



Introduction to IPv6

ISP/IXP Workshops

Early Internet History

- Late 1980s
 - Exponential growth of the Internet
- Late 1990: CLNS proposed as IP replacement
- 1991-1992
 - Running out of “class-B” network numbers
 - Explosive growth of the “default-free” routing table
 - Eventual exhaustion of 32-bit address space
- Two efforts – short-term vs. long-term
 - More at “The Long and Windy ROAD”
<http://rms46.vlsm.org/1/42.html>

Early Internet History

- CIDR and Supernetting proposed in 1992-3
Deployment started in 1994
- IETF “ipng” solicitation – RFC1550, Dec 1993
- Direction and technical criteria for ipng choice – RFC1719 and RFC1726, Dec 1994
- Proliferation of proposals:
 - TUBA – RFC1347, June 1992
 - PIP – RFC1621, RFC1622, May 1994
 - CATNIP – RFC1707, October 1994
 - SIP – RFC1710, October 1994
 - NIMROD – RFC1753, December 1994
 - ENCAPS – RFC1955, June 1996

Early Internet History

→ 1996

- Other activities included:

 - Development of NAT, PPP, DHCP,...

 - Some IPv4 address reclamation

 - The RIR system was introduced

- → Brakes were put on IPv4 address consumption

- IPv4 32 bit address = 4 billion hosts

 - HD Ratio (RFC3194) realistically limits IPv4 to 250 million hosts

Recent Internet History

The “boom” years → 2001

- IPv6 Development in full swing
 - Rapid IPv4 consumption
 - IPv6 specifications sorted out
 - (Many) Transition mechanisms developed
- 6bone
 - Experimental IPv6 backbone sitting on top of Internet
 - Participants from over 100 countries
- Early adopters
 - Japan, Germany, France, UK,...

Recent Internet History

The “bust” years: 2001 → 2004

- The DotCom “crash”
 - i.e. Internet became mainstream
- IPv4:
 - Consumption slowed
 - Address space pressure “reduced”
- Indifference
 - Early adopters surging onwards
 - Sceptics more sceptical
 - Yet more transition mechanisms developed

2004 → Today

- Resurgence in demand for IPv4 address space
 - 17.7% address space still unallocated (06/2008)
 - Exhaustion predictions range from wild to conservative
 - ...but late 2010 seems realistic at current rates
 - ...but what about the market for address space?
- Market for IPv4 addresses:
 - Creates barrier to entry
 - Condemns the less affluent to tyranny of NATs
- IPv6 offers vast address space
 - The only compelling reason for IPv6**

Current Situation

- General perception is that “IPv6 has not yet taken hold strongly”

IPv4 Address shortage is not “today’s news” yet

Private sector requires a business case to “migrate”

No easy Return on Investment (RoI) computation

- But reality is very different from perception!

IPv6 needed to sustain the Internet growth

Do we really need a larger address space?

- Internet population
 - ~630 million users end of 2002 – 10% of world pop.
 - ~1320 million users end of 2007 – 20% of world pop.
 - Future? (World pop. ~9B in 2050)
- US uses 81 /8s – this is 3.9 IPv4 addresses per person
 - Repeat this the world over...
 - 6 billion population could require 23.4 billion IPv4 addresses
 - (6 times larger than the IPv4 address pool)

Do we really need a larger address space?

- Other Internet Economies:

Japan 7 IPv4 /8s

UK 4 IPv4 /8s

Korea 3 IPv4 /8s,...

- Emerging Internet economies need address space:

China uses more than 94 million IPv4 addresses today (5.5 /8s)

Would need more than a /4 of IPv4 address space if every student (320M) is to get an IPv4 address

India lives behind NATs (using less than half /8)

Africa lives behind NATs (using three-quarters of a /8)

Do we really need a larger address space?

- Mobile Internet introduces new generation of Internet devices
 - PDA (~20M in 2004), Mobile Phones (~1.5B in 2003), Tablet PC
 - Enable through several technologies, eg: 3G, 802.11,...
- Transportation – Mobile Networks
 - 1B automobiles forecast for 2008 – Begin now on vertical markets
 - Internet access on planes, e.g. Connexion by Boeing
 - Internet access on trains, e.g. Narita Express
- Consumer, Home and Industrial Appliances

Do we really need a larger address space?

- RFC 1918 is not sufficient for large environments
 - Cable Operators (e.g. Comcast – NANOG37 presentation)
 - Mobile providers (fixed/mobile convergence)
 - Large enterprises
- The Policy Development process of the RIRs turned down a request to increase private address space
 - RIR membership guideline is to use global addresses instead
 - This leads to an accelerated depletion of the global address space
- 240/4 being proposed as new private address space

IPv6 OS and Application Support

- All software vendors officially support IPv6 in their latest Operating System releases

Apple Mac OS X; HP (HP-UX, Tru64 & OpenVMS); IBM zSeries & AIX; Microsoft Windows XP, Vista, .NET, CE; Sun Solaris,...

*BSD, Linux,...

