

CSE 3151

Computer Networks

Course Objectives

- To help you gain a general understanding of the principles of computer networks.
- To give concepts governing the operations of computer networks.
- To give the definition of the two often-used terms in the discussion of the Internet: protocol and standard.
- To provide you with the opportunity to become skillful in the implementation and use of communication protocols.
- To help you grasp the basic research methodologies in the field of computer networks.

Textbook

❑ *Required:*

- ❖ ``Computer Networks, '' by Andrew S. Tanenbaum

❑ *Recommended:*

- ❖ "Computer Networks: A Systems Approach" by Larry L. Peterson and Bruce S. Davie.
- ❖ "TCP/IP Protocol Suite" by Behrouz A. Forouzan.
- ❖ Data Communication and Networking: by Behrouz A. Forouzan
- ❖ "Data and Computer Communication" by Willam Stallings

Class Expectations

- ❑ Class participation - Your input is needed for good discussion
- ❑ Keep up with **reading** material
- ❑ Complete assignments and projects **on time**
- ❑ Submit clean, organized, and concise reports.

Chapter 1

Introduction

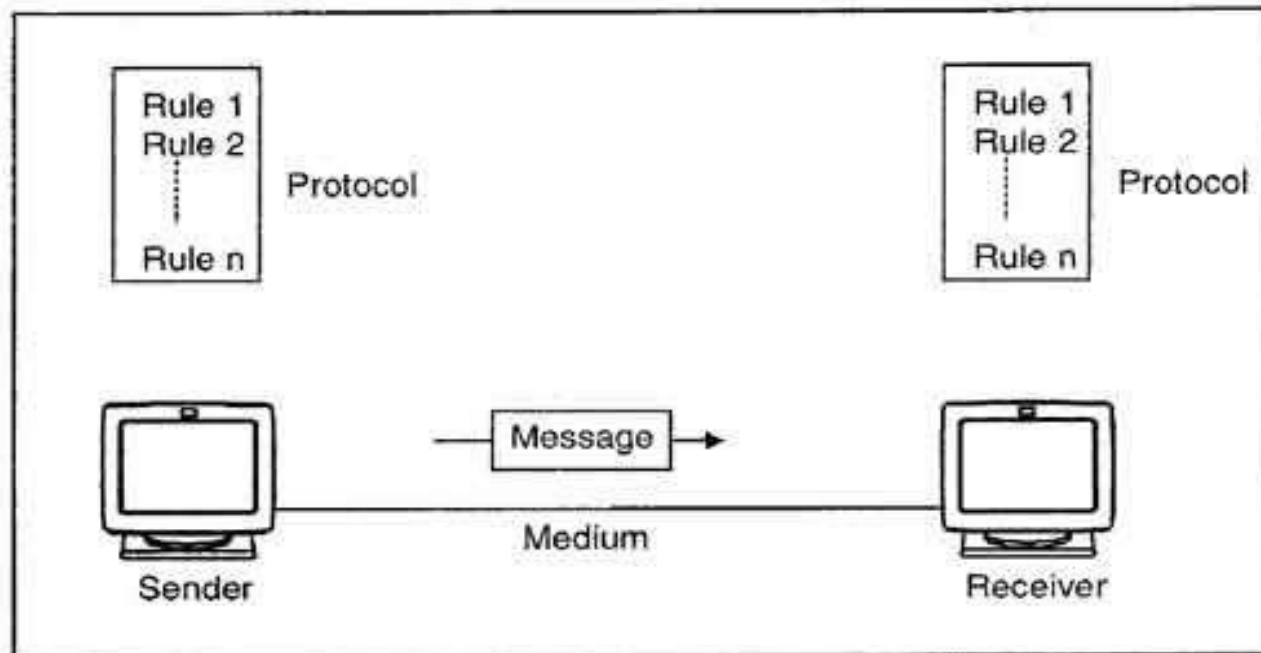
Tentative topics

- ❑ Data Communication
- ❑ Computer Networks
- ❑ Applications
- ❑ Network Hardware
- ❑ Network Software
- ❑ Connectionless and connection oriented services
- ❑ OSI and TCP/IP Network models
- ❑ ARPANET

Data Communication

- ❑ The transmission of digital data between two or more computers.
- ❑ Data communication aims at the transfer of data and maintenance of the data during the process.
- ❑ These technologies include telecommunications, computer networking and radio/satellite communication.
- ❑ Usually requires existence of a transportation or communication medium between the nodes wanting to communicate with each other, such as copper wire, fiber optic cables or wireless signals.

Data Communication System



Components of data communication system

1. **Message:** It is the information or data to be communicated. It can consist of text, numbers, pictures, sound or video or any combination of these.
2. **Sender:** It is the device/computer that generates and sends that message.
3. **Receiver:** It is the device or computer that receives the message. The location of receiver computer is generally different from the sender computer.
4. **Medium:** It is the channel or physical path through which the message is carried from sender to the receiver.
5. **Protocol:** It is a set of rules that govern the communication between the devices. Both sender and receiver follow same protocols to communicate with each other.

Computer Networks

- ❖ A group of computer systems and other computing hardware devices that are linked together through communication channels to facilitate communication and resource-sharing among a wide range of users.
- ❖ The most common resource shared today is connection to the Internet. Other shared resources can include a printer or a file server.
- ❖ The Internet itself can be considered a computer network.

Cont..

- ❖ An *internet* is two or more networks that can communicate with each other.
the internet, composed of hundreds of thousands of interconnected networks.
- ❖ Private individuals as well as various organizations such as government agencies, schools, research facilities, corporations, and libraries in more than 100 countries use the Internet.

Characteristics of a Computer Network

- ❑ Share resources from one computer to another.
- ❑ Create files and store them in one computer, access those files from the other computer(s) connected over the network.
- ❑ Connect a printer, scanner, or a fax machine to one computer within the network and let other computers of the network use the machines available over the network.

Applications of Networks

❑ Resource Sharing

- ❑ Hardware (computing resources, disks, printers)
- ❑ Software (application software)

❑ Information Sharing

- ❑ Easy accessibility from anywhere (files, databases)
- ❑ Search Capability (WWW)

❑ Communication

- ❑ Email
- ❑ Message broadcast

❑ Remote computing

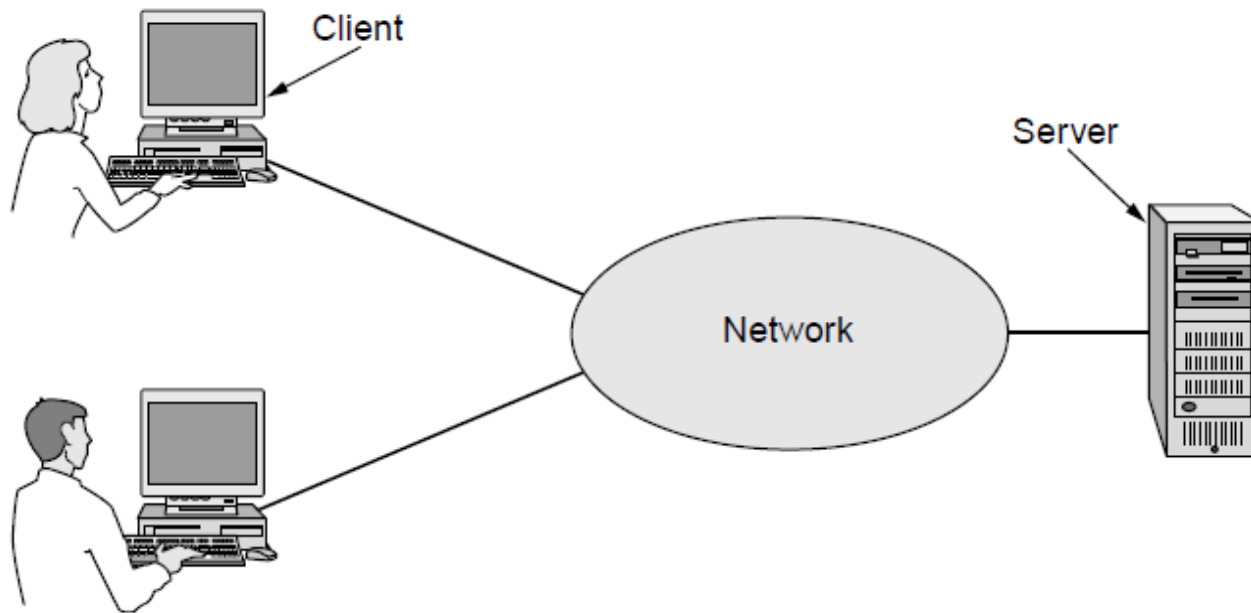
❑ Distributed processing (GRID Computing)

