# 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.
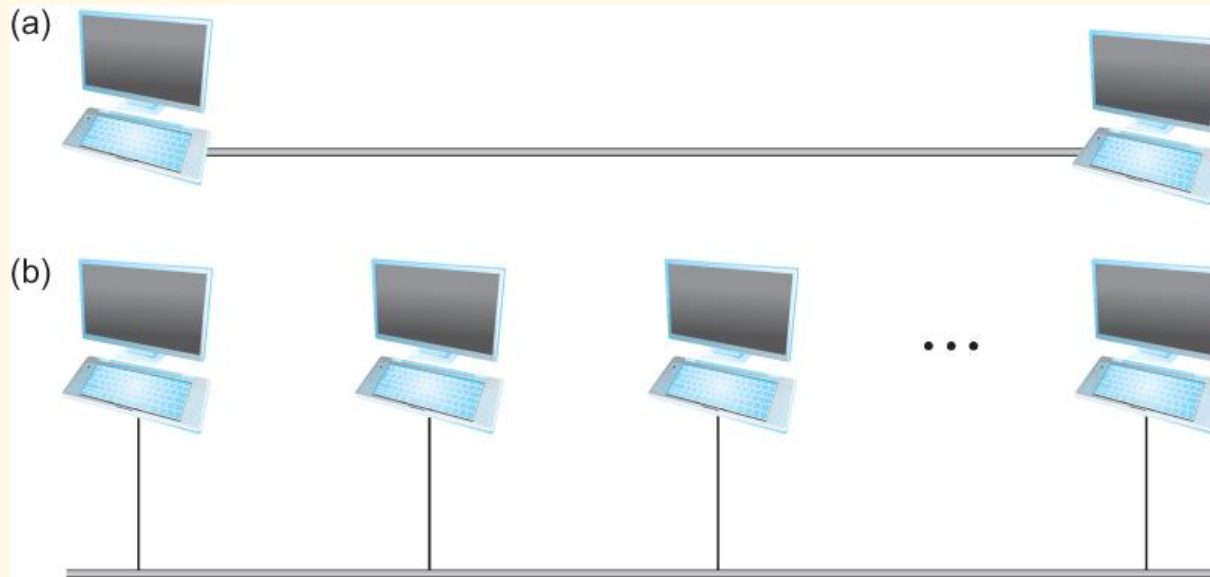
# Physical Connectivity



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

P&D

# Other Forms of Connectivity

- Indirect connectivity through a set of cooperating nodes.
- Wireless connectivity:
  - WiFi   (IEEE802.11) with MIMO
  - Cellular (3G, 4G LTE, 5G ???)
  - Bluetooth
  - Zigbee (part of IEEE802.15.4)
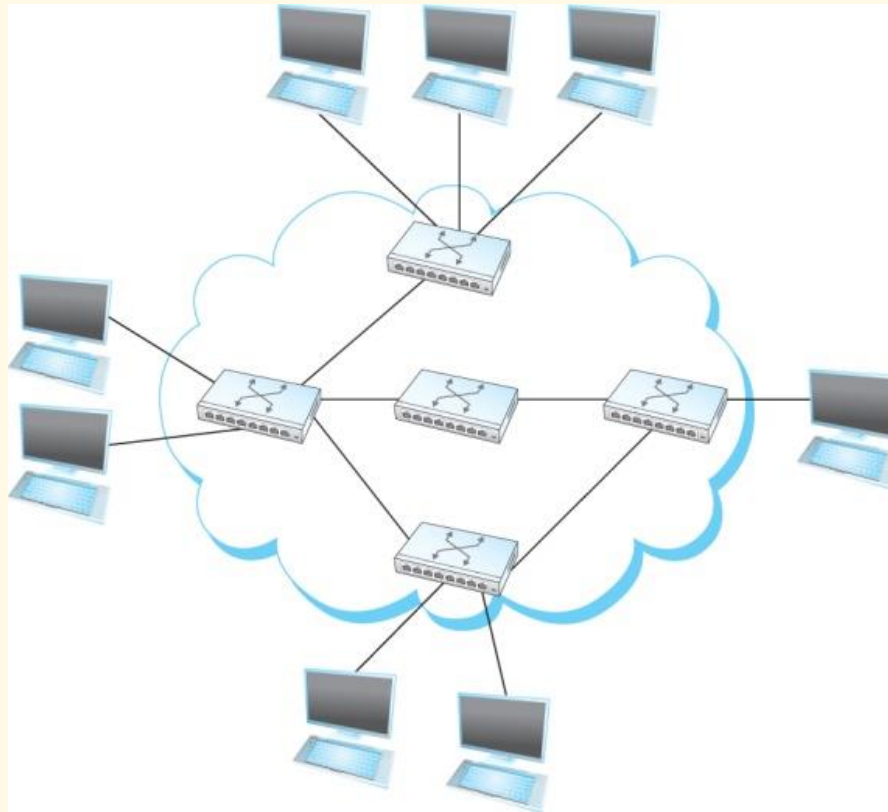  - WiMAX

# Switched Network
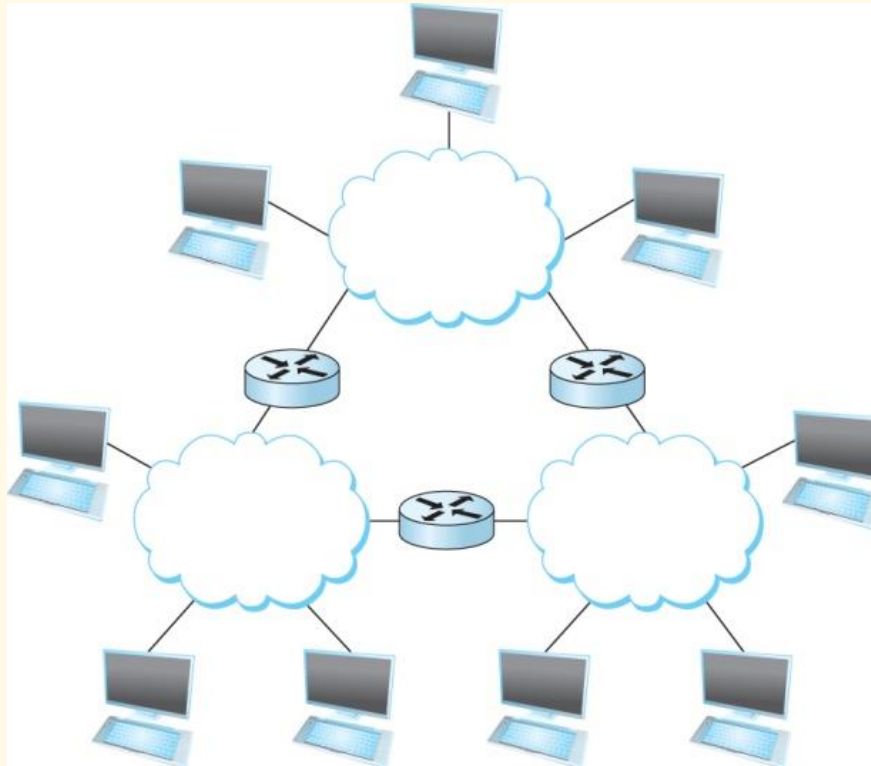


Figure  1.3   Switched network

Figure 1.4  Interconnection of Networks

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# 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.

Examples:

