

Introduction



Computer Networks
Spring 2013

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

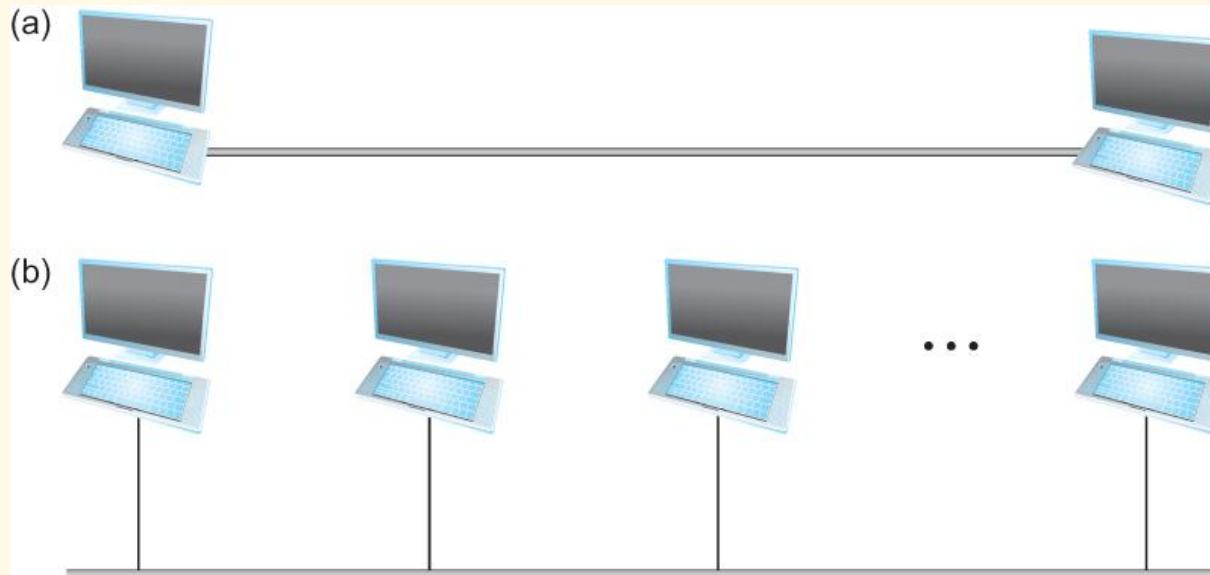


Figure 1.2 Direct links:

(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 (3G, 4G LTE)
 - Bluetooth
 - Zigbee (part of IEEE802.15.4)
 - WiMAX

