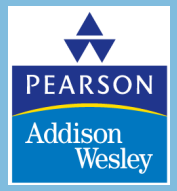
Chapter 4:
Networking and the Internet

Computer Science: An Overview



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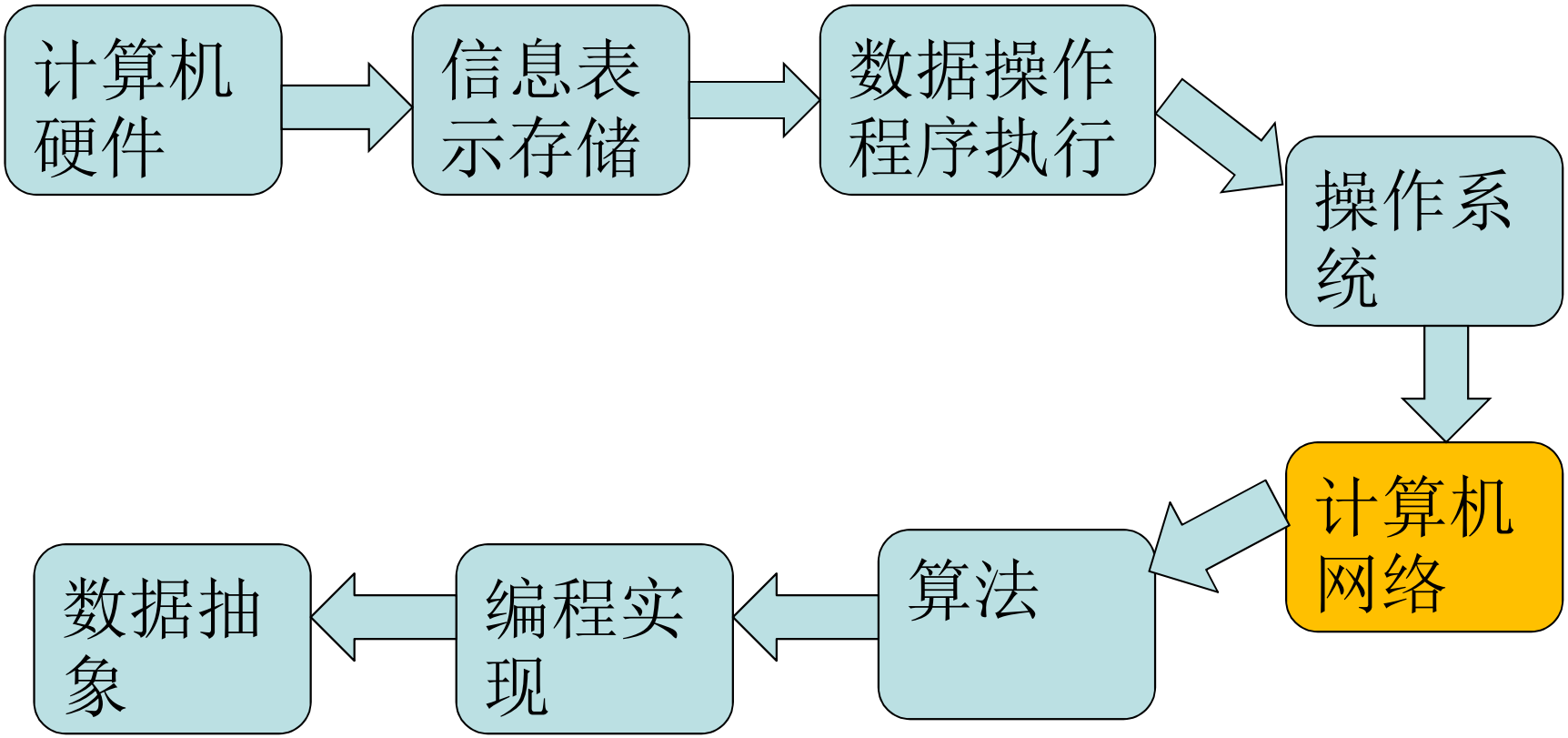
从程序的角度了解计算机系统



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Chapter 4: Networking and the Internet

- 4.1 Network Fundamentals
- 4.2 Network Protocols
- 4.3 The Internet
- 4.4 The World Wide Web

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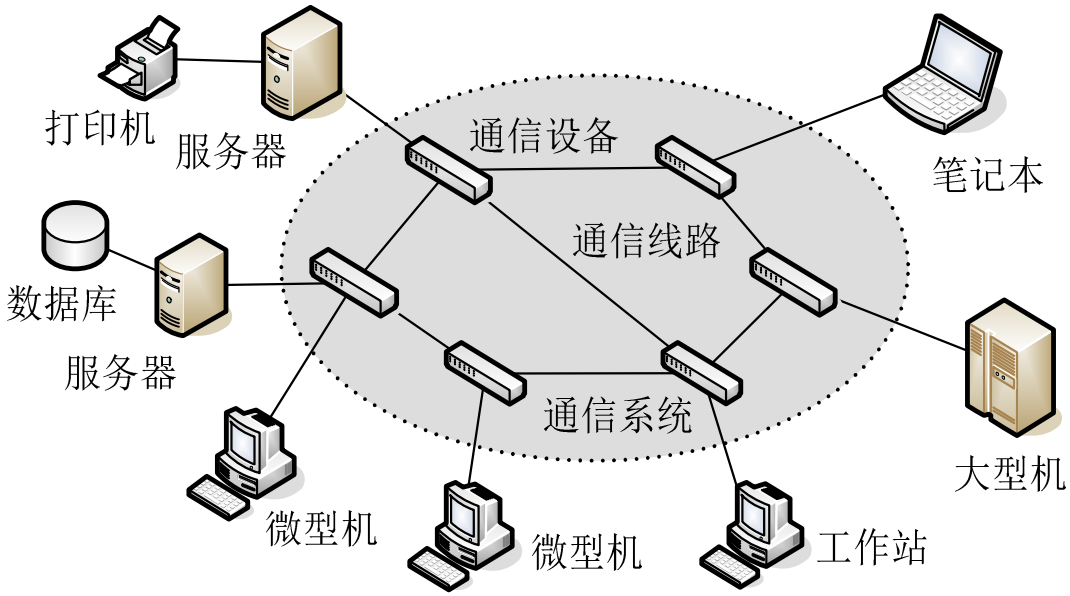
What is a computer network?

- How many devices? 2 or more
- Connected
- Sharing resources



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Element of a computer network

- Sender / Receiver
- Messages (signal)
- Media
- Protocol (rules)

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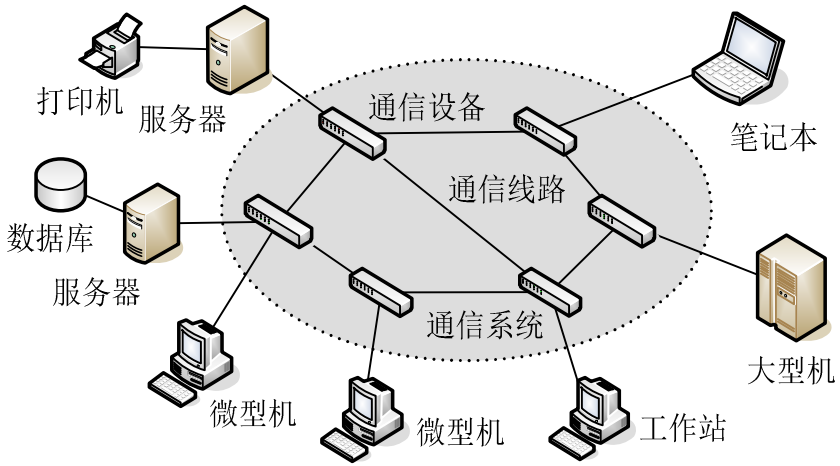
What is the computer network ?

A **computer network**, often simply referred to as a network, is a collection of hardware components and computers interconnected by communication channels that allow sharing of resources and information

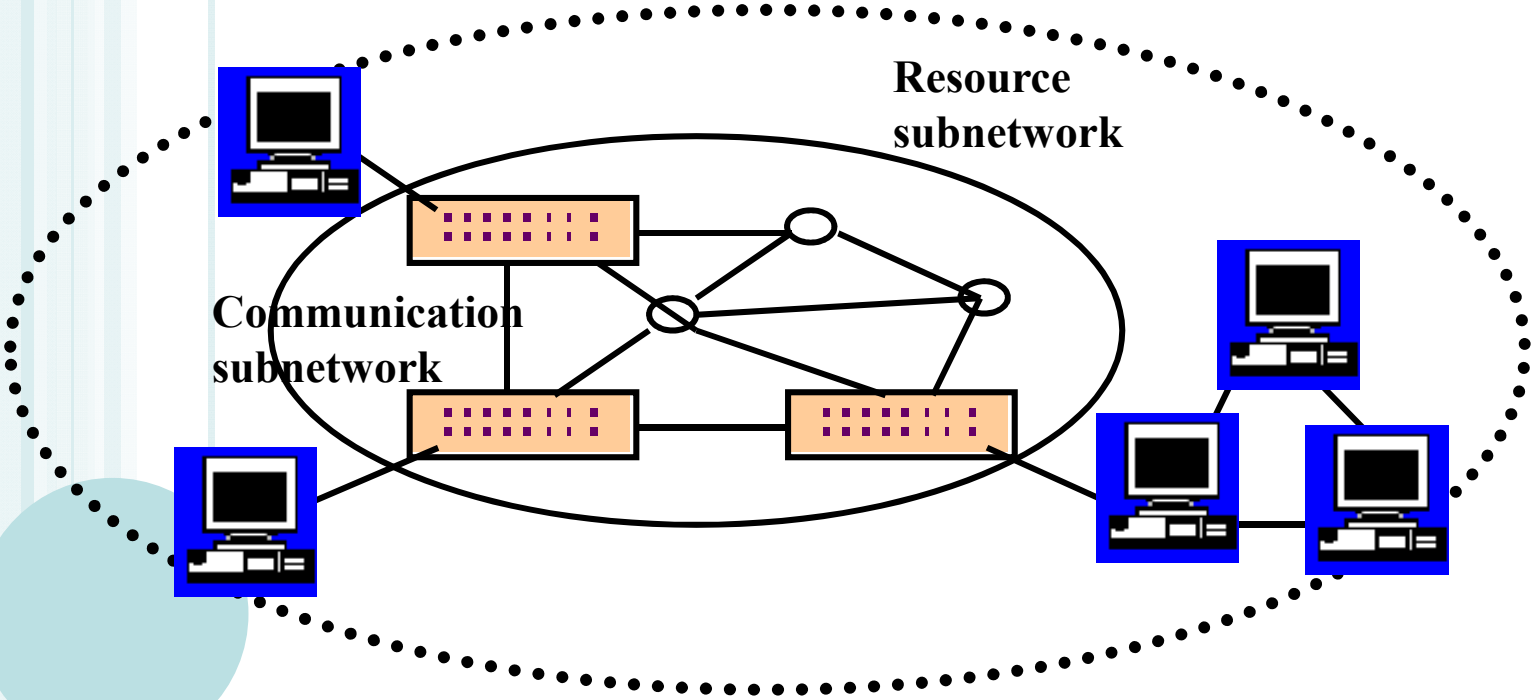
Network techniques:

Communication

Computer science



Network structure



What are the functions of the network?

