Data Communication and Computer Networks

Text Books:

1. Data Communications and Networking, B Forouzan, McGraw-Hill, 4th edition.
2. Computer Networks, Andrew S Tanenbaum, 4th edition.

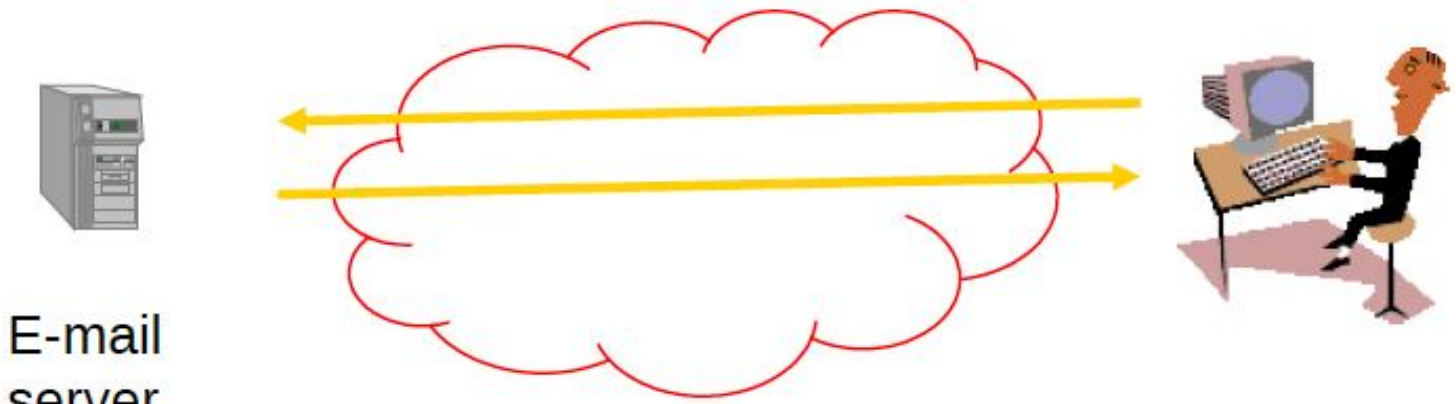
DATA COMMUNICATIONS

The term telecommunication means communication at a distance. The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

A communication service enables the exchange of information between users at different locations.

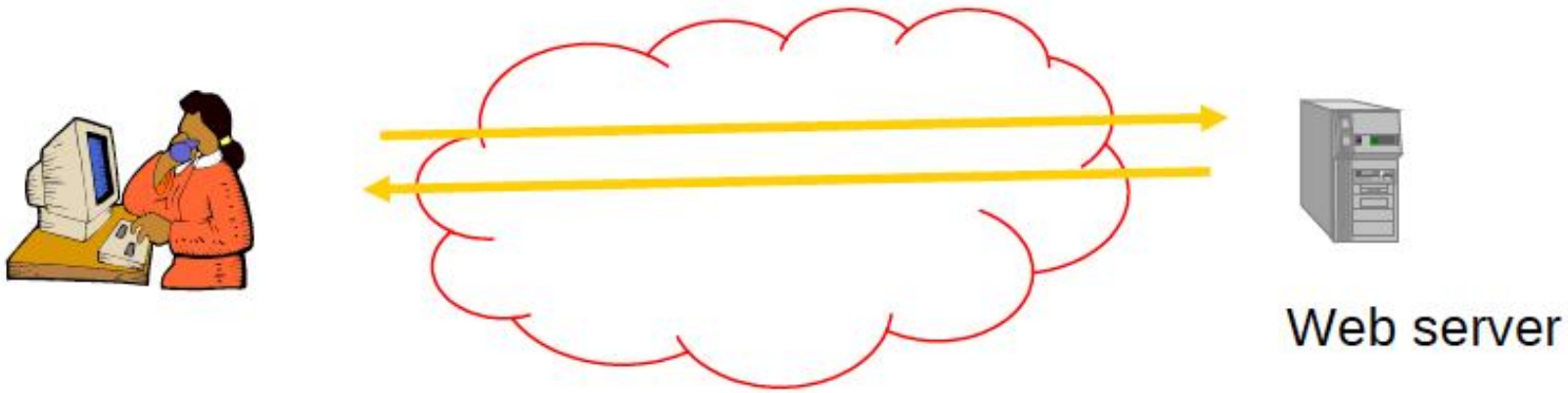
E-mail



Exchange of text messages via servers

A communication service enables the exchange of information between users at different locations.

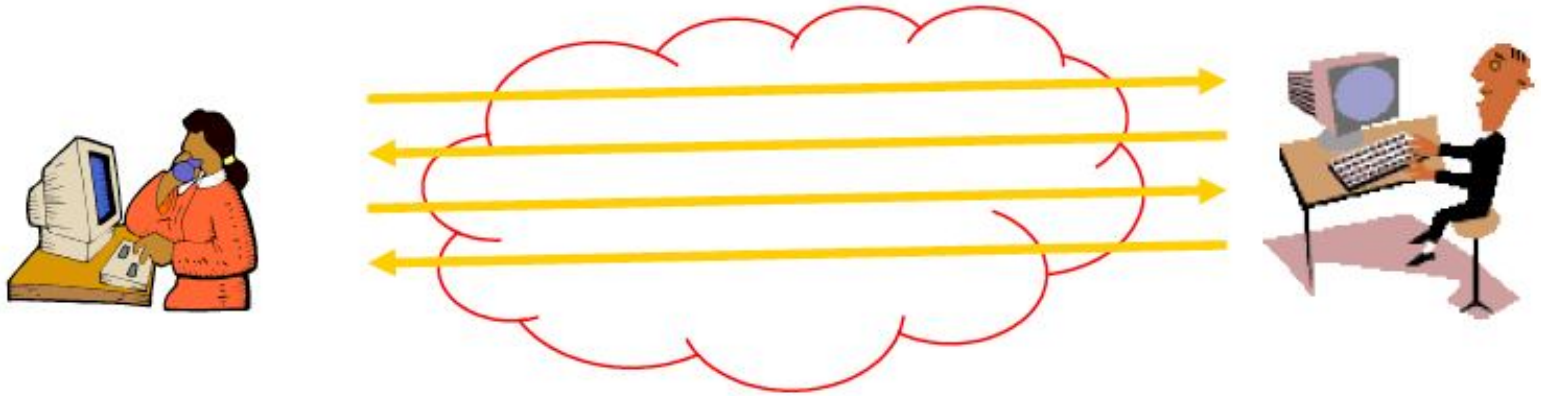
Web Browsing



Retrieval of information from web servers

A communication service enables the exchange of information between users at different locations.

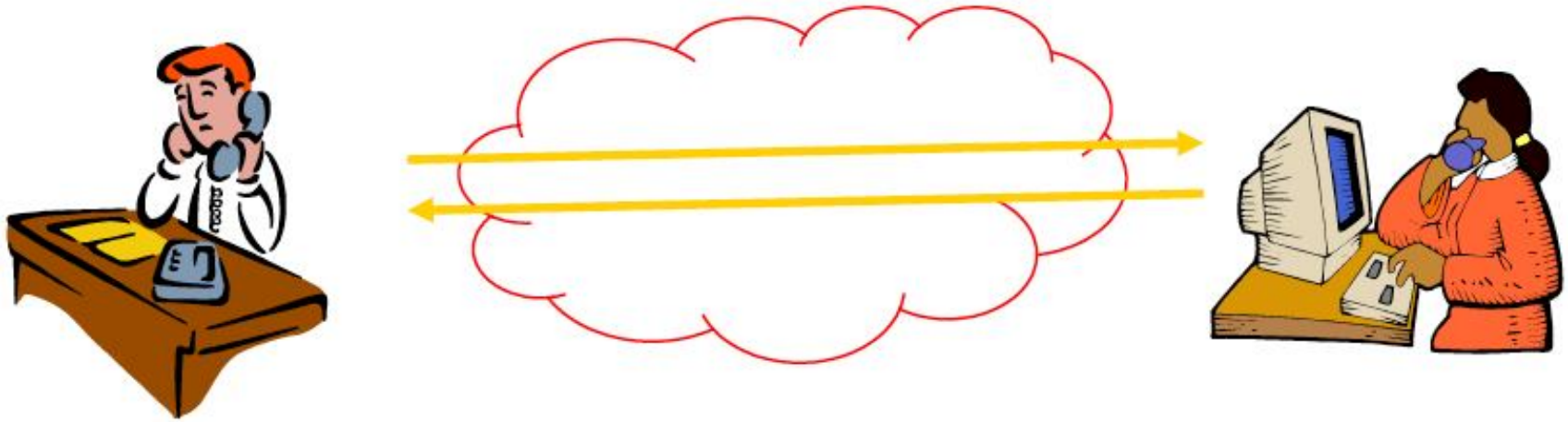
Instant Messaging



Direct exchange of text messages

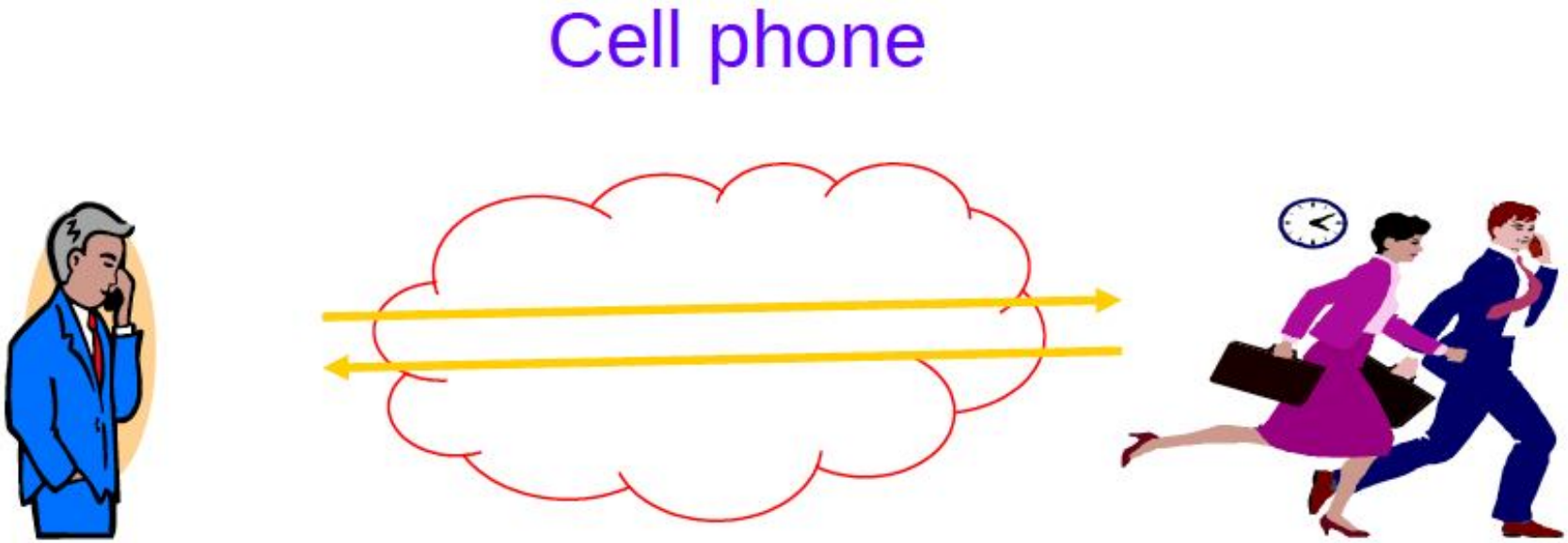
A communication service enables the exchange of information between users at different locations.

Telephone



Real-time bidirectional voice exchange

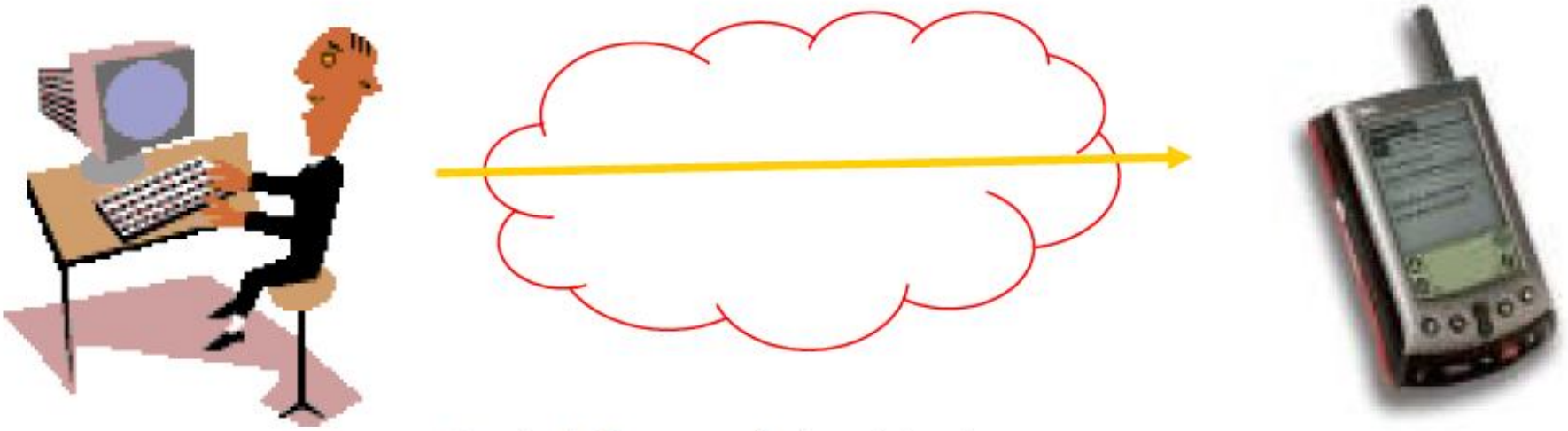
A communication service enables the exchange of information between users at different locations.



Real-time voice exchange with mobile users

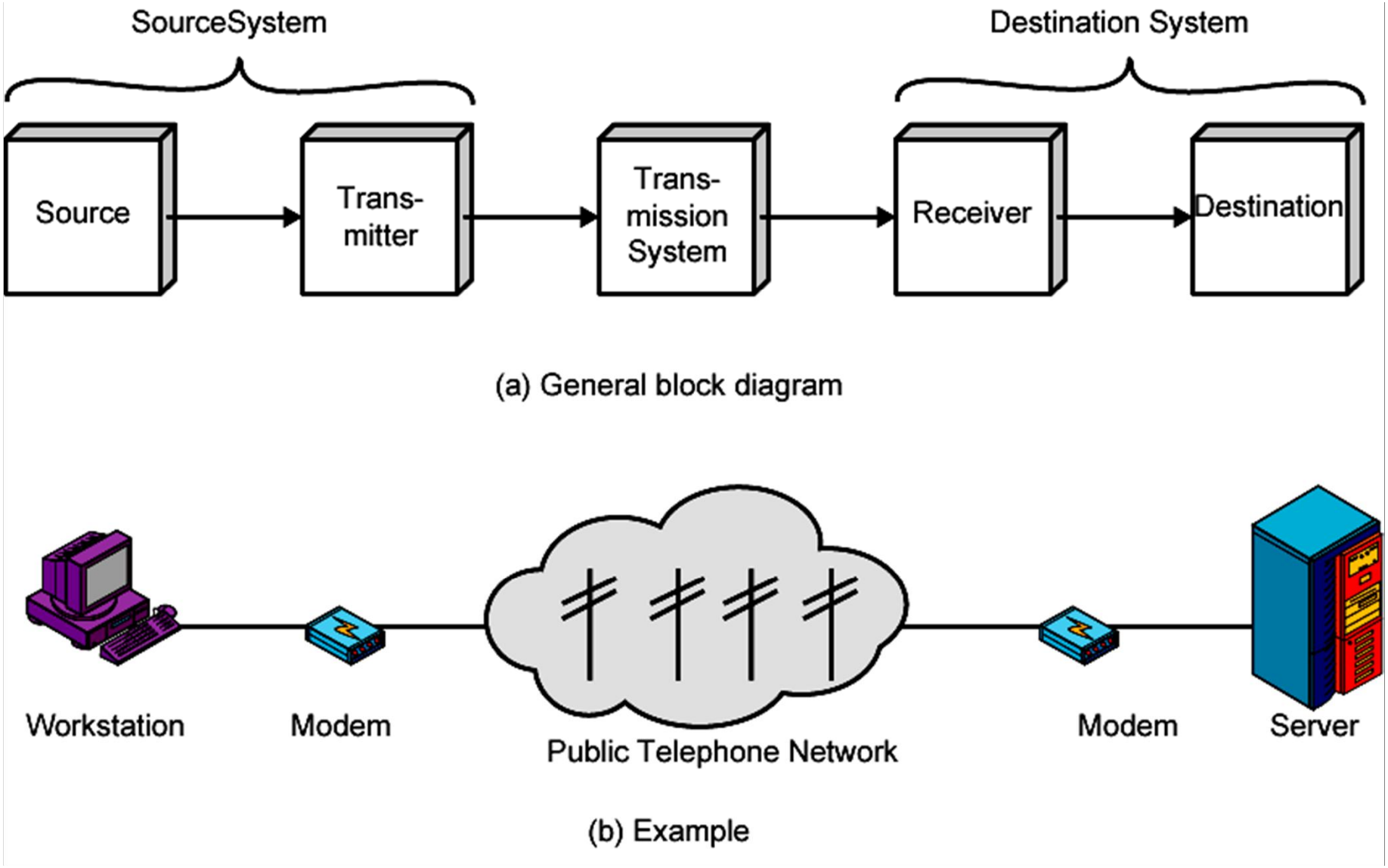
A communication service enables the exchange of information between users at different locations.