Switched Network

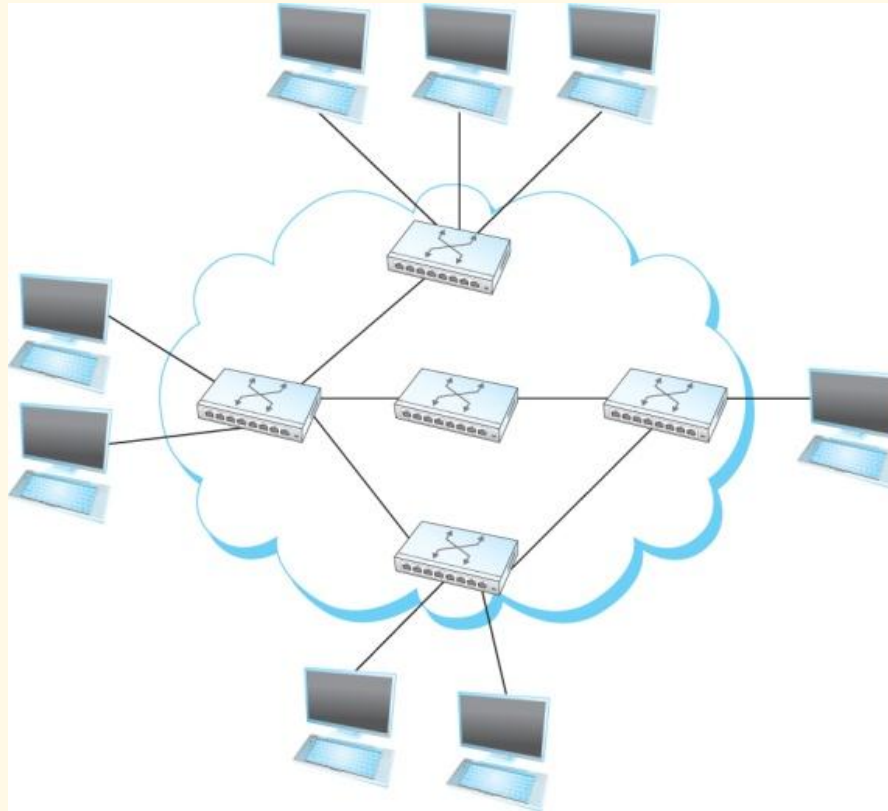


Figure 1.3 Switched network

An internet

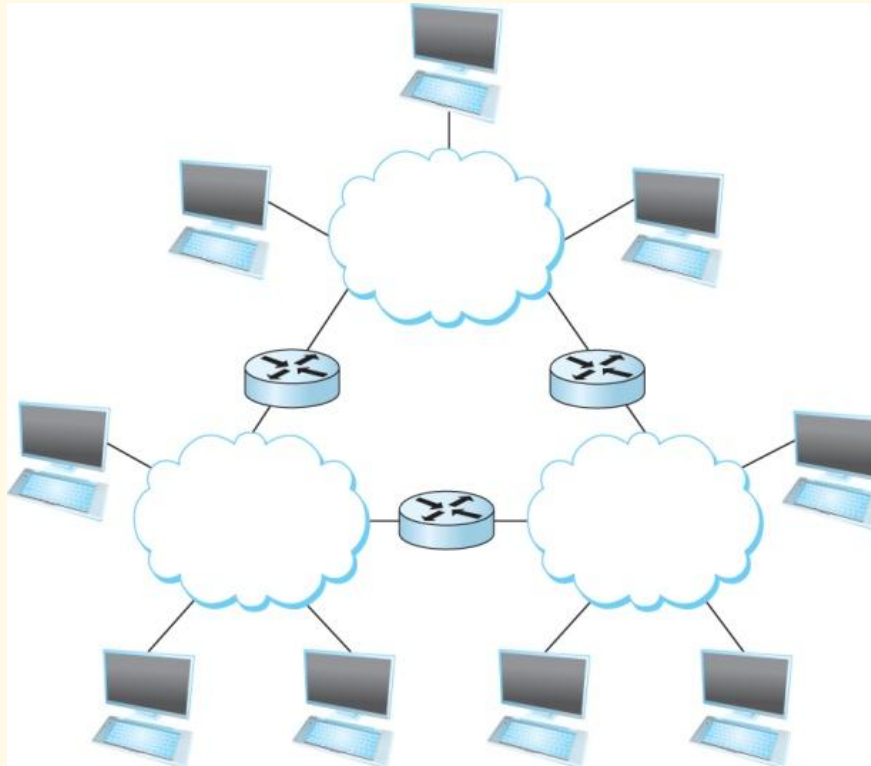


Figure 1.4 Interconnection of Networks

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.

