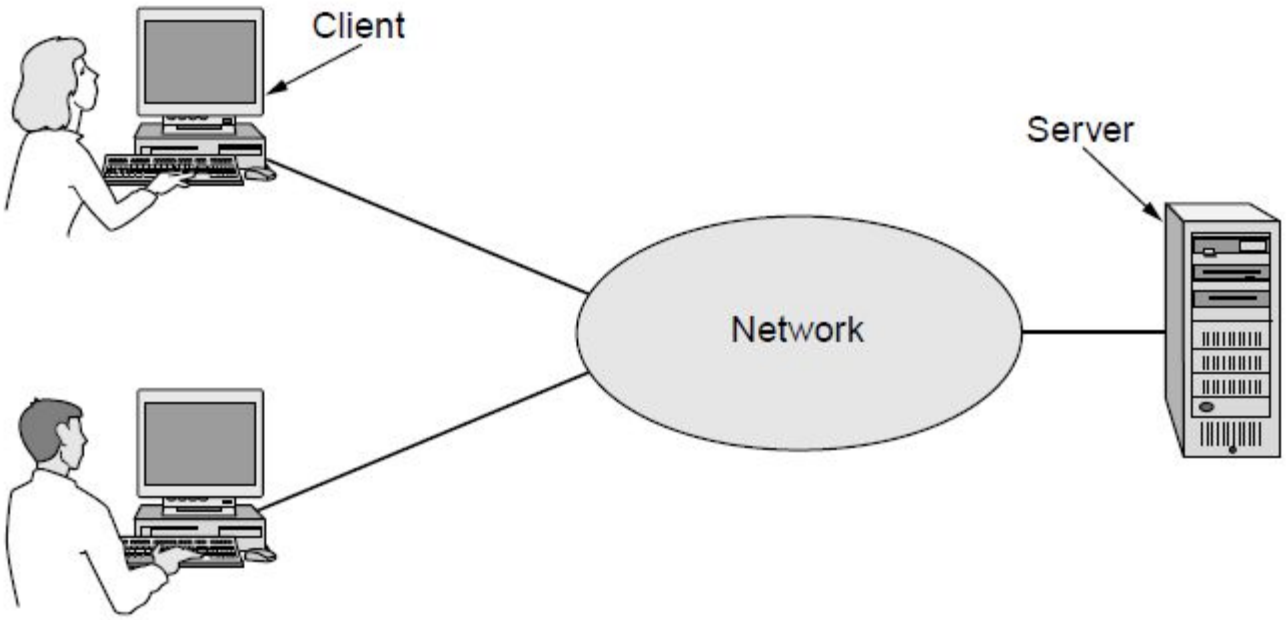
# Introduction

Chapter 1

# Uses of Computer Networks

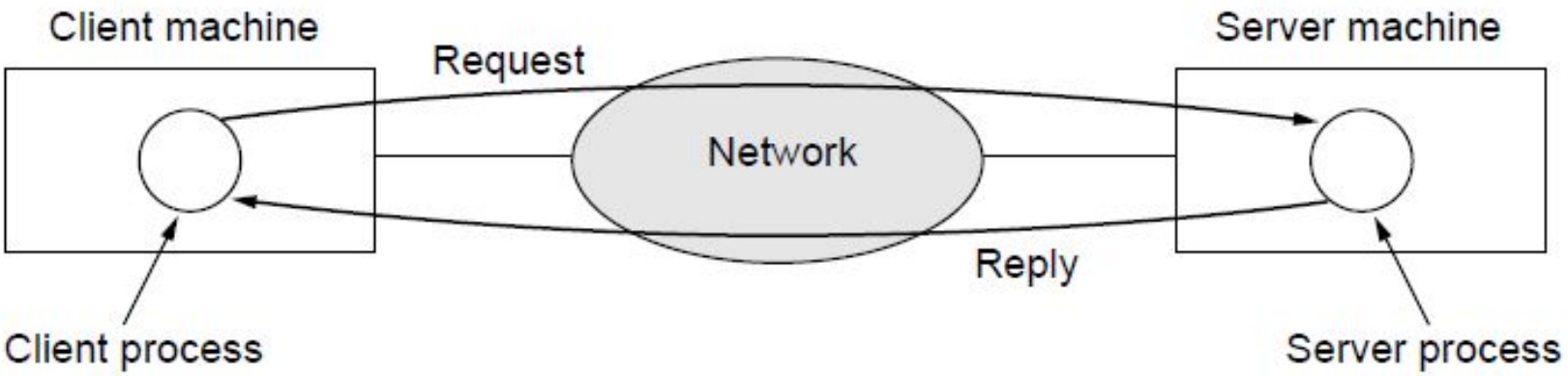
- Business Applications
- Home Applications
- Mobile Users
- Social Issues

# Business Applications (1)



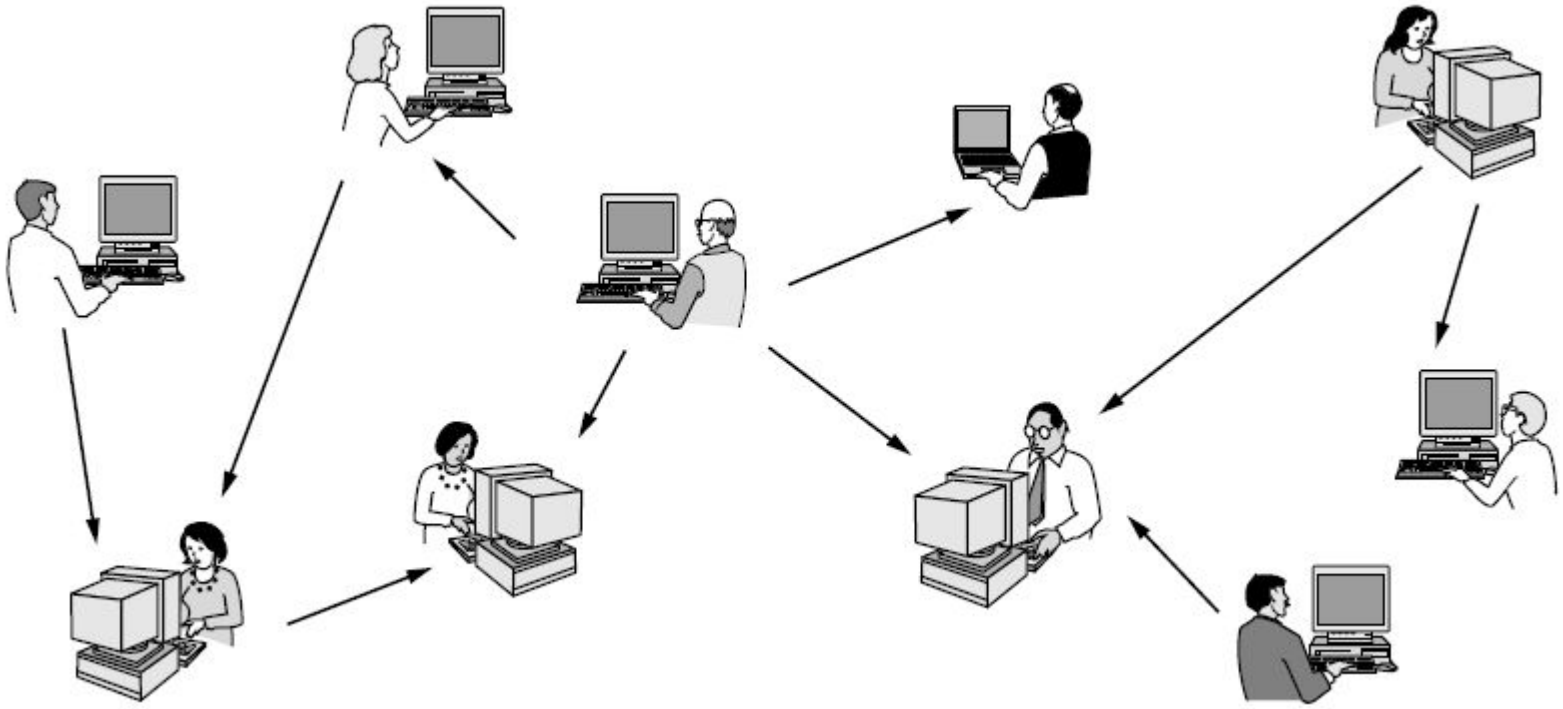

A network with two clients and one server

# 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)

| 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 |

Some forms of e-commerce

# Mobile Users

| 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 |

Combinations of wireless networks and mobile computing

# Social Issues

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

# Network Hardware (1)

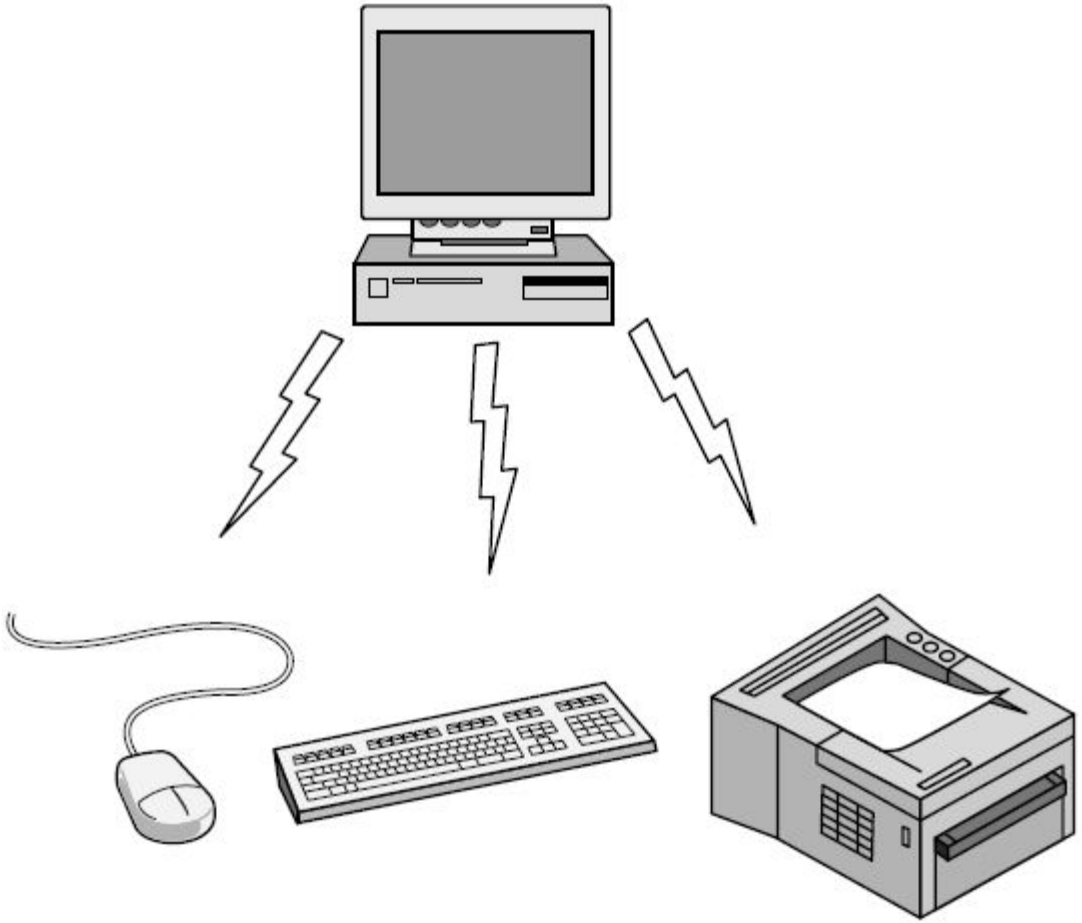
- Personal area networks
- Local area networks
- Metropolitan area networks
- Wide are networks
- The internet

# Network Hardware (2)

| 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 |

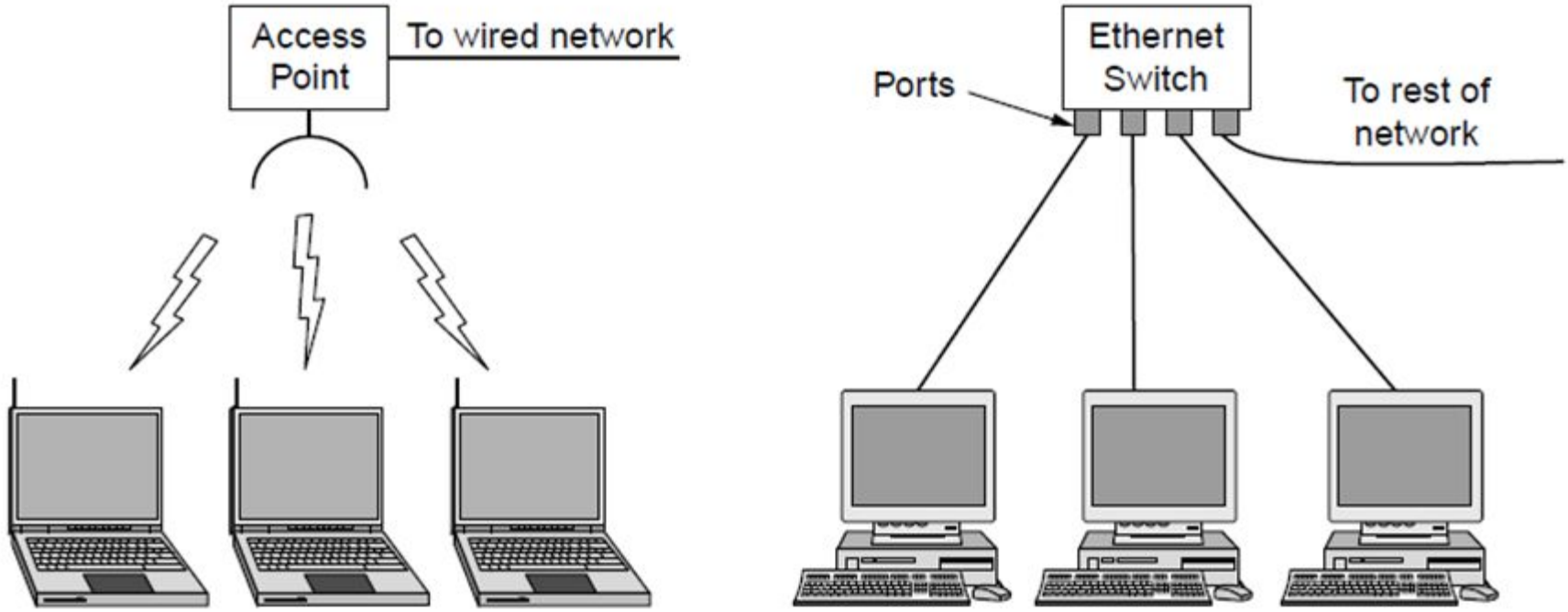
Classification of interconnected processors by scale.

