Internetworking

TCP/IP

- Born out of the ARPA net in the late 1960's
- TCP ==> Transmission Control Protocol
- IP ==> Internet Protocol
- UDP ==> User Datagram Protocol
- Open standard, runs on PC's to supercomputers
- Runs at speeds from Kb/s to 100's Mb/s

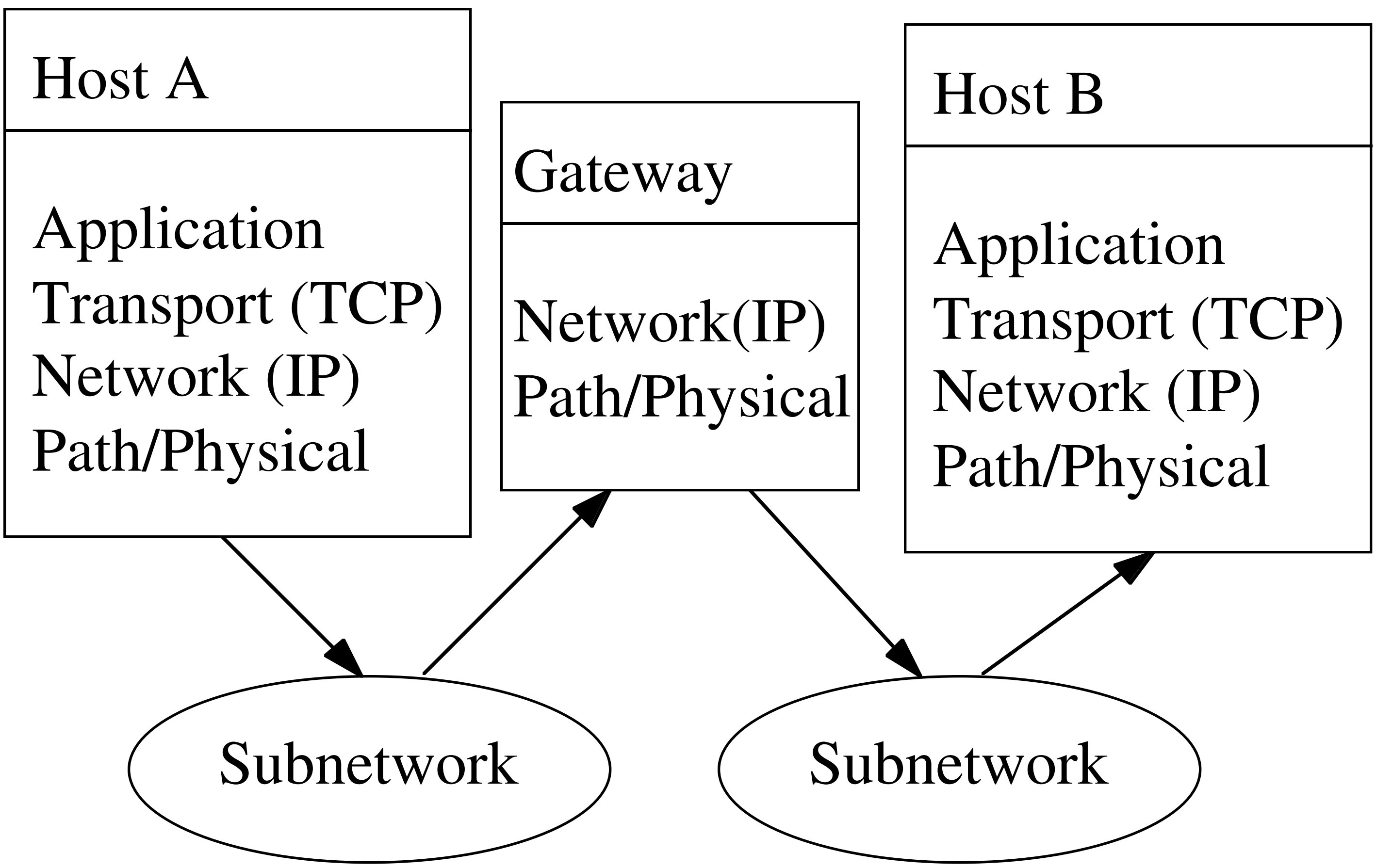
Internetworking

TCP/IP

- Internet Architecture
  - Application, e.g., FTP, Telnet, e-mail Simple Mail Transfer Protocol, (SMTP)
  - Service Provider, end-to-end communications (**TCP**)
  - Internetwork, functions to connect networks and gateways into a total system, (**IP**)
  - Subnetwork, e.g., ARPANET, Ethernet

Internetworking

TCP/IP



Internetworking
IP

- IP is connectionless
  - No call set up
  - PDU's may be lost
