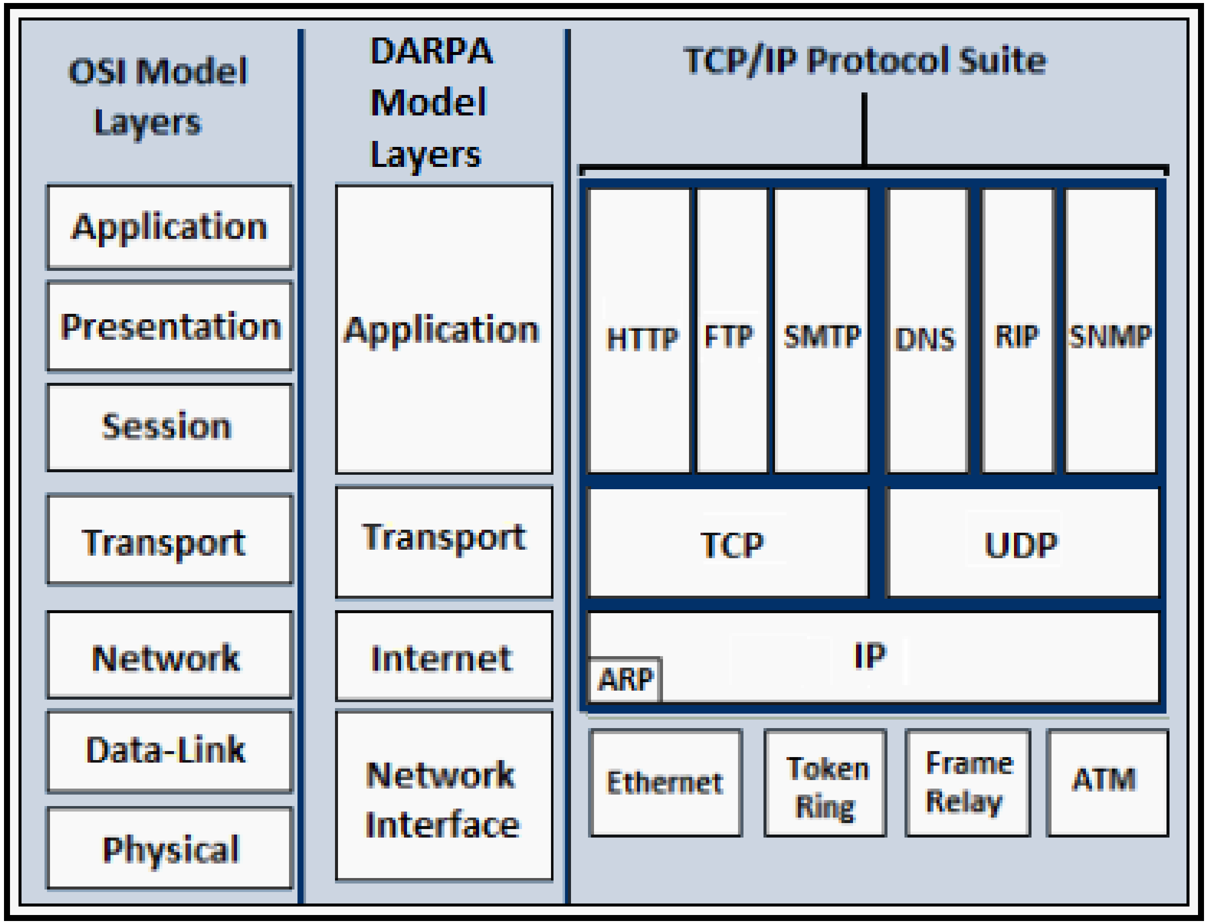
Lecture 6.d
In Class Test 1 Review

Network Layer

Dr. Gabriele Pierantoni

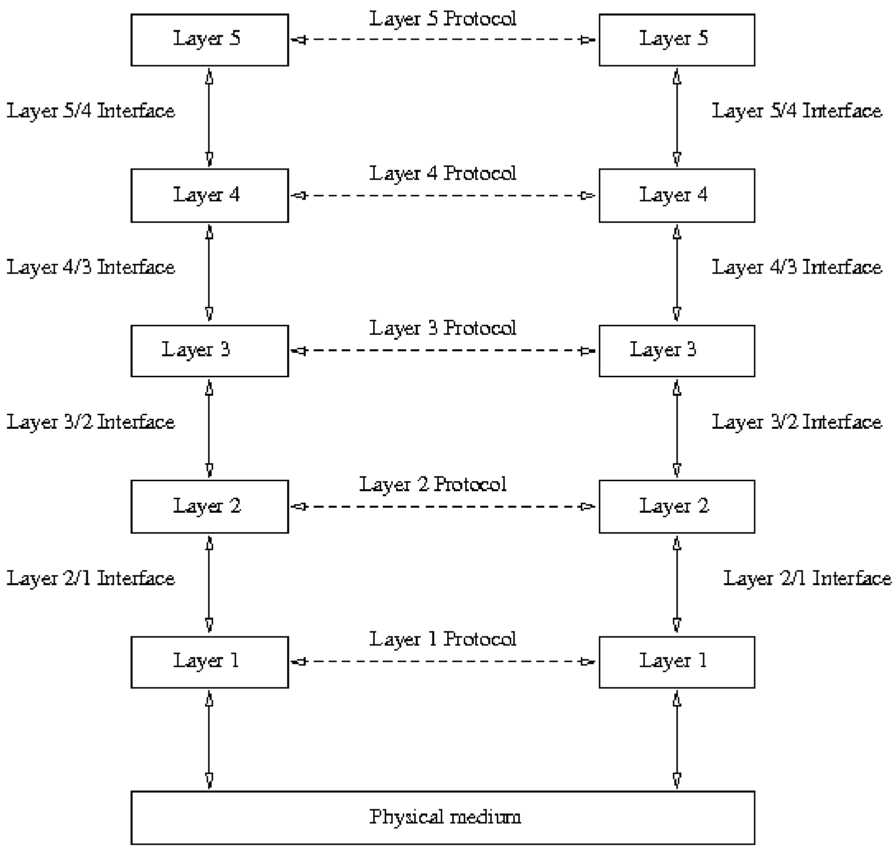
22.02.2021

Networking Protocols



