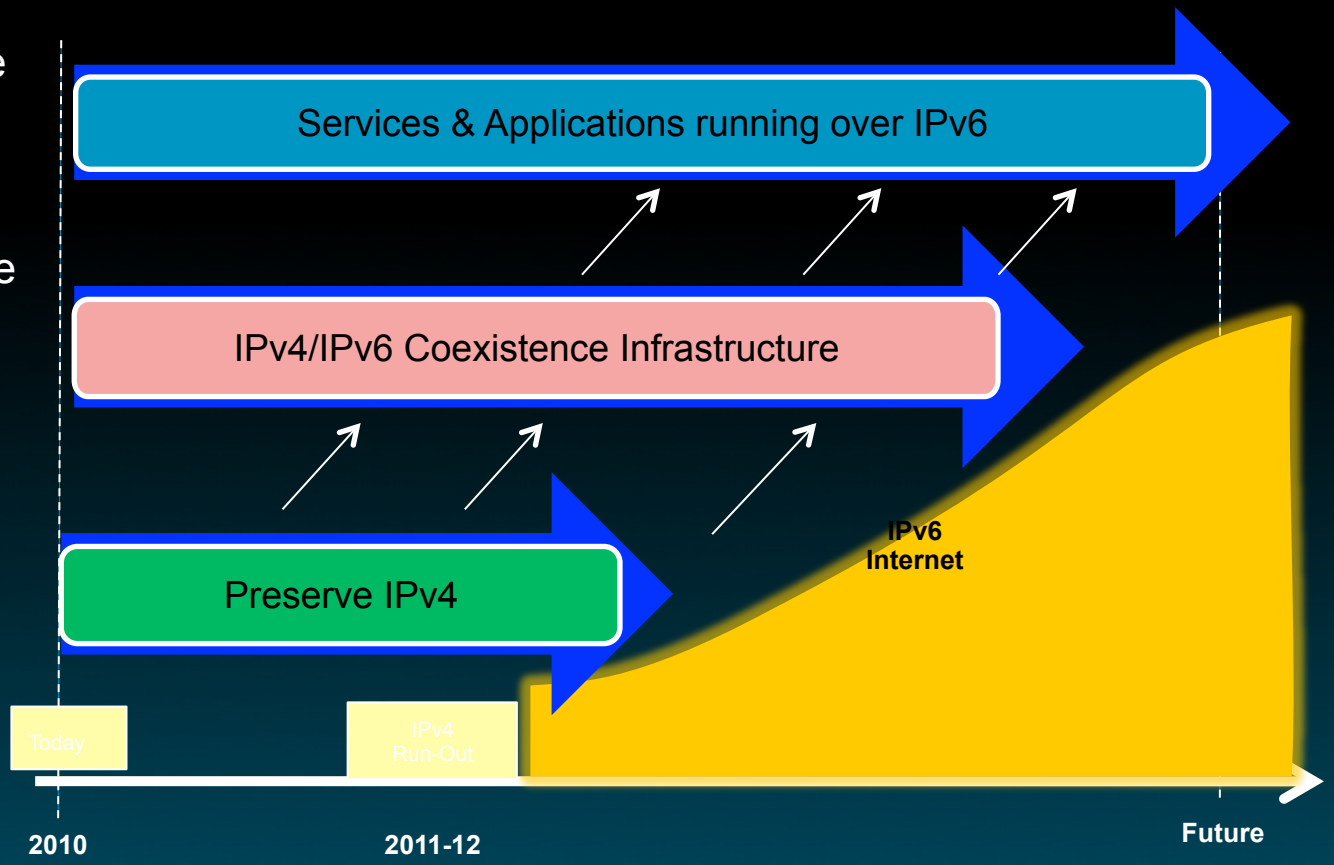


Coexistence Strategy

Don’t forget the Applications

While infrastructure is everyone’s initial focus, nothing happens until the applications use the new API.

IPv4-only apps will remain IPv4-only, and these legacy apps will fail when presented with an IPv6-only infrastructure.