# Personal Area Network



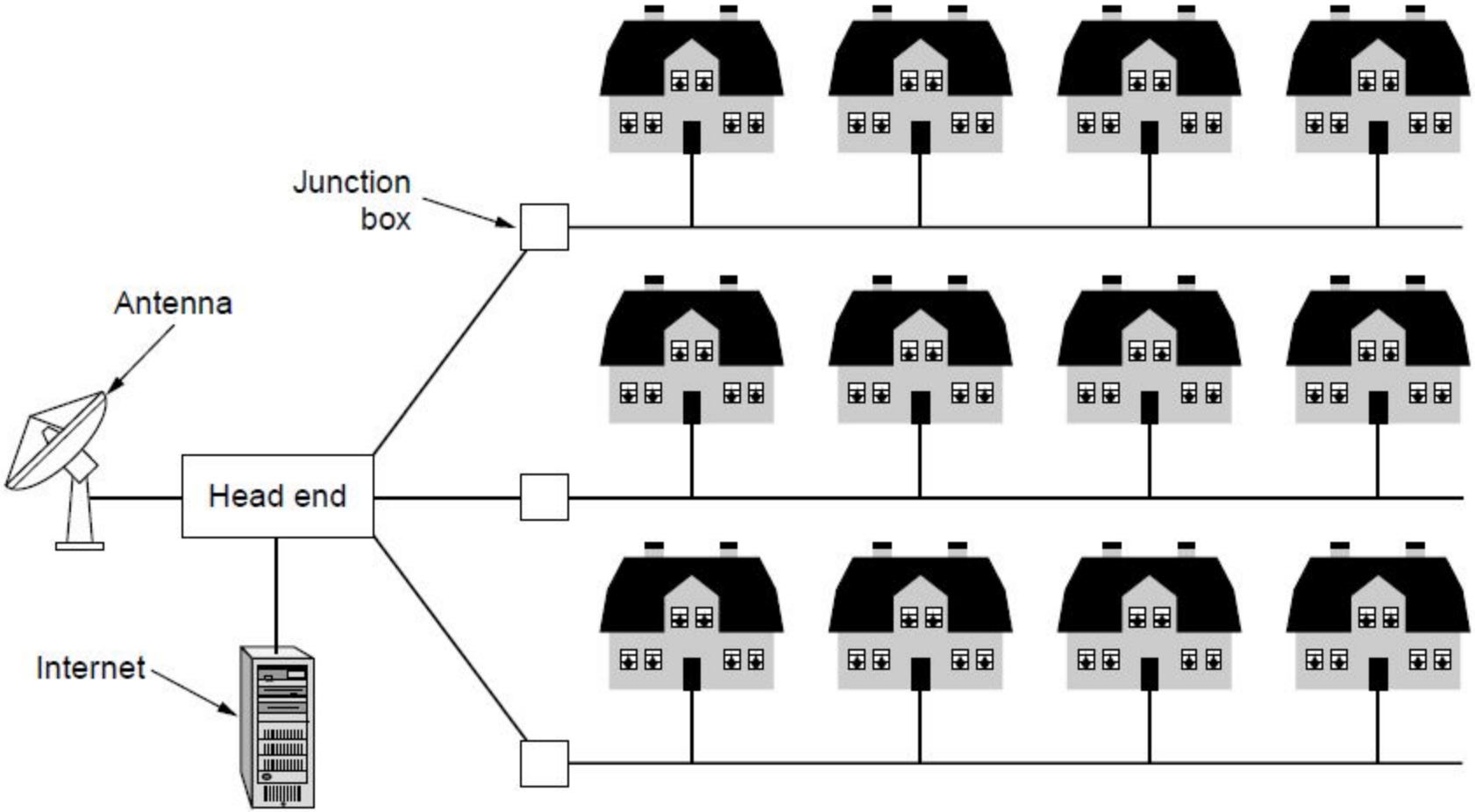
Bluetooth PAN configuration

# Local Area Networks



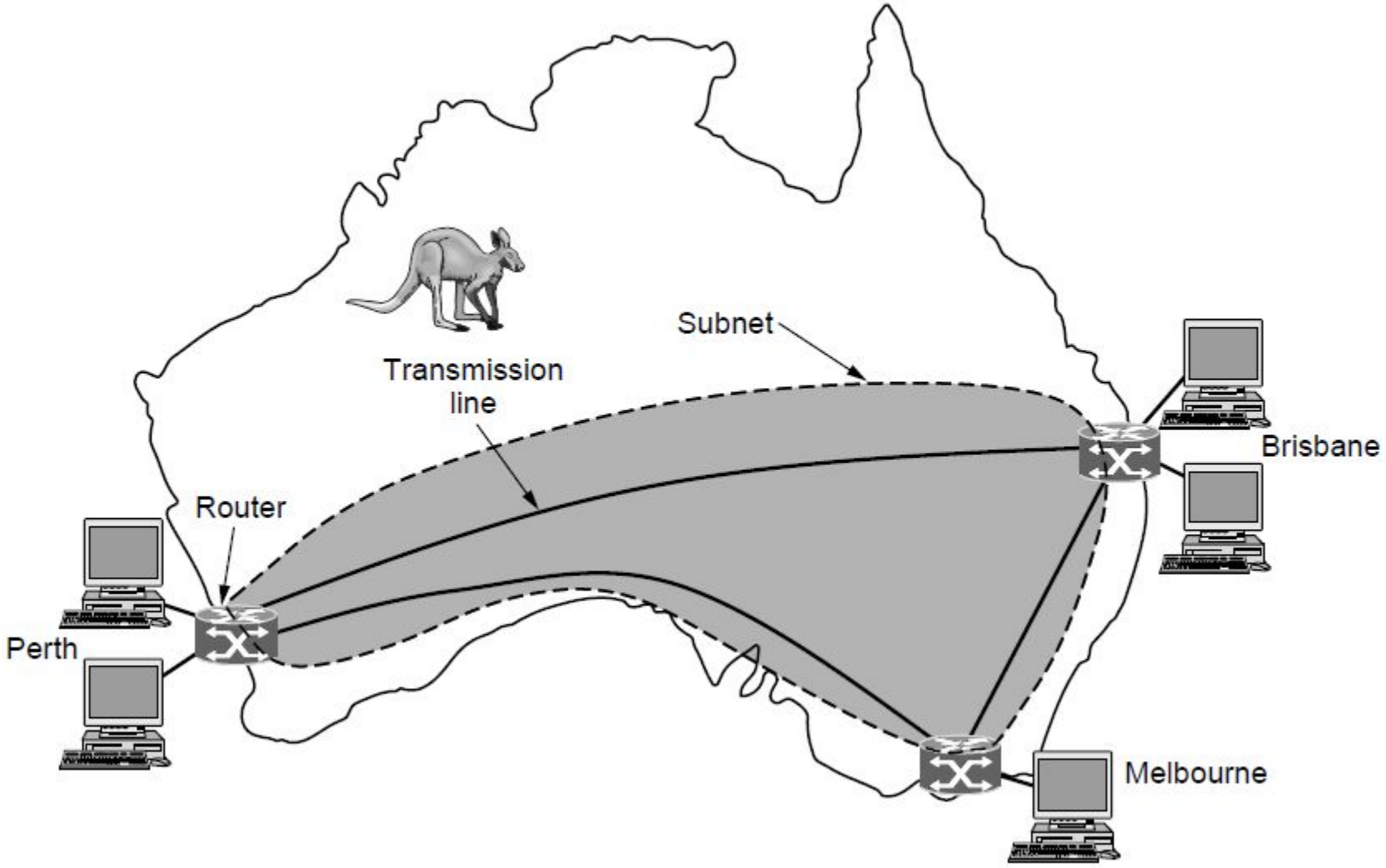

Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.

# Metropolitan Area Networks



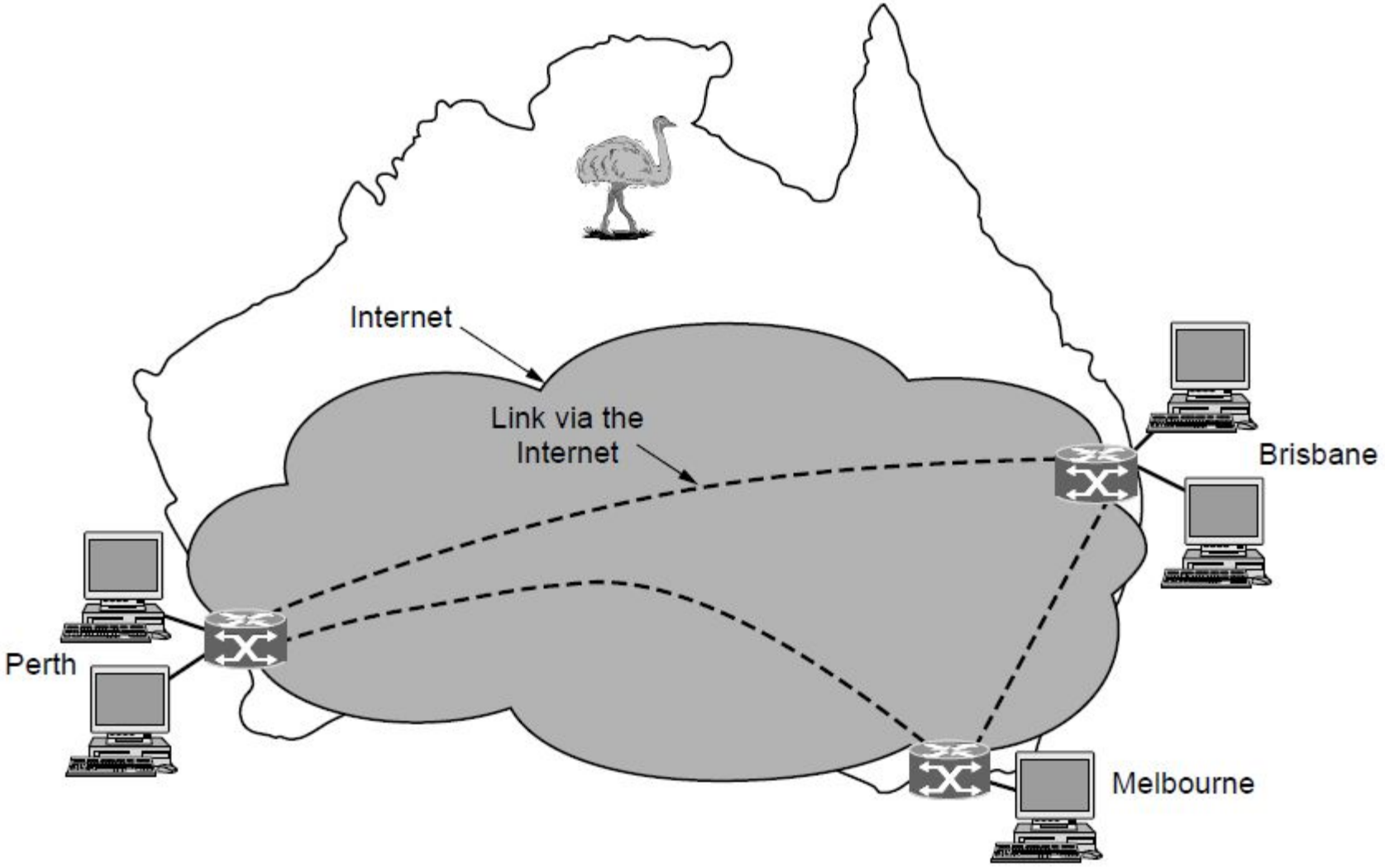

A metropolitan area network based on cable TV.

