Computer Networks (5th Edition)

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Chapter 1

Introduction

1.1 Uses of Computer Networks

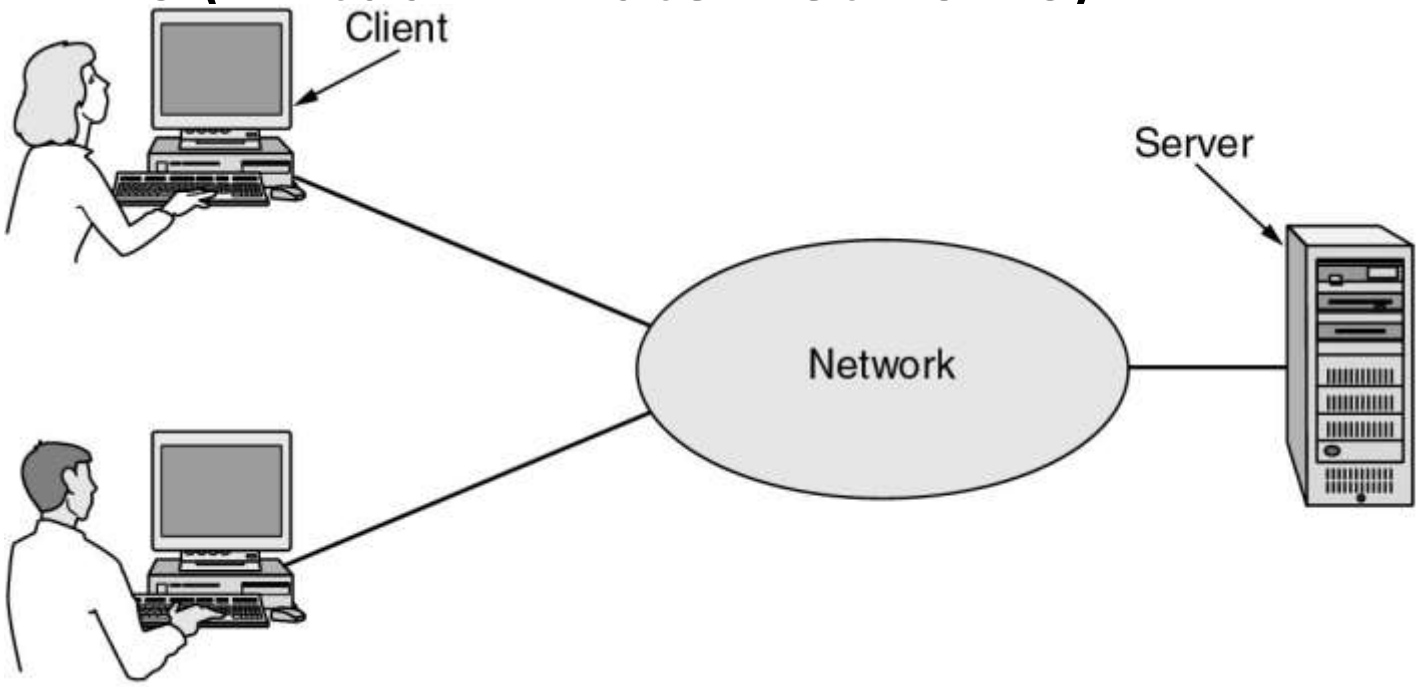
- Business Applications
- Home Applications
- Mobile Users
- Social Issues

1.1.1 Business Applications of Networks

- 资源共享(Resource Sharing)
- 高可靠性(High Reliability)
- 节约经费(Saving Investment)

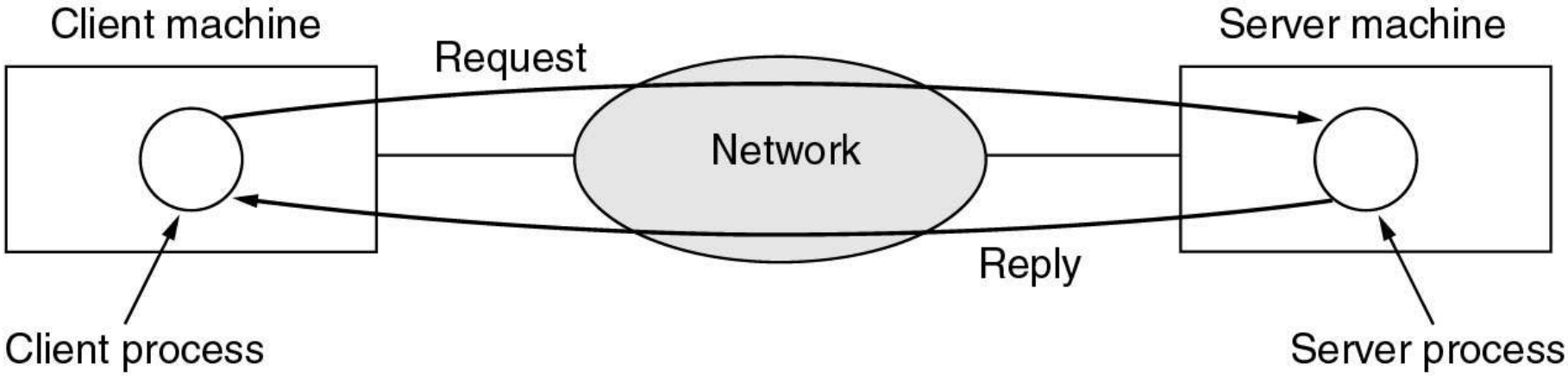
Business Applications of Networks (2)

- A network with two clients and one server.
- VPNs (Virtual Private Networks)



Business Applications of Networks (3)

- The client-server model involves requests and replies.



Business Applications of Networks (4)

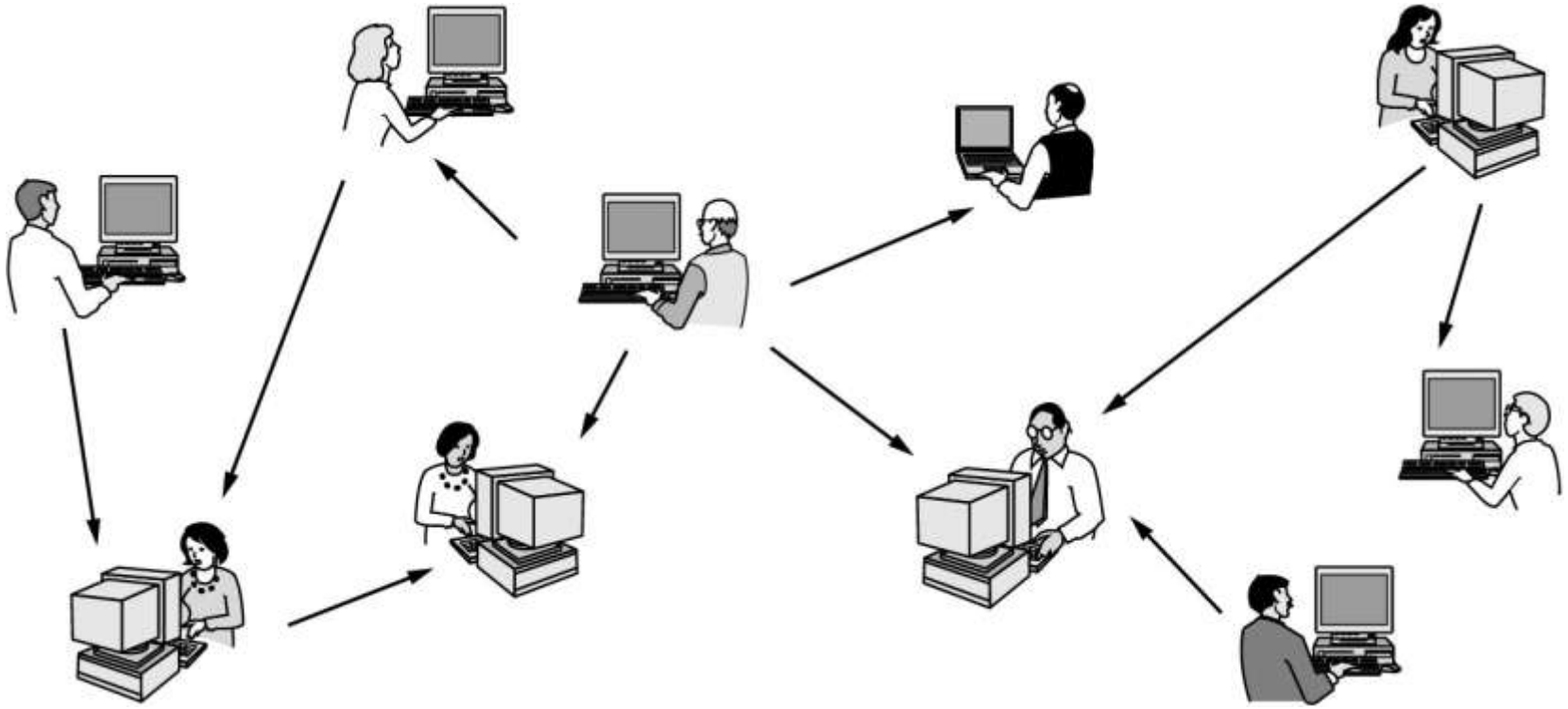
- Email
- Ftp
- Web
- VoIP(Voice over IP, IP telephony)
- Videoconference
- E-commence

1.1.2 Home Network Applications

- Access to remote information
- Person-to-person communication
- Interactive entertainment
- Electronic commerce

Home Network Applications (2)

- In peer-to-peer system there are no fixed clients and servers.
  - BitTorrent
  - Facebook、Wiki、Blog



Home Network Applications (3)

- 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 Network Applications (3)

- **Entertainment**
  - **IPTV**
- **Power-line networks**
- **RFID（Radio Frequency Identification）**

1.1.3 Mobile Network 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

1.1.4 Social Issues

- Politics
- Religion
- Security
- Sex
- Employer vs. employee
- Government vs. citizen

1.2 Network Hardware

- Personal Area Networks（PAN）
- Local Area Networks (LAN)
- Metropolitan Area Networks (MAN)
- Wide Area Networks (WAN)
- Wireless Networks (WLAN / WWAN)
- Home Networks
- Internetworks

Broadcast Networks

- 2 types of transmission technology
  - Broadcast links
  - Point-to-point links
    - Also called Unicasting

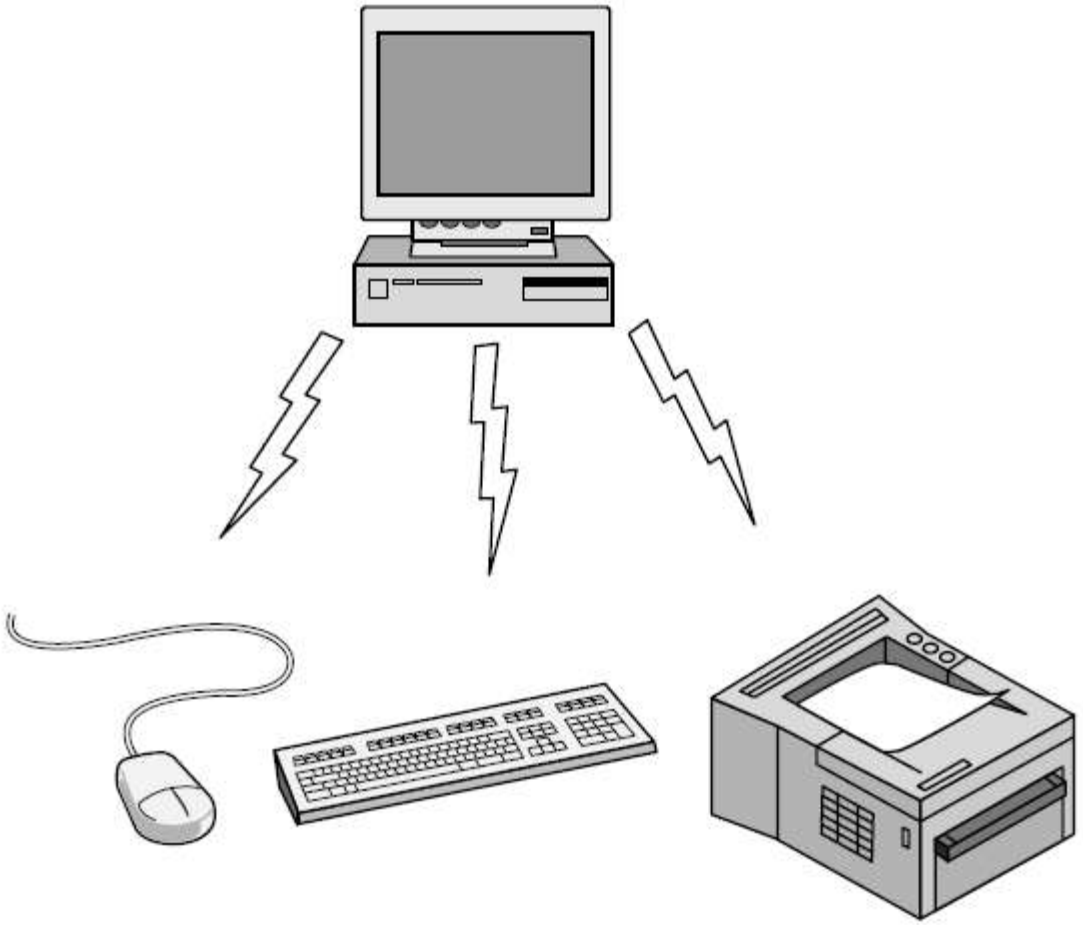
Broadcast Networks (2)

- Classification of interconnected processors

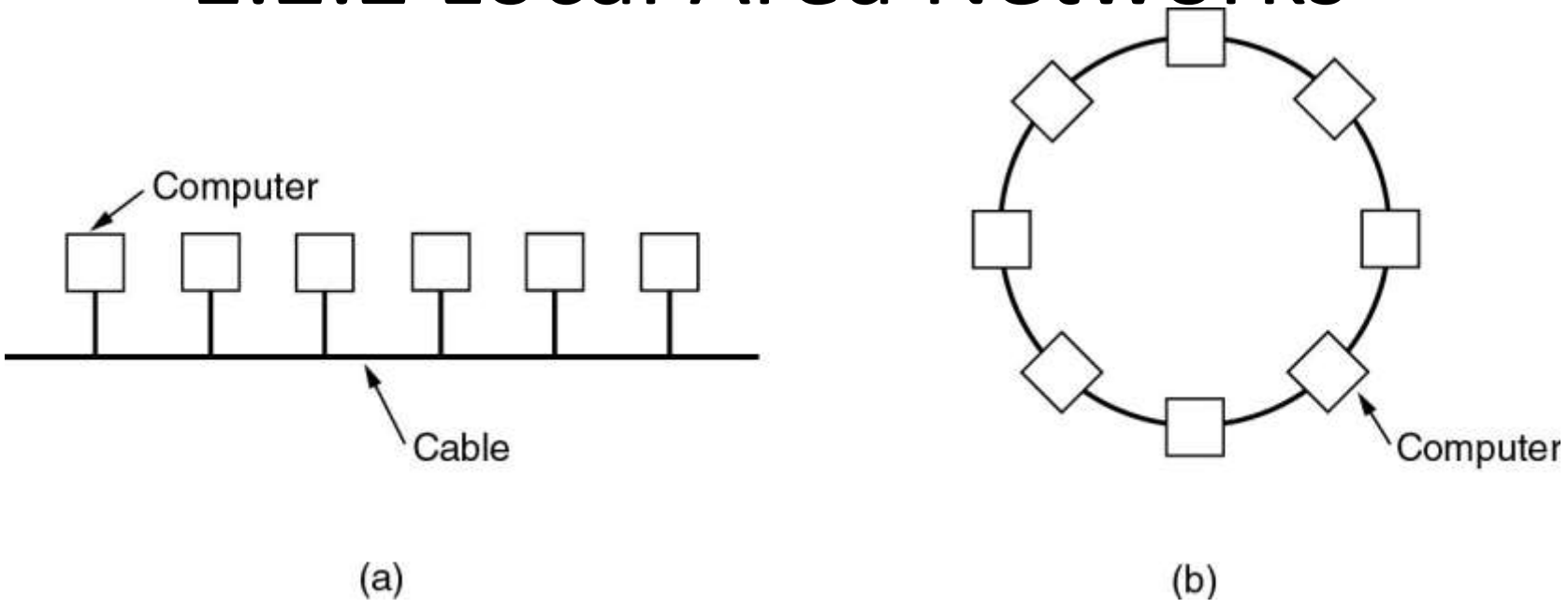
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