1. NFS is a distributed files system.

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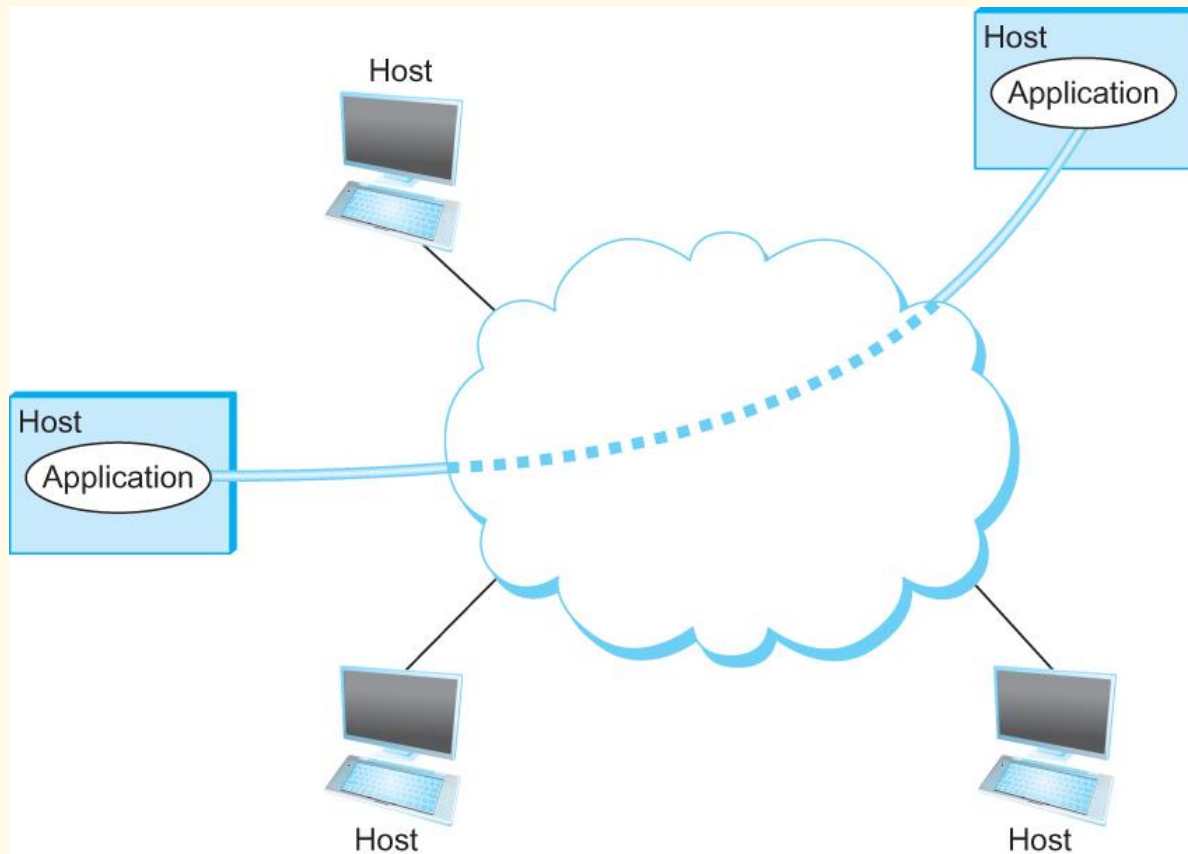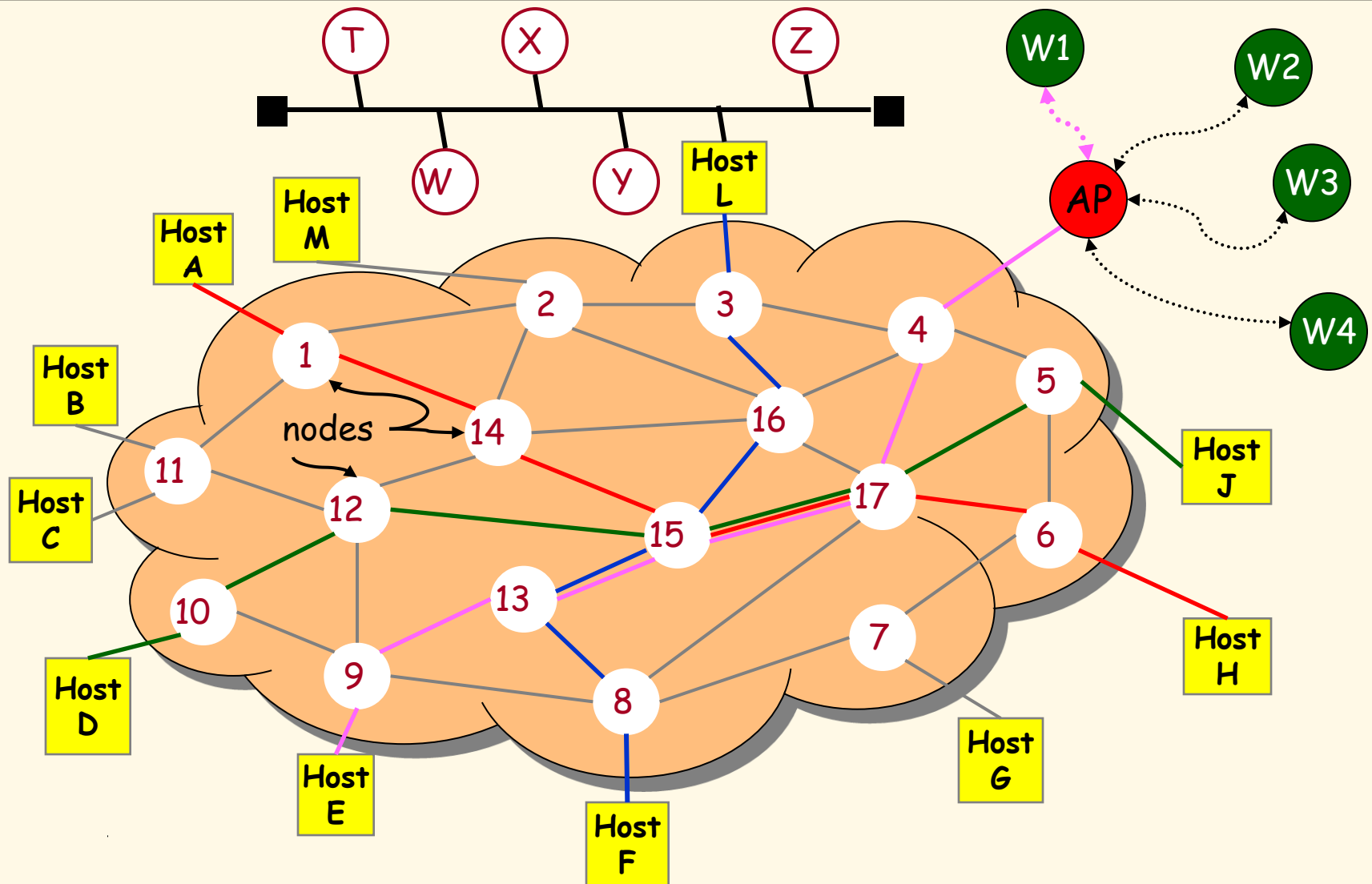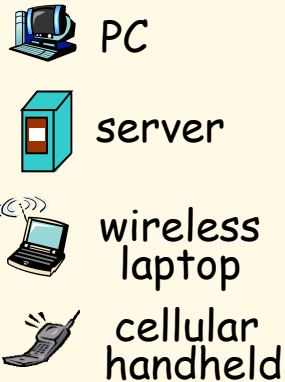
# Application Communication



Figure 1.7  Processes communicating over an abstract channel

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# Internet Access and Flows

# The Internet: "nuts and bolts" view

PC

server

wireless laptop

cellular handheld

access points

wired links

router

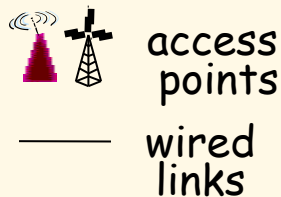**billions of connected computing devices:**

*hosts = end systems*
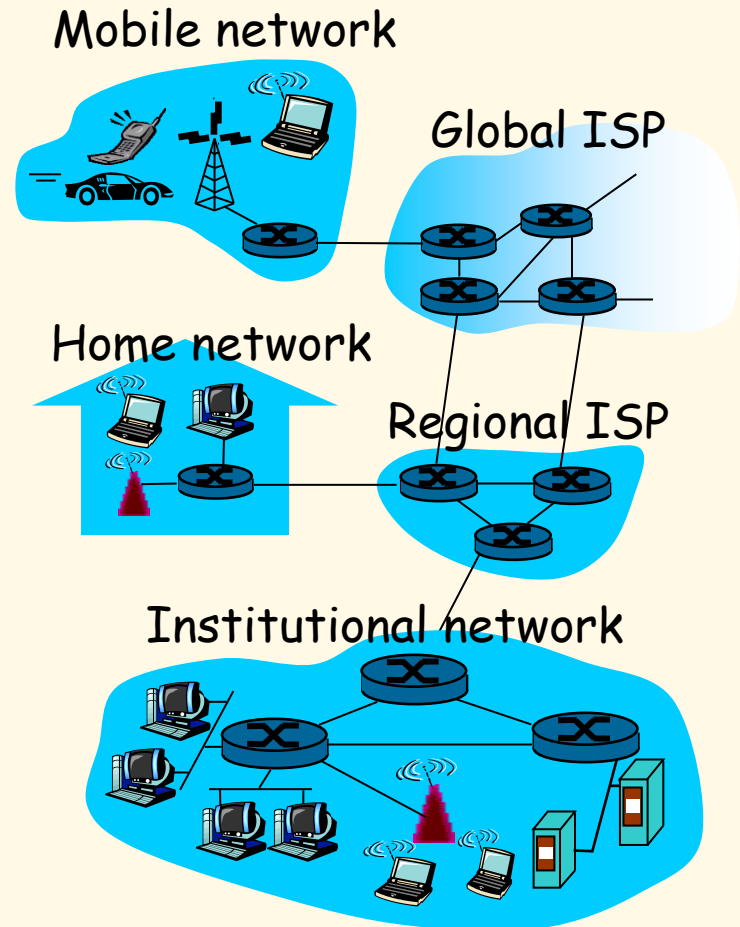
– **running *network apps***