  - Hides the subnet technology from the application to allow the use of many different subnet technologies

Internetworking

IP

- IP Services
  - Routing
    - IP host and gateways have routing tables
    - Source routing
      - PDU contains a list of network addresses, last in the list is the destination
  - Time Stamping Option
  - Fragmentation and reassembly
    - If PDU size > MTU for subnet the IP must fragment the PDU and reassemble at the destination

Internetworking

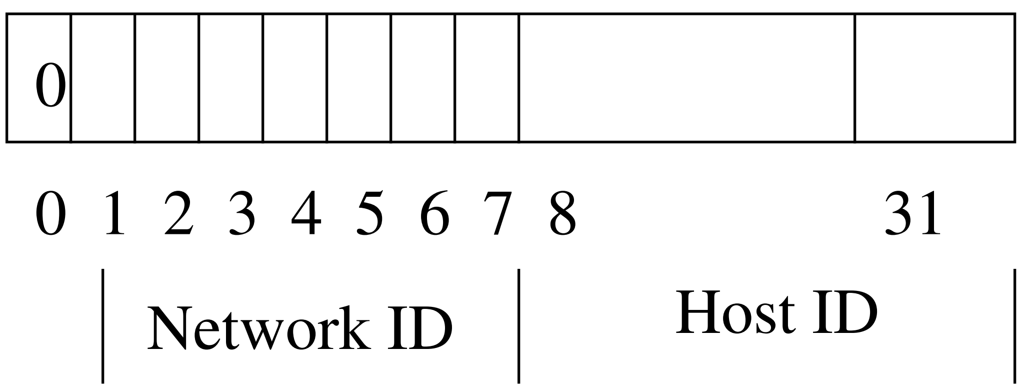
IP

- IP addressing
  - 32 bits/address ==> 4.295×10^9 addresses
  - Addresses contains
    - Host ID
      - Identifies a unique host on a network
    - Network ID
      - Identifies the network that the host is connected to
    - Five formats for IP addresses