1.2.1 Personal Area Networks

- Bluetooth



1.2.2 Local Area Networks

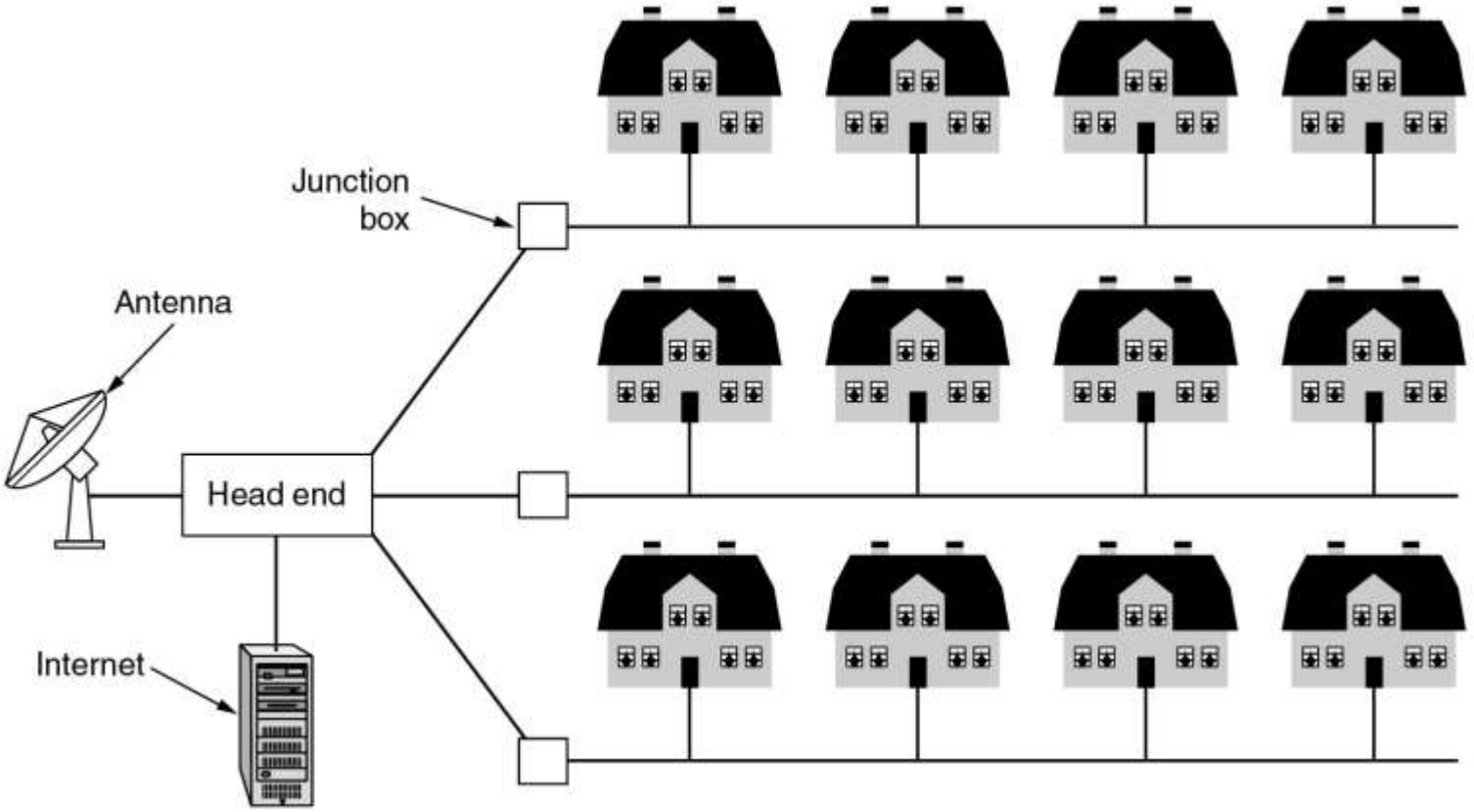


- IEEE 802.3 Ethernet
- 10Mbps – 10Gbps
- IEEE 802.5 (IBM, 4/16Mbps)

- Two broadcast networks
  - (a) Bus
  - (b) Ring

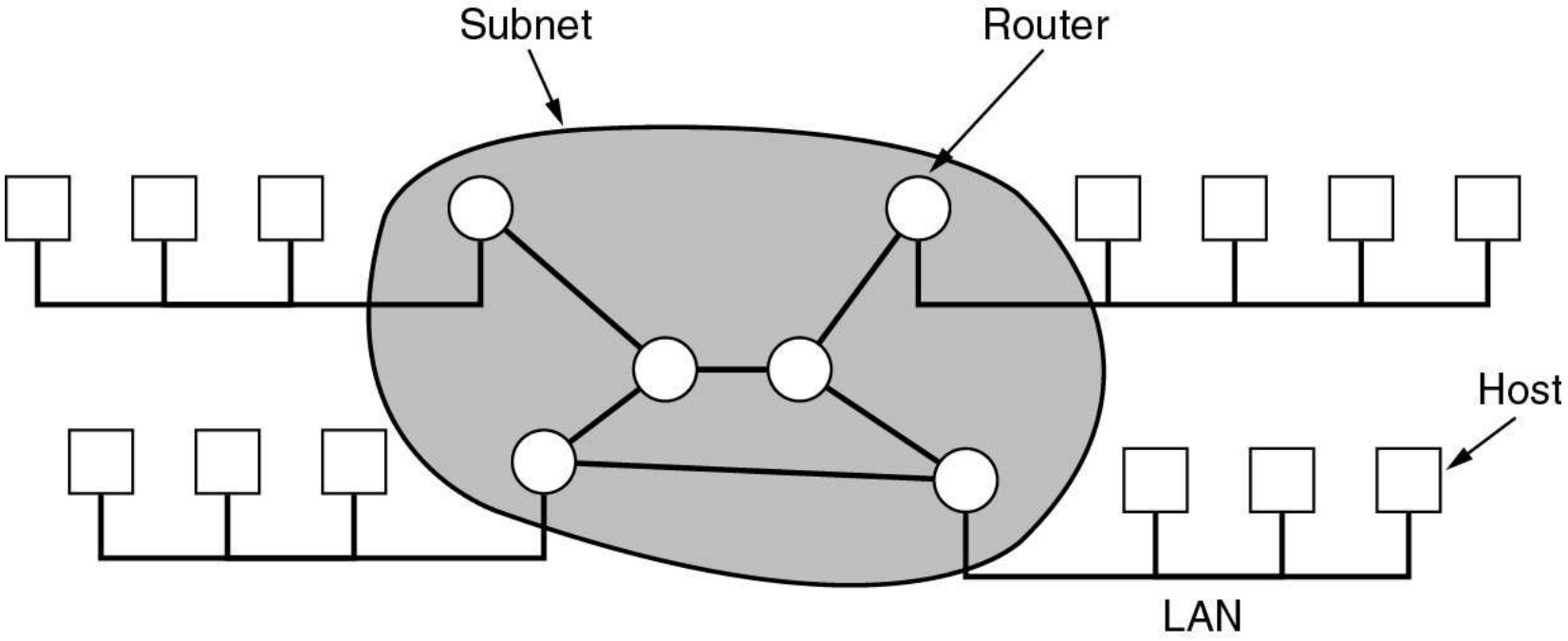
1.2.3 Metropolitan Area Networks

- A metropolitan area network based on cable TV.



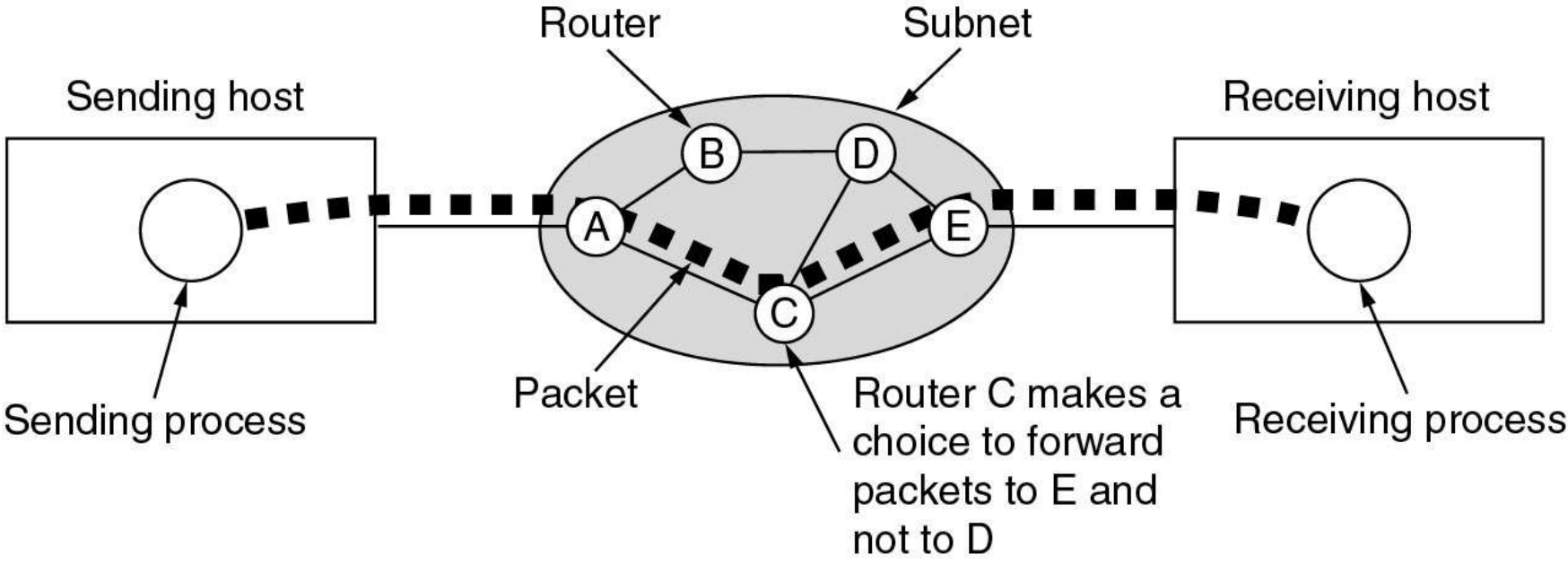
1.2.4 Wide Area Networks

- Relation between hosts on LANs and the



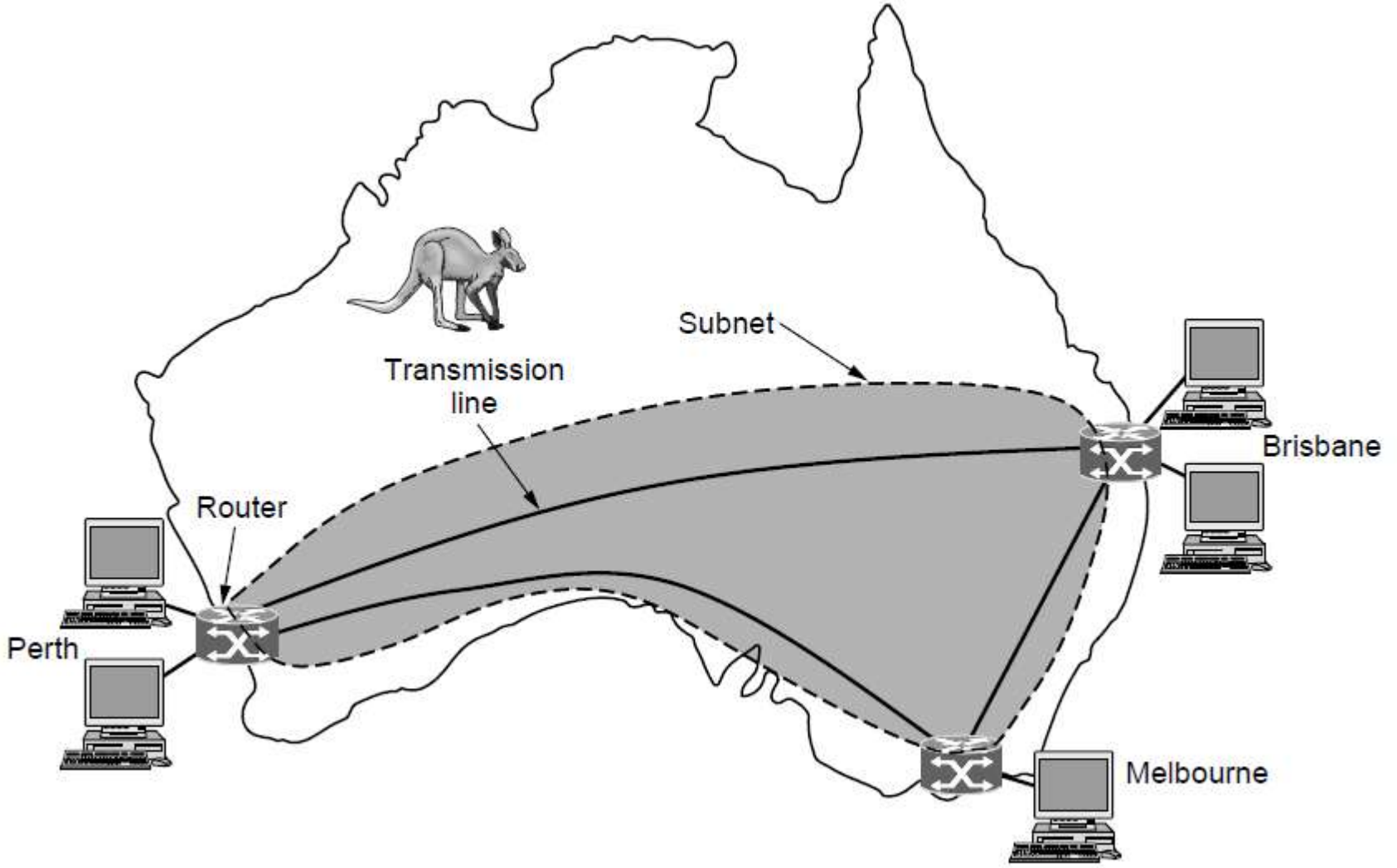
Wide Area Networks (2)

- A stream of packets from sender to



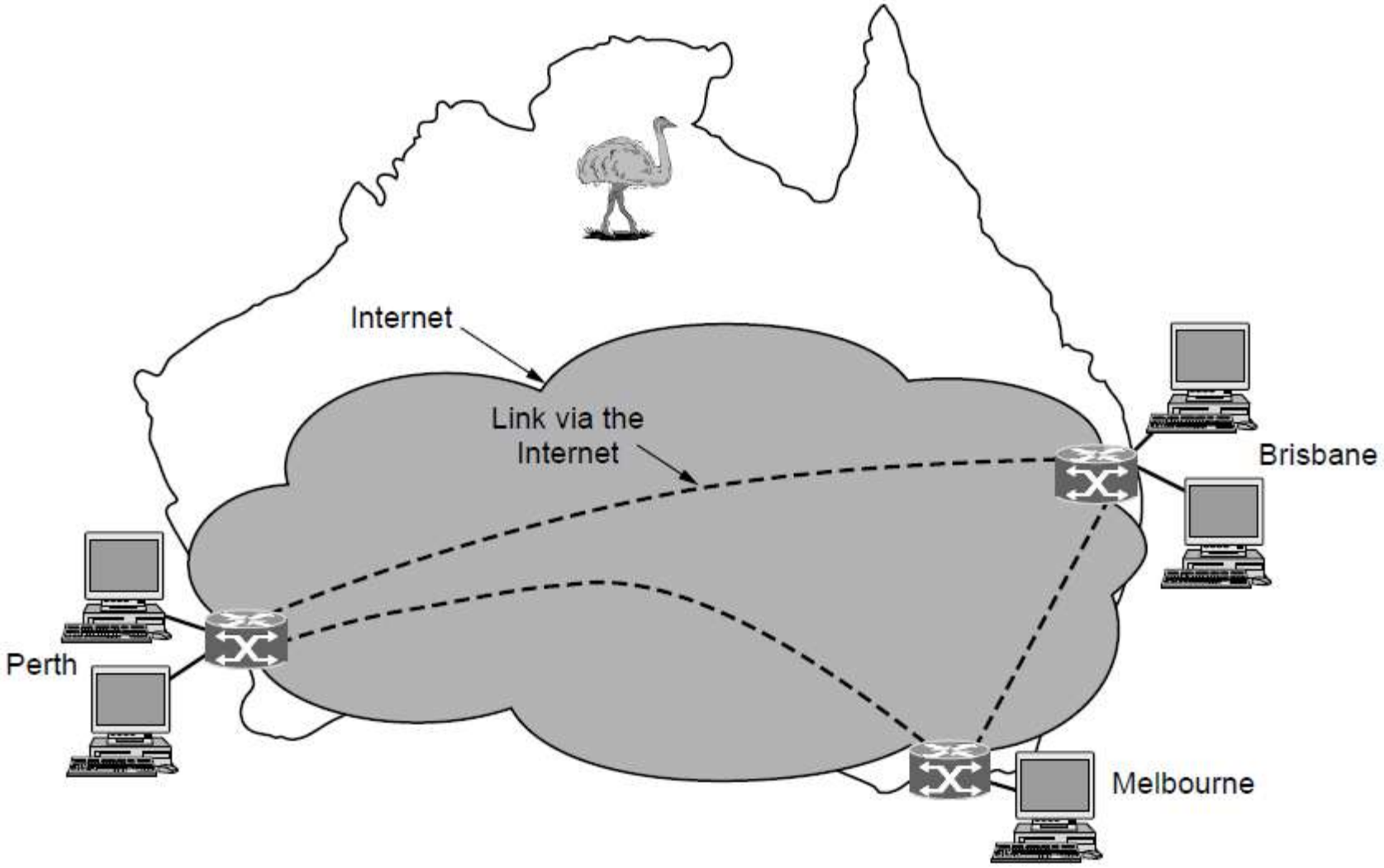
- **Router**
- **Store-and-forward**
- **Packet switching**