❑ *communication links*

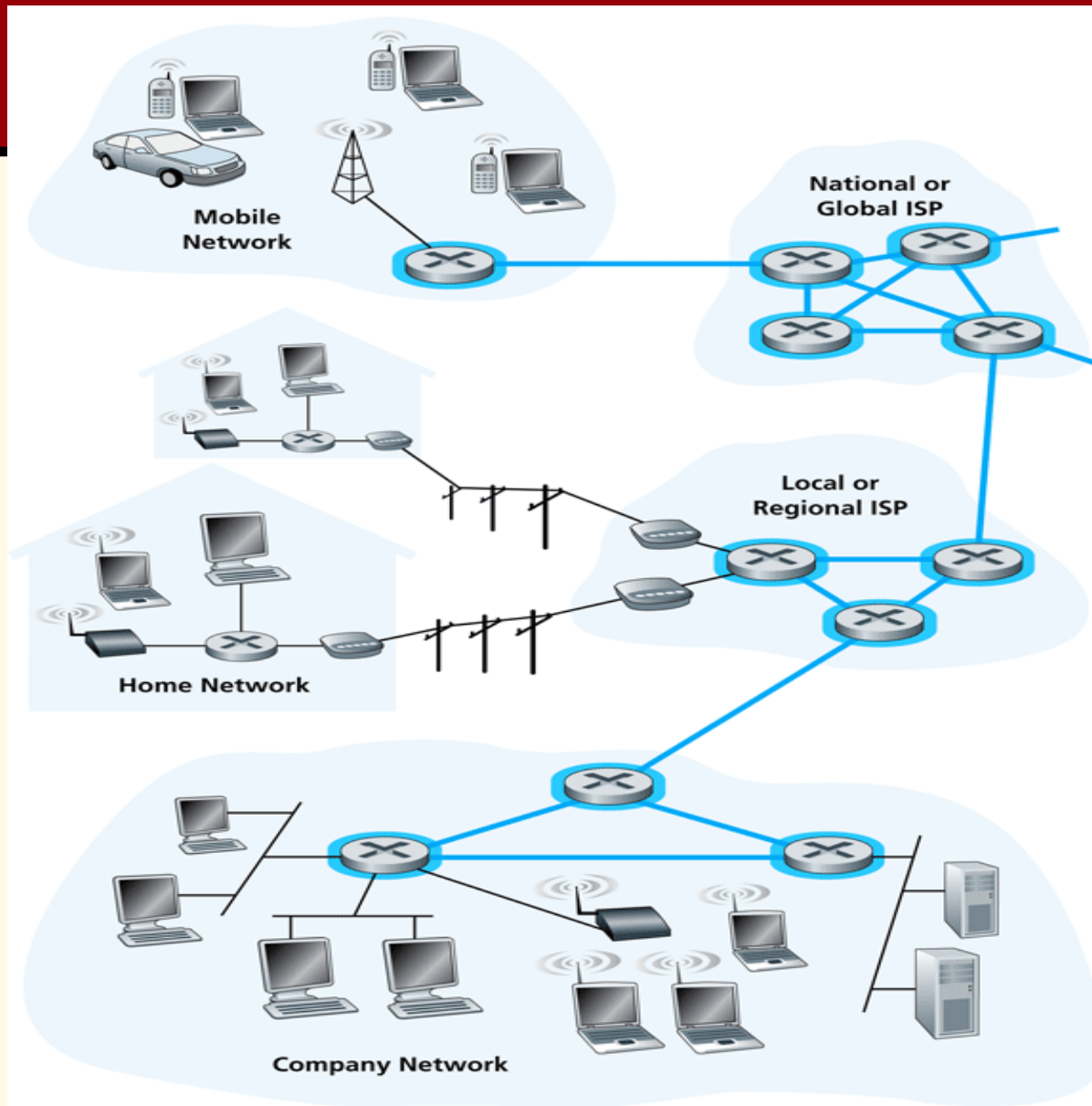❖ fiber, copper, radio, satellite

❖ transmission rate = *capacity*

❑ *routers*$^*$: forward packets (chunks of data)

* Also referred to as switches or gateways.

Mobile network

Global ISP

Home network

Regional ISP

Institutional network

K & R

Figure 1.7 ♦ The network core

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# 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.
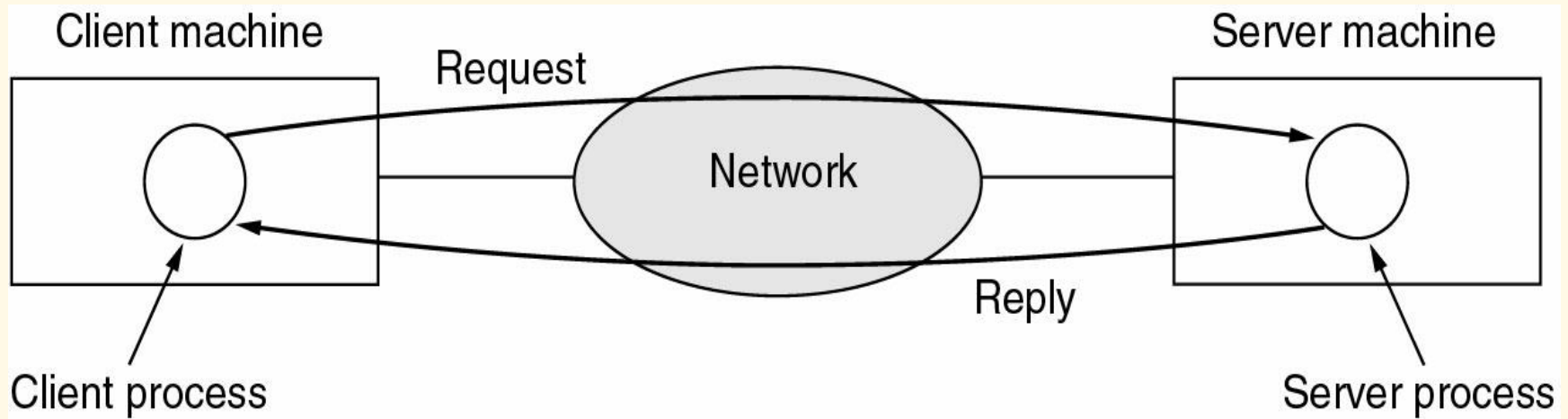
# Networking Application Paradigms

# Client-Server Applications
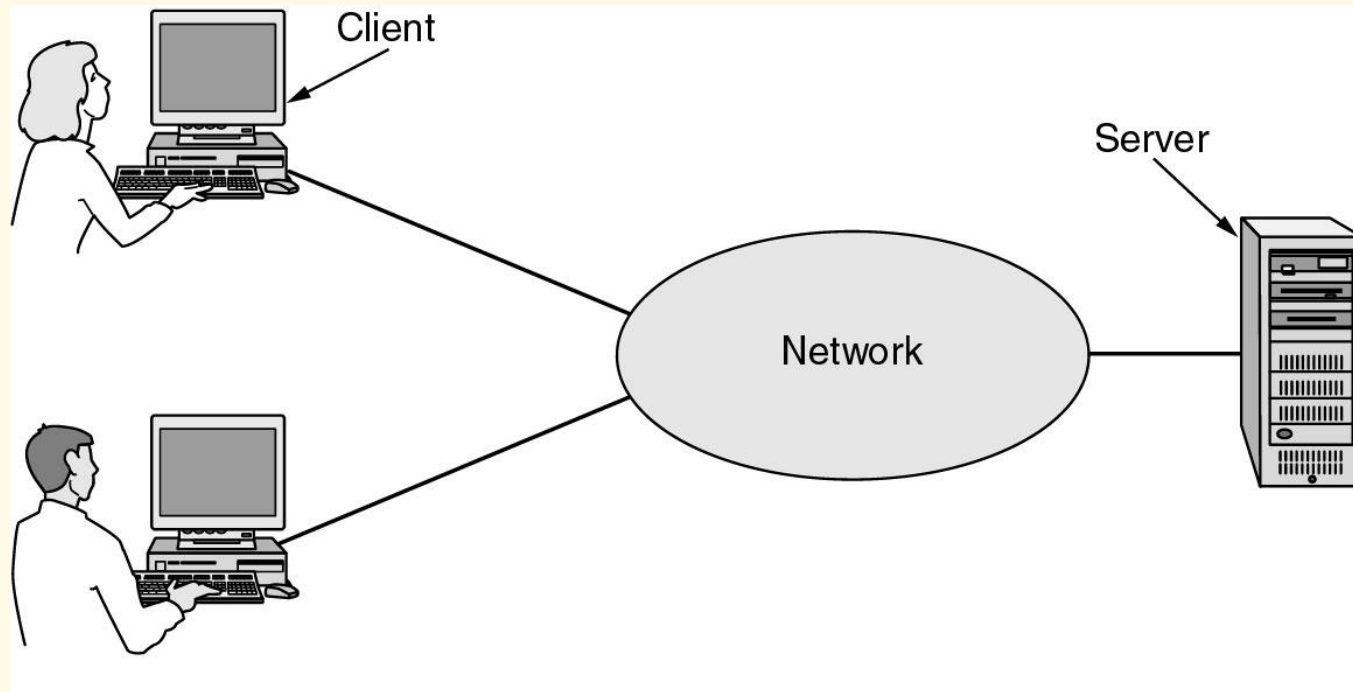


Figure 1.1   A network with two clients and one server.

