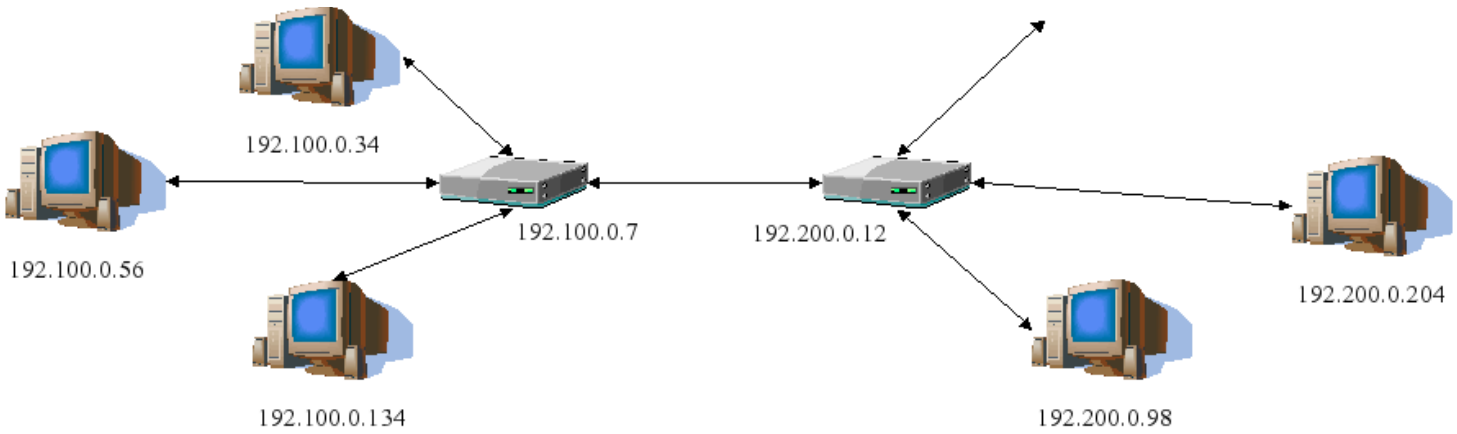
IP Address

- Every host or router on the Internet is uniquely identified through an IP address.
- No two machines have the same IP address at any one time
- IP addresses encode:
  - Network number
  - Host number
- Think of this as being like a street name, and a street number in a postal address



IP Address

- An IPv4 address is a 32-bit number.
  - 11000010 01111101 01010100 10011001
  - In decimal this is equal to: 3,262,993,561
- This is how computers manage IP addresses internally. 32 bits implies
- approximately 4,000,000,000 different addresses.
- The number of IP addresses available will become a problem!
  - We are fast approaching the time when there will not be enough IP addresses for all of the machines in the world (remember handhelds etc.)
  - IP Version 6 (we are currently using version 4) proposes changing addresses to 128 bits
  - This will allow approximately 3*1038 (or 300,000,000,000,000,000, 000,000,000,000,000,000,000) addresses.
- We are now in the middle of the conversion to IPv6. This is not nearly finished, and some people think it never will be finished!

Dotted Quad Notation

- Its far too tricky for us to deal with these long IP addresses.
- Instead we use the Dotted-Quad Notation:
  - Represent the 32-bit number as 4 8-bit numbers dotted together
  - An 8 bit number can be between 00000000 and 11111111 (0 and 255 in decimal)
  - So each of the 4 numbers in an IP address can be between 0 and 255
- In our previous example: 11000010 01111101 01010100 10011001
  - 11000010 = 194
  - 01111101 = 125
  - 01010100 = 84
  - 10011001 = 153
- This gives us the final IP address: 194.125.84.153

Addressing

- Different layers use different addressing
  - App. layer allows people to use hostnames
  - IP (network) layer requires IP addresses
    - Link layer requires MAC (a.k.a. LAN) addresses
- Ports identify process or service on a host

Address types

- IP layer and link layer have multiple address types
  - **Unicast** – single host (network interface)
  - **Broadcast** – addresses that include all hosts on a particular network
    - All bits in host part of address are ones
  - **Multicast** – addresses that identify a group of hosts
    - IPv4 addresses with first byte in 224-239