Wide Area Networks (3)



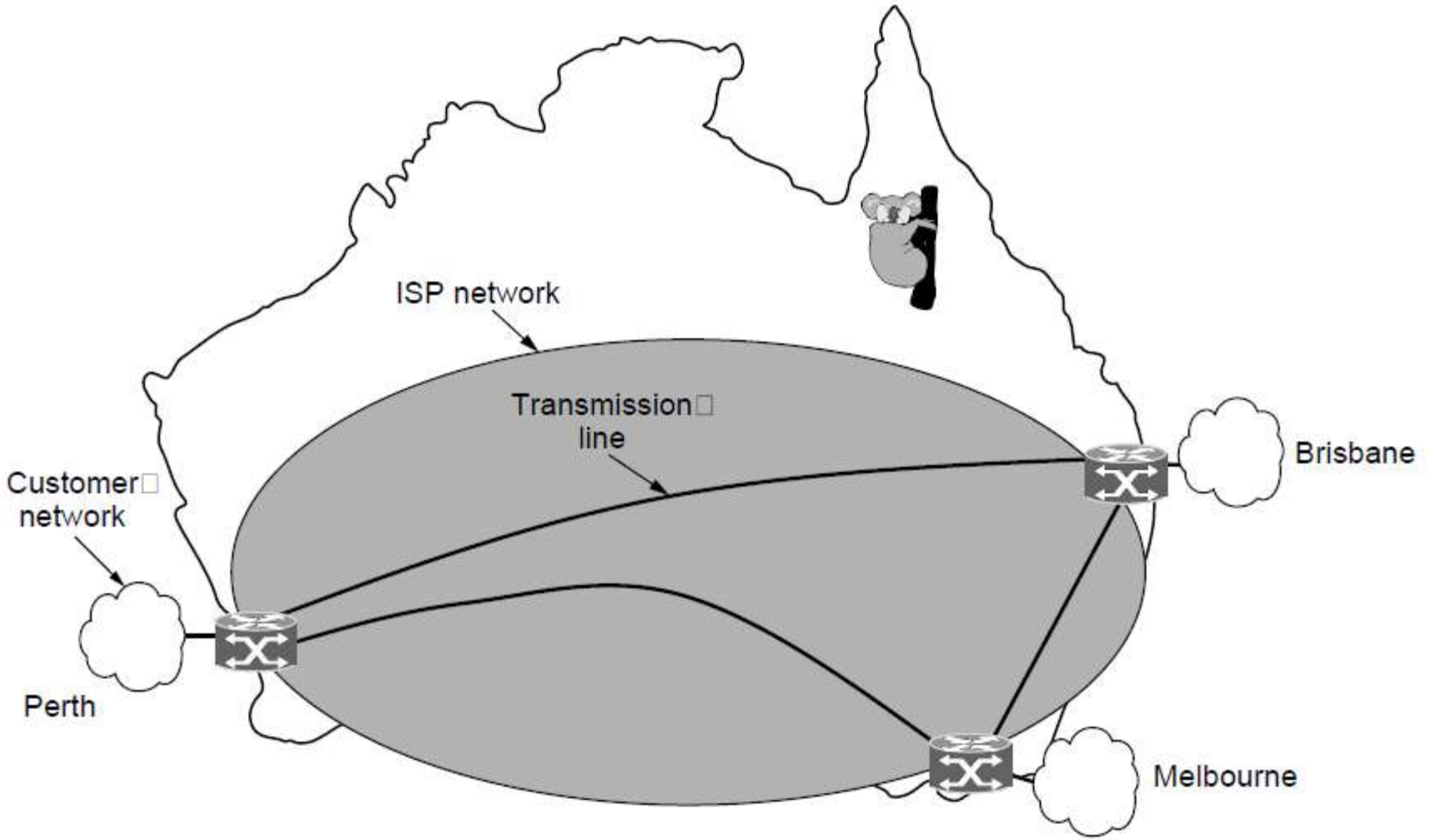
WAN that connects three branch offices in Australia

Wide Area Networks (4)



WAN using a virtual private network.

Wide Area Networks (5)



WAN using an ISP network.

1.2.5 Wireless Networks

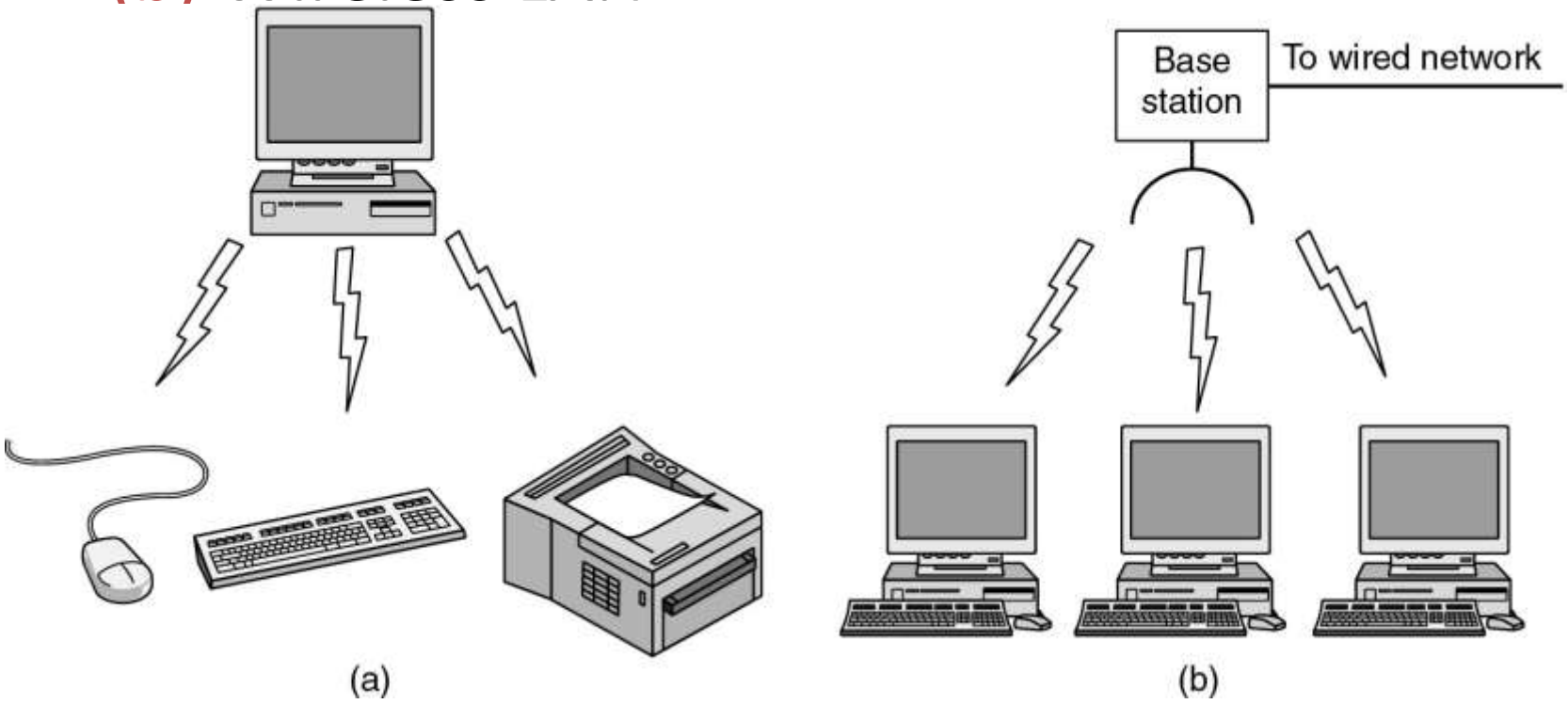
- 3 categories of wireless networks:
  - System interconnection
  - Wireless LANs （WiFi）
    - IEEE 802.11(.11a,.11b,.11g,.11i,.11n,…)
    - WAPI (无线局域网鉴别与保密基本结构)
  - Wireless WANs
    - IEEE 802.16 （WiMAX）

Wireless Networks (2)

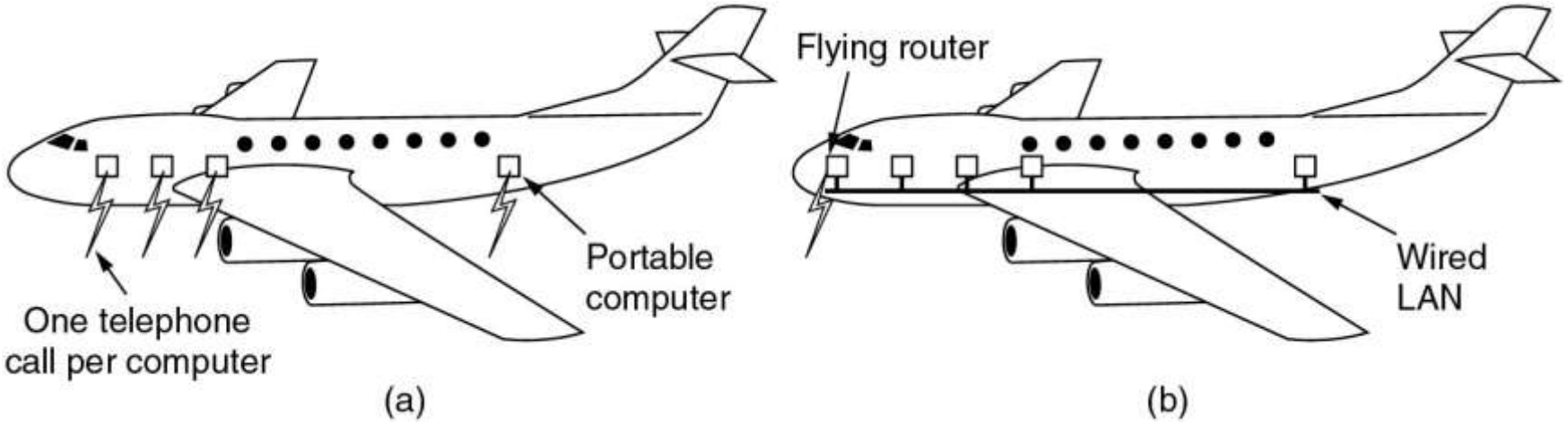
Wireless Networks (3)

(a) Bluetooth configuration

(b) Wireless LAN



Wireless Networks (4)



(a) Individual mobile computers

(b) A flying LAN

1.2.5 Home Network Categories

- Computers (desktop PC, PDA, shared peripherals)
- Entertainment (TV, DVD, VCR, camera, stereo, MP3)
- Telecomm (telephone, cell phone, intercom, fax)
- Appliances (microwave, fridge, clock, furnace, airco)
- Telemetry (utility meter, burglar alarm, babycam).

1.2.6 Internetworks

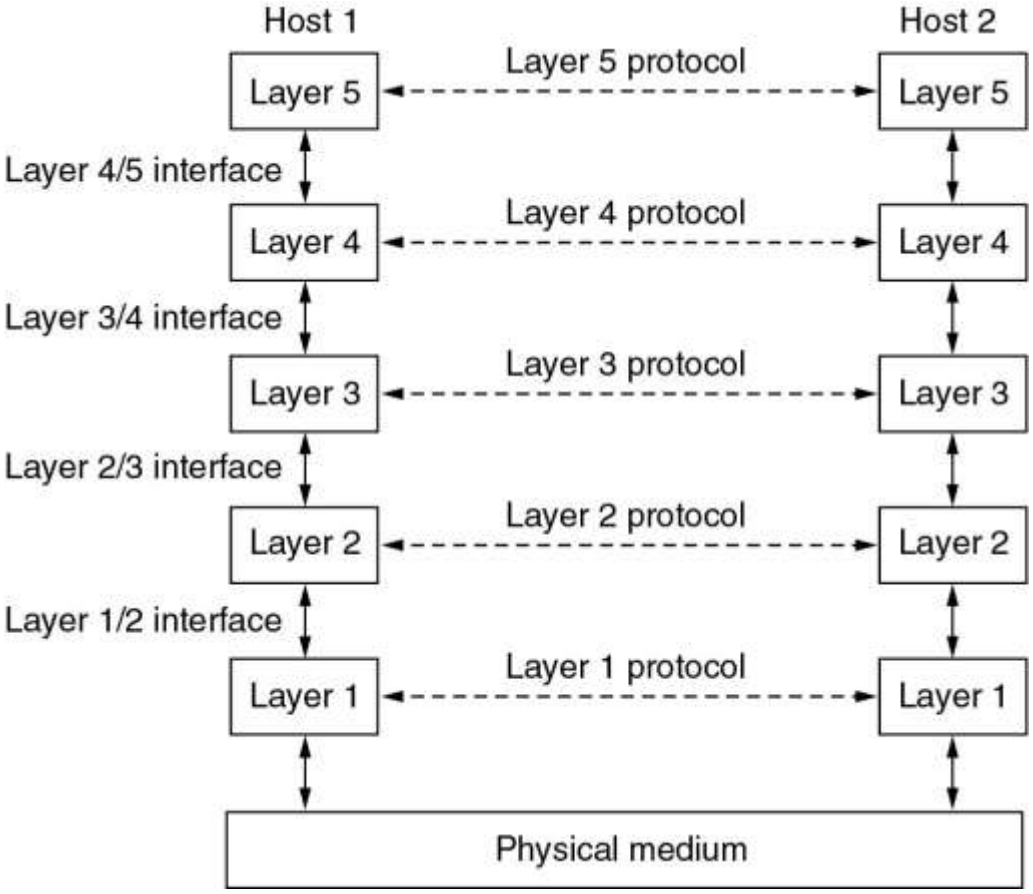
- Gateways
- Internetwork or internet

1.3 Network Software

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

1.3.1 Network Software

Protocol Hierarchies



Layers, protocols, and interfaces.