# Client-Server Model



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

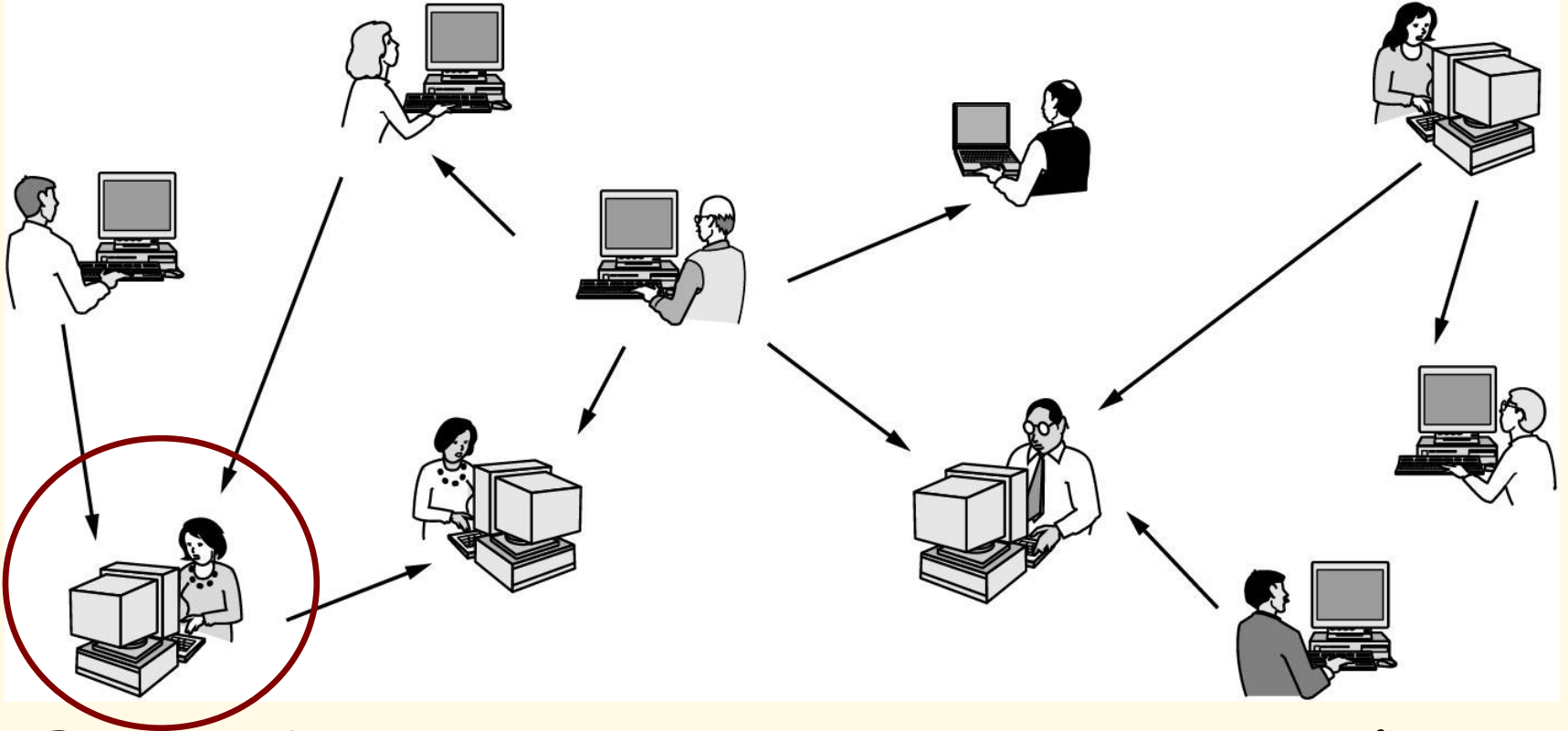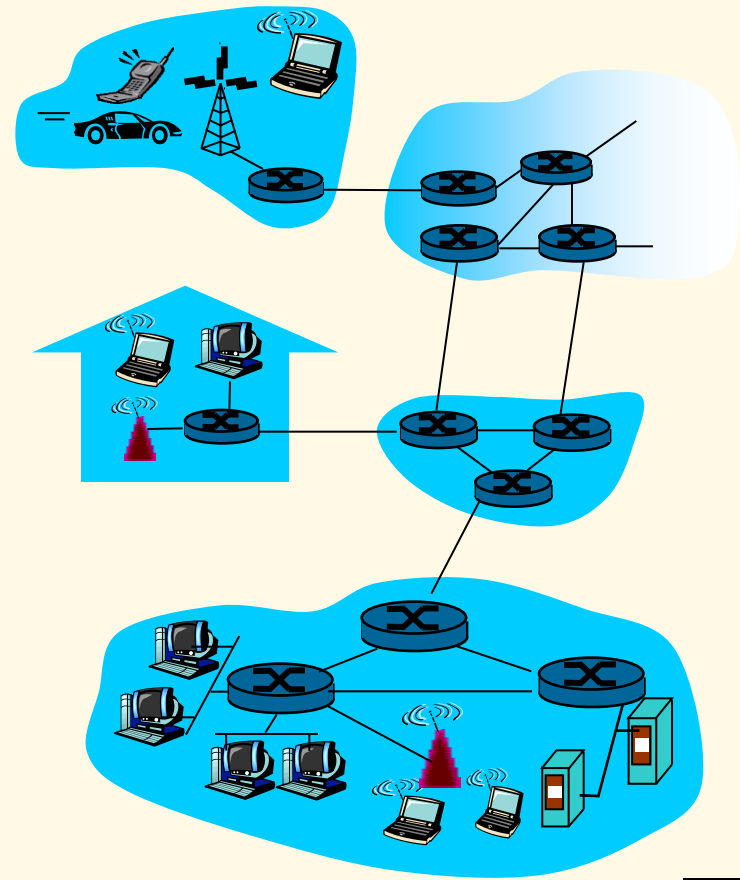Tanenbaum

# Peer-to-Peer Applications



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

Tanenbaum

# 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



K & R

# 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
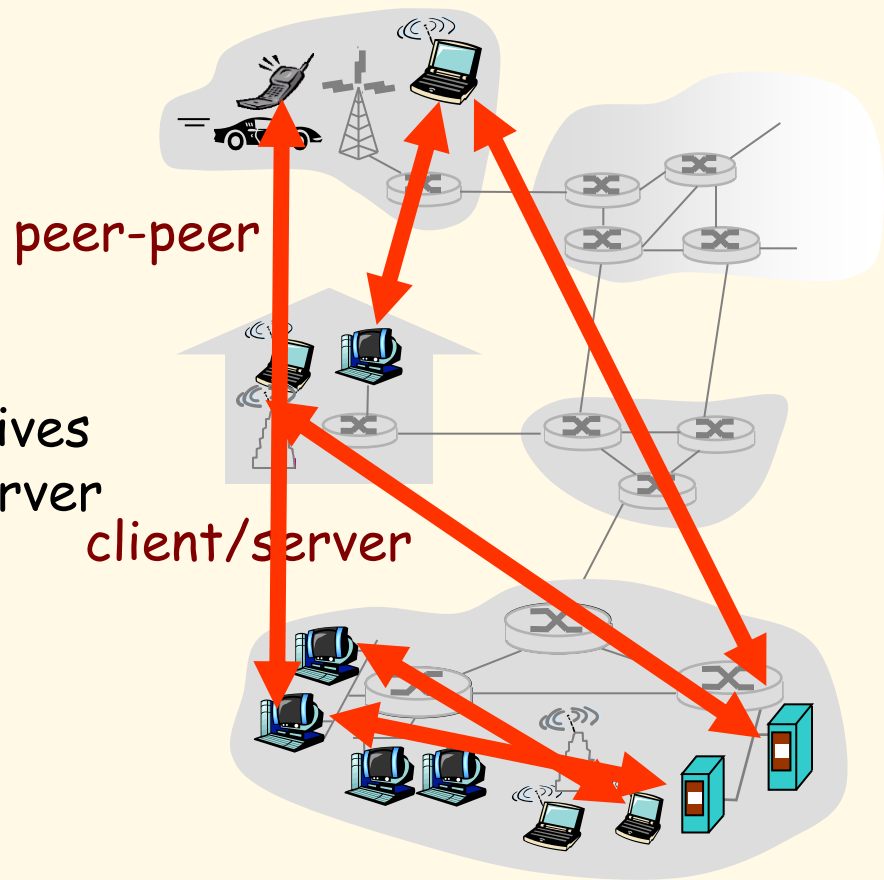


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# Wireless versus Mobile Applications

- **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 LTE**

# 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 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).
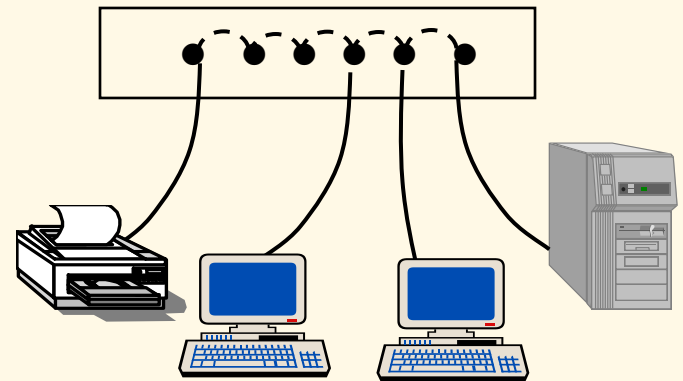
# PANs
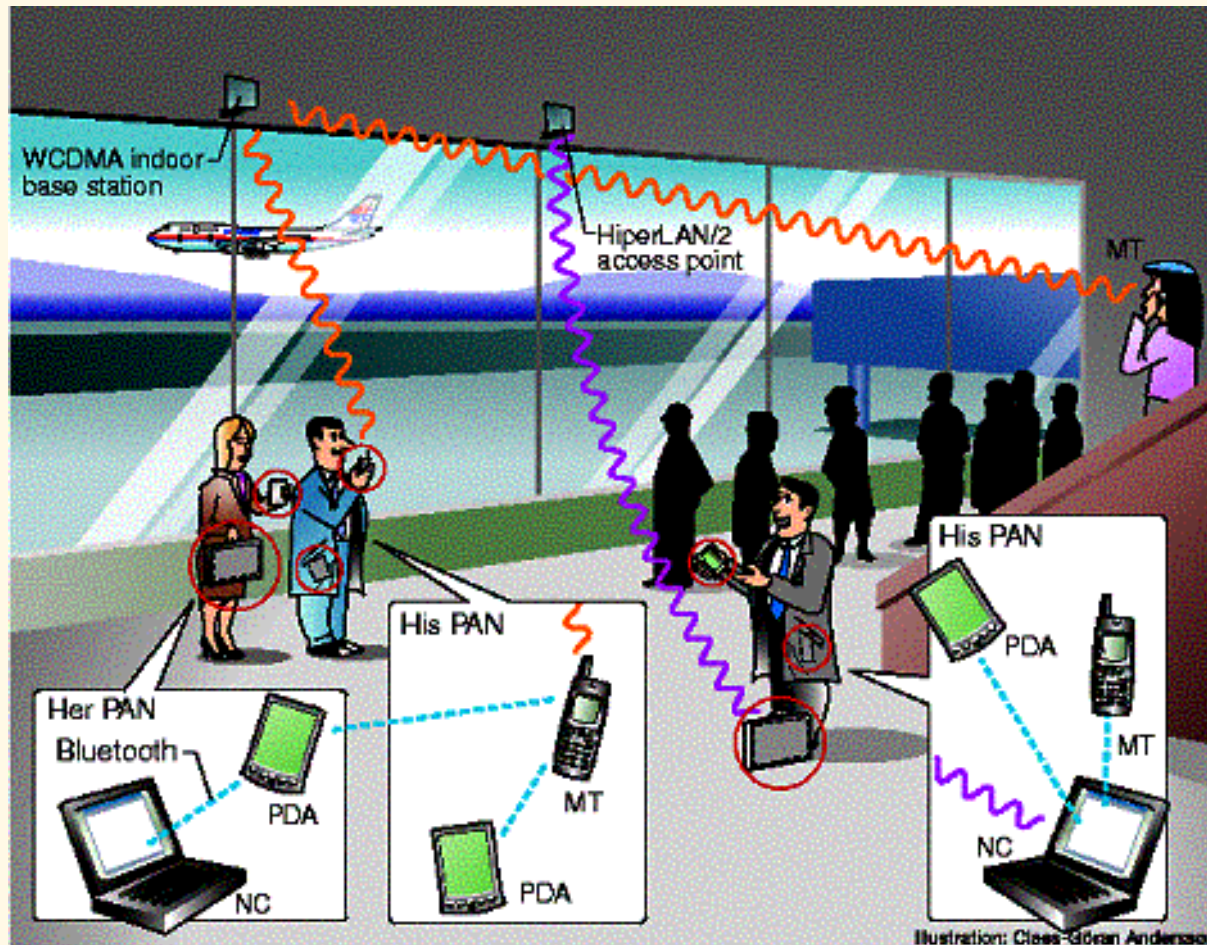