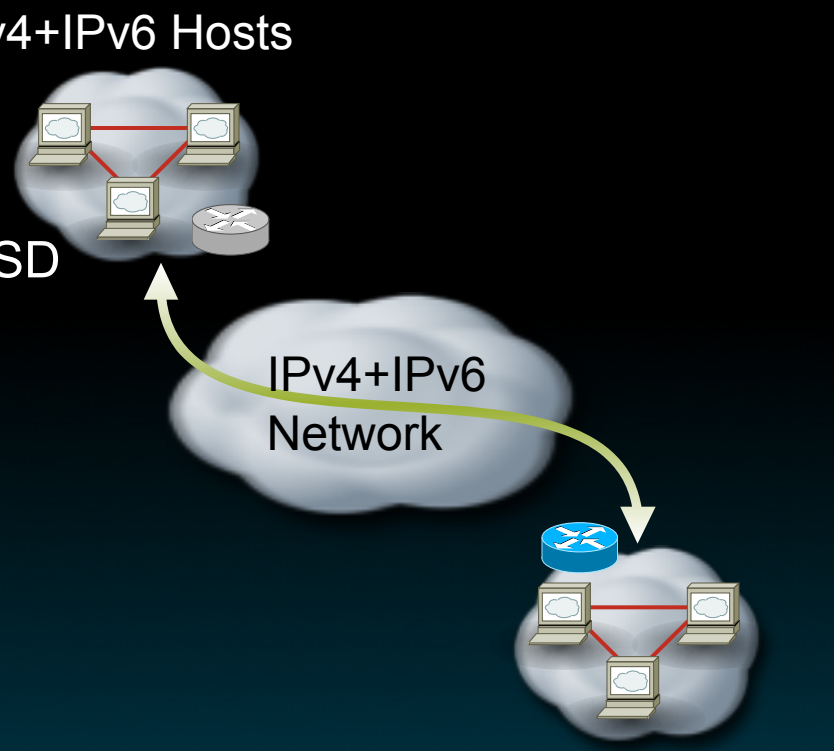
Industry best practices for IPv6 deployment

IETF looking at deployment

- IPv4/IPv6 coexistence
  - IPv4/IPv6 Dual Stack Deployment
  - IPv4/IPv6 Translation
  - IPv4/IPv6 and IPv6/IPv4 Tunneling
- Moving along
  - Securing the network
  - General operational issues

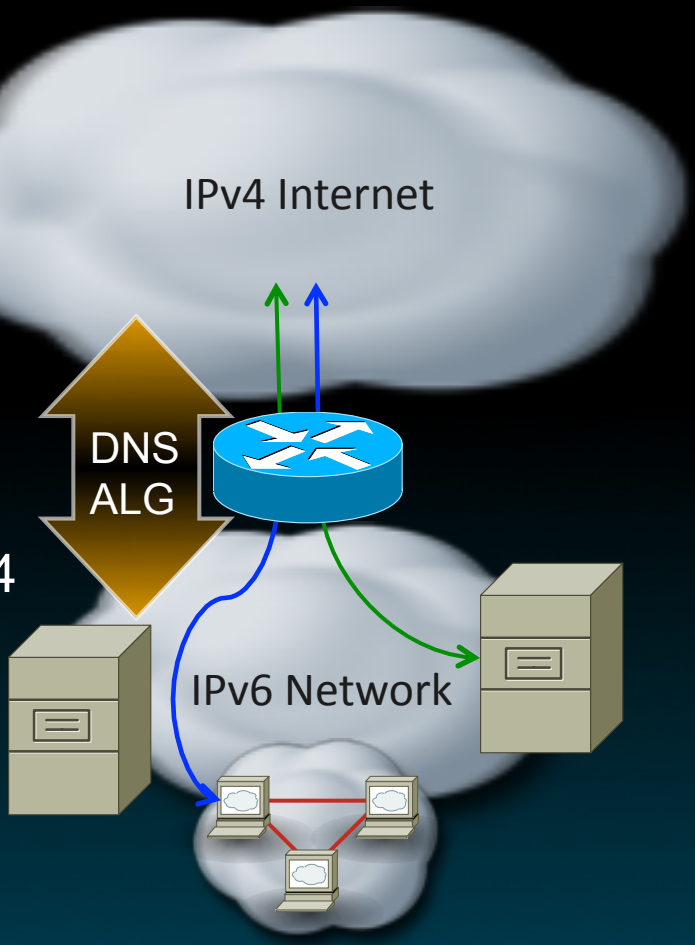
Recommended Approach to Deployment:
RFC 4213 Dual-Stack Deployment

- **Solution:**
  - Hosts today are IPv4+IPv6:
    - Windows Vista, Macintosh, Linux, BSD
  - Make the network IPv4+IPv6.
  - When forced to deploy IPv6-only networks, they will be able to talk with other hosts.
- **But…**
  - We have run out of time for this to be smooth