# Wide Area Networks (1)



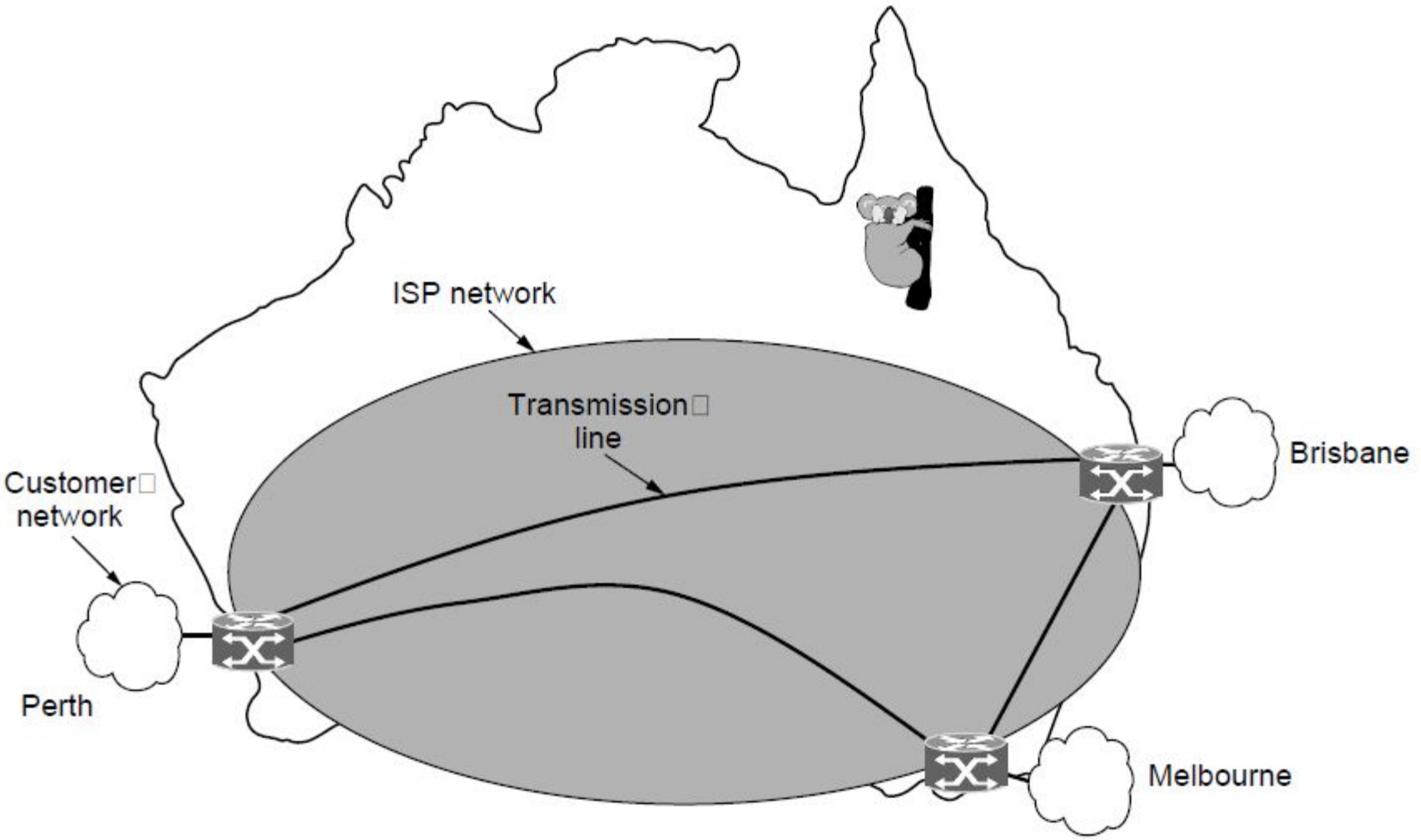

WAN that connects three branch offices in Australia

# Wide Area Networks (2)




WAN using a virtual private network.

# Wide Area Networks (3)

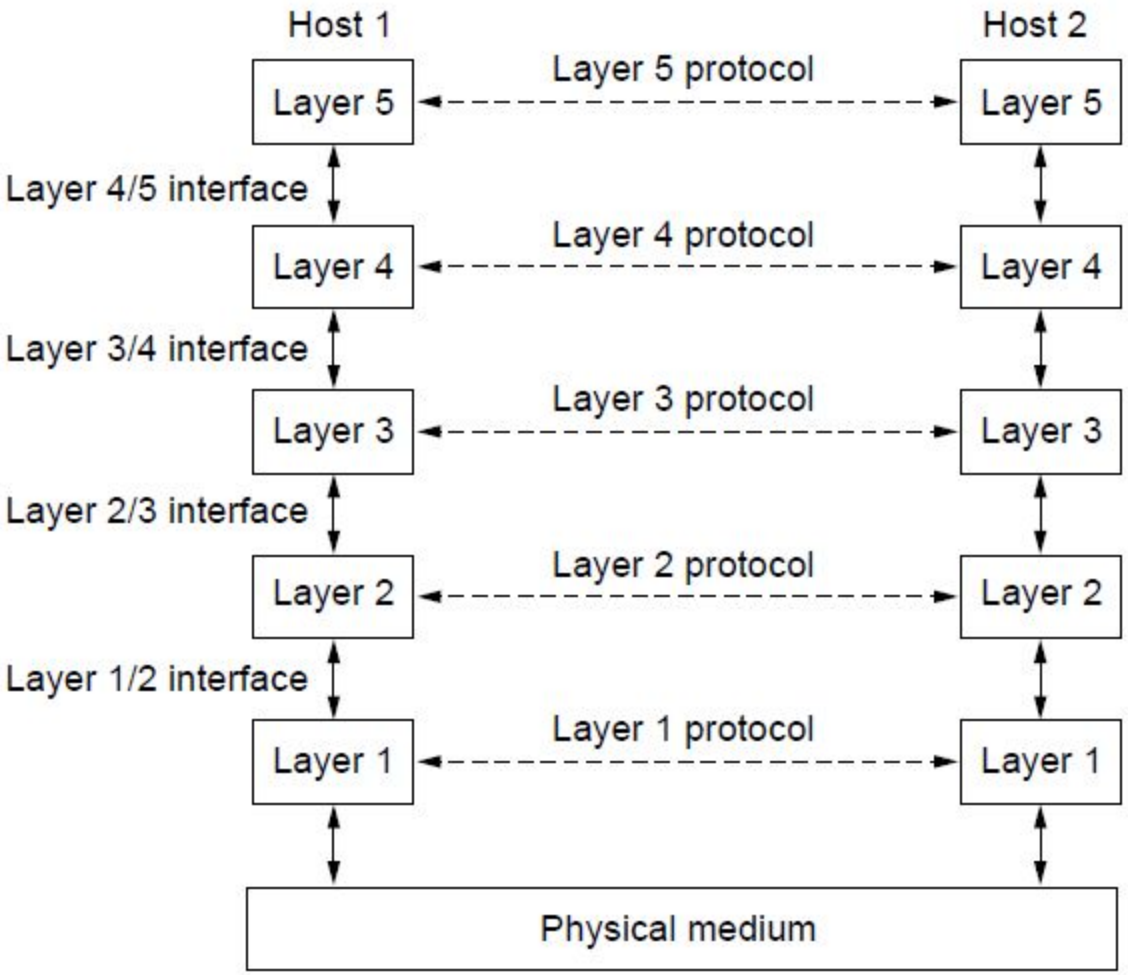



WAN using an ISP network.

# Network Software

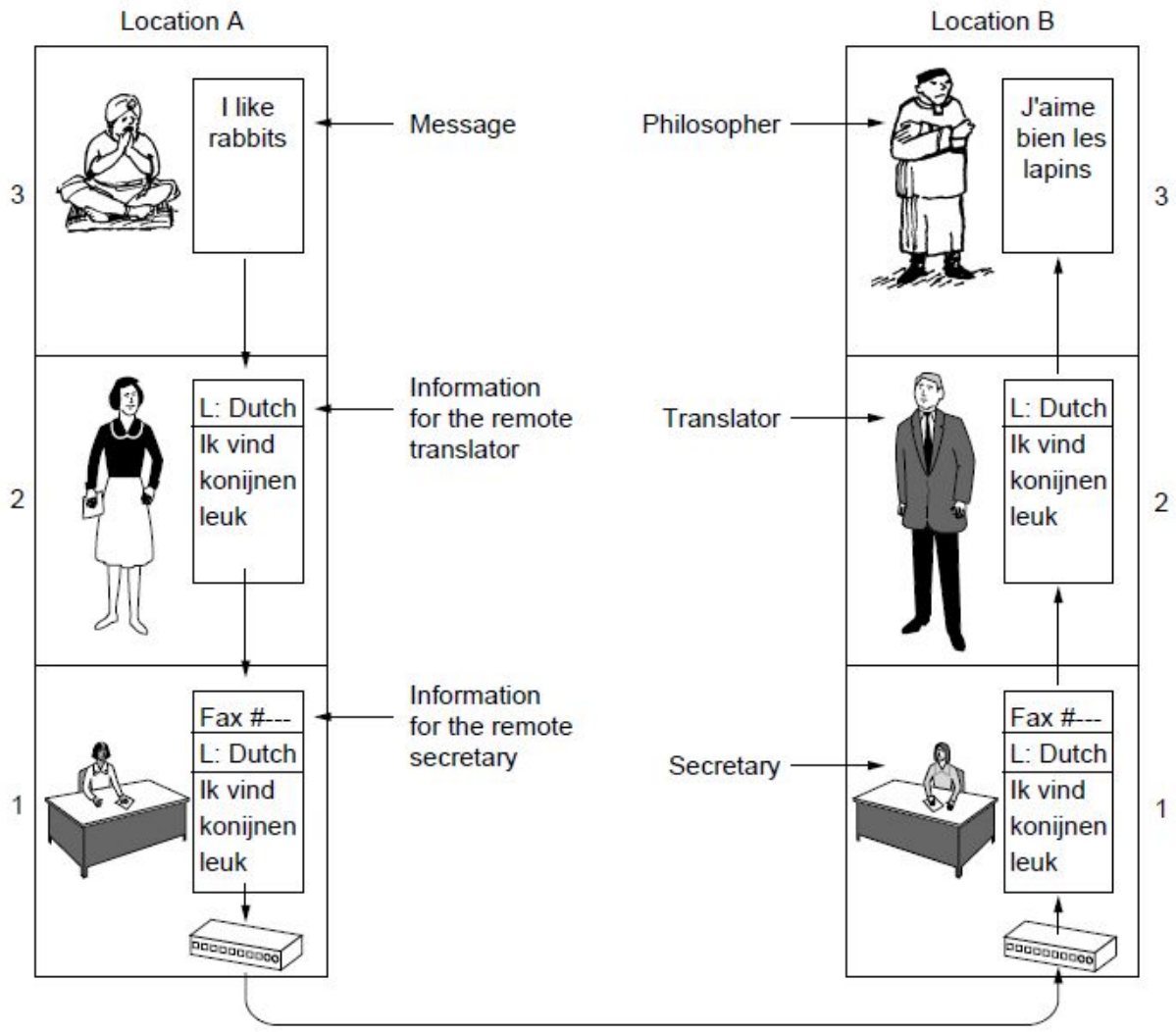
- Protocol hierarchies
- Design issues for the layers
- Connection-oriented versus connectionless service
- Service primitives
- Relationship of services to protocols

# Protocol Hierarchies (1)



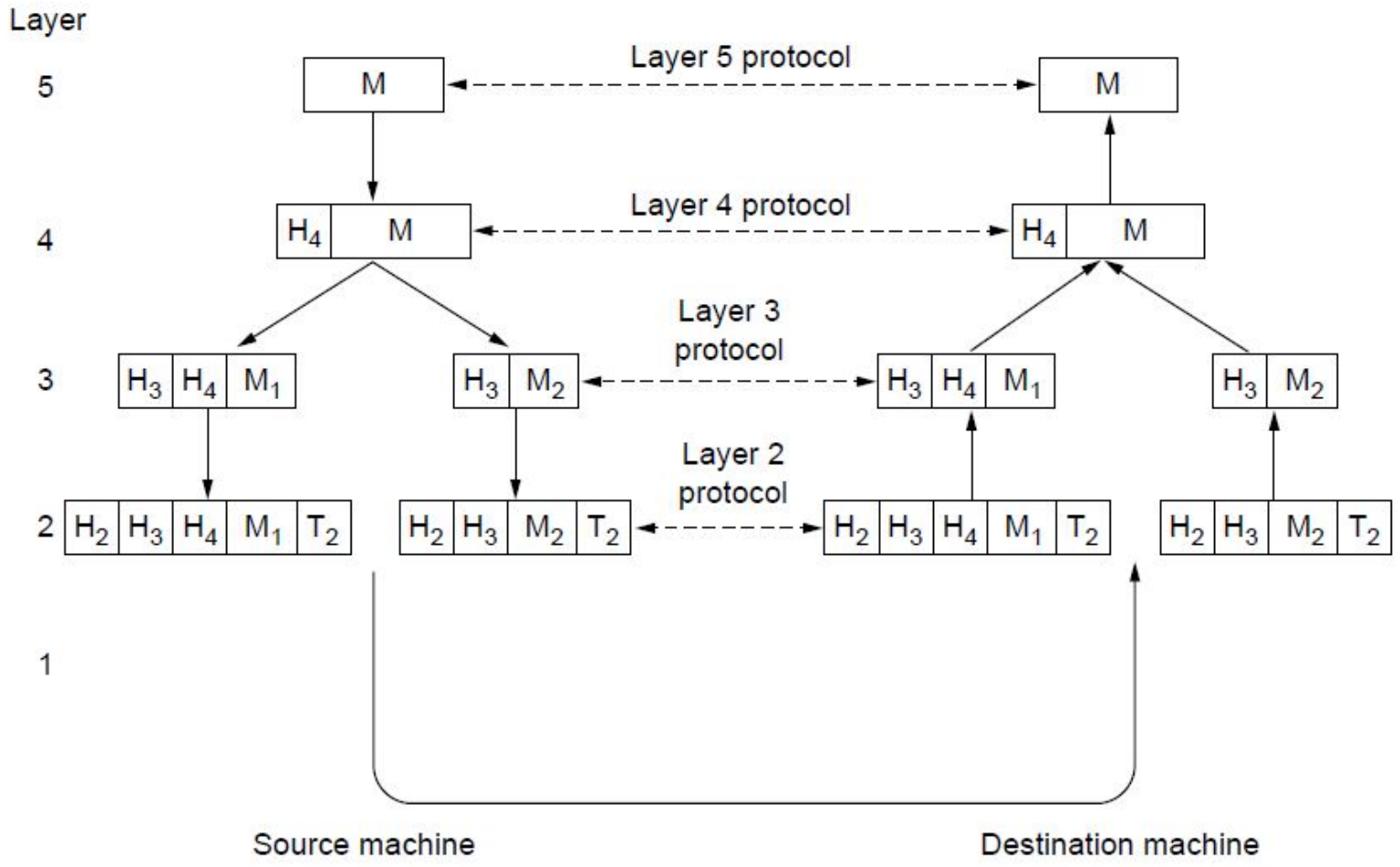

Layers, protocols, and interfaces.

# Protocol Hierarchies (2)




The philosopher-translator-secretary architecture

# Protocol Hierarchies (3)




Example information flow supporting virtual communication in layer 5.