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

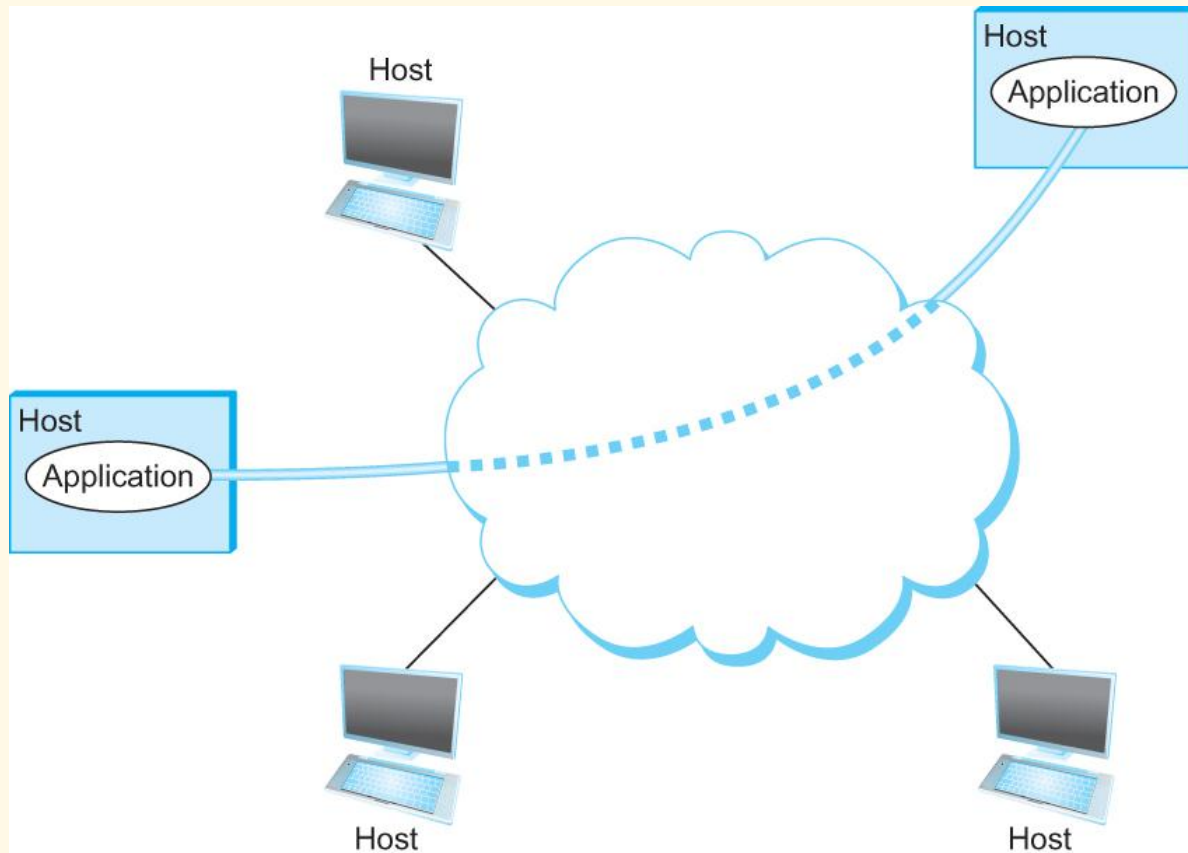
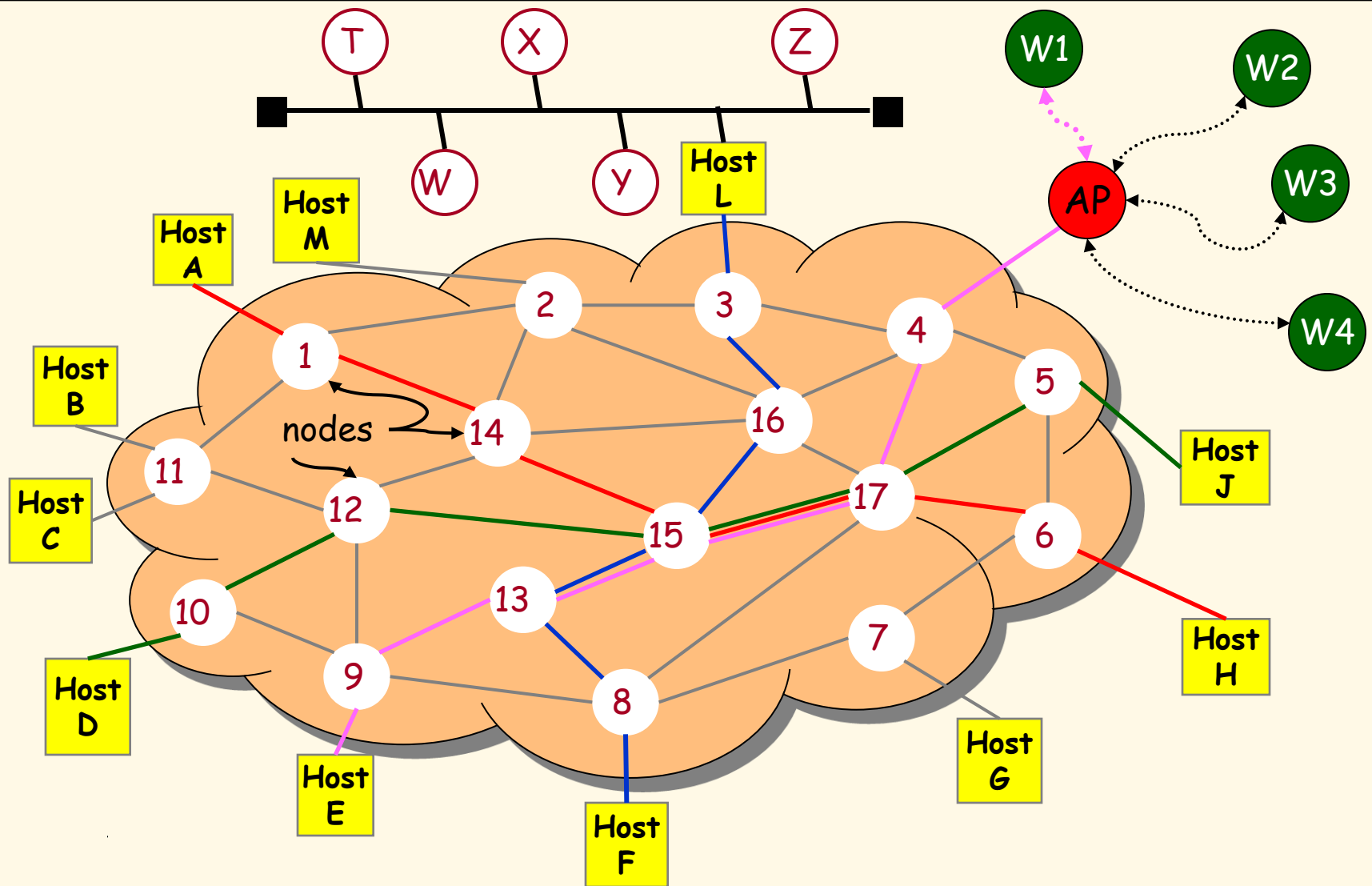
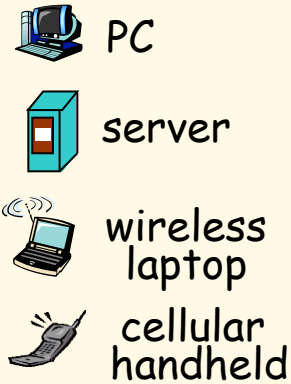