Internetworking

IP

– Class A addresses

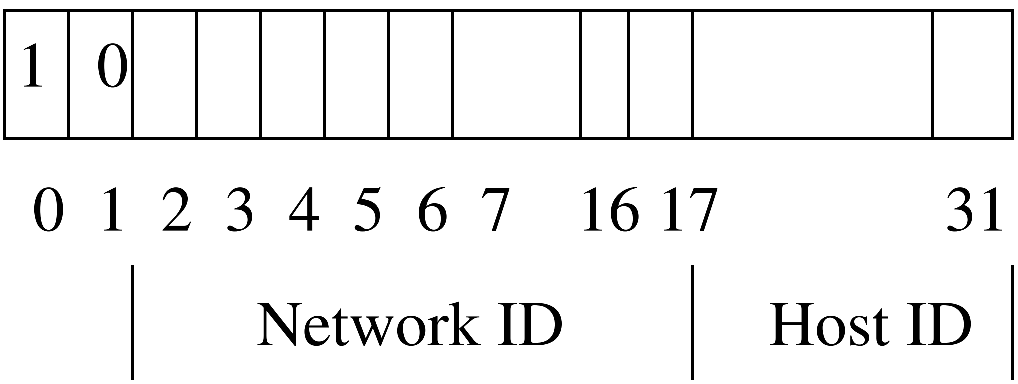


There are 127 class A networks, each with 16,777,216 hosts

Internetworking

IP

– Class B addresses



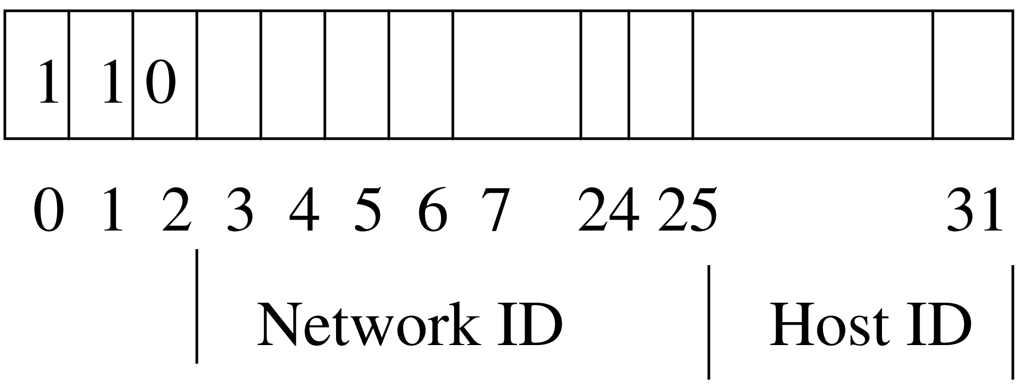
16383 Class B addresses (address ‘0’ is reserved)
65,536 hosts/ network

KU has a class B address

Internetworking

IP

– Class C addresses

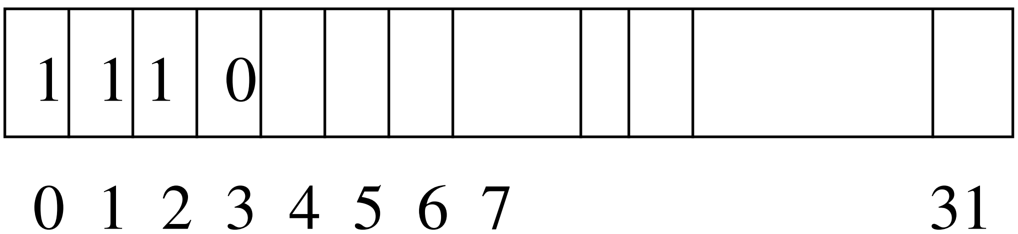


There are 2,097,152 class C networks
(‘0’ and ‘2,097,151’ reserved)
There are 256 hosts/network.

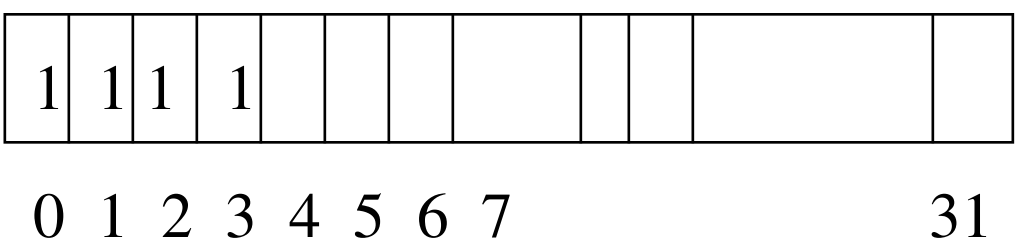
Internetworking

IP

– Class D and E addresses



Class D is used for multicasting



Class E reserved for future use

Internetworking
IP

- IP address notation
  - 32 bits = 4 bytes
  - Represent each byte by a decimal
  - Example: 10.55.31.84

    00001011 . 00110111 . 00011111 . 1010100

    10 55 31 84

    - This is a Class A address
      - 0001011 is the network address
      - 00110111 000111111010100 is the host address