Uses of Computer Networks

- Business Applications
- Home Applications
- Mobile Users
- Social Issues

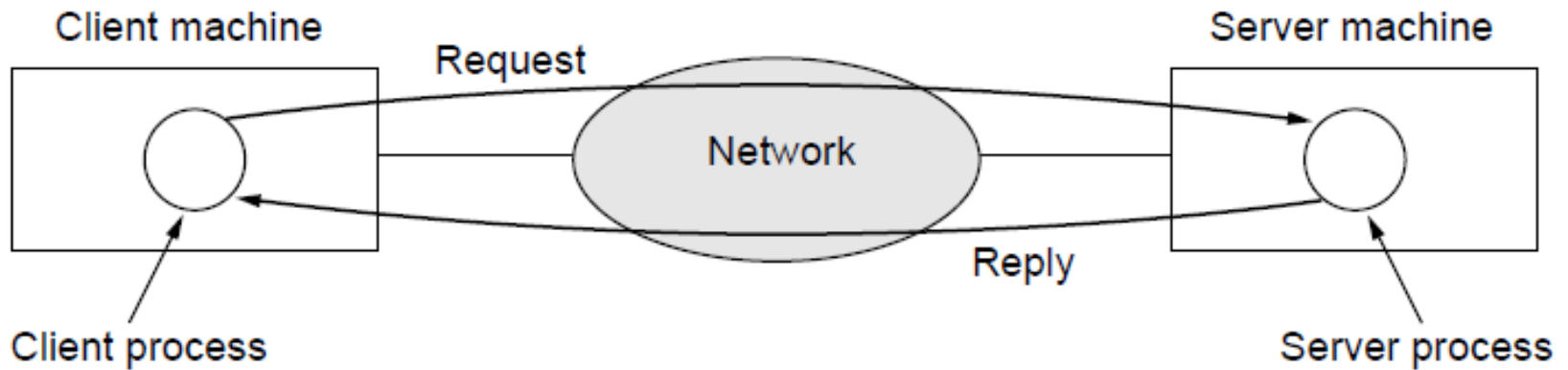
Business Applications (1)

A network with two clients and one server

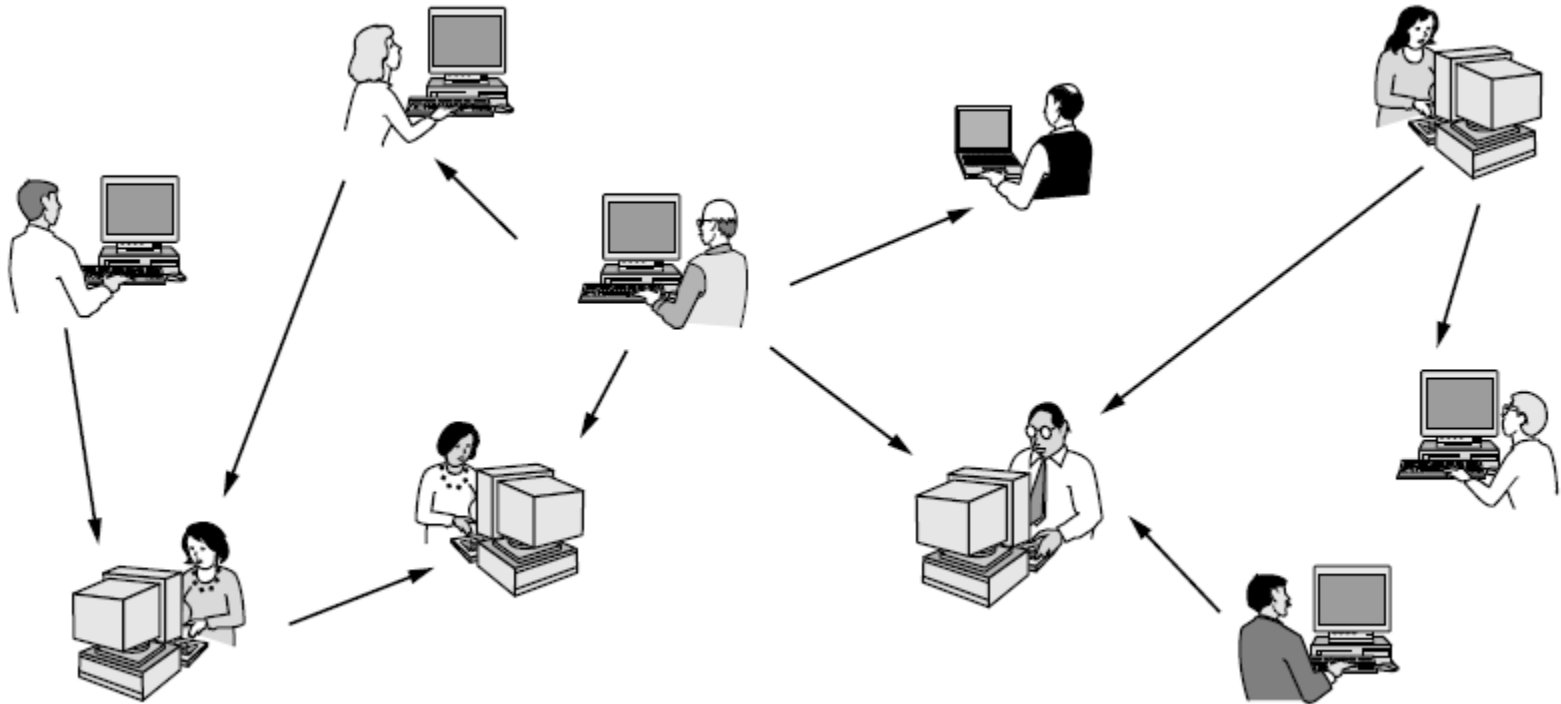


Business Applications (2)

The client-server model involves requests and replies



Home Applications (1)



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

Home Applications (2)

Some forms of e-commerce

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books online
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 online
P2P	Peer-to-peer	Music sharing

Mobile Users

Combinations of wireless networks and mobile computing

Wireless	Mobile	Typical applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in unwired buildings
Yes	Yes	Store inventory with a handheld computer

Social Issues

- Network neutrality
- Digital Millennium Copyright Act
- Profiling users
- Phishing

Network Hardware (1)

- Personal area networks
- Local area networks
- Metropolitan area networks
- Wide area networks
- The internet

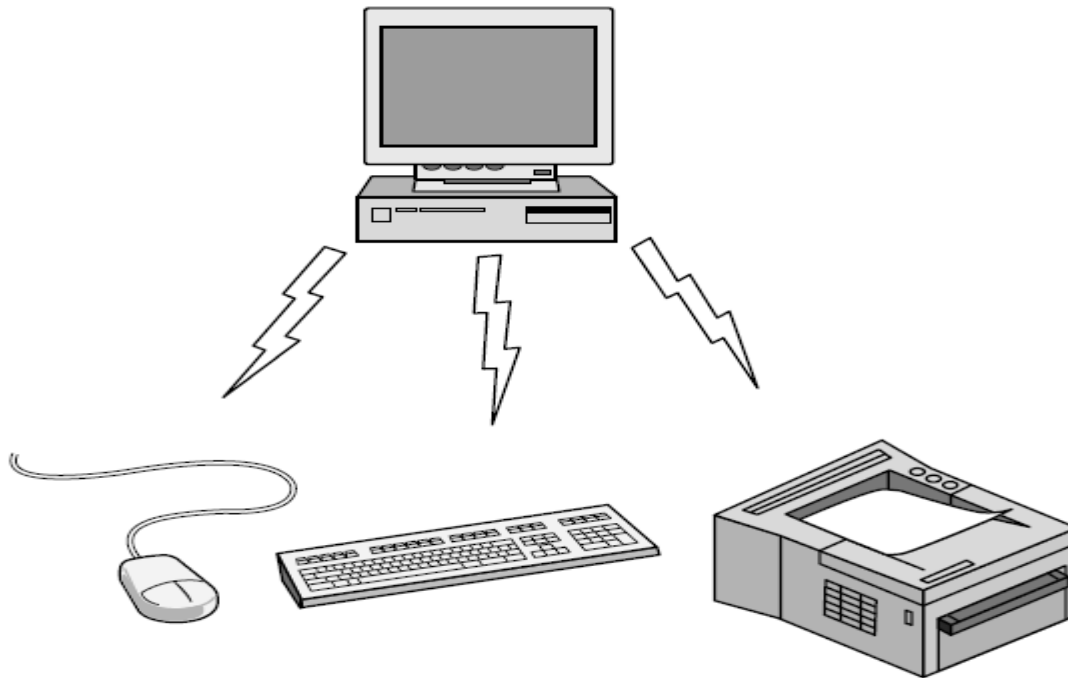
Network Hardware (2)

Classification of interconnected processors by scale.