- **Data communication**
- **Resource-sharing**
- **Distributed processing**

e.g. email, e-businnes, etc.

e.g. share the hardware, software and data resource

Divide the complicated problem into sub problems to process

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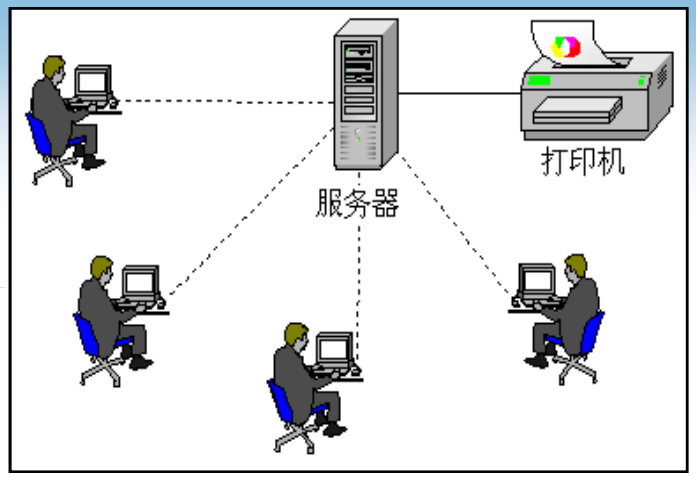
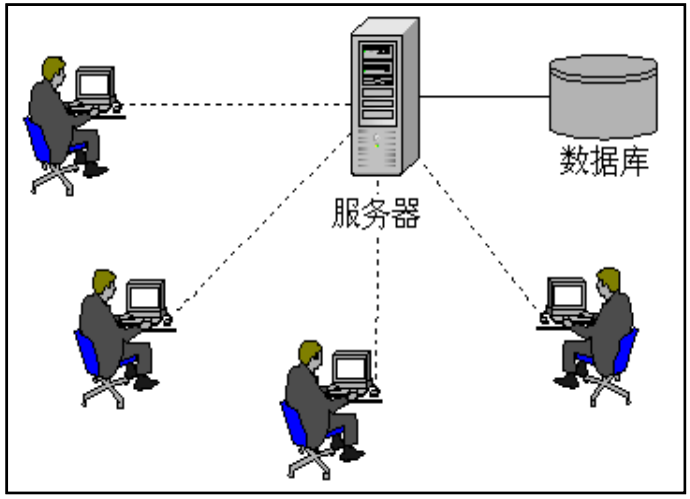
Resource sharing

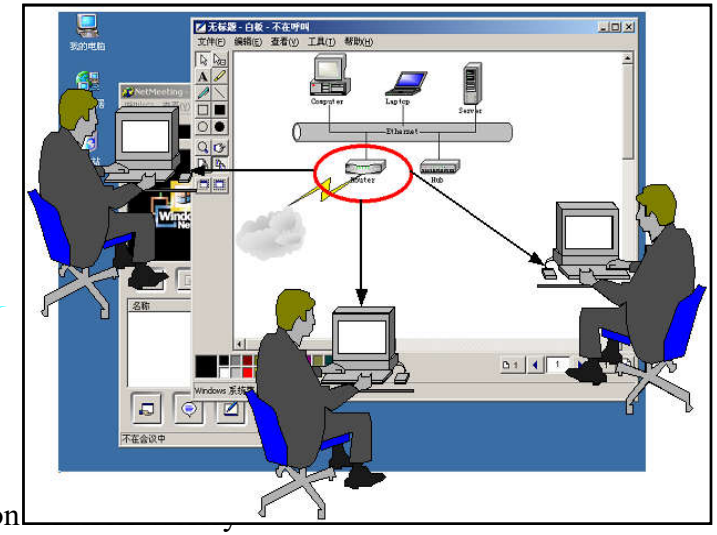
Hardware



Data



Software



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Cloud computing

- Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet).
- Application
  - Yahoo email
  - Amazon Web Services
  - Google Docs

Software as a service (SaaS) means delivering a software application from the cloud, often to users' browsers as a web-based application

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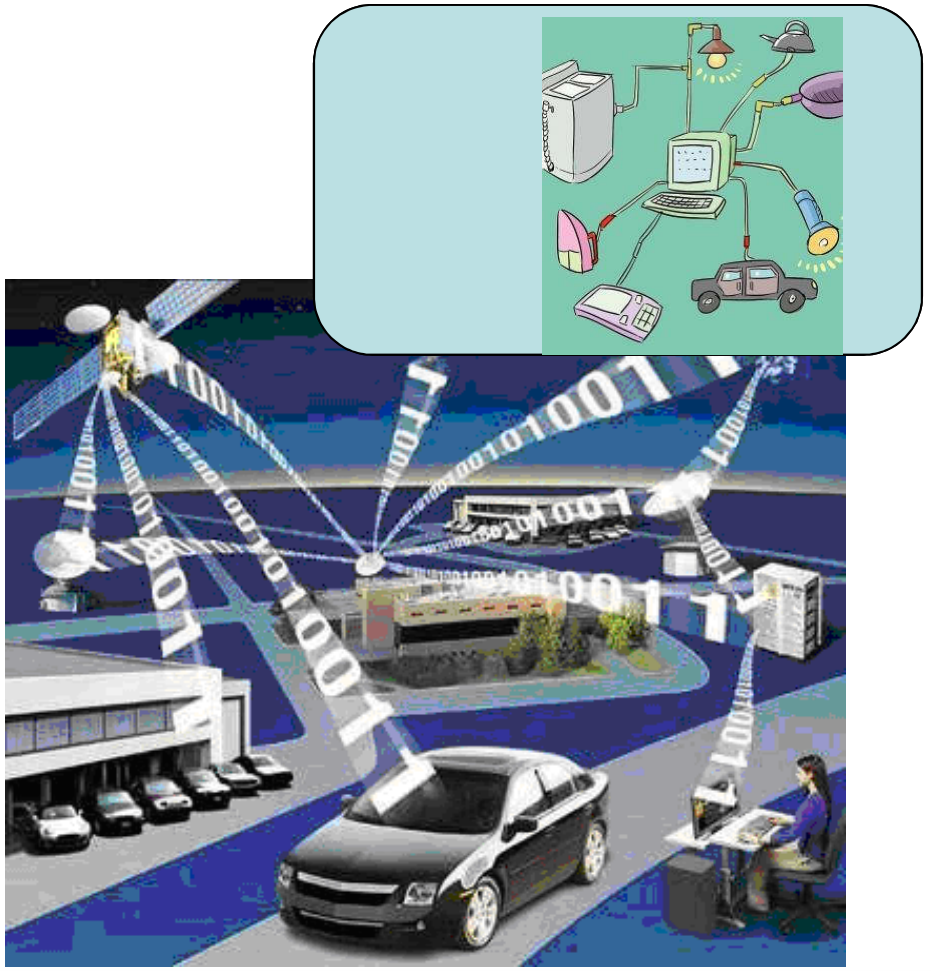
Internet of things

- **Internet of things： From anytime, any place connectivity for anyone, we will now have connectivity for anything.**

➢Auto-alarm for wrong driving operations
➢ Your suitcase will remind you of something missing
➢ Washing machine will tell you the required temperature
➢……



车联网

车联网：以车内网、车际网和车载移动互联网为基础，按照约定的通信协议和数据交互标准，在车-X（X：车、路、行人及互联网等）之间，进行无线通讯和信息交换的大系统网络，是能够实现智能化交通管理、智能动态信息服务和车辆智能化控制的一体化网络，是物联网技术在交通系统领域的典型应用。

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大数据

- 大数据分析常和云计算联系到一起，需要像MapReduce一样的框架来向数十、数百或甚至数千的电脑分配工作
- 数据量已经从TB（1024GB=1TB）级别跃升到PB（1024TB=1PB）、EB（1024PB=1EB）乃至ZB(1024EB=1ZB)级别
- 深度学习
- 美国疾病控制和预防中心依据网民搜索，分析全球范围内流感等病疫的传播状况

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Network Classifications

- Scope
  - Local area network (LAN)
  - Metropolitan area (MAN)
  - Wide area network (WAN)
- Ownership
  - Closed versus open
- Topology (configuration)
  - Bus (Ethernet)
  - Star (Wireless networks with central Access Point)

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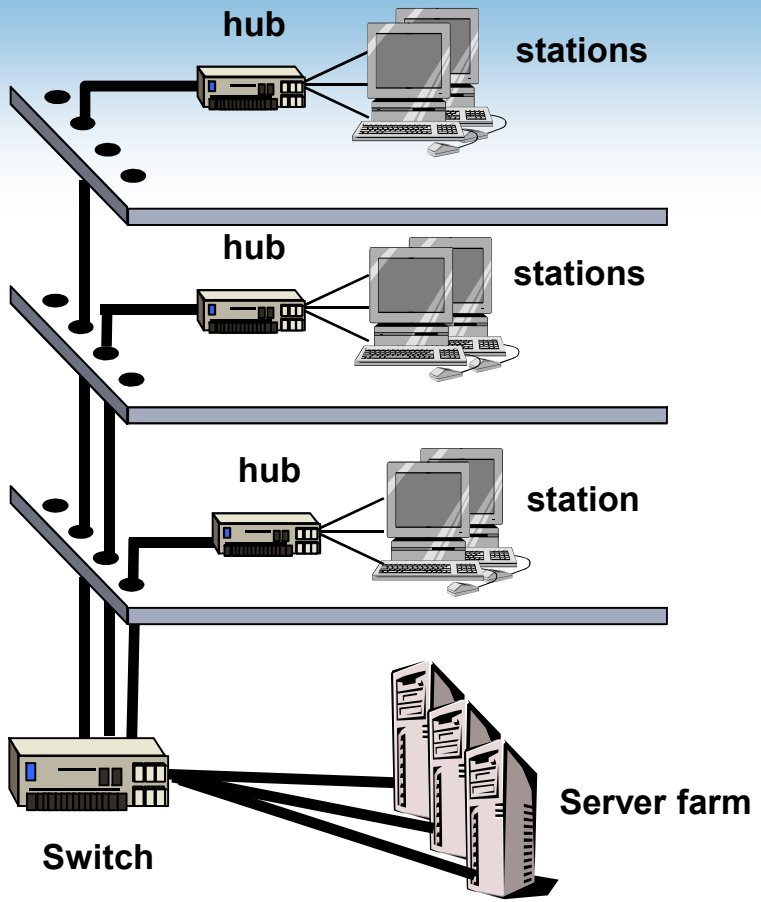

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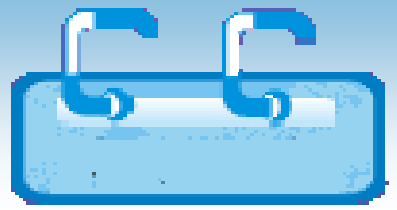
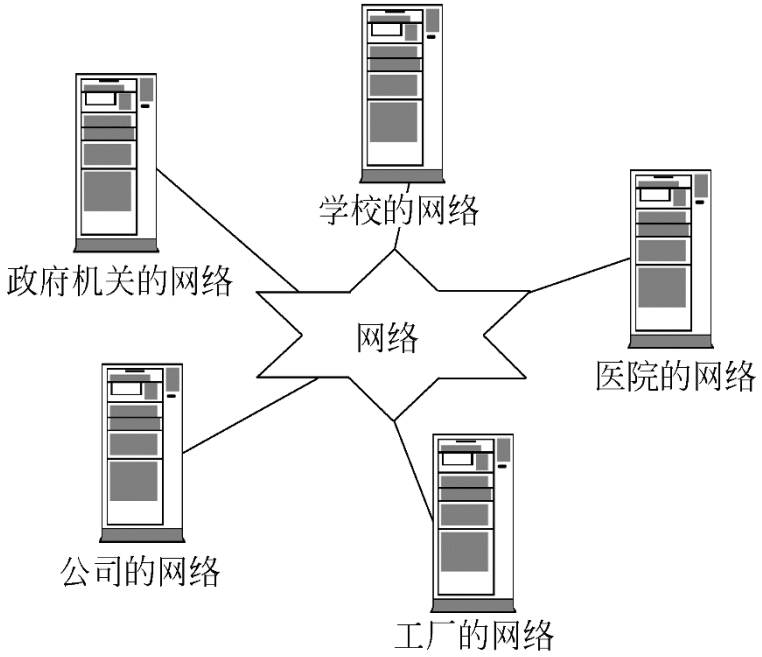