Short Message Service

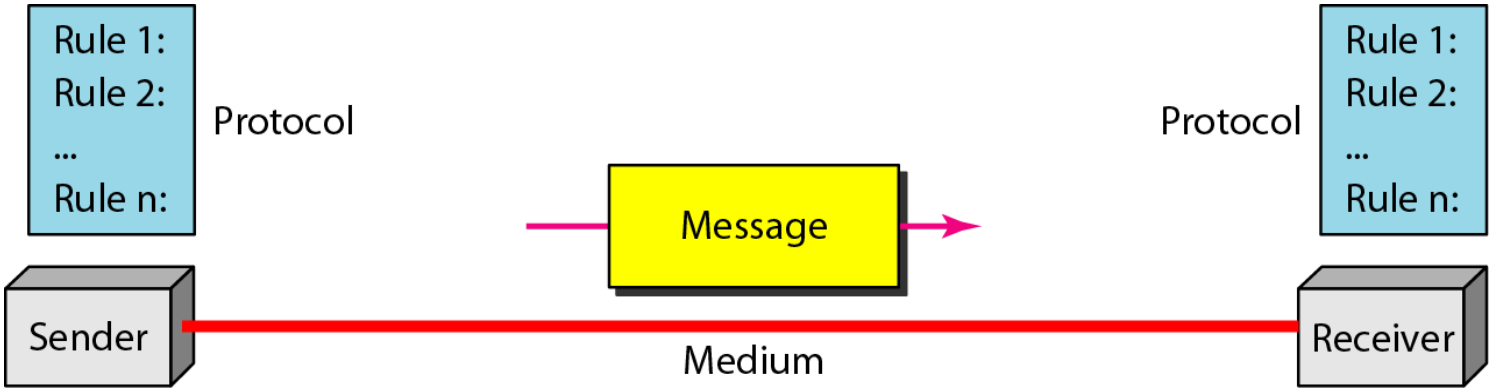


Fast delivery of short text messages

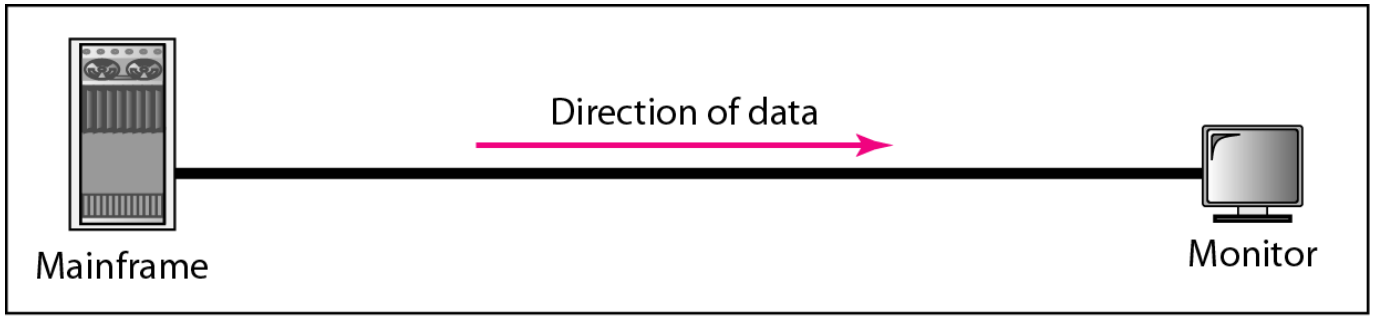
Communications Model



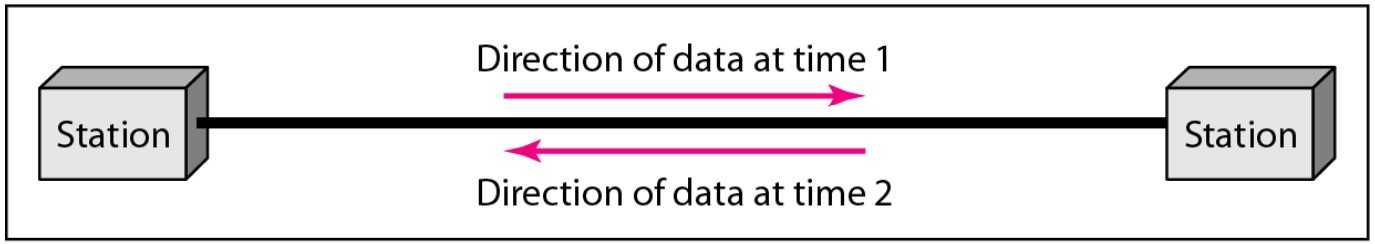
Five components of data communication



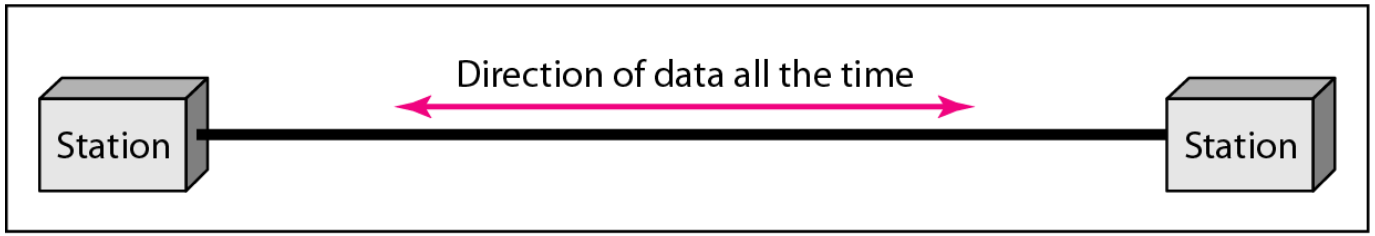
Data flow (simplex, half-duplex, and full-duplex)



a. Simplex

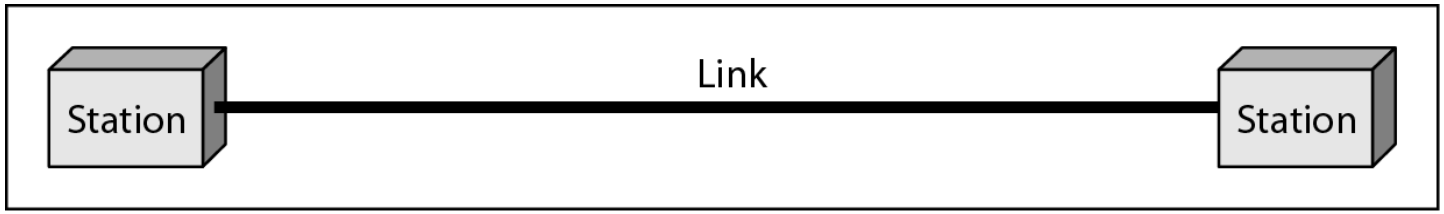


b. Half-duplex

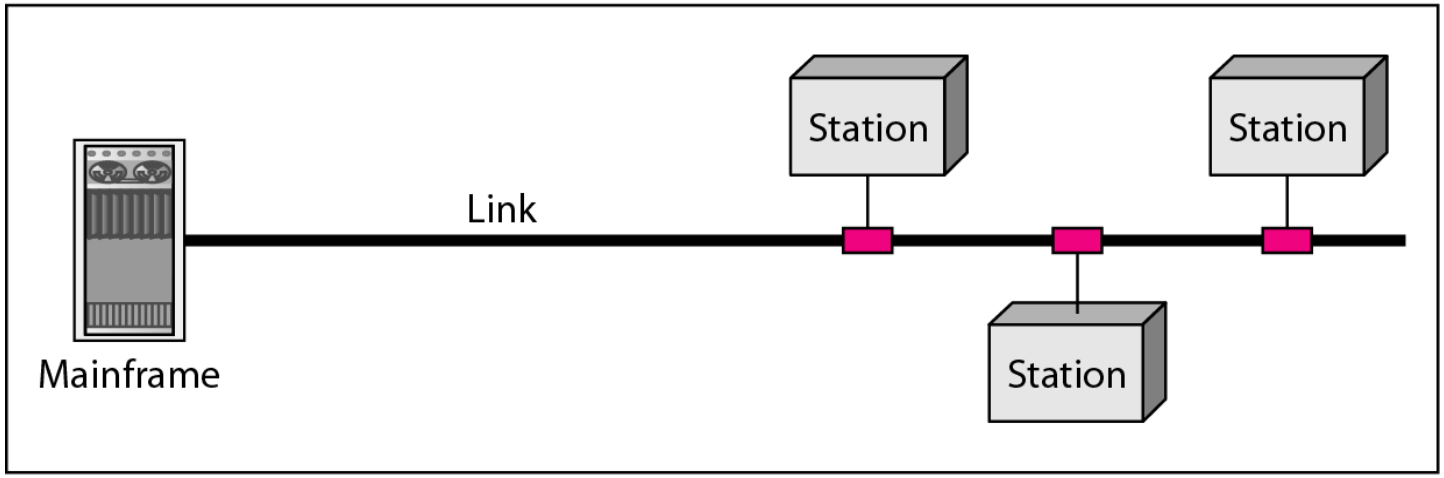


c. Full-duplex

Types of connections: point-to-point and multipoint



a. Point-to-point



b. Multipoint

Why Networking??

- Point to point communication NOT usually practical
  - Devices are too far apart
  - Large set of devices would need impractical number of connections

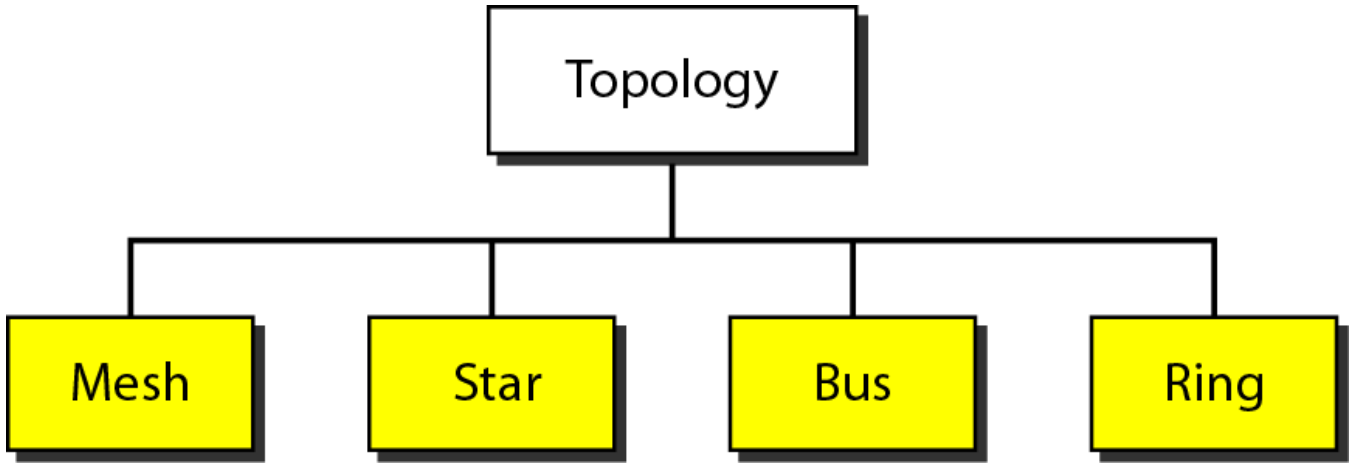
  (have you heard of N^2 *problem* ???)
- Solution is a *communications network*

What is a (communication) network?

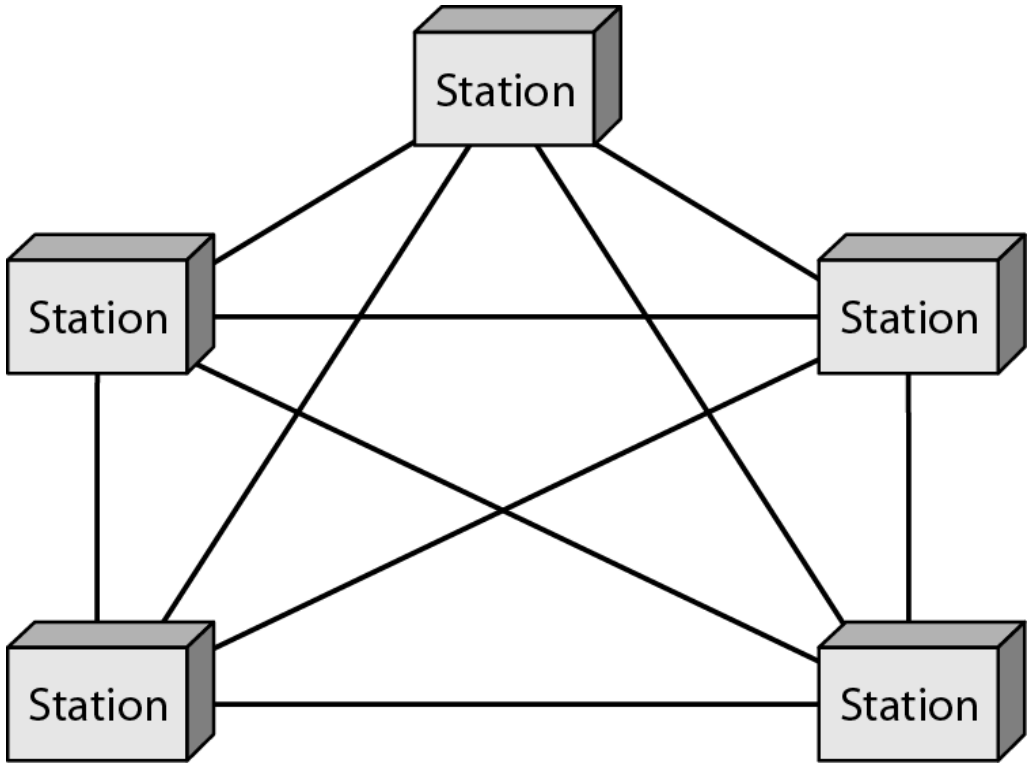
Set of devices communicating with each other.

- Could be a CPU, monitor and other peripheral devices connected (and exchanging data) to each other.
- Could be a group of people …. A network of friends.
- Or, could be a set of computers communicating with each other.