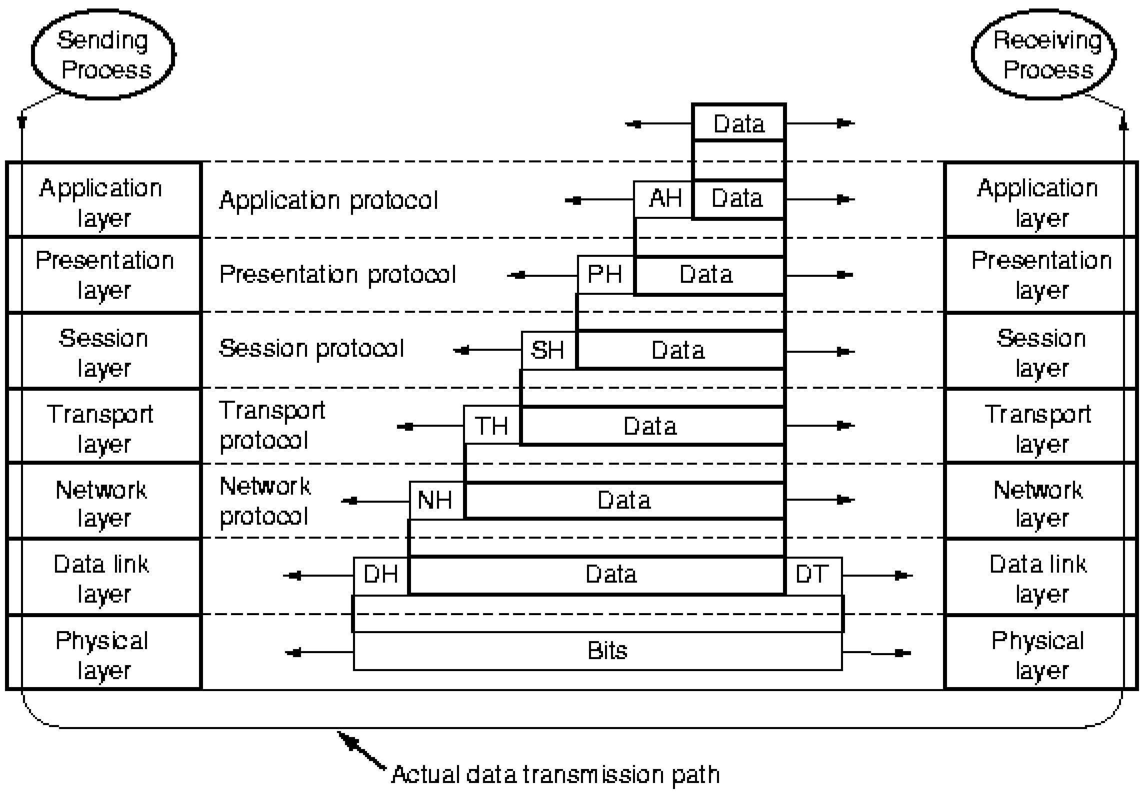
Protocol Hierarchies

- Reduce the complexity of network communication design
- Organise network communication as a series of layers