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

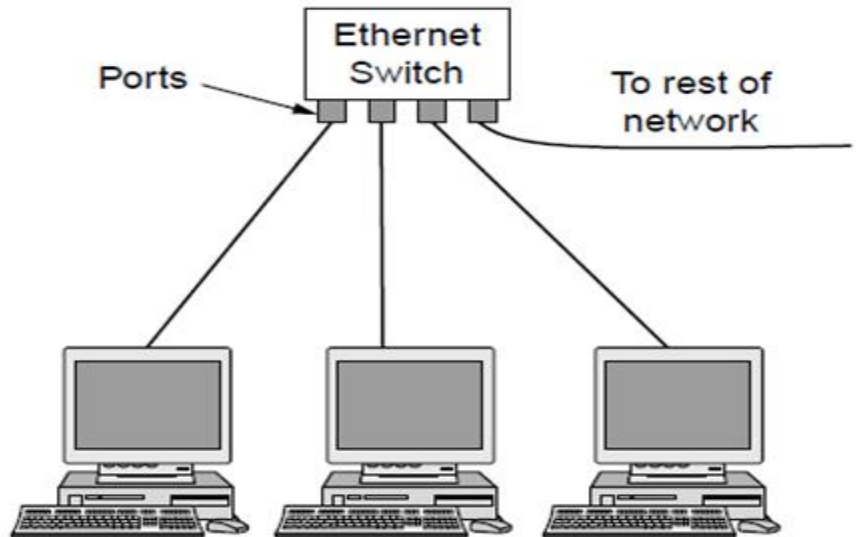
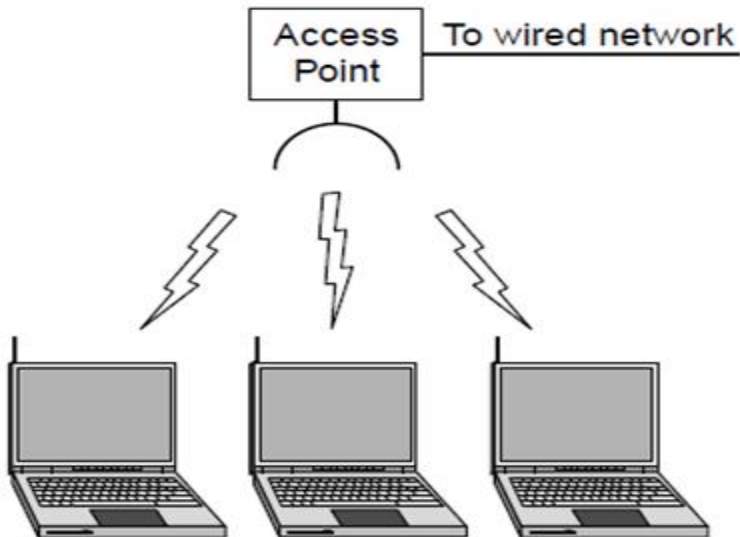
Personal Area Network

Bluetooth PAN configuration

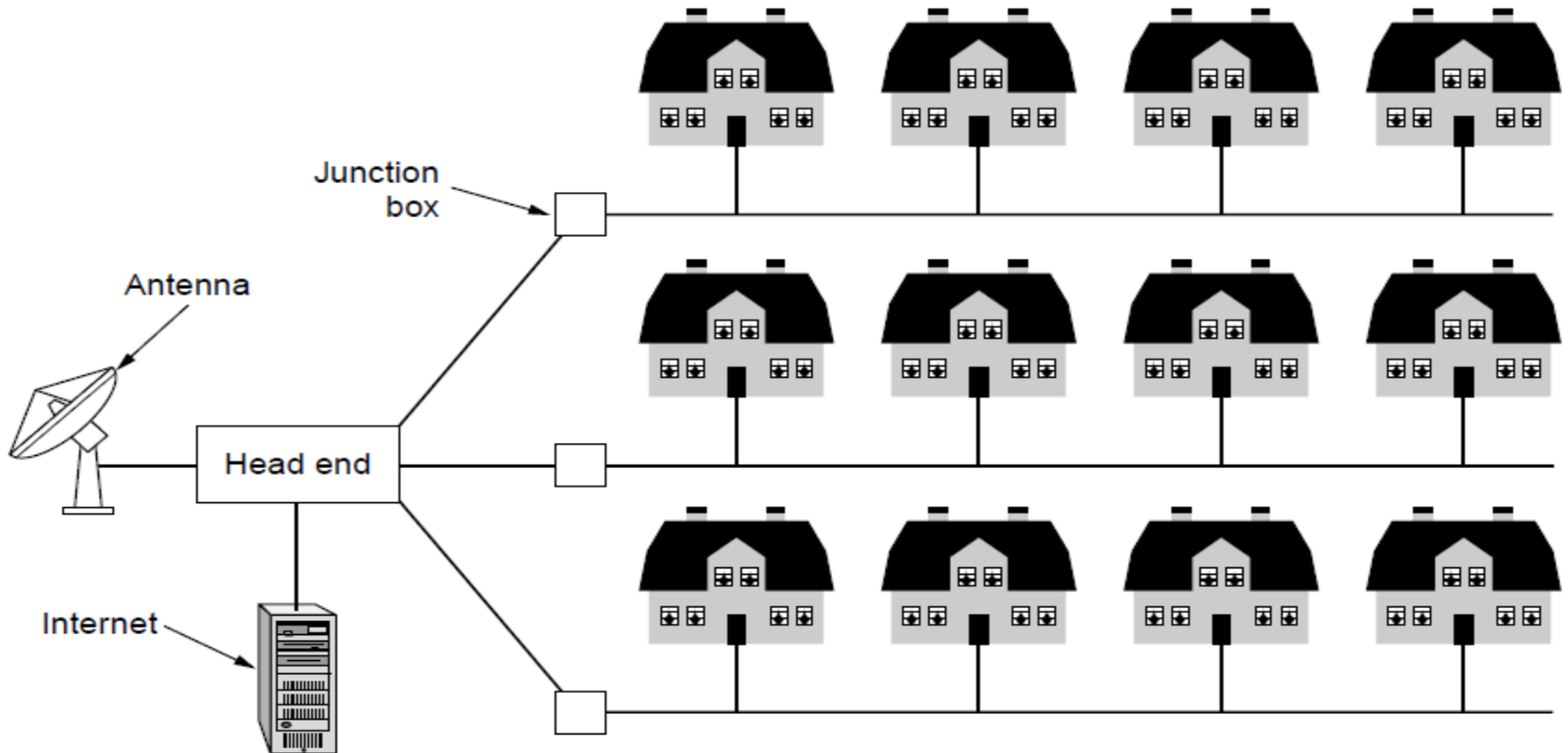


Local Area Networks

Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.