Protocol Hierarchies (2)

- **Urdu**
- **English**

- **Chinese**
- **French**

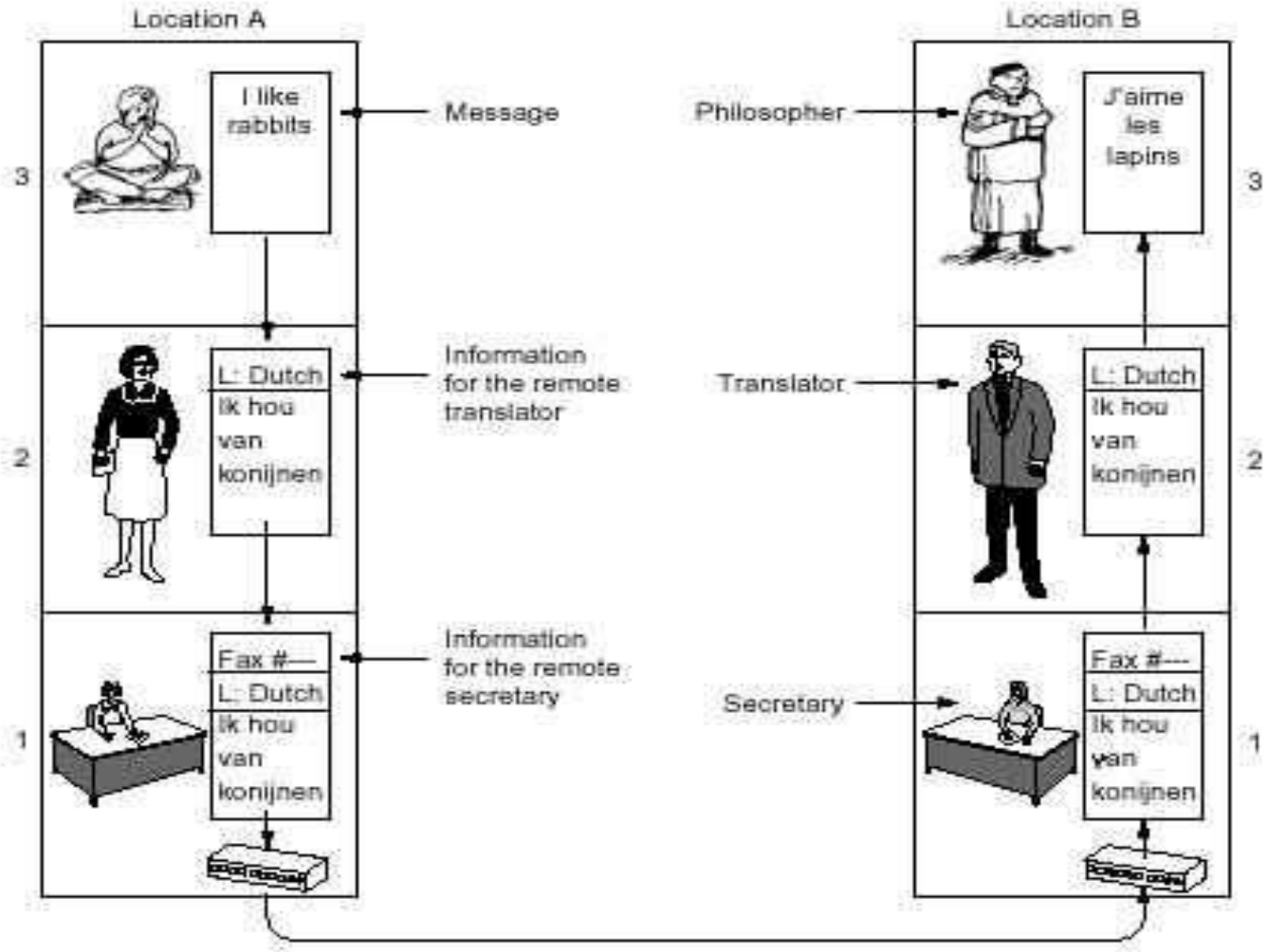
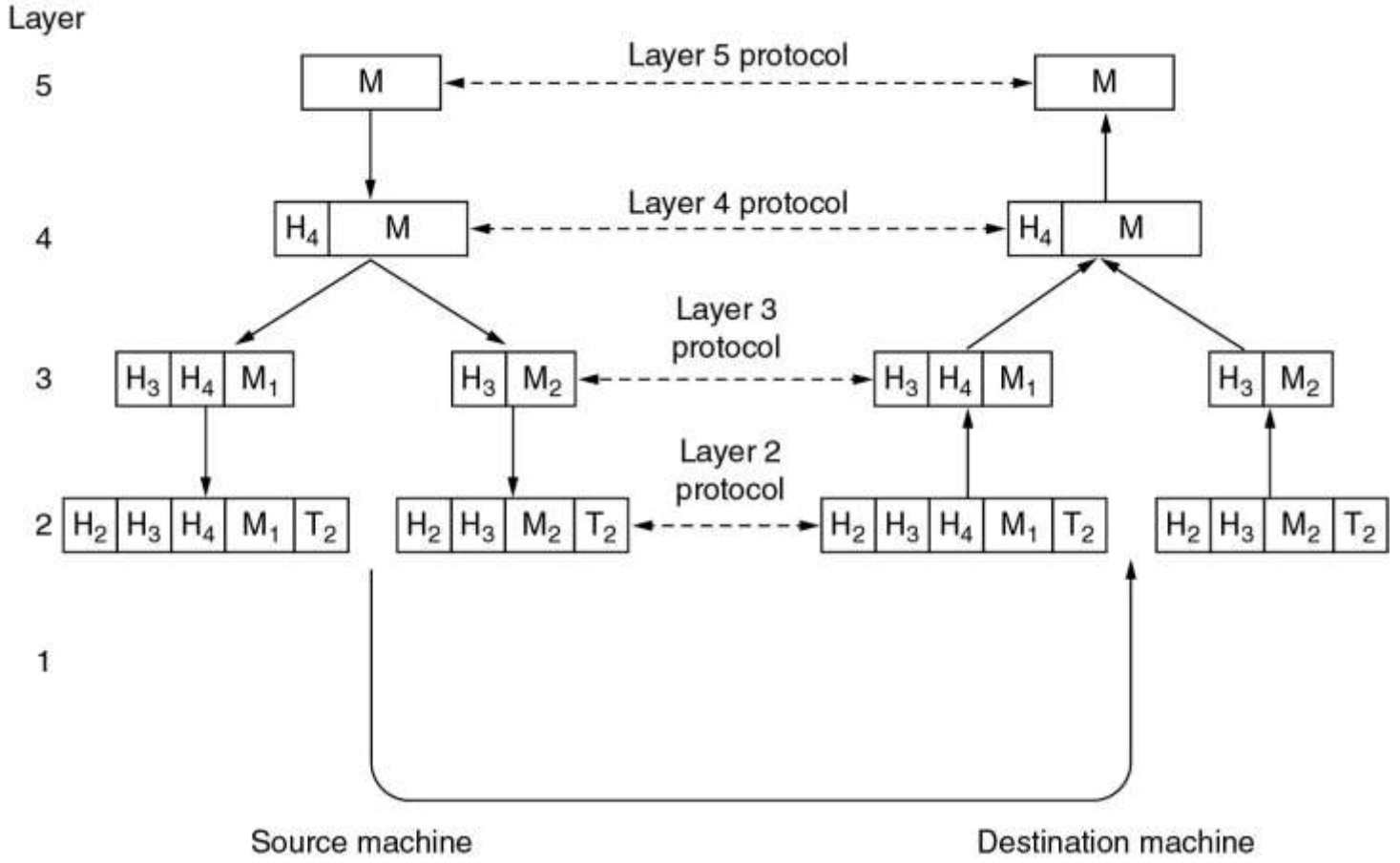


Fig. 1-10. The philosopher-translator-secretary architecture.

The ire.

Protocol Hierarchies (3)

- Example information flow supporting virtual communication in layer 5.



1.3.2 Design Issues for the Layers

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

1.3.3 Connection-Oriented and Connectionless Services

- Six different types of service.

	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

- Negotiation
- Quality of service

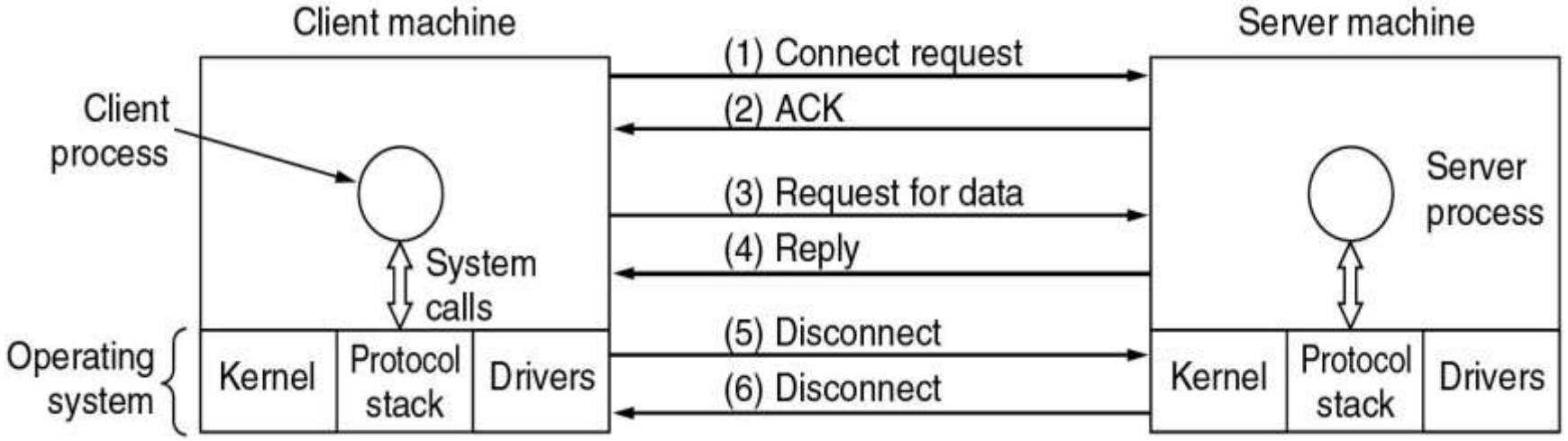
1.3.4 Service Primitives

- Five service primitives for implementing a simple connection-oriented 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

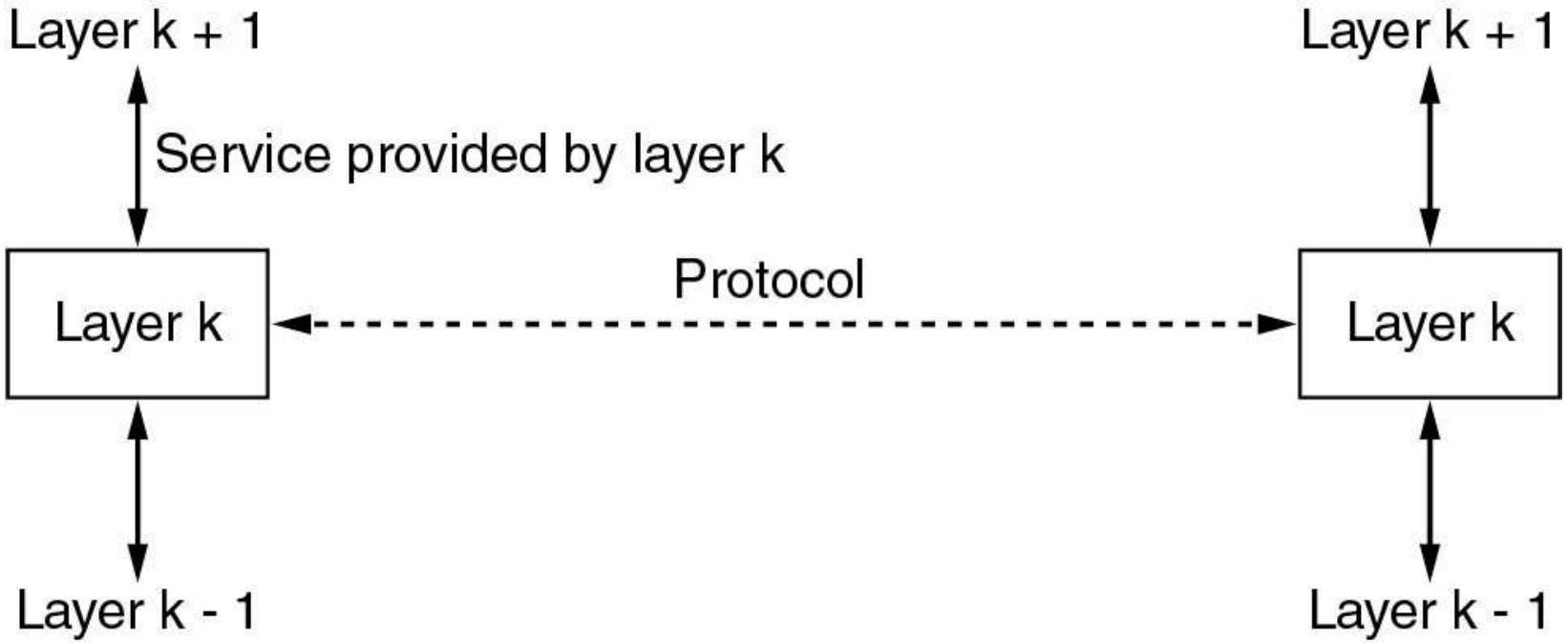
Service Primitives (2)

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



1.3.5 Services to Protocols Relationship

- The relationship between a service and a protocol.



1.3.5 Services to Protocols Relationship

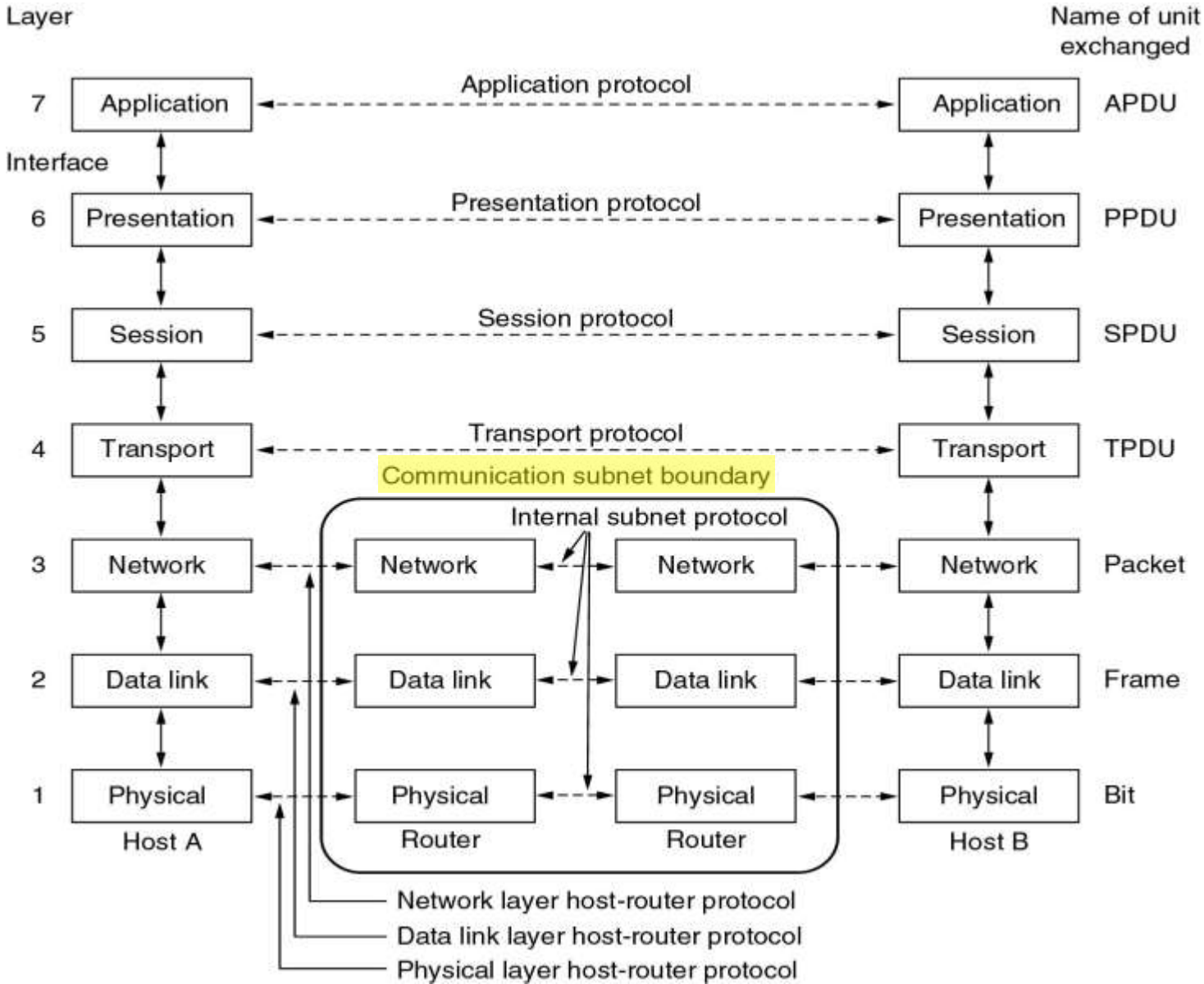
- Services：
  - 各层向它上层提供的一组原语（操作）
- Protocols：
  - 定义同层对等实体之间交换的帧、分组和报文的格式及意义的一组规则

1.4 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

1.4.1 The OSI Reference Models

The OSI reference model.