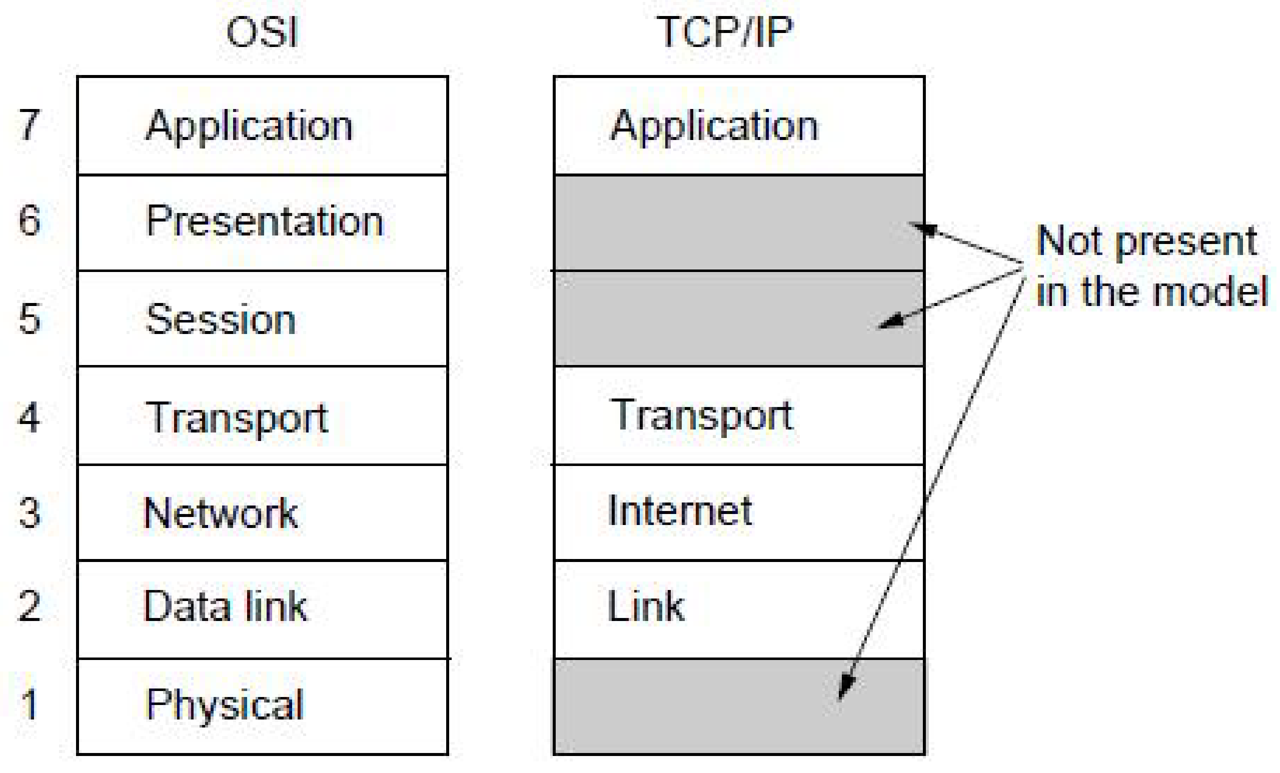


OSI Reference Model

- The ISO have divided up these issues over a layered hierarchy of 7 levels called the ISO Open Systems Interconnection (OSI) Reference Model