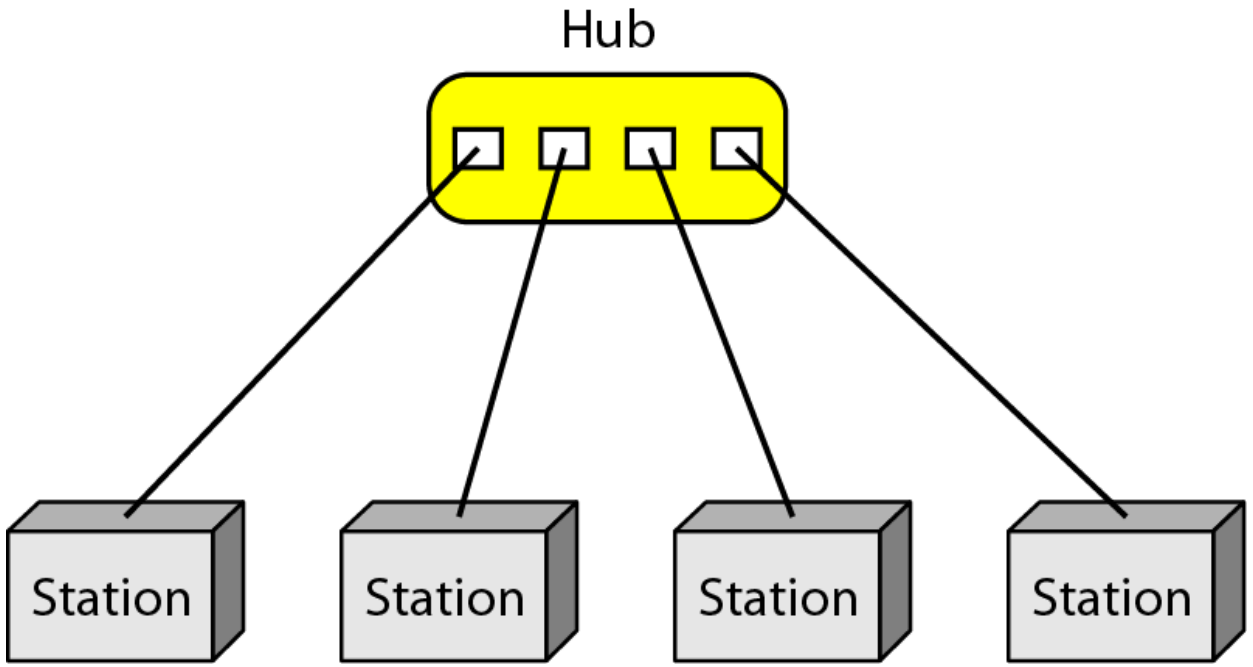
Categories of network topology



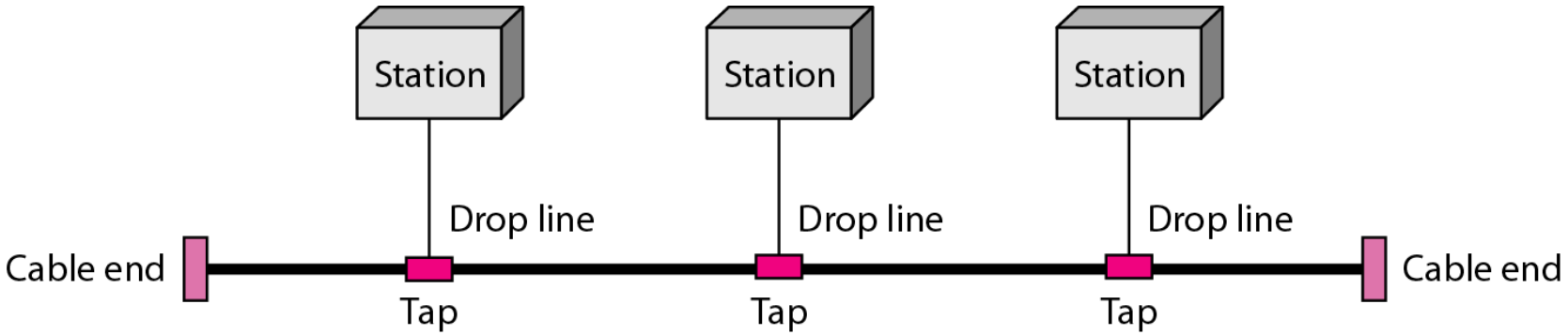
A fully connected mesh topology (five devices)



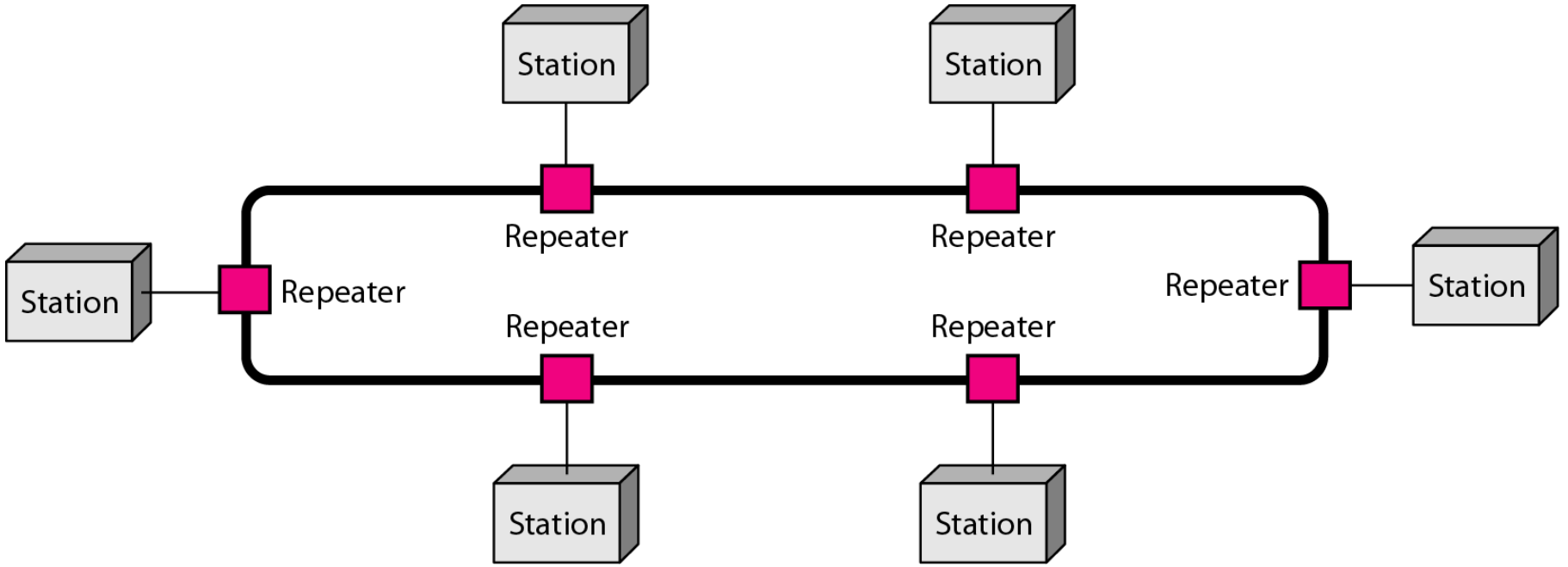
A star topology connecting four stations



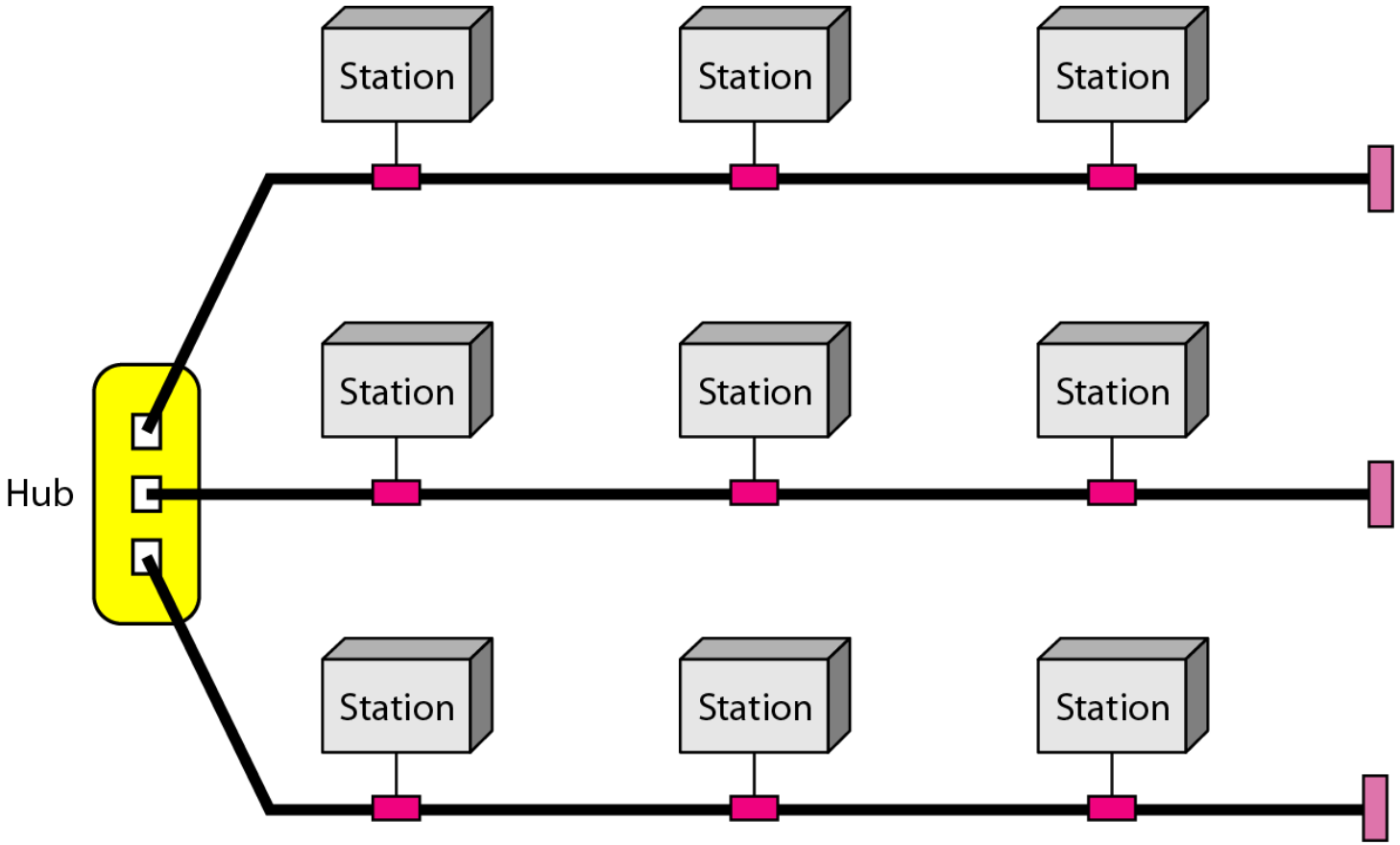
A bus topology connecting three stations



A ring topology connecting six stations



A hybrid topology: a star backbone with three bus networks



Classification(Categories) of Networks

On the basis of

- Applications
- Model
- Size of Geographical Area covered (Scale)

Such As (Scale):

- Local Area Networks
- Metropolitan Area Networks
- Wide Area Networks
- Internetworks

Classification of Broadcast Networks

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Classification of interconnected processors by scale.

Uses of Computer Networks

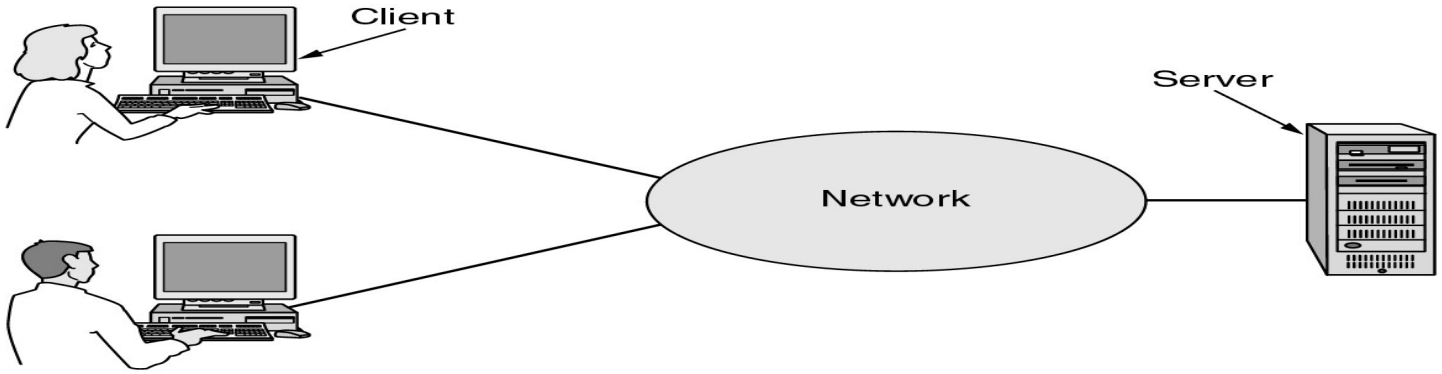
- Business Applications: Some forms of e-commerce

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books on-line
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products on-line
P2P	Peer-to-peer	File sharing

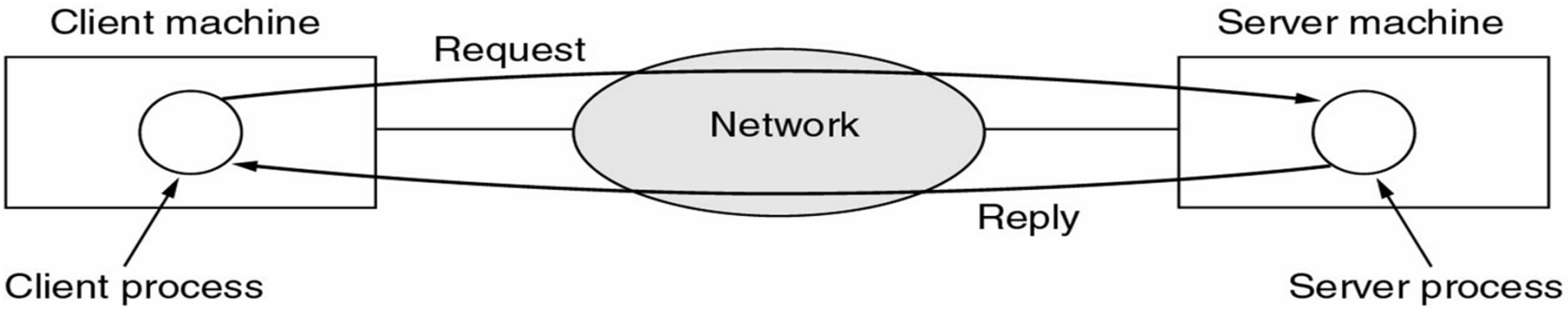
- Home Applications
  - Access to remote information(WWW etc)
  - Person-to-person communication(Email, Instant Messaging etc, Phone)
  - Interactive entertainment(Remote operated or online Games)
  - Electronic commerce
- Mobile Users: Combinations of wireless networks and mobile computing