The OSI Reference Models

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

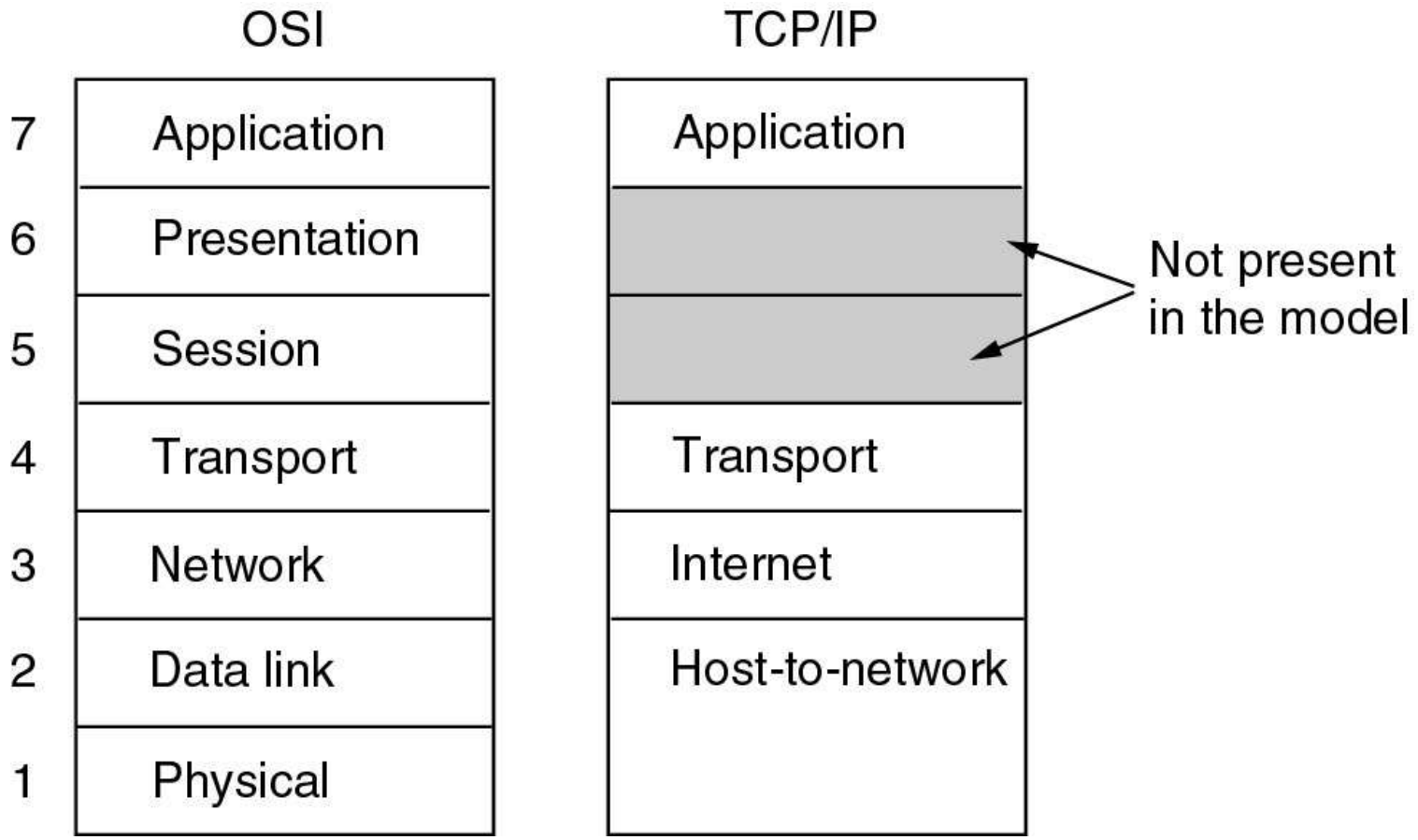
Communication subnet

includes:

- **physical layer**
- **data link layer**
- **network layer**

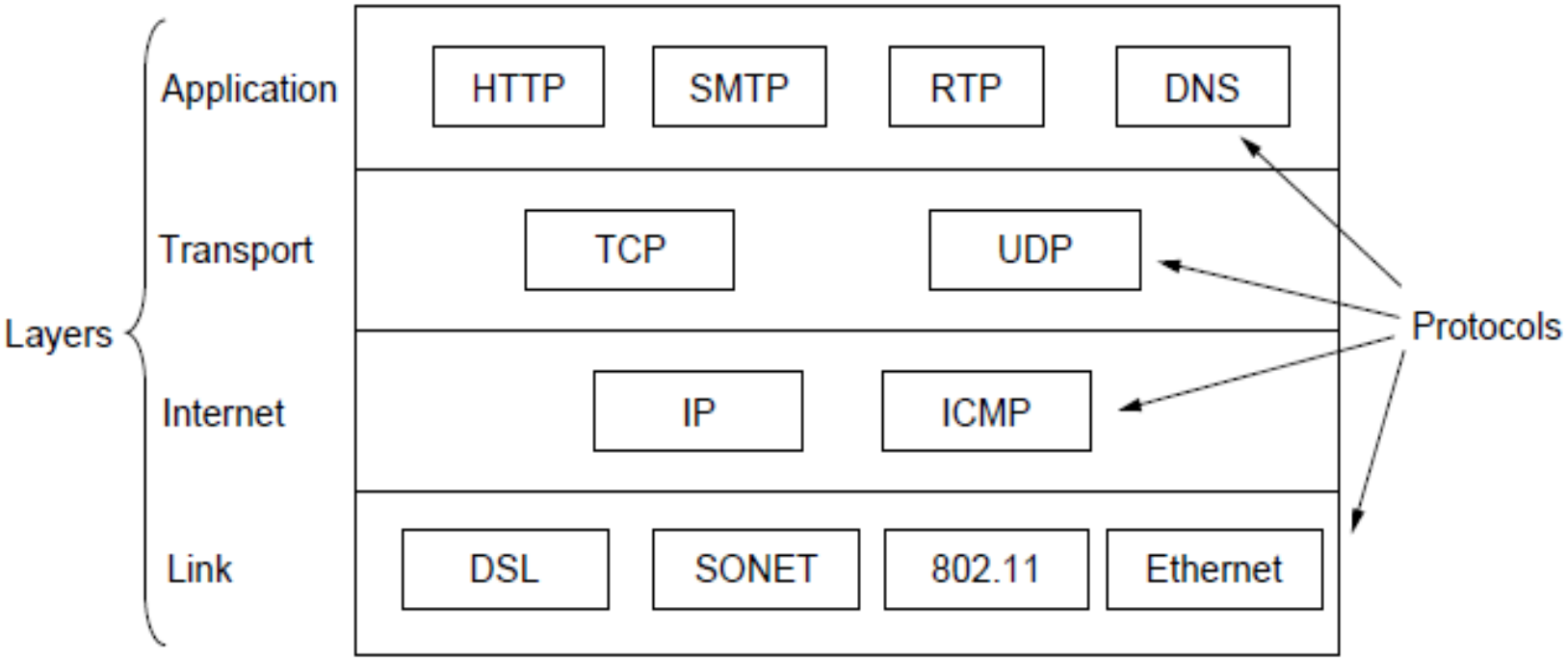
1.4.2 The TCP/IP Reference Models

- The TCP/IP reference model.



Reference Models (3)

- Protocols and networks in the TCP/IP model initially.



1.4.3 Comparing OSI and TCP/IP Models

- Concepts central to the OSI model
- Services
- Interfaces
- Protocols

OSI参考模型vs TCP/IP参考模型

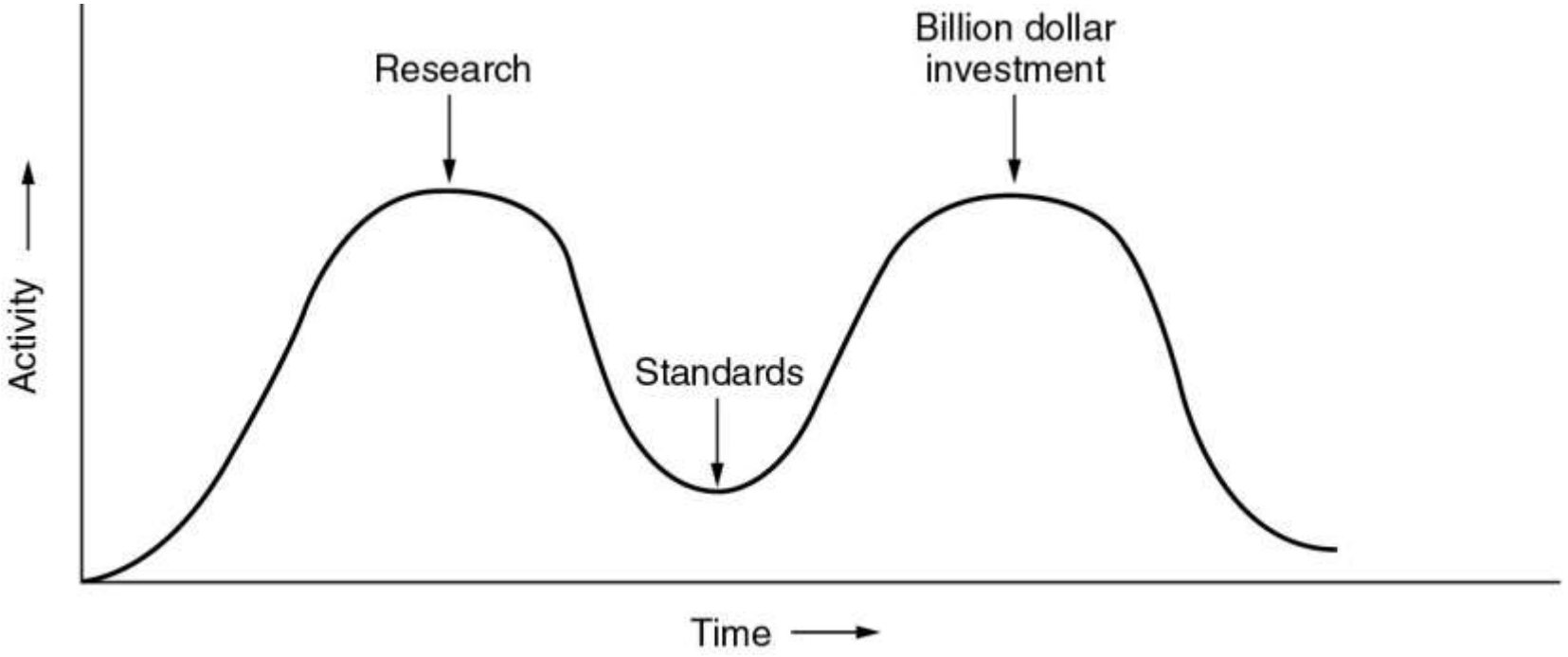
- OSI ：
  - 3个主要概念：服务、接口、协议
  - 协议有很好的隐藏性
  - 产生在协议发明之前
  - 共有7层
    - 网络层：连接和无连接
    - 传输层：面向连接
- TCP/IP
  - 没有明确区分：服务、接口、协议
  - 产生在协议发明之后
  - 共有5层
    - 网络层：无连接
    - 传输层：面向连接和无连接

1.4.4 A Critique of the OSI Model and Protocols

- Why OSI did not take over the world
- Bad timing
- Bad technology
- Bad implementations
- Bad politics

Bad Timing

- The apocalypse of the two elephants.

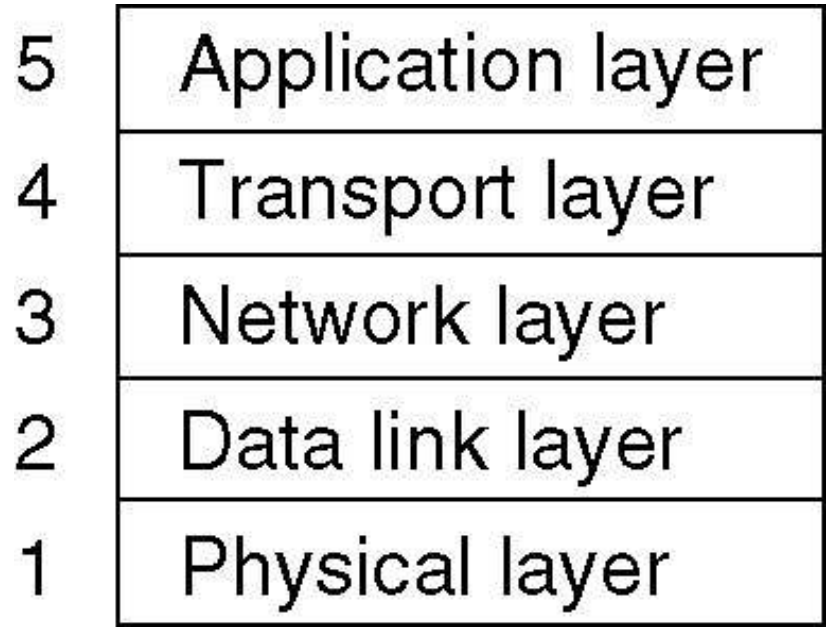


1.4.5 A Critique of the TCP/IP Reference Model

- 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 to be used in this book.



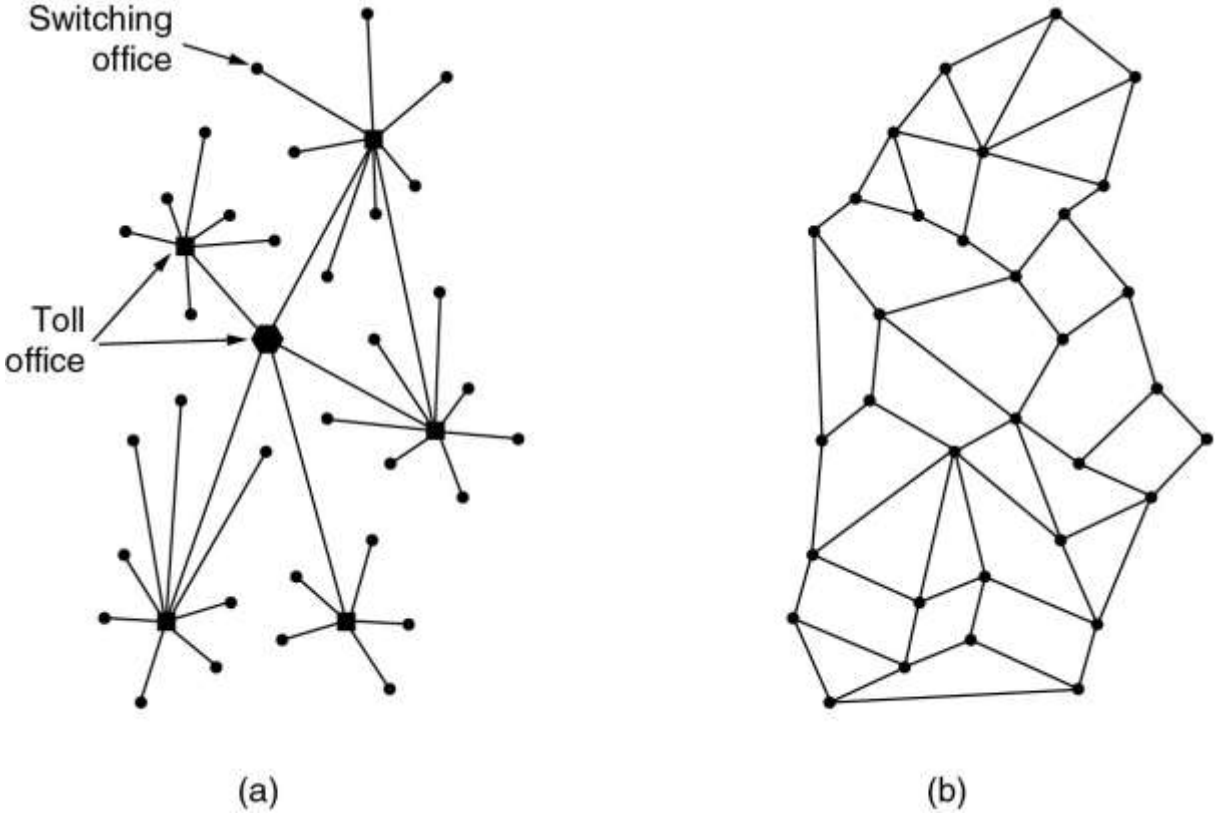
1.5 Example Networks

- ARPANET
- The Internet
- Connection-Oriented Networks:
  X.25, Frame Relay, and ATM
- Ethernet
- Wireless LANs: 802.11
- Third-generation mobile phone networks
- RFID and sensor networks

1.5.1 The ARPANET

(a) Structure of the telephone system.

