Multicast

▶ Client will send to multicast address

▶ Anyone who is waiting for the multicast group can see this message

▶ mclient.c

▶ multicast.c

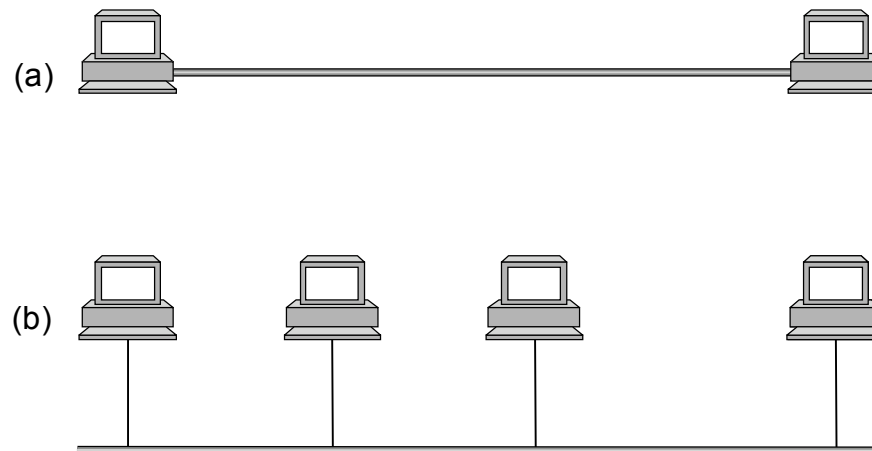# Outline: Network architecture

▶ Definitions: Node, link, switch, Internetwork

▶ Organization: Layer, protocols, encapsulating higher level messages into lower level messages

Network Architecture

▸ Node: communications end-point, e.g. computers

▸ Link: network communication

- Point-to-point - connects two nodes
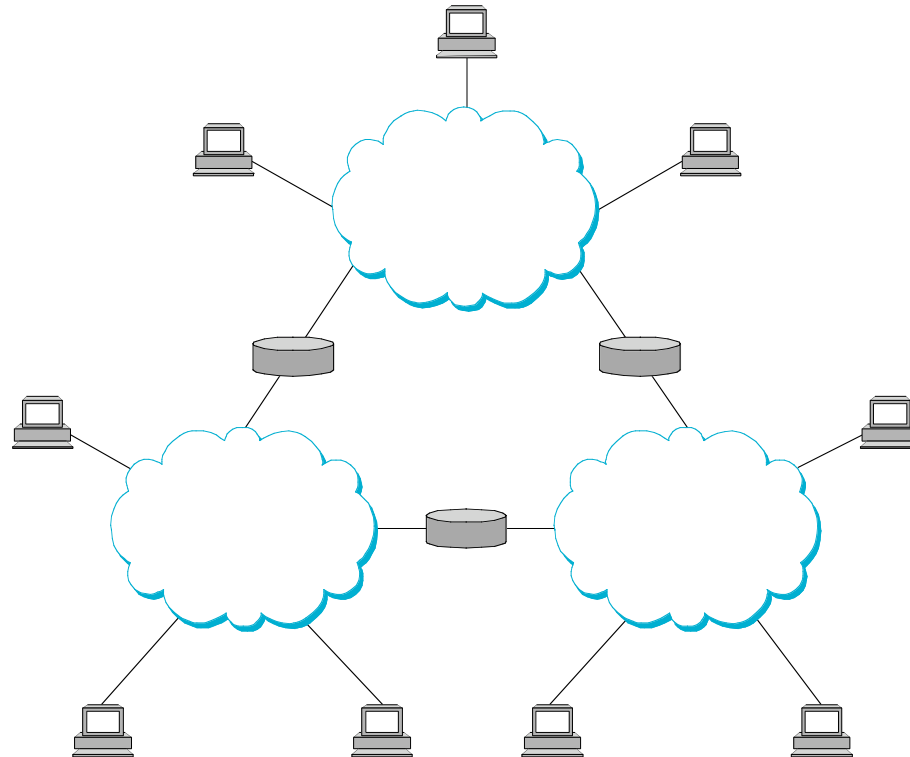- Multiple access - connects many nodes