Wireless	Mobile	Applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

Business Applications of Networks

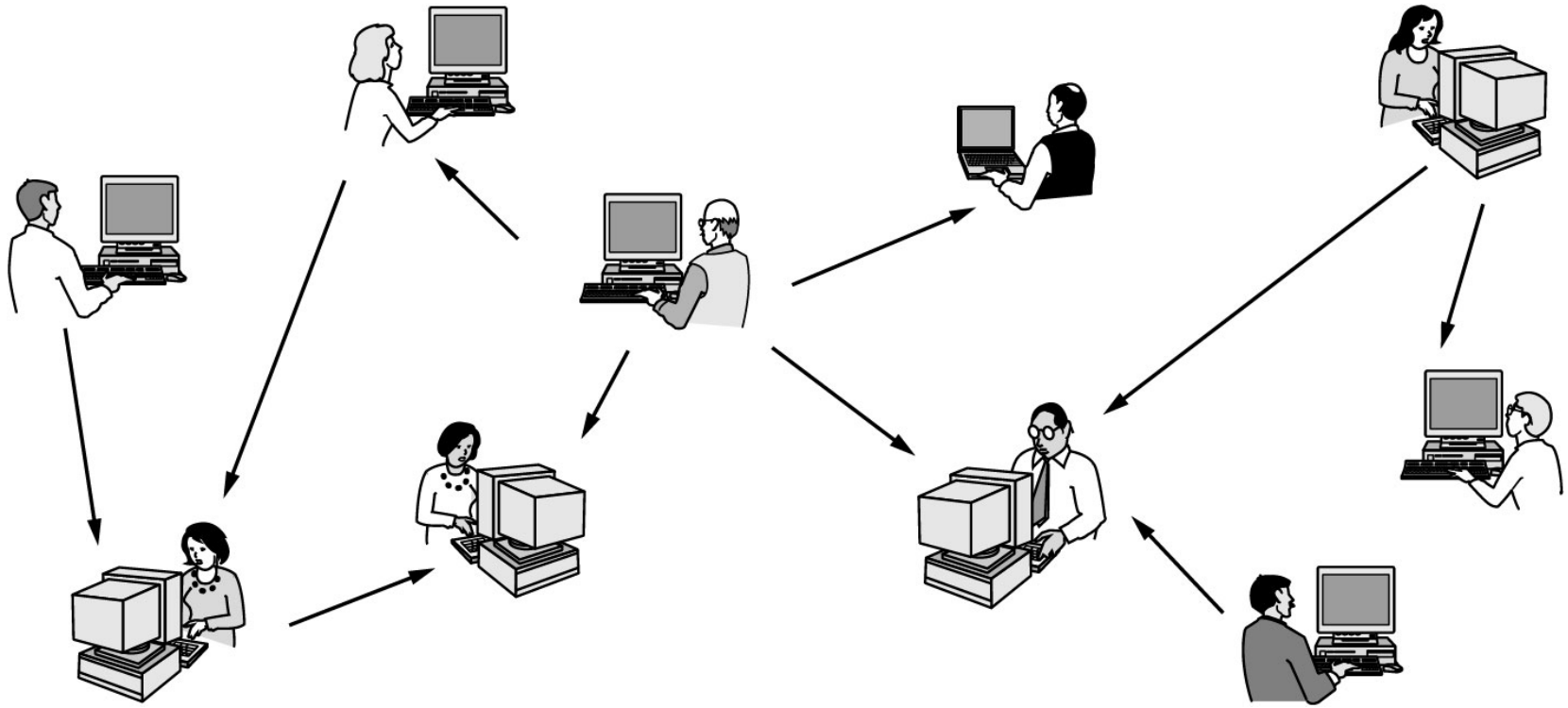


Client Server Model : A network with two clients and one server:
Employees accessing company's Information System



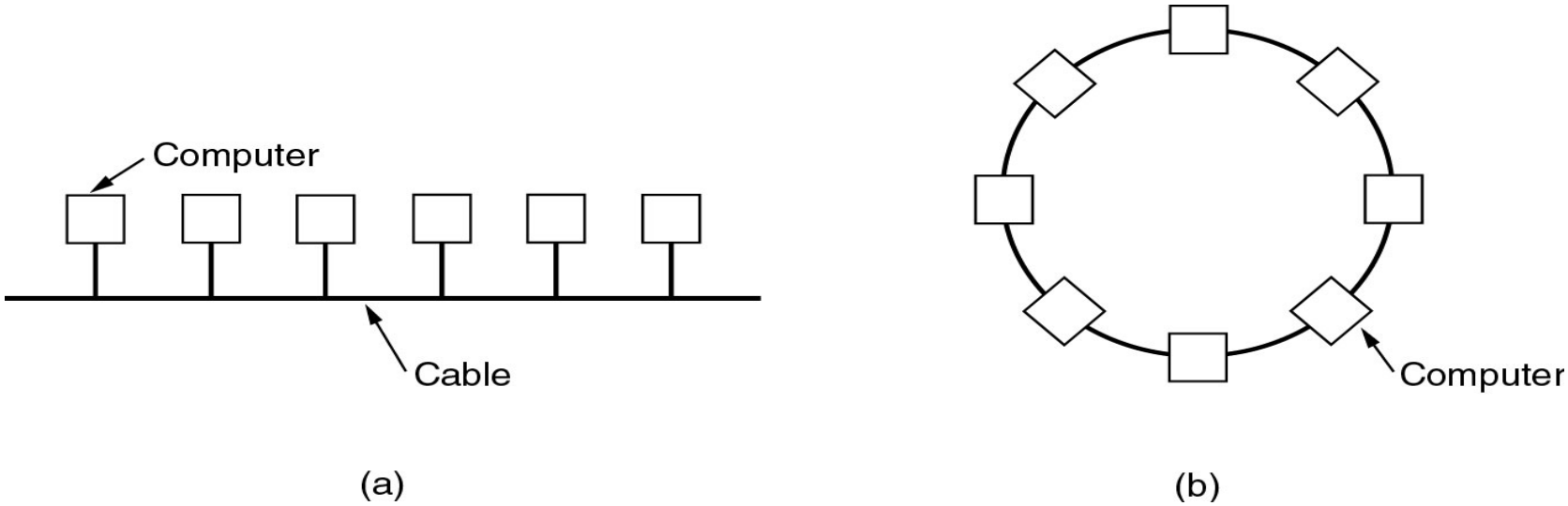
The client-server model involves requests and replies.

Peer-to-Peer Model of Communication



In peer-to-peer system there are no fixed clients and servers.

Local Area Networks topologies

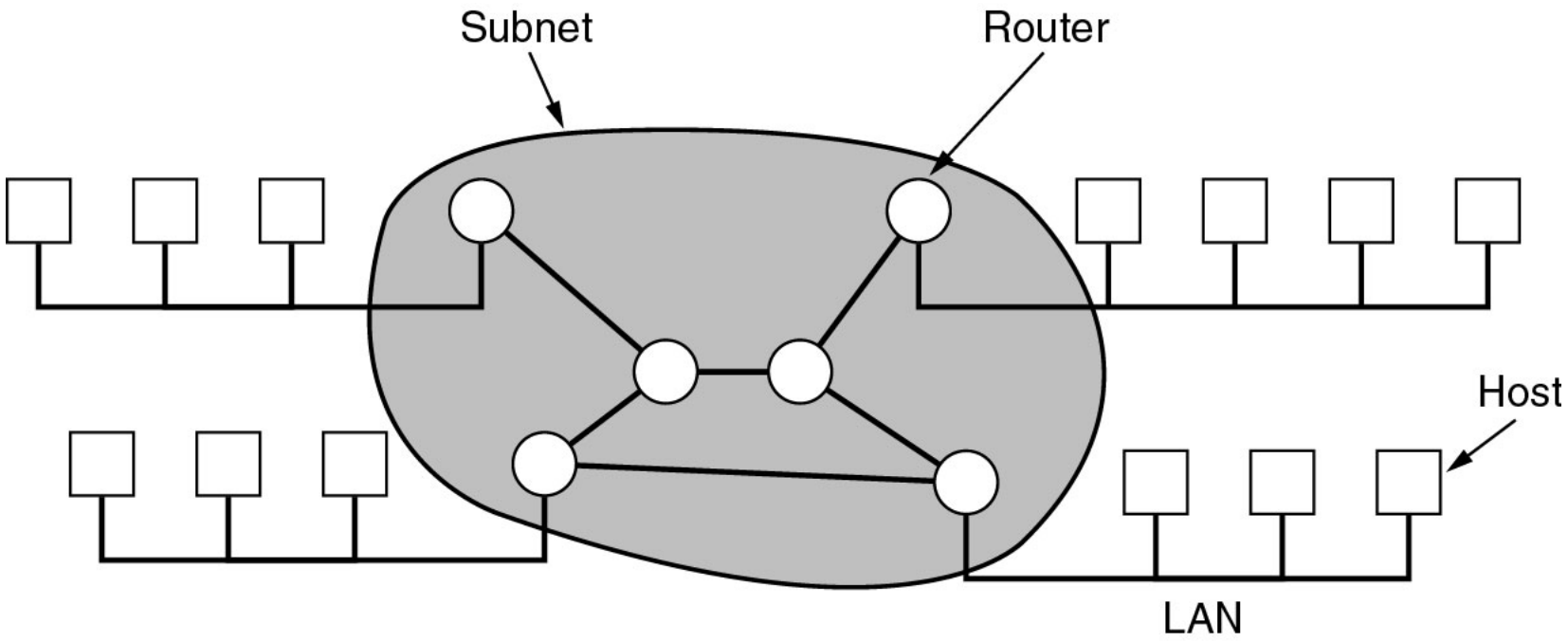


Two topologies for broadcast networks

(a) Bus

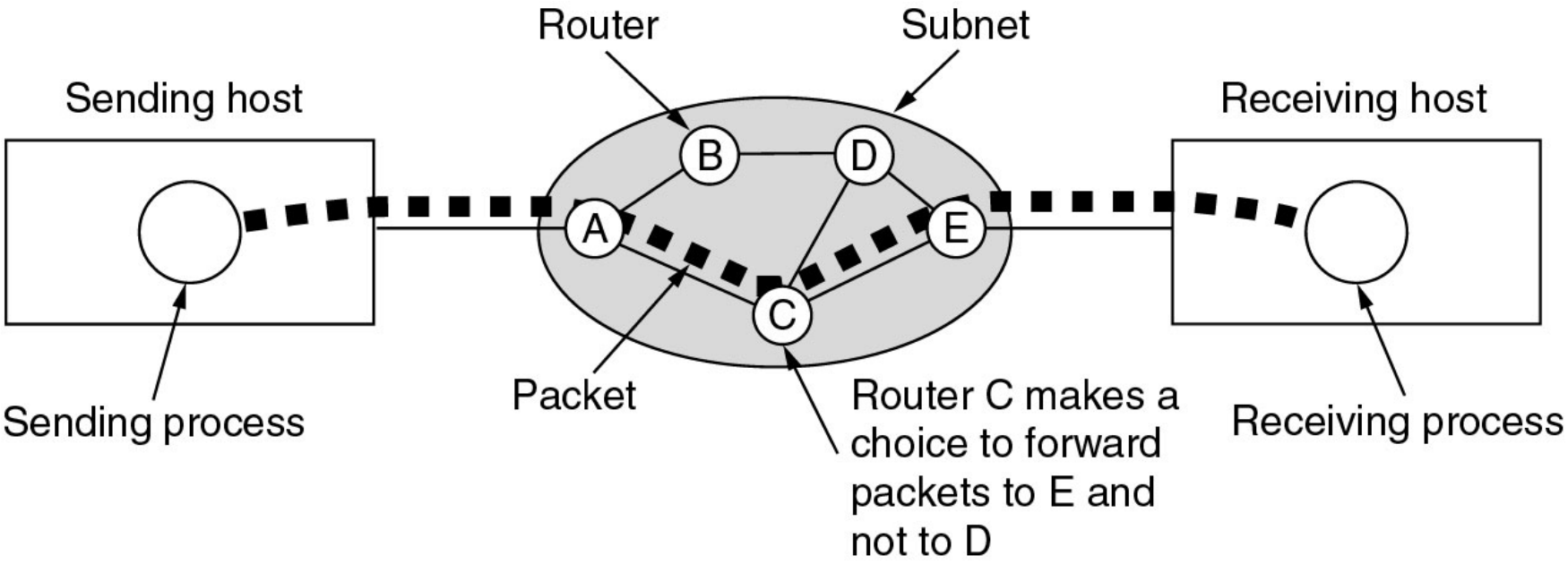
(b) Ring

Wide Area Networks



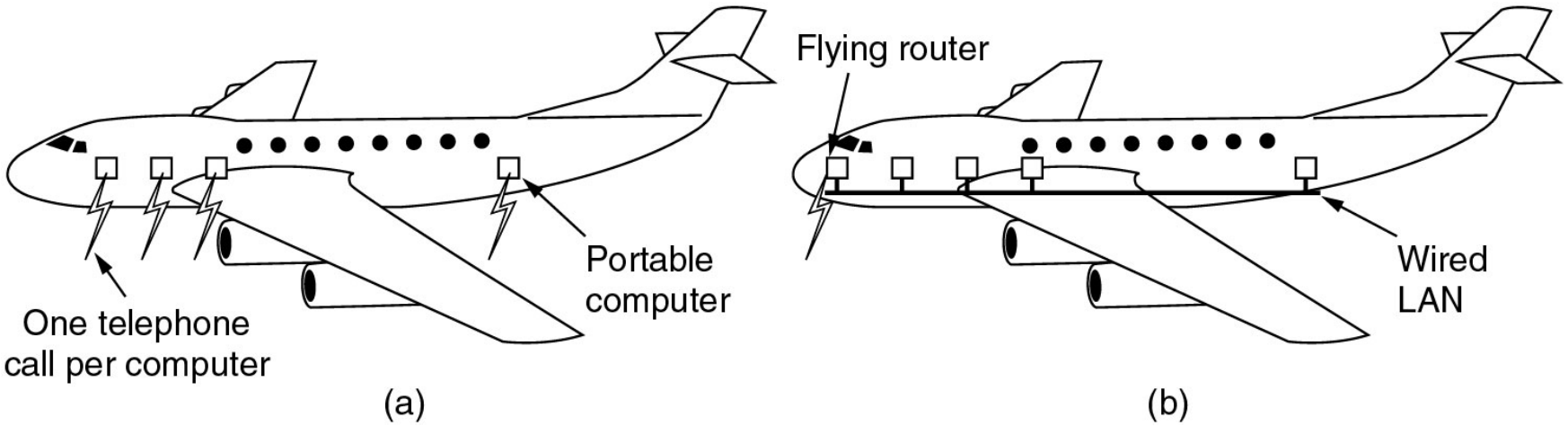
Relation between hosts on LANs and the subnet.

Wide Area Networks (2)



A stream of packets from sender to receiver.