# Connection-Oriented Versus Connectionless Service

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

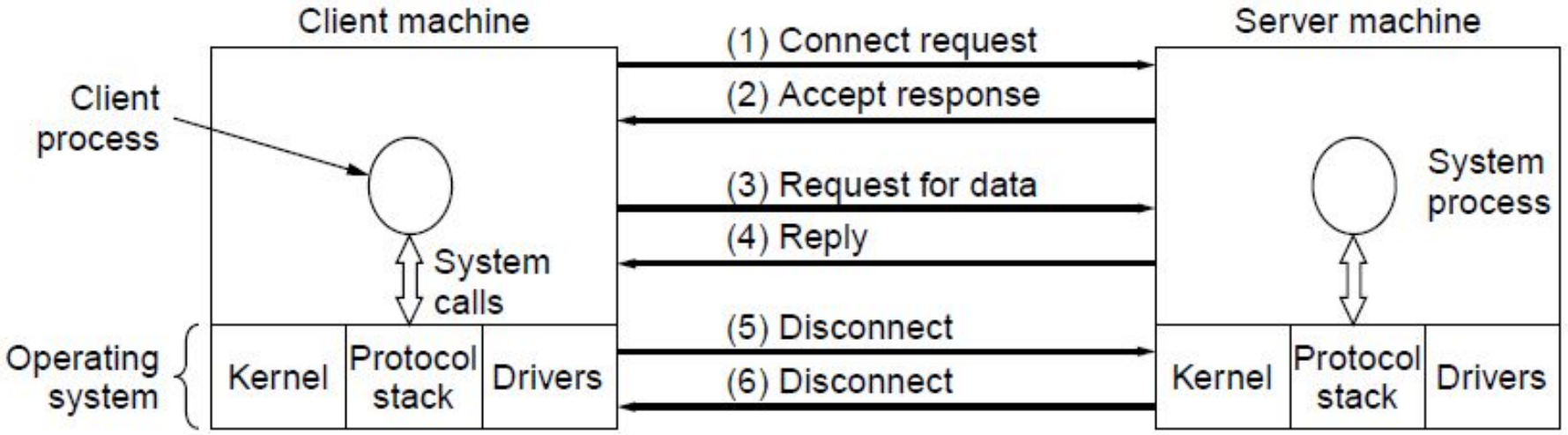
Six different types of service.

# Service Primitives (1)

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

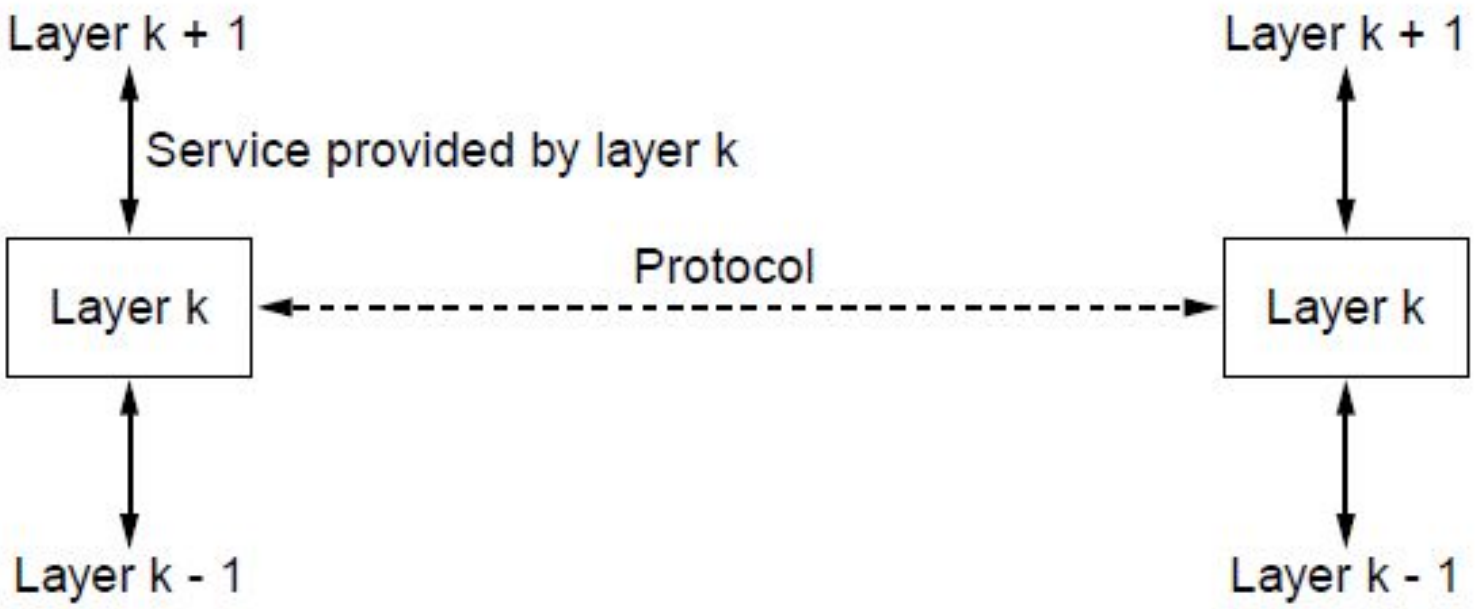
Six service primitives that provide a simple connection-oriented service

# 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

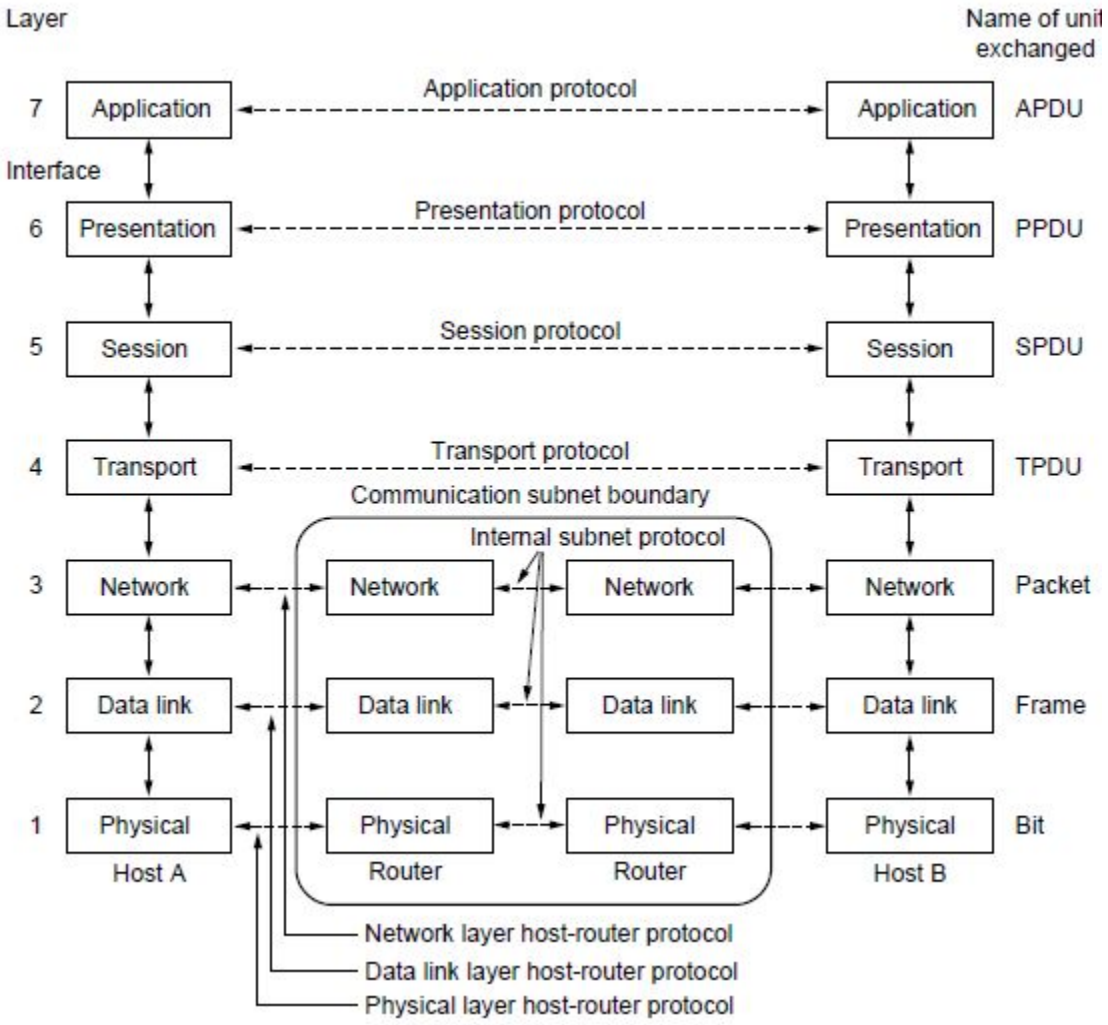
- OSI reference model
- TCP/IP reference model
- Model used for this text
- Comparison of OSI and TCP/IP
- Critique of OSI model and protocols
- Critique of TCP/IP model

# 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

# The OSI Reference Model




The OSI reference model

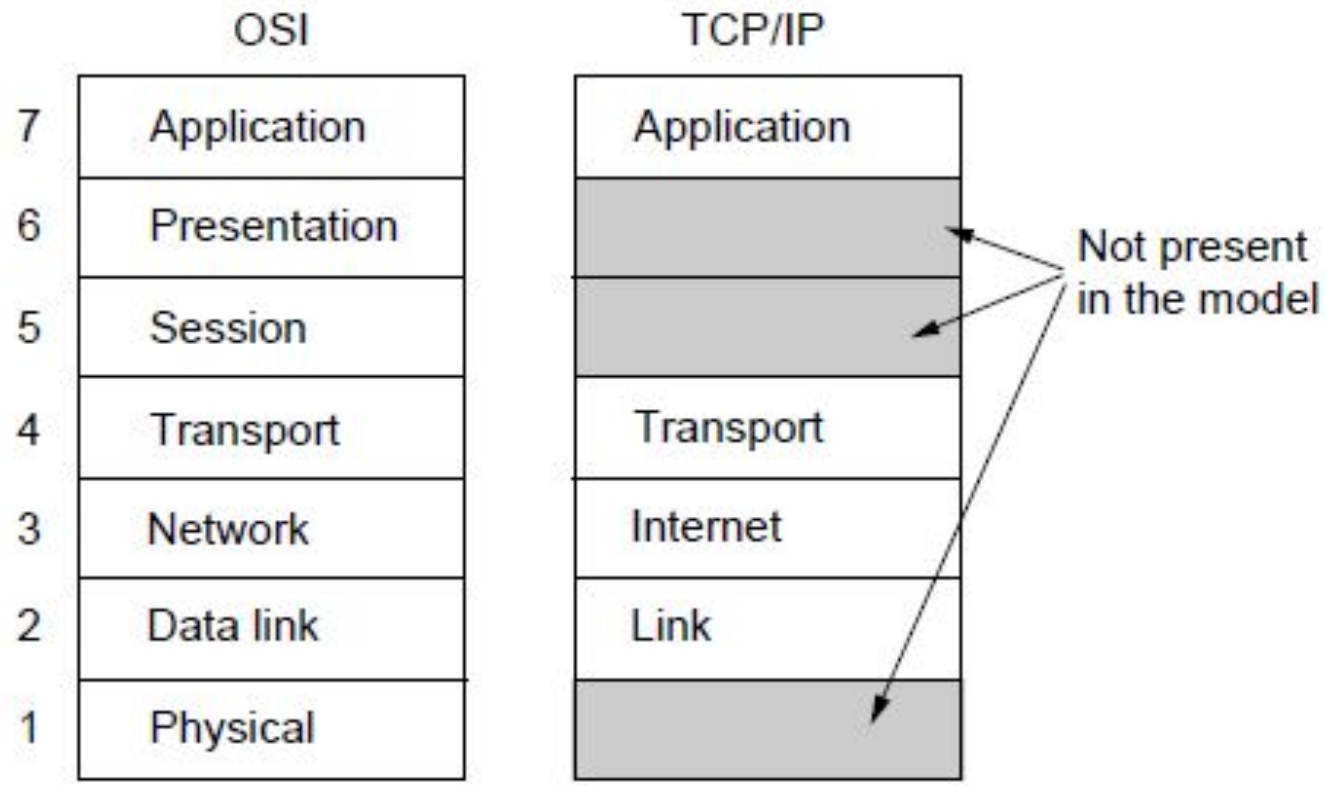
# OSI Reference Model Layers

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

# The TCP/IP Reference Model Layers

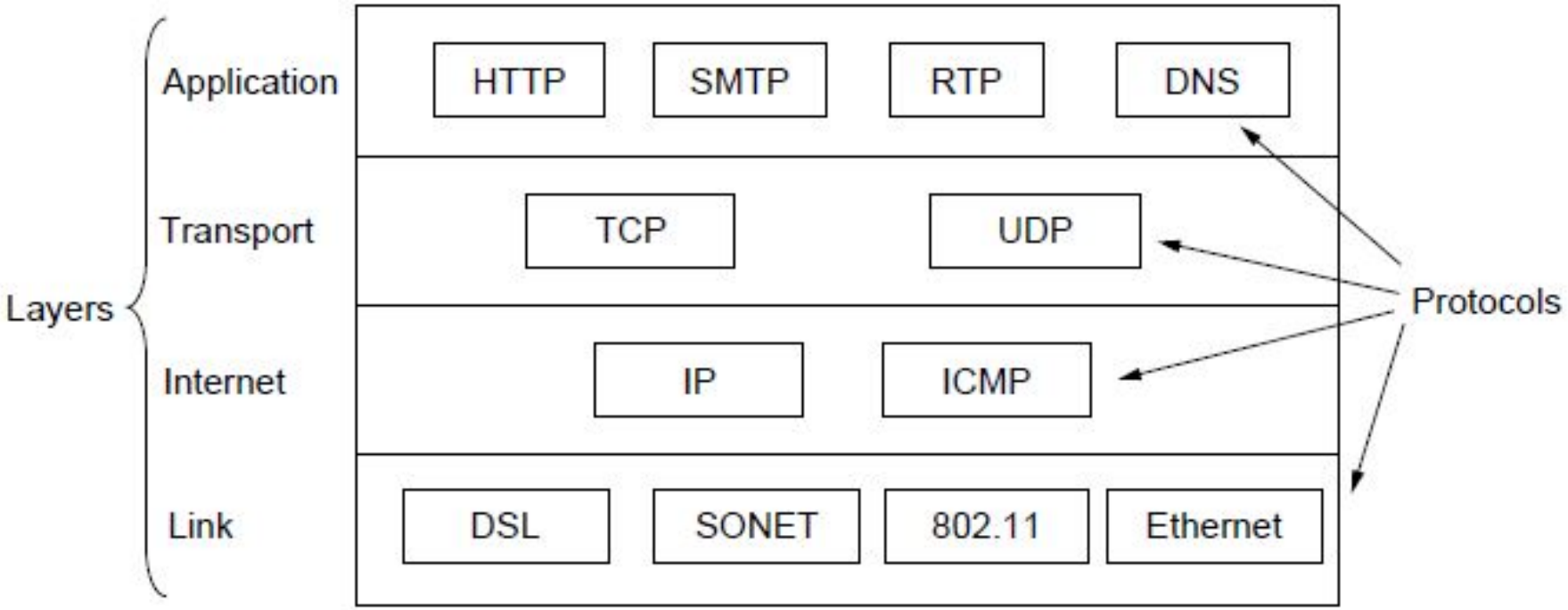
- Link layer
- Internet layer
- Transport layer
- Application layer