(a)

(b)

Switched networks

▸ Its not possible to have all nodes be connected to all other nodes. Use switches that forward traffic from one cluster to another
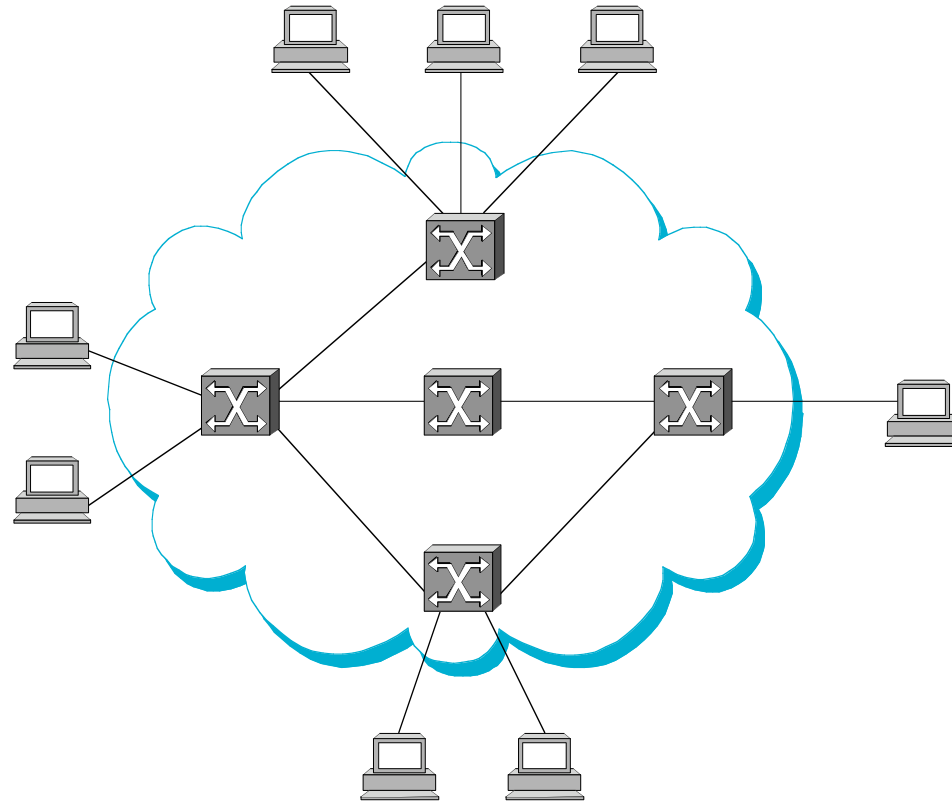
Internetwork - Network of networks

▶ Connect networks to build more complex networks

Switching mechanisms

▸ Describes how the switching of networks works

- Circuit switched: establish a connection (circuit) between nodes that are communicating
  - E.g. telephones
- Packet switched: each packet is independently switched
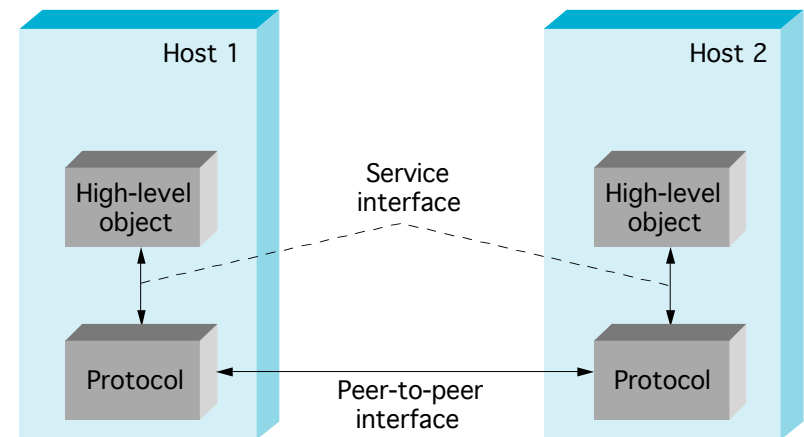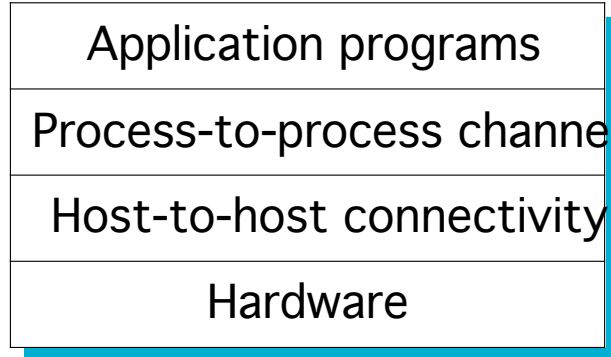 - Packets are stored-and-forwarded by the switches