OSI vs TCP/IP



OSI
TCP/IP
7
6
5
4
3
2
1
Application
Presentation
Session
Transport
Network
Data link
Physical
Application
Transport
Internet
Link
Not present in the model

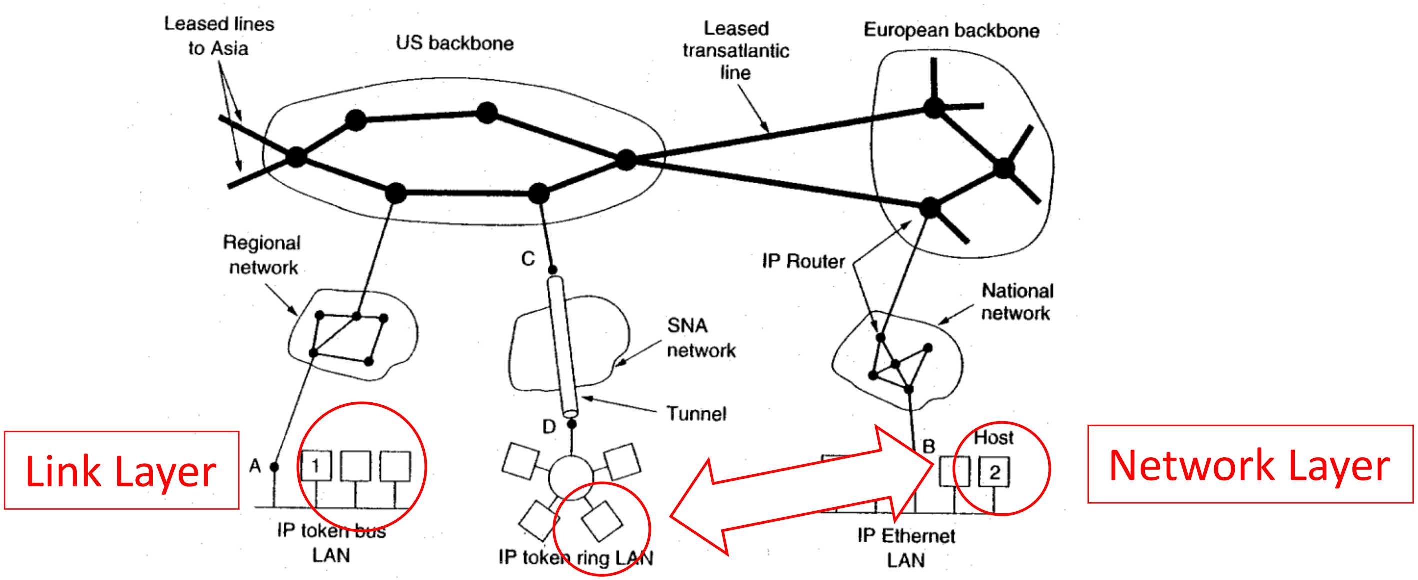
Network Layer

Application
Transport
Network (internet)
Link
Physical

- Using the Link Layer we can move data between adjacent hosts
- We now need to consider how we can move data between machines that are more widely separated
- Separation must be considered both geographically and in terms of communication media.
- This is the job of the Network Layer

Internet Structure

- Recall that the Internet is composed of a **collection of interconnected networks**
- These **networks are connected together using routers**
- The collection of routers and communication lines interconnecting them is known as the **communication subnet**



Responsibilities

- **The Network Layer** is responsible for getting data across the subnet all the way from a source to a destination
- It must know about the topology (or shape) of the communication subnet
- The Network Layer must **route data across the communication subnet**
- Remember that there are most probably a range of routes between any two routers
- Routes chosen must avoid overloading some lines while leaving others idle

Store and Forward

- If a host needs to send a message across the subnet the message is broken into packets

1. A host with a packet to send sends it to the nearest router
2. The packet is stored at this router until it has fully arrived
3. Checksum is verified
4. The packet is then forwarded to the next router until it finally reaches the destination

