Introduction

Introduction Outline

- **Preliminary Definitions**
- **Internet Components**
- **Network Application Paradigms**
- **Classifying Networks**
  - **by transmission technology**
  - **by size/scale**
  - **by topology**
- **Summary**

Definitions

computer network ::

[Tan] a collection of autonomous computers interconnected by a single technology.

[LG&W] communications network ::a set of equipment and facilities that provide a service.

[P&D] a network provides connectivity among a set of computers.

Initially, computers were directly connected over a physical medium such as copper, coaxial cable or optical fiber.

Selecting the set of computers involves security and scalability issues.
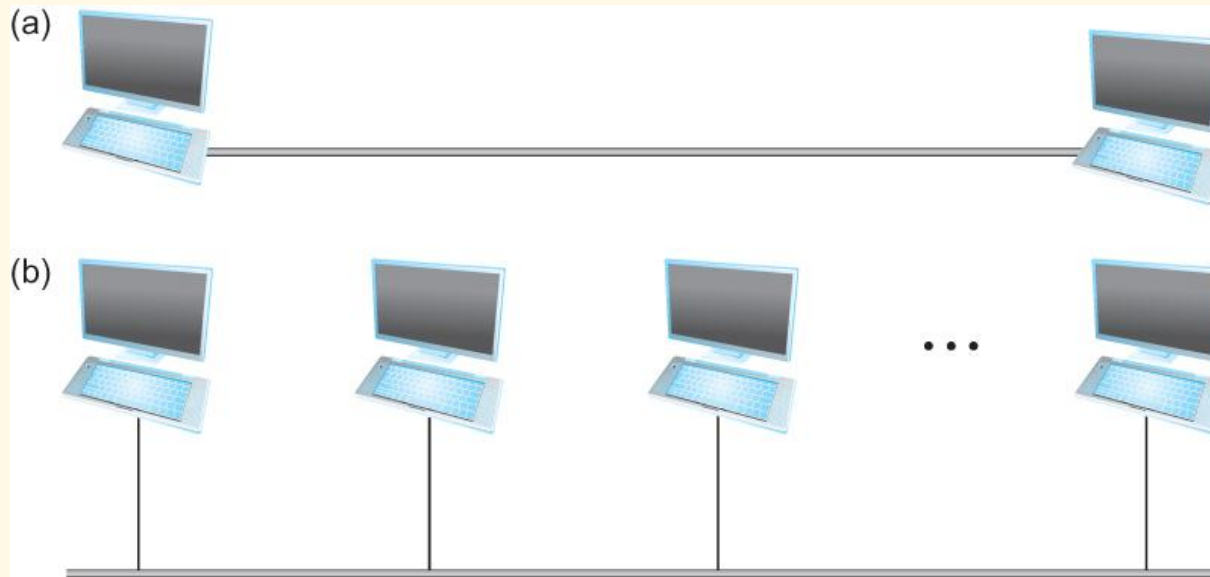
Physical Connectivity

Figure 1.2 Direct links:
(a) point-to-point
(b) multiple access (MA)

Other Forms of Connectivity

- Indirect connectivity through a set of cooperating nodes.
- Wireless connectivity:
  - WiFi   (IEEE802.11)
  - Cellular
  - Bluetooth
  - Zigbee (part of IEEE802.15.4)
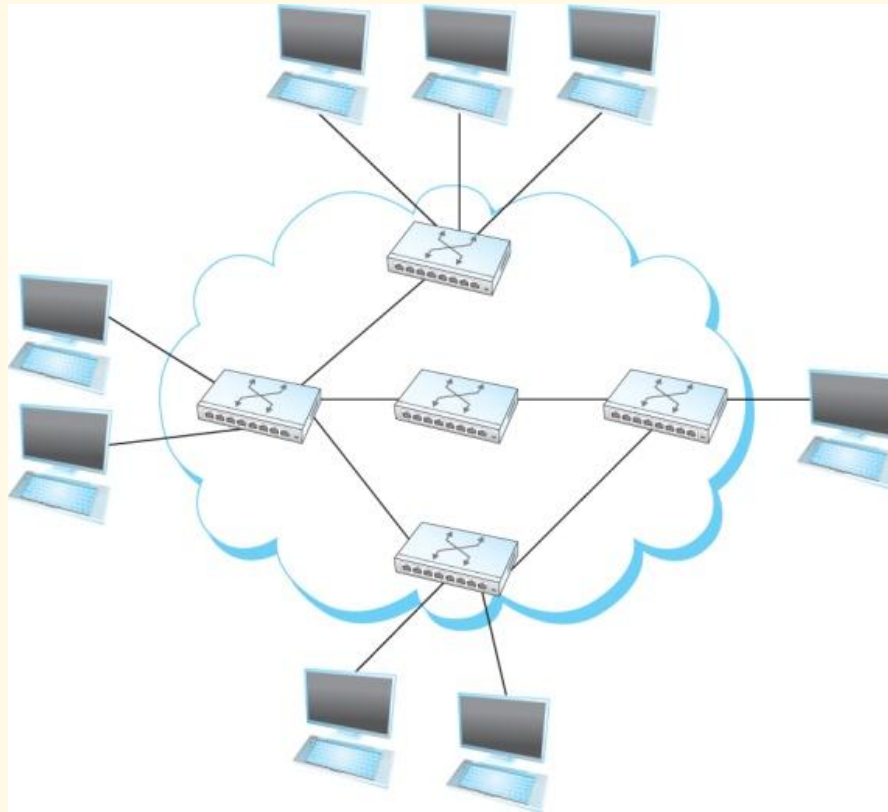 - WiMAX

Switched Network
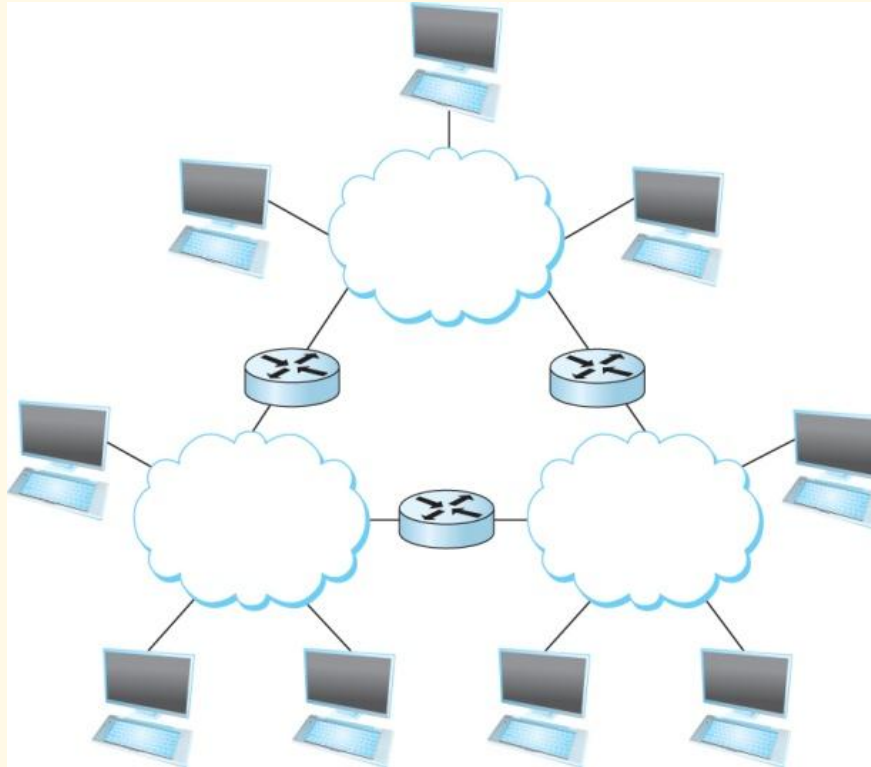

Figure 1.3 Switched network

An internet

Figure 1.4 Interconnection of Networks

Definitions

In a **distributed system::** the collection of independent computers appears to its users as a single coherent system.
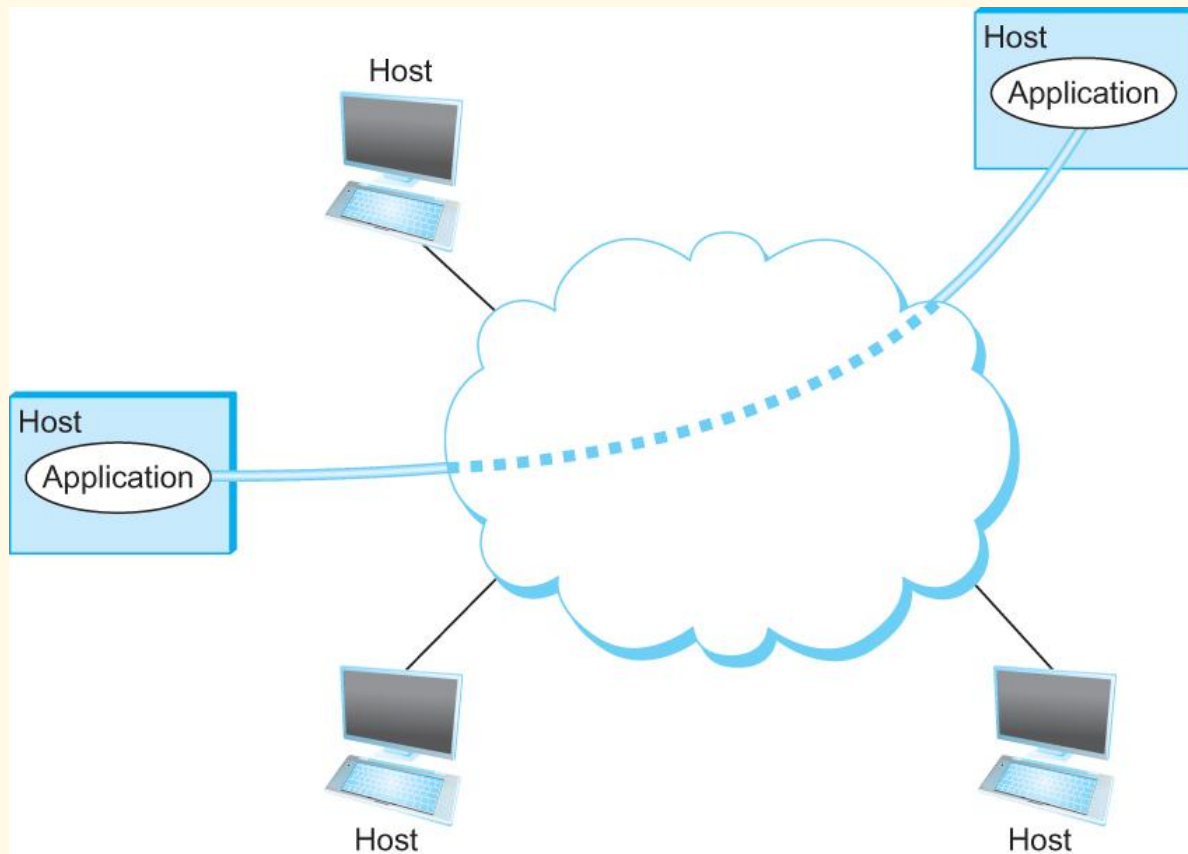
Namely, the distinction between a computer network and a distribution system lies in the transparency in assigning tasks to computers.