Figure 1.7 Processes communicating over an abstract channel

Internet Access and Flows



The Internet: "nuts and bolts" view



billions of connected computing devices:
hosts = end systems

– running *network apps*

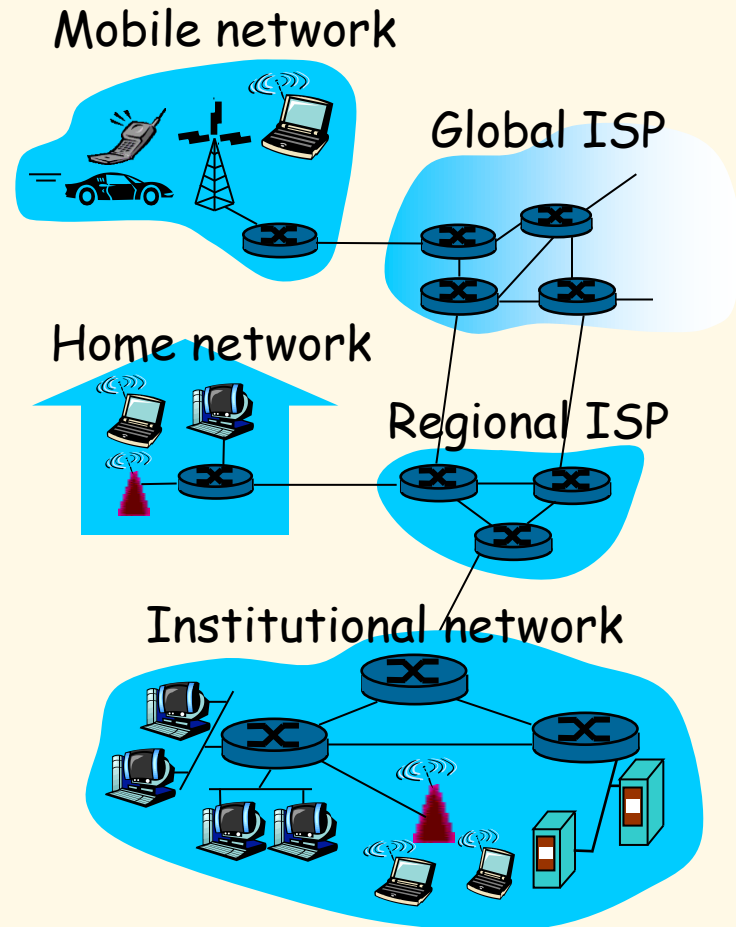
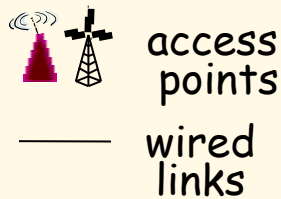
□ *communication links*

❖ fiber, copper, radio, satellite

❖ transmission rate = *capacity*

□ *routers**: forward packets (chunks of data)

* Also referred to as switches or gateways.



