TDC 563
Protocols and Techniques for Data Networks

Network Addressing
Why have addresses at layer 3?

Aren't there already globally unique addresses at L2? If not, should there be?
Characteristics

• Fixed versus variable length address fields
• Hierarchical addressing and aggregation
• Centralized and distributed address assignment
• Derived and assigned addressing
• Address syntax, notation and representation
• An address as an identifier or locator
• Host or interface address association
• Privacy
IP address semantics

- Virtual, not specific to a hardware device
- 32-bit or 128-bit fixed address length (IPv4/IPv6)
- Unique address for each interface (typically)
- Registry or upstream ISP assigns net bits (prefix)
- Local admin assigns subnet and host bits (suffix)
- IPv4 usually written in dotted decimal (dotted quad)
  - e.g. 140.192.5.1
- IPv6 usually written as colon-separated text strings
  - e.g. 2001:DB8::1
Special Addresses

• “Special” because we decree them to be so
• Loopback 127.0.0.1/8 - ::1
• Private use (e.g. IETF RFC 1918)
• IPv4 Broadcast
  • Limited local 255.255.255.255
  • Directed net_id | {all 1's in the host_id}
• All 0's (0.0.0.0 or ::) usually used for bootstrapping
• Others include (not exhaustive):
  • “this network”, multicast, documentation use
More Special Addresses - IPv6

• ::ffff/96
  • e.g. ::ffff:192.0.2.1
  • For application transition usage
• ffc00::/7
  • unique local (ULAs) – similar to RFC 1918
• fe80::/10
  • link local
  • widely used for link local communications
Classful addressing is obsolete!

STOP saying Class A, Class B or Class C.
Use the slash notation.
Historic: Classful IPv4 addressing

*diagram courtesy of http://www.netbook.cs.purdue.edu*
Historic: Classful address sizes
*diagram courtesy of http://www.netbook.cs.purdue.edu

<table>
<thead>
<tr>
<th>Address Class</th>
<th>Bits In Prefix</th>
<th>Maximum Number of Networks</th>
<th>Bits In Suffix</th>
<th>Maximum Number Of Hosts Per Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>128</td>
<td>24</td>
<td>16777216</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>16384</td>
<td>16</td>
<td>65536</td>
</tr>
<tr>
<td>C</td>
<td>21</td>
<td>2097152</td>
<td>8</td>
<td>256</td>
</tr>
</tbody>
</table>
Classful addressing is obsolete!

**STOP** saying Class A, Class B or Class C. Use the slash notation.
Classful addressing limitations

• Internet growth and address depletion
• Route table size (potentially lots of class C nets)
• Misappropriation of addresses
• Lack of support for varying sized networks
  • class B is often too big, class C often too small
IP addressing solutions

• Subnetting
• Supernetting
• Classless interdomain routing (CIDR)
• Variable length subnet masks (VLSM)
• Temporary addresses (e.g. BOOTP, DHCP)
• NATs with port address translation (blech!)
• IPv6
Subnetting

network  host

140.192.9.63

network  subnet  host

140.192.9.63
Subnet masks

• The bit length of the prefix or the 'network' bits
• No more A, B or C class addresses ← important
• Use of the slash '/' notation to address and network
  • 140.192.5.1 with mask of 255.255.255.128 is:
  • 140.192.5.1/25
• A /25 mask in binary is:
  • 11111111.11111111.11111111.10000000
Subnet masks example

• Given 140.192.50.8/20 what is the...
  • subnet mask in dotted decimal notation?
  • directed broadcast address in dotted quad?
  • total number of hosts that can be addressed?
Supernetting

- Combine smaller address blocks into an aggregate
- If class B is too big and class C is too small...
  - Combine 199.63.0.0/24 to 199.63.15.0/24
  - To form 199.63.0.0/20
CIDR

classless inter-domain routing

• Routers “announce” prefixes
  • maintain and announce millions of /24's or...?
• Aggregate
  • thank you, supernetting
• So instead of adding multiple class C blocks...
• Check out The Internet CIDR report:
  • http://www.cidr-report.org
CIDR example

- Given an ISP that announces:
  - 64.5.0.0/20
  - 64.5.16.0/20
  - 192.0.2.0/25
  - 192.0.2.192/26
  - 192.0.2.128/26
- What is the least number of CIDR announcements that can be made for this ISP?
- Why might address blocks not be aggregated?
VLSM
variable length subnet masks

- Many subnet sizes in an autonomous system (AS)
- Allows for efficient use of address space
- Can be used to build an internal hierarchy
- External view of the AS does not change
- An AS may be allocated 140.192.0.0/16, but...
- Internally may use:
  - 140.192.0.0/17
  - 140.192.128.0/24
  - 140.192.129.0/25 and so on...
VLSM example

• Given an assignment of 140.192.0.0/16, create an addressing strategy to support:
  • 6 satellite offices and 1 large headquarter site
  • 6000 total hosts on all combined networks
  • headquarters needs about 50% of all addresses
  • satellite offices need 200 to 700 addresses
  • overall growth per year is 500 hosts
Obtaining IP addresses

• IANA has global authority for assignment
• RIRs delegate to LIRs and ISPs
• ISPs assign addresses to end users and small nets
• IETF RFC 1918 defines private address blocks
  • NOT globally unique
  • NOT for hosts attached directly to public Internet
  • 10.0.0.0/8, 172.16.0.0/12 and 192.168.0.0/16
  • Also see IETF RFCs 5735 and 6598
IPv4 Address Exhaustion

• Post-depletion options
  • Wait-list
  • Transfers
  • After market solutions
  • IPv6
• Dual-stack, will be a semi-permanent position
• More and more NAT
• IPv6 transition jerks and starts
IPv6 Address Allocation

• IANA, RIR, ISP policies similar as in IPv4
• /64 is the de facto and assumed LAN subnet size
• /127 used in BGP peering (of /64 reserved)
• /48 widely used minimum network allocation
• Most are NOT worried about IPv6 exhaustion
WHOIS for address information

- A rudimentary plain text over TCP service
  - See IETF RFC 3912 (WHOIS)
- WHOIS servers run by IANA, RIRs, LIRs and ISPs
- Some clients follow referral to a specific maintainer
  - See IETF RFC 2167 (Rwhois)
- e.g. ARIN.net for North American RIR delegations

  http://whois.arin.net/rest/net/NET-140-192-0-0-1/pft.txt
IP address types

- Unicast (one-to-one)
  - source addresses should always be unicast
- Multicast (one-to-many)
  - receivers join/listen to group destination address
- Broadcast (one-to-all)
  - special case of multicast, usually unnecessary
- Anycast (one-to-one-of-many)
  - usually one-to-nearest, often used for reliability
NAT
network address translation

• Originally a solution to a shortage problem
  • became a security dilettante's best practice
• It can help alleviate renumbering problems
  • but if the net is that big, get your own allocation
• NAT back slaps the e2e argument in the face
• What has been a big motivating factor for IPv6?
  • is NAT for IPv6 rational?
  • IETF, try as you might to “standardize” it away...
Final thoughts

- IP addressing is a pain, IPv6 isn't much easier
- IP addresses today are both a who and a where
- IP addresses make for poor trust relationships
- Private addresses and NATs, blech! Get a real net