Example:

NFS is a distributed files system.

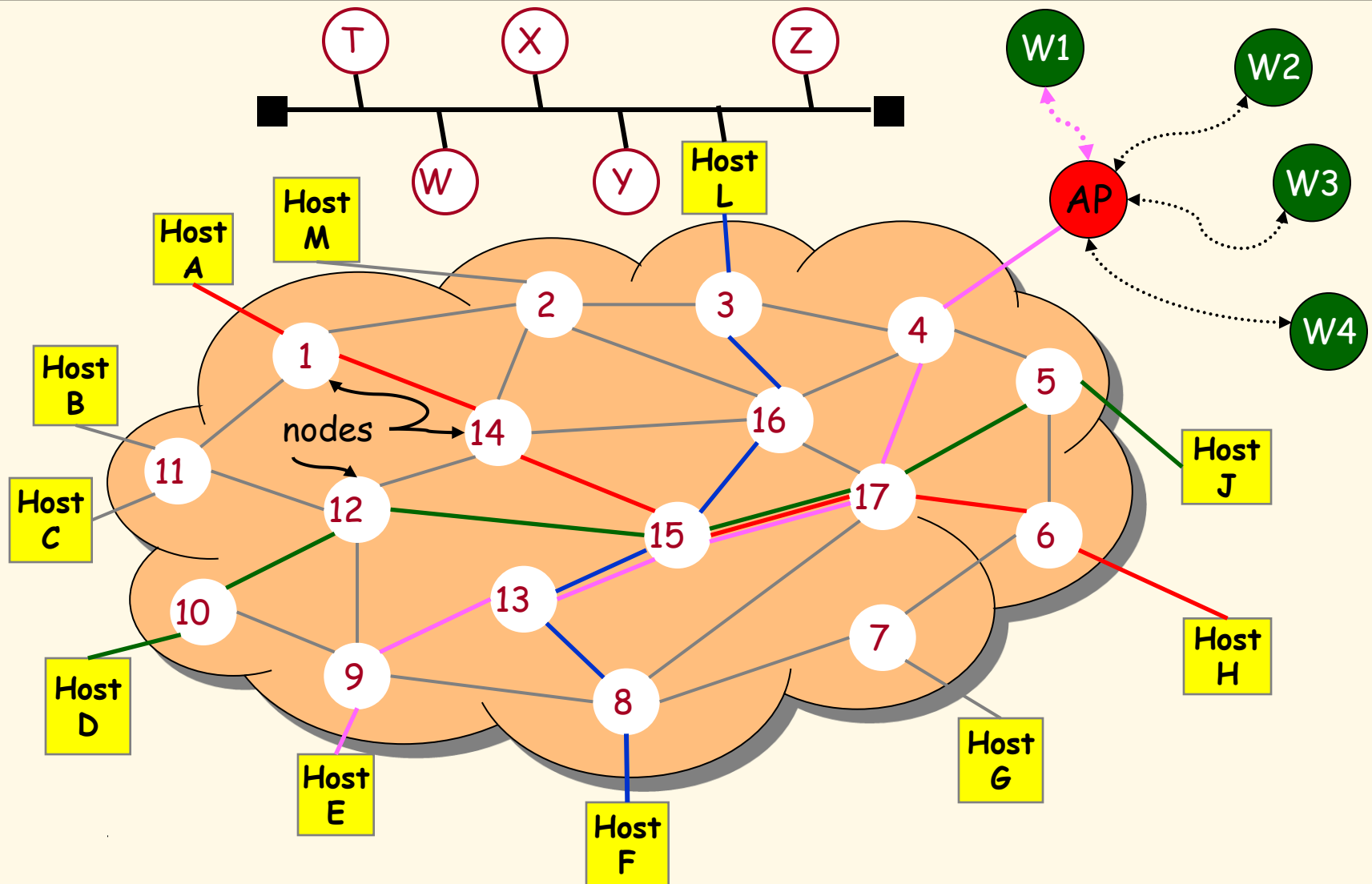Computer networks provide host-to-host connectivity by assigning an address to each node.
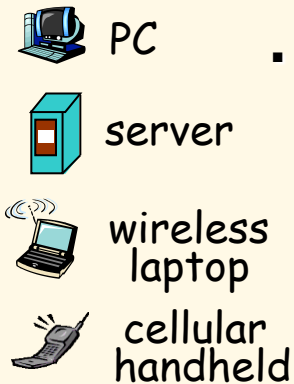
Application Communication

Figure 1.7   Processes communicating over an abstract channel
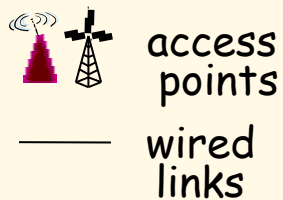
Internet Access and Flows

The Internet: "nuts and bolts" view

PC

server

wireless laptop

cellular handheld

- **billions of connected computing devices:** *hosts = end systems*
  - **running *network apps***
  - ❑ *communication links*
    - ❖ fiber, copper, radio, satellite
    - ❖ transmission rate = *capacity*

access points

wired links

router

Mobile network

Global ISP

Home network

Regional ISP

Institutional network

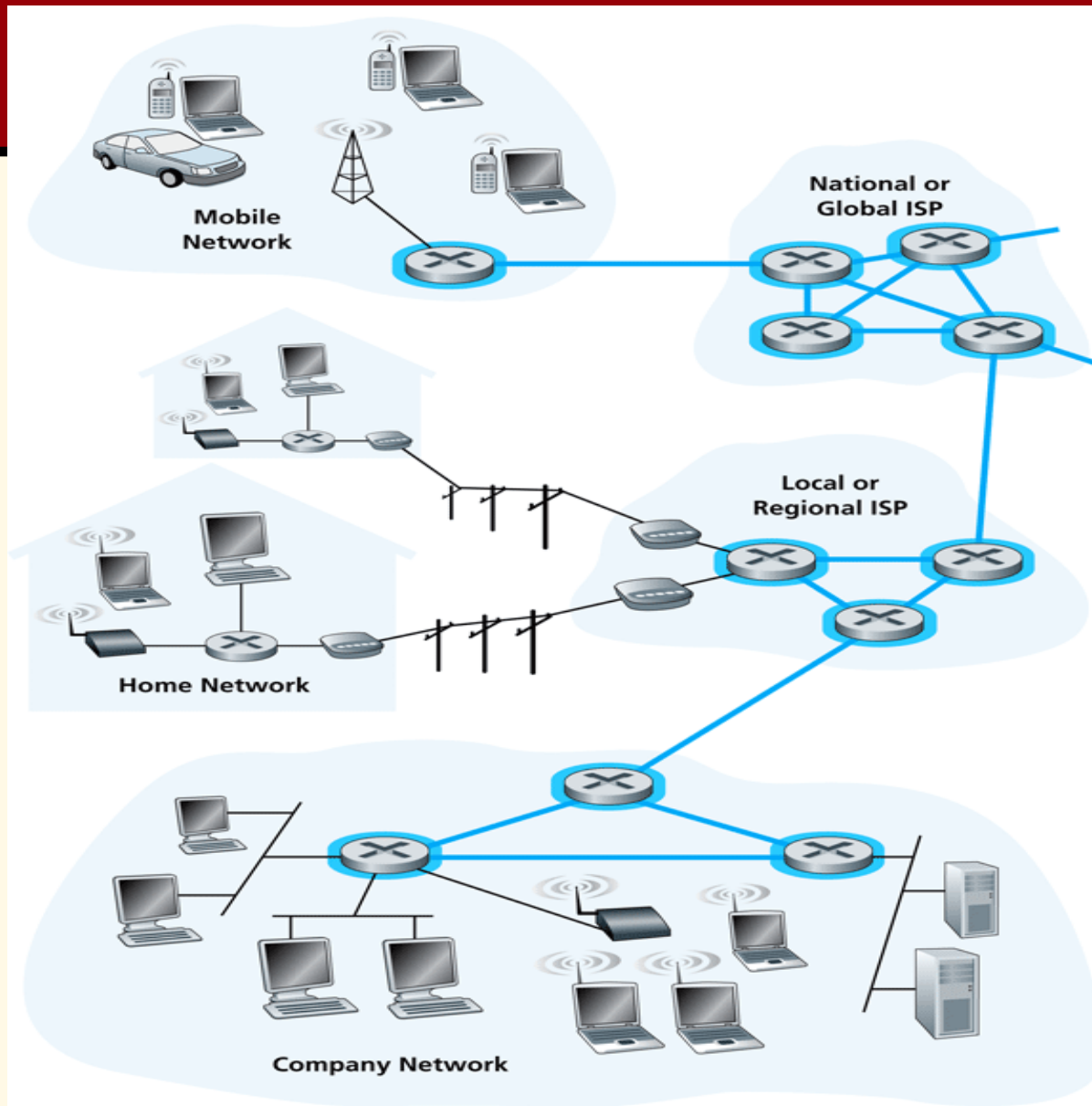- ❑ *routers**: forward packets (chunks of data)