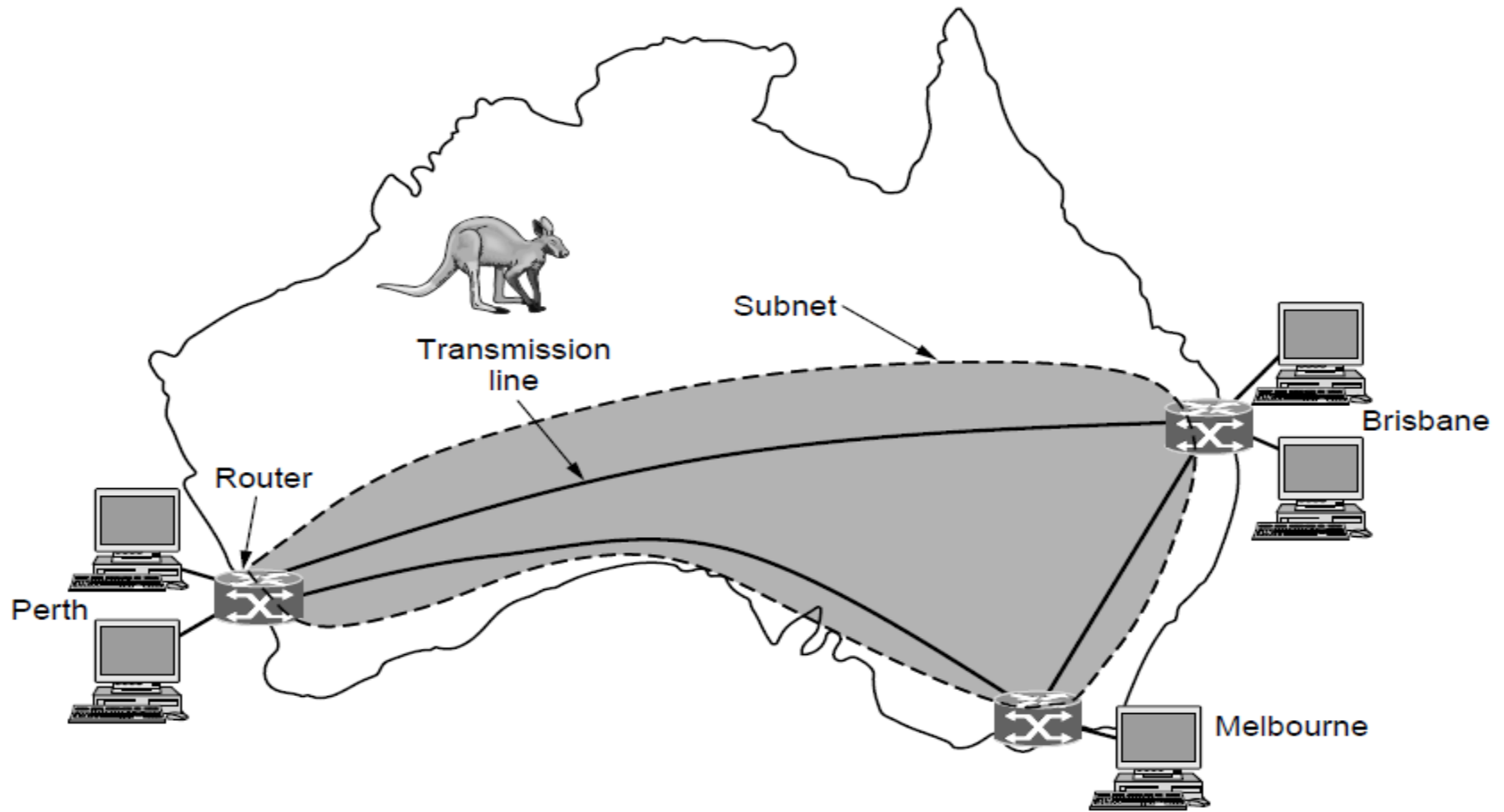


Metropolitan Area Networks



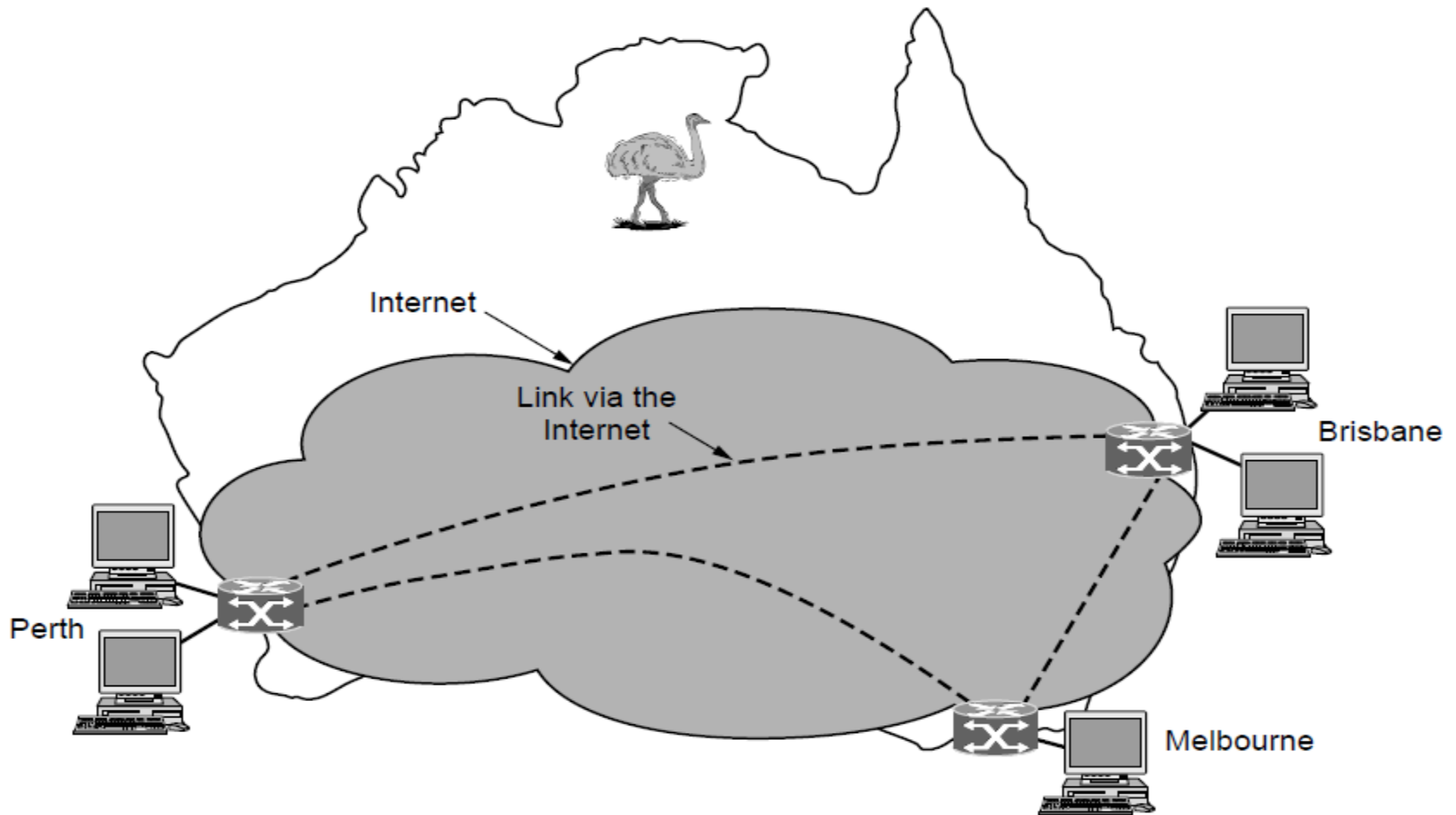
A metropolitan area network based on cable TV.

Wide Area Networks (1)



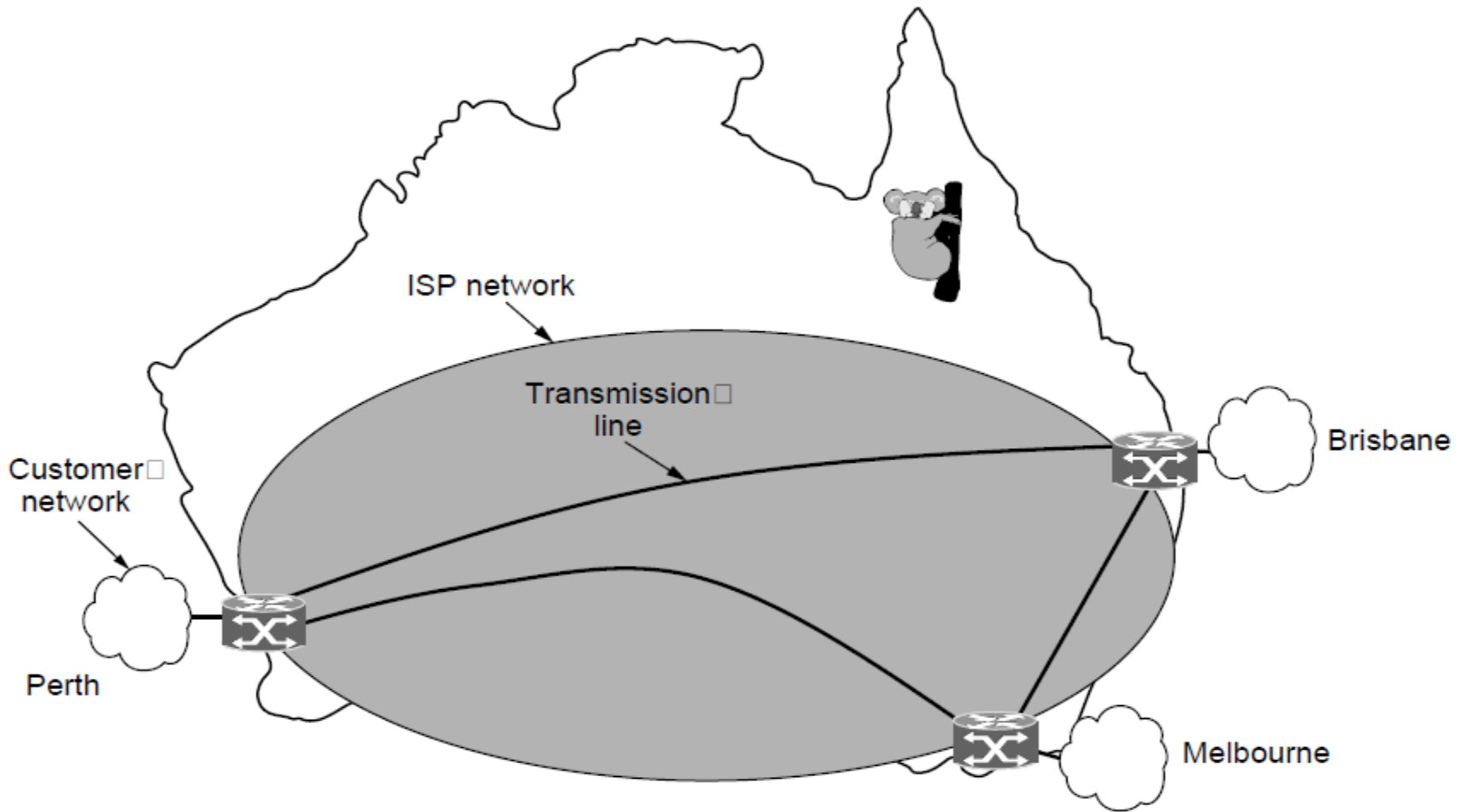
WAN that connects three branch offices in Australia

Wide Area Networks (2)



WAN using a virtual private network.

Wide Area Networks (3)



WAN using an ISP network.