Multiplexing multiple flows on a link

▸ Logically multiplex multiple links over a single physical link.
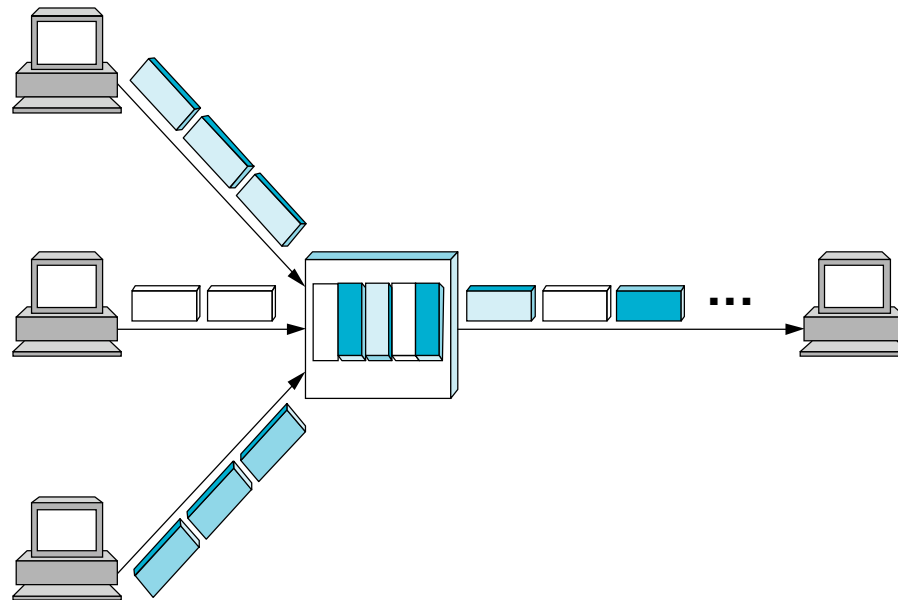
Network Architecture