MAN



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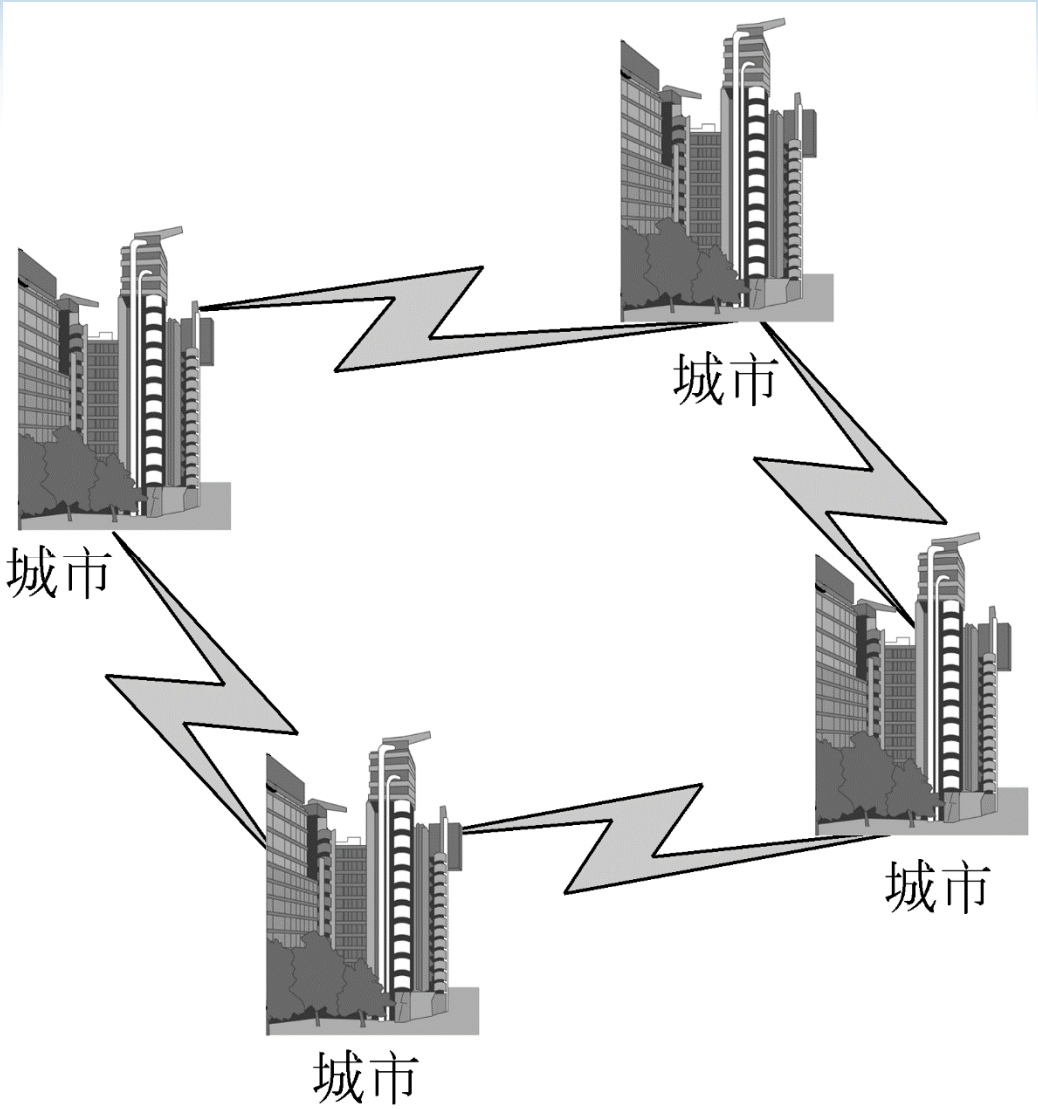
WAN



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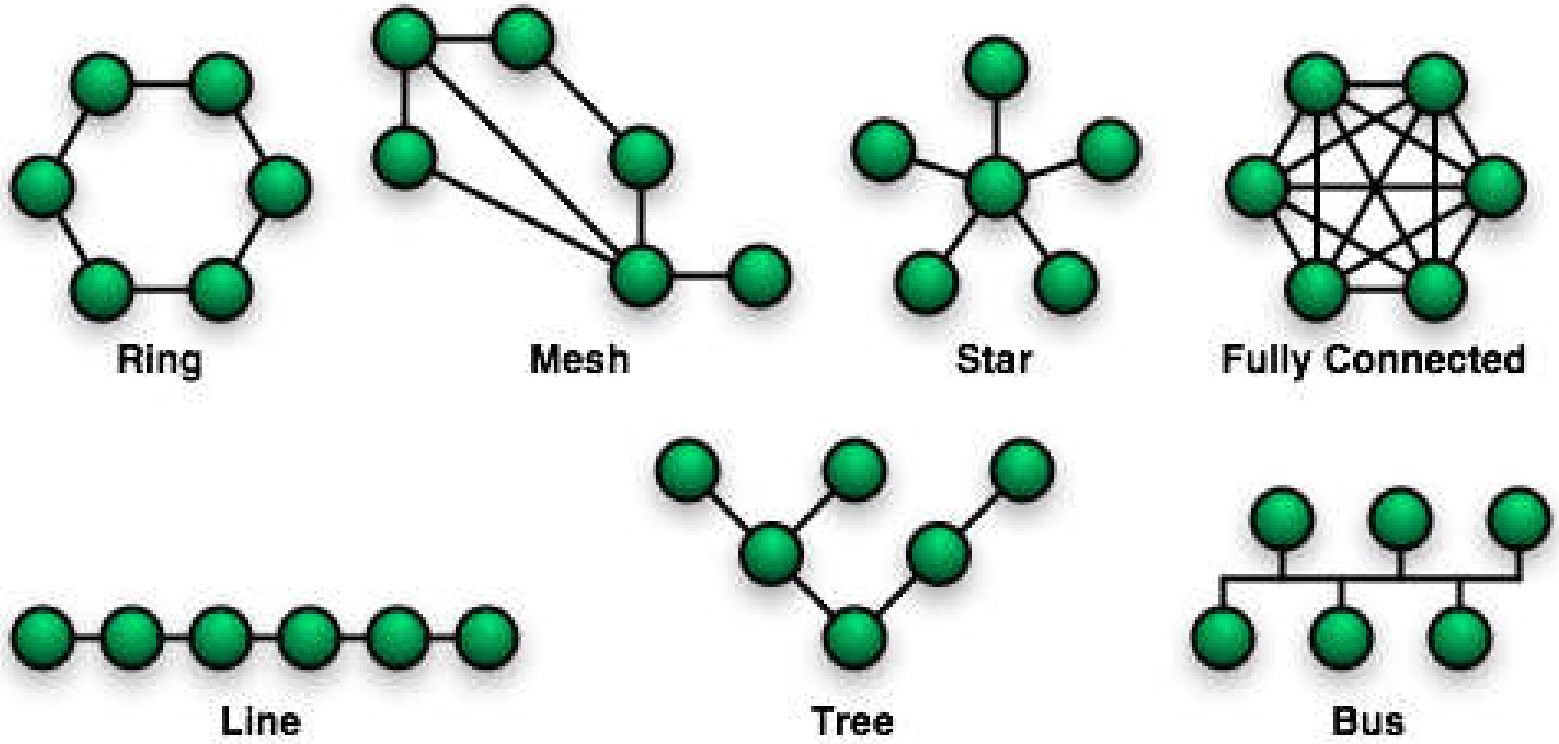
Various topologies



Wikipedia

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Network Topologies

- Topology - Physical and logical network layout
  - Physical – actual layout of the computer cables and other network devices
  - Logical – illustrates how data flows within a network, regardless of its physical design.
  - Common topologies:
    - Bus, ring, star, mesh and wireless

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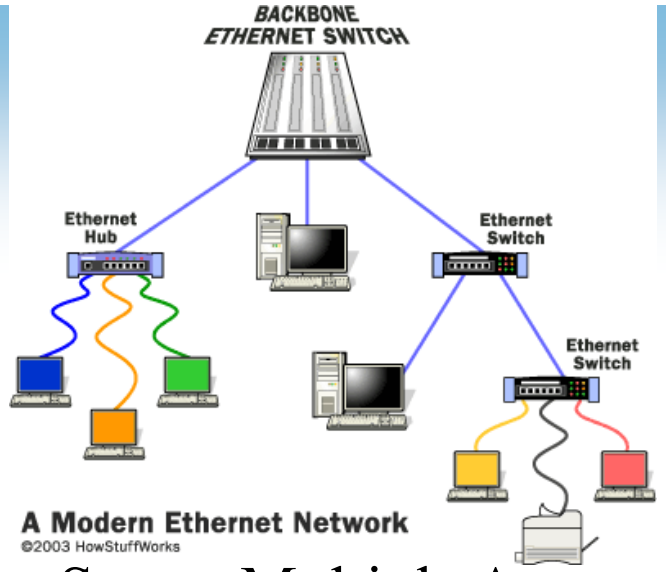
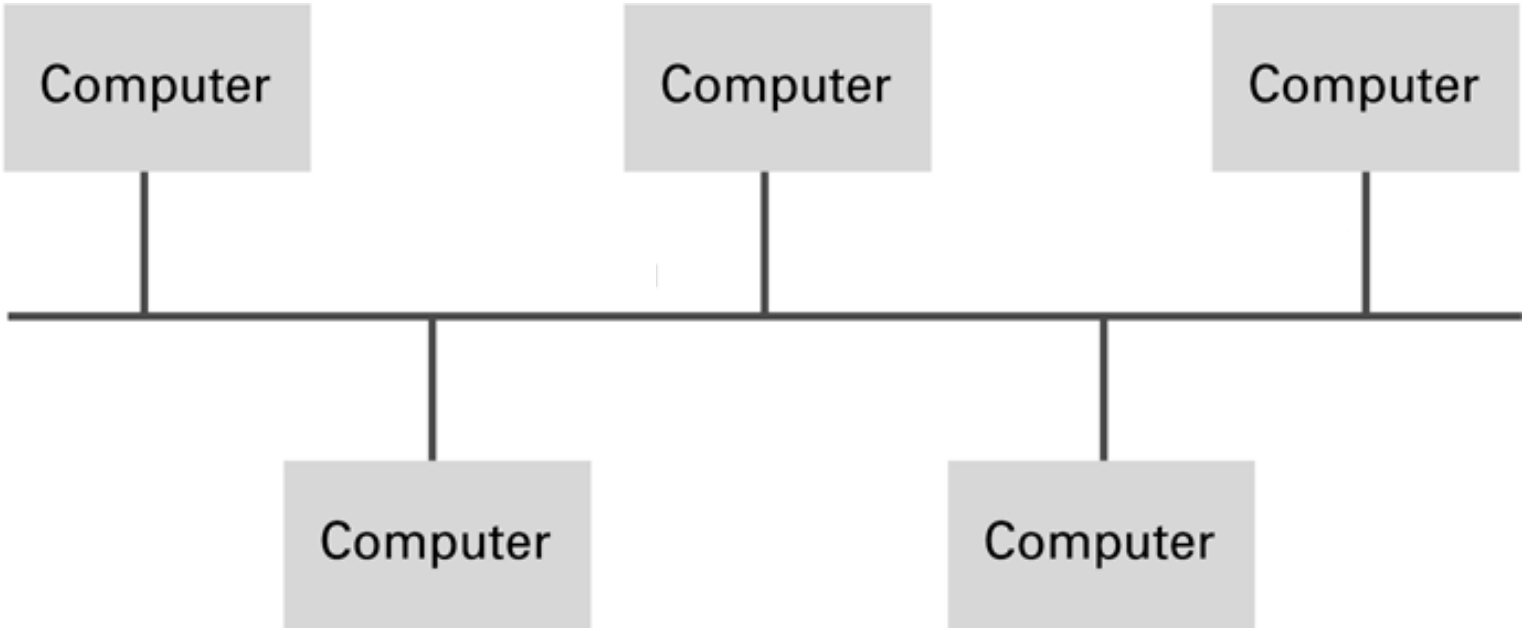
Topology