K & R

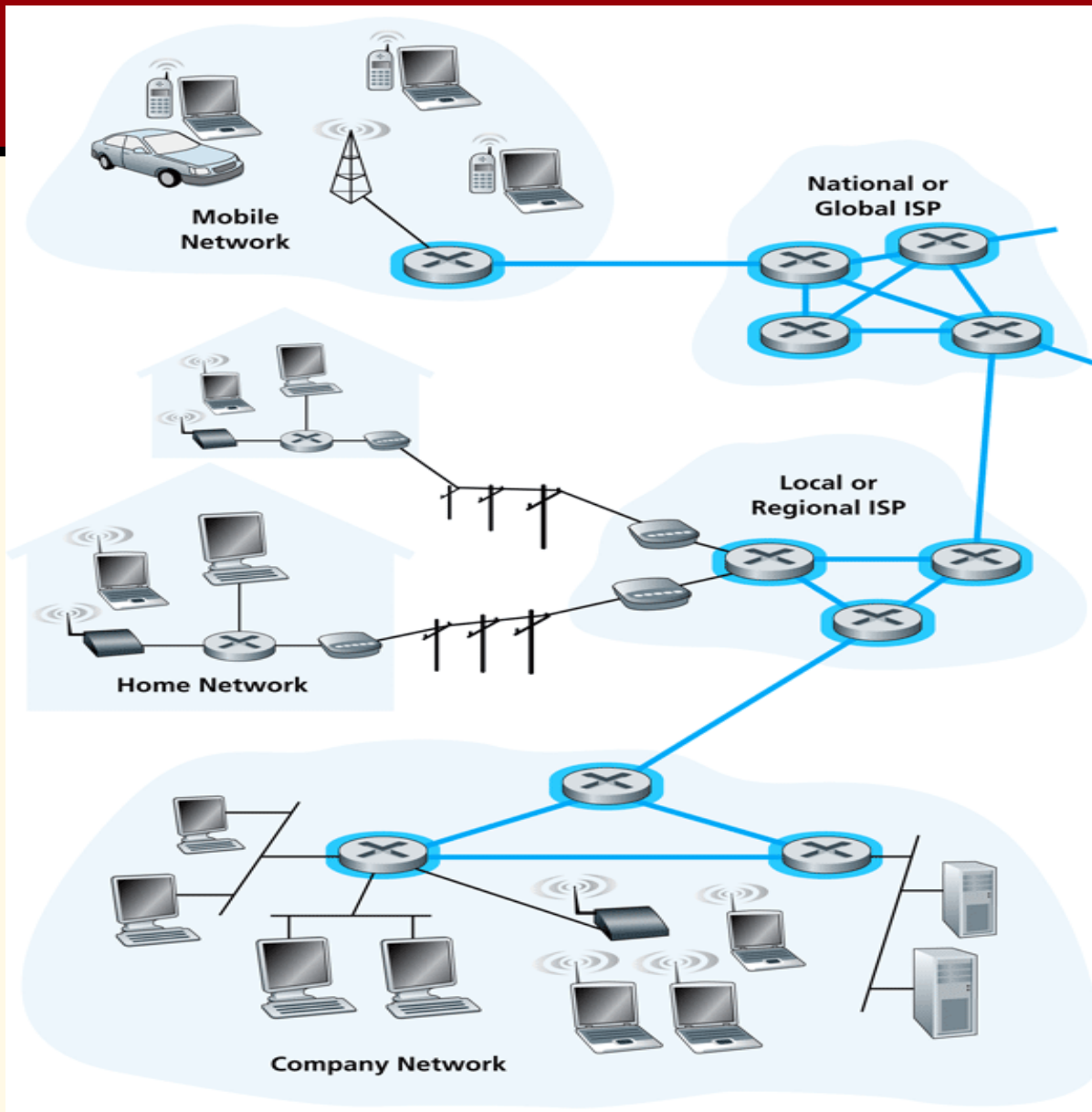


Figure 1.7 ♦ The network core

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



Introduction

Client-Server Applications

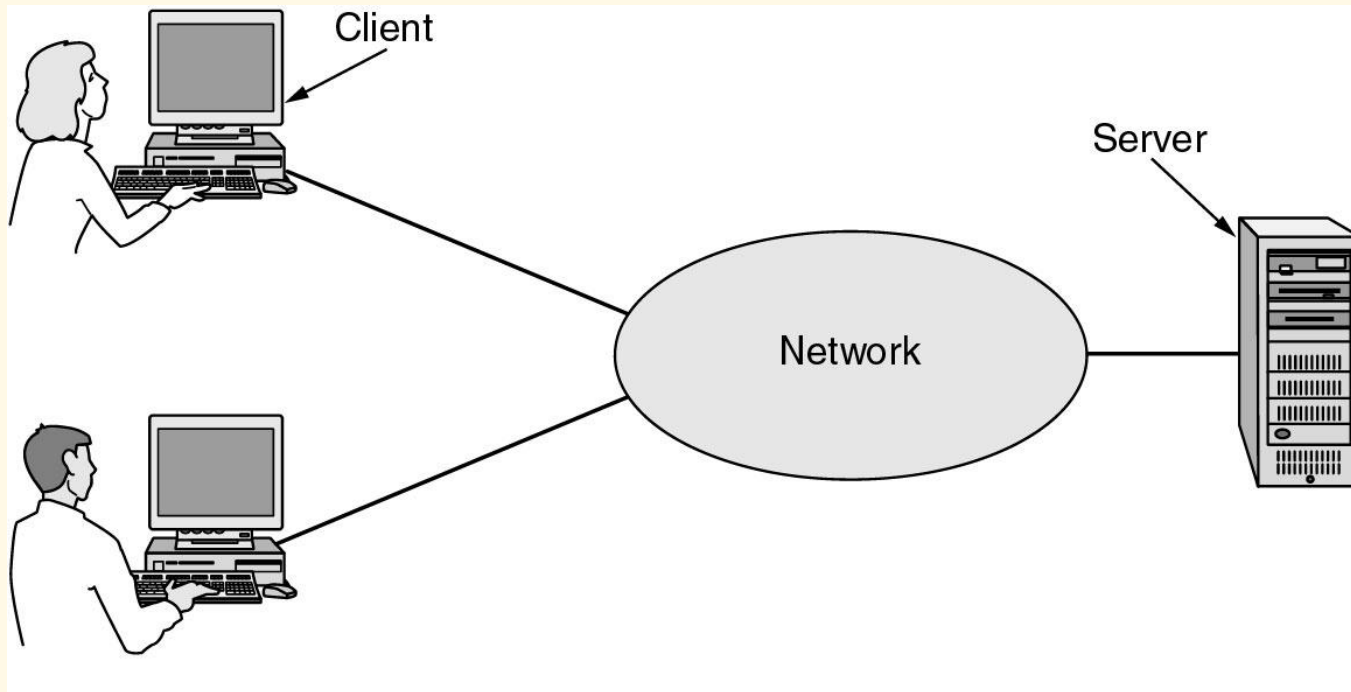


Figure 1.1 A network with two clients and one server.