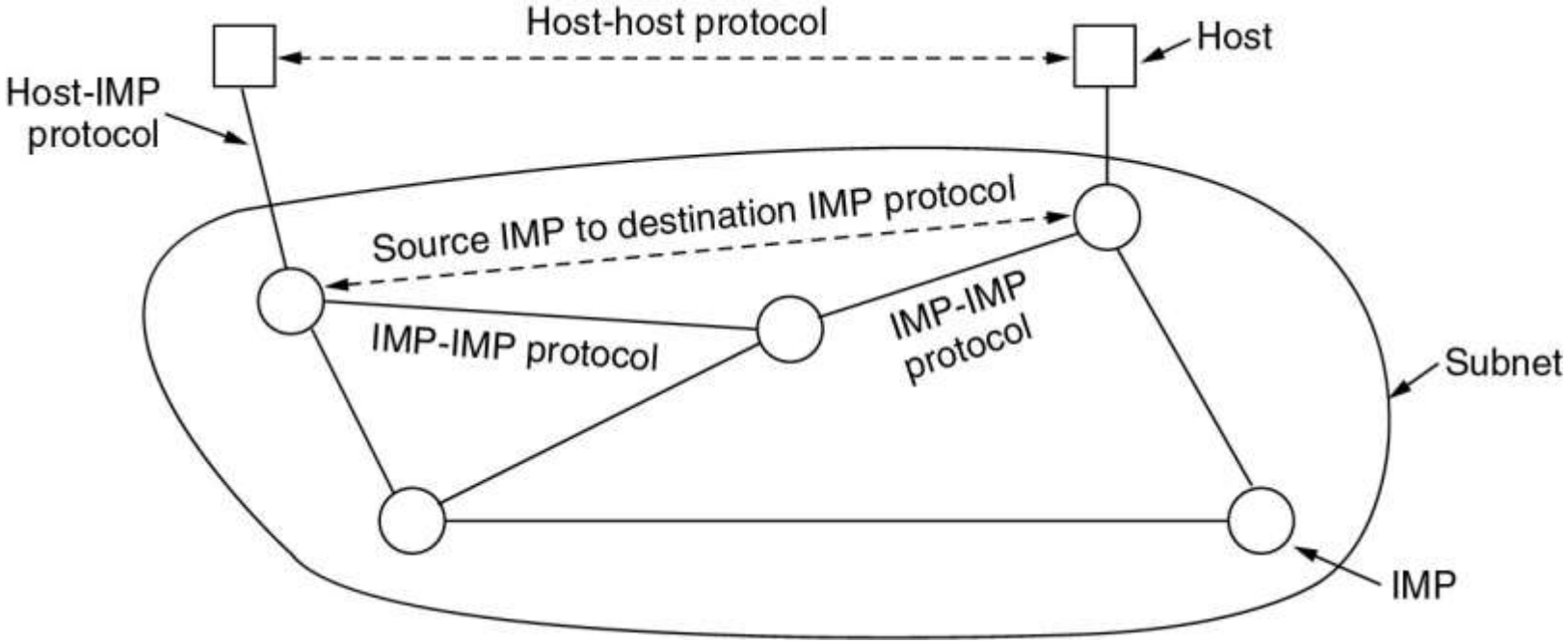
(b) Baran's proposed distributed switching



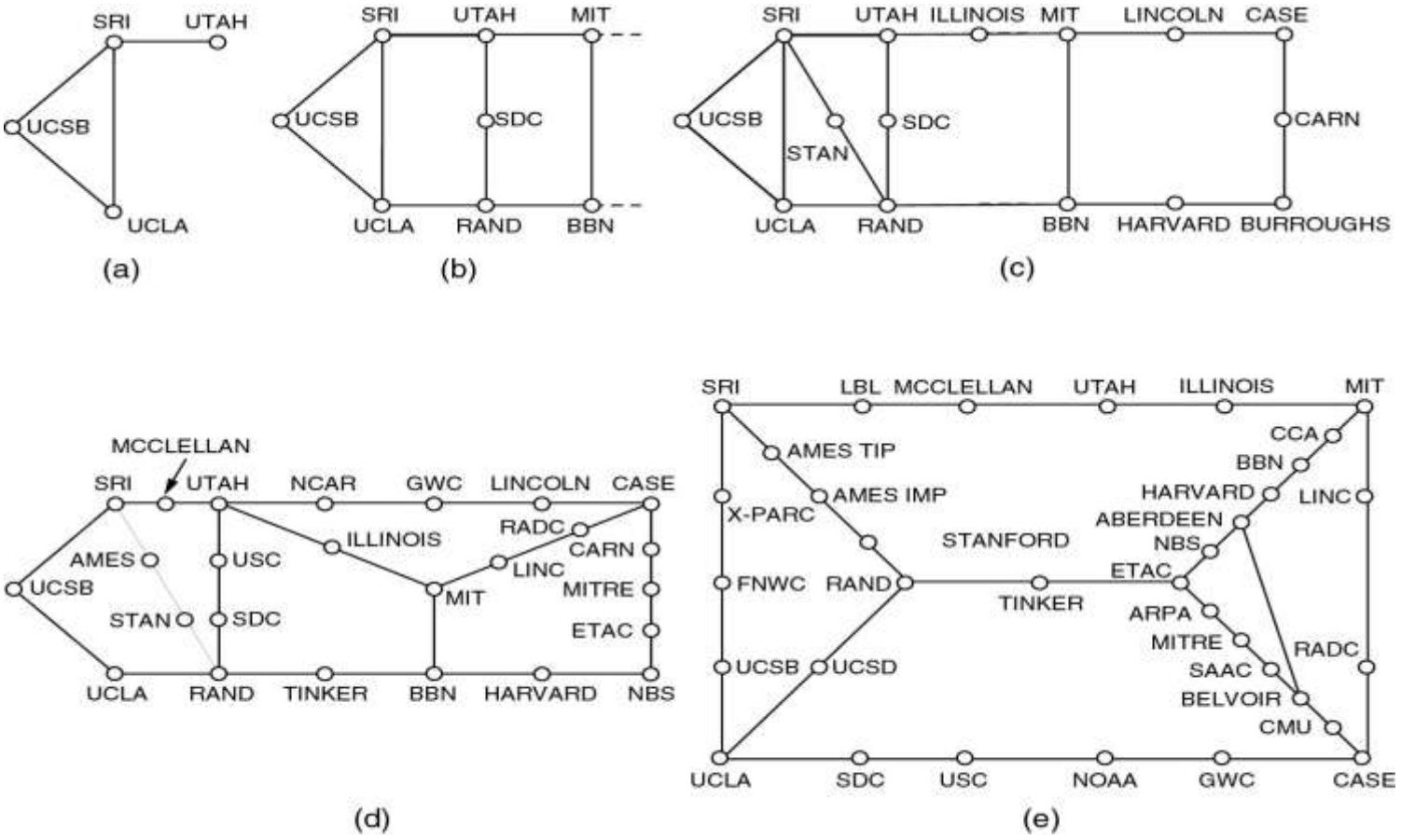
ARPA: Advanced Research Projects Agency of Department of Defense

The ARPANET (2)

- The original ARPANET design.



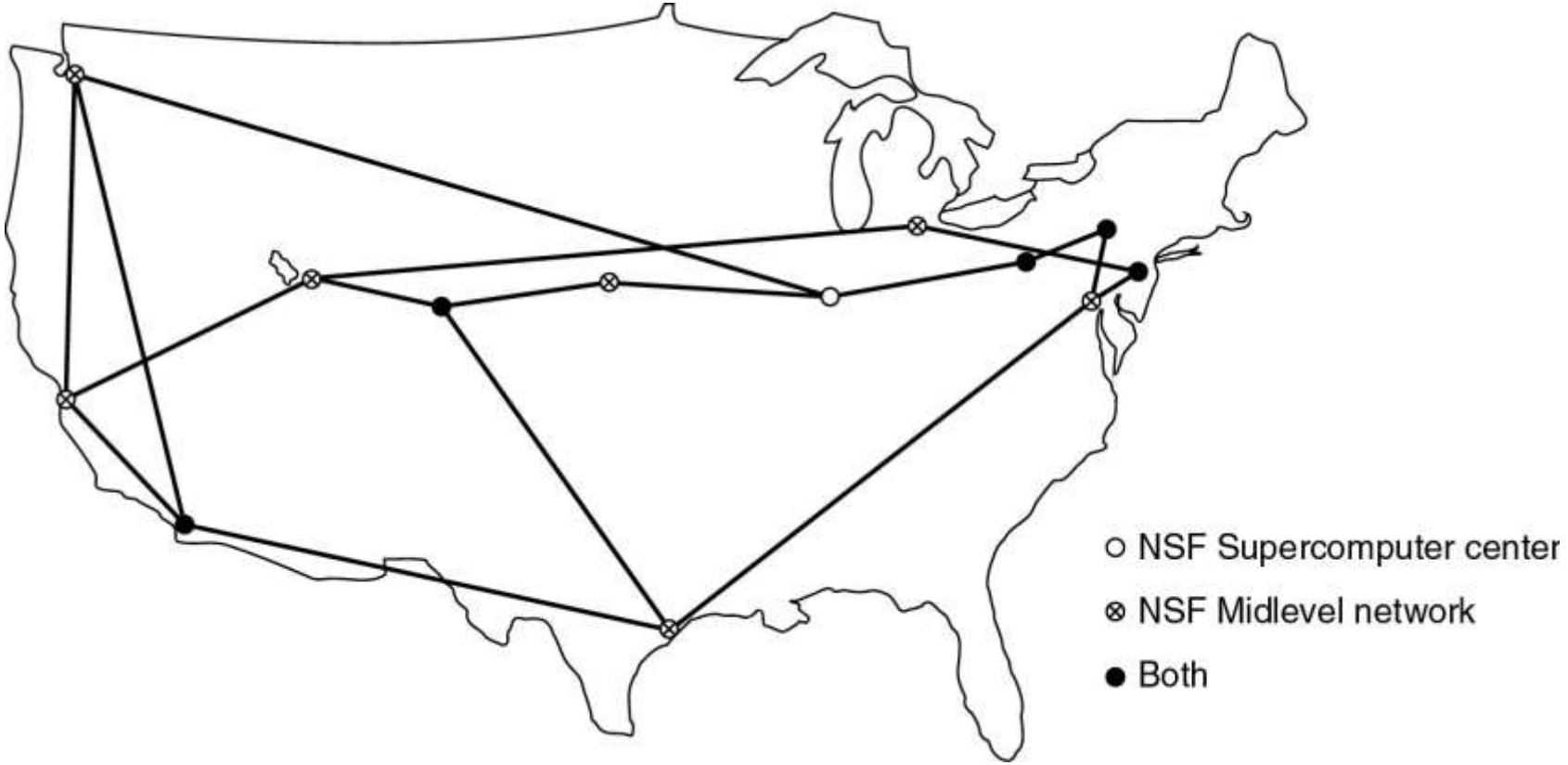
The ARPANET (3)



Growth of the ARPANET (a) December 1969. (b) July 1970.
(c) March 1971. (d) April 1972. (e) September 1972.

NSFNET

- The NSFNET backbone in 1988.

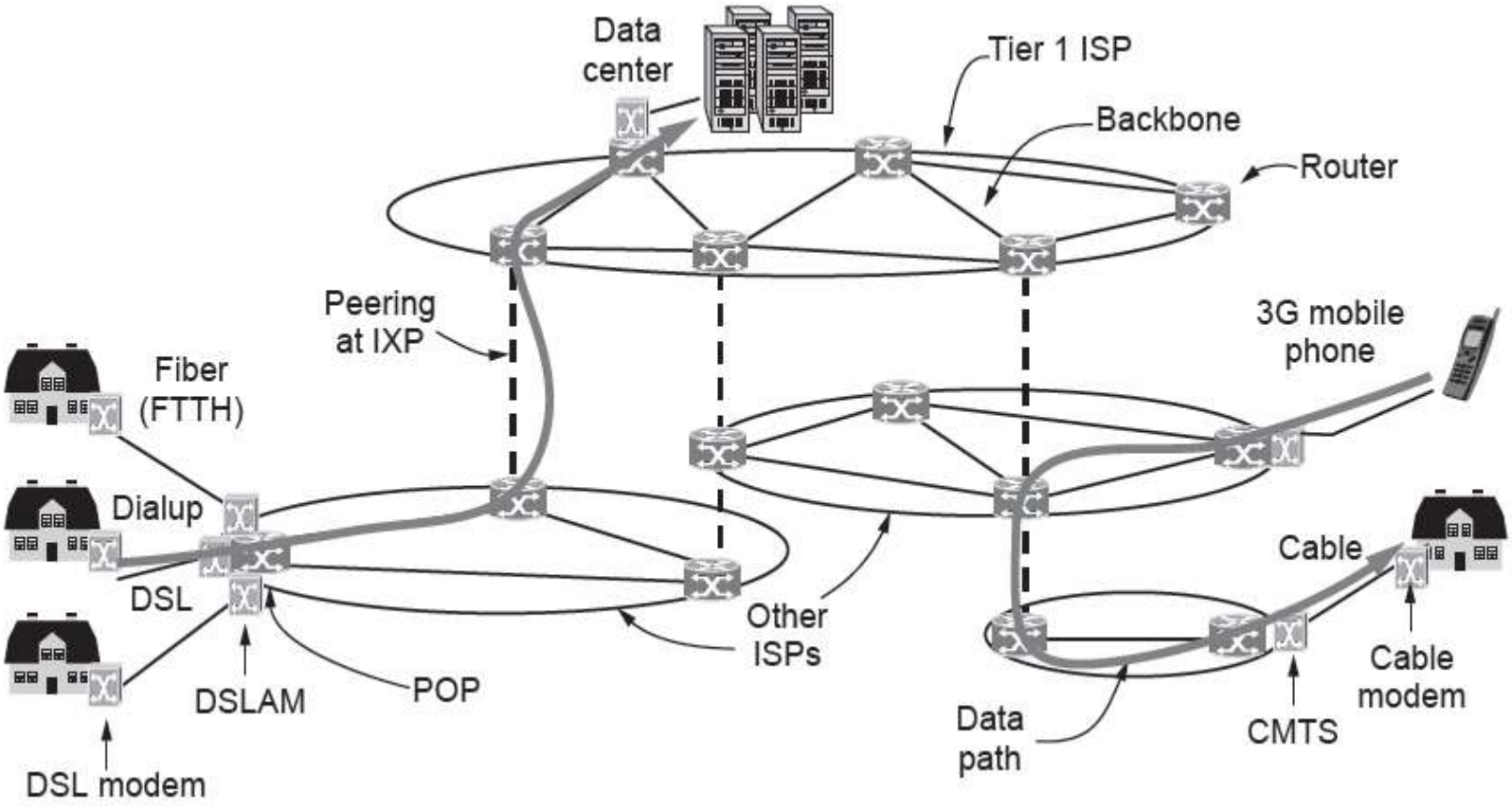


Internet Usage

- Traditional applications (1970 – 1990)
- E-mail
- News
- Remote login
- File transfer

Architecture of the Internet

- Overview of the Internet.