Internetworking
IP

- Identification of class
  - Class A 1 - 127
  - Class B 128 - 191
  - Class C 192 - 233
  - Class D 224 - 254
- Example: My x-terminals address is 129.237.116.111 ==> Class B network,
- All KU hosts are 129.237..xxx.xxx

Internetworking
IP

- Non-numberic form for IP addresses
  - user@host.department.institution.domain
  - Domain name servers (DNS) contain tables to convert:

  host.department.institution.domain

  to a 32-bit address
- Common Domains
  - .edu
  - .com
  - .mil
  - .org
  - .gov
  - .net
  - .{country} .il, .uk

Internetworking

IP

- Example:
- gauss.eecs.ukans.edu ==> 129.237.125.220
- A different IP address can be assigned to each physical interface on a host, note a physical interface will have a unique physical address, for IEEE 802.3 this is a 48-bit number

Internetworking
TCP

- TCP provides for assured delivery of PDU’s
- TCP Services
  - Connection oriented
    - Need call processing
    - Information on the status of each connection is available
  - Reliable data transfer
    - Uses acknowledgments
    - Uses sequence numbers

Internetworking
TCP

- Stream-oriented
  - TCP collect user bytes and forms segments to be passed on to the IP layer
  - Sequence number based on byte counts
- Push
  - Upper layer protocol send Push message to TCP to force it to send all the bytes collected in a segment
- Resequencing
  - IP may deliver information out of order, TCP must put it back together

Internetworking

TCP

- Inclusive Acknowledgment
  - Acknowledgment number, acknowledges all received bytes prior to the one specified
- Flow control
  - Window size is in bytes
  - Transmit N-bytes and the must wait for acknowledgment
  - Window size is dynamic, i.e., it changes based on knowledge of network congestions

Internetworking
TCP

- Multiplexing
  - Allows multiple sessions within one host to be transmitted over an IP path
- Full duplex
- Security and precedence
- Graceful close
  - All traffic in flow is acknowledged before the session is ended.

Internetworking

TCP

- TCP Ports and sockets
  - Port address + IP address = socket address
  - Both sender and receive have socket addresses
  - A connection is identified by a pair of sockets
  - The port address is internal to the host
  - A socket address is unique in the internet

Internetworking
TCP

- Once an application creates a socket and TCP connection then a *write* is used to send to the network and a *read* used to receive from the network.
- There are some commonly used port numbers
  - Example:
    - File data transfer (20)
    - TELNET (23)
    - SMTP (25)
    - Remote Procedure Call [RPC] (111)

Internetworking
TCP

- Retransmission procedures
  - TCP uses a positive acknowledgment
  - Selecting timeout timer value
    - Delay unknown a-priori
    - Segments may be lost making measurements of the round-trip time (RTT) difficult

Internetworking

TCP

- Determining the timeout interval
  - Estimate the RTT for the ith segment, RTT(i)
  - RTT(i+1) = aRTT(i) + (1-a)RTT (i-1) where 0<a<1
  - Timeout interval = bRTT(i)
  - The ‘a’ parameter governs the time response to changes in RTT
  - Standards recommend b=2

Internetworking

TCP

- Adaptive congestion control algorithm
  - If time out assume congestion caused loss
  - If the network is congested then want to slow the source down to reduce congestion
  - When the network congestion disappears then want to allow the source to send faster

Internetworking
TCP

- Decrease Algorithm
  - If timeout then set

    new_window =

    min(old_windo/2, one segment)
  - Multiplicative decrease will cause an exponential decrease in TCP traffic flow into the network
- Increase algorithm
  - If acknowledge received then increase the window size by one segment, i.e.,
  - new_window =

    old_window + 1 segment
  - This is *slow-start* recovery procedure and avoids opening the window to fast and thus causing more congestion
- Exponential decrease/linear increase is a common feature of some congestion control algorithms.