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Client-Server Model

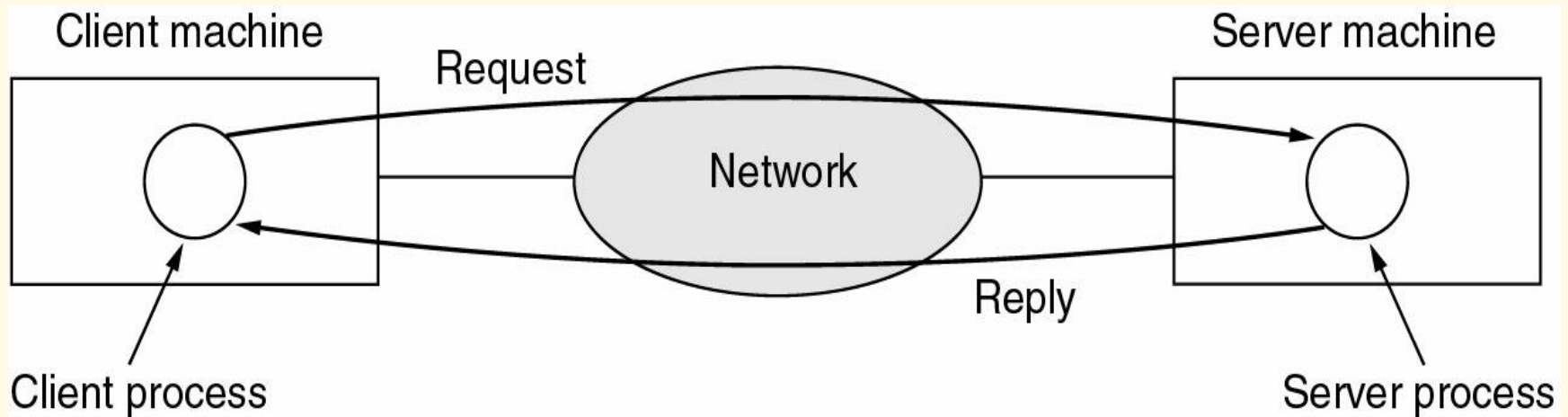


Figure 1-2. The client-server model involves requests and replies.

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Peer-to-Peer Applications

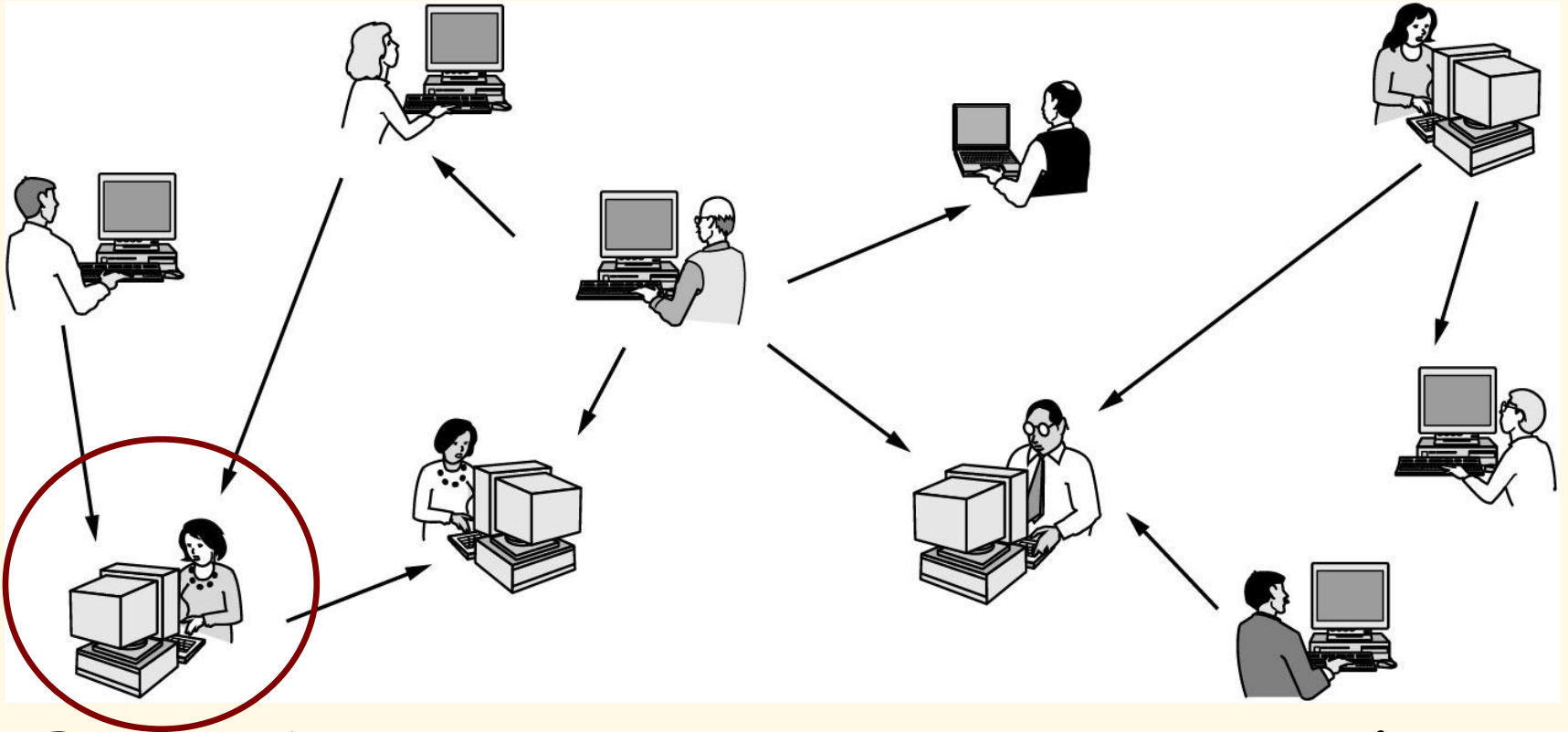
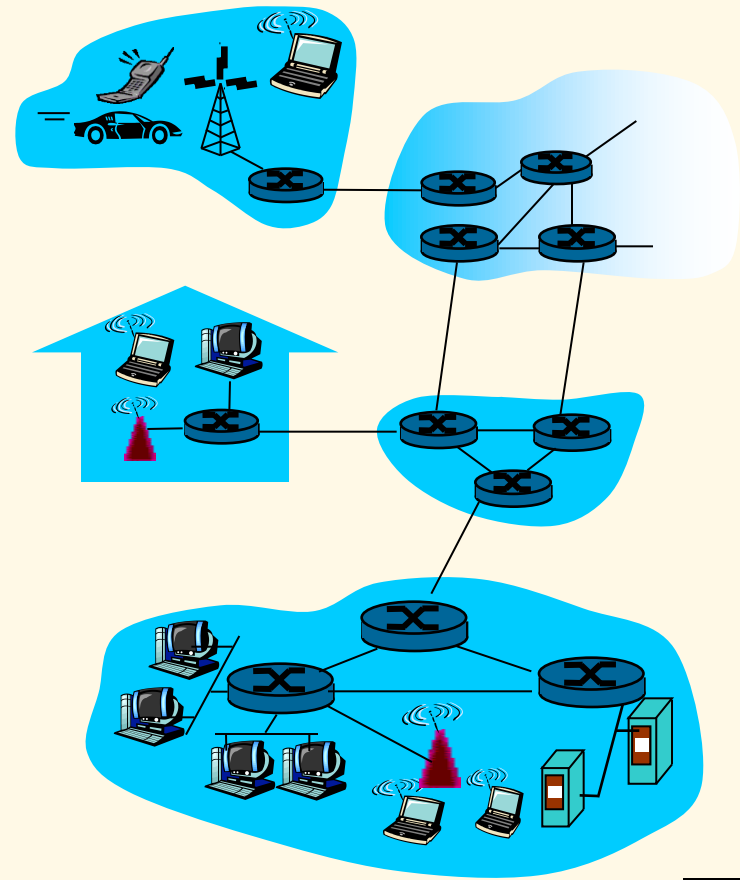