* Also referred to as switches or gateways.
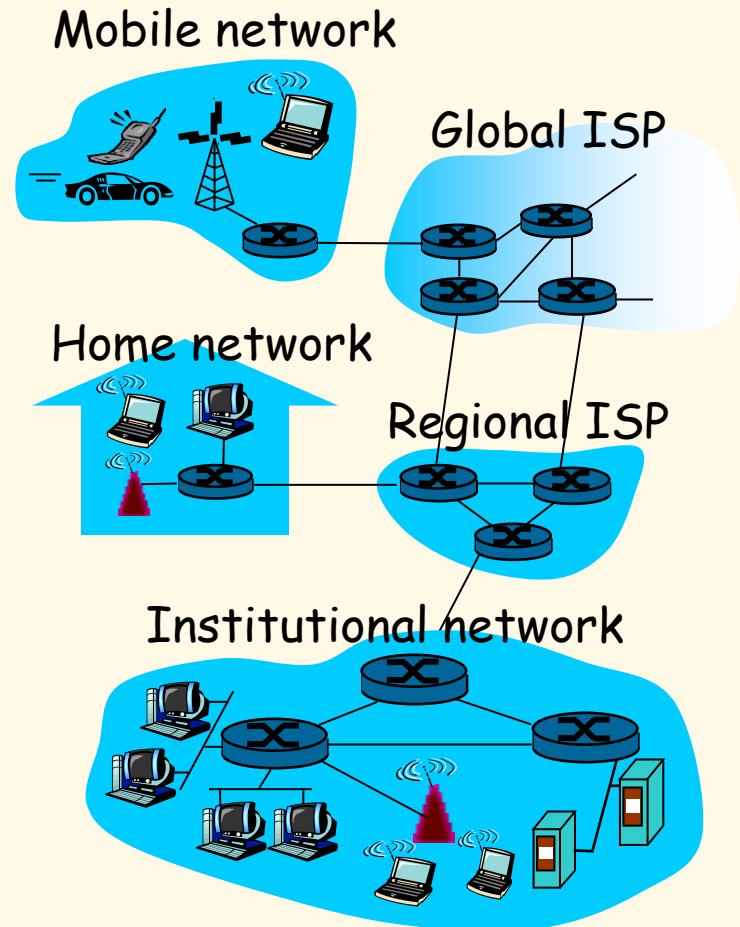
K & R

Figure 1.7 ♦ The network core

Mobile Network

National or Global ISP

Home Network

Local or Regional ISP

Company Network

K & R

Student Perspectives

- ## Application Programmer
  - List the services that an application needs with QoS (Quality of Service) delivery targets.

- ## Network Designer
  - Design a cost-effective network with fair resource sharing.

- ## Network Provider/Operator
  - List the characteristics of a system that is easy to administer and manage. Concerns include: quick fault diagnosis, correct configurability, and easy growth.
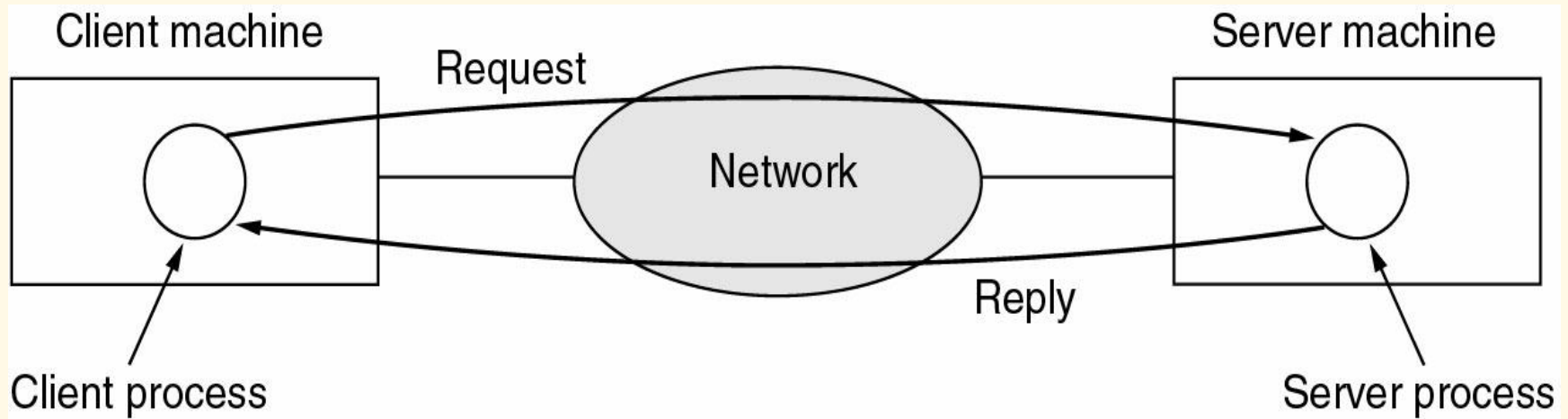
Networking Application Paradigms

Client-Server Applications
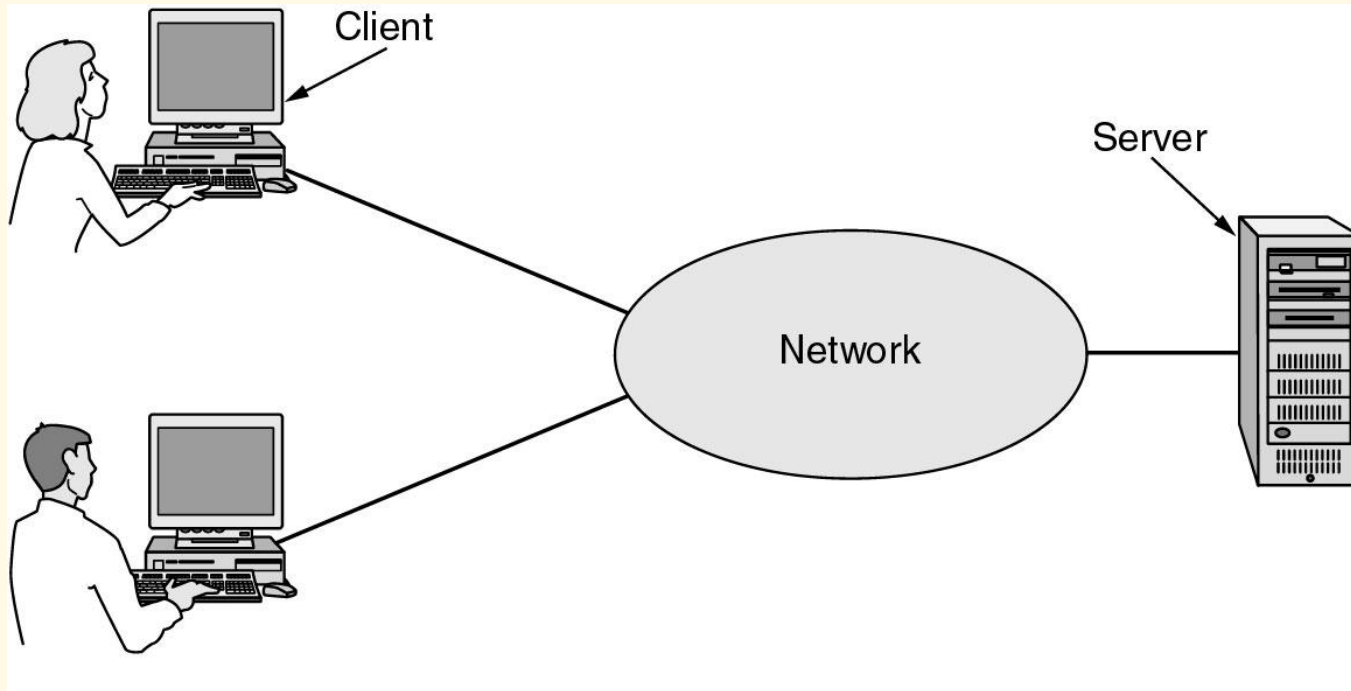
Figure 1.1   A network with two clients and one server.

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Client-Server Model

Figure 1-2. The client-server model involves requests and replies.