[Brunell University West London]

# 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
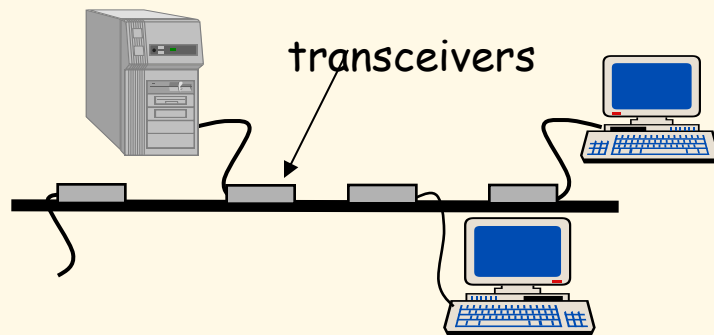
Ethernet bus

Ethernet hub

# Wireless LANs (WLANs)



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

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# Wireless Sensor Networks (WSNs)
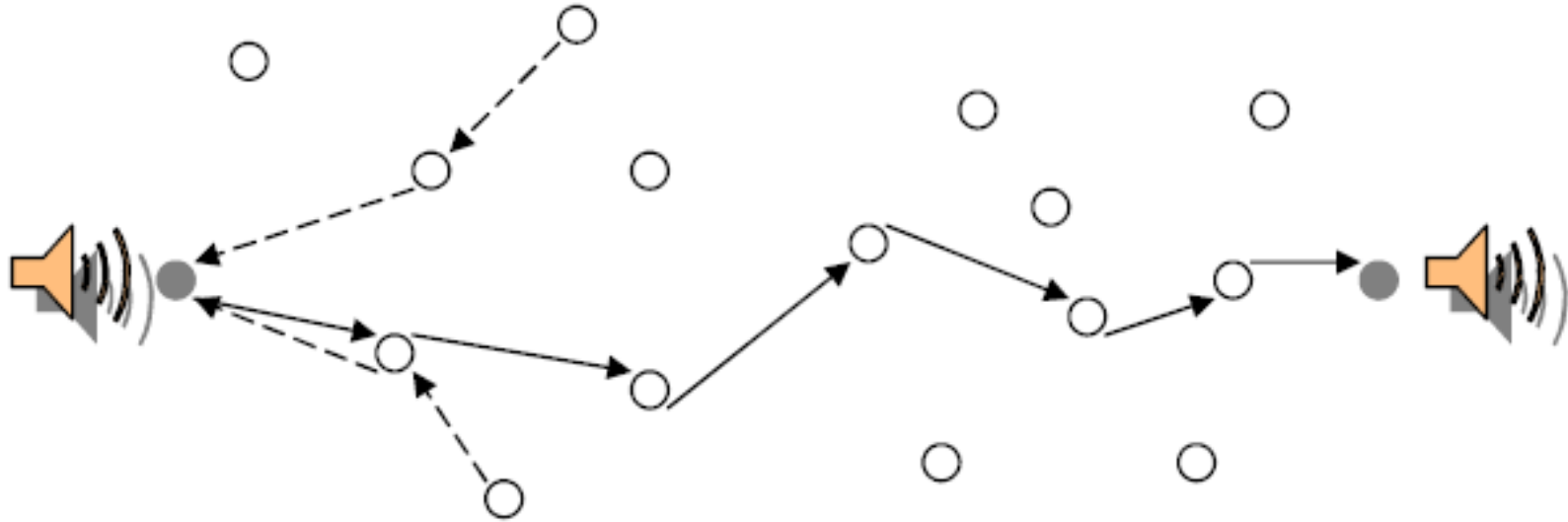


Figure 1: Routing paths for end to end and mote-to-sink.

N. Chohan

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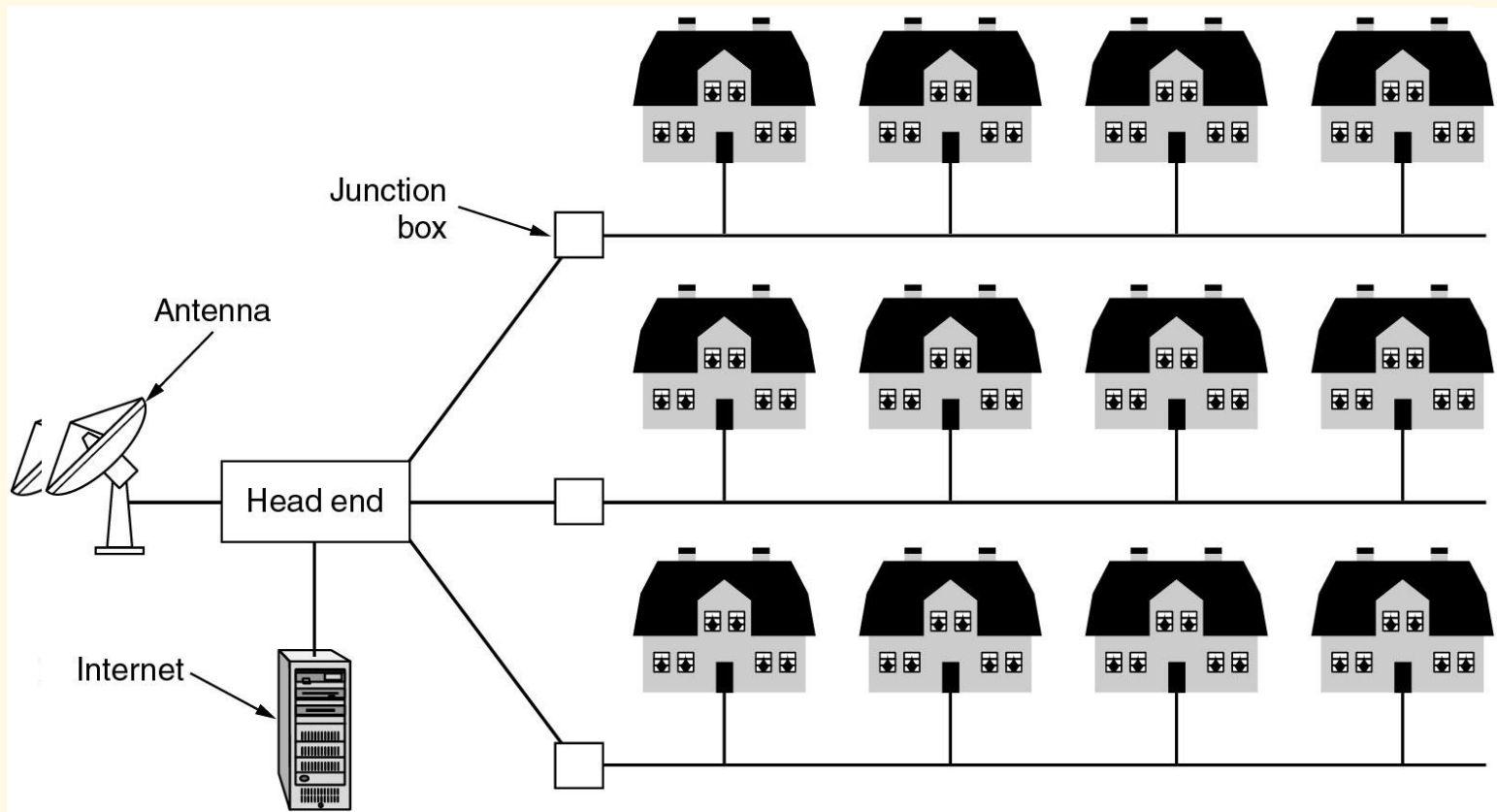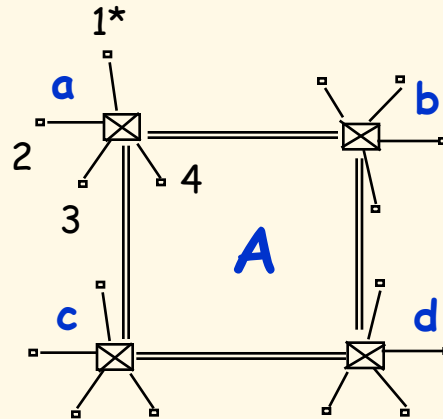
# Metropolitan Area Networks (MANs)
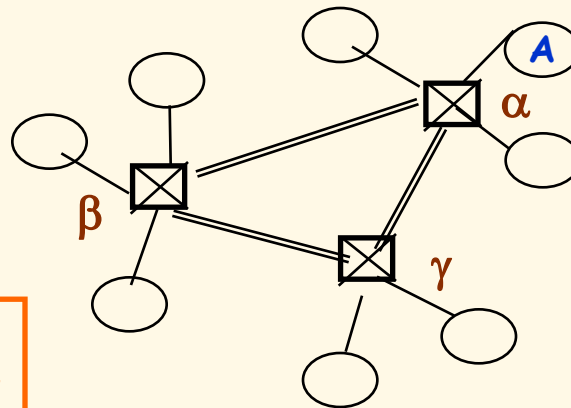


Figure 1-8. A metropolitan area network based on cable TV.

