Computer Networks and Data Systems

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

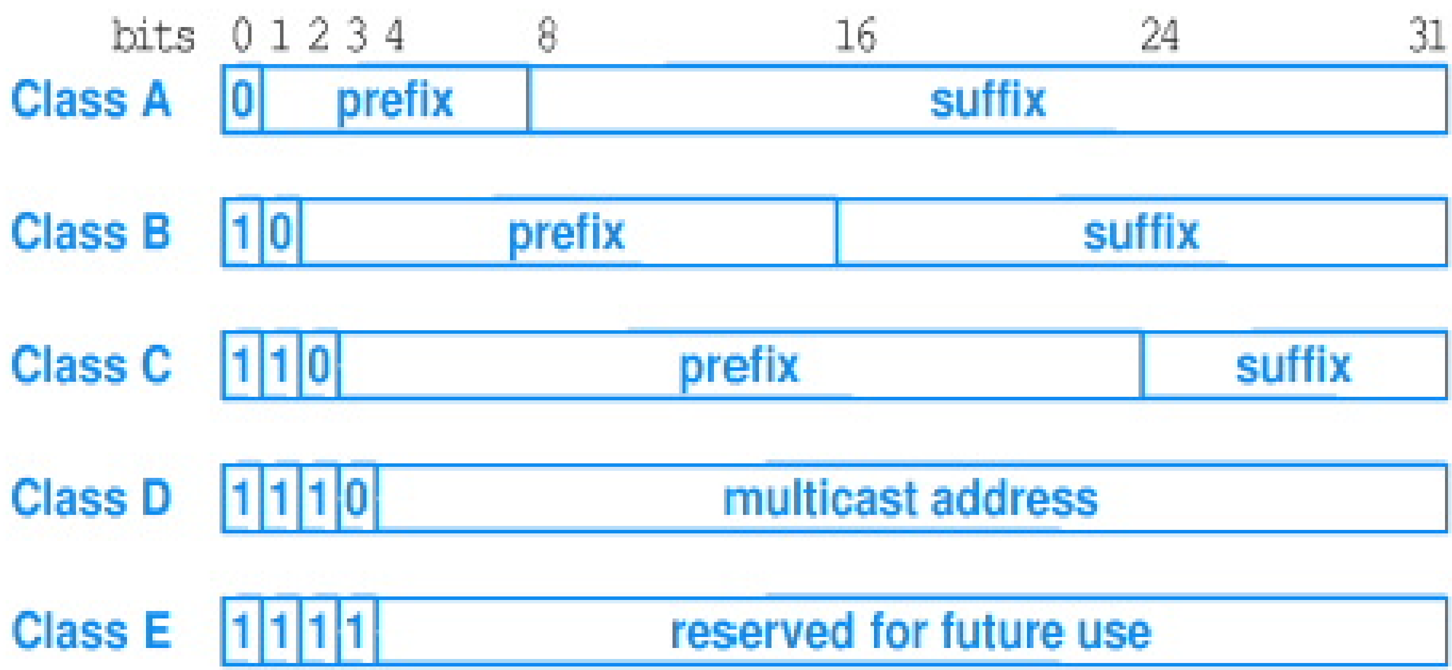
Classful addressing is obsolete!

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**

Address Class	Bits In Prefix	Maximum Number of Networks	Bits In Suffix	Maximum Number Of Hosts Per Network
A	7	128	24	16777216
B	14	16384	16	65536
C	21	2097152	8	256

Classful addressing is obsolete!

<u>STOP</u> saying Class A, Class B or Class C.

Use the slash notation.

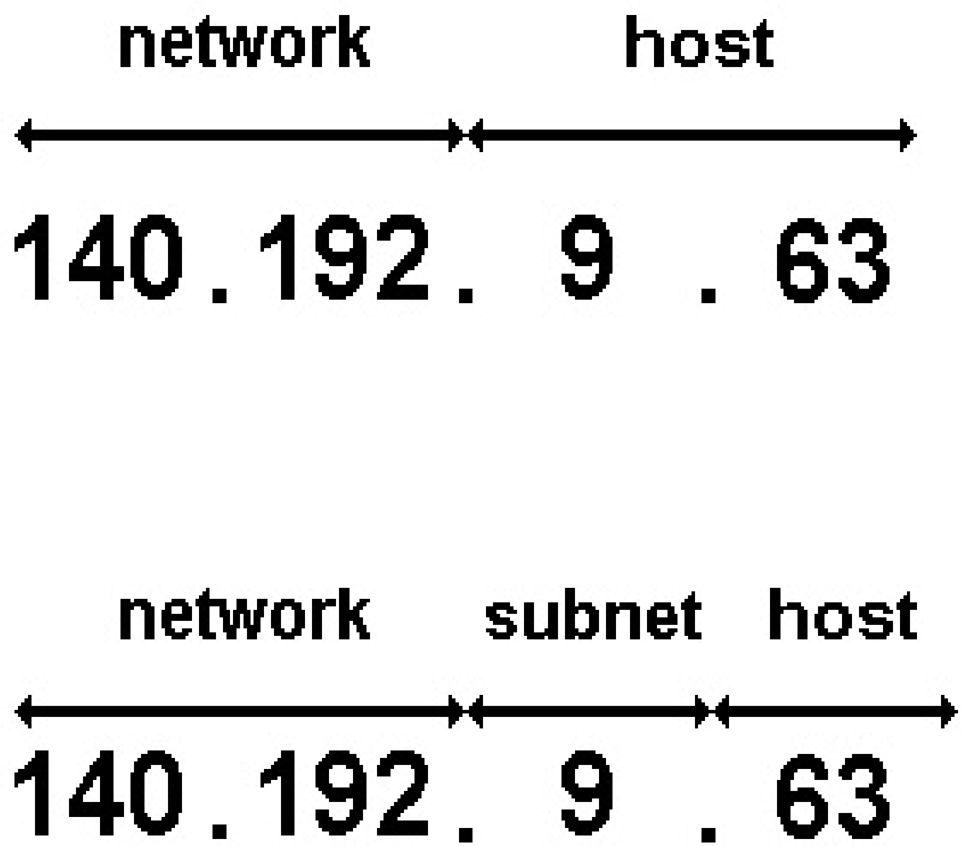
Classful addressing limitations

- 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



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

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