- Bus
  - Ethernet（以太网）
  - Protocal: CSMA/CD (Carrier Sense, Multiple Access with Collision Detection)带冲突检测的载波侦听多路访问



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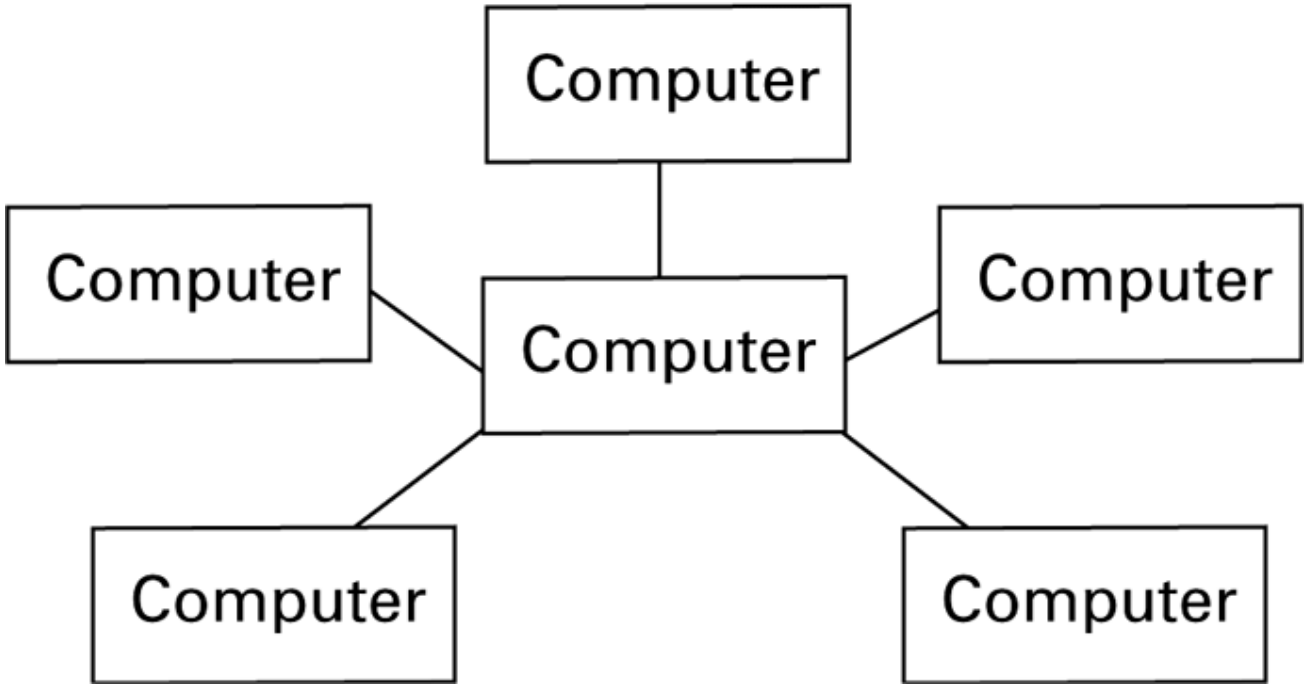
Topology (logical)

- Star
  - Wireless
  - Protocal: CSMA/CA带冲突避免的载波侦听多路访问



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- 网络拓扑可以根据通信子网中通信信道类型分为两类：
  - 点到点线路通信子网 （如：星型）
  - 广播信道通信子网 （如：总线型）

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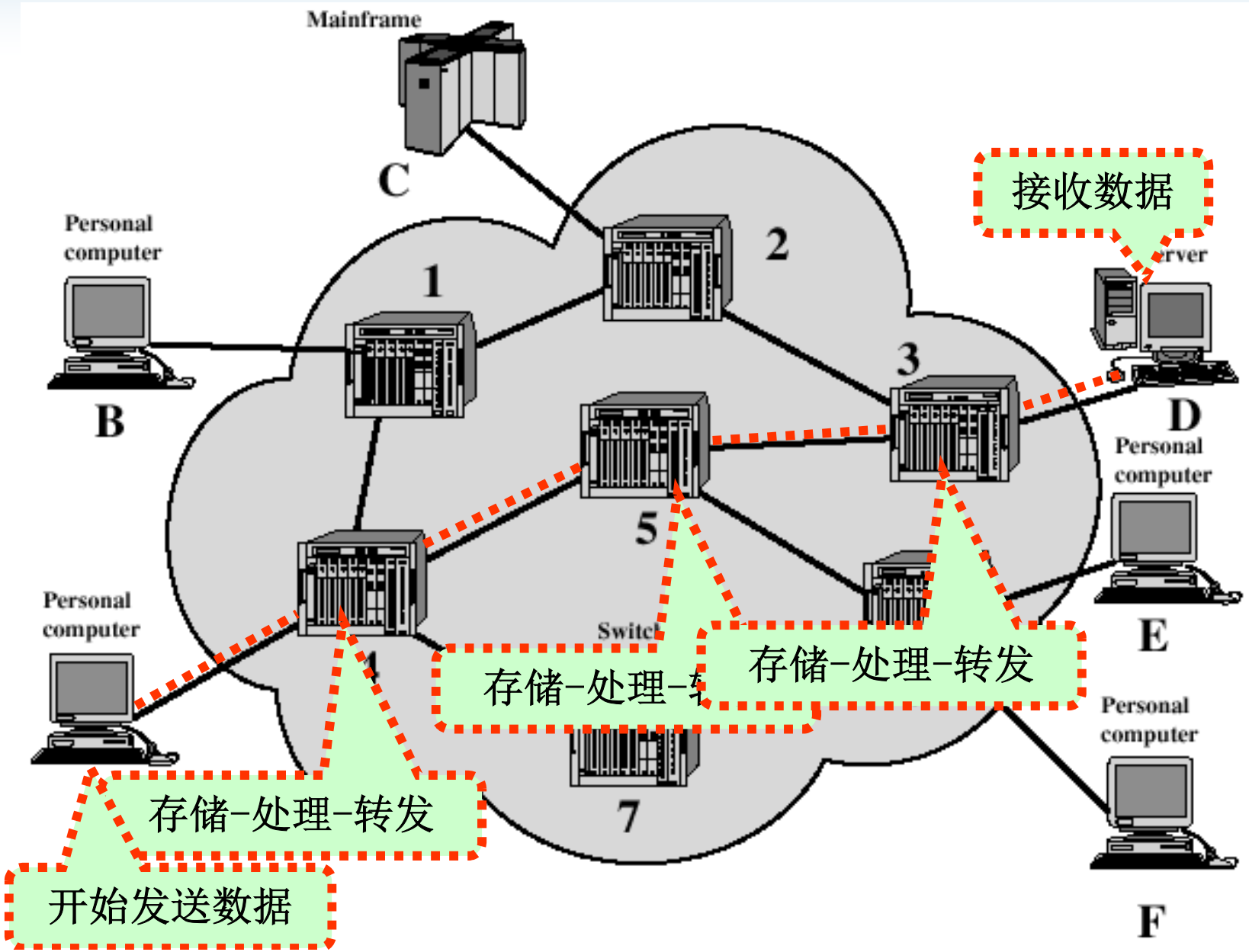
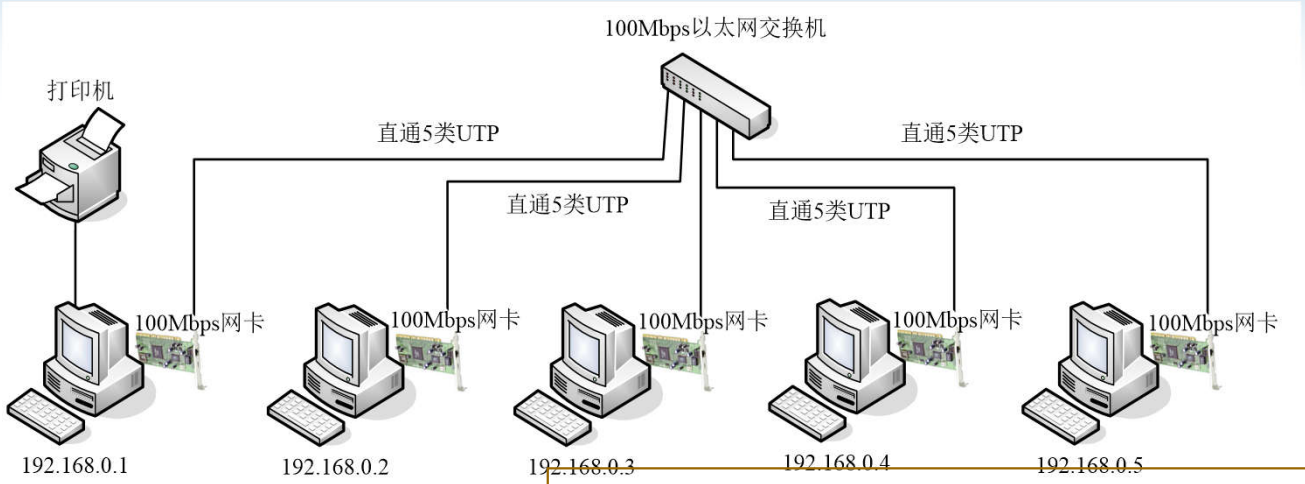
点到点式网络


Mainframe
C
Personal computer
B
1
2
3
5
7
Switch
D
Personal computer
E
Personal computer
F
Personal computer
接收数据
存储-处理-转发
存储-处理-转发
存储-处理-转发
开始发送数据

Build a local area network

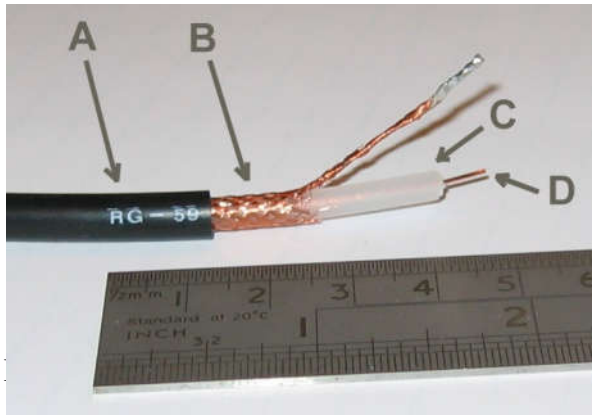


Components：

Switch

Network adapter

Network communication wires



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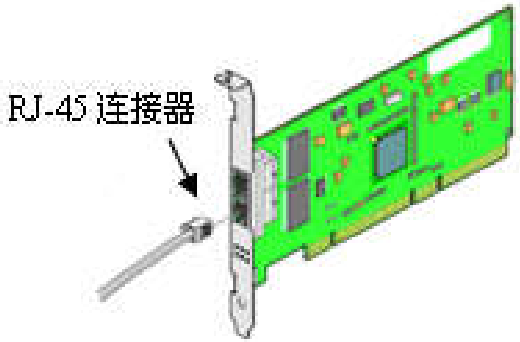
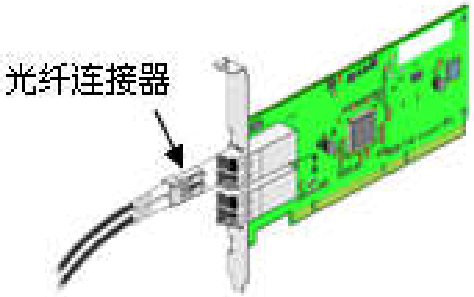
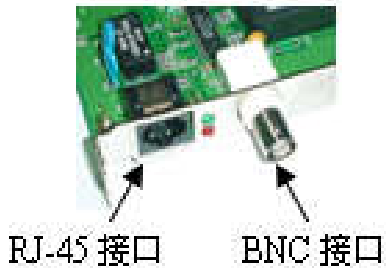
Network Adapter