Network Software

- Protocol hierarchies
- Design issues for the layers
- Connection-oriented versus connectionless service
- Service primitives
- Relationship of services to protocols

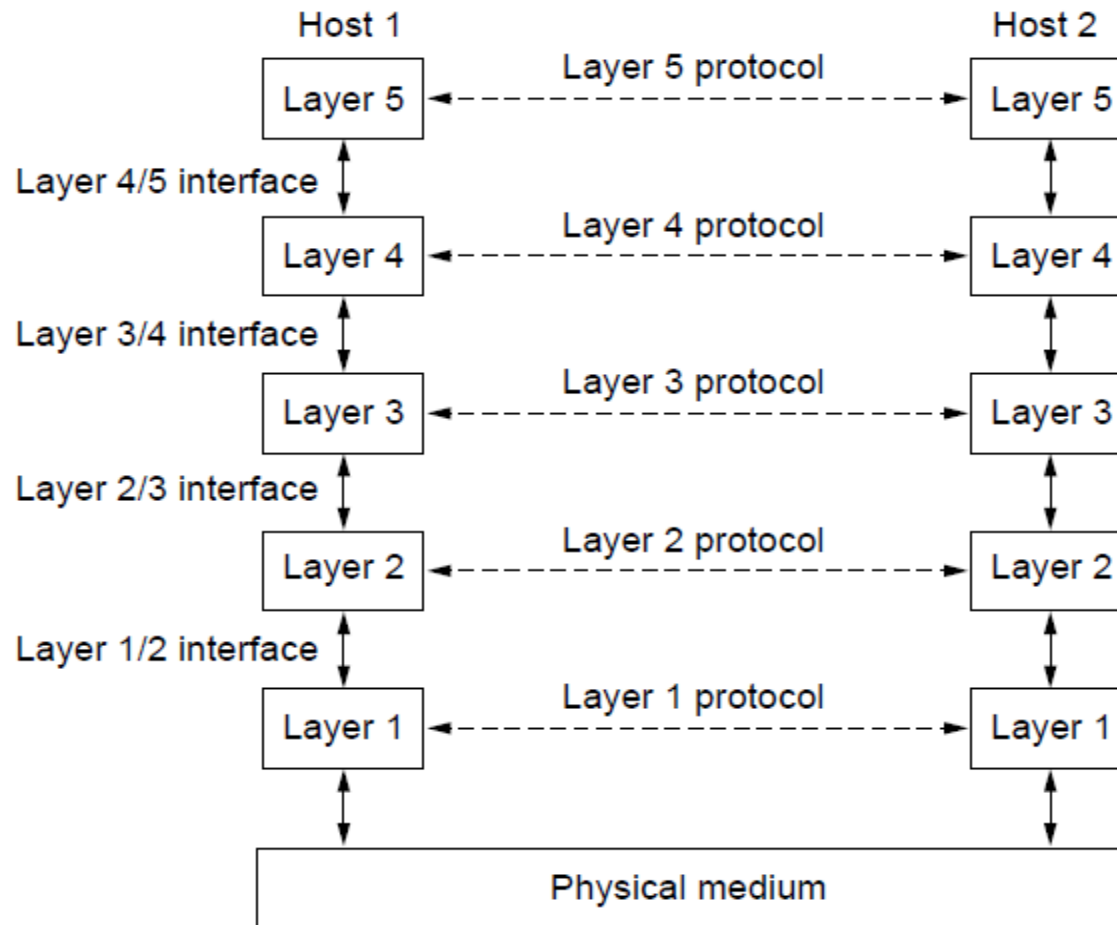
Protocols

- ❑ A protocol is an agreement between the communicating peers on how communication is to proceed.
- ❑ Network protocols are sets of established rules that dictate how to format, transmit and receive data so computer network devices -- from servers and routers to endpoints -- can communicate regardless of the differences in their underlying infrastructures, designs or standards.

How network protocols work

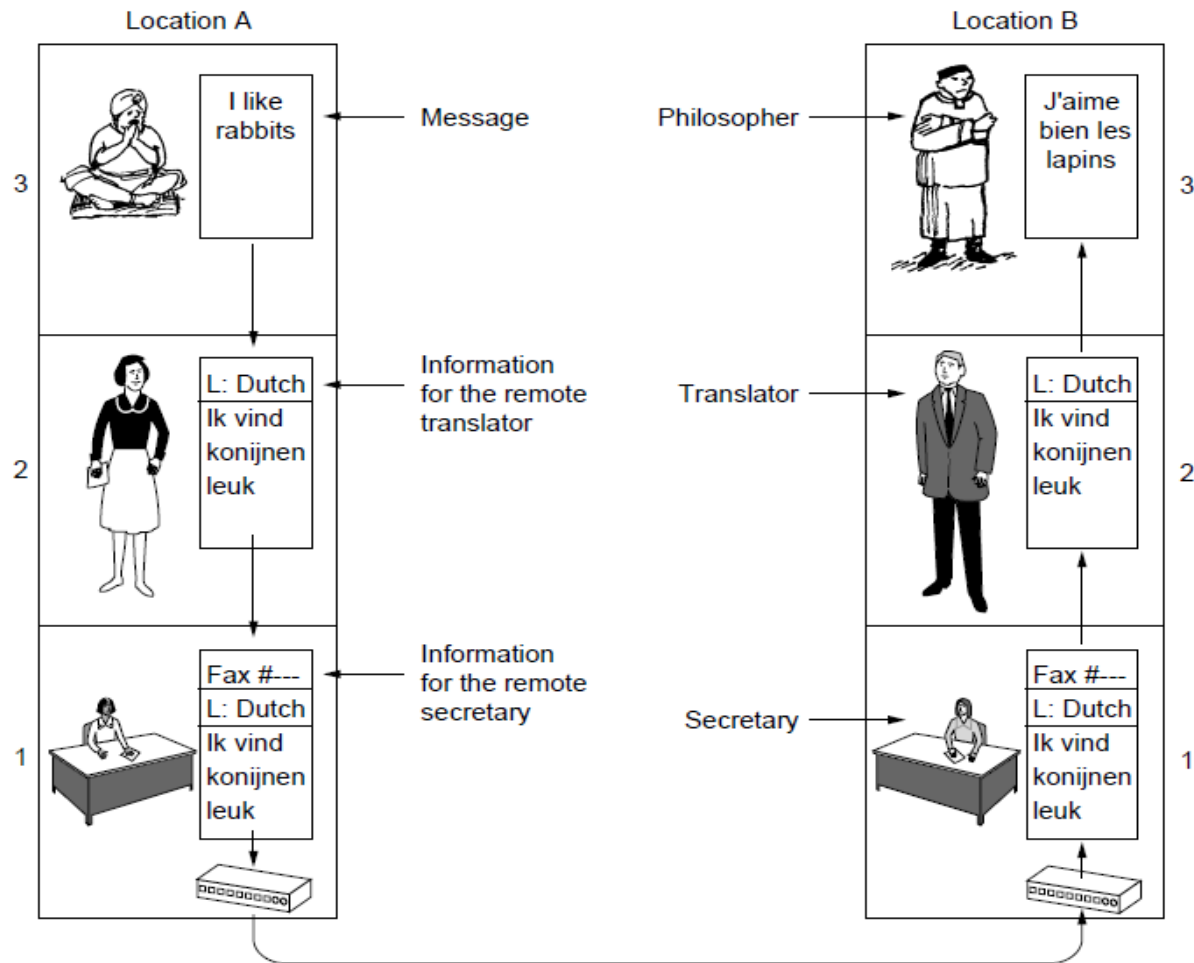
- ❑ Network protocols break larger processes into discrete, narrowly defined functions and tasks across every level of the network.
- ❑ In the standard model, known as the Open Systems Interconnection ([OSI](#)) model, one or more network protocols govern activities at each layer in the telecommunication exchange.

Protocol Hierarchies (1)



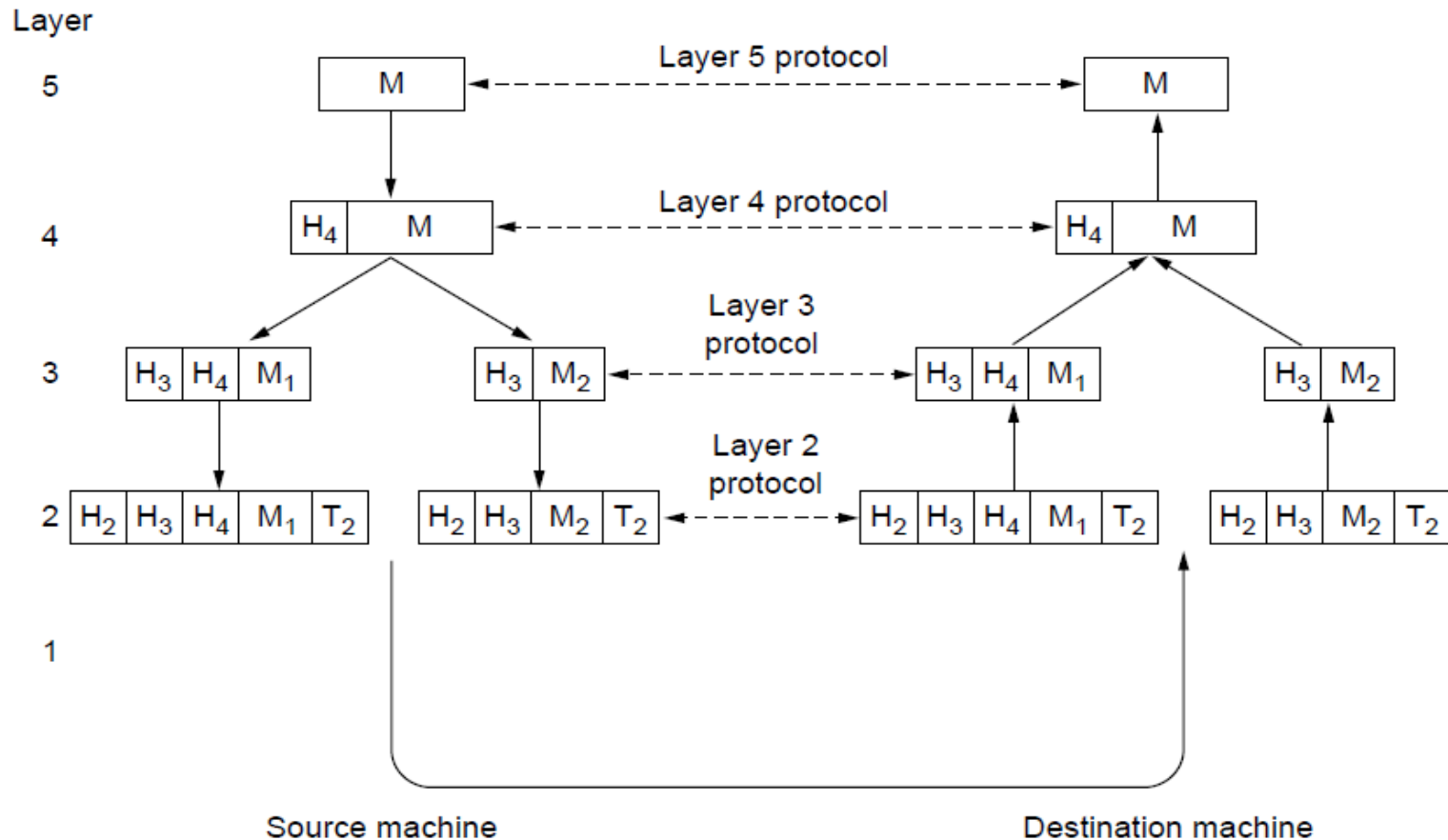
Layers, protocols, and interfaces.