# The TCP/IP Reference Model (1)



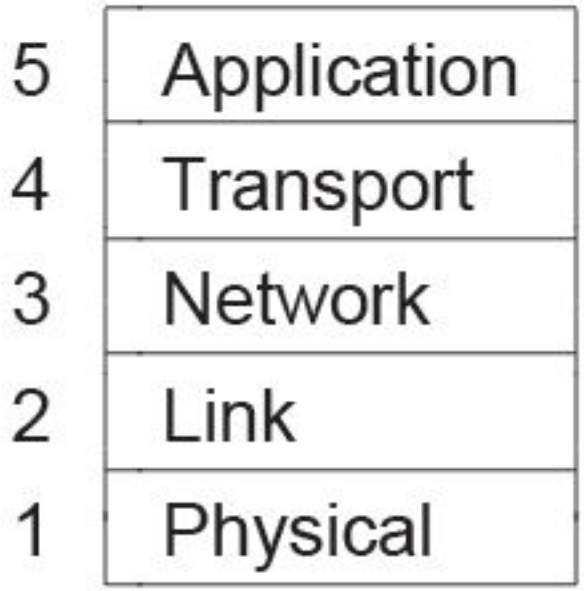

The TCP/IP reference model

# The TCP/IP Reference Model (2)




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

# The Model Used in this Book




The reference model used in this book.

# Comparison of the OSI and TCP/IP Reference Models

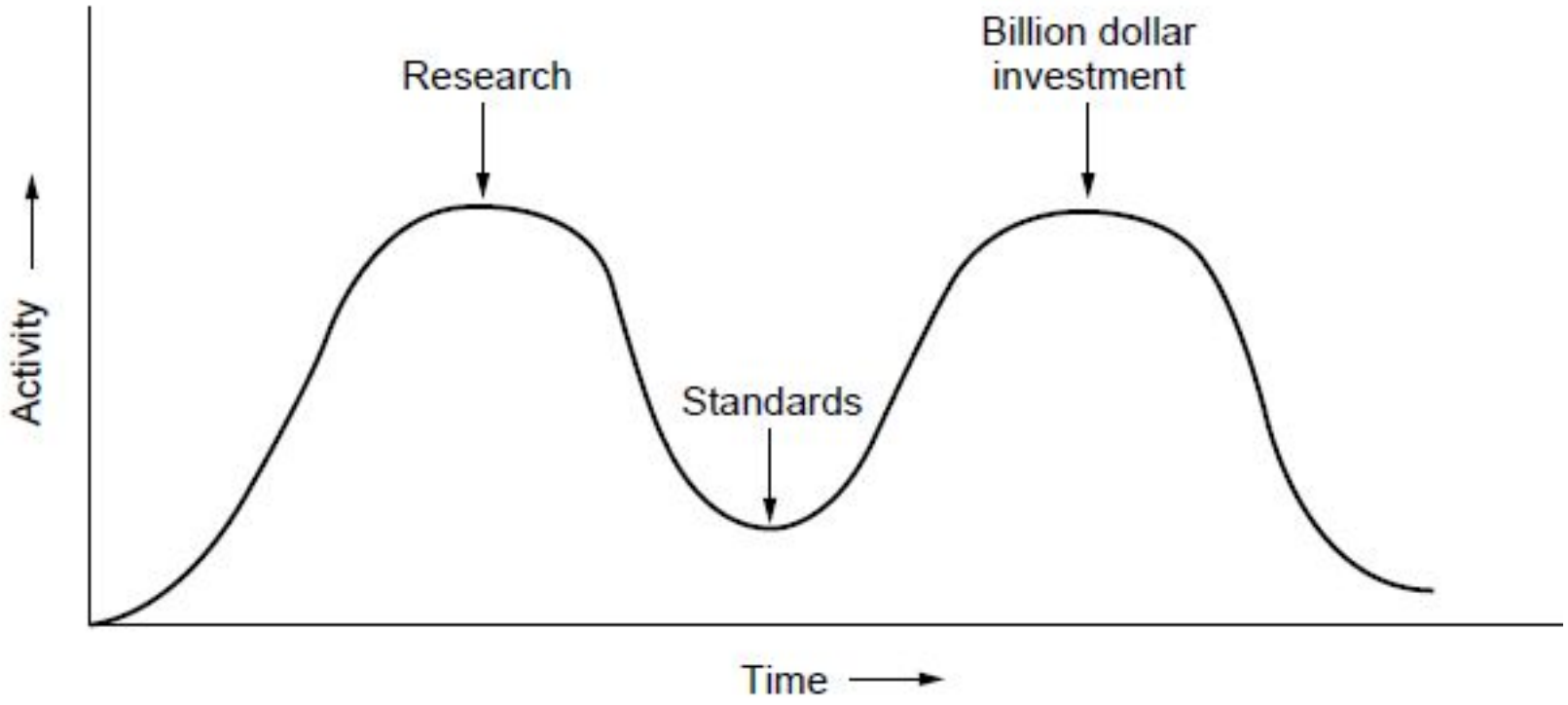
Concepts central to OSI model

- Services
- Interfaces
- Protocols

# Critique of the OSI Model and Protocols

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

# OSI Model Bad Timing

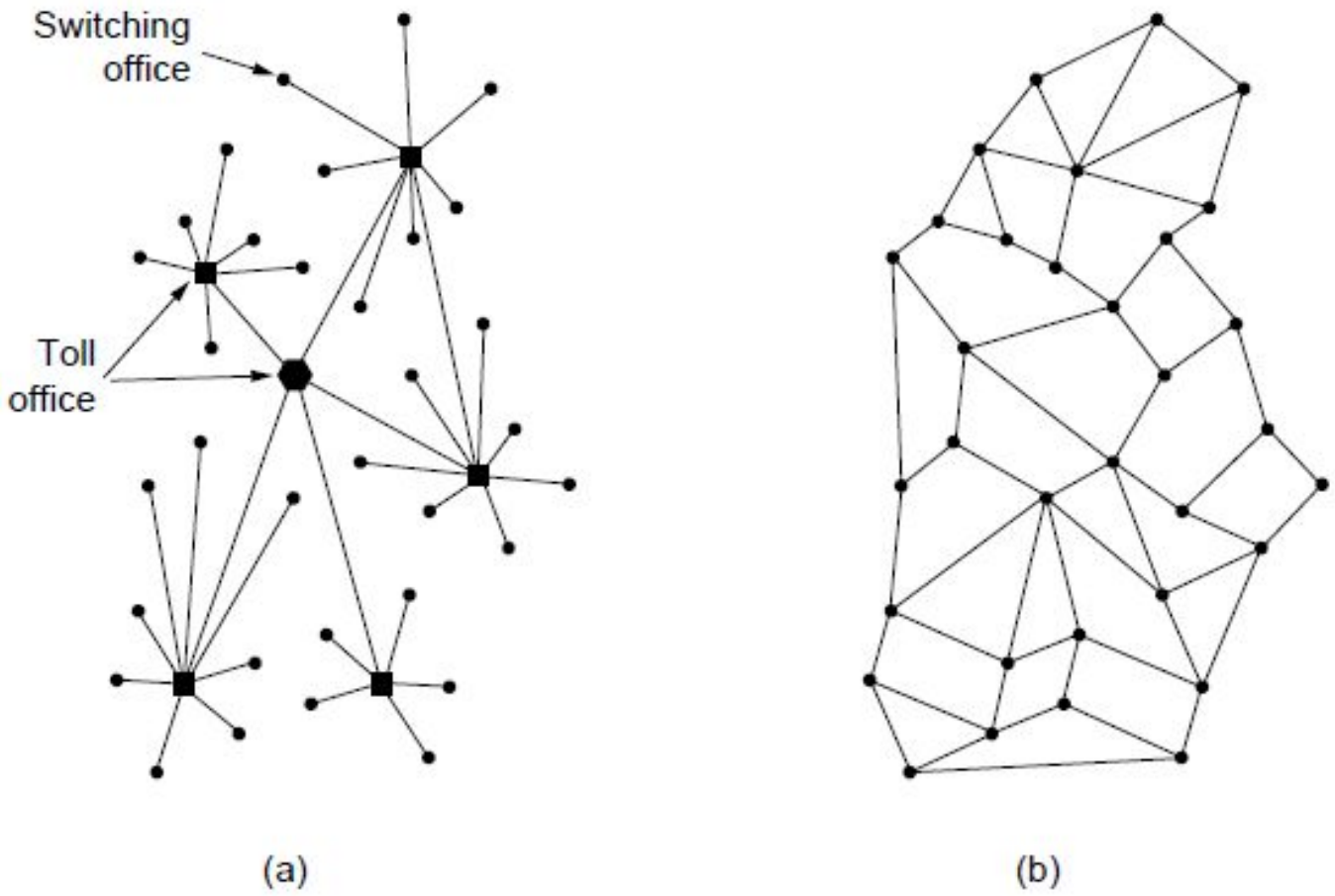



The apocalypse of the two elephants.

# Example Networks

- Internet
- ARPANET
- NSFNET
- Third-generation mobile phone networks
- Wireless LANs: 802.11
- RFID and sensor networks

# The ARPANET (1)



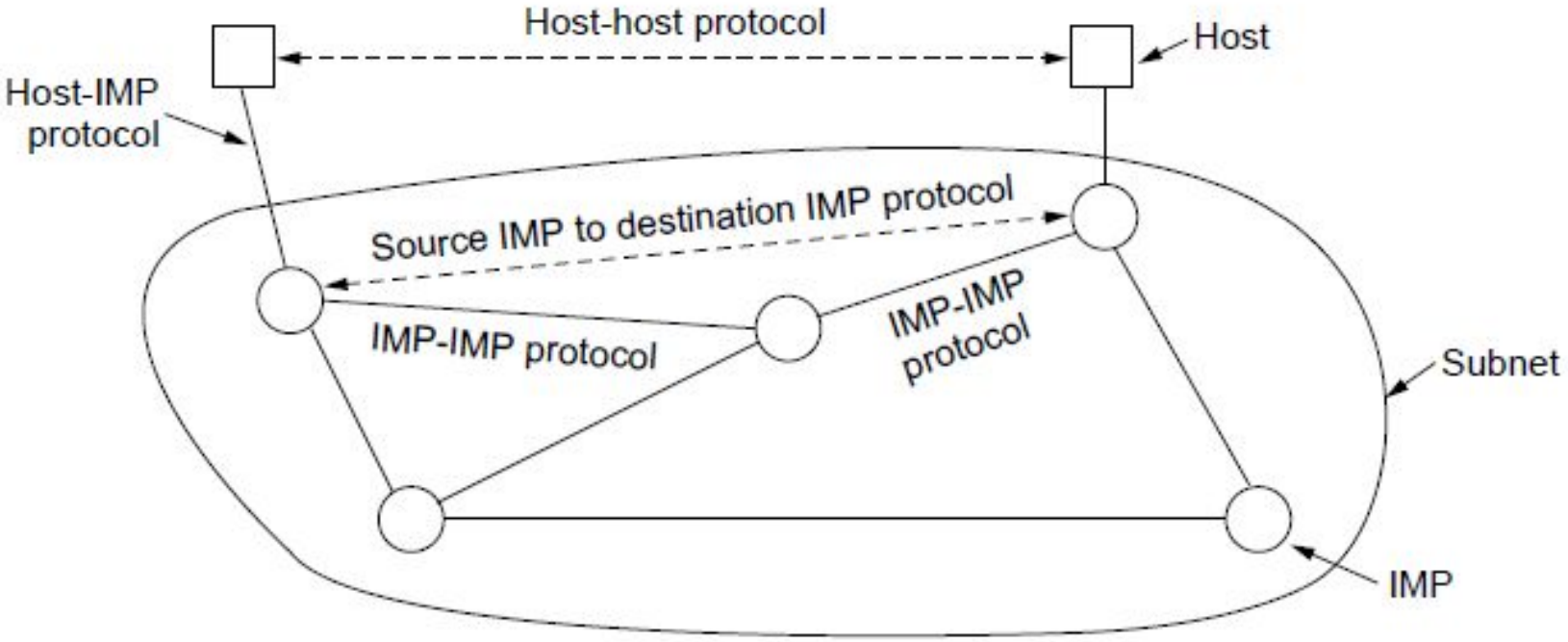

a) Structure of the telephone system.

b) Baran's proposed distributed switching system.