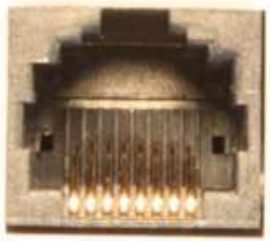
(a) RJ-45 接口网卡



(b) 光纤接口网卡



(c) 双接口网卡



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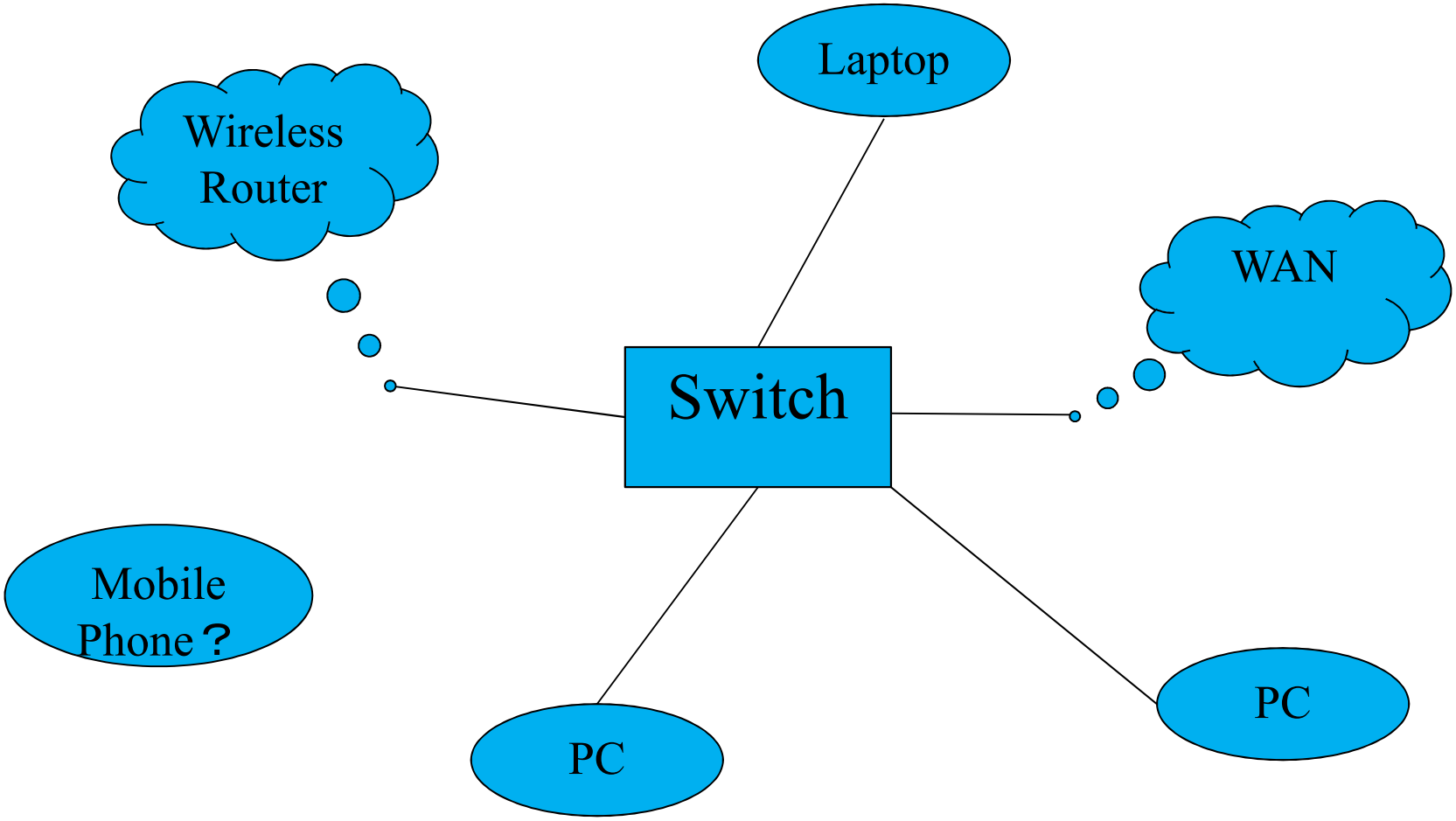
How to build a LAN?



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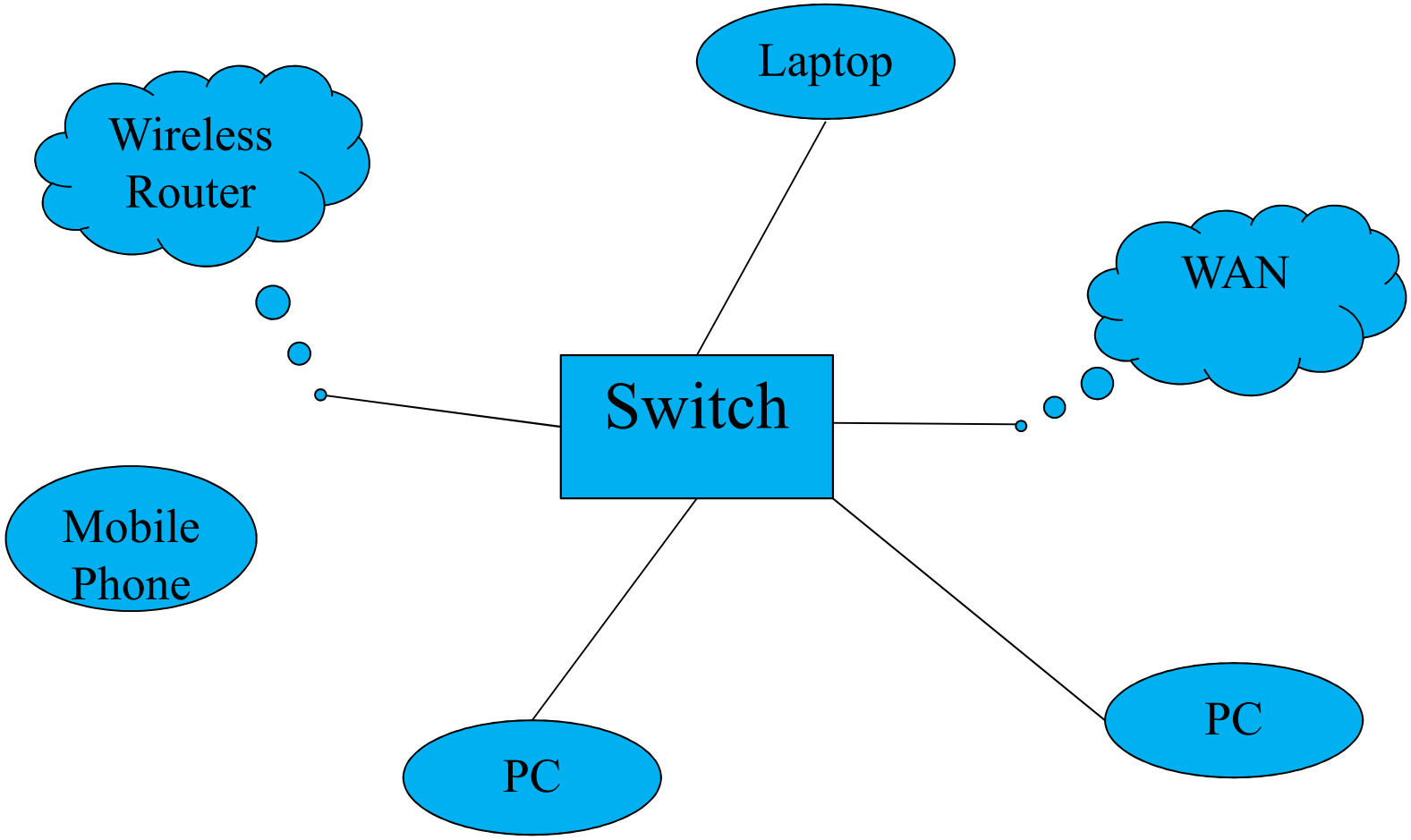
How to build a LAN?



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Connecting Networks

- **Repeater:** Extends a network
- **Bridge:** Connects two compatible networks
- **Switch:** Connect several compatible networks
- **Router:** Connects two incompatible networks resulting in a network of networks called an **internet**

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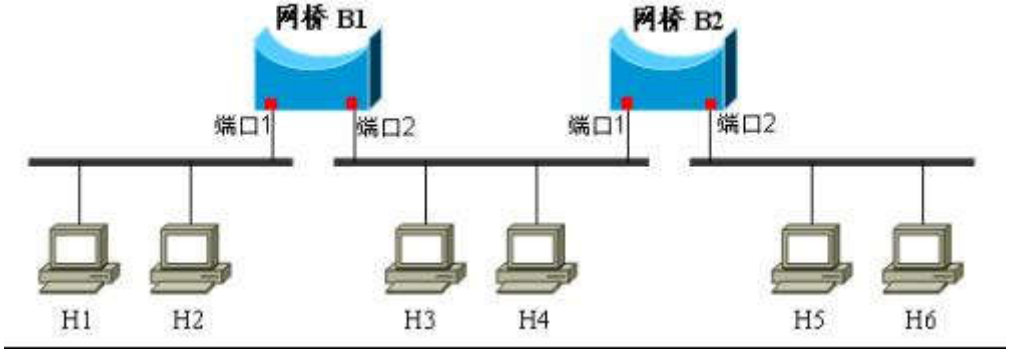
Connecting Networks

- 中继器（Repeater）：网络物理层上面的连接设备。适用于完全相同的两类网络的互连，通过对数据信号的重新发送或者转发，来扩大网络传输的距离，是两个原始总线间简单地来回传送信号

- 网桥(Bridge): 也叫桥接器，是连接两个局域网的一种存储/转发设备，要检查每条报文的目的地址，并且当该报文的目的地是另一边的计算机时才将其在线路上传输



- 交换机(Switch)

  扩大网络的器材，能为子网络中提供更多的连接端口，以便连接更多的计算机

- 路由器(Router)

  连接因特网中各局域网、广域网的设备，它会根据信道的情况自动选择和设定路由，以最佳路径，按前后顺序发送信号

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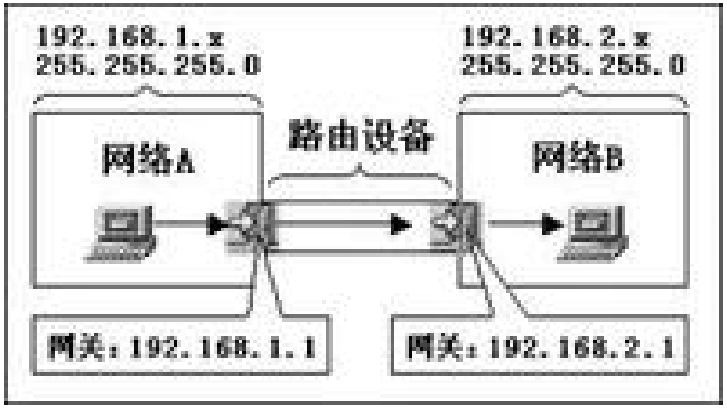
- 网关(gateway)
  - 复杂的网络互连设备，仅用于两个高层协议不同的网络互连。是一种充当转换重任的计算机系统或设备。在使用不同的通信协议、数据格式或语言，甚至体系结构完全不同的两种系统之间，网关是一个翻译器。与网桥只是简单地传达信息不同，网关对收到的信息要重新打包，以适应目的系统的需求。