Connectionless Service

- There are two options for what kind of service the network layer should provide
  - **Connectionless Service**
  - **Connection Oriented Service**
- In a connectionless service all the network layer must do is move data packets from a source to a destination
- Packets that are part of the same communication **need not take** the same route
- **No error control or correction performed at network layer**
- **No packet ordering performed by network layer**
- No flow control performed at network layer
- Supported by the Internet community
- **The Internet Protocol (IP) uses a Connectionless Service**

How data is sent

- A connectionless service sends independent packets of data across the subnet.
- These packets are called datagrams
- Each datagram (even though it may be part of the same message) is routed individually across the subnet. Successive packets may follow very different routes.
- For these reasons a connectionless service is considered extremely robust. Any single router crashing is not a catastrophic event

Routing I

- It is the responsibility of the network layer to route datagrams across the subnet.

- The routing algorithm is the part of the network layer software responsible for choosing which output line a datagram should be sent out on when it arrives at a router.

Network Layer on the net

- Network layer for a datagram service has two principle components:
  - **Path Determination component.**
    - Routing protocols - protocols that determine how a packet is forwarded on from one router to the next
  - **Network protocol component.**
    - Network layer addressing
    - The fields within the datagram
    - How the end systems act on these fields
- On the Internet this is the Internet Protocol (IP)

Internet Protocol I

- Internet Network layer offers a connectionless datagram service to the Transport Layer
- Network layer encapsulates the segments received from the Transport layer in an IP datagram.
- The IP header includes the destination address.
- IP service is best effort
  - Does not guarantee packet will arrive within a certain time
  - Does not guarantee sequential delivery
  - Does not guarantee that delivery will occur at all

Internet Protocol II

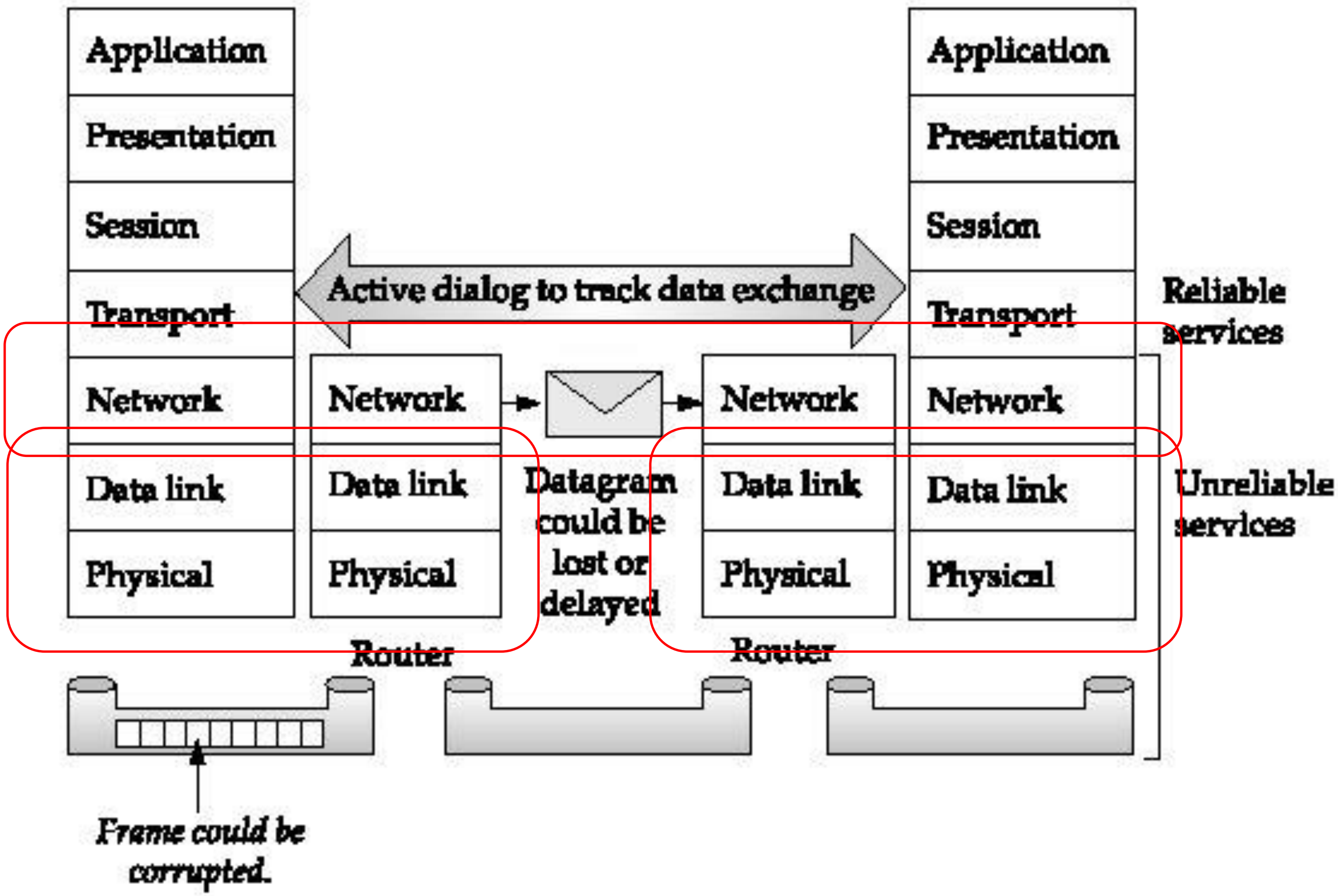
- There are network layer components on every host and router on the Internet