The **Advanced Research Projects Agency Network** (**ARPANET**)

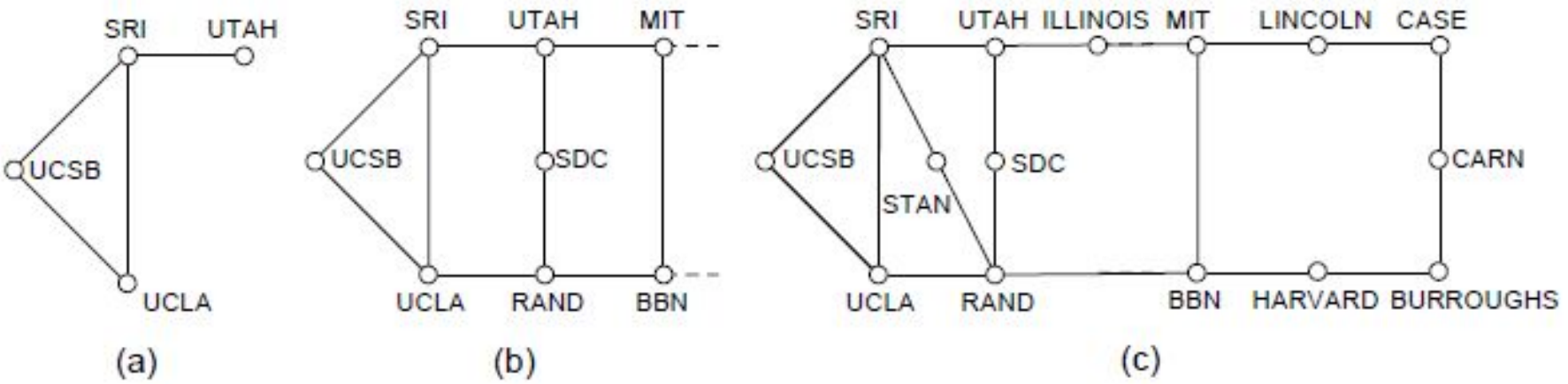
was an early packet-switching network and the first network to implement the TCP/IP protocol suite. Both technologies became the technical foundation of the Internet.

# The ARPANET (2)




The original ARPANET design

# The ARPANET (3)



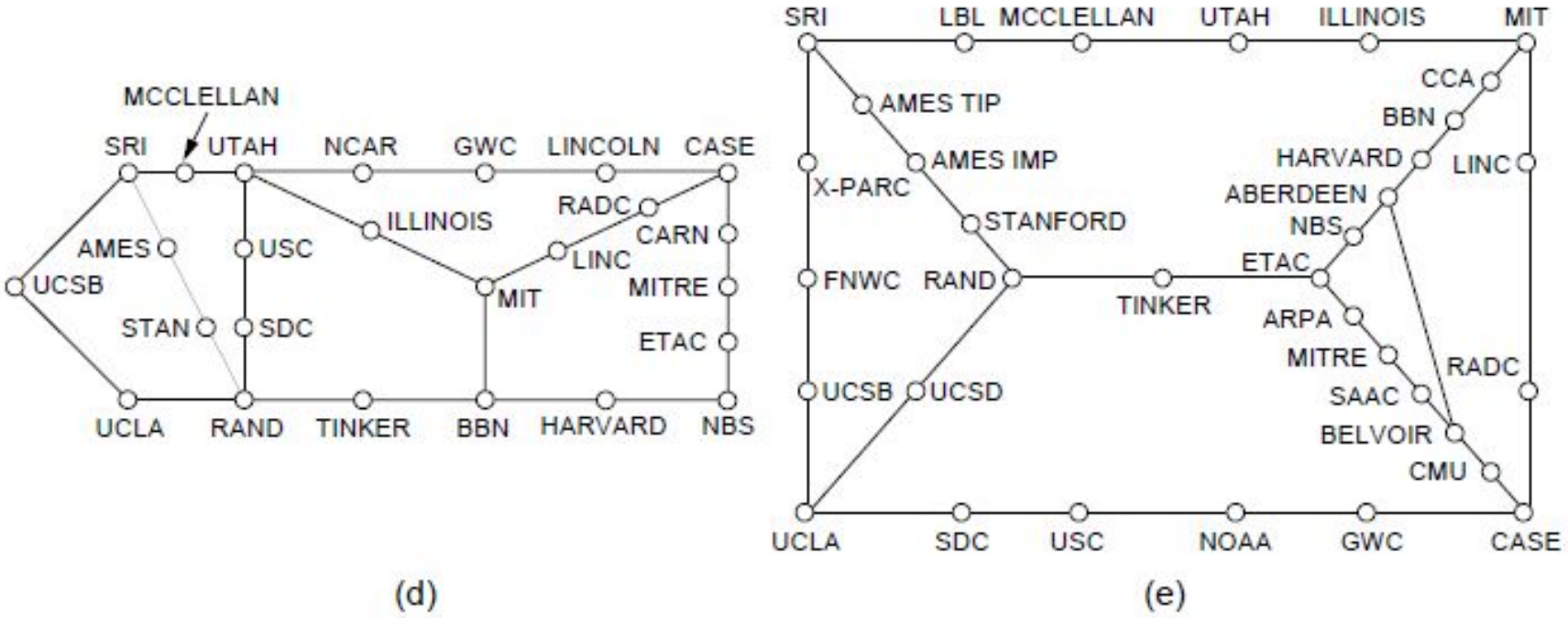

Growth of the ARPANET.

a) December 1969.

b) July 1970.

c) March 1971.

# The ARPANET (4)

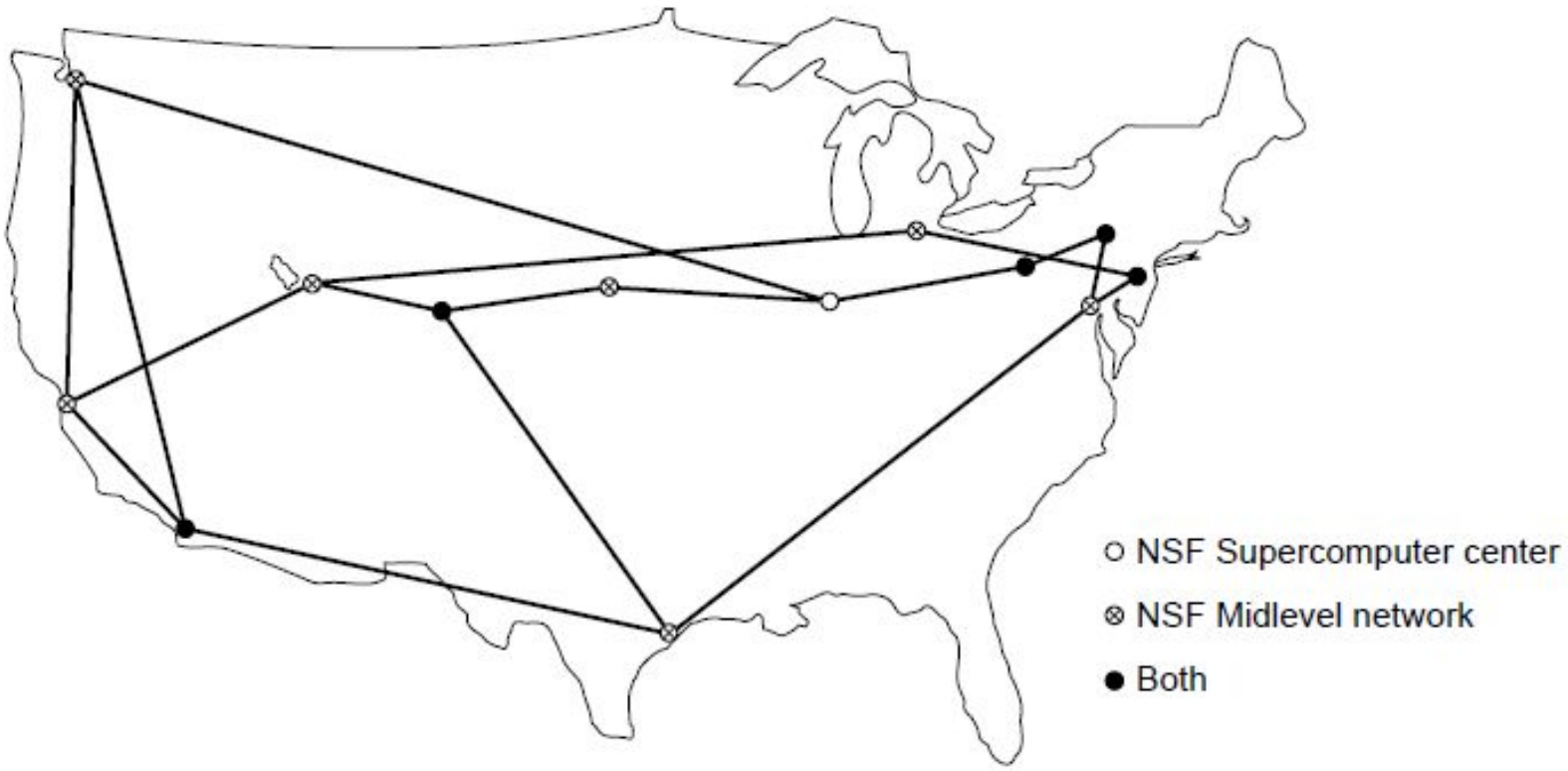



Growth of the ARPANET.

d) April 1972.

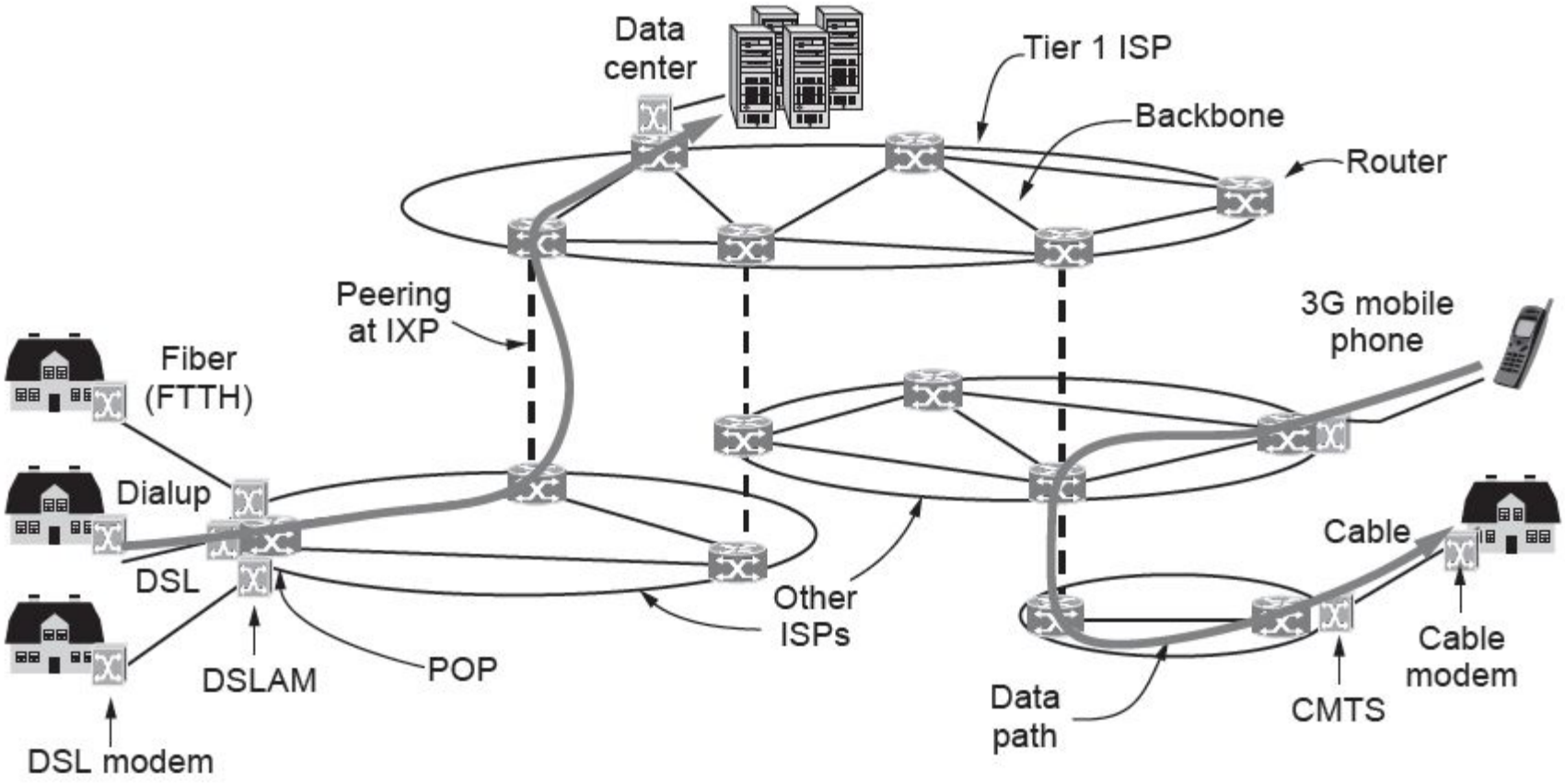
e) September 1972.