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Hub (集线器)

- the ***simplest*** of these devices
- ***cannot filter data*** so data packets are sent to all connected devices/computers
- **Bandwidth of each port: Total bandwidth / W (numbers of ports)**

Bandwidth 带宽：发送信号中含有的有效成分的频率范围。在数据系统中，带宽用比特每秒（b/s）来度量

Bandwidth：10M bps 100M bps 1000M bps

http://www.teqlog.com/switch-vs-router-hub-bridge-repeater-wireless-access-point.html

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Switch(交换机)

- ***maintains a MAC address table***
- ***filters traffic on the LAN***
- ***looks at the destination of the packet before forwarding***
- **Each port: Total bandwidth**

http://www.teqlog.com/switch-vs-router-hub-bridge-repeater-wireless-access-point.html

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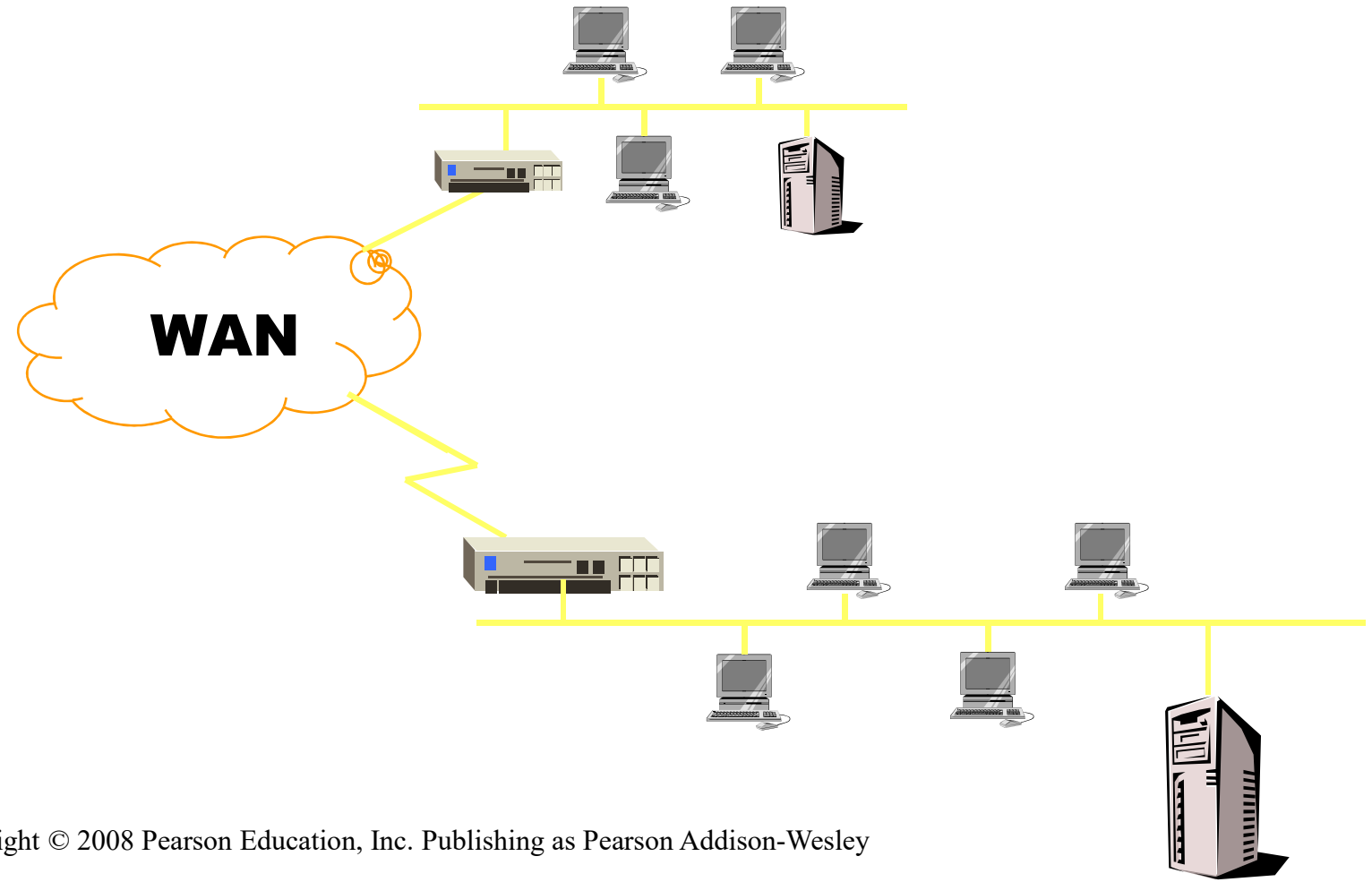
Router

A router is a device that forwards data packets between computer networks



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Router

- ***uses the IP address to forward packets***
- ***forward packets based on software***
- ***support different WAN technologies*** but switches do not
- Wireless Routers have ***Access Point built in***

http://www.teqlog.com/switch-vs-router-hub-bridge-repeater-wireless-access-point.html

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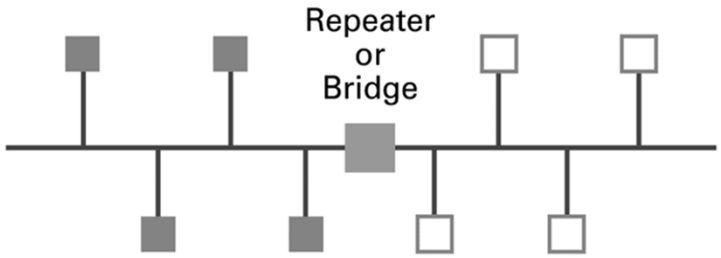
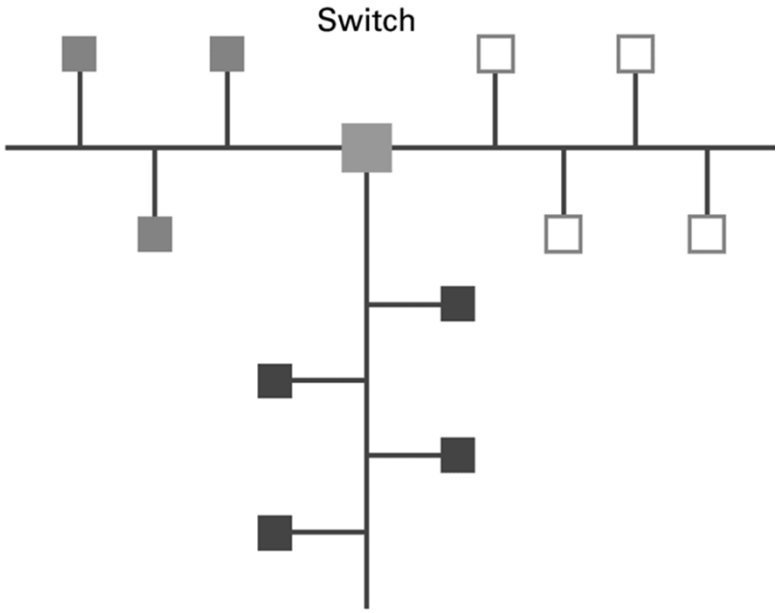
Figure 4.4 Building a large bus network from smaller ones



a. A repeater or bridge connecting two buses



b. A switch connecting multiple buses

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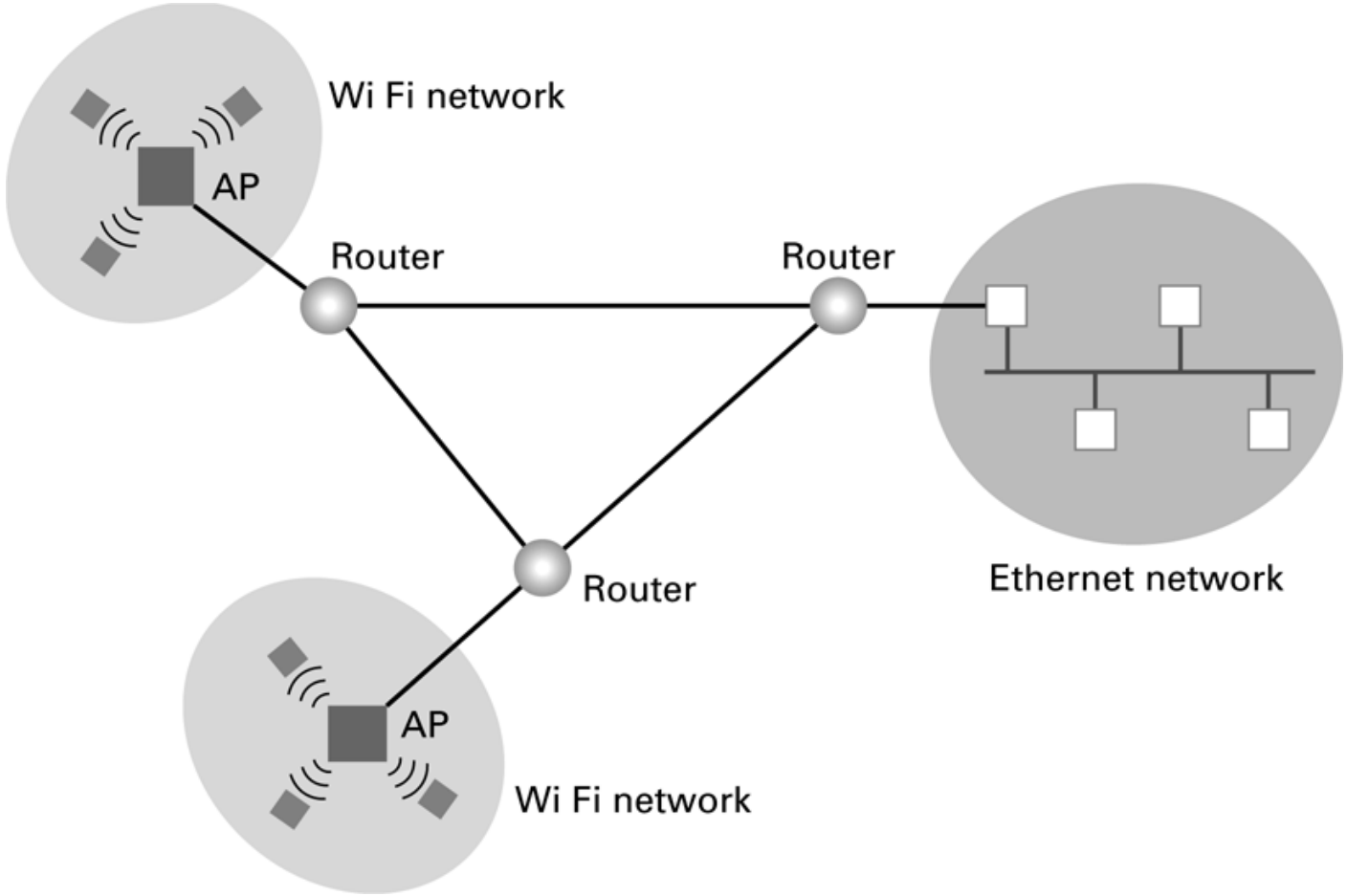
Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet



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Inter-process Communication

- Client-server
  - One server, many clients
  - Server must execute continuously
  - Client initiates communication
- Peer-to-peer (P2P) 对等网
  - Two processes communicating as equals
  - Peer processes can be short-lived