Protocol Hierarchies (2)



The philosopher-translator-secretary architecture

Protocol Hierarchies (3)



Example information flow supporting virtual communication in layer 5.

Design issues for the layers

A number of design issues exist for the layer to layer approach of computer networks. Some of the main design issues are as follows:

❑ **Reliability**

Network channels and components may be unreliable, resulting in loss of bits while data transfer. So, an important design issue is to make sure that the information transferred is not distorted.

❑ **Scalability**

Networks are continuously evolving. The sizes are continually increasing leading to congestion. Also, when new technologies are applied to the added components, it may lead to incompatibility issues. Hence, the design should be done so that the networks are scalable and can accommodate such additions and alterations.

❑ **Addressing**

At a particular time, innumerable messages are being transferred between large numbers of computers. So, a naming or addressing system should exist so that each layer can identify the sender and receivers of each message.

Cont..

❑ Error Control

Unreliable channels introduce a number of errors in the data streams that are communicated. So, the layers need to agree upon common error detection and error correction methods so as to protect data packets while they are transferred.

❑ Flow Control

If the rate at which data is produced by the sender is higher than the rate at which data is received by the receiver, there are chances of overflowing the receiver. So, a proper flow control mechanism needs to be implemented.

❑ Resource Allocation

Computer networks provide services in the form of network resources to the end users. The allocation/deallocation should occur so that minimal interference among the hosts occurs and there is optimal usage of the resources.

Cont..

❑ **Statistical Multiplexing**

It is not feasible to allocate a dedicated path for each message while it is being transferred from the source to the destination. So, the data channel needs to be multiplexed, so as to allocate a fraction of the bandwidth or time to each host.

❑ **Routing**

There may be multiple paths from the source to the destination. Routing involves choosing an optimal path among all possible paths, in terms of cost and time. There are several routing algorithms that are used in network systems.

❑ **Security**

A major factor of data communication is to defend it against threats like eavesdropping and surreptitious alteration of messages. So, there should be adequate mechanisms to prevent unauthorized access to data through authentication and cryptography.

Connection-Oriented Versus Connectionless Service

Connection-oriented	Service	Example
	Reliable message stream	Sequence of pages
	Reliable byte stream	Movie download
	Unreliable connection	Voice over IP
Connection-less	Unreliable datagram	Electronic junk mail□
	Acknowledged datagram	Text messaging
	Request-reply	Database query

Six different type of services.

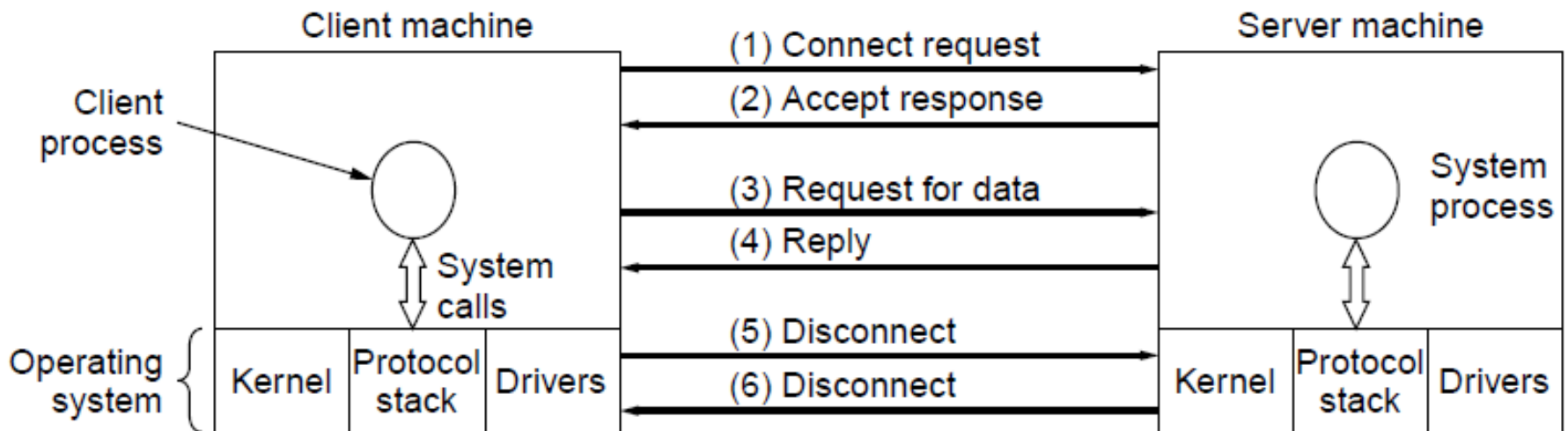
Service Primitives

A service is formally specified by a set of primitives (basic operations) available to a user or other entity to access the service.

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

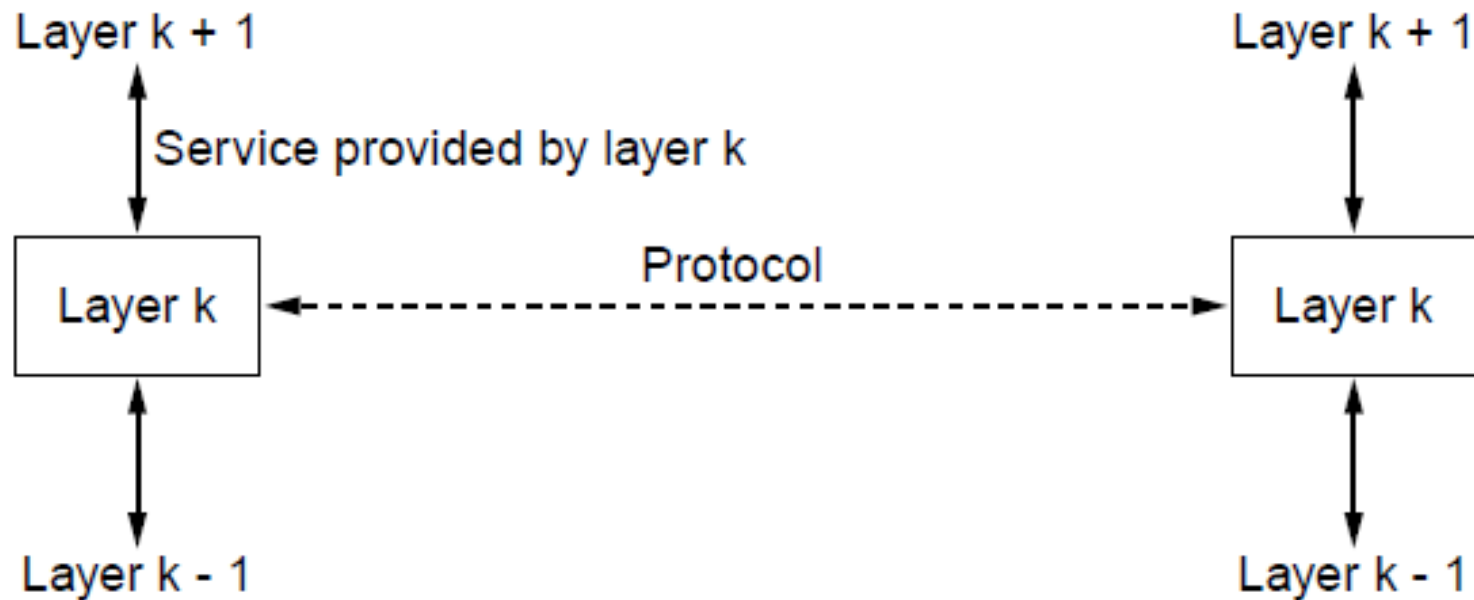
Example: five service primitives for implementing a simple connection-oriented service.