IP Addresses

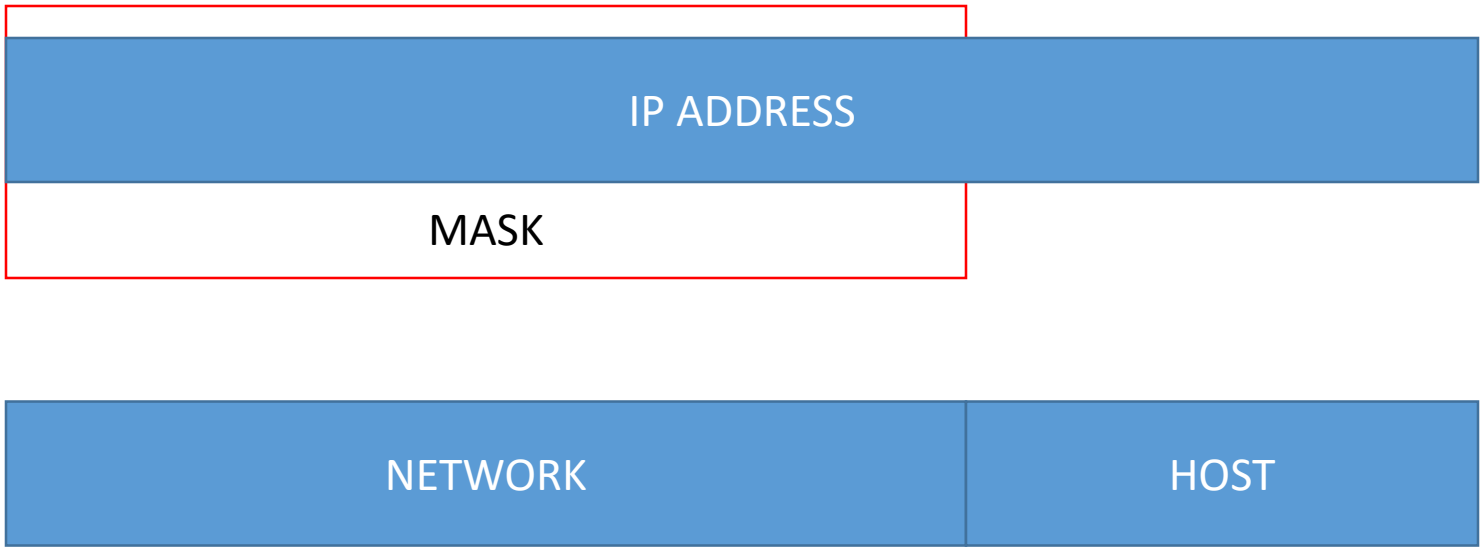
- IPv4 address has four bytes
  - Split into network and host portions
  - Internet originally used classes of IP addresses

Class	1st byte	Format	Comments
A	1-126	N.H.H.H.	Very early networks, DoD
B	128-191	N.N.H.H.	Large sites, usually subnetted
C	192-223	N.N.N.H.	Smaller sites
D	224-239		Multicast addresses
E	240-255		Experimental

Subnetting

- Individual networks are often **much** smaller than the class sizes
- Subnetting permits breaking up an allocation into multiple smaller networks

Subnetting



Subnetting Example

- 128.180 under class-full addressing is a Class-B with 65,534 addresses
- Subnetting extends the network address into host portion
- We specify a subnet 128.180.98
  - Using explicit subnet mask 255.255.255.0
  - Alternatively, with network bits specified explicitly
    - 128.180.98.0/24
- Can also break on non-byte boundaries
  - 128.180.98.128/25
  - 128.180.120.0/22

CIDR

- Classless Inter-Domain Routing
  - Allows for shorter network address than class-specified obsoletes network classes
  - Requires length field, e.g., 128.180.0.0/16
  - Aggregates smaller networks into single larger one
    - 192.200.254.0 + 192.200.255.0 = 192.200.254.0/23
  - Can now allocate portions of class A and B addresses
  - Aggregated networks reduces routing table growth

ARP: Address Resolution Protocol

- Once the routing of a packet has been determined, it must be transmitted to the next gateway or host on the local network
- LAN transmissions use LAN (MAC) addresses
- ARP is used to discover the hardware address of the target IP address
- ARP sends a LAN broadcast asking who has the desired IP address; the owner responds with a unicast message with answer
  - Results cached in a table (also collected via snooping)