- Application Support

Applications must be IPv4 and IPv6 agnostic

User should not have to “pick a protocol”

Successful deployment is driven by Applications

- Latest info:

www.ipv6-to-standard.org

IPv6 Geo-Politics

- Regional and Countries IPv6 Task Force
 - Europe – <http://www.ipv6-taskforce.org/>
Belgium, France, Spain, Switzerland, UK,...
 - North-America – <http://www.nav6tf.org/>
 - Japan IPv6 Promotion Council – <http://www.v6pc.jp/en/index.html>
China, Korea, India,...
- Relationship
 - Economic partnership between governments
China-Japan, Europe-China,...
- Recommendations and project's funding
 - IPv6 2005 roadmap recommendations – Jan. 2002
 - European Commission IPv6 project funding: 6NET & Euro6IX
- Tax Incentives
 - Japan only – 2002-2003 program

ISP Deployment Activities

- Several Market segments
IX, Carriers, Regional ISP, Wireless
- ISP have to get an IPv6 prefix from their Regional Registry
www.ripe.net/ripenncc/mem-services/registration/ipv6/ipv6allocs.html
- Large carriers planning driven by customer demand:
Some running trial networks (e.g. Sprint)
Others running commercial services (e.g. NTT, FT)
- Regional ISP focus on their specific markets
- Much discussion by operators about transition
www.civil-tongue.net/clusterf/
<http://www.nanog.org/mtg-0710/presentations/Bush-v6-op-reality.pdf>

Why not use Network Address Translation?

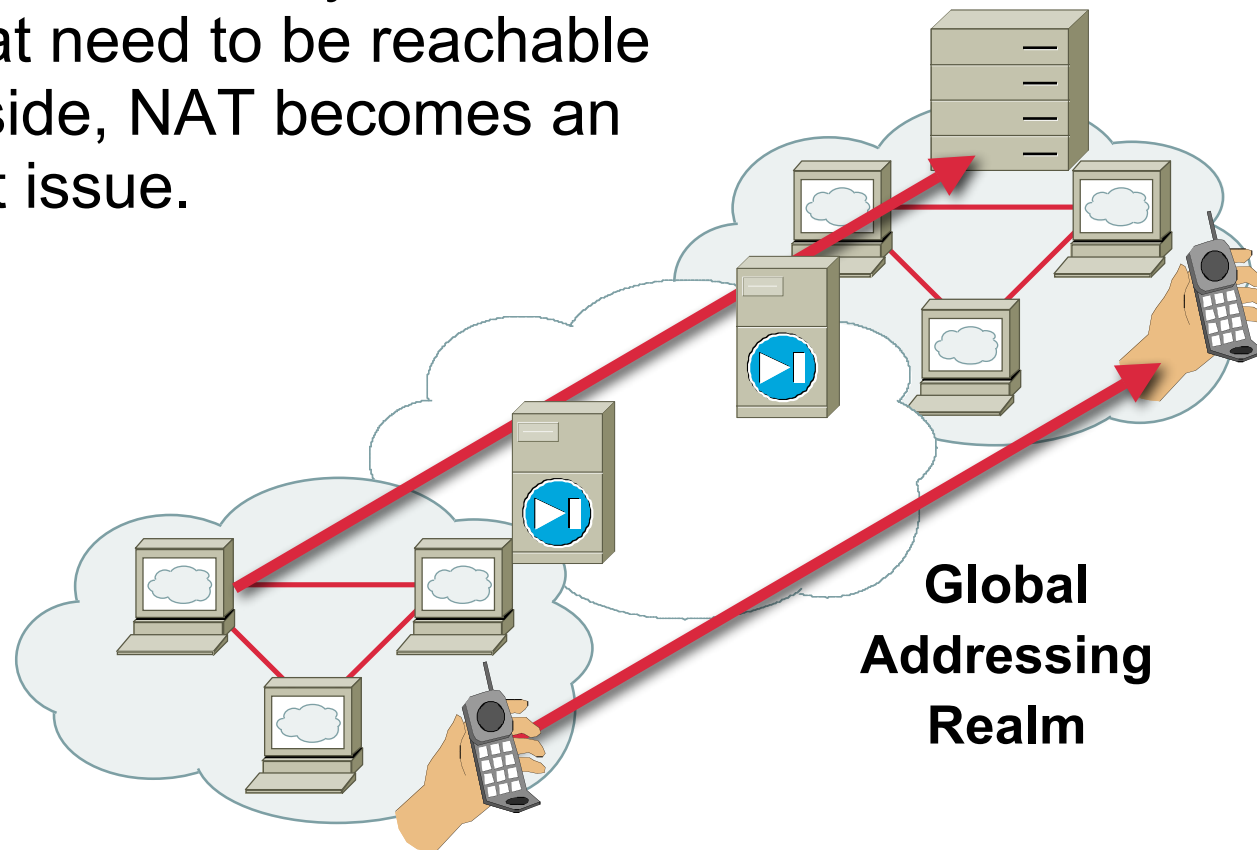
- Private address space and Network address translation (NAT) could be used instead of a new protocol
- But NAT has many serious issues:
 - Breaks the end-to-end model of IP
 - Layered NAT devices
 - Mandates that the network keeps the state of the connections
 - Scaling NAT performance for large networks
 - Makes fast rerouting difficult
 - Service provision inhibited

NAT has many implications

- Inhibits end-to-end network security
- When a new application is not NAT-friendly, NAT device requires an upgrade
- Some applications cannot work through NATs
- Application-level gateways (ALG) are not as fast as IP routing
- Complicates mergers
 - Double NATing is needed for devices to communicate with each other
- Breaks security
- Makes multihoming hard
- Simply does not scale
- RFC2993 – architectural implications of NAT

NAT Inhibits Access To Internal Servers

- When there are many servers inside that need to be reachable from outside, NAT becomes an important issue.



Conclusion

- There is a need for a larger address space
 - IPv6 offers this – will eventually replace NAT
 - But NAT will be around for a while too
 - Market for IPv4 addresses looming also
- Many challenges ahead



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