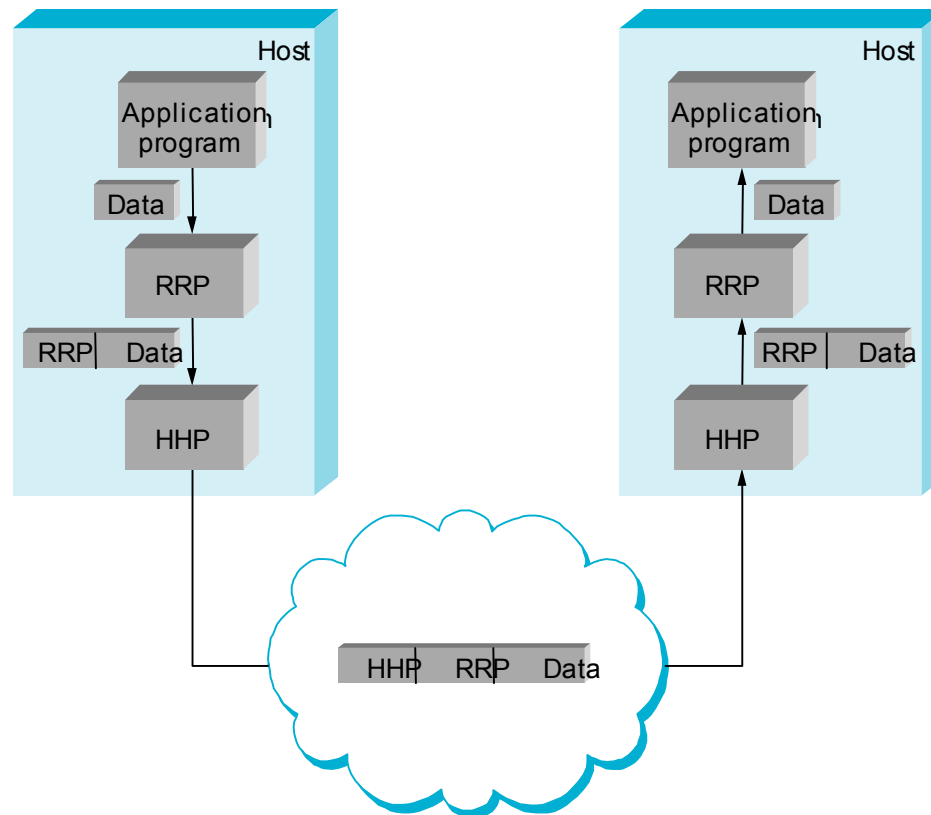▶ Layering to provide higher level abstractions on top of lower level networks

▶ The layers implement a protocol
  - Service and peer interfaces to communication across protocol layers and nodes

| Application programs |
| Process-to-process channel |
| Host-to-host connectivity |
| Hardware |