# NSFNET



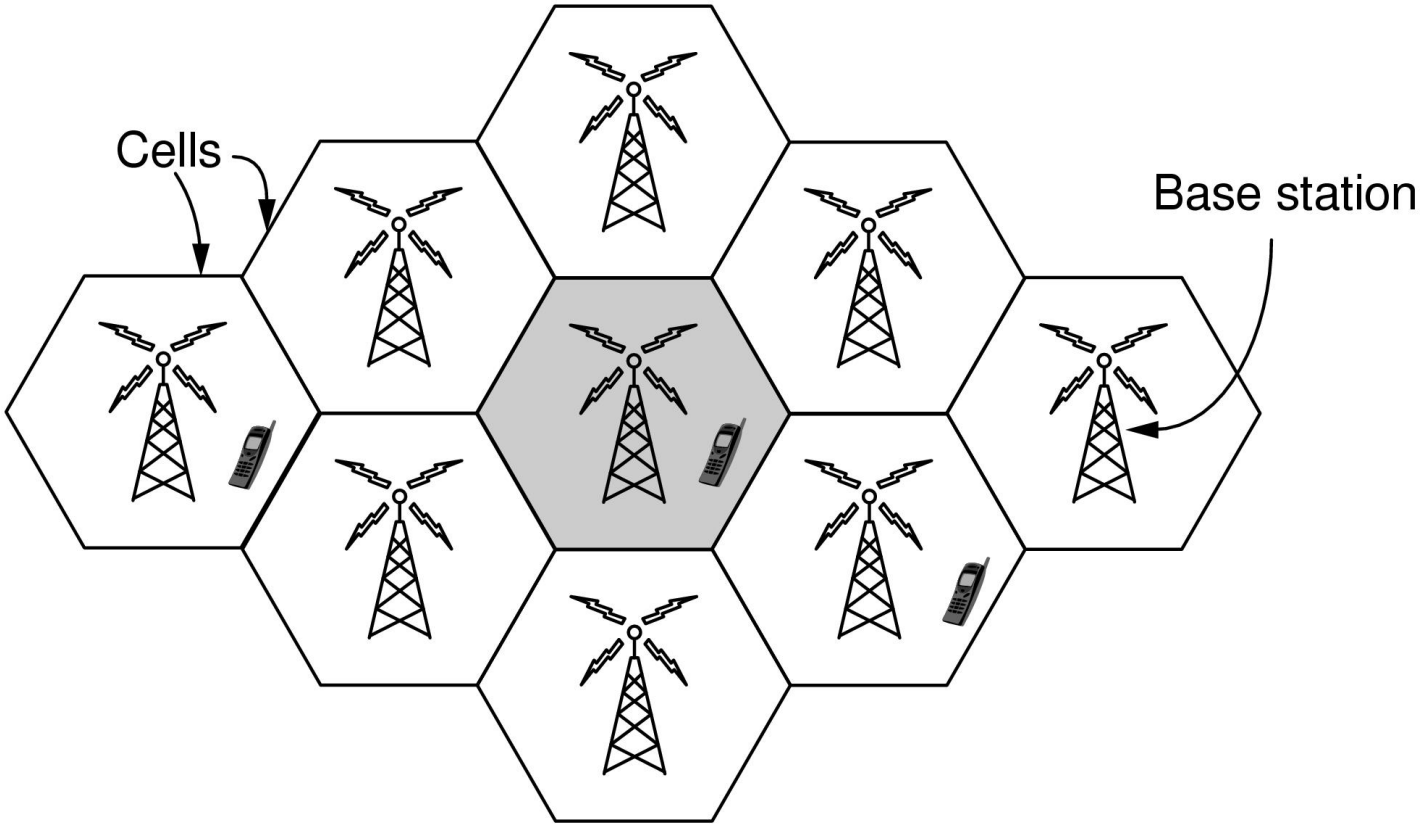

The NSFNET backbone in 1988.

# Architecture of the Internet



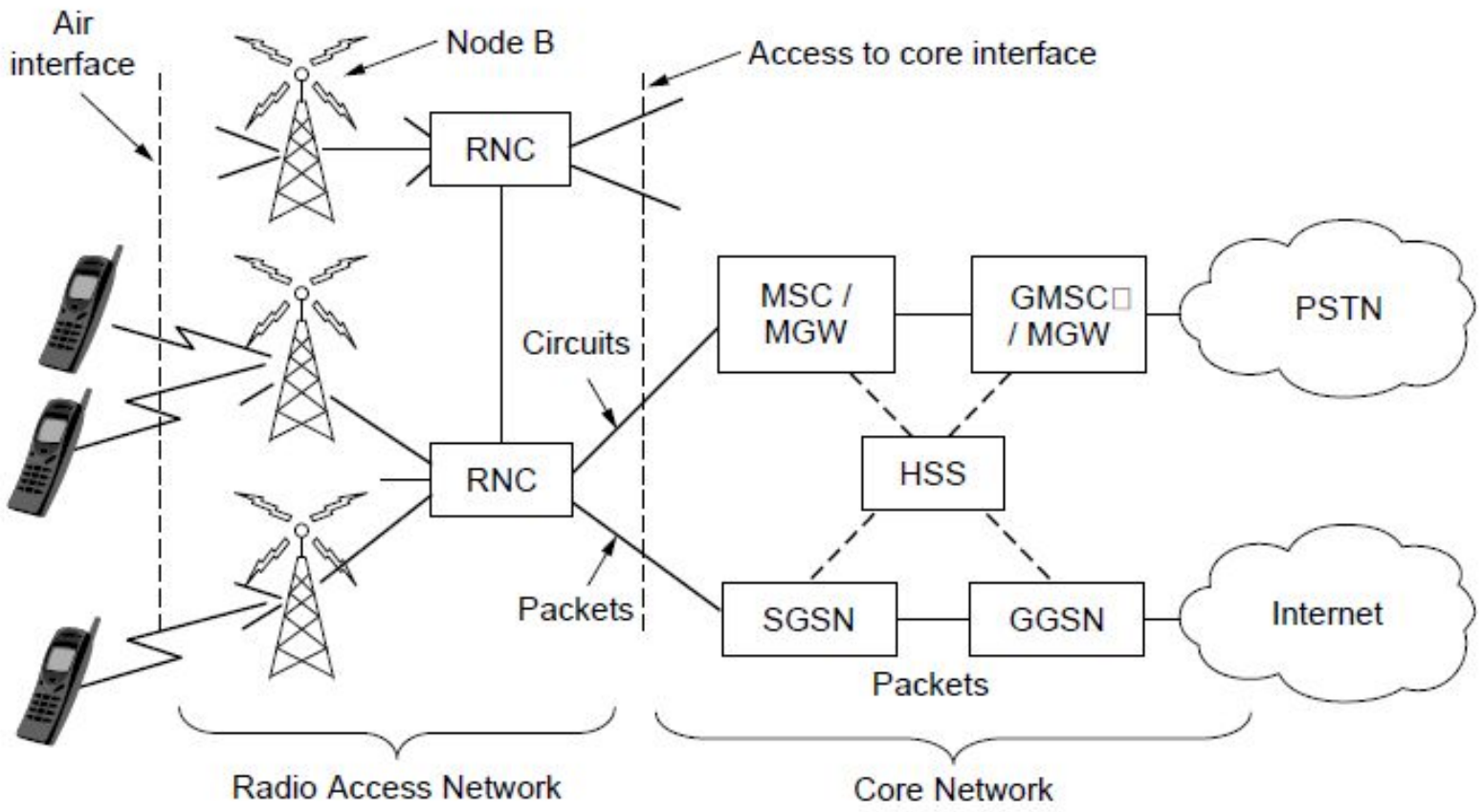

Overview of the Internet architecture

# Third-Generation Mobile Phone Networks (1)



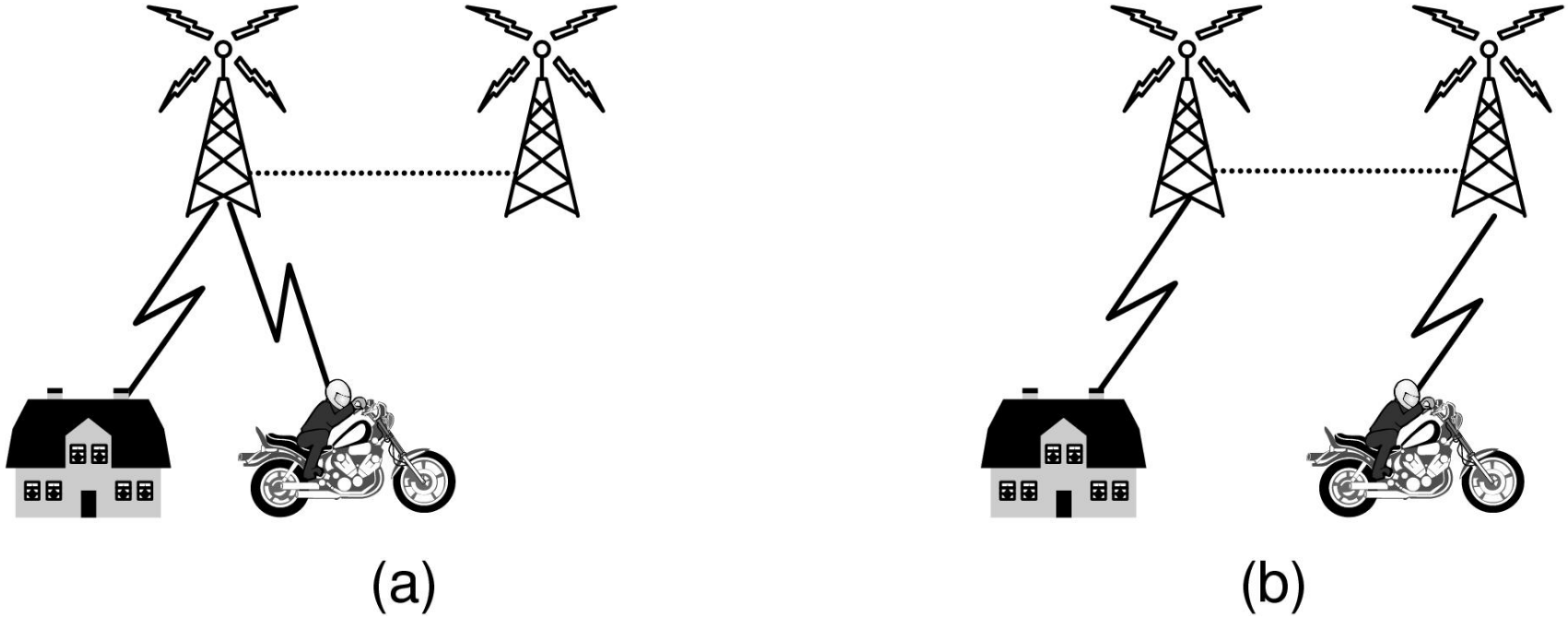

Cellular design of mobile phone networks

# Third-Generation Mobile Phone Networks (2)



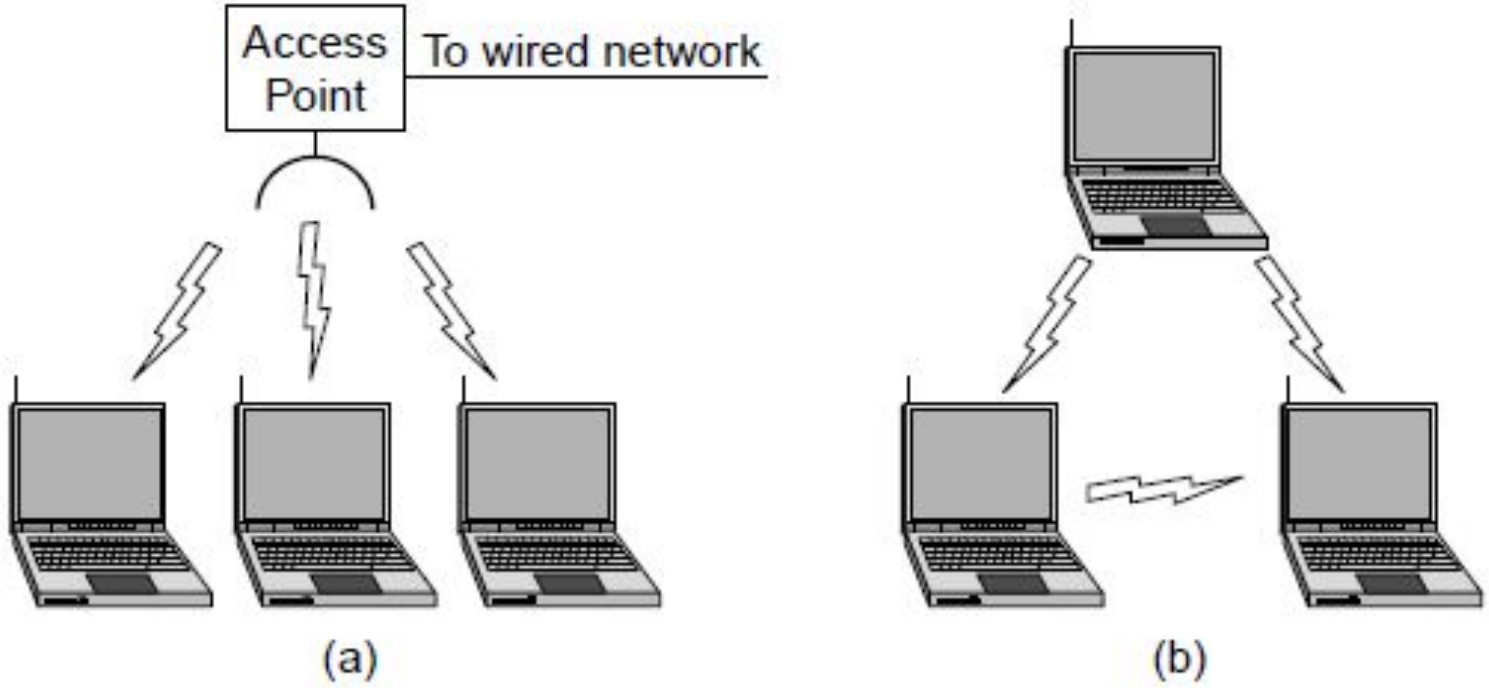

Architecture of the UMTS 3G mobile phone network.

# Third-Generation Mobile Phone Networks (3)




Mobile phone handover (a) before, (b) after.