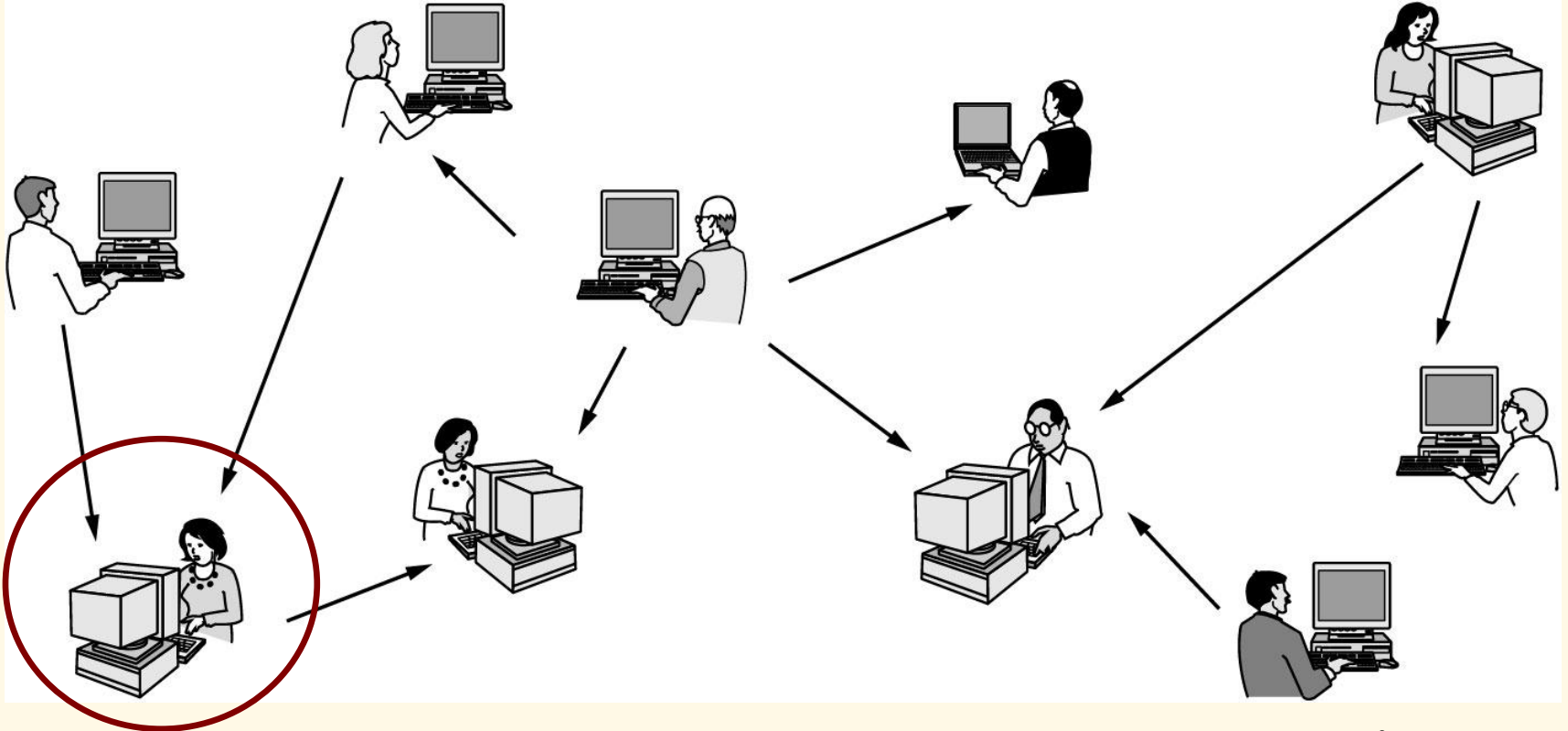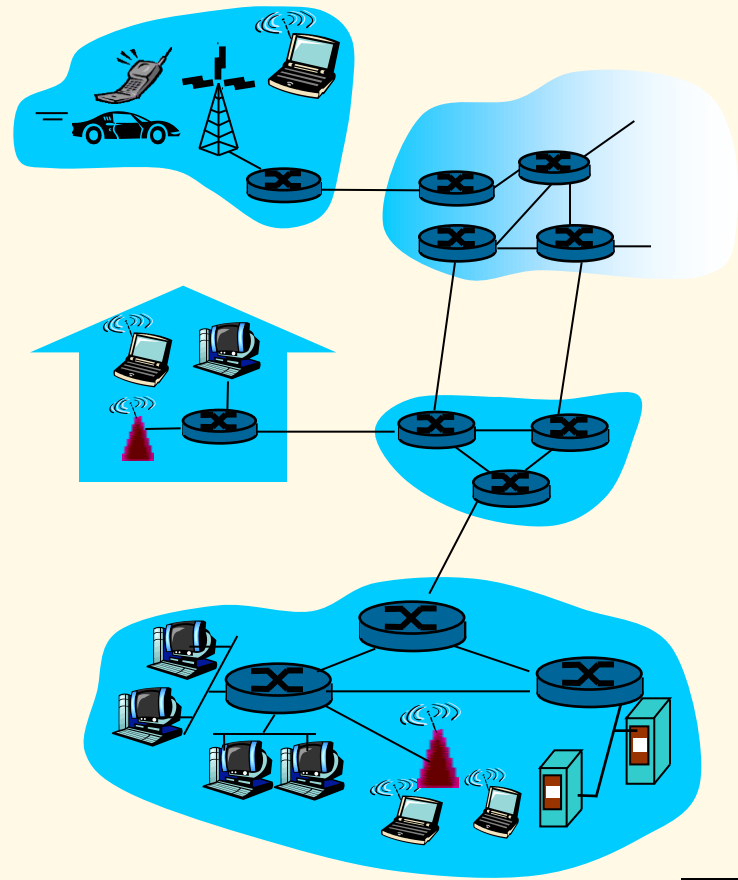Tanenbaum

Peer-to-Peer Applications

Figure 1.3 In a peer-to-peer system there are no fixed clients and servers.

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A Closer Look at Network Structure

- **network edge:** applications and hosts

  ❑ access networks, physical media: wired, wireless communication links

  ❑ network core:
  - ❖ interconnected routers
  - ❖ network of networks

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The Network Edge

- **end systems (hosts):**
  - **run application programs**
  - **e.g. Web, email**
  - **at "edge of network"**

- **client/server model**
  - ❖ client host requests, receives service from always-on server
  - ❖ e.g. Web browser/server; email client/server

- **peer-peer model:**
  - ❖ minimal (or no) use of dedicated servers
  - ❖ e.g. Skype, BitTorrent

peer-peer

client/server
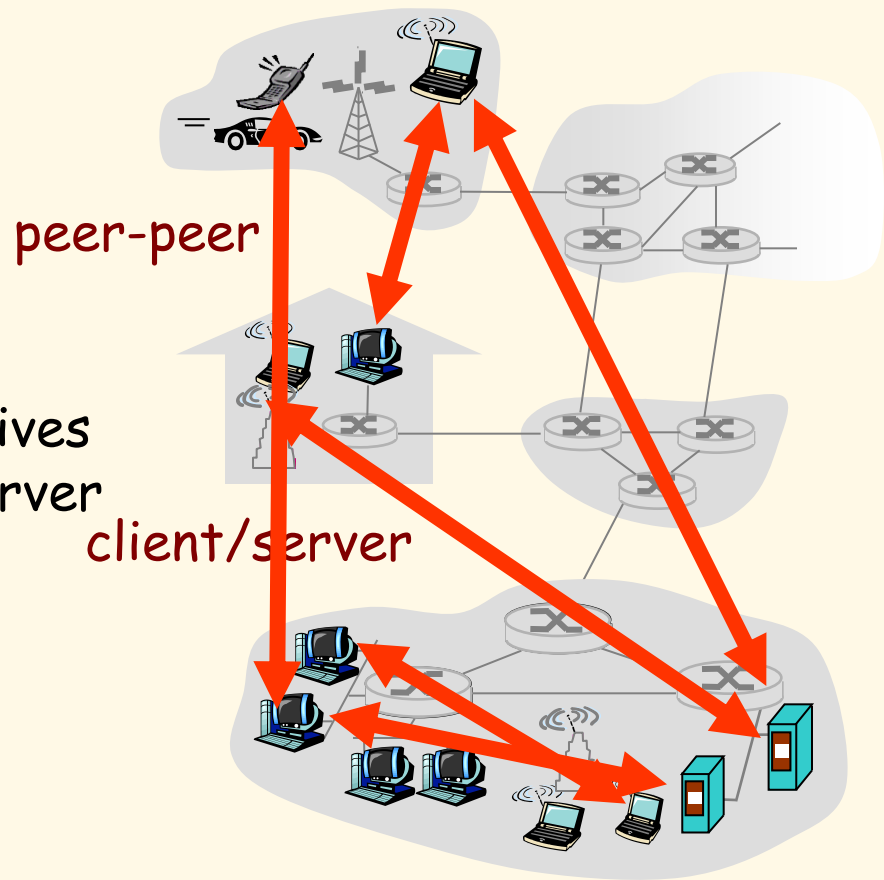
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Wireless versus Mobile Applications

- Wireless involves transmissions through the air (type depends on frequency).
  - **Residential access networks**
    - Residential access points
  - **Institutional access networks**
    - Institutional and corporate access points or mesh networks
  - **Public access networks**
    - e.g., Cities, towns, libraries and coffee shops
  - **Cellular networks**
    - 2.5G, 3G and 4G

Wireless versus Mobile Applications

- **Mobile can refer to the Hosts.**
  - Laptops can be moveable and wired.
  - Laptops can be moveable and wireless.
  - Cell phones, smart phones, PDAs and devices in vehicles are mobile and wireless.

- **Mobile Ad Hoc NETworks (MANETs)::**
  - wireless devices are both Hosts and subnet nodes (routers).
  - The distinction is that MANET nodes may relay traffic intended for other nodes (multi-hop traffic).

Network Classifications

Classifying by Transmission Technology

broadcast :: a single communications channel shared by all machines (addresses) on the network. *Broadcast can be both a* logical *or* a physical *concept* (e.g. Media Access Control (MAC) sublayer).

multicast :: communications to a specified group. *This requires a group address* (e.g. – multimedia multicast).

unicast :: a communication involving a single sender and a single receiver.

point-to-point :: connections made via links between pairs of nodes.

Classification by Size

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

Figure 1-6. Classification of interconnected processors by scale.

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Classification by Size

- PANS {Personal Area Networks}
  - Used for communication among computer devices, including smart phones and PDA's in proximity to an individual's body. [Wikipedia].
  - Reach up to meters.
  - Includes 'wearable' devices and protocols such as Bluetooth, Zigbee and UWB (Ultra Wide Band) and BANs (Body Area Networks).
 - IEEE 802.15 Working Group for Wireless PANs (WPANs).