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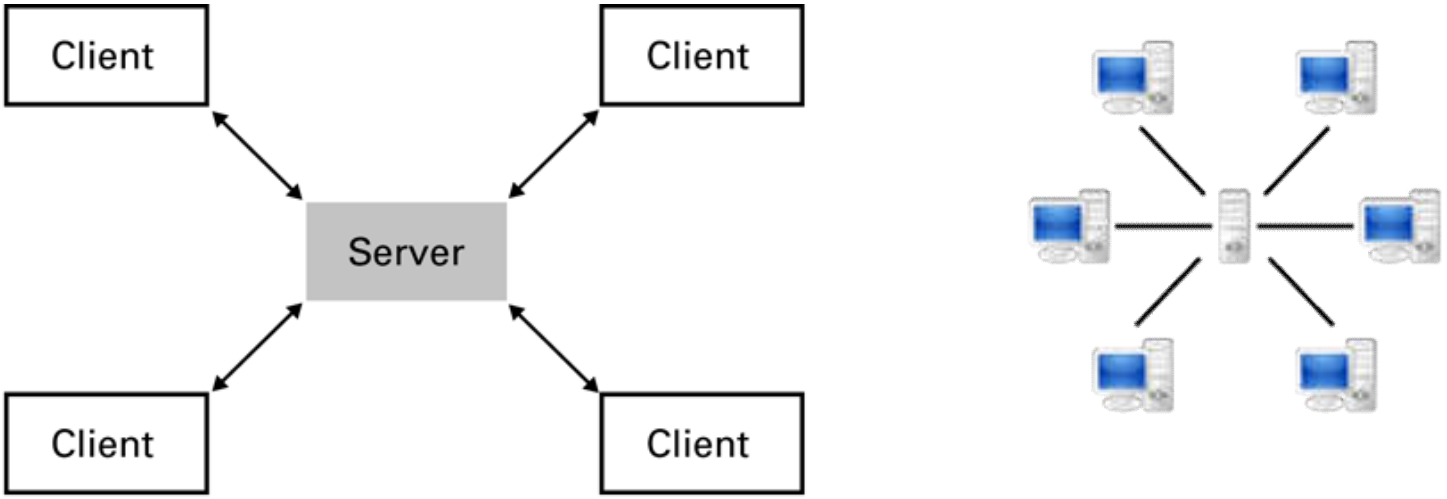
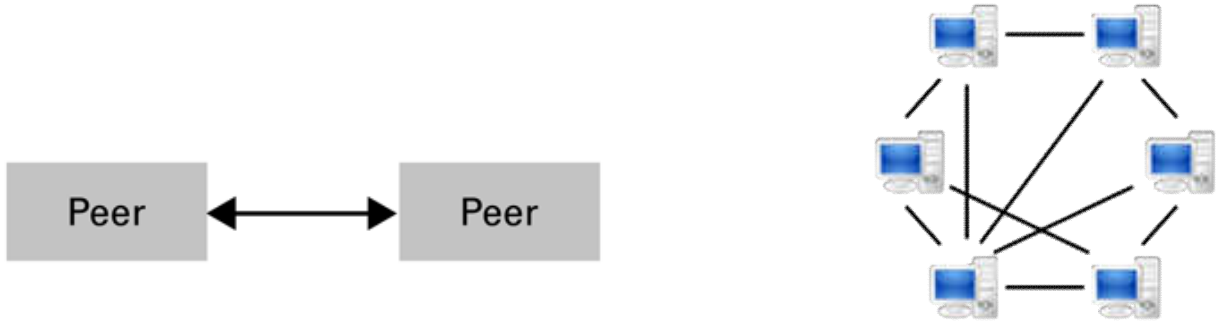
Figure 4.6 The client/server model compared to the peer-to-peer model



a. Server must be prepared to serve multiple clients at any time.



b. Peers communicate as equals on a one-to-one basis.

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对等网

- 通常是由计算机组成的工作组
- 计算机无主从之分
- 网上任意节点既可以作为网络服务器，也可以作为工作站
- 任一台计算机均可同时兼作服务器和工作站，也可只作其中之一
- 对等网除了共享文件之外，还可以共享打印机

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Server/Client

（Server）

A computer or computer program that manages access to a centralized resource or service in a network.

（Client）

Common computers

Working styles

（Client/Server， C/S）

（Browser/Server， B/S）

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C/S：Client/Server(客户机/服务器)结构

- 任务合理分配到Client端和Server端
- 降低了系统的通讯开销
- 充分利用两端硬件环境的优势

B/S：Browser/Server(浏览器/服务器)结构

- 用户界面完全通过WWW浏览器实现
- 一部分事务逻辑在前端实现
- 主要事务逻辑在服务器端实现

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Network model

计算机网络是指由通信线路互相连接的许多自主工作的计算机构成的集合体，各个部件之间以何种规则进行通信，就是网络模型研究的问题

Video: how does it work?

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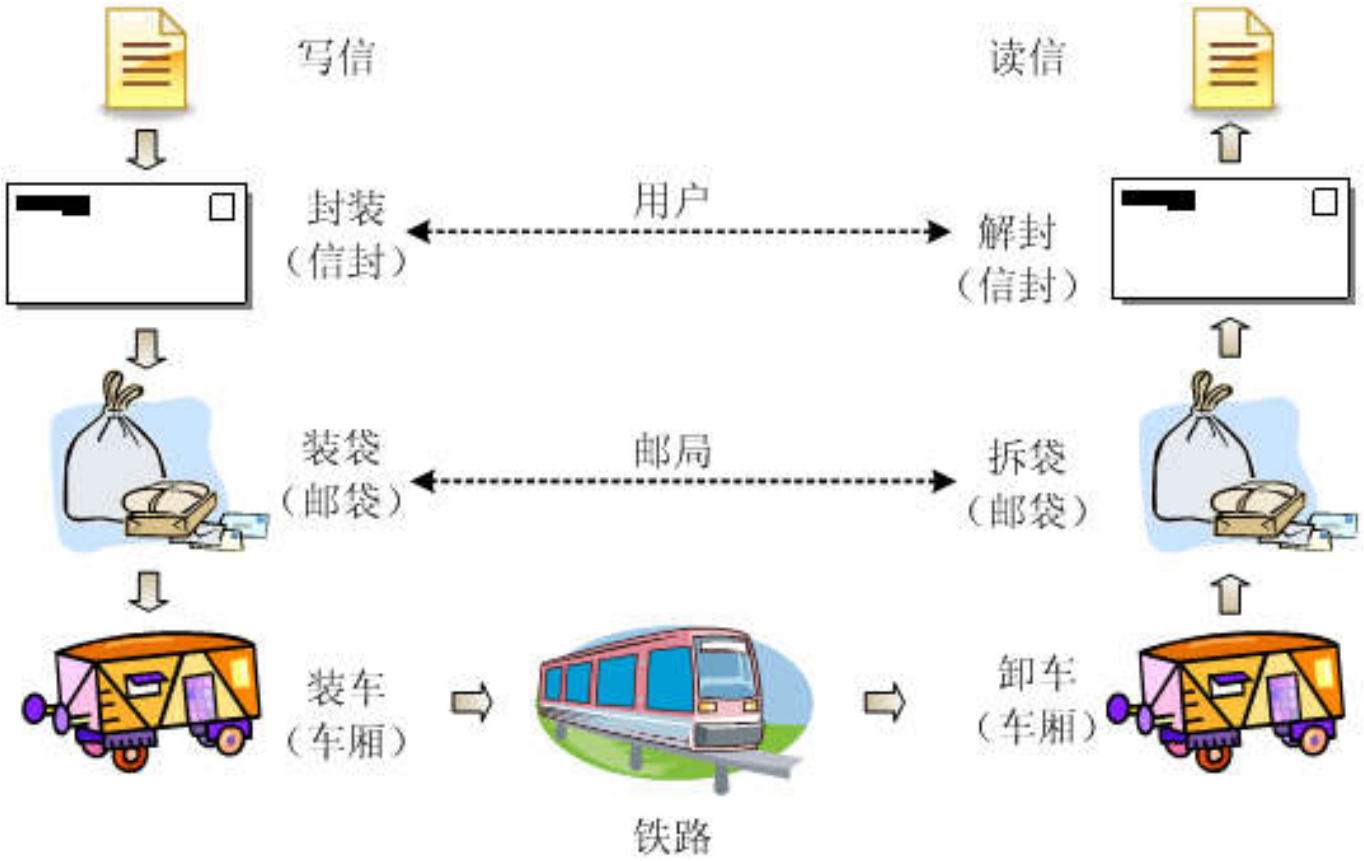
Figure 4.12 Package-shipping example



