sources:
RFCs
books
presentations
Outline

- Limitations of IPv4 and modern day Internet
- Features of IPv6
- Differences between IPv4 and IPv6
- IPv6 terminology
- Case for IPv6 deployment
Quick Review of IPv4 vs IPv6

- IPv4 has problems with address space, fragmentation overhead, Quality of Service, security, autoconfiguration, etc.
  - 4-byte addresses
  - Default 20-byte header

- IPv6 addresses those problems
  - 16-byte address
  - Flow labels for QoS support
  - No more fragmentation in routers or checksums
  - IPv4 Options become IPv6 Extension Headers

4/1/14
Limitations of IPv4

- Exponential growth of the Internet and the impending exhaustion of the IPv4 address space
- Growth of the Internet and the ability of Internet backbone routers to maintain large routing tables
- Mobile Computing
- IPv4 Missing Features
  - Need for simpler configuration - startup
  - Requirement for security at the IP level
  - Need for better support for real-time delivery of data—quality of service (QoS)
Competition from NAT Boxes

- One of the strongest perceived incentives for migration was the shortage of IPv4 addresses

- **Network Address Translators** helped to solve this problem by translating “official” external IP addresses into “private” internal addresses (10.x.x.x, etc.)

- Created a disincentive for migration
Consequences of the Limited IPv4 Address Space: NATs

Impact peer to peer Applications

Remove End-to-End Nature of Internet
Features of IPv6

- New header format – faster processing
- Large address space – IP everywhere
- Efficient and hierarchical addressing and routing infrastructure – faster routing
- Stateless and stateful address config
- Built-in security
- Better support for QoS – use header fields
- New protocol for neighboring node interaction – new nodes, mobile nodes
- Extensibility – Designed in
Quick Summary of IPv6

- IPv6 still an unreliable connectionless datagram protocol
- IPv6 Base Header contains address, flow label (a QoS feature)
- Extension Headers handle fragmentation, security, etc. (referenced by Next Header field)
- Fragmentation avoided by Path MTU discovery
IPv6 Address Space

- Number of possible 128-bit addresses = 340,282,366,920,938,463,463,374,607,431,768,211,456
- \((3.4 \times 10^{38})\)
- That’s about \(4 \times 10^{18}\) per square meter of the Earth’s surface
- Nevertheless, we could run short again if addresses are **NOT** allocated efficiently
## Differences Between IPv4 and IPv6

<table>
<thead>
<tr>
<th>Feature</th>
<th>IPv4</th>
<th>IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address length</td>
<td>32 bits</td>
<td>128 bits</td>
</tr>
<tr>
<td>IPSec support</td>
<td>Optional</td>
<td>Required</td>
</tr>
<tr>
<td>QoS support</td>
<td>Some</td>
<td>Better</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>Hosts and routers</td>
<td>Hosts only</td>
</tr>
<tr>
<td>Packet size</td>
<td>576 bytes</td>
<td>1280 bytes - Ethernet</td>
</tr>
<tr>
<td>Checksum in header</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Options in header</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Link-layer address resolution</td>
<td>ARP (broadcast)</td>
<td>Multicast Neighbor Discovery Messages</td>
</tr>
<tr>
<td>Multicast membership</td>
<td>IGMP</td>
<td>Multicast Listener Discovery (MLD)</td>
</tr>
<tr>
<td>Router Discovery</td>
<td>Optional</td>
<td>Required</td>
</tr>
<tr>
<td>Uses broadcasts</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Configuration</td>
<td>Manual, DHCP</td>
<td>Automatic, DHCP</td>
</tr>
<tr>
<td>DNS name queries</td>
<td>Uses A records</td>
<td>Uses AAAA records</td>
</tr>
<tr>
<td>DNS reverse queries</td>
<td>Uses IN-ADDR.ARPA</td>
<td>Uses IP6.INT</td>
</tr>
</tbody>
</table>
IPv6 Terminology

- Neighbors
  - Host
  - Bridge
  - Intra-subnet router
  - Link
  - Subnet
  - LAN segment

- Additional subnets
- Network

IPv6 Intro
The Case For IPv6 Deployment

- IPv6 solves the address depletion problem
- IPv6 solves the international address allocation problem – assign chunks
- IPv6 restores end-to-end communication
- IPv6 uses scoped addresses and address selection
- IPv6 has more efficient forwarding
- IPv6 has built-in security and mobility
- Probably reached ‘standardization’ without enough implementation and testing...
Migration Issues

- The “Flag Day” problem
  - Cannot simply pull the plug on IPv4 at some prearranged date

- IPv4 will be around indefinitely

- Need to provide for a phased transition, but even more need to develop a ‘need’ to work that hard...
IPv6 Products

- Done deal
- All major players have IPv6 implementations for their OS's and routers
  - Cisco – Linux
  - Nortel – Solaris
  - Microsoft – HP-UX
  - Novell – Mac OS X
  - BSD (KAME)
- www.moonv6.org
- Renault car with Cisco router and Mobile IPv6 implementation
Useful Books

- **IPv6 Essentials** by S. Hagen (O’Reilly) (Best introduction)

- **IPng, The New Internet Protocol** by C. Huitema (Prentice Hall)

- **IPng, Internet Protocol Next Generation** by S. Bradner & A. Mankin (Addison-Wesley)

- **Internetworking with TCP/IP Vol. I, 5th Ed.** by D. Comer (Prentice Hall)

- **IPng and the TCP/IP Protocols** by S. Thomas (Wiley)