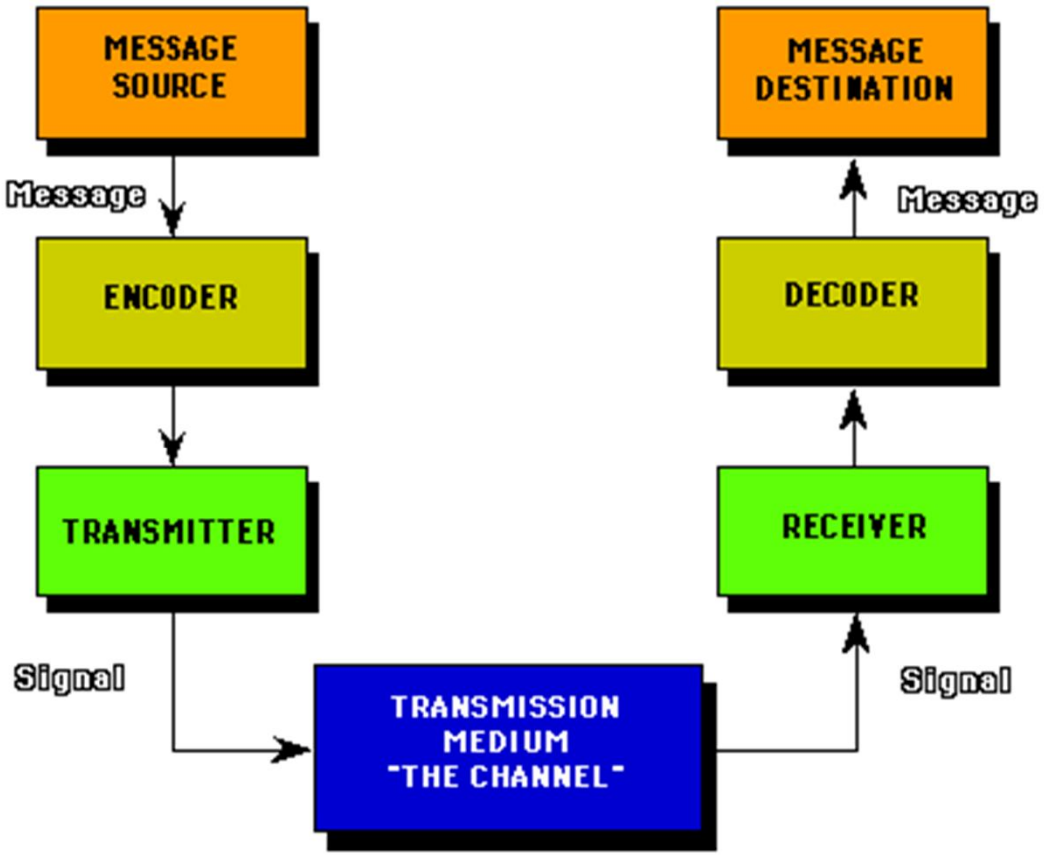
Wireless Networks



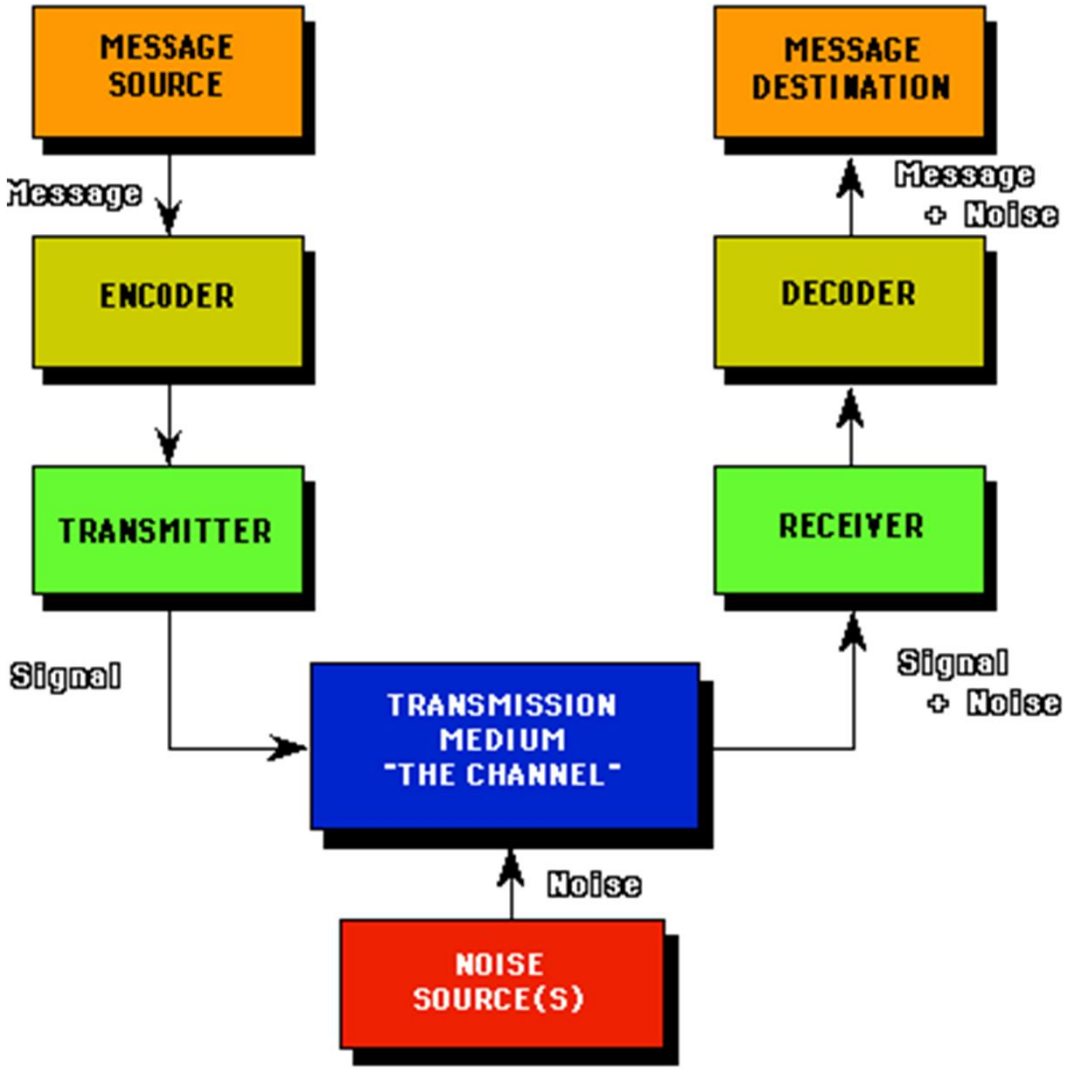
(a) Individual mobile computers

(b) A flying LAN

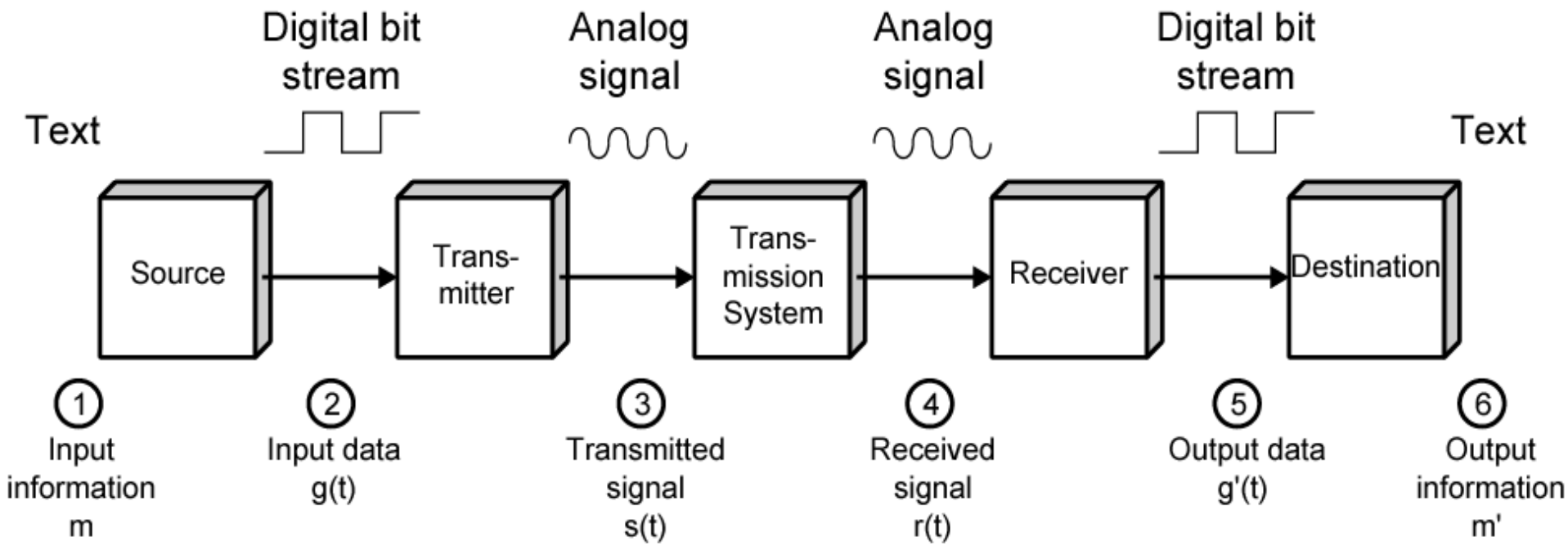
Intro to Network Software: Shannon Communication Model



Shannon Communication Model



Data Communications Model

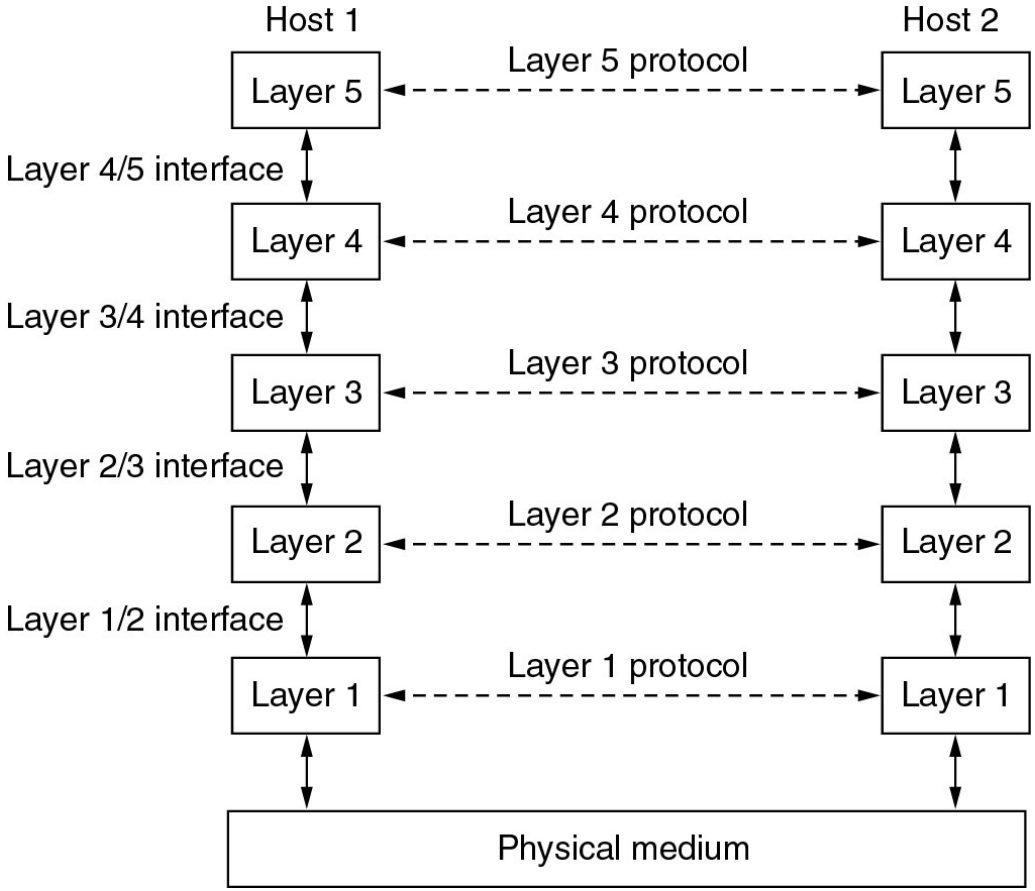


Network Software

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols

Network Software

Protocol Hierarchies



Layers, protocols, and interfaces.

What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

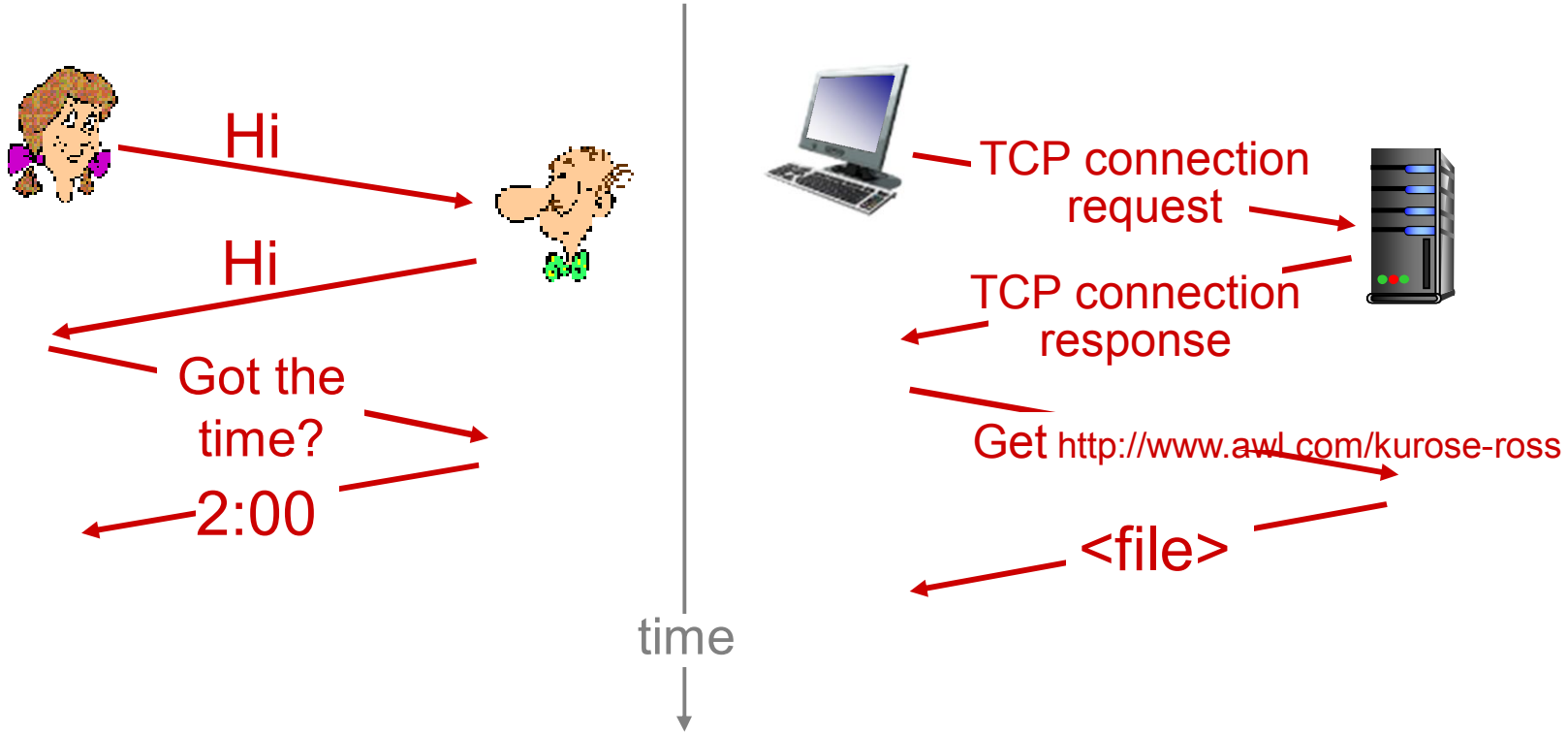
network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



Q: other human protocols?

Protocol "layers"

Networks are complex, with many "pieces":

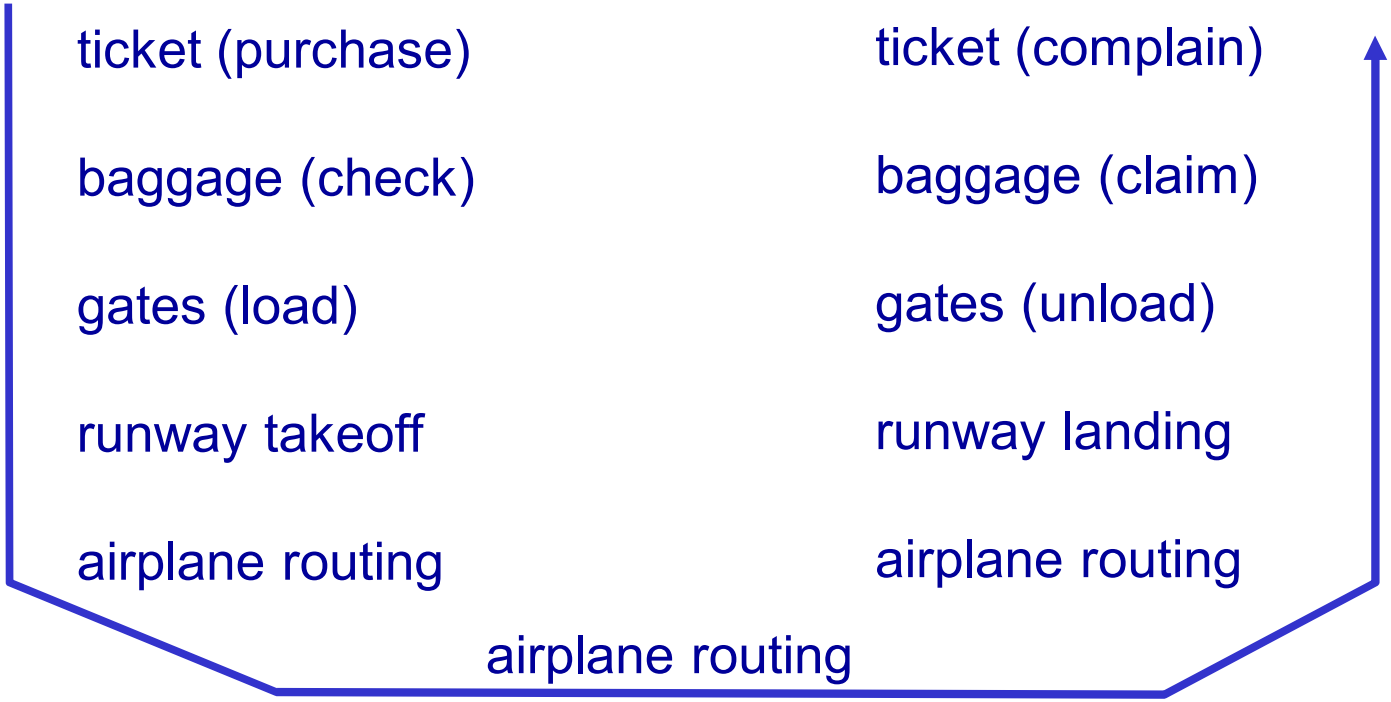
- hosts
- routers
- links of various media
- applications
- protocols
- hardware, software

Question:

is there any hope of *organizing* structure of network?