PANs
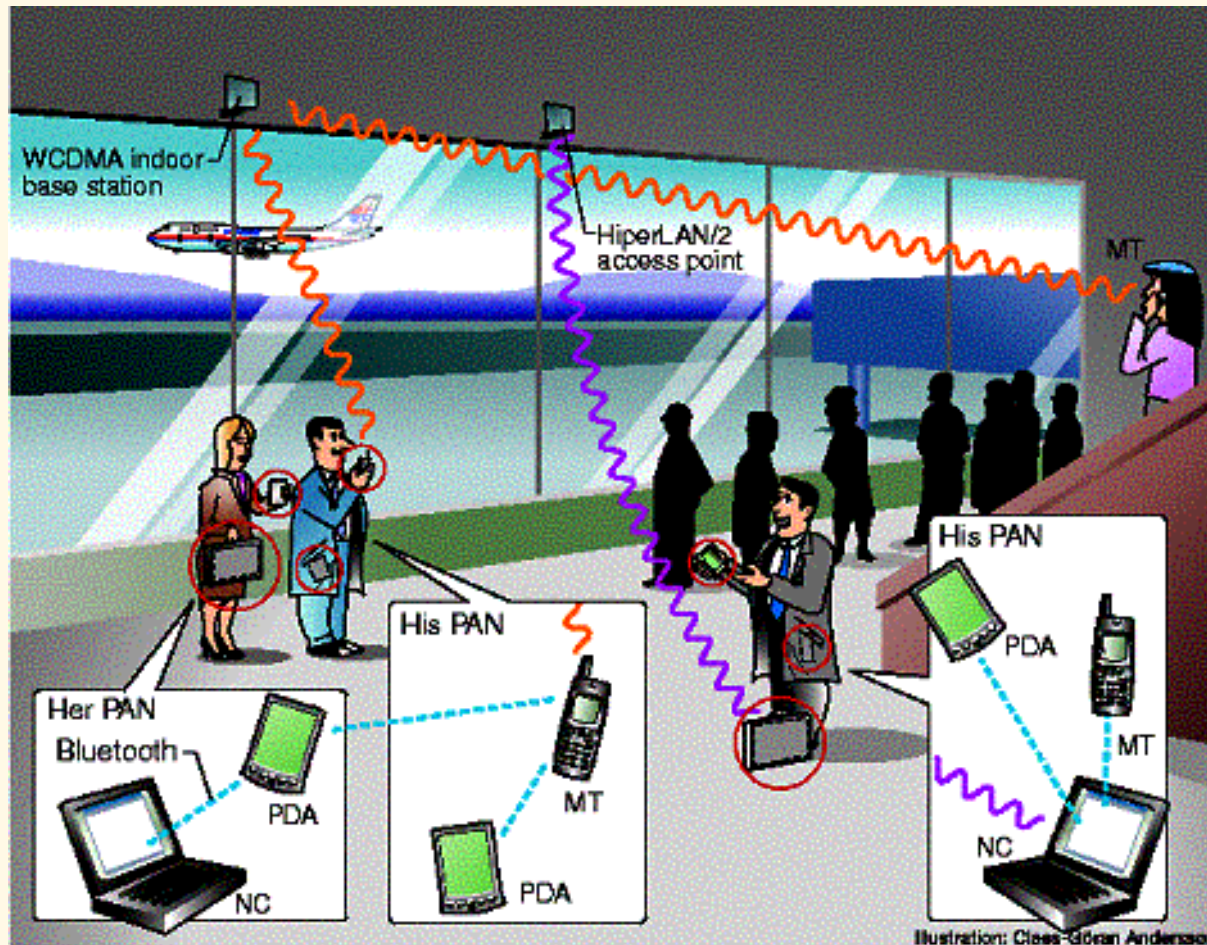
[Brunell University West London]

Classification by Size

- **LANs {Local Area Networks}**
  - Wired LANs: typically physically broadcast at the MAC layer (e.g., Ethernet, Token Ring)
  - Wireless LANs (WLANs)
  - Wireless Sensor Networks (WSNs)

- **MANs {Metropolitan Area Networks}**
  - campus networks connecting LANs logically or physically.
  - often have a **backbone** (e.g., FDDI, ATM or a mesh) to connect campus networks.

Wired LANs

transceivers
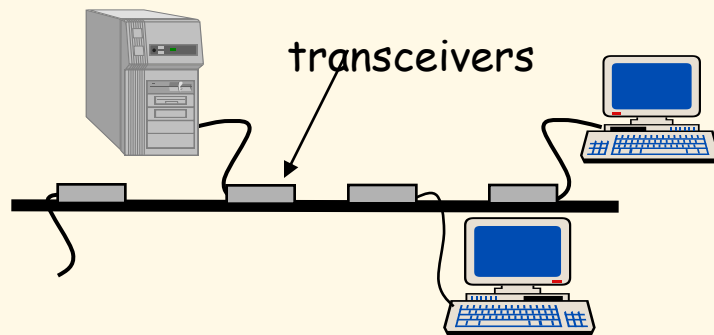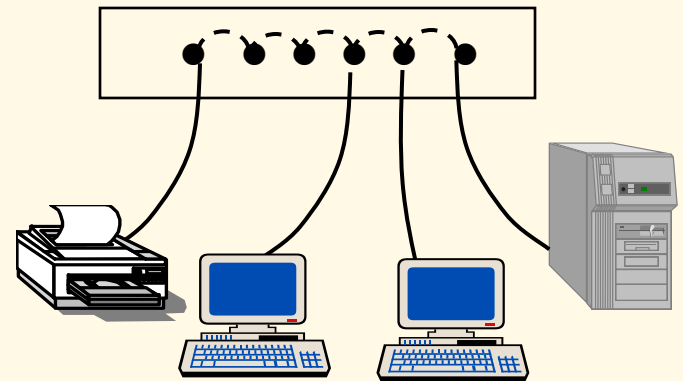
Ethernet bus

Ethernet hub

Leon-Garcia & Widjaja:
Communication Networks

Wireless LANs (WLANs)
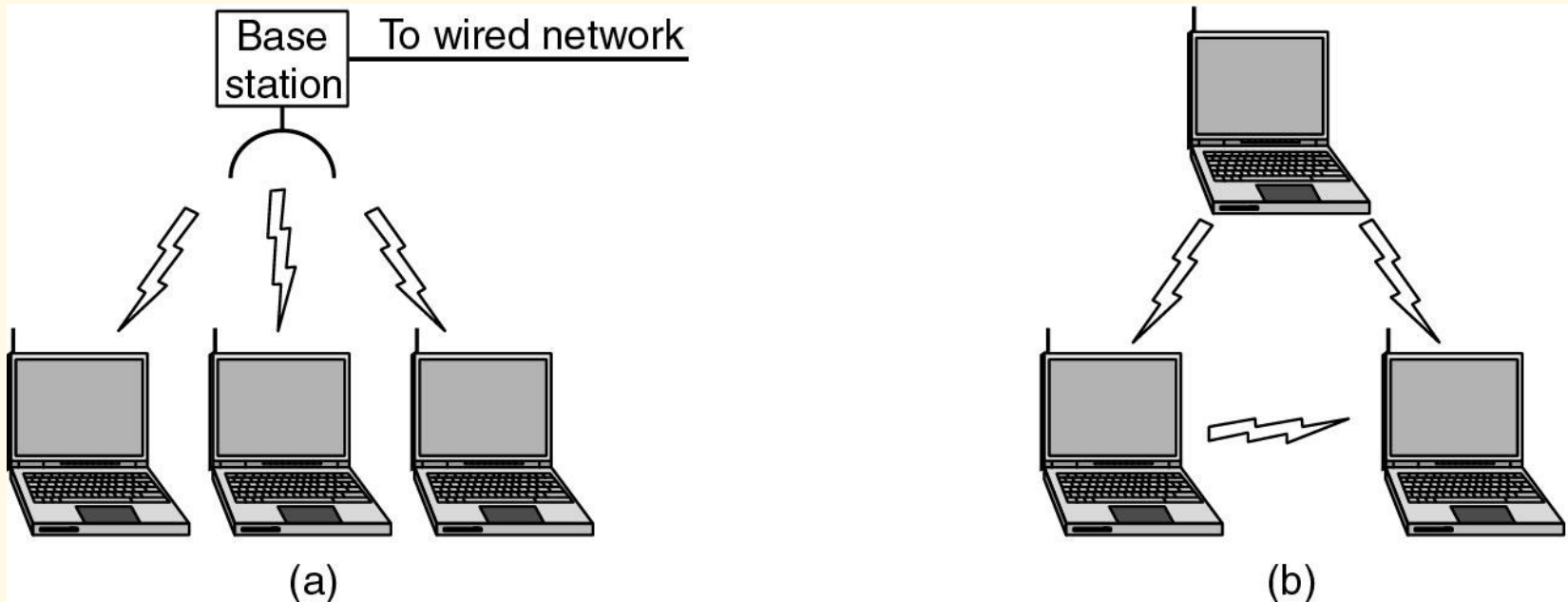
Figure 1-35. (a) Wireless networking with a base station. (b) Ad hoc networking.

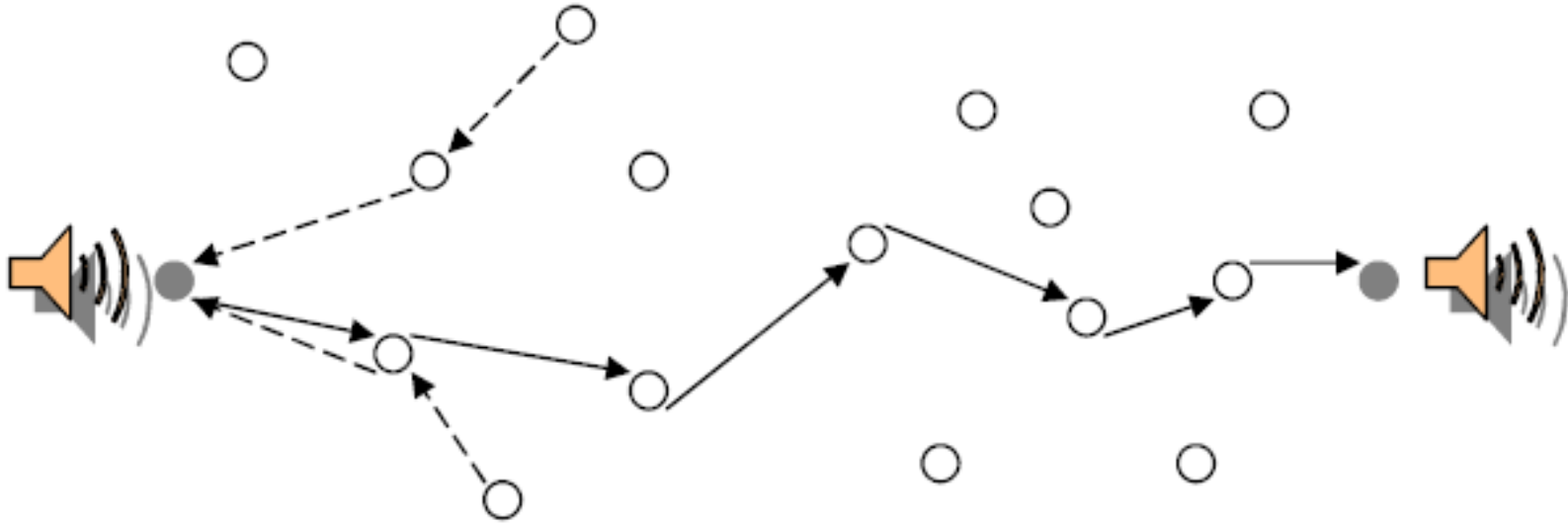Tanenbaum

Wireless Sensor Networks (WSNs)

Figure 1: Routing paths for end to end and mote-to-sink.