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# MANs within a Hierarchical Topology

1*

a                    b

2

4

3

**A**

c                    d

Hierarchical Network Topology

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

A

α

β

γ

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

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

# 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).

# ARPAnet circa 1972
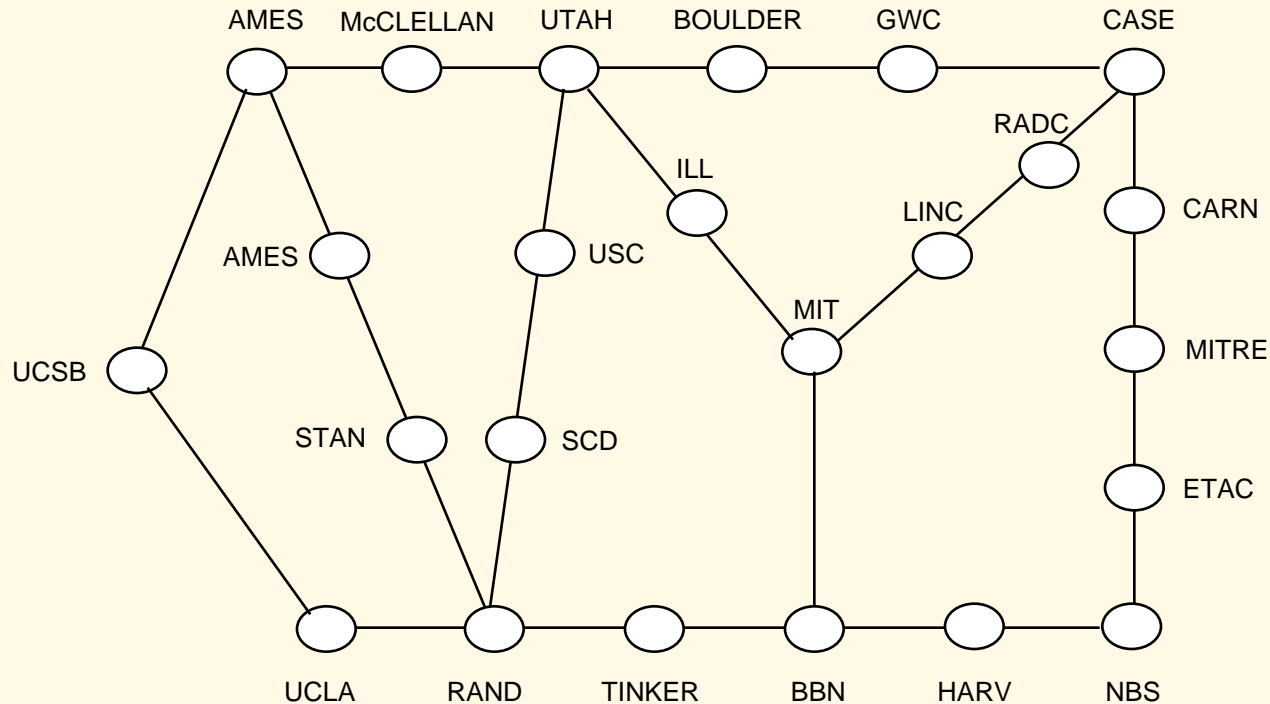


## A point-to-point network

Leon-Garcia & Widjaja:
*Communication Networks*
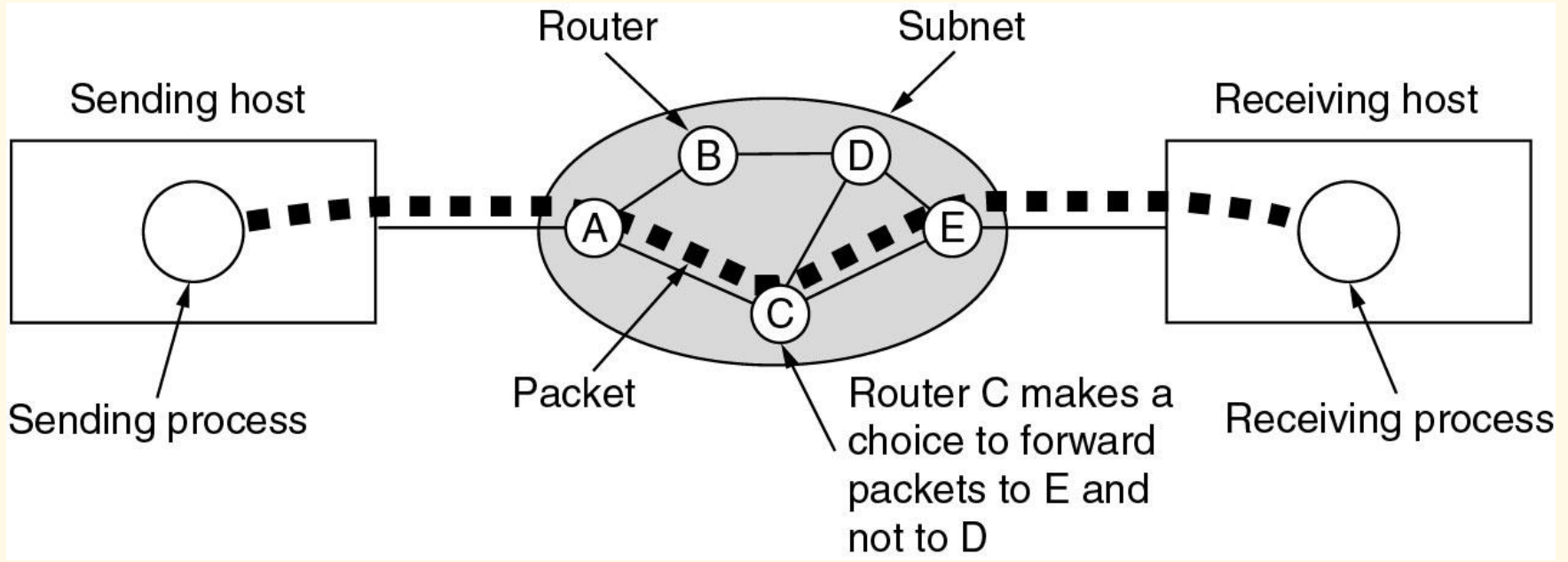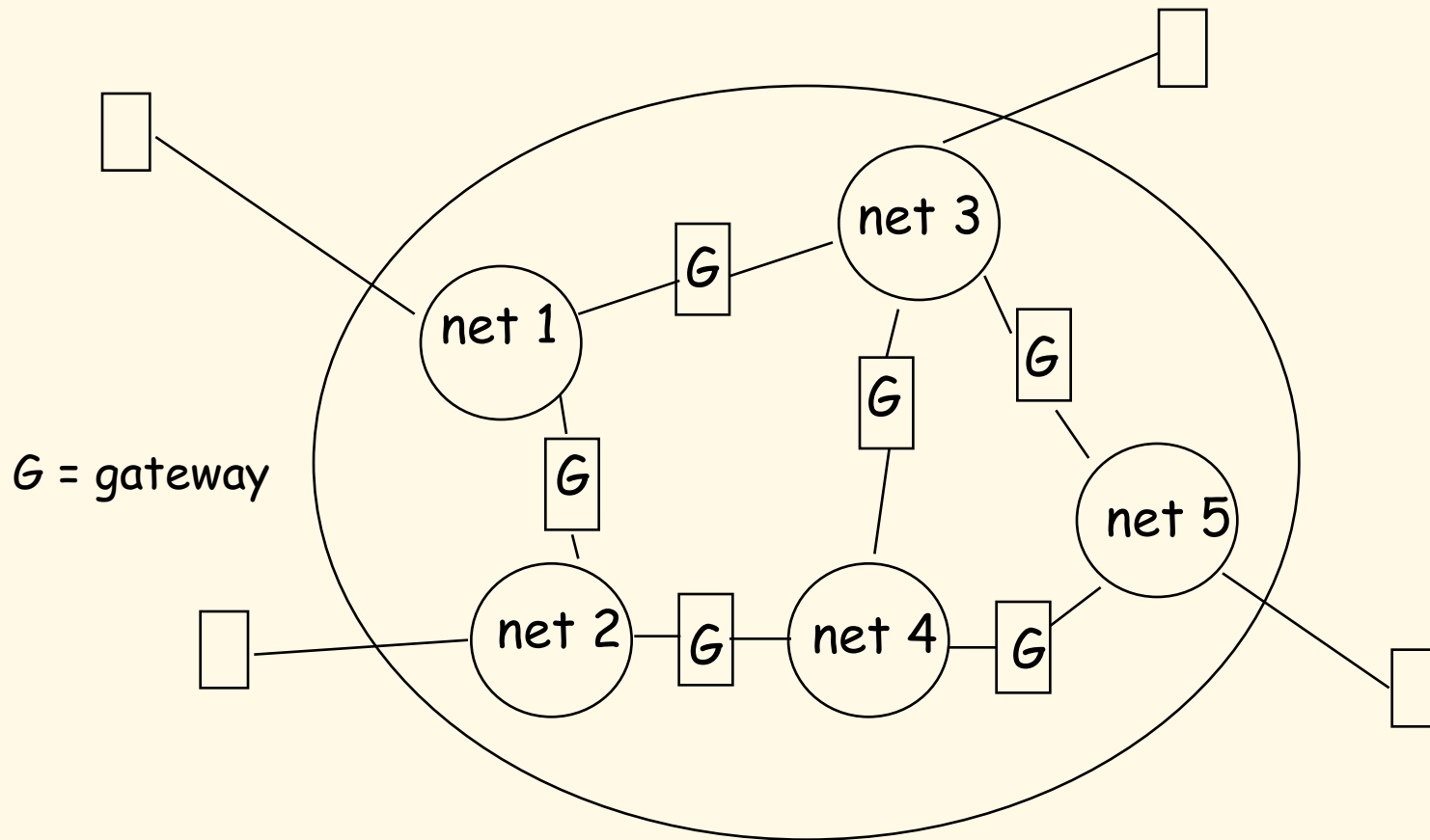
# Wide Area Networks (WANs)