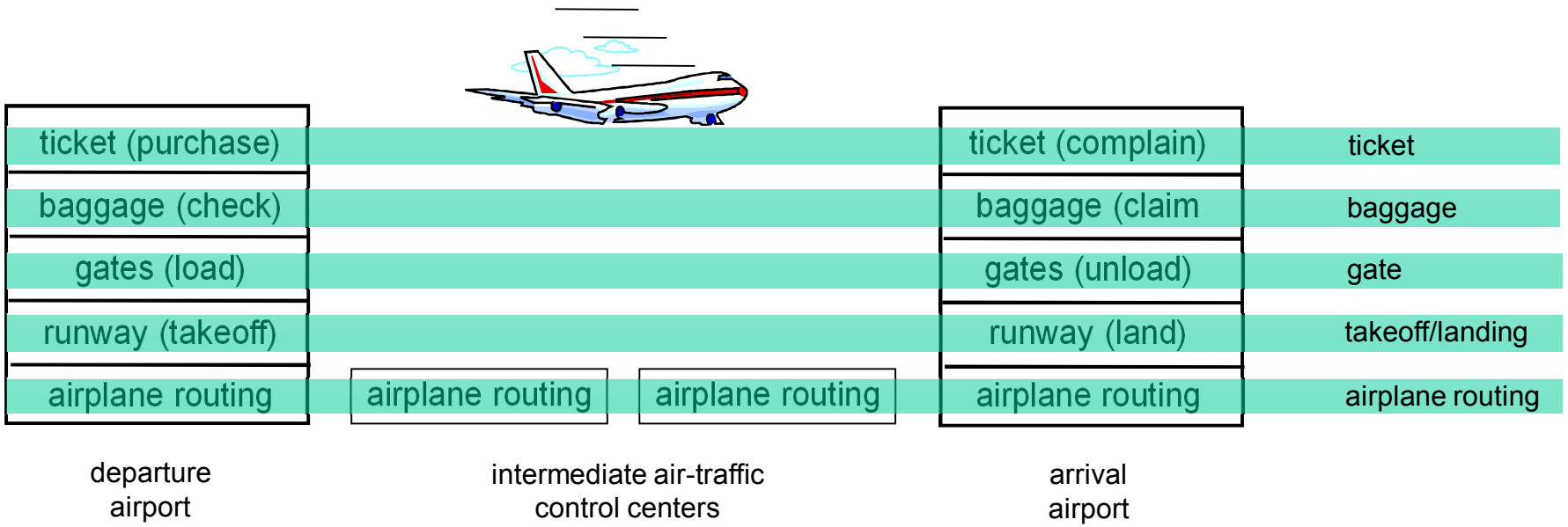
…. or at least our discussion of networks?

Organization of air travel



- a series of steps

Layering of airline functionality



layers: each layer implements a service

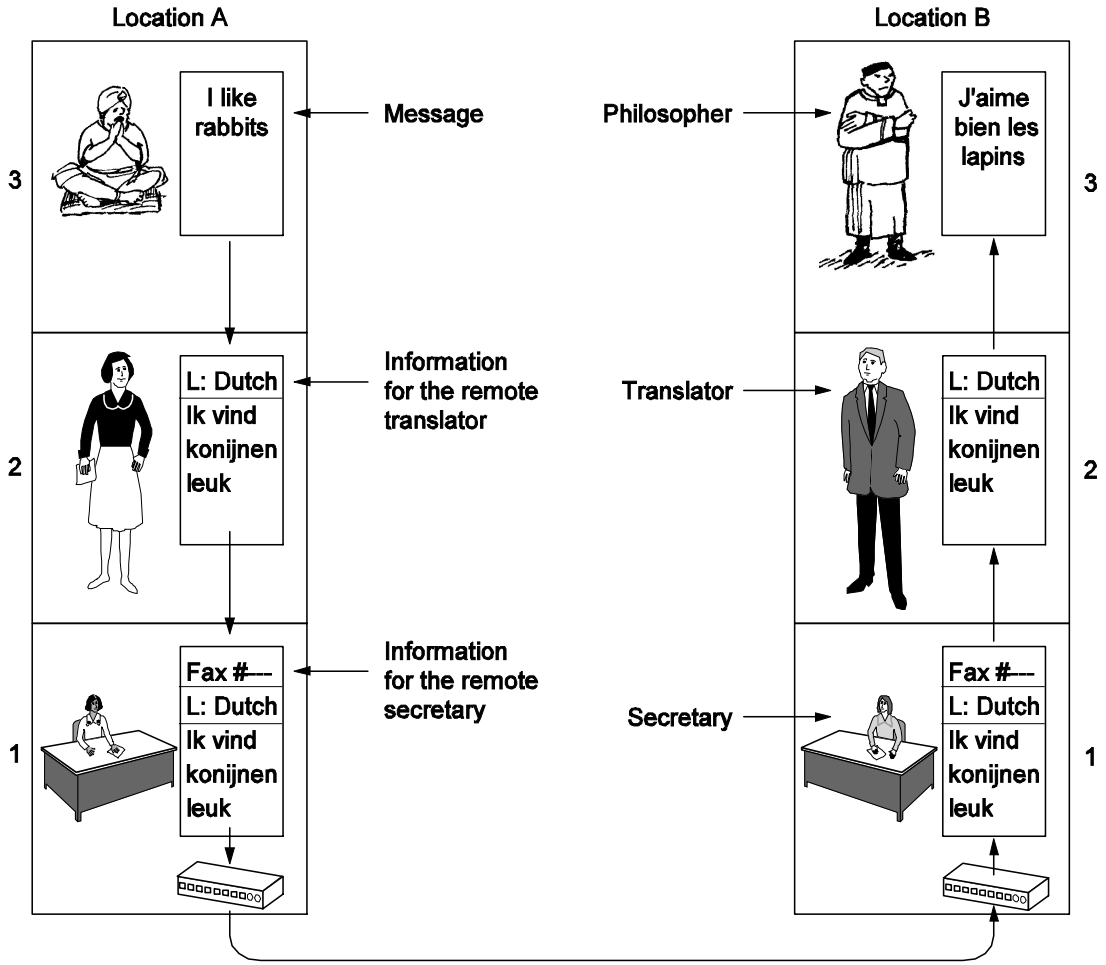
- via its own internal-layer actions
- relying on services provided by layer below

Why layering?

dealing with complex systems:

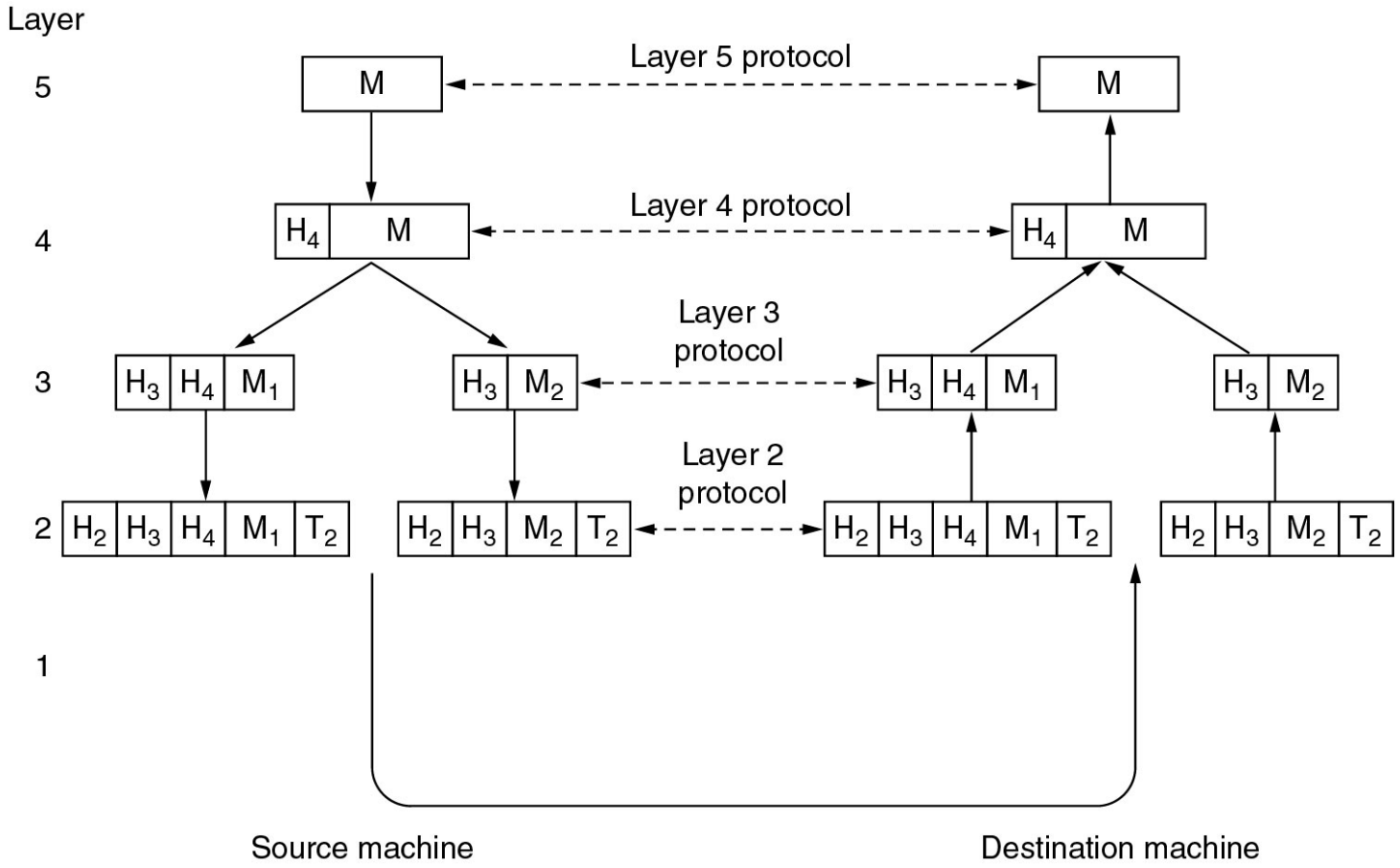
- explicit structure allows identification, relationship of complex system's pieces
  - layered *reference model* for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system

Protocol Hierarchies



The philosopher-translator-secretary architecture.

Protocol Hierarchies (2)



Example information flow supporting virtual communication in layer 5.

Design Issues for the Layers

- Addressing
- Error Control
- Flow Control
- Multiplexing
- Routing

Connection-Oriented and Connectionless Services

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

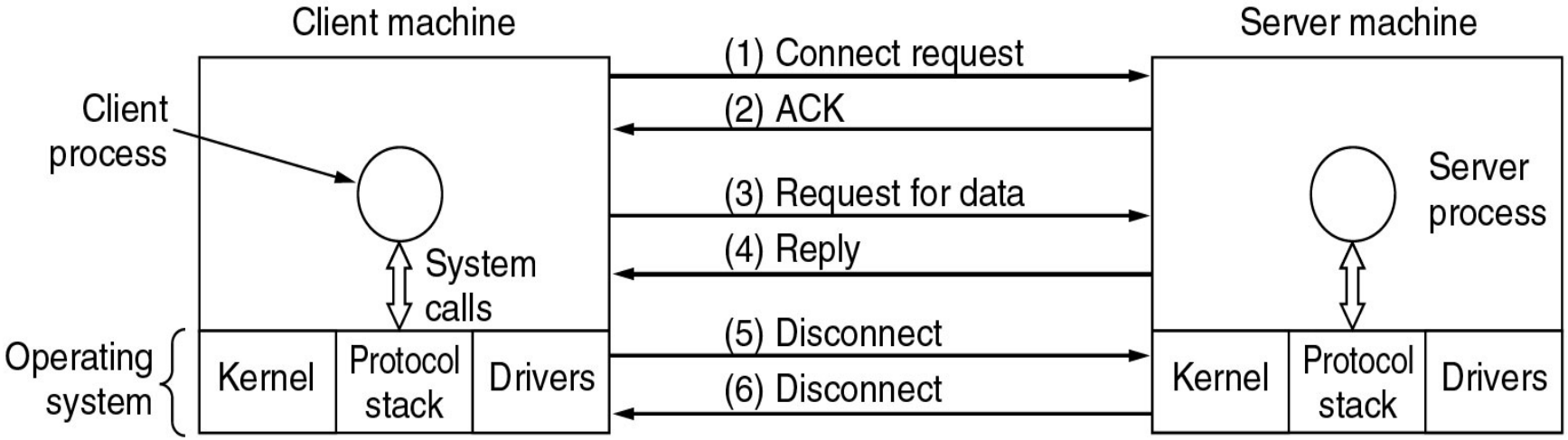
Six different types of service.

Service Primitives

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

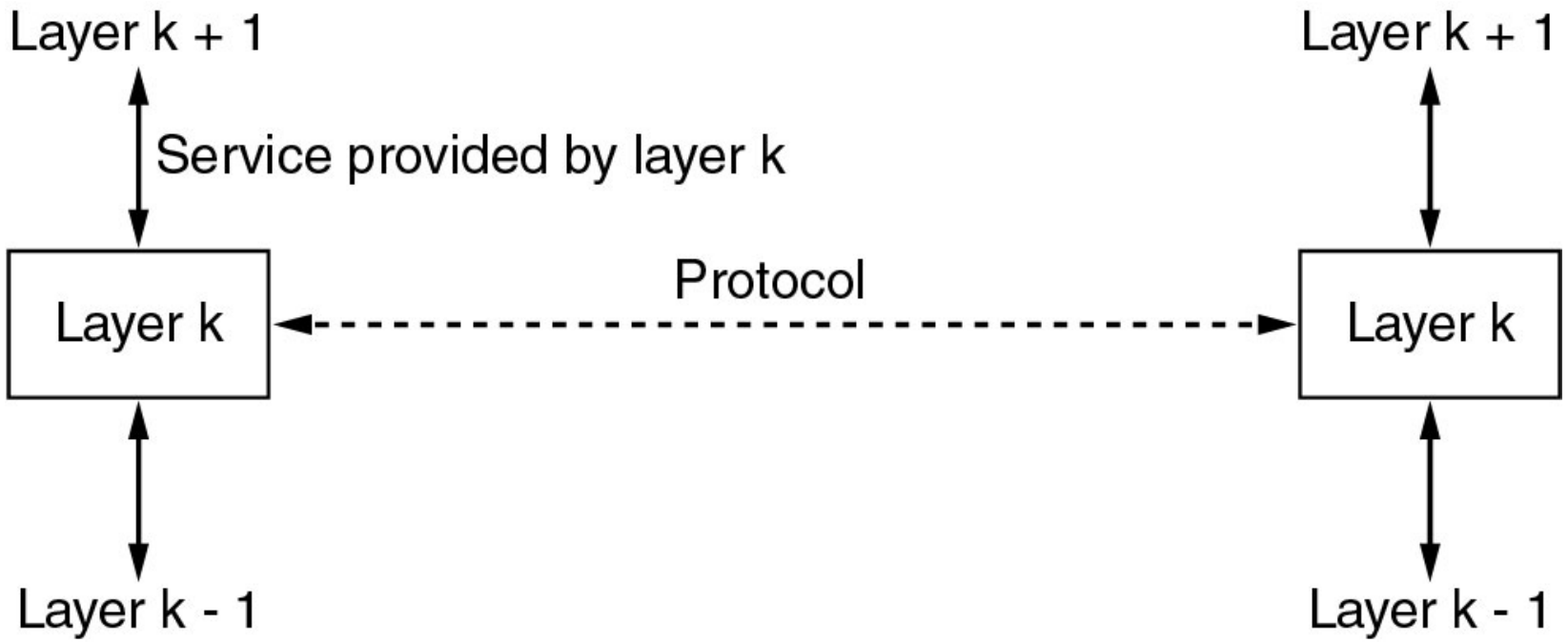
Five service primitives for implementing a simple connection-oriented service.