N. Chohan

WSNs can have mobile or fixed nodes but require a routing algorithm and normally have power concerns.
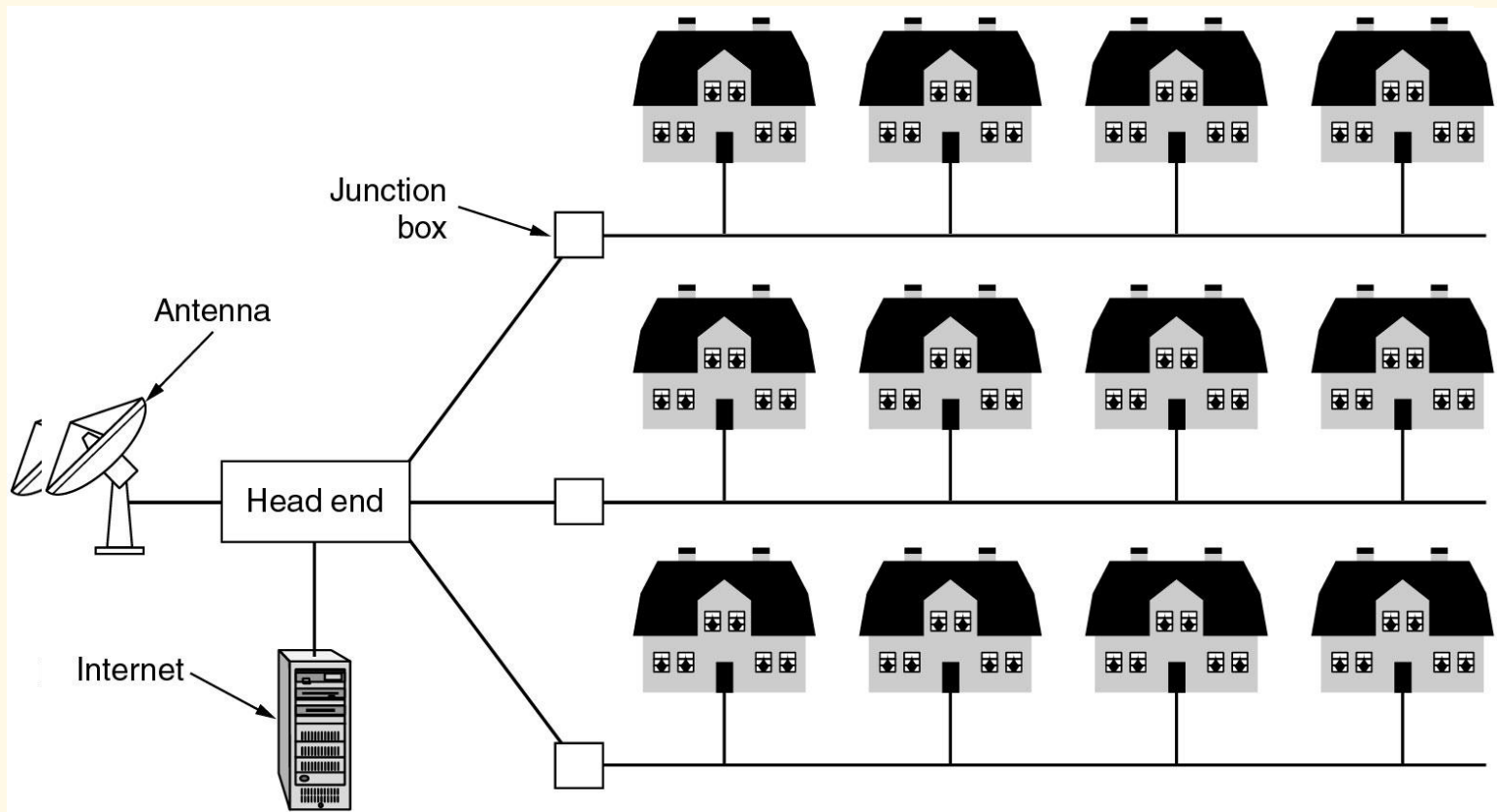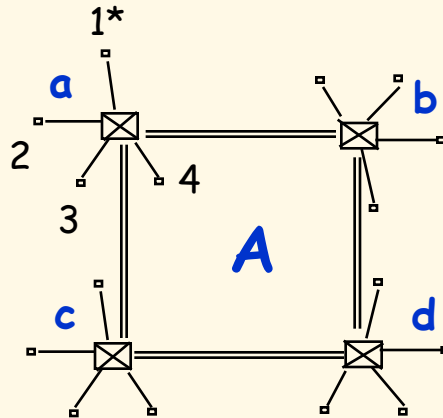
Metropolitan Area Networks (MANs)

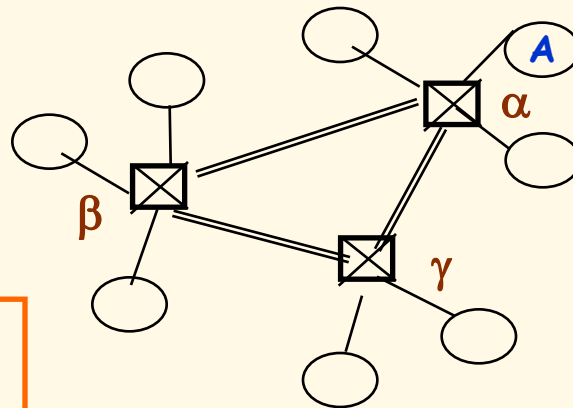Figure 1-8. A metropolitan area network based on cable TV.

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MANs within a Hierarchical Topology

1*

a

b

2

4

3

A

c

d

Metropolitan network **A** consists of access subnetworks: **a, b, c, d**.

Hierarchical Network Topology

A

α

β

γ

National network consists of regional subnetworks: α, β, γ.

Metropolitan network **A** is part of regional subnetwork α.

Leon-Garcia & Widjaja:
Communication Networks

Network Classification by Size

- WANs {Wide Area Networks}
  - *also referred to as "point-to-point" networks.*
  - ARPANET → Internet
  - usually hierarchical with a backbone.
  - Enterprise Networks, Autonomous Systems (ASs)
  - VPNs (Virtual Private Networks).

AMES McCLELLAN UTAH BOULDER GWC CASE
RADC
ILL CARN
USC LINC
AMES MITRE
MIT
UCSB ETAC
STAN SCD

UCLA RAND TINKER BBN HARV NBS
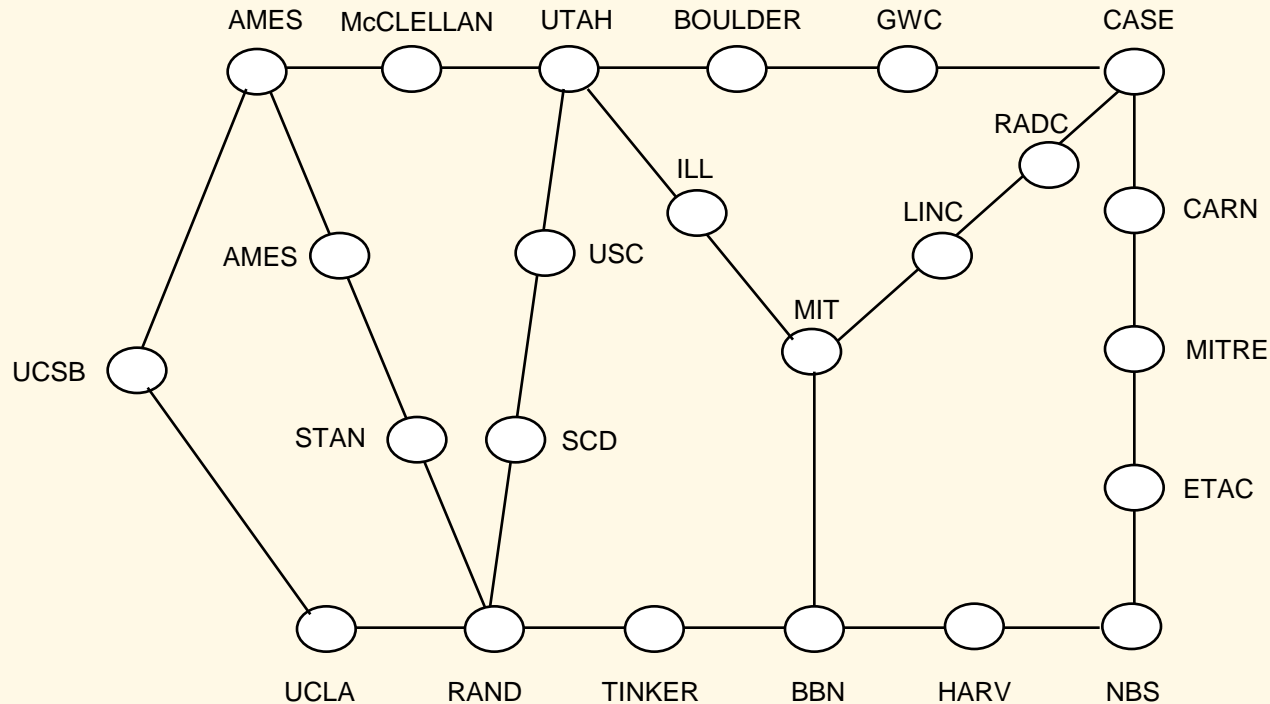
A point-to-point network