Host 1

Host 2

High-level object

High-level object

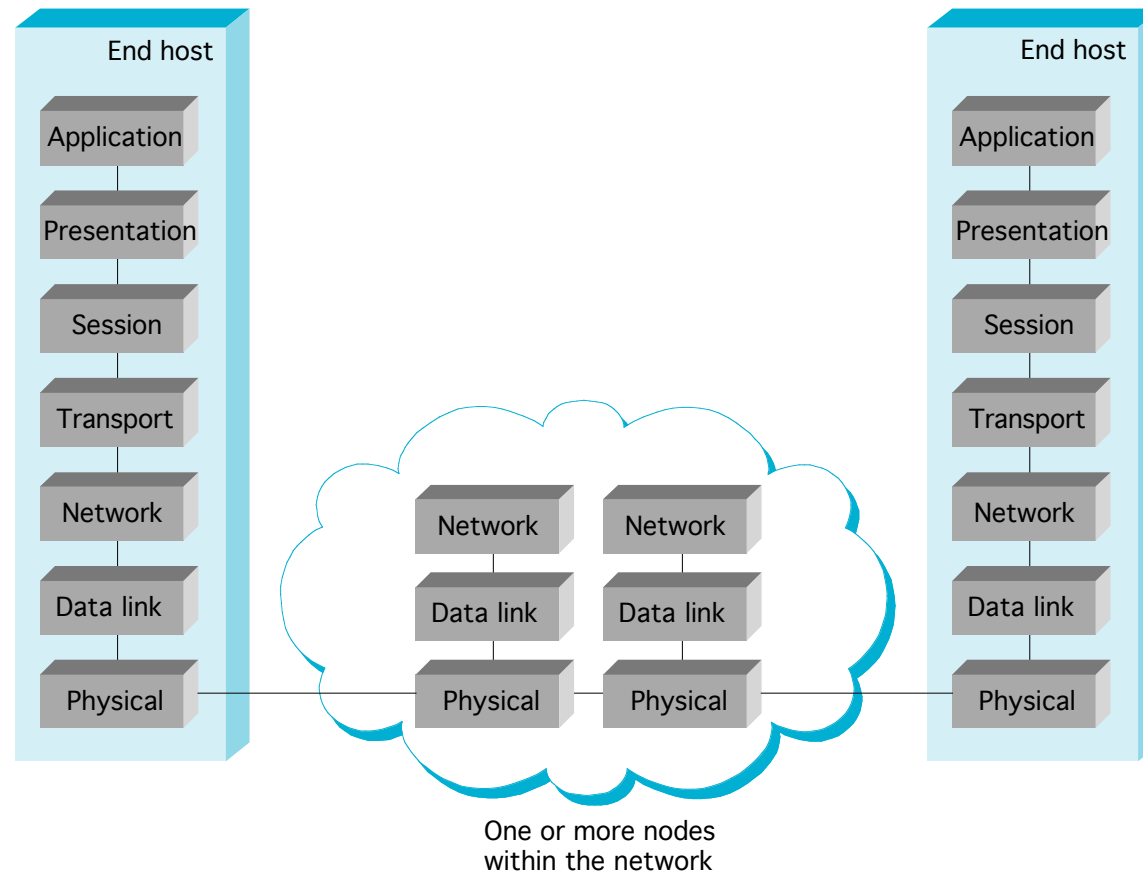Service interface

Protocol

Protocol

Peer-to-peer interface

Encapsulation

▶ Higher level messages are encapsulated inside lower level messages

OSI layers

▶ **Seven layer OSI Protocol**

End host		End host
Application		Application
Presentation		Presentation
Session		Session
Transport		Transport
Network	Network Network	Network
Data link	Data link Data link	Data link
Physical	Physical Physical	Physical

One or more nodes
within the network

Internet Protocol layer
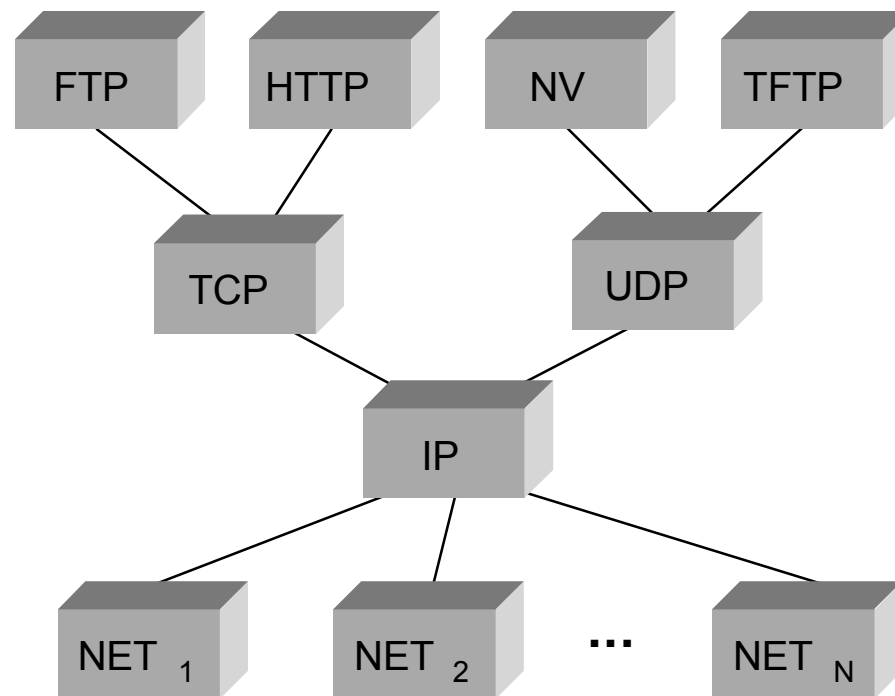
Outline: Performance

- Bandwidth, latency, bandwidth delay product, jitter

Bandwidth and Latency

▶ Bandwidth: amount of data transmitted in a given duration

  ■ E.g. 100 Mbps (million bits per second)