Service Primitives (2)



Packets sent in a simple client-server interaction on a connection-oriented network.

Services to Protocols Relationship



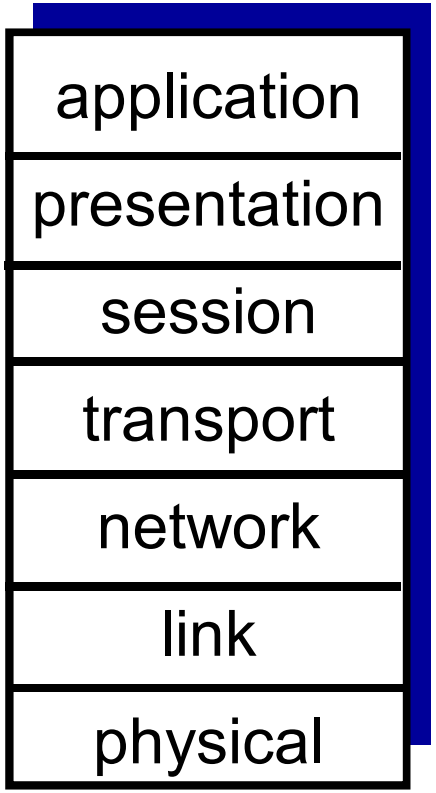
The relationship between a service and a protocol.

Reference Models

- The OSI Reference Model
- The TCP/IP Reference Model
- A Comparison of OSI and TCP/IP
- A Critique of the OSI Model and Protocols
- A Critique of the TCP/IP Reference Model

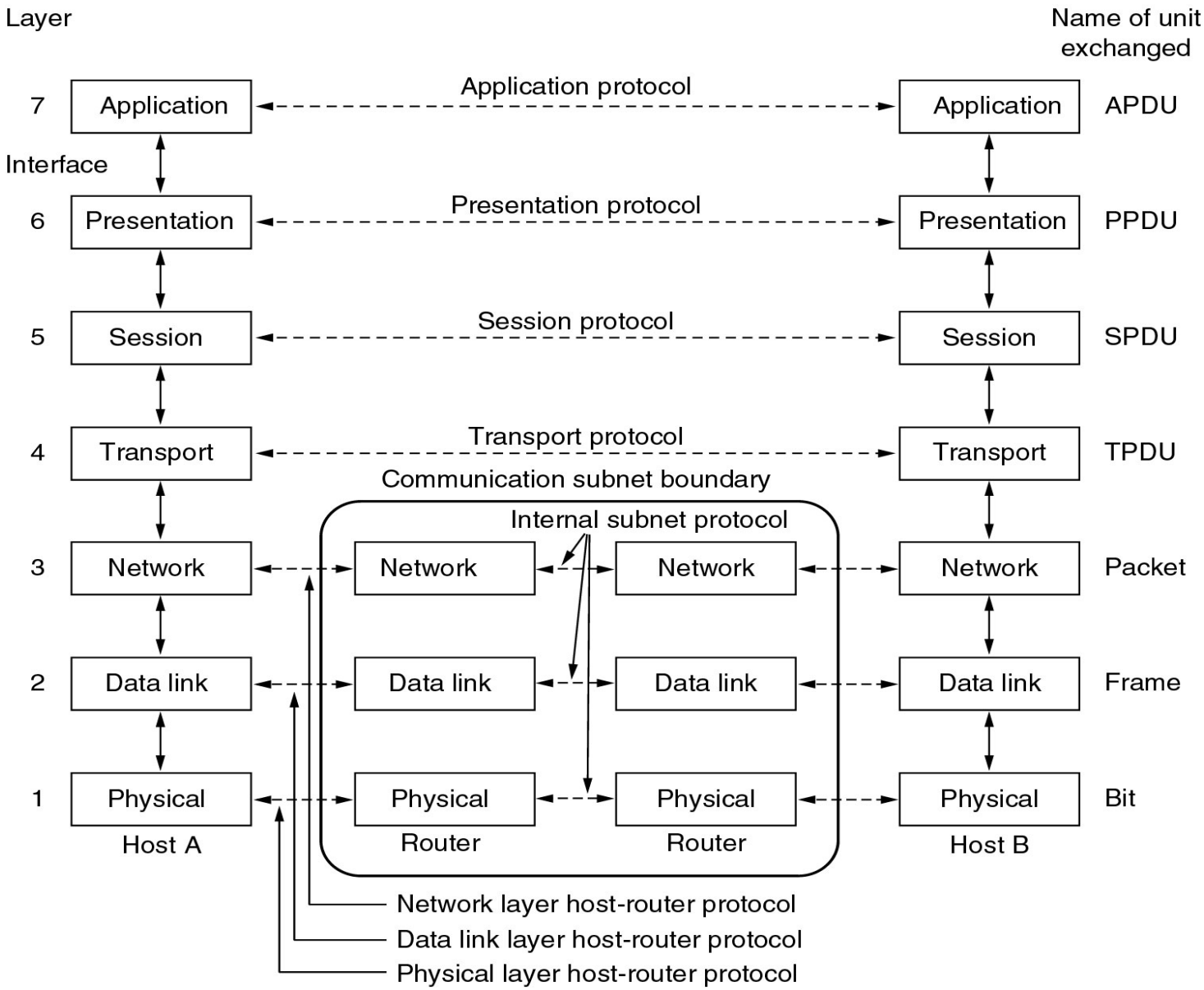
ISO/OSI reference model

- *presentation:* allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- *session:* synchronization, checkpointing, recovery of data exchange
- Internet stack "missing" these layers!
  - these services, *if needed*, must be implemented in application
  - needed?



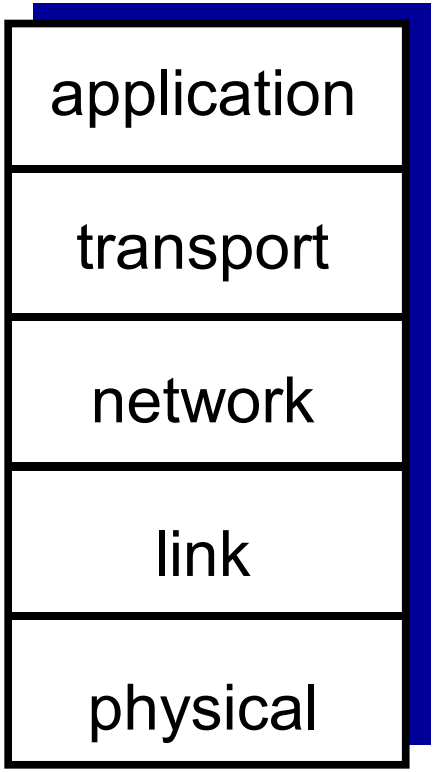
Reference Models

The OSI reference model.

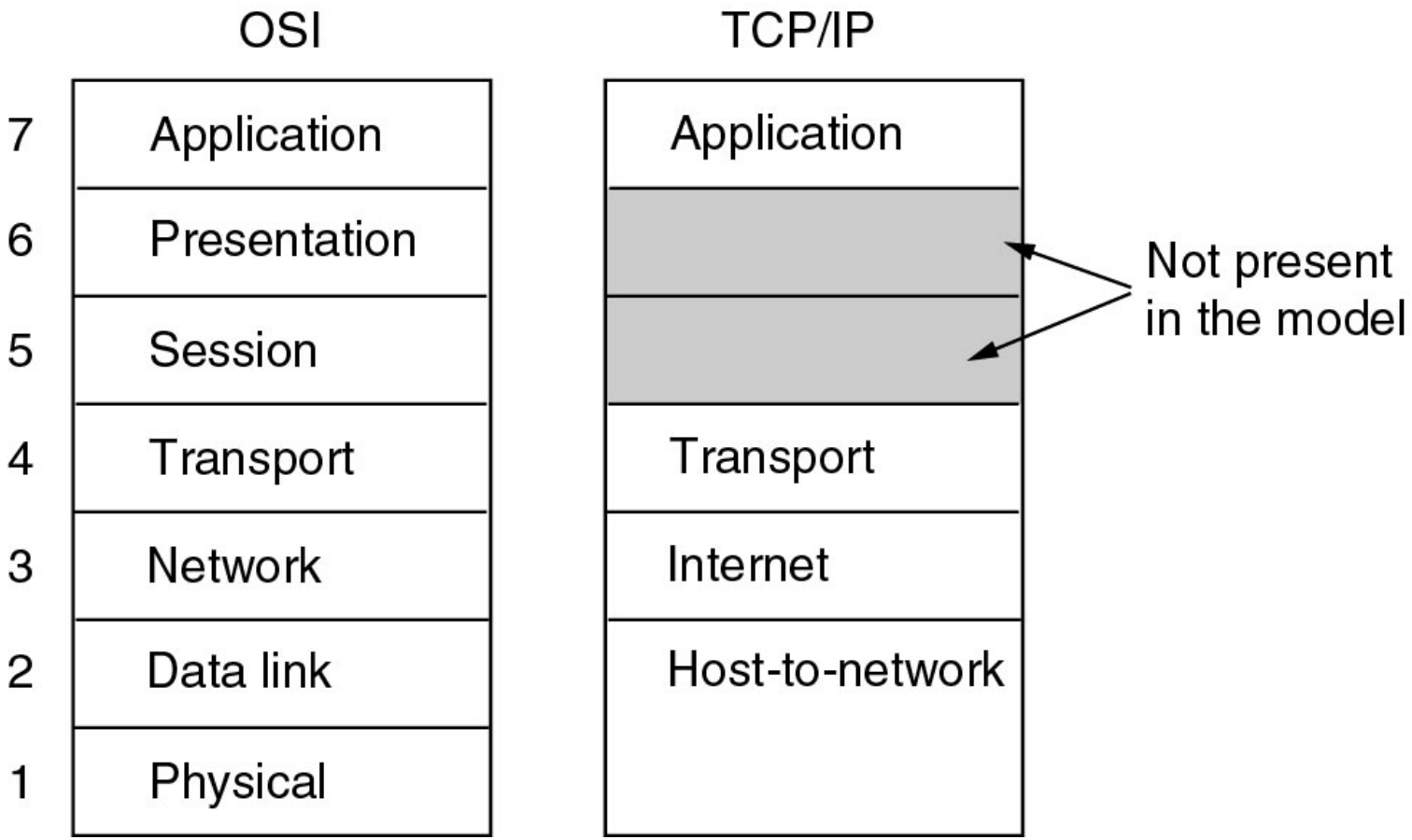


Internet protocol stack

- *application:* supporting network applications
  - FTP, SMTP, HTTP
- *transport:* process-process data transfer
  - TCP, UDP
- *network:* routing of datagrams from source to destination
  - IP, routing protocols
- *link:* data transfer between neighboring network elements
  - Ethernet, 802.111 (WiFi), PPP
- *physical:* bits "on the wire"

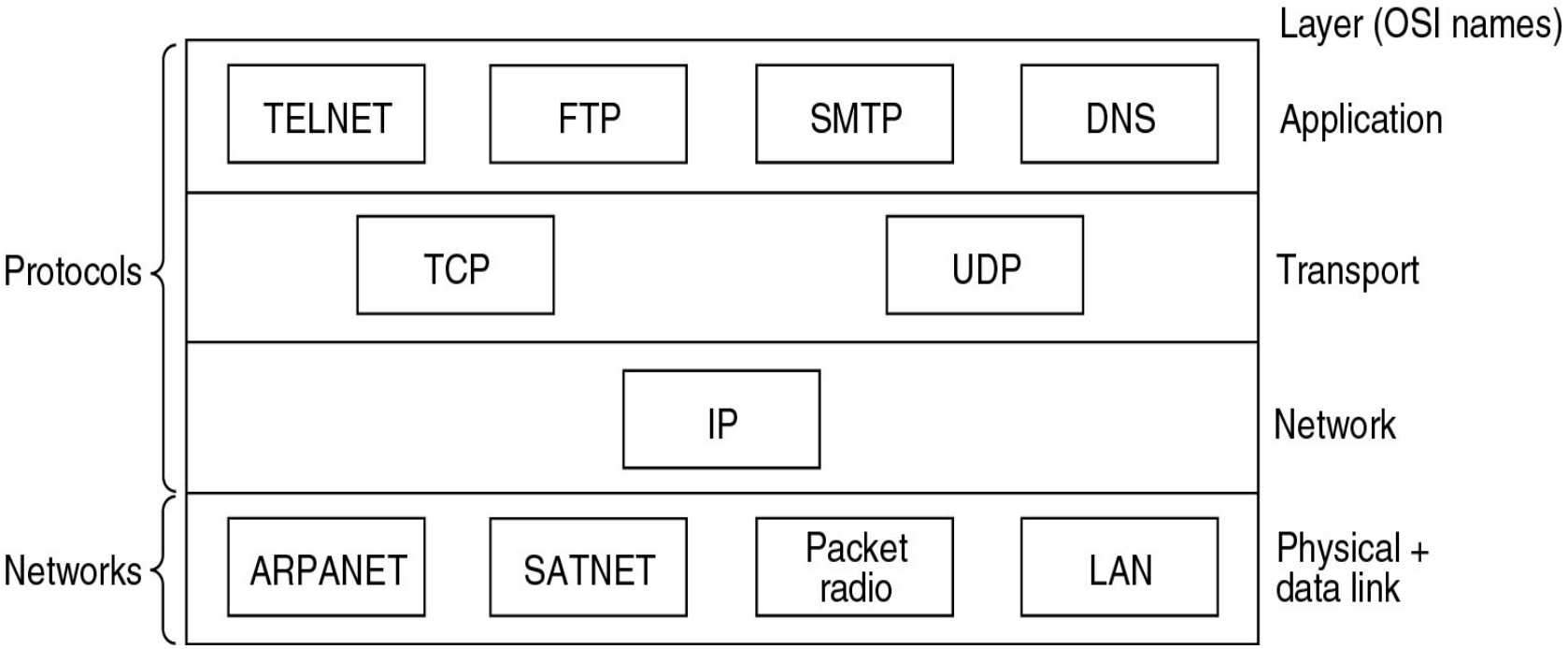


Reference Models (2)



The TCP/IP reference model.

Reference Models (3)



Protocols and networks in the TCP/IP model initially.

Comparing OSI and TCP/IP Models

Concepts central to the OSI model

- Services
- Interfaces
- Protocols

A Critique of the OSI Model and Protocols

Why OSI did not take over the world

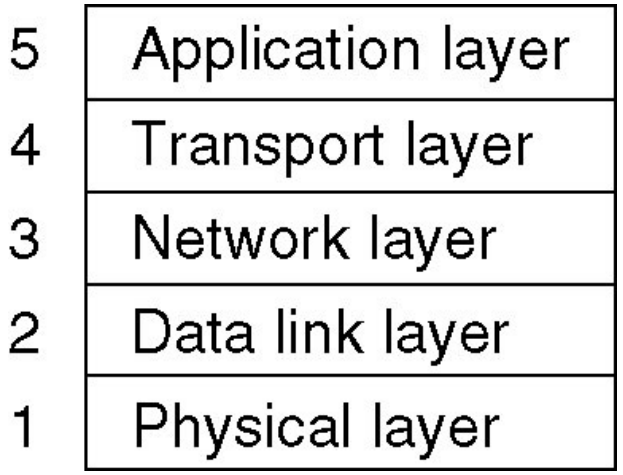
- Bad timing
- Bad technology
- Bad implementations
- Bad politics

A Critique of the TCP/IP Reference Model

Problems:

- Service, interface, and protocol not distinguished
- Not a general model
- Host-to-network “layer” not really a layer
- No mention of physical and data link layers
- Minor protocols deeply entrenched, hard to replace

Hybrid Model



The hybrid reference model.