Leon-Garcia & Widjaja:
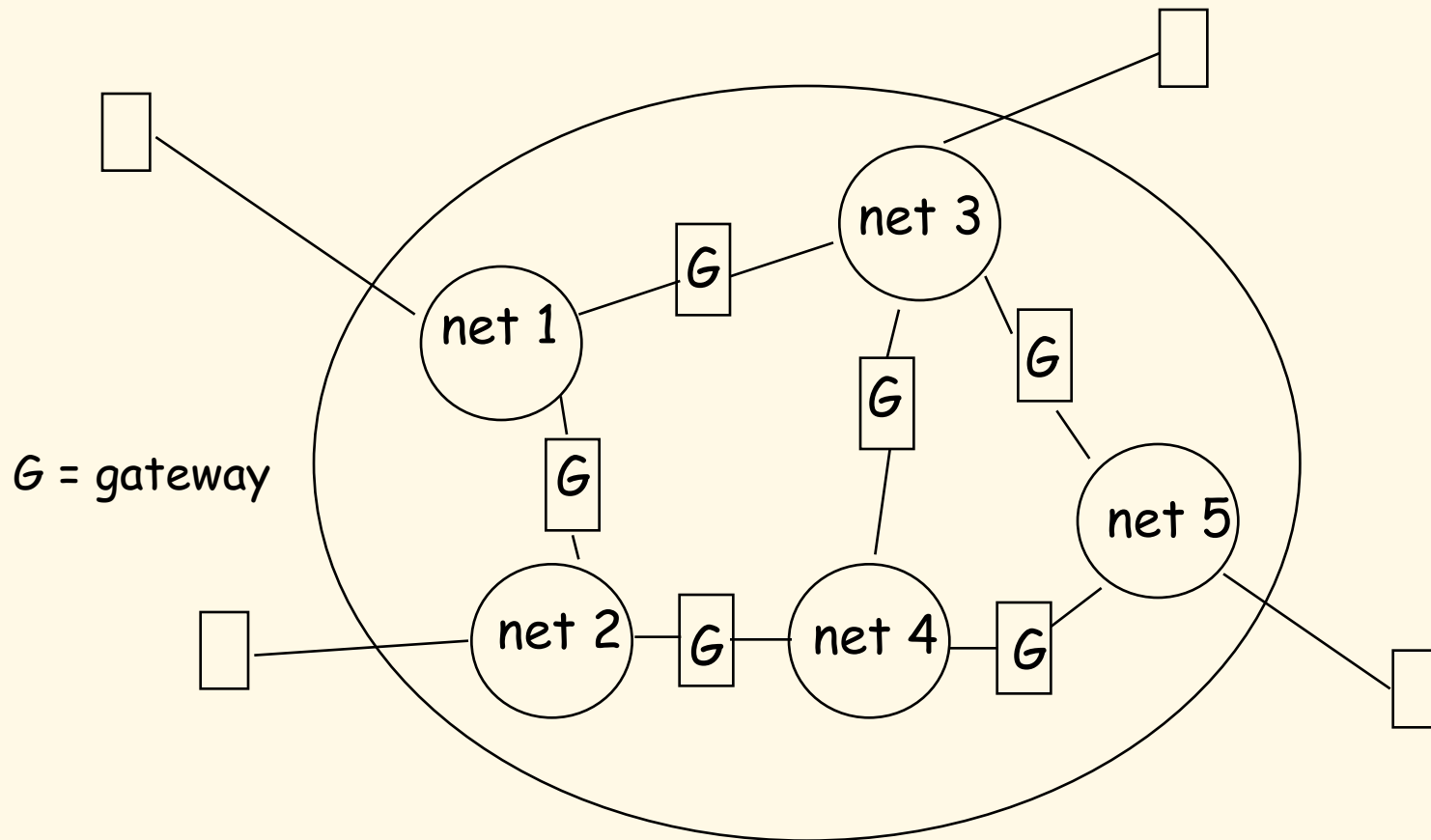*Communication Networks*

Wide Area Networks (WANs)
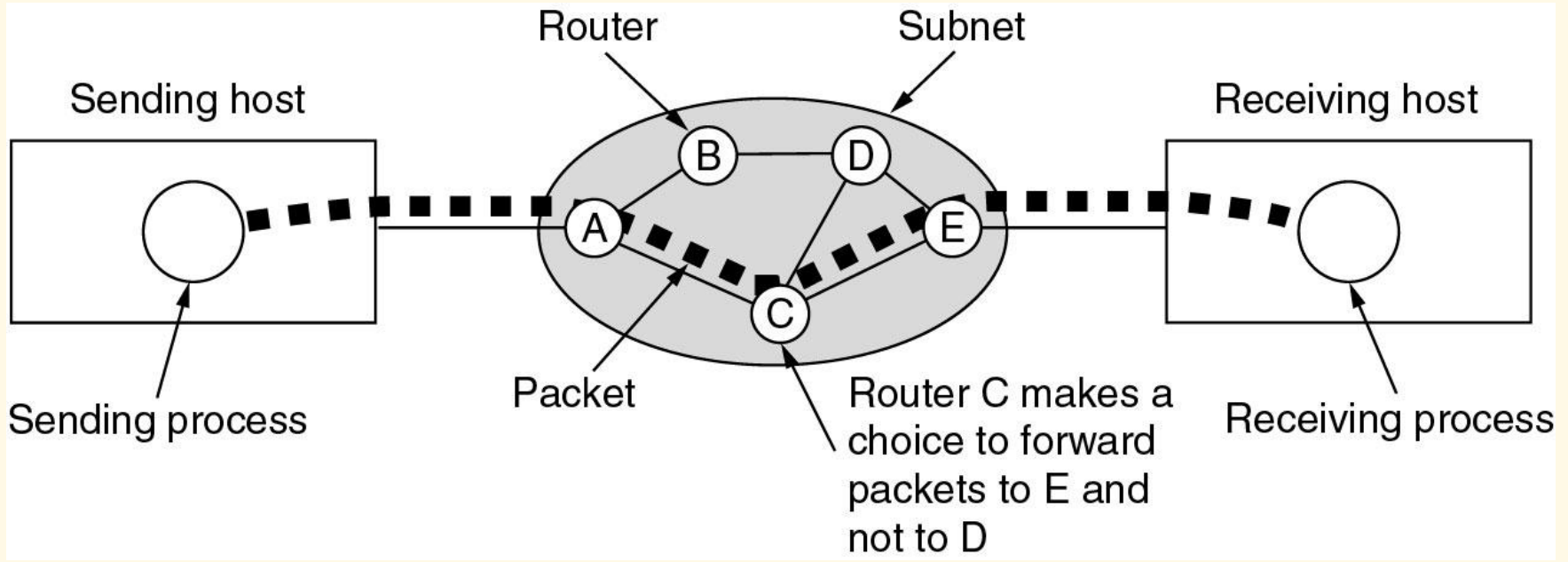
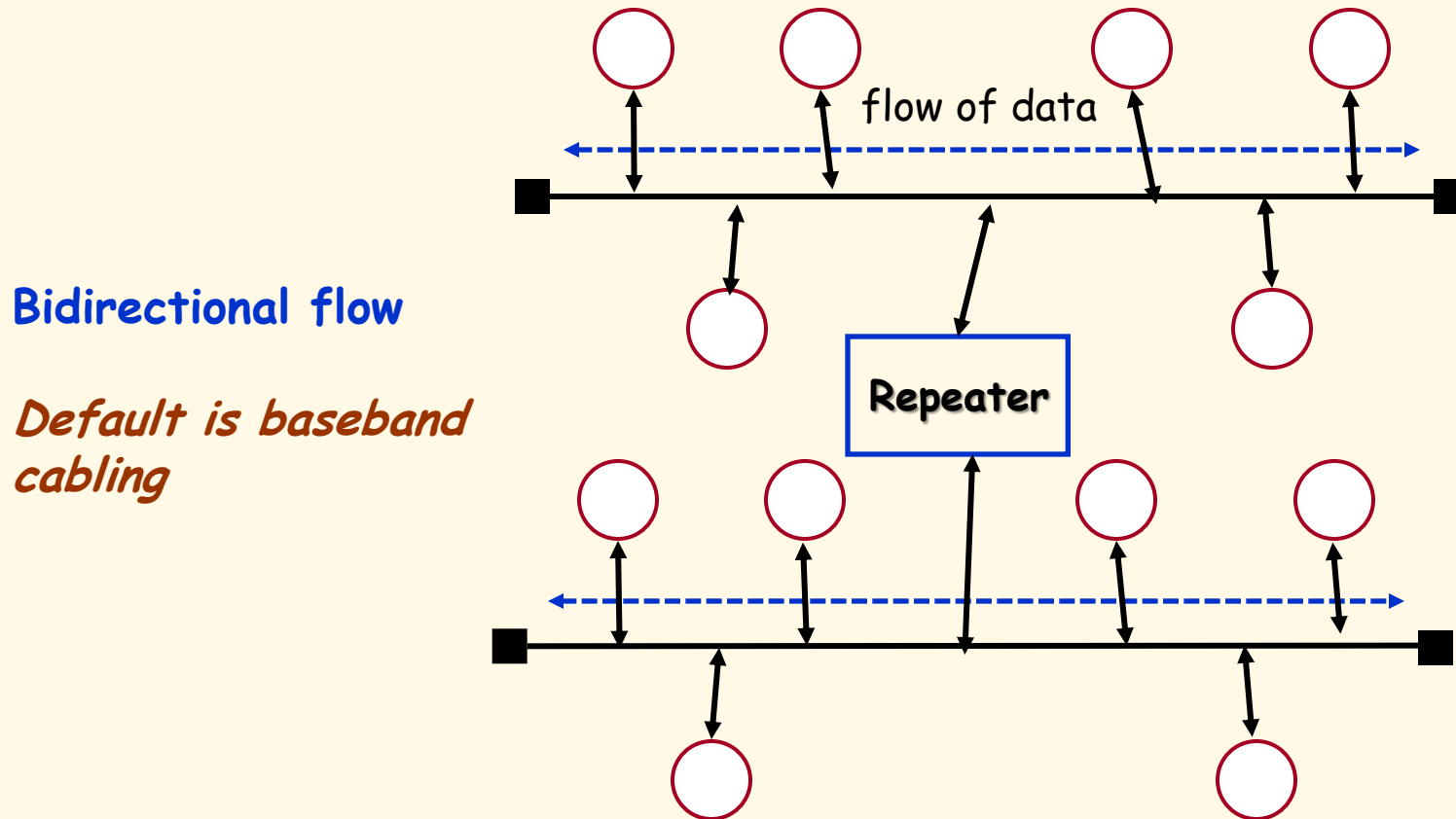Figure 1-10.A stream of packets from sender to receiver.