- Whereas end-hosts implement the full protocol stack, routers only implement the stack as far as the Network Layer

- Recall encapsulation - when a packet enters a router, it is un-encapsulated at each layer as far as the Network layer

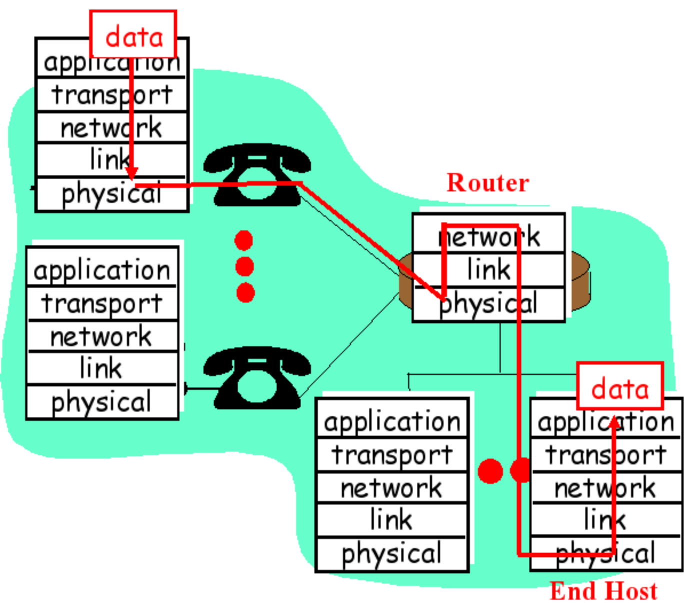
- It undergoes some processing and a decision is made where to route it next, it is then re-encapsulated at each layer

