Desirable Properties Of An Internet Addressing Scheme

- Compact
- Universal
- Works with all network hardware
- Supports efficient decision making
  - Test whether a destination can be reached directly
  - Decide which gateway to use for indirect delivery
  - Choose next gateway along a path to the destination

The TCP/IP Internet Address Scheme - IPv4

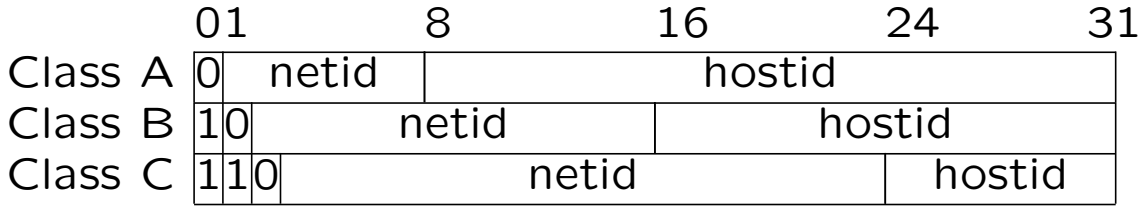
- Each host assigned a 32-bit, hardware independent address (IP address)
- Prefix of the address uniquely identifies the network to which the host attaches (all machines on the same net share the same prefix)
- Prefixes assigned by central authority (IANA)
- Suffix of the address gives a unique id for the host on the network (no two machines on a given network share the same suffix)
- Suffixes assigned by local network administrator

Division Of Internet Address Into Prefix And Suffix

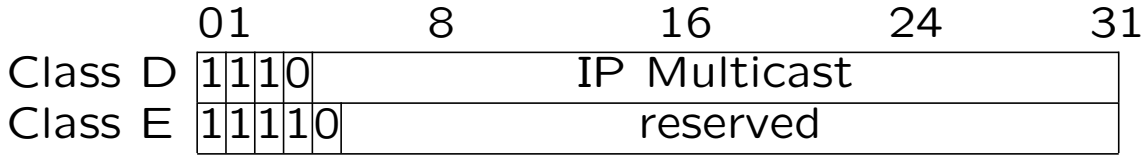
- How should division be made?
  - Large prefix, small suffix means many possible networks, but each is limited in size
  - Large suffix, small prefix means each network can be large, but there can only be a few networks
- Internet address scheme designed to accommodate both possibilities

Old-Style IPv4 Address Classes

- IPv4 addresses are 32 bits wide
- Three principle classes



- Lesser-used classes



Why Partition Internet Addresses Into Network And Host Portions?

- Each address must be unique
- Want to make routing efficient
- Partition allows us to assign unique id to each network, so we can do routing using network portion and delivery using unique host portion

Dotted Decimal Notation

- Syntactic form for expressing 32-bit address
- Used throughout the Internet and associated literature
- Represents each byte in decimal separated by periods (dots)
- Example
  - A 32-bit number in binary

    ```
    10000100 11101011 00000001 00000010
    ```

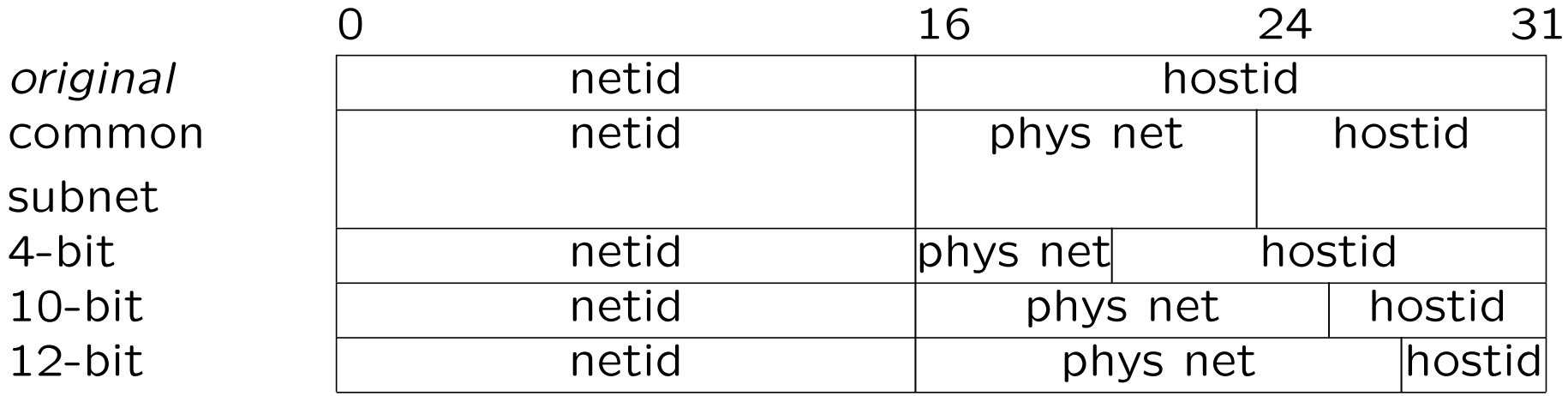
  - The same 32-bit number expressed in dotted decimal notation

