# Internet Engineering

241-461

Robert Elz

kre@munnari.OZ.AU
kre@coe.psu.ac.th

http://fivedots.coe.psu.ac.th/~kre

## Network Layer

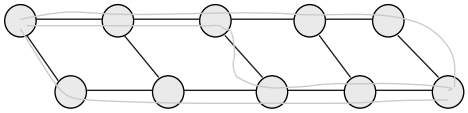
- Requirements
  - Addressing
  - Packet transport
    - Between systems identified by addresses
      - With some kind of packet importance
  - Packet Lifetime
    - TCP requires old packets die
      - Not loop forever
    - So does network sanity!
  - Transport Protocol Identification
    - TCP or UDP or ...
  - Error Detection
    - Very limited error detection
      - Relates to packet delivery only
  - Packet Length
  - Link Layer Interface
    - Cope with many different link layers

## Network Layer Addressing

- Requirements
  - Identify a network entity
    - (host)
  - Allow network to find it
    - So packets can be sent there
  - Vanity free
    - So any address is OK
      - No-one wants to buy particular address
- Identify
  - Just by unique numbers
    - 1 2 3 4 5 6 ...
  - Mostly Vanity free
  - But
    - How to locate system 17204 ?
    - Where is it?
  - Not an address
    - A name

# Network Layer Addressing (2)

- Address needs to specify location
  - Where something is to be found
  - Not (necessarily) how to get there
    - That depends upon where we start

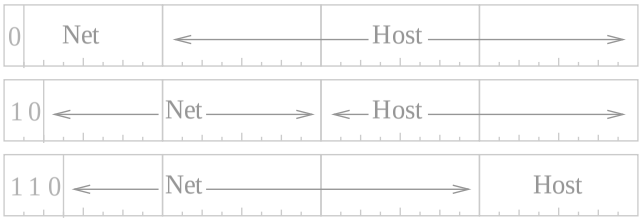


Links
Some Possible Paths

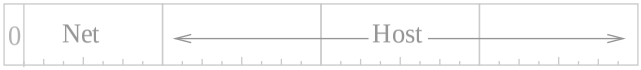
- For Internet (originally)
  - Specify network system connects to
  - Give network specific info
    - how to find host on that network


# Network Layer Addressing (3)


- Assumed
  - Not very many networks
    - Maximum 256
      - But 0 reserved, so 255
  - networks quite large
- Revision




# Address Classes (A)




- Class A
  - 127 Network Numbers
    - 1 .. 127
  - Up to 16 million hosts on each network

$2^{24}$ (16777216)

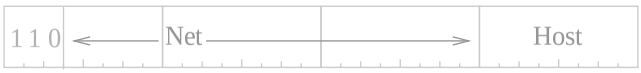
- For very big networks
  - Public access networks
  - Very large companies
  - (etc)

# Address Classes (B)


- Class B
  - 16384 Network Numbers
    - 32768 .. 49151
  - Up to 65 thousand hosts on each network

    $2^{16}$ (65536)
- For average networks
  - University
  - Average (medium sized) companies
  - (etc)

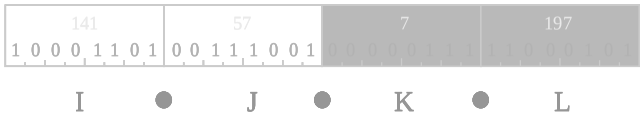
# Address Classes (C)




- Class C
  - 2097152 Network Numbers
    - 12582912 .. 14680063
  - Up to 256 hosts on each network
- For small networks
  - Homes
  - Small Companies
  - (etc)

# Problems with addresses

- Notation
  - 0 Reserved
  - 1 .. 127 Class A
  - 32768 .. 49151 Class B
  - 12582912 .. 14680063 Class C
- Very Ugly
  - Want something better




    - Each I J K L value 0 .. 255
- Notation
  - 0 Reserved
  - 1.0.0.0 .. 127.0.0.0 Class A
  - 128.0.0.0 .. 191.255.0.0 Class B
  - 192.0.0.0 .. 223.255.255.0 Class C