Service Primitives (2)



A simple client-server interaction using acknowledged datagrams.

The Relationship of Services to Protocols



The relationship between a service and a protocol.

Reference Models

- OSI reference model
- TCP/IP reference model
- Comparison of OSI and TCP/IP
- Critique of OSI model and protocols
- Critique of TCP/IP model

The OSI Reference Model

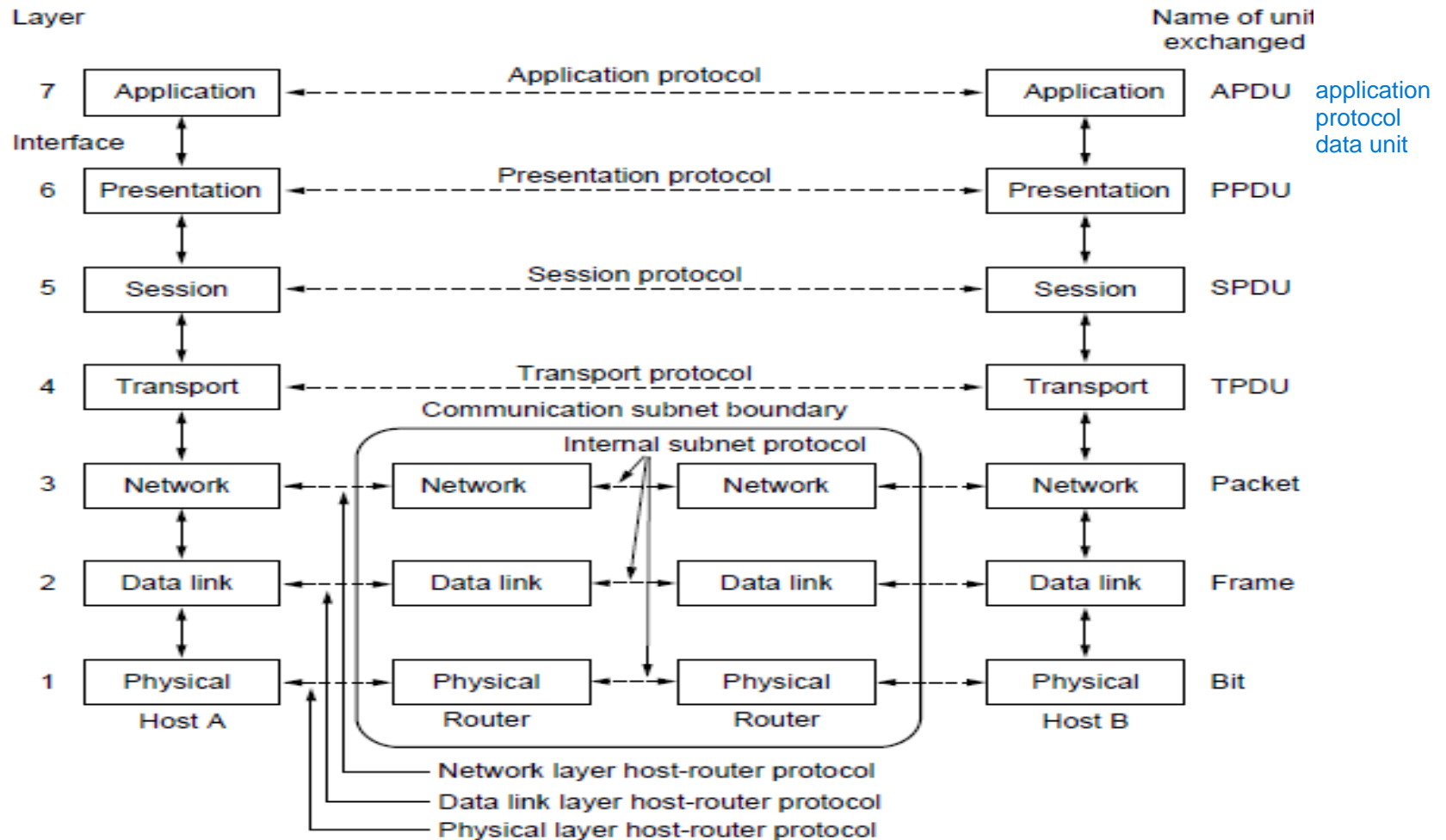
Principles for the seven layers

- Layers created for different abstractions
- Each layer performs well-defined function
- Function of layer chosen with definition of international standard protocols in mind
- Minimize information flow across interfaces between boundaries
- Number of layers optimum

OSI Reference Model Layers

- Physical layer
- Data link layer
- Network layer
- Transport layer
- Session layer
- Presentation layer
- Application layer