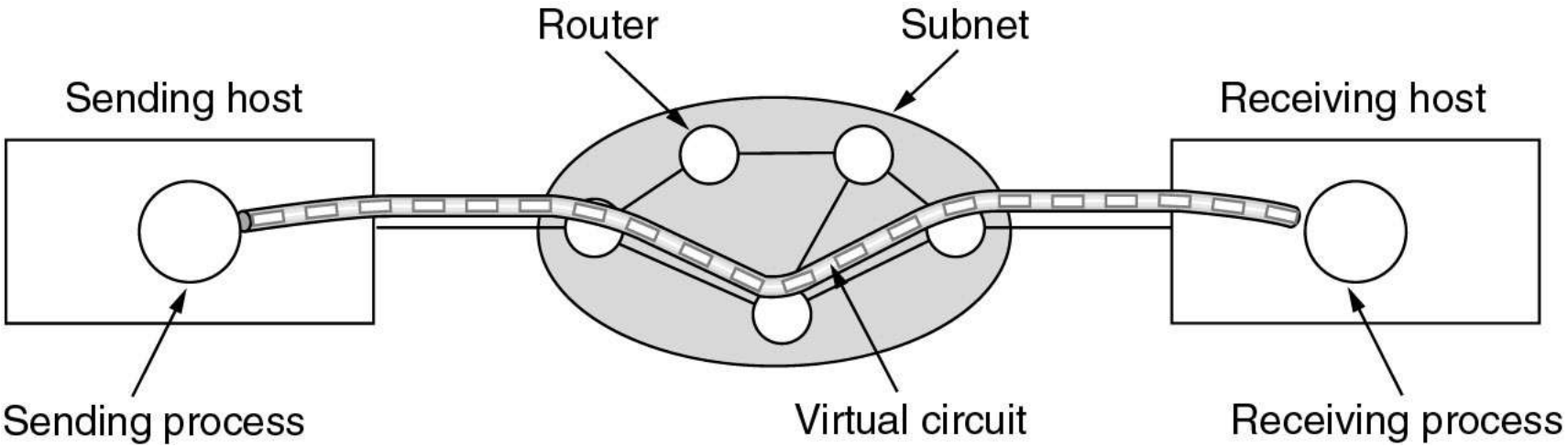


1.5.2 Connection-Oriented Networks: X.25, Frame Relay and ATM

- X.25 -- 1970s
  - First connection-oriented network
- Frame Relay --1980s
  - No error control and no flow control
- ATM (Asynchronous Transfer Mode) – 1990s
  - Cells

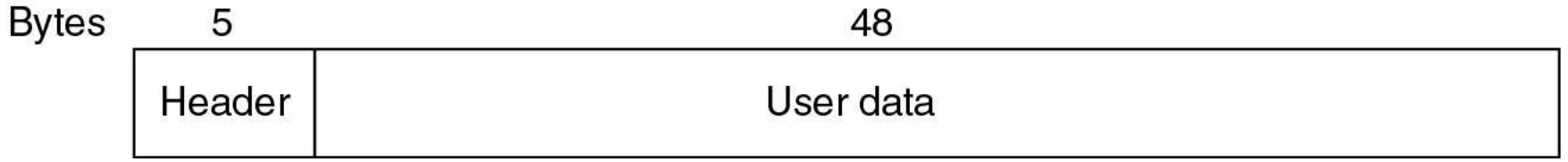
1.5.2 ATM Virtual Circuits

- A virtual circuit.

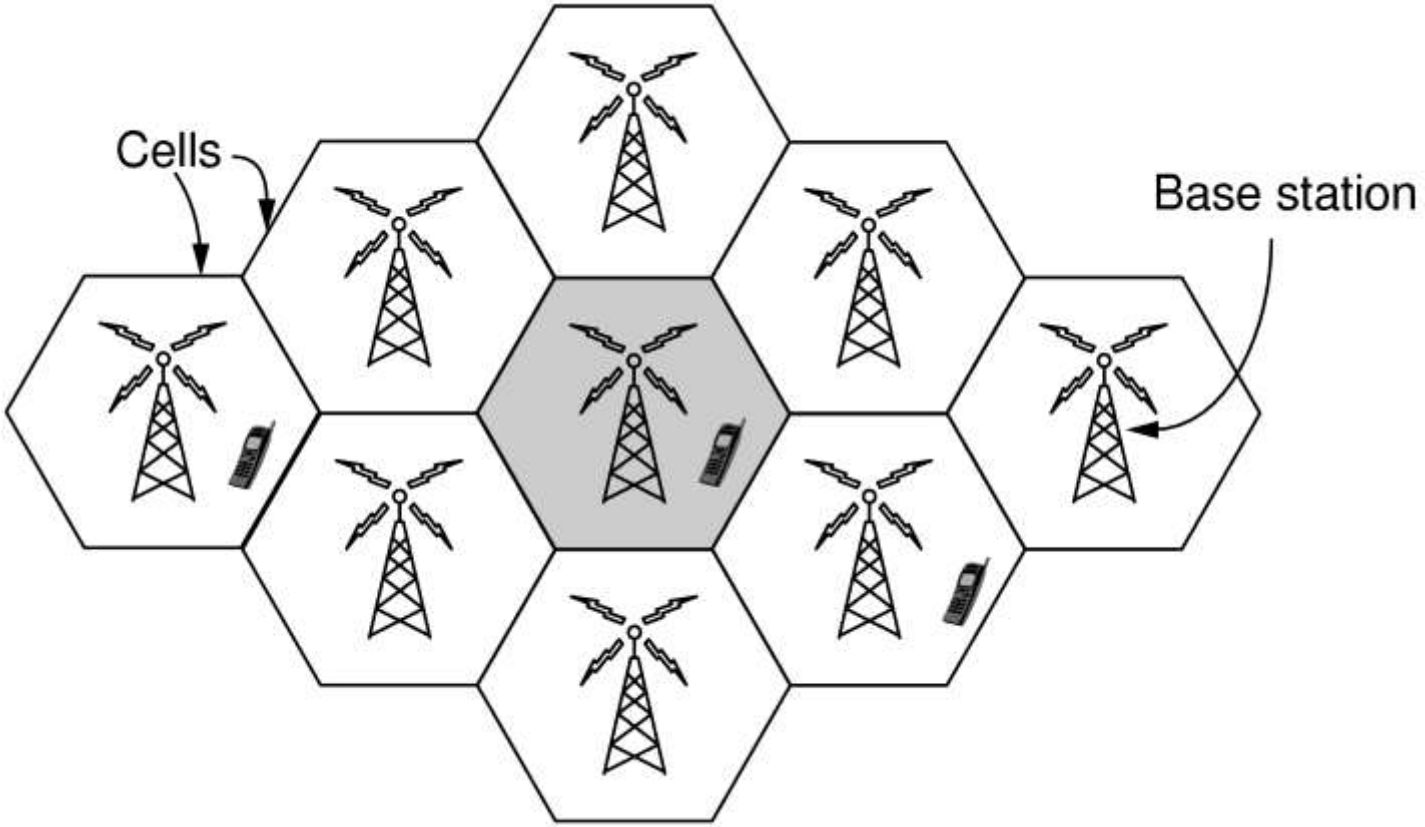


ATM Virtual Circuits (2)

- An ATM cell.

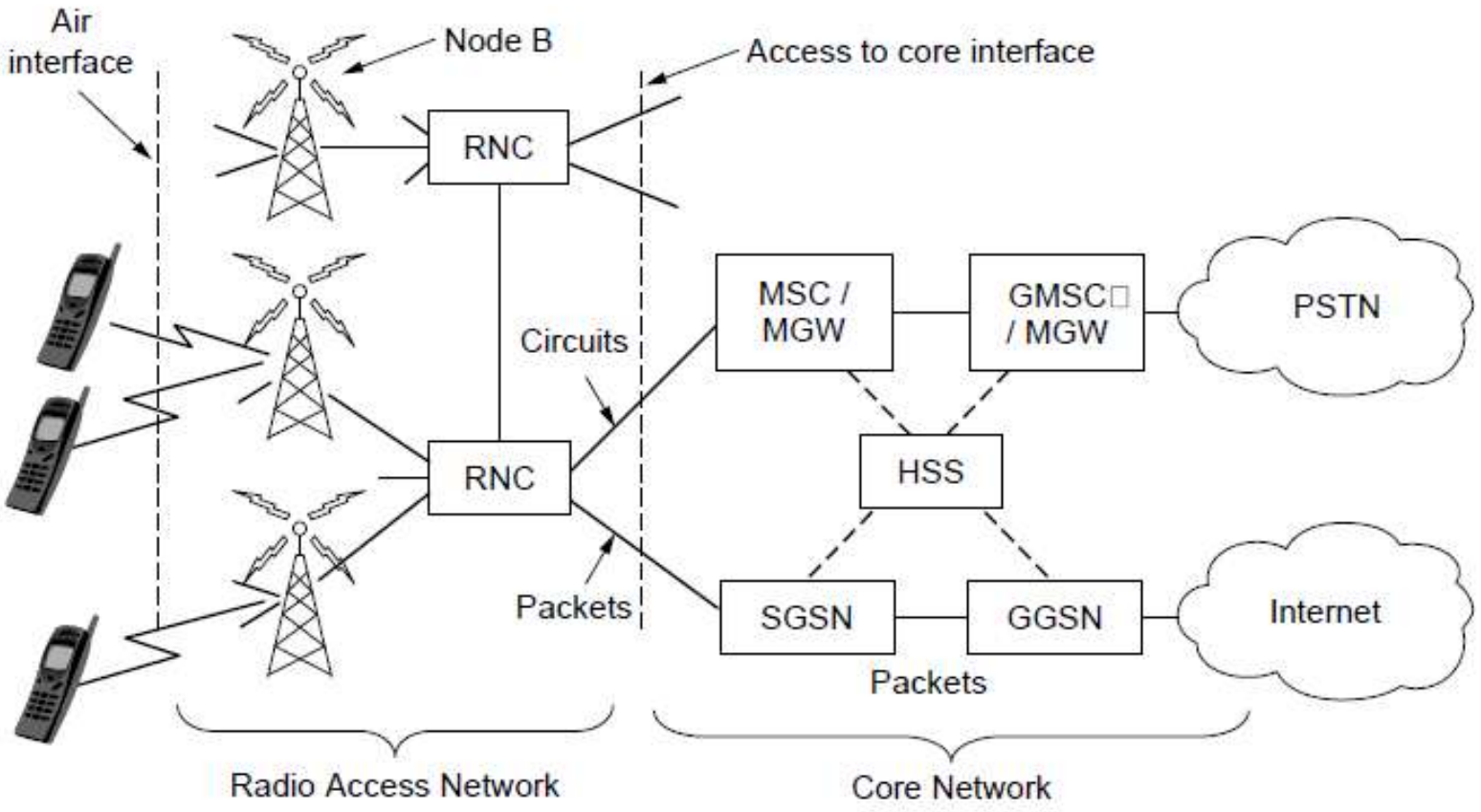


1.5.3 Third-Generation Mobile Phone Networks (1)



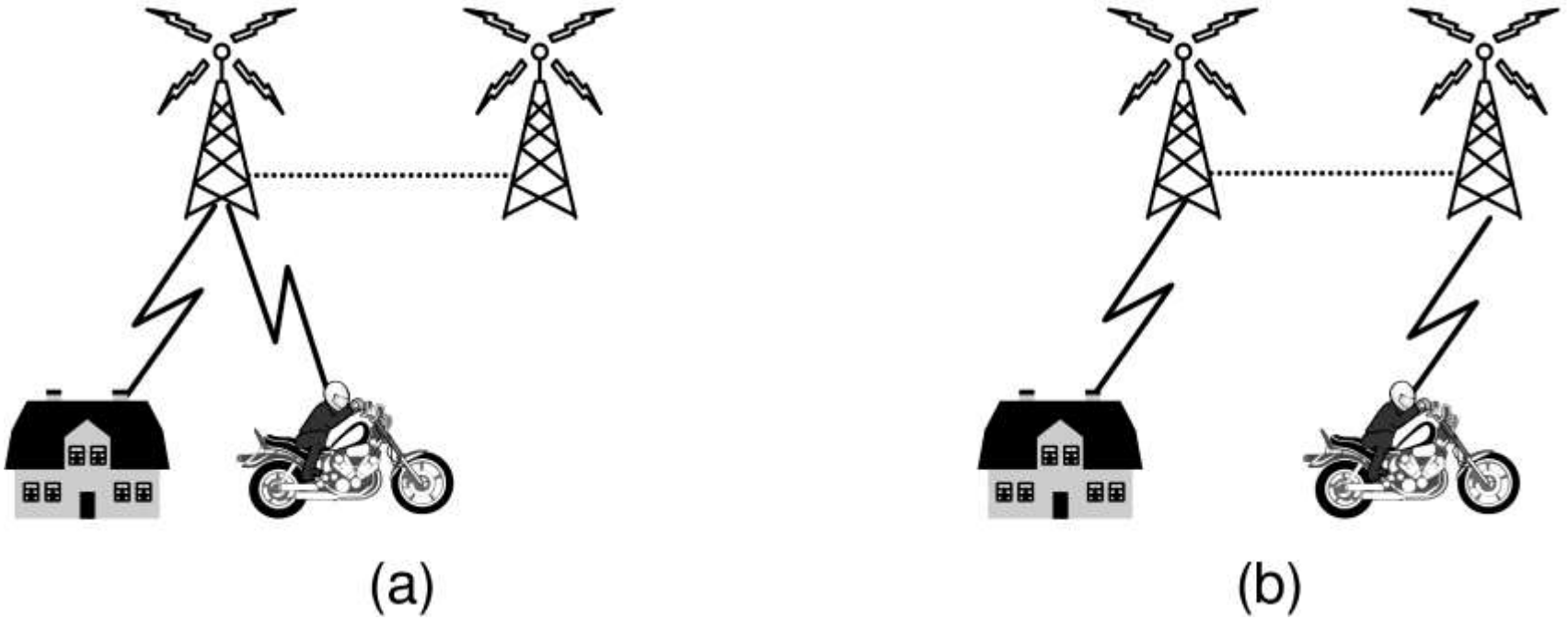
Cellular design of mobile phone networks

Third-Generation Mobile Phone Networks (2)



Architecture of the UMTS 3G mobile phone network.

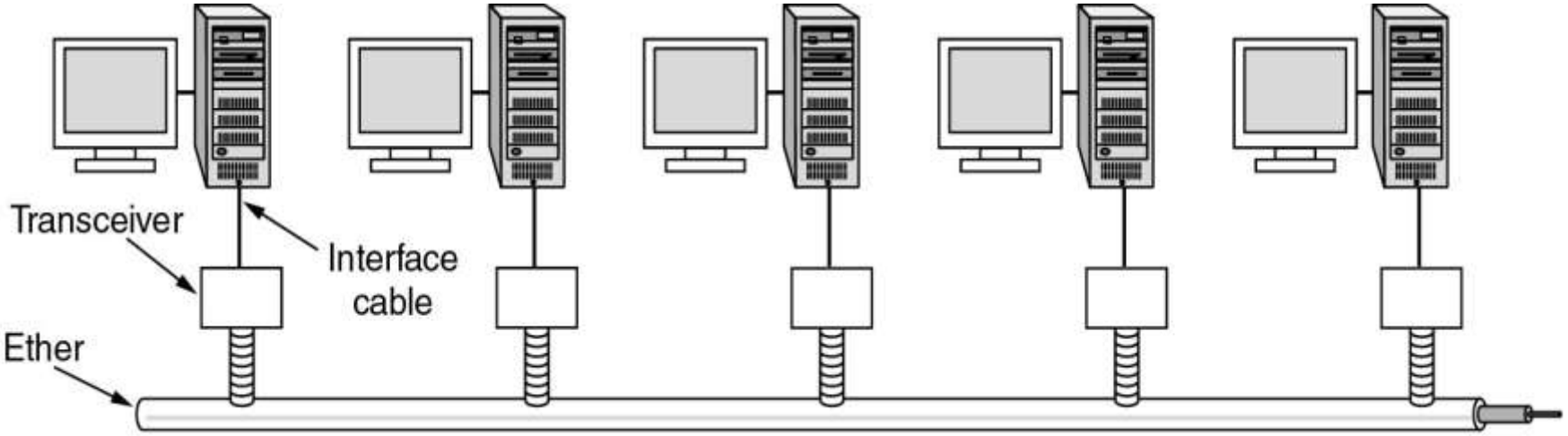
Third-Generation Mobile Phone Networks (3)



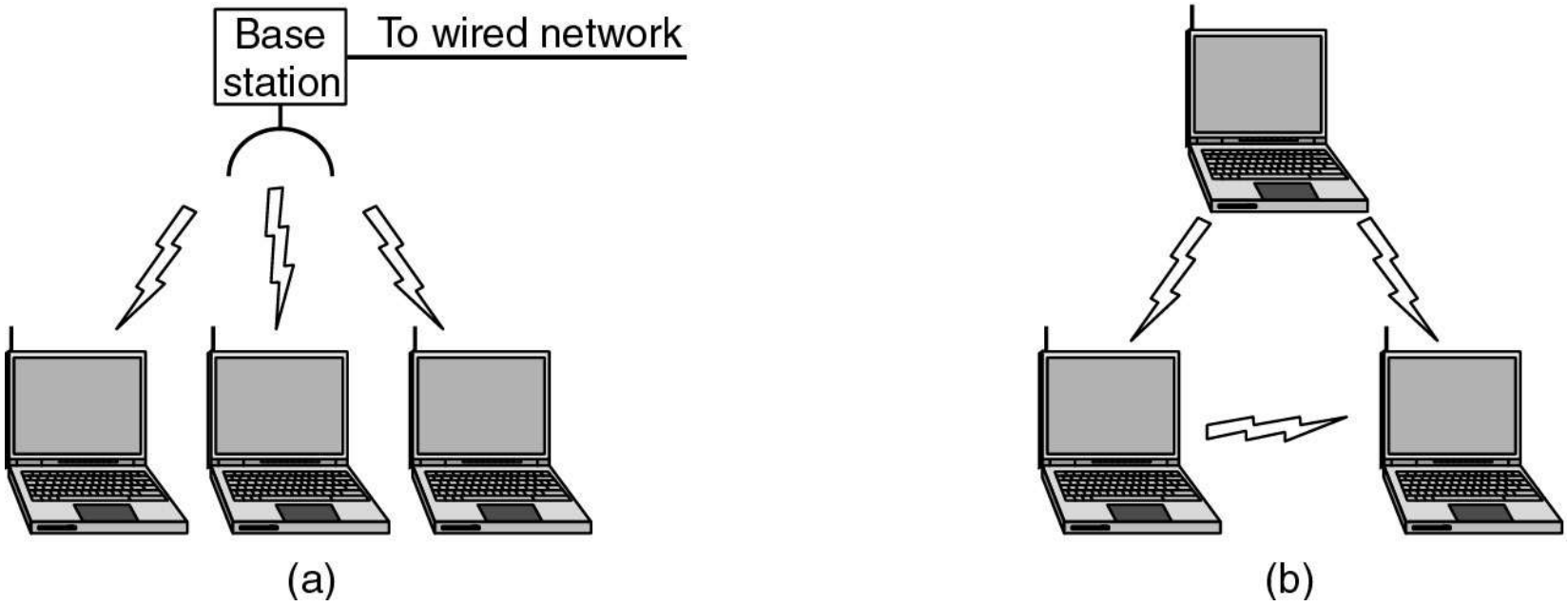
Mobile phone handover (a) before, (b) after.