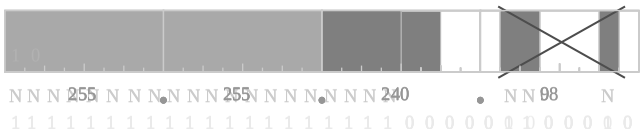
# Problems with addresses (2)

- Not Enough Addresses
  - 2 Million + 16 thousand + 1 hundred
  - To number every network in the world
    - Every ethernet (etc)
- Inefficient allocations
  - 3 hosts
    - Class C: 253 wasted addresses
  - 300 hosts
    - Class B: 16,000 wasted addresses
  - 50000 hosts
    - Class A: 16,000,000 wasted addresses
- First update
  - Organisations have many ethernets
  - Need many network numbers
  - Create sub-networks (subnet)
    - One network divided

# Subnets

- Class B
  - 16 network number bits
- Plus Subnet
  - 6 more network bits (this example)
- Organisation has
  - 1 Class B network number
  - 64 internal network numbers
  - Each with 1024 addresses available
- Subnets only visible inside organisation
  - Outside just sees 1 class B network
    - How many (if any) subnets unknown
  - So, all subnets much be connected
    - Return to this with routing

# Identifying Subnets




/20

- Inside network
  - need to know which bits are network number
  - not necessarily all together
    - because of existing numbering schemes
  - mark network bits somehow
    - each bit of address is either
      - Network bit, or local number on network
  - Binary choice
    - Use binary values (1 -> Network Number; 0 -> Local Part)
  - Then write mask
    - Just like network number 255.255.240.98 (0xFFFFF062)
- These days
  - All network bits required to be adjacent
  - Can simply count network bits -- 20 bit subnet mask here

# The Local Part

- Network part identifies a network
- Local part selects host on that network
  - 1, 2, 3, ...
  - Any value that fits
  - Except
    - All zero bits
      - The network number itself
      - Number for unknown host
    - All one bits
      - Every host
      - Broadcast

        Subnet directed broadcast
- So
  - /24 network — /20 network
    - 8 local part bits (32 - 24) — 12 local part bits
    - 256 available numbers ($2^8$) — 4096 numbers ($2^{12}$)
    - 254 hosts can be connected — 4094 hosts
      - 256 - 2 (reserved numbers) — 4096 - 2

# Network Numbers

- Network number 0 (Class A)
  - Reserved
    - Unknown
  - In particular IP address 0.0.0.0
    - Unknown IP address
    - Meaningless as destination address
    - Some rare uses as source address
- Network number 255 (Not Class A B or C)
  - Reserved anyway
  - In particular IP address 255.255.255.255
    - Local subnet broadcast
      - Send to all hosts on net
      - without knowing network address
- Network number 127 (Class A)
  - Host local networking (Packets never leave host)
  - In particular IP address 127.0.0.1
    - Loopback address
    - Send to myself whatever my real address is

# Network Numbers (2)

- With subnets
  - Generally need just 1 net number / organisation
- But still just 2,000,000 (and a few) net numbers
  - Many more than 2M organisations
- In 1980's early 1990's
  - Many organisations used IP networking
    - So need IP address(es)
  - Few connected to internet
    - Only communicate locally
  - Consuming many of the network addresses
    - Or just "borrowing" someone else's address
    - Copying documentation
- RFC1918
  - Private Use Addresses
    - Addresses not to be connected to Internet
    - Available for anyone to use
      - for their local (disconnected) network

# RFC1918 Addresses

- 10.0.0.0/8
  - 1 Class A network (ARPANET)
- 172.16.0.0/12
  - 16 Class B networks
- 192.168.0.0/16
  - 256 Class C networks
- Eventually with even greater address shortage
  - Organisations only able to obtain
    - very small number of addresses
- RFC1918 addresses used by connected organisations
  - Number all their hosts
- Network Address Translation (NAT)
  - Converts private address
    - to an available public address
  - When packet leaves organisation's network
    - and the reverse for incoming packets