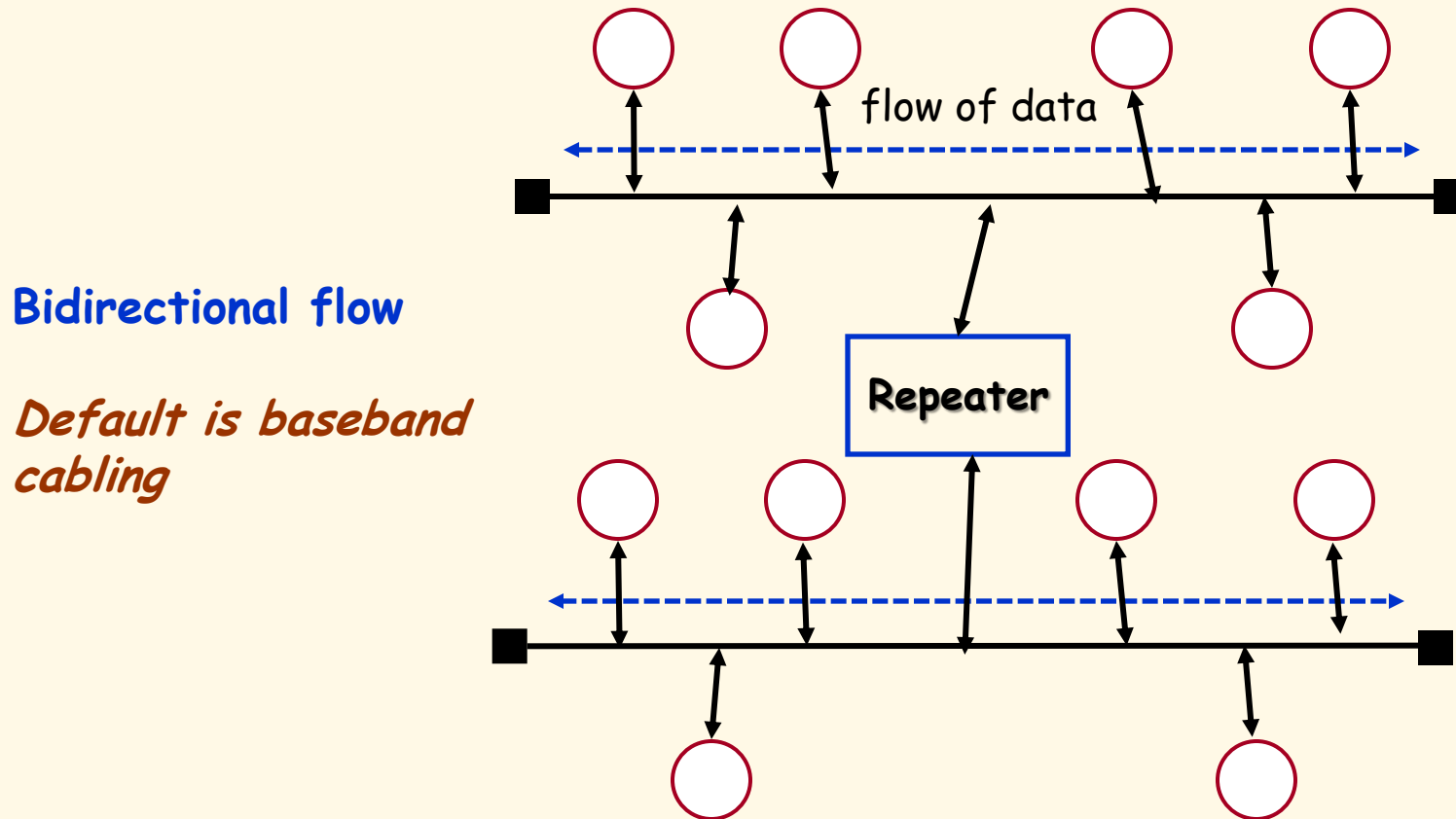Figure 1-10. A stream of packets from sender to receiver.