Example Networks

- The Internet
- Connection-Oriented Networks:
  X.25, Frame Relay, and ATM
- Ethernet
- Wireless LANs: 802:11

1-3 THE INTERNET

The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time. The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.

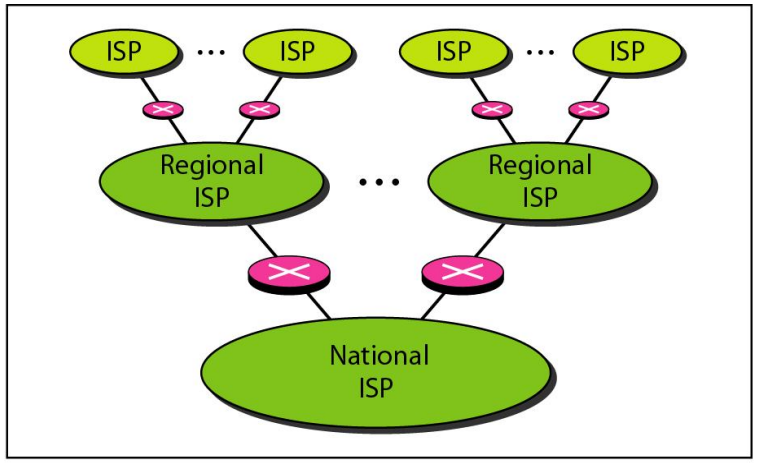
A Brief History: Adv Research Projects Agency(ARPAnet) by DoD
The Internet Today (ISPs): many LANs & WANs connected

Internet Usage

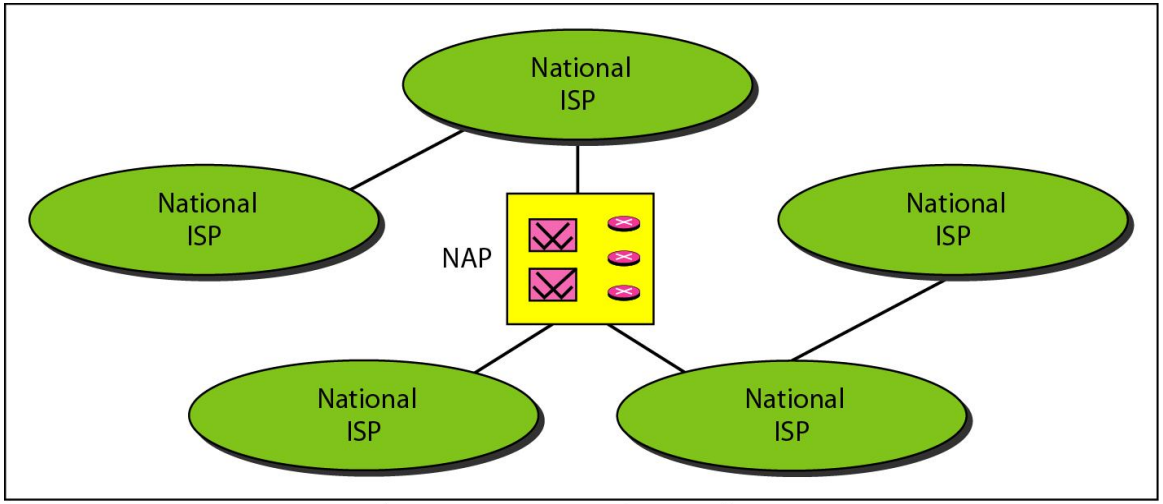
Traditional applications (1970 – 1990)

- E-mail
- News
- Remote login
- File transfer

Hierarchical organization of the Internet; NAP:Network Access Point



a. Structure of a national ISP



b. Interconnection of national ISPs

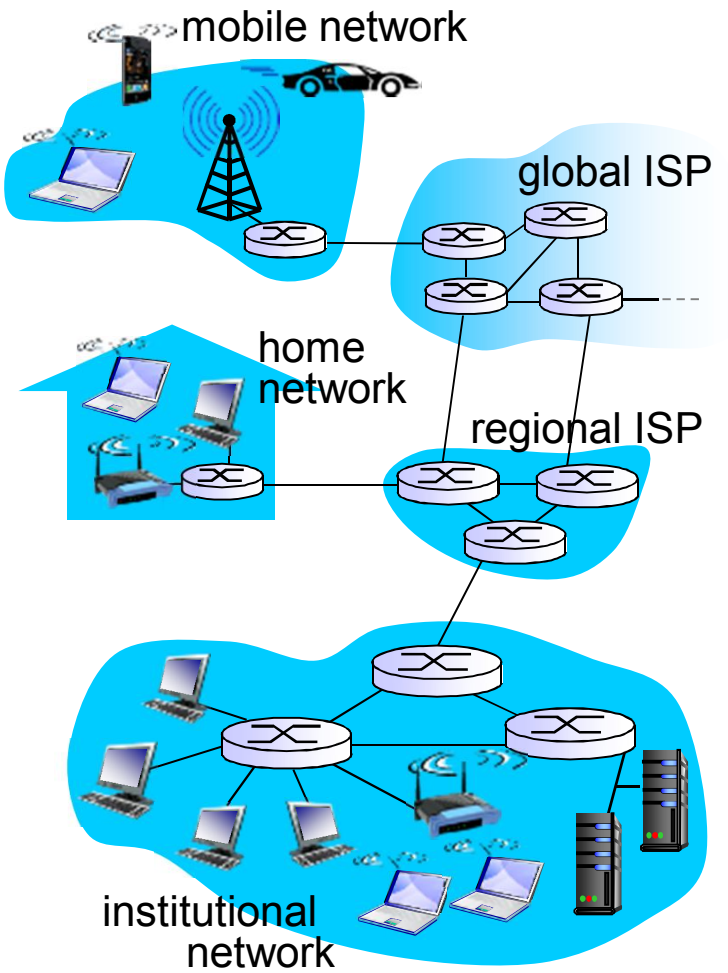
1-4 PROTOCOLS AND STANDARDS

In this section, we define two widely used terms: protocols and standards. First, we define protocol, which is synonymous with rule. Then we discuss standards, which are agreed-upon rules.

Protocols: what, how, when to communicate (syntax, semantics, timing)
Standards
Standards Organizations
Internet Standards

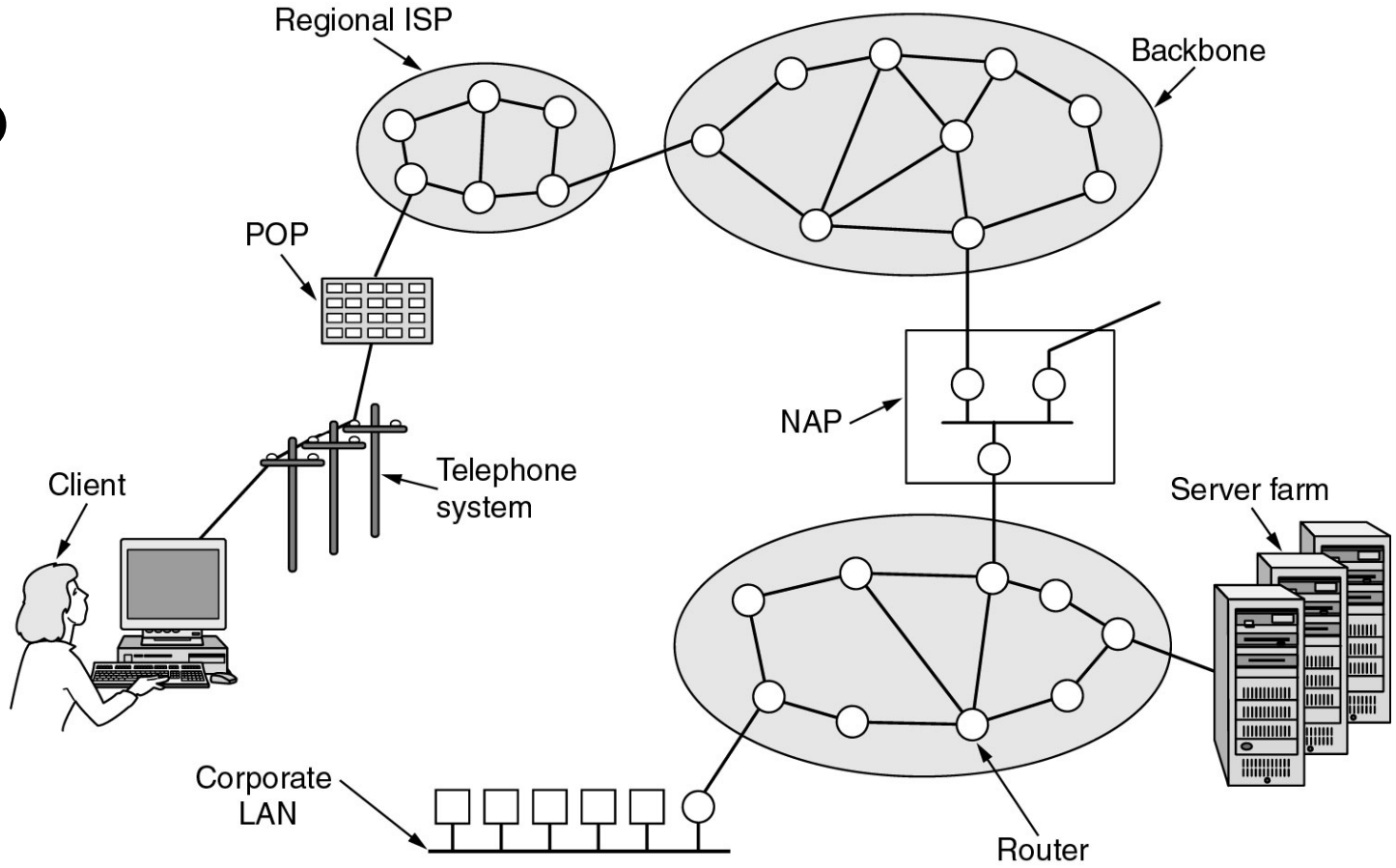
A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers
- *access networks, physical media:* wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks

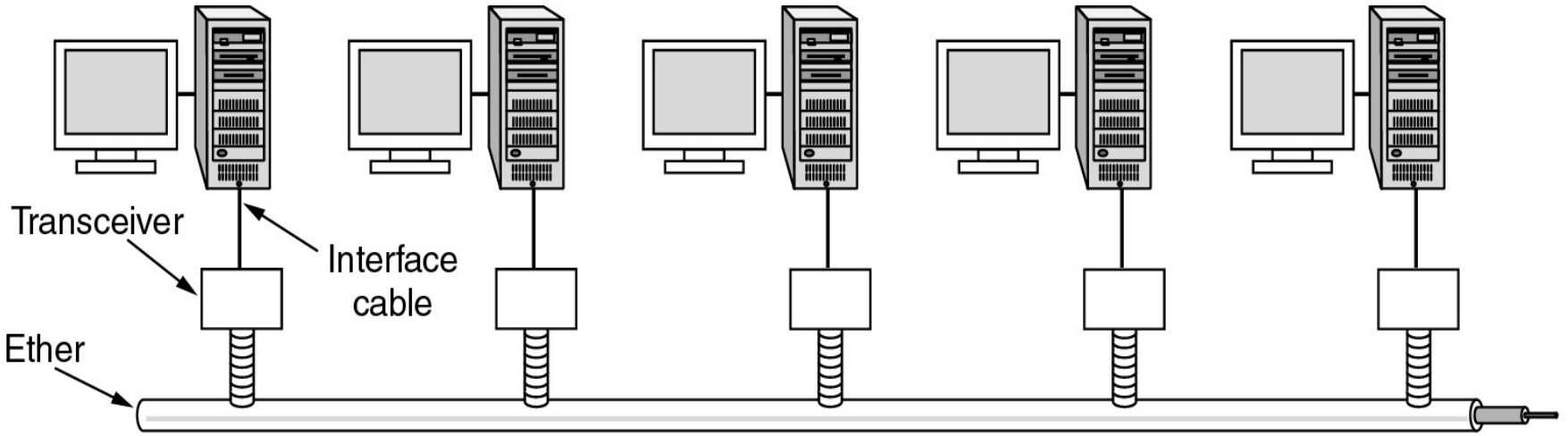


Architecture of the Internet

- O

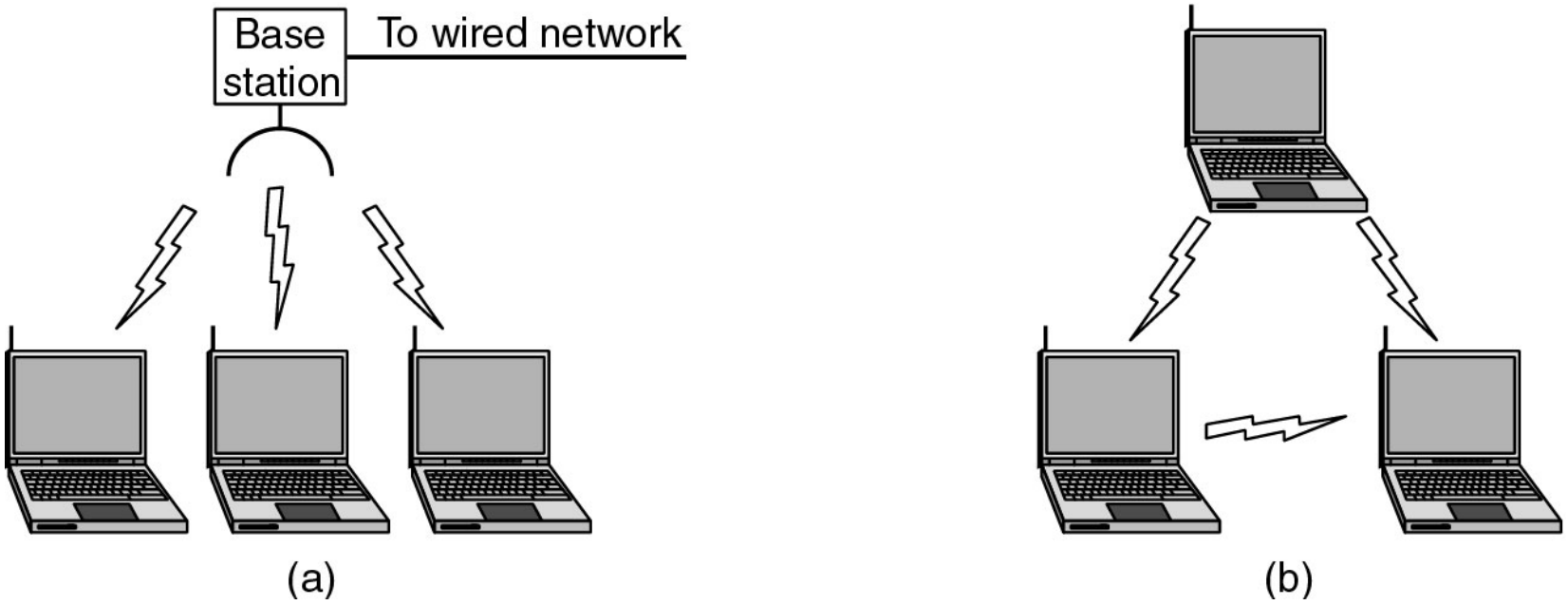


Ethernet



Architecture of the original Ethernet.

Wireless LANs



(a) Wireless networking with a base station.

(b) Ad hoc networking.

Network Standardization

- Who's Who in the Telecommunications World
- Who's Who in the International Standards World
- Who's Who in the Internet Standards World

ITU(International Telecommunication Union)

- Main sectors
  - Radiocommunications(allocating Radio Frequencies) :ITU-R
  - Telecommunications Standardization(telephone and data communication systems) : ITU-T
  - Development: ITU-D
- Classes of Members
  - National governments(members of United Nations)
  - Sector members(Telecom, Computer, Media)
  - Associate members(Smaller Oragnizations interested in a particular Study Group)
  - Regulatory agencies(Controlling authorities)

IEEE 802 Standards

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

The 802 working groups. The important ones are marked with *. The ones marked with ↓ are hibernating. The one marked with † gave up.