The OSI Reference Model

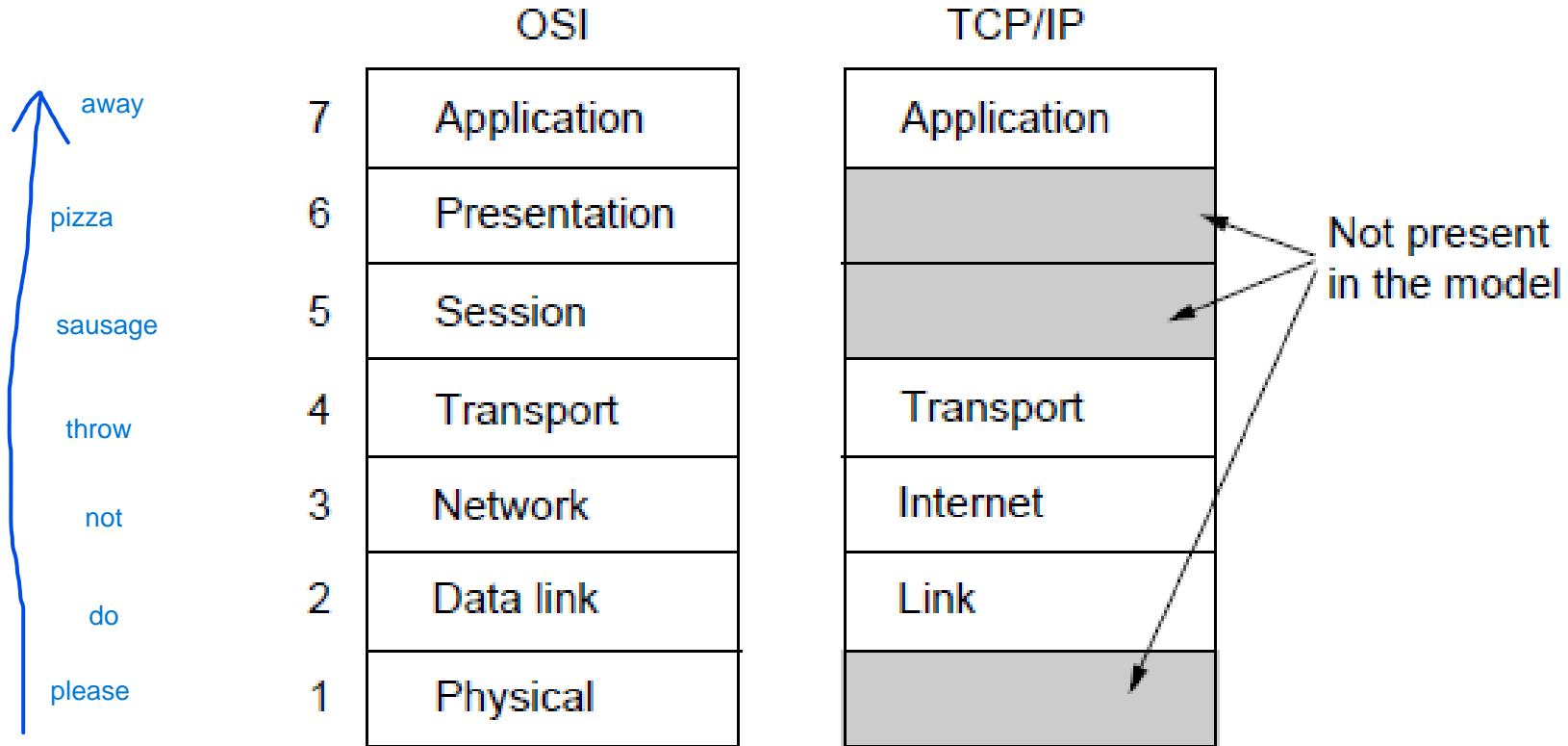


The OSI reference model

The TCP/IP Reference Model Layers

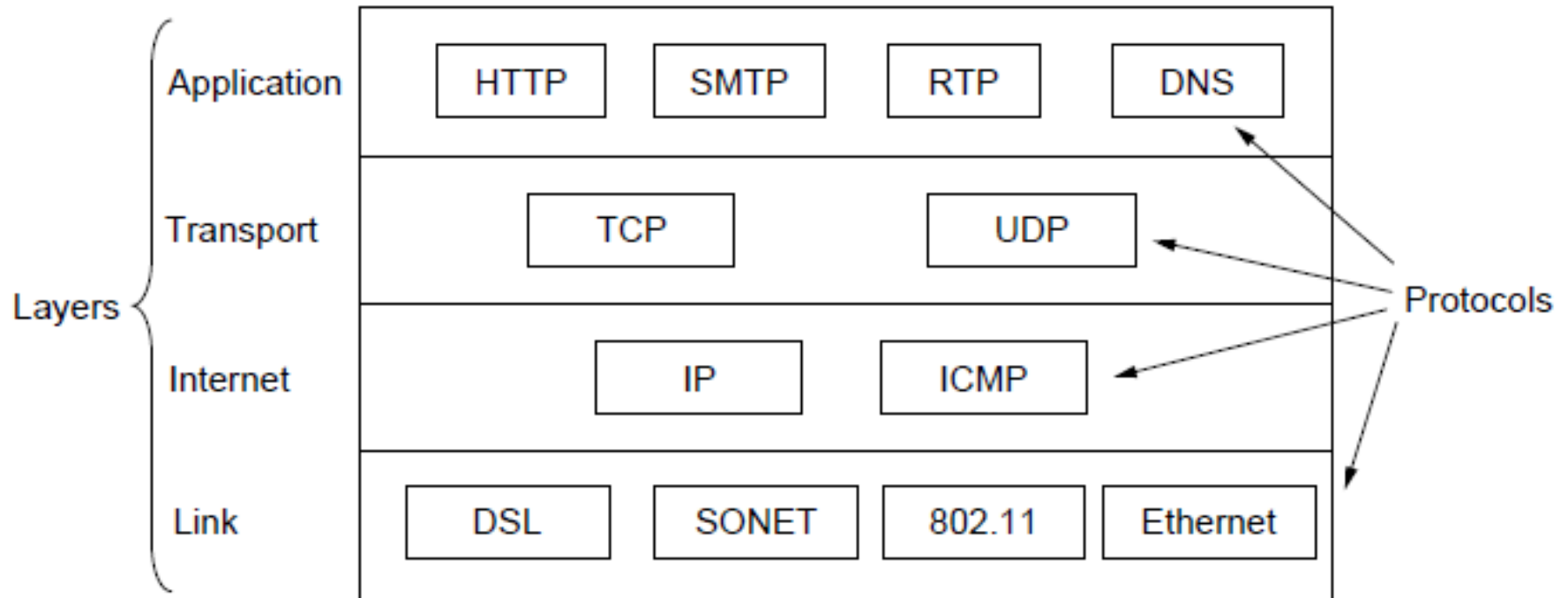
- Link layer
- Internet layer
- Transport layer
- Application layer

The TCP/IP Reference Model (1)



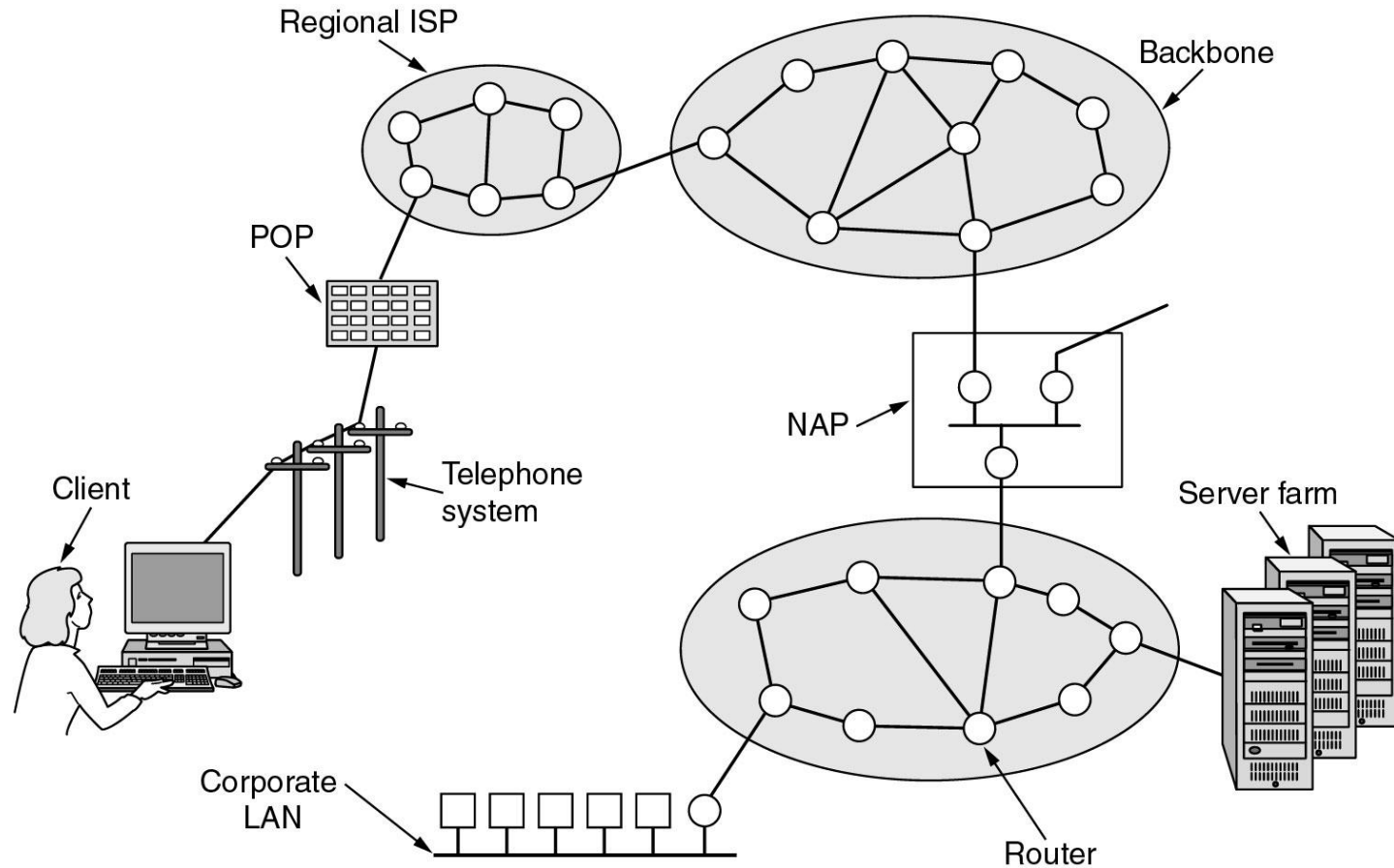
The TCP/IP reference model

The TCP/IP Reference Model (2)



The TCP/IP reference model with some protocols we will study

The TCP/IP Reference Model (3)

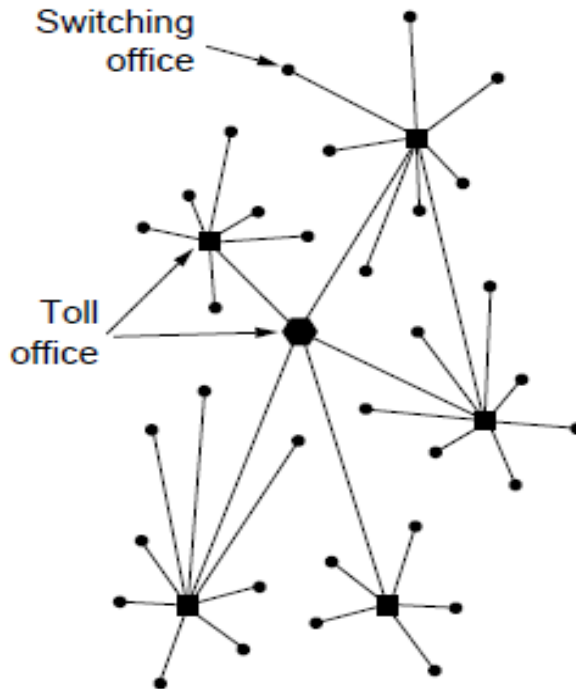


Overview of the Internet.

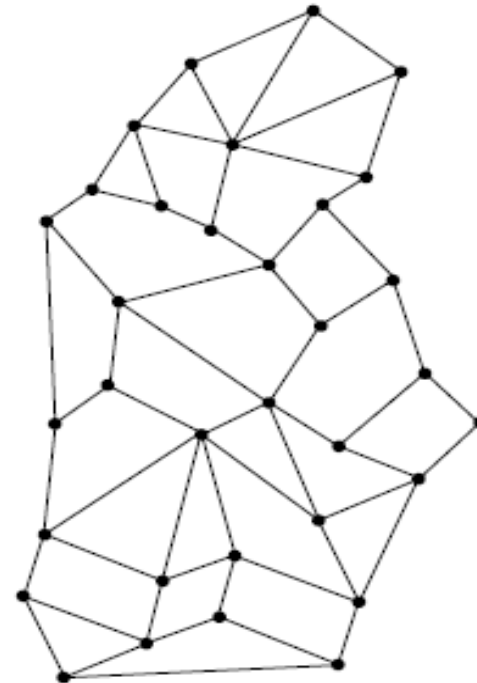
ARPANET

- ❑ Advanced Research Projects Agency.
- ❑ First public packet-switched computer network.

The ARPANET (1)



(a)



(b)

- ❑ Structure of the telephone system.
- ❑ Baran's proposed distributed switching system.