▶ Latency: time to send bits from source to destination

  ■ RTT: Round trip time is measurable
  ■ RTT does not depend on b/w

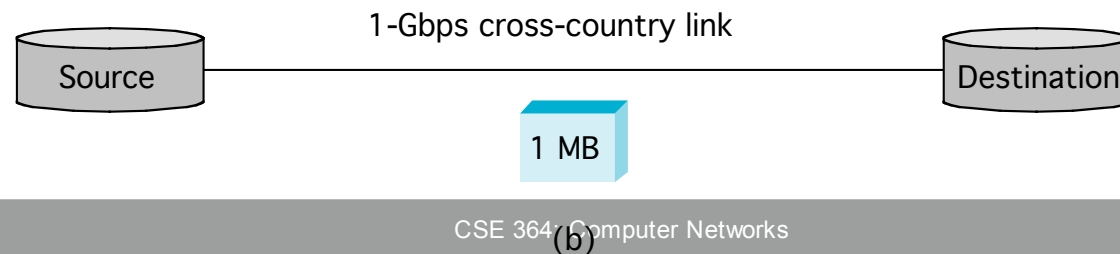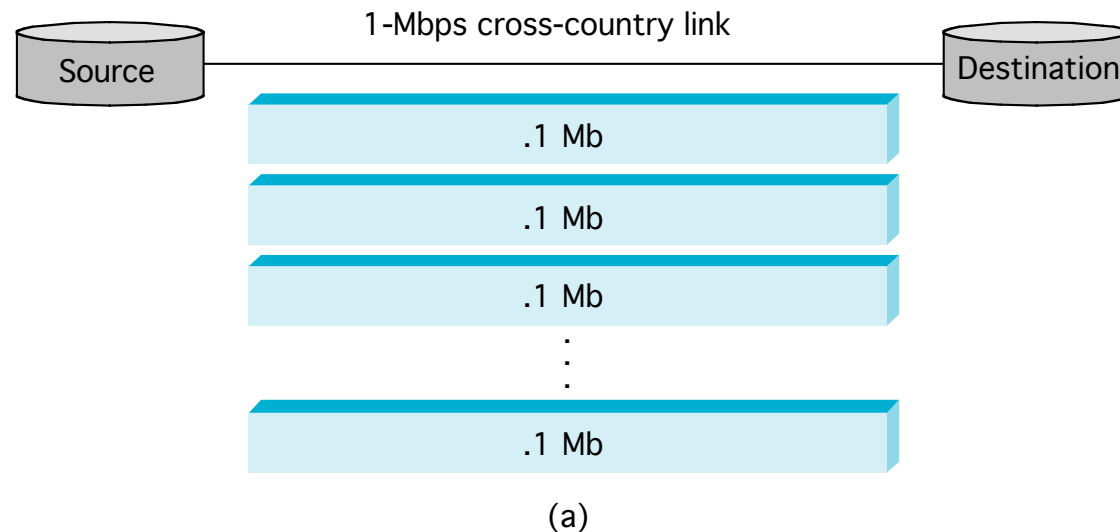Latency = Propagation + Transmit + Queueing delay

Propagation = Distance/(Speed of light in medium)

Transmit = Size/Bandwidth

Bandwidth x delay product

▸ Assume the link as a pipe. Up to bandwidth x delay will be in the link before it is received on the other side. Assume 100 ms delay

1-Mbps cross-country link

Source   Destination

.1 Mb

.1 Mb

.1 Mb

.
.
.

.1 Mb

(a)

1-Gbps cross-country link

Source   Destination

1 MB

(b)

- Using a 1 Mbps packet in 1 Gbps link wastes most of the pipe if you are waiting for confirmation before you send the next packet
- Important to keep the pipe full for better link utilization
- The bandwidth x delay product is the basis for a lot of networking tricks
- Jitter: induced interpacket delay

Interpacket gap

| 4 | 3 | 2 | 1 |

Packet source

Network

| 4 | 3 | 2 | 1 |

Packet sink

Examples

- Satellite link: high b/w, high latency
- Dialup: low b/w, low latency

- Bandwidth tells you how fast you can transmit data (once the first bit - which is measured by latency) is received

- http, ftp: high bandwidth
- Video conferencing: low latency and low jitter
- Streaming video: low jitter