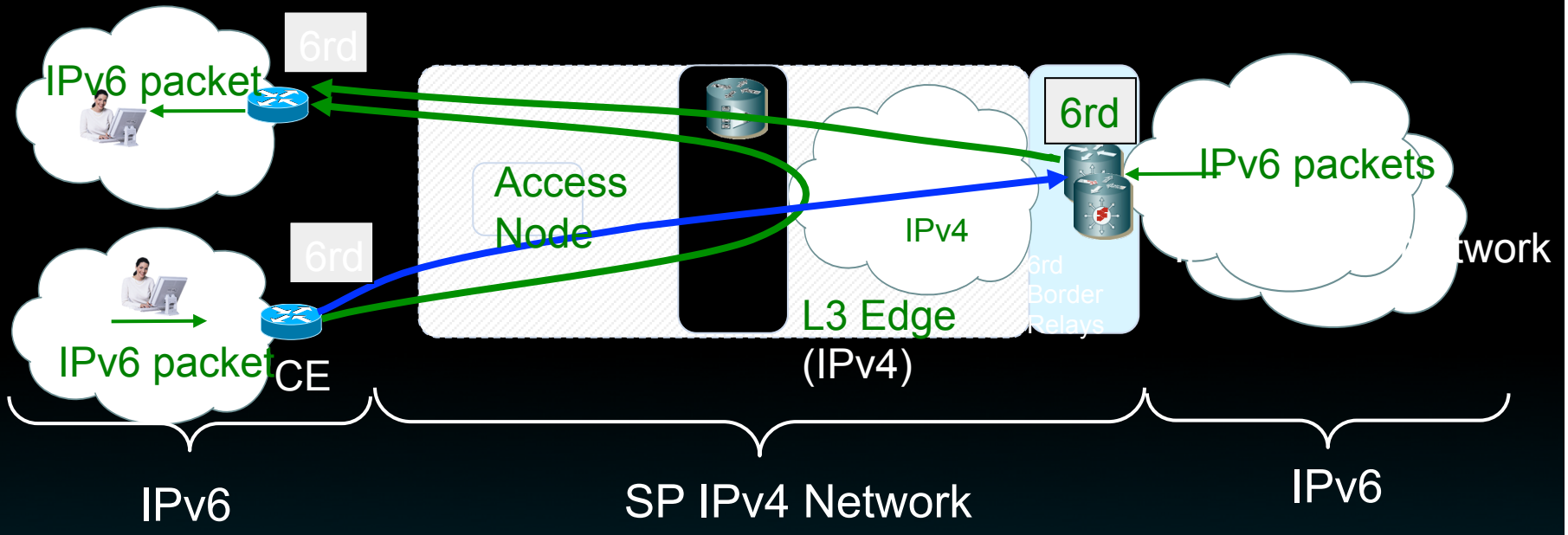


Translation: three components

- DNS64:
  - Translate DNS records
- Translator
  - Stateless mode
    - Modified SIIT algorithm
    - Uses Service Provider Prefix, IPv4 prefix embedded in IPv6 prefix
    - Scalable translation IPv4<->IPv6
  - Stateful mode (NAT64) similar to IPv4/IPv4 NAT
    - Permits session initiation IPv6-native -> IPv4 hosts
    - No session initiation IPv4 -> IPv6-native
- Effect:
  - Encourage movement of IPv4 servers to IPv6-only network



Dynamic IPv6/IPv4 tunneling



- IPv6 service in the home is essentially identical to native IPv6 service
- IPv6 Packets Follow IPv4 routing
- 6rd Border Relay traversed only when exiting or entering a 6rd Domain
- 6rd Border Relays are fully stateless, no limit on “number of subscribers” supported
- Border Relays may be placed in multiple locations, addressed via anycast.

"…it is possible to employ IPv6-only networking, though there are a number of issues such as lack of IPv6 support in some applications and bugs in untested parts of code.

As a result, dual-stack [RFC4213] remains as our recommended model for general purpose networking at this time, but IPv6-only networking can be employed by early adopters or highly controlled networks."

Jari Arkko

http://tools.ietf.org/html/draft-arkko-ipv6-only-experience

The biggest problems with coexistence mechanisms

- They give the illusion of full service but deliver a small subset
  - Example – the web works well through IPv4/IPv4 translation, but BitTorrent shows us that far more interesting services are possible
- Issues of management and fault diagnosis
  - Everything gets harder for the operator
- Operational and capital costs increase
  - Since everything is a little harder, it takes smart people to run the network

For further reading…

- http://tools.ietf.org/html/draft-arkko-ipv6-transition-guidelines

  "Guidelines for Using IPv6 Transition Mechanisms during IPv6 Deployment", Jari Arkko, Fred Baker, 9-Nov-10

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