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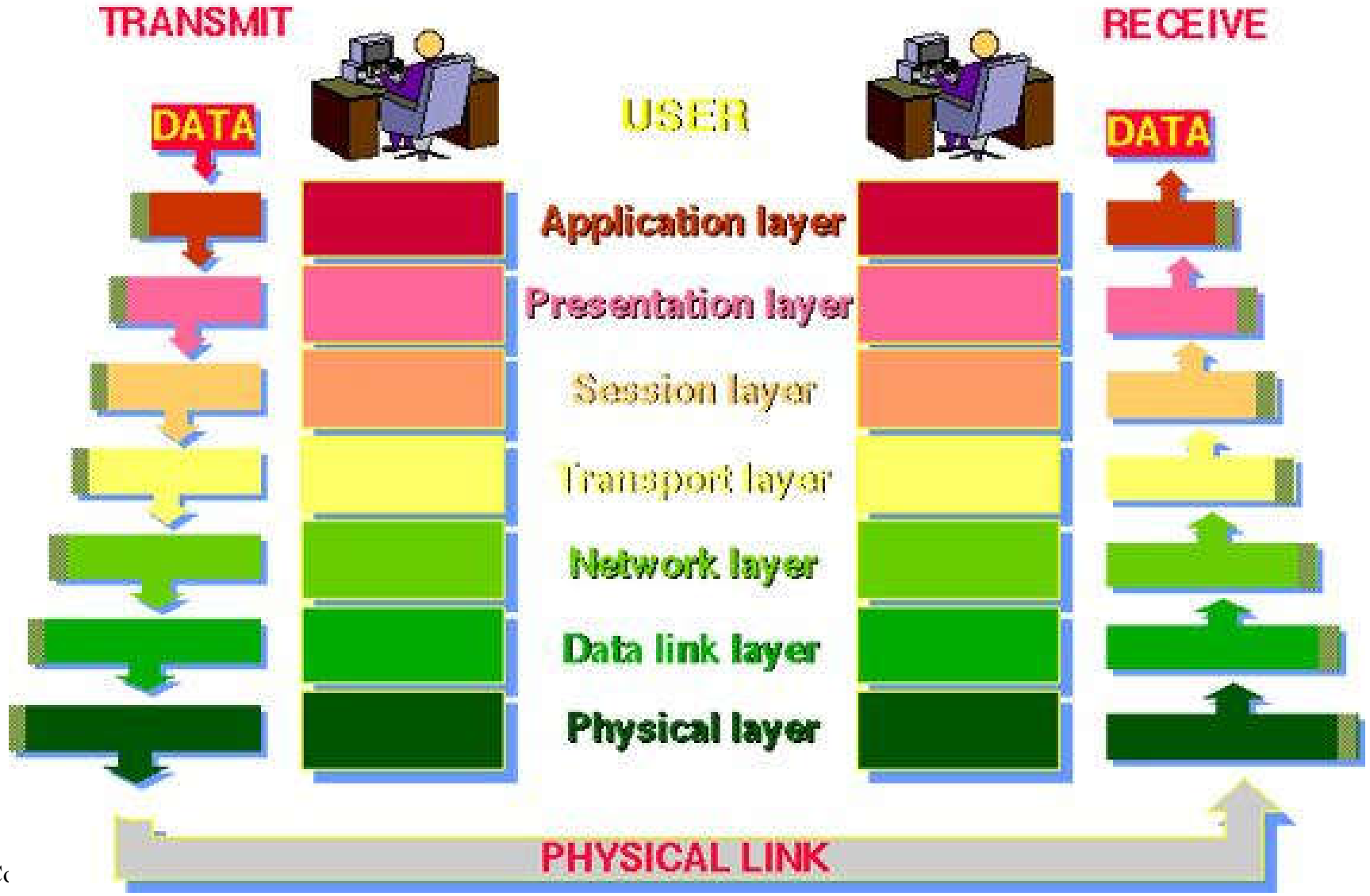
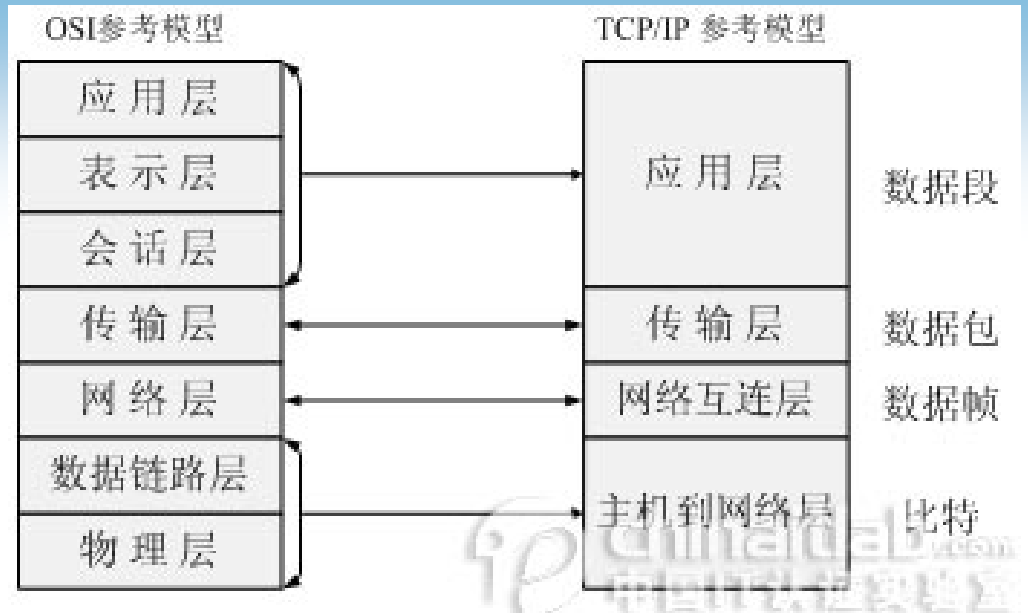
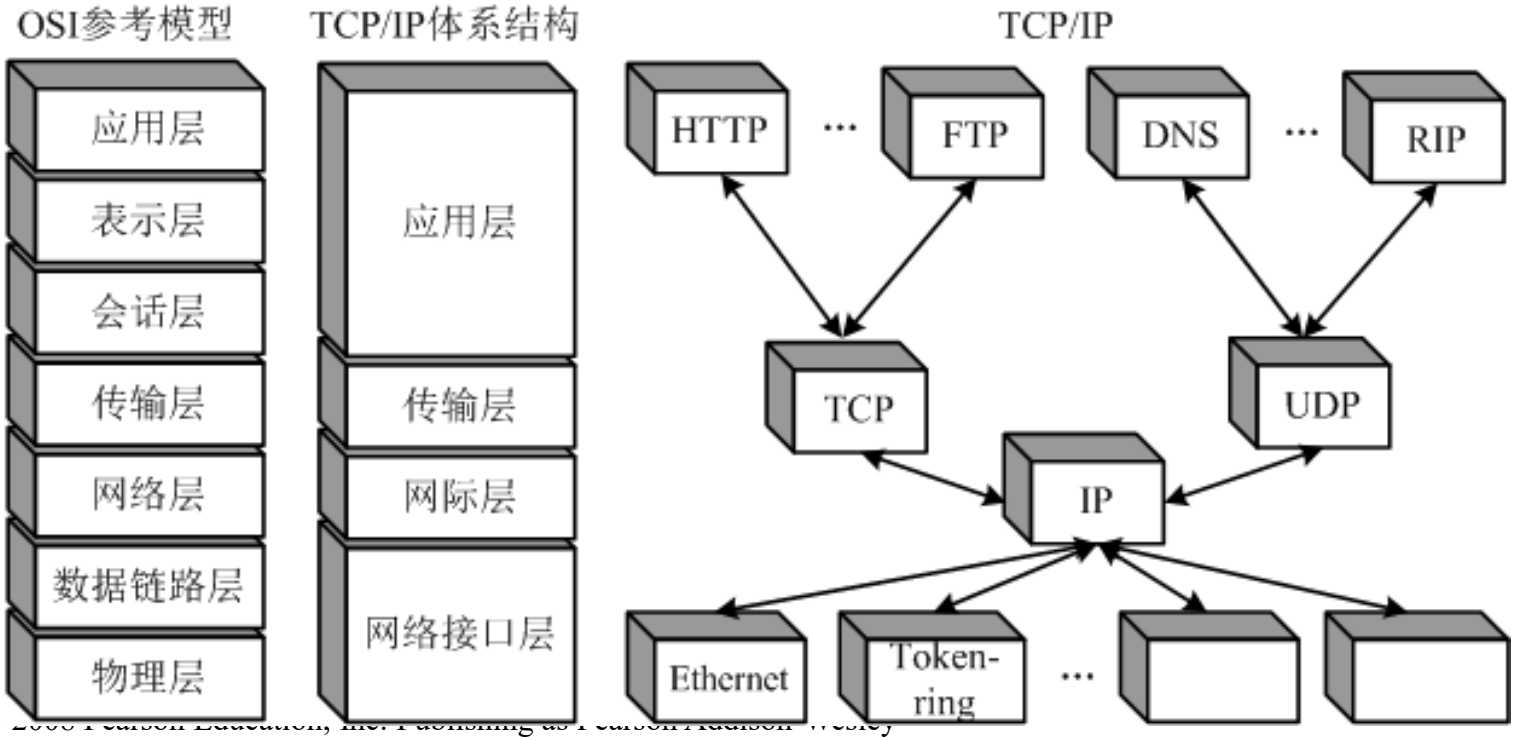
THE 7 LAYERS OF OSI







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Internet Software Layers

- **Application:** Constructs message with address
- **Transport:** Chops message into packets
- **Network:** Handles routing through the Internet
- **Link:** Handles actual transmission of packets

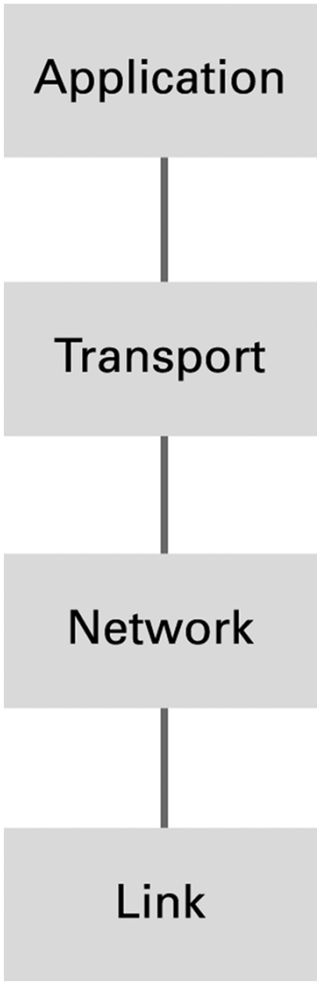

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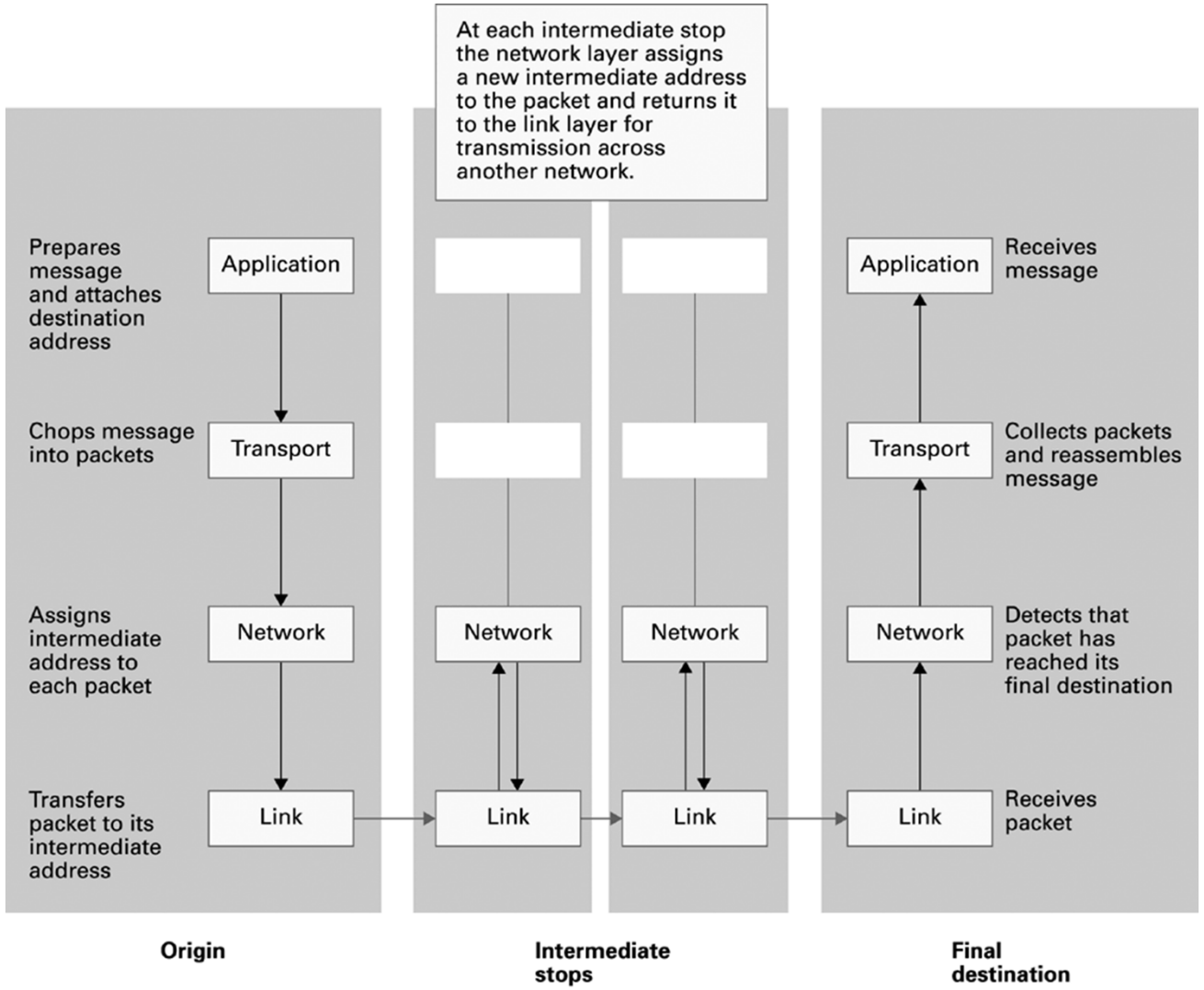
Figure 4.14 Following a message through the Internet



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Layered Approach: Why?

- Each task in different layer can be handled more easily without considering the details of the tasks in other layers.
  - For example, they can decide a “best” restaurant without considering how to go there
- Methods in different layers can be changed easily.
  - For example, different applications can use the same transport protocol.

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