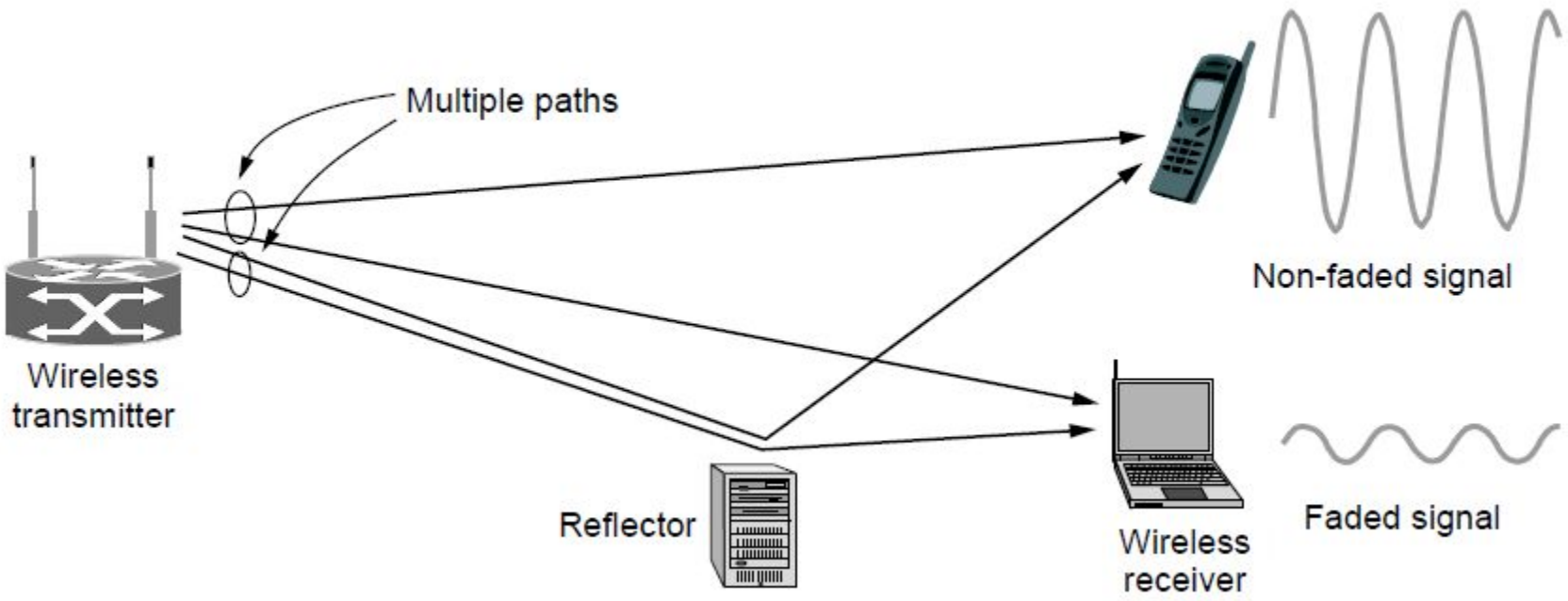
# Wireless LANs: 802.11 (1)




(a) Wireless network with an access point.

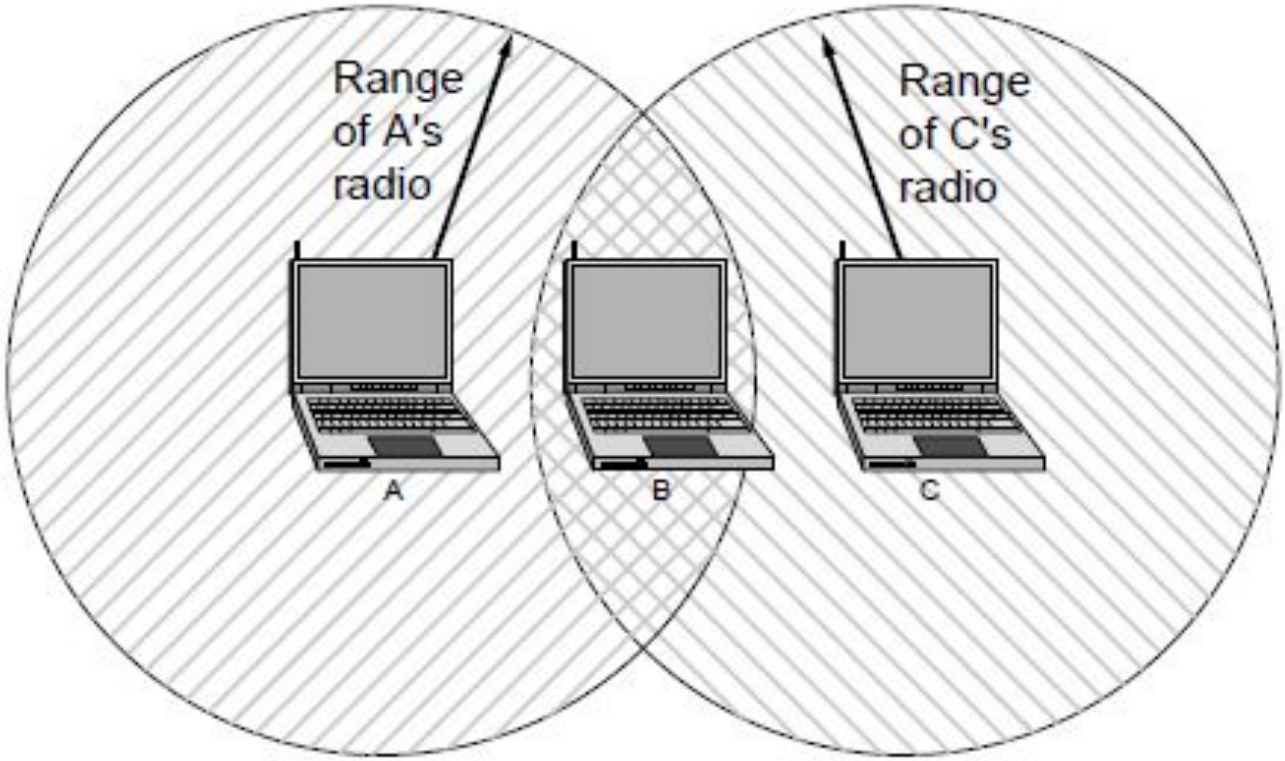
(b) Ad hoc network.

# Wireless LANs: 802.11 (2)



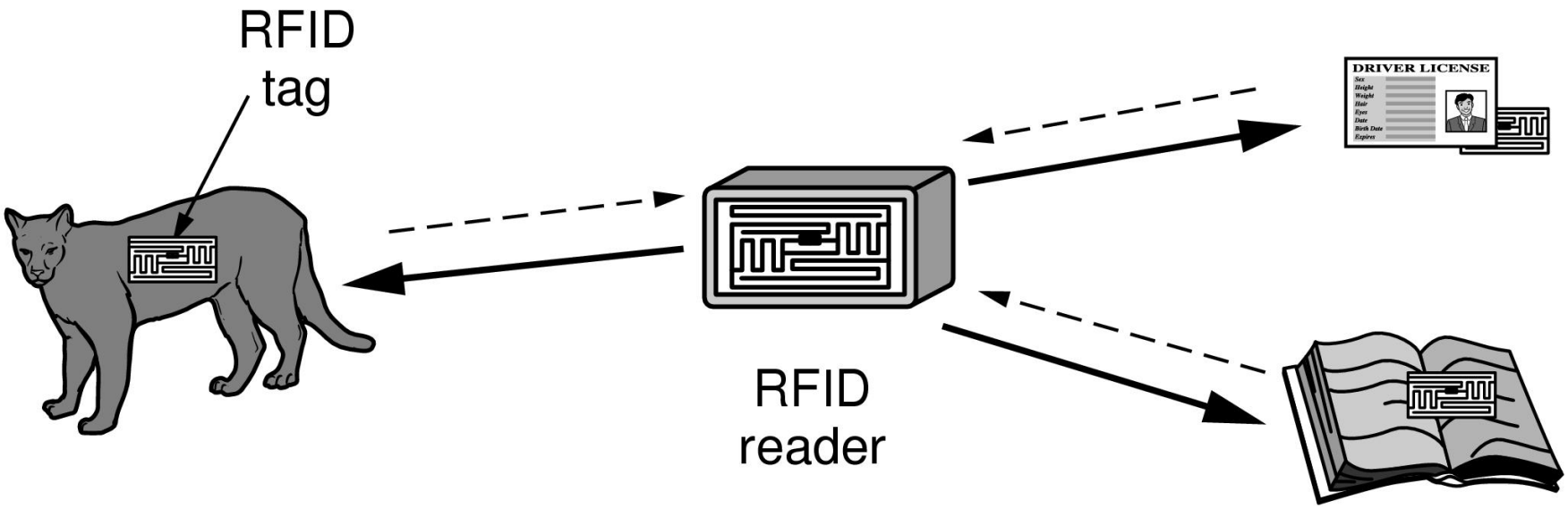

Multipath fading

# Wireless LANs: 802.11 (3)



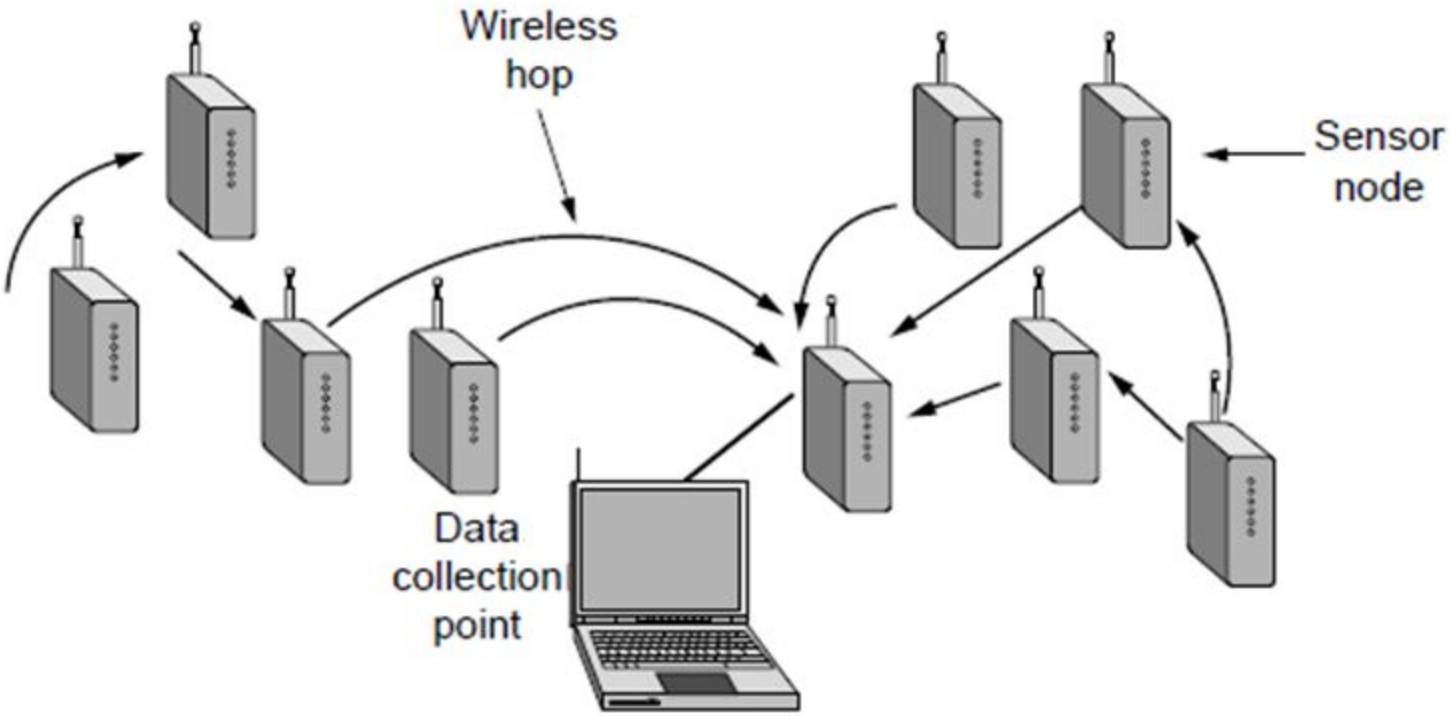

The range of a single radio may not cover the entire system.

# RFID and Sensor Networks (1)




RFID used to network everyday objects.

# RFID and Sensor Networks (2)




Multihop topology of a sensor network

# Network Standardization

- Who's Who in telecommunications
- Who's Who in international standards
- Who's Who in internet standards

# Who's Who in International Standards (1)

| 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 (WiFi) |
| 802.12 ↓ | Demand priority (Hewlett-Packard's AnyLAN) |

The 802 working groups. The important ones are marked with *.

The ones marked with ↓ are hibernating. The one marked with † gave up and disbanded itself.

# Who's Who in International Standards (2)

| | |
|---|---|
| 802.13 | Unlucky number; nobody wanted it |
| 802.14 ↓ | Cable modems (defunct: an industry consortium got there first) |
| 802.15 * | Personal area networks (Bluetooth, Zigbee) |
| 802.16 * | Broadband wireless (WiMAX) |
| 802.17 | Resilient packet ring |
| 802.18 | Technical advisory group on radio regulatory issues |
| 802.19 | Technical advisory group on coexistence of all these standards |
| 802.20 | Mobile broadband wireless (similar to 802.16e) |
| 802.21 | Media independent handoff (for roaming over technologies) |
| 802.22 | Wireless regional area network |

The 802 working groups. The important ones are marked with *.

The ones marked with ↓ are hibernating. The one marked with † gave up and disbanded itself.

# Metric Units (1)

| Exp. | Explicit | Prefix |
|---|---|---|
| $10^{-3}$ | 0.001 | milli |
| $10^{-6}$ | 0.000001 | micro |
| $10^{-9}$ | 0.000000001 | nano |
| $10^{-12}$ | 0.000000000001 | pico |
| $10^{-15}$ | 0.000000000000001 | femto |
| $10^{-18}$ | 0.000000000000000001 | atto |
| $10^{-21}$ | 0.000000000000000000001 | zepto |
| $10^{-24}$ | 0.000000000000000000000001 | yocto |

The principal metric prefixes

# Metric Units (2)

| Exp. | Explicit | Prefix |
|---|---|---|
| $10^3$ | 1,000 | Kilo |
| $10^6$ | 1,000,000 | Mega |
| $10^9$ | 1,000,000,000 | Giga |
| $10^{12}$ | 1,000,000,000,000 | Tera |
| $10^{15}$ | 1,000,000,000,000,000 | Peta |
| $10^{18}$ | 1,000,000,000,000,000,000 | Exa |
| $10^{21}$ | 1,000,000,000,000,000,000,000 | Zetta |
| $10^{24}$ | 1,000,000,000,000,000,000,000,000 | Yotta |

The principal metric prefixes

# End

Chapter 1