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internet

A network of networks
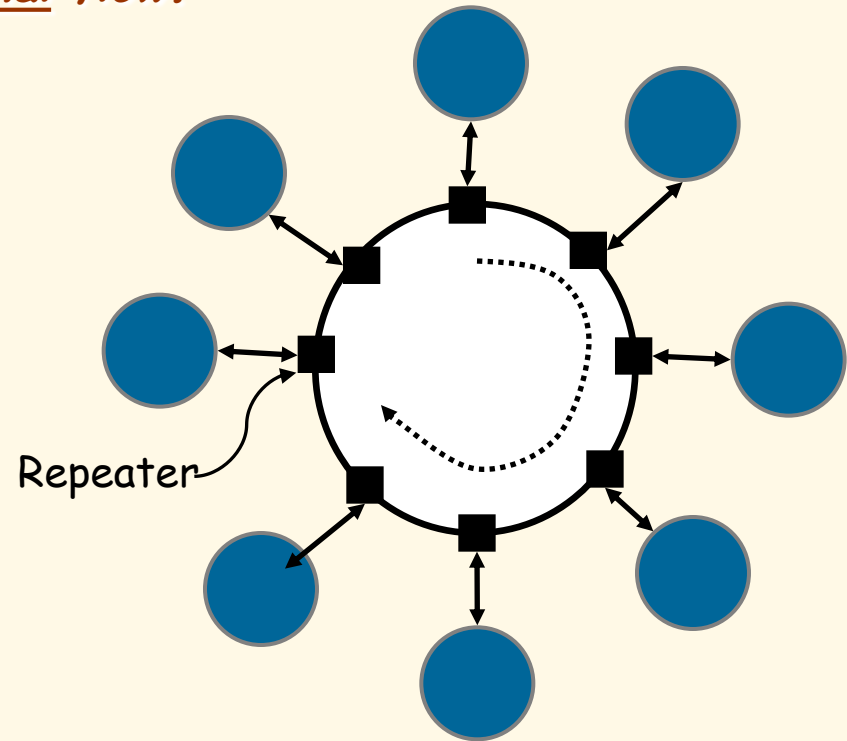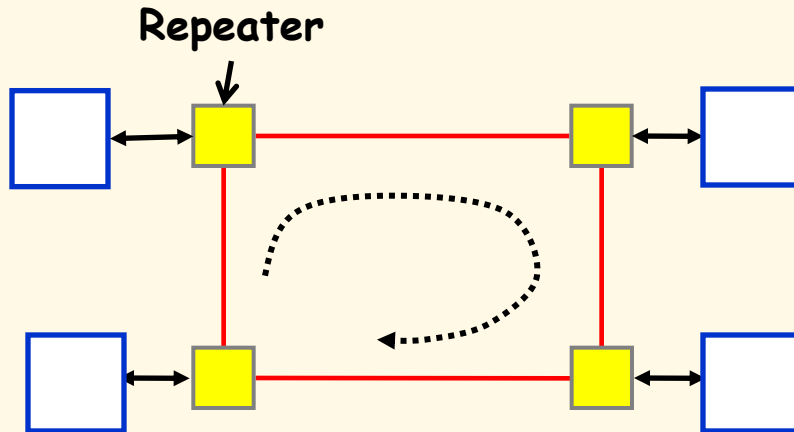
G = gateway

Leon-Garcia & Widjaja:
Communication Networks

Bidirectional flow

Default is baseband cabling

flow of data

Repeater

Bus Topology

Note - *A ring implies <u>unidirectional</u> flow.*
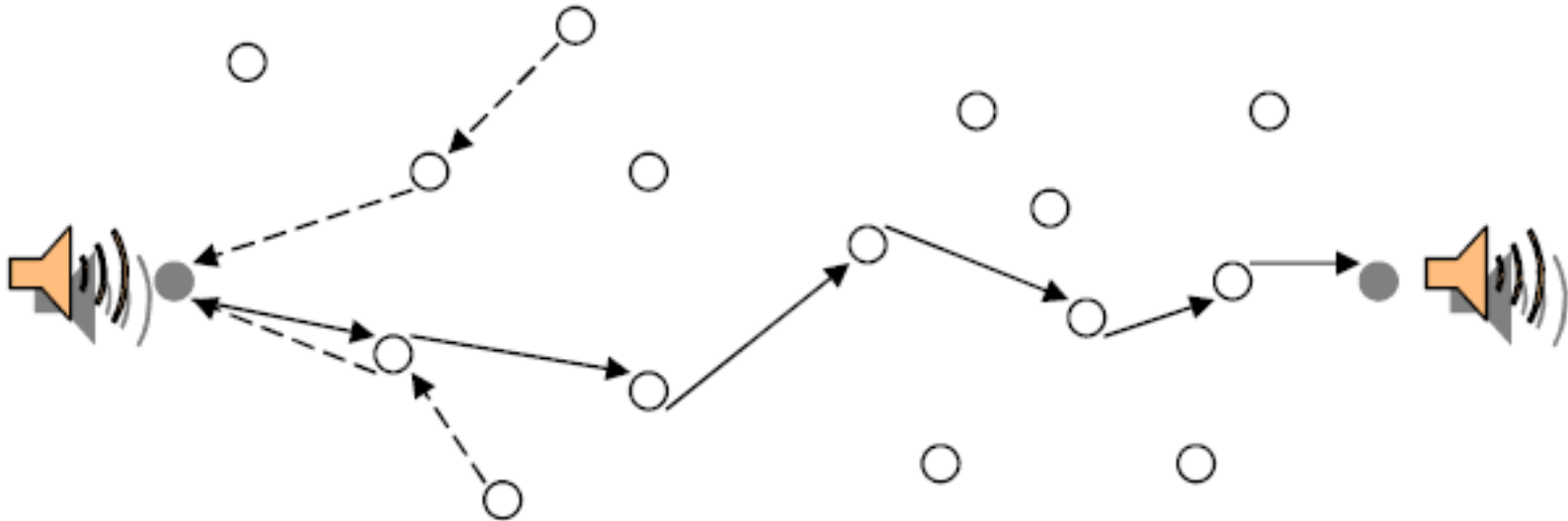
Repeater

Repeater

Ring Topology

Tree Topology

Tree Topology
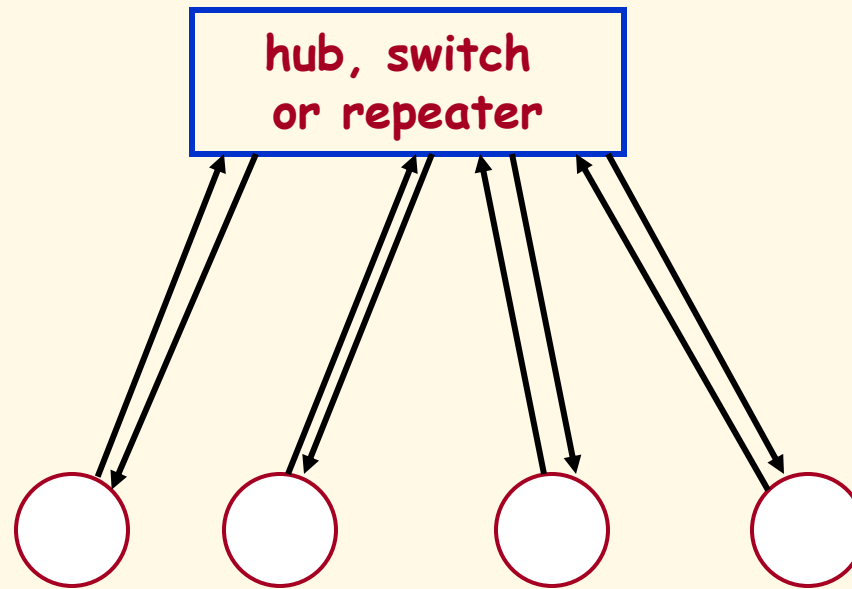

Figure 1: Routing paths for end to end and mote-to-sink. N. Chohan

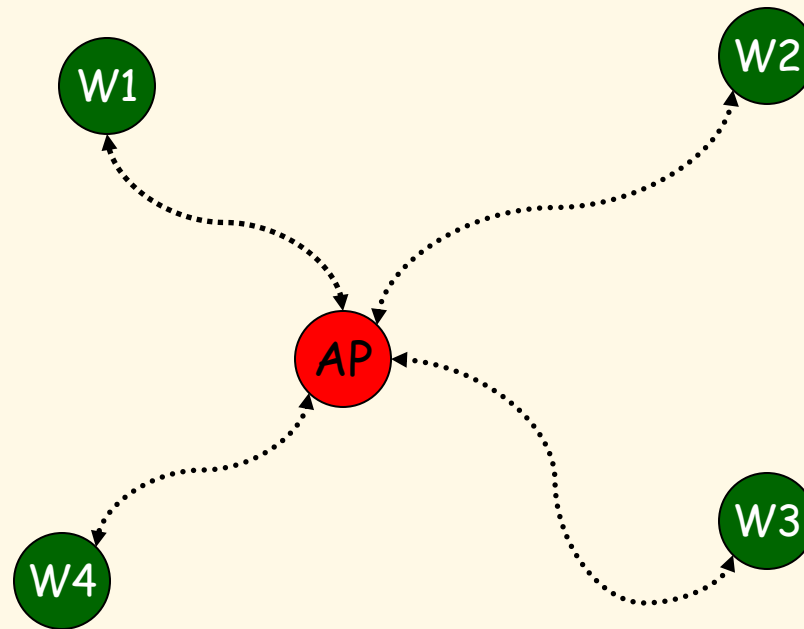**WSN end-to-end routing often employs a spanning tree for routing.**

hub, switch
or repeater

Star Topology

Network Classification by Topology

Wireless Infrastructure

Star Topology

Introduction Summary

- **Define: network, distributed system, subnet, host, node, flow, channel and link.**

- **Paradigms: Client-Server, Peer-to-Peer, Wireless and Mobile.**

- **Classifications and Acronyms:**
  - **Broadcast, multicast, unicast**
  - **PAN, LAN, MAN, WAN, WLAN, WSN**
  - **The Internet versus an internet**
  - **Hierarchical, bus, ring, tree, and star topology**