Figure 1.3 In a peer-to-peer system there are no fixed clients and servers.

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A Closer Look at Network Structure

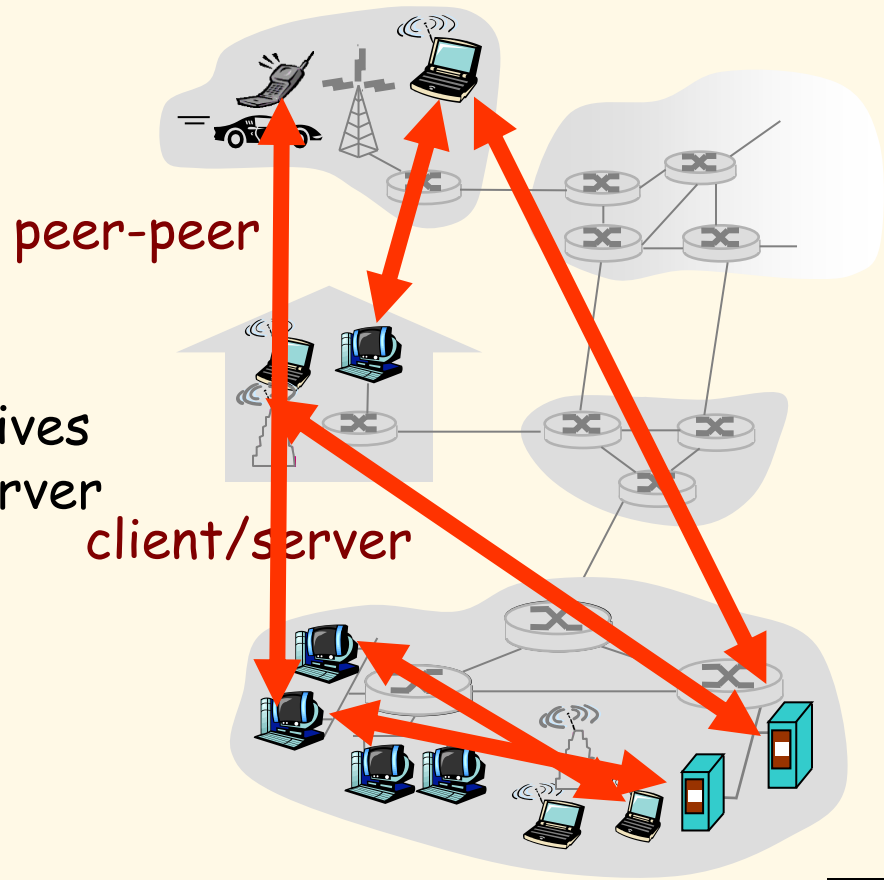
- **network edge:**
applications and hosts
- **access networks,**
physical media:
wired, wireless communication links
- **network core:**
 - ❖ interconnected routers
 - ❖ network of networks



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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



K & R

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 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	