Internet Protocol III



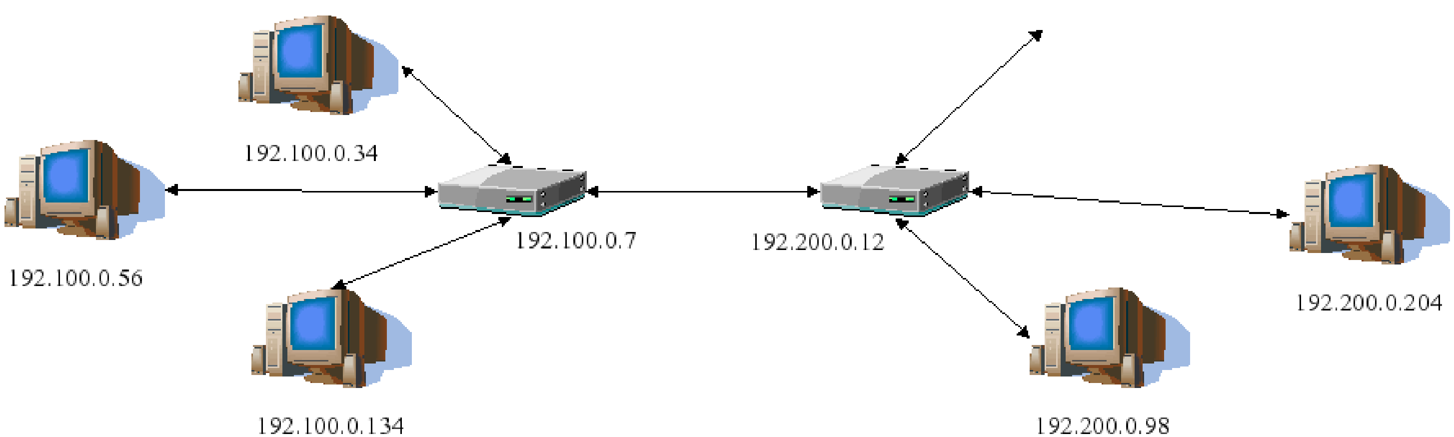
Example

- IP accepts data segments from the transport layer
- IP packets are routed through the Internet
- However, IP has no mechanisms for receiving congestion information back from routers.
- IP cannot reserve a minimum bandwidth for its packets It just sends them out with an appropriate destination address and hopes for the best.



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

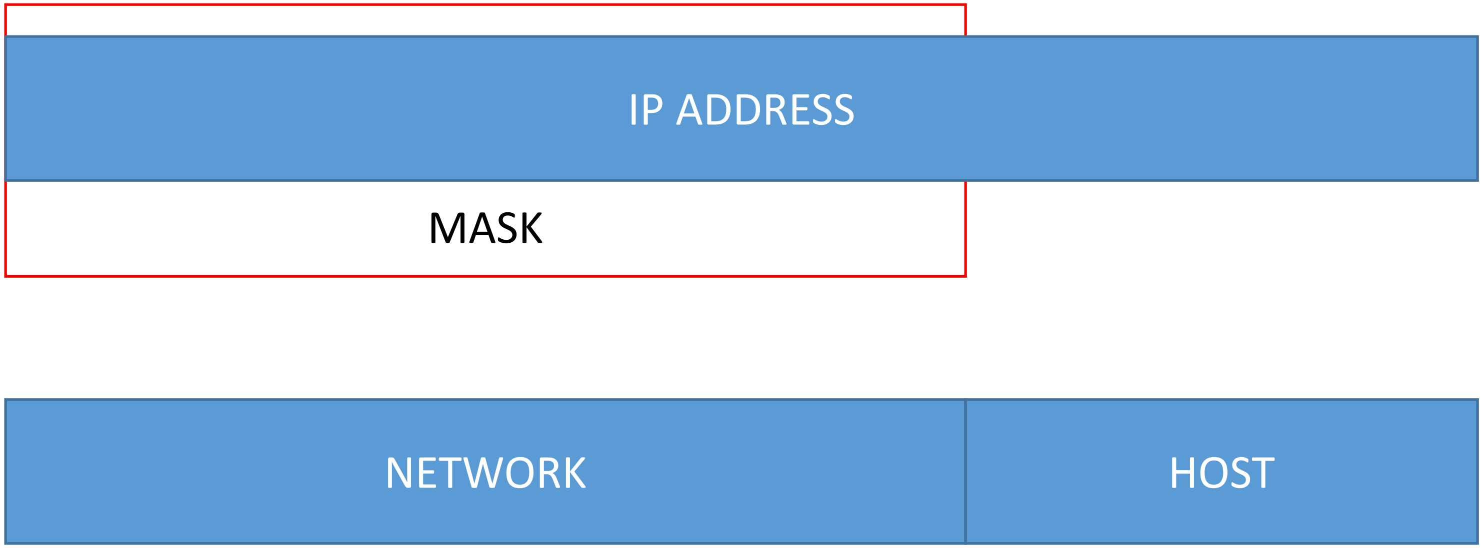
- IPv4 address has four bytes
  - Split into network and host portions
  - Internet originally used classes of IP addresses

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