    ```
    132.235.1.2
    ```

Subnet Addressing

- Not part of original TCP/IP address scheme
- Allows a site to use a single network address for multiple physical networks
- Subdivides the *hostid* portion of an address into a pair of fields for physical network and host
- Interpreted only by gateways and hosts at the site; treated like normal address elsewhere
- Like the IP address scheme in miniature

Example Of Subnet Addressing



- How many subnets and hosts-per-subnet are there in each example??
- Can we have a 15-bit subnet on a class B address??
- Can we have a 14-bit subnet on a class B address??

Subnet Address Details

- Each physical network is assigned subnet mask
- Mask covers netid portion plus zero or more bits of hostid portion
- When mask is applied to an IP address, it gives the address of a subnet
- Site may choose a different mask for each of its networks (not advisable)

Subnet Mask Examples

- A class B network has an implicit mask:
  - `11111111.11111111.00000000.00000000`
  - `255.255.0.0`
- Many places use the first 8 bits of the host portion as the subnet address:
  - `11111111.11111111.11111111.00000000`
  - `255.255.255.0`
- To use the first 5 bits for subnet, you have
  - `11111111.11111111.11111000.00000000`
  - `255.255.248.0`
- If a site uses a 12 bit subnet id, how many hosts can be on each network?

Address Mask - Shorthand

- Representing the mask as an address is more general
  - Handles non-contiguous masks
  - Some commands insist on this format
- As shorthand, you can just give the "size" of the mask
  - `132.235.0.0/16`
    - All of OU
  - `132.235.201.0/24`
    - All ITL addresses
  - `132.235.201.64/28`
    - A block of 16 addresses in the ITL
  - `132.235.201.131/32`
    - A specific address

The "New Way"

- With the predicted exhaustion of some address classes (particularly class B) in the early 90's, the notion of predefined address classes was abandoned
- All address blocks are assigned by the Internet Assigned Numbers Authority (IANA)
  - Later subcontracted to ARIN and other international organizations
- Non-huge organizations get address space from their ISP
- You must be able to prove that you have need for them

Addressing Details

- Addresses really go with *interfaces*, not hosts
  - A machine with multiple interfaces has multiple IP addresses
- By convention, when the *hostid* (suffix) of an address is all 0's, it refers to the network itself, not a particular host
- When the hostid portion is all 1's, that's a *directed broadcast*
  - Addresses all of the machines on the network
  - *Might* travel across parts of the Internet to get to the network
    - Has security "implications"
- If the entire address is all 1's, that's a *limited directed broadcast*
  - Only refers to the local network
- The address `127.x.y.z` is the *loopback address*

Remaining Problems

- IPv4 address space will soon be exhausted
  - Large blocks have already all been allocated by IANA to regional registrars
  - Address space is too "expensive" to give to socks
- Lack of hierarchy in the address space makes huge address tables necessary in "central routers"
- So, what is the solution?

Network Byte Order

- Different machines use different encoding of numbers
  - Two predominant integer encoding schemes
    - *Big Endian*
      - Lowest memory address contains high order bits of data
      - Used by IBM, Motorola, Sun (Sparc)
    - *Little Endian*
      - Lowest memory address contains low order bits of data
      - Used by DEC PDP/Vax, Intel (x86,Pentium)
- Internet standard is to transmit numbers in big endian order