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
  - SIPP – 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
  - 13.6% address space still unallocated (04/2009)
  - Exhaustion predictions range from wild to conservative
  - …but mid 2011 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”
  - IPv4 Address run-out is not “headline news” yet
    - More discussions and run-out plans proposed
  - Private sector requires a business case to “migrate”
    - No easy Return on Investment (RoI) computation
- But reality is very different from perception!
  - Something needs to be done to sustain the Internet growth
  - IPv6 or NAT or both or something else?

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
- Some want 240/4 as new private address space
  - But how to back fit onto all TCP/IP stacks released since 1995?

Do we really need a larger address space?

- Large variety of proposals to “make IPv4 last longer” to help with IPv6 deployment
  - NAT444
    - Lots of IPv4 NAT
  - NAT464
    - IPv4 to IPv6 to IPv4 NAT
  - Dual Stack Lite
    - Improvement on NAT464
    - Activity of IETF Softwires Working Group
  - NAT64 & IVI
    - Translation between IPv6 and IPv4
    - Activity of IETF Behave Working Group

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
  - Successful Application support is driven by Content
- Content Availability
  - Needs to be on IPv4 **and** on IPv6

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/ripencc/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/6and4/
  - http://www.nanog.org/mtg-0710/presentations/Bush-v6-op-reality.pdf

Why not use Network Address Translation?

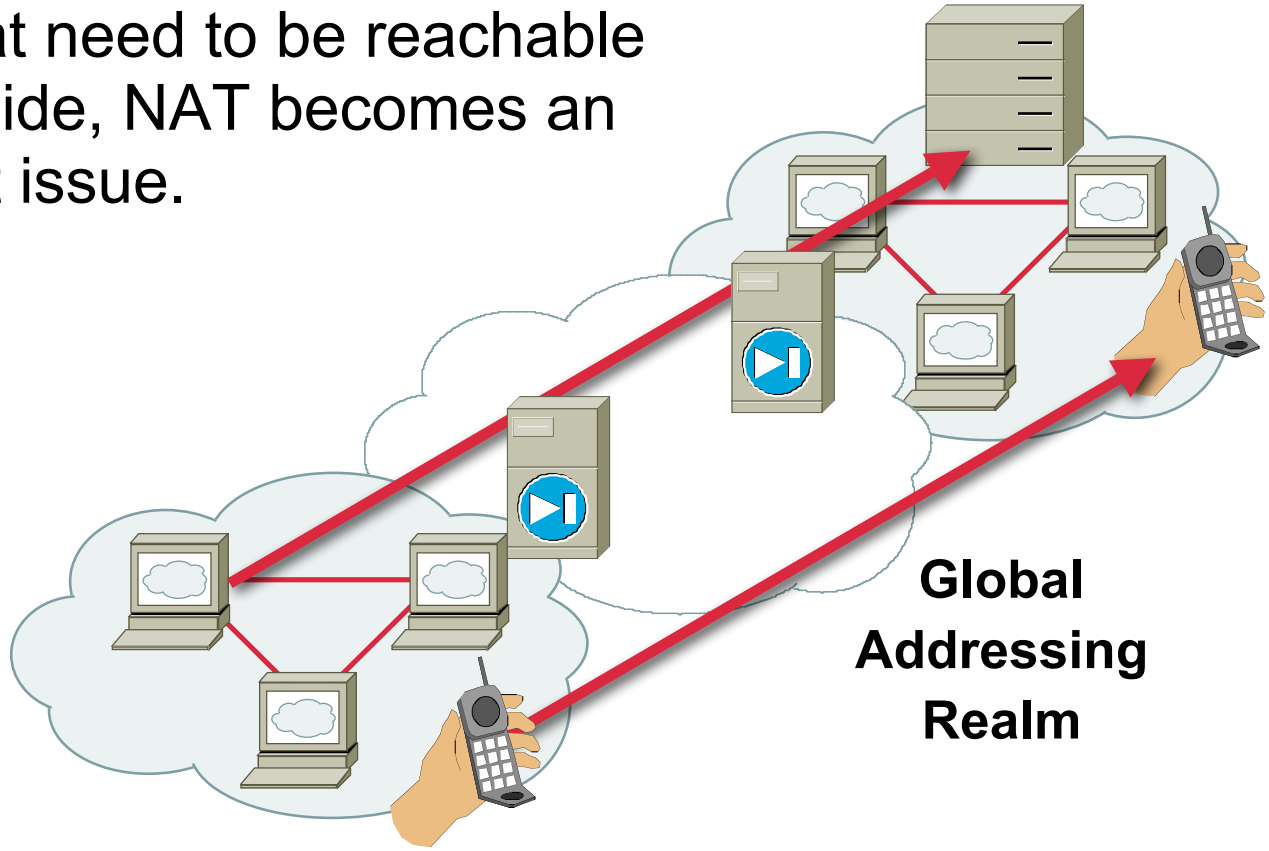
- Private address space and Network address translation (NAT) could be used instead of a new protocol
- But NAT has many serious issues:
  - Breaks the end-to-end model of IP
  - Layered NAT devices
  - Mandates that the network keeps the state of the connections
  - Scaling NAT performance for large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