# internet



net 3

net 1

G

G = gateway

G

net 2　　G　　net 4　　G

G

net 5

## A network of networks

# Network Classification by Topology



flow of data

**Bidirectional flow**

*Default is baseband cabling*

Repeater

Bus Topology

# Network Classification by Topology

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



Repeater

Repeater
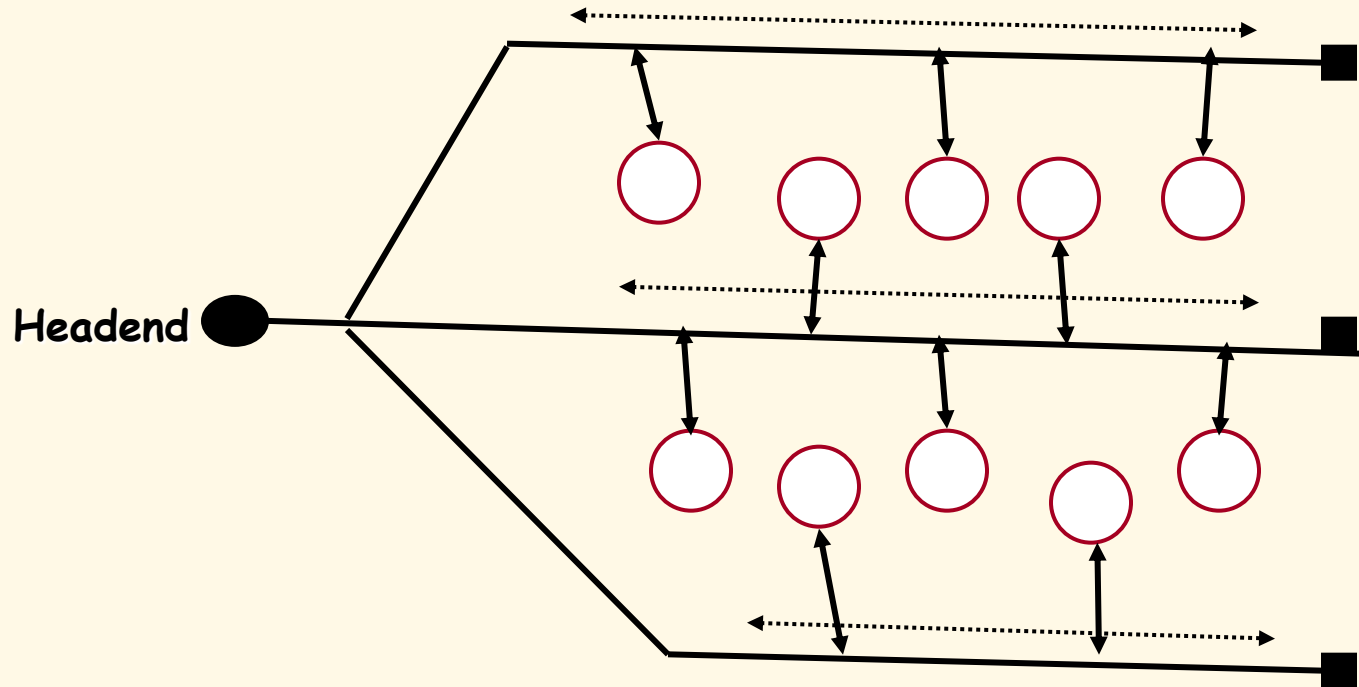
## Ring Topology
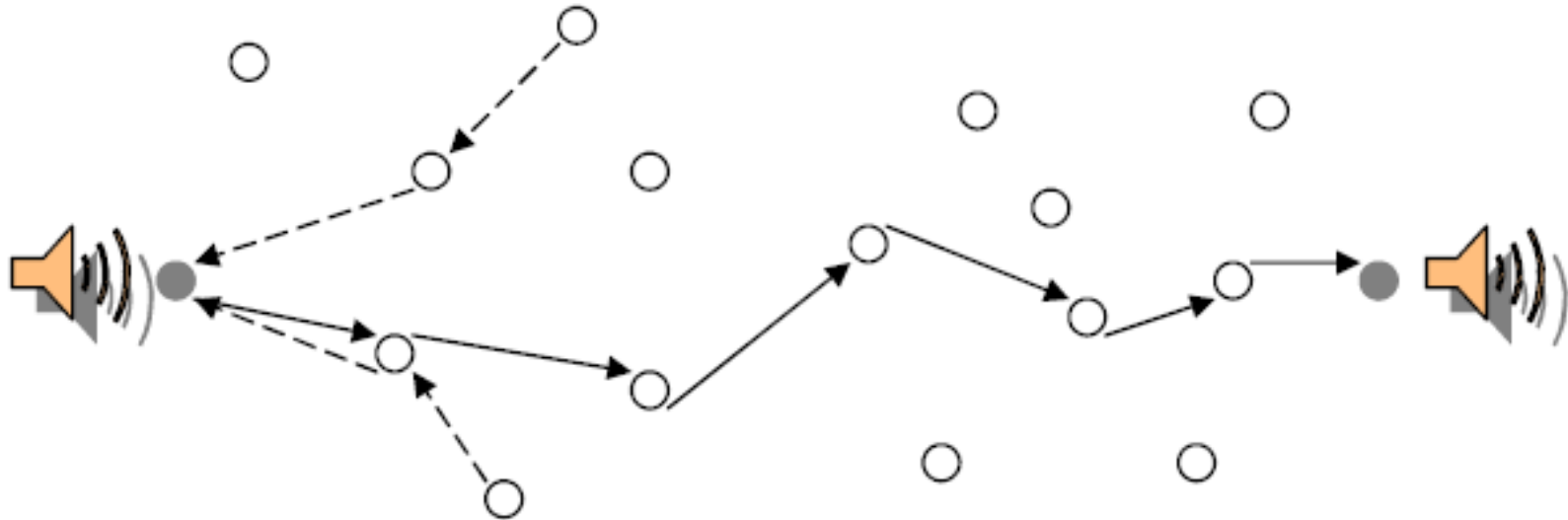
Tree Topology
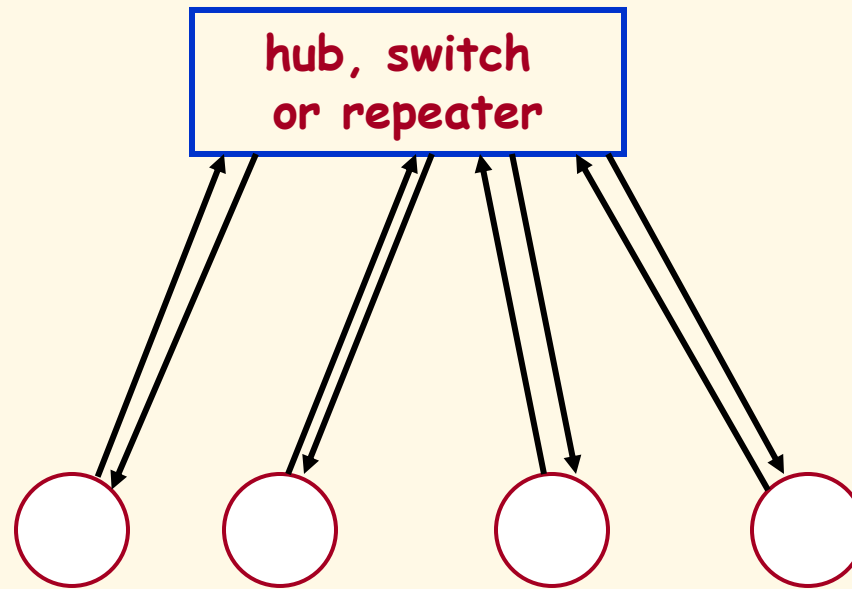
# Tree Topology



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

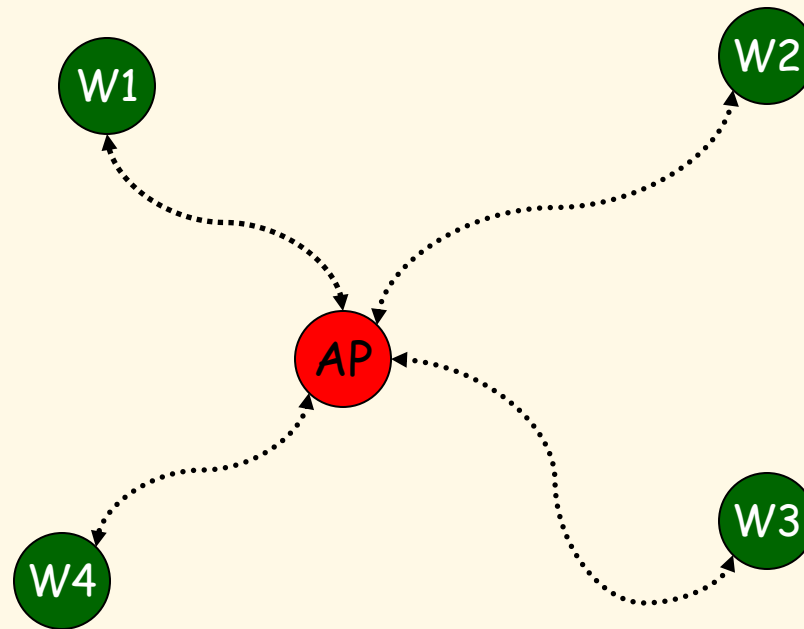**WSN end-to-end routing often employs a spanning tree for routing.**

# Network Classification by Topology

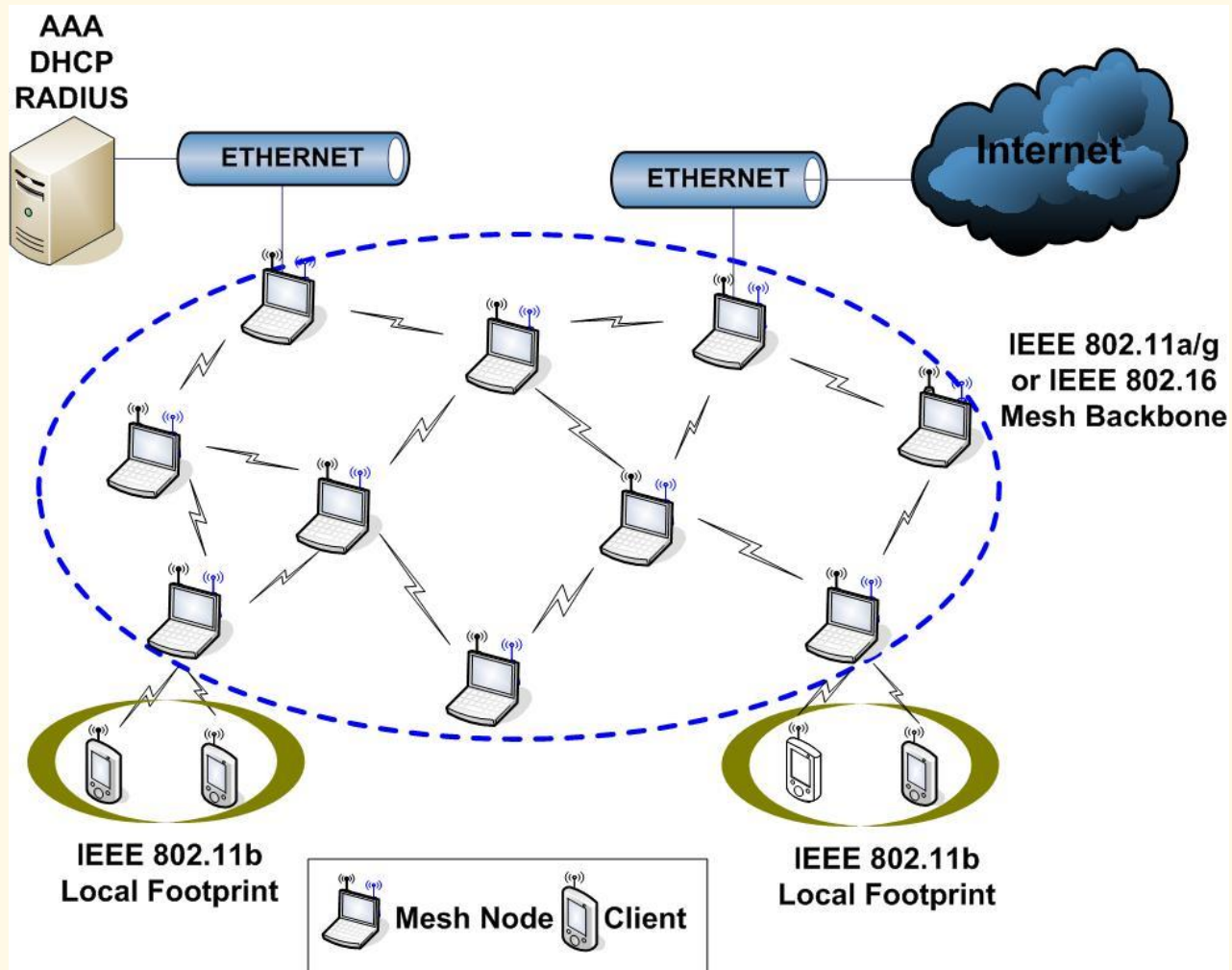hub, switch
or repeater

## Star Topology

Wireless Infrastructure

Star Topology

# Wireless Mesh Network

# 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, star and mesh topology