1.5.4 Ethernet

- Architecture of the original Ethernet.

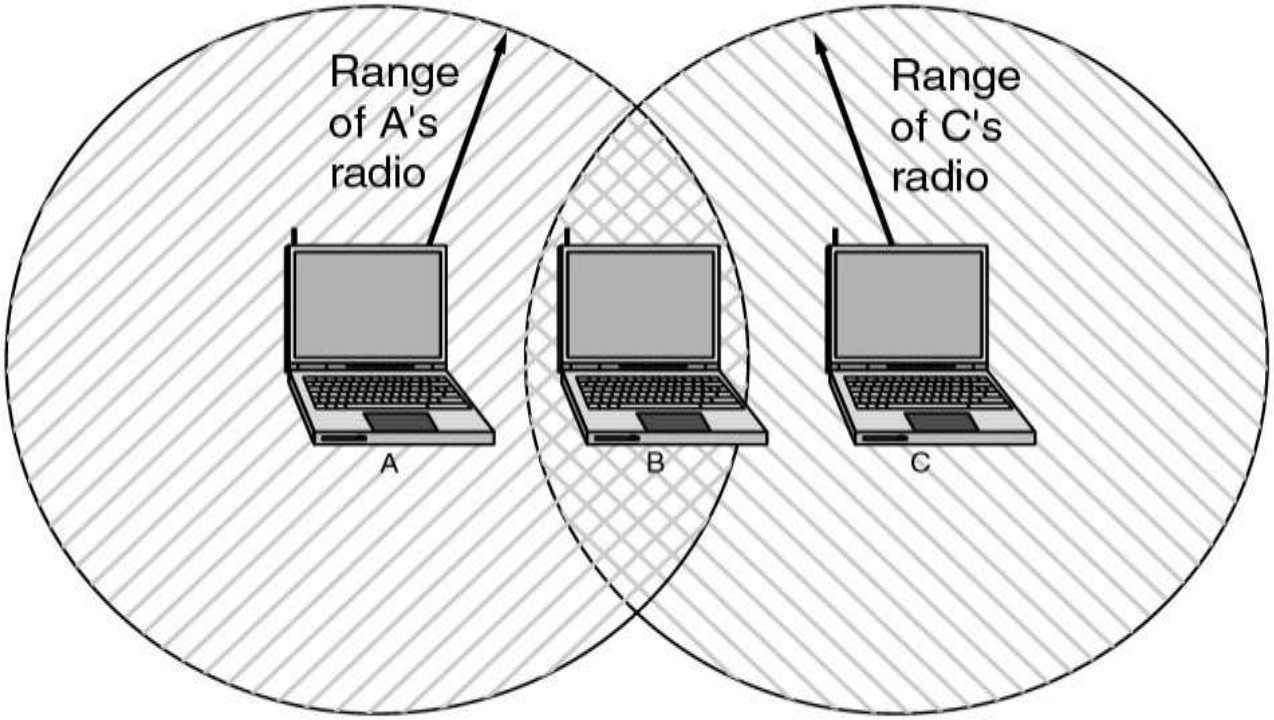


1.5.5 Wireless LANs:802.11



(a) Wireless networking with a base station.
(b) Ad hoc networking.

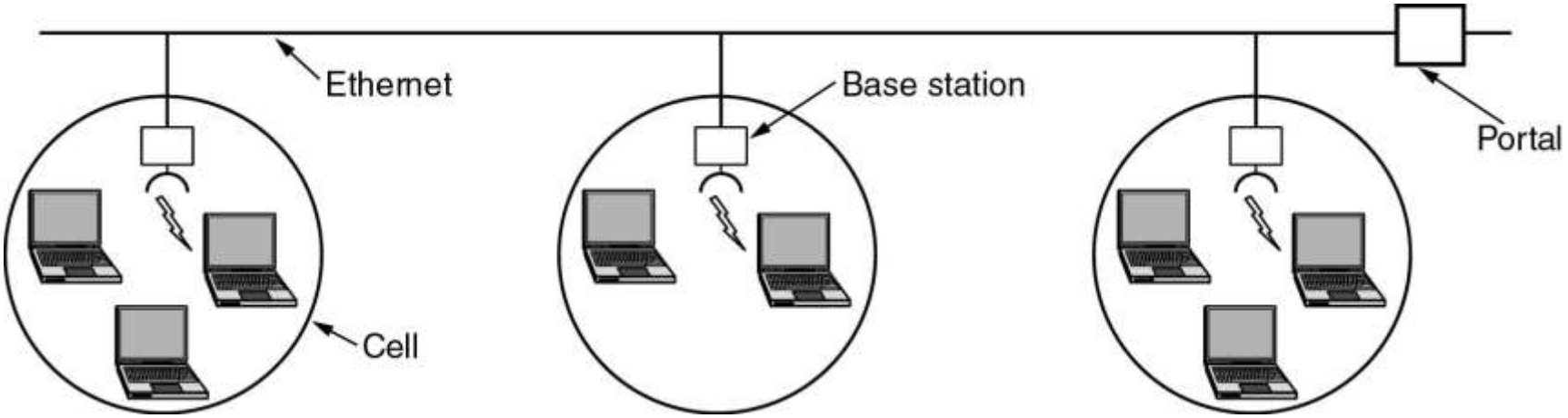
Wireless LANs (2)



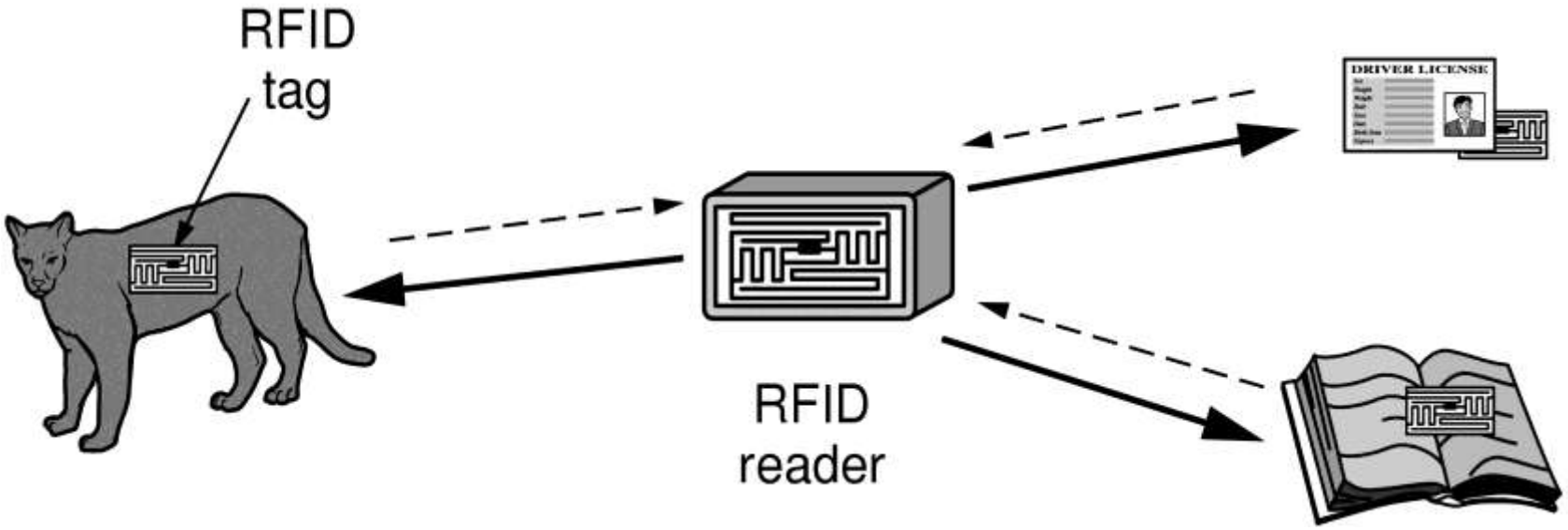
- The range of a single radio may not cover the entire system.

Wireless LANs (3)

- A multicell 802.11 network.

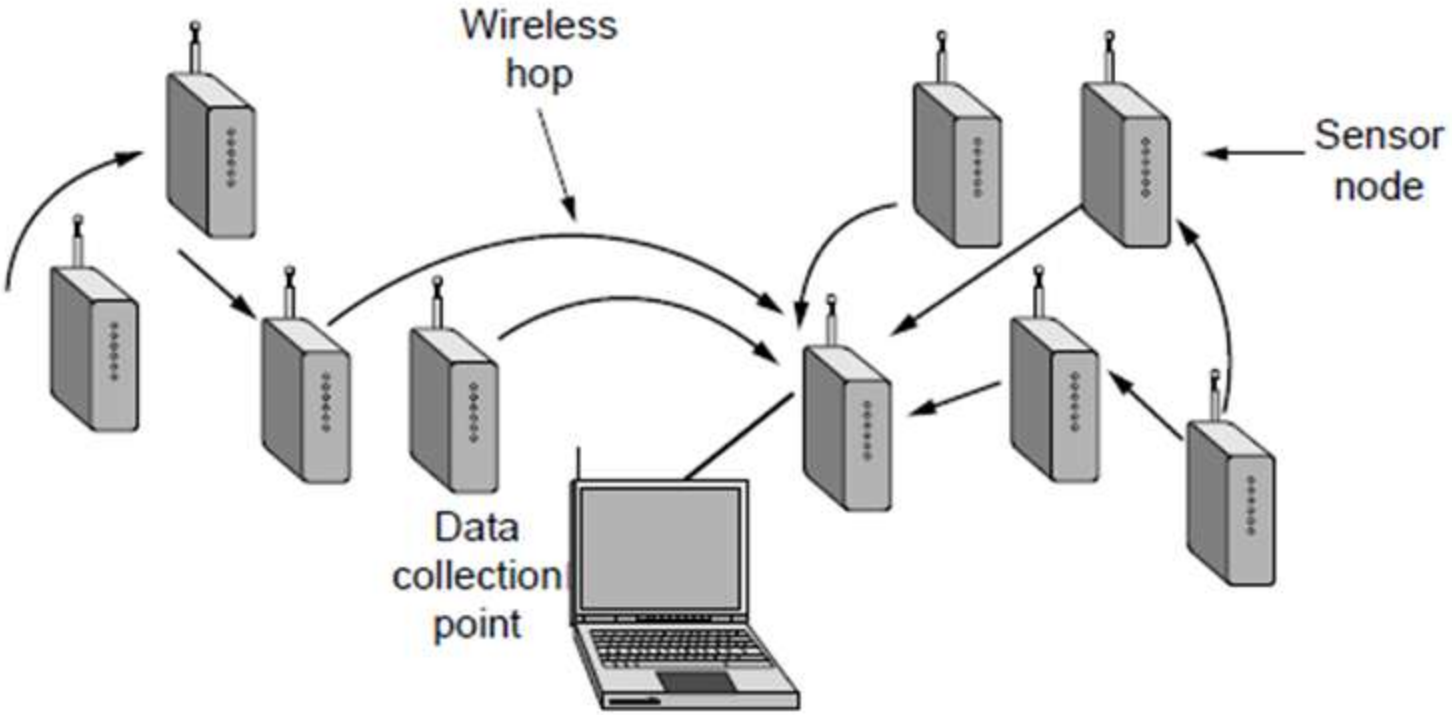


1.5.6 RFID and Sensor Networks (1)



RFID used to network everyday objects.

RFID and Sensor Networks (2)



Multihop(多跳) topology of a sensor(传感器) network

1.6 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

1.6.1 Who's Who in the Telecommunications World

–International Telecommunication Union （ITU）

ITU has three main sectors:

- Radiocommunications Sector (ITU-R).
- Telecommunications Standardization Sector (ITU-T).
- Development Sector (ITU-D).

–Post, Telegraph & Telephone administration（邮电部，PTT)

–Public Telecommunication Companies, AT&T, Bell

ITU

- Main sectors
  - Radiocommunications (ITU-R)
  - Telecommunications Standardization (ITU-T)
    - （被称为 CCITT, 1953-1993）
  - Development (ITU-D)
- Classes of Members
  - National governments, more than 200
  - Sector members, more than 500, AT&T, Cisco…
  - Associate members, Study Group
  - Regulatory agencies, as FCC

1.6.2 Who's Who in the International Standards World

- International Standards Organization （ISO）
  - 标准化程序:委员会草案(CD)→国际标准草案(DIS)→IS
- American National Standards Institute（美国国家标准协会，ANSI）
- National Institute of Standards and Technology（国家标准和技术协会，NIST）
- Institute of Electrical and Electronics Engineers（电器和电子工程师协会，IEEE）
  - 802.x --->ISO 8802.x

1.6.2 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.

1.6.3 Who's Who in the Internet Standards World

- Internet Activities Board（因特网活动委员会，IAB,1983)-> Internet Architecture Board（因特网体系结构委员会，IAB)
  - RFC (Request For Comments,请求评注)
- Internet Research Task Force（因特网研究特别任务组，IRTF)
- Internet Engineering Task Force（因特网工程特别任务组，IETF)
- Internet society（因特网协会）

- RFC→Proposed Standard→Draft Standard→Internet Standard

1.7 Metric Units

- The principal metric prefixes.

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

Note:

1. KB,MB,GB for 2^{10},2^{20},2^{30} bytes
2. Kbps,Mbps,Gbps for 10^{3},10^{6},10^{9} bit/sec

1.8 Outline of the Book

- CHAPTER 1 INTRODUCTION
- CHAPTER 2 THE PHYSICAL LAYER
- CHAPTER 3 THE DATA LINK LAYER
- CHAPTER 4 THE MEDIUM ACCESS SUBLAYER
- CHAPTER 5 THE NETWORK LAYER
- CHAPTER 6 THE TRANSPORT LAYER
- CHAPTER 7 THE APPLICATION LAYER
- CHAPTER 8 NETWORK SECURITY

Exercises

In 4th Edition：

- 5, 6, 11，13，18，
- 20，22，27，28

In 5th Edition：

- 4, 5, 10，11，16，
- 18，20，24，25，35