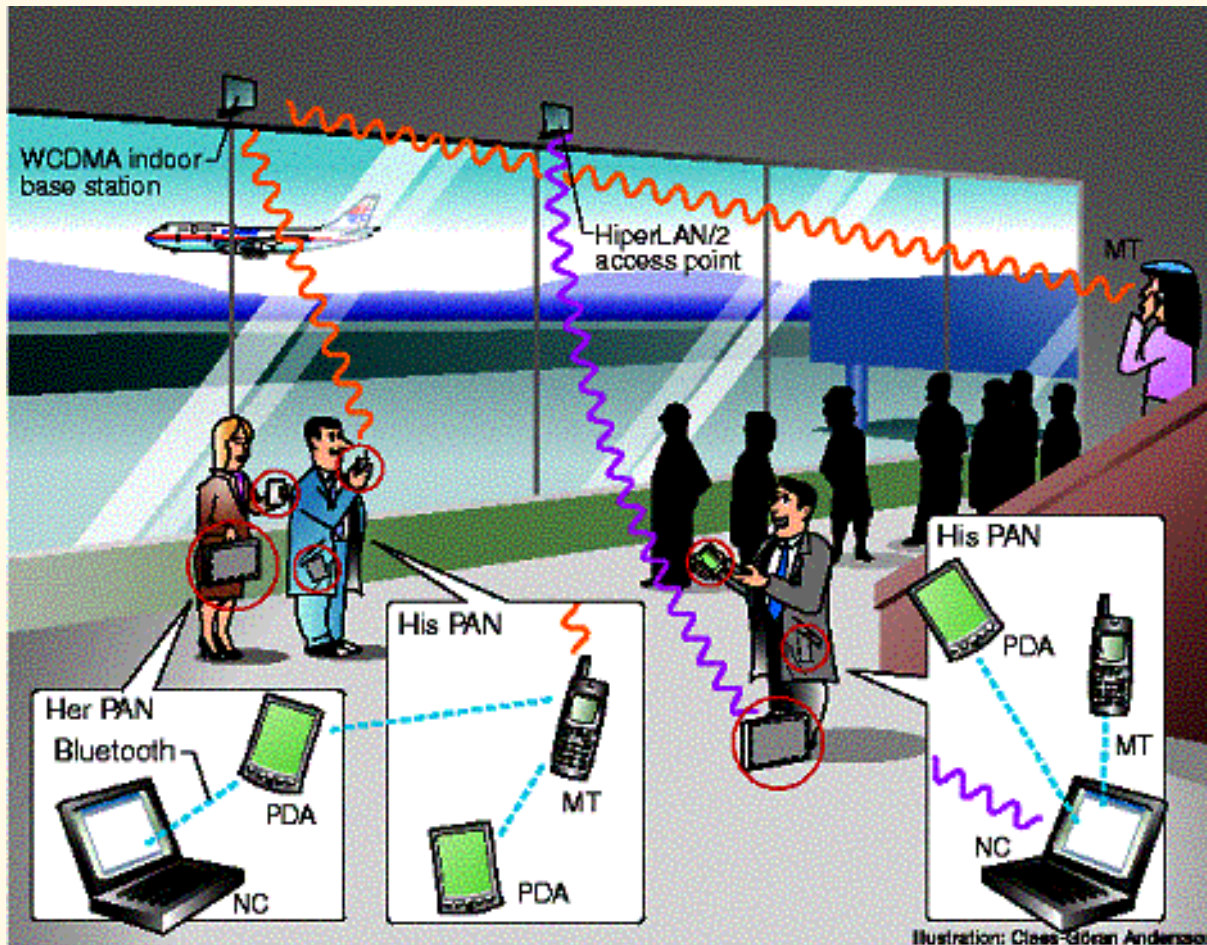
Figure 1-6. Classification of interconnected processors by scale.

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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

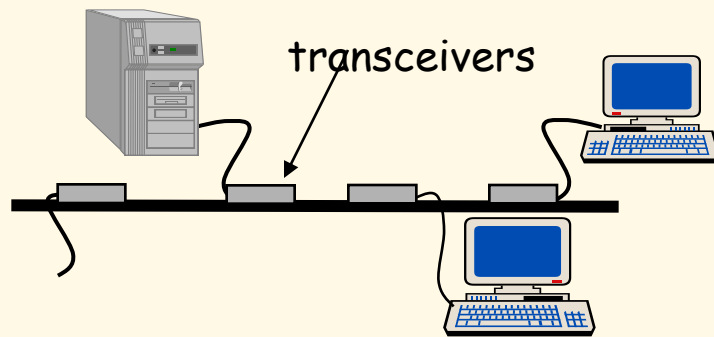


[Brunell University West London]

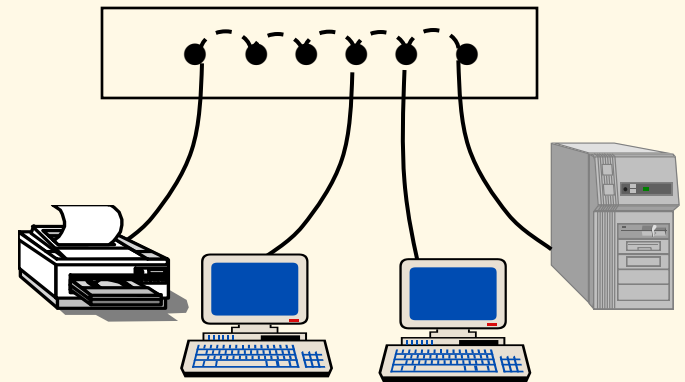
Classification by Size

- **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



Ethernet bus



Ethernet hub

Leon-Garcia & Widjaja:
Communication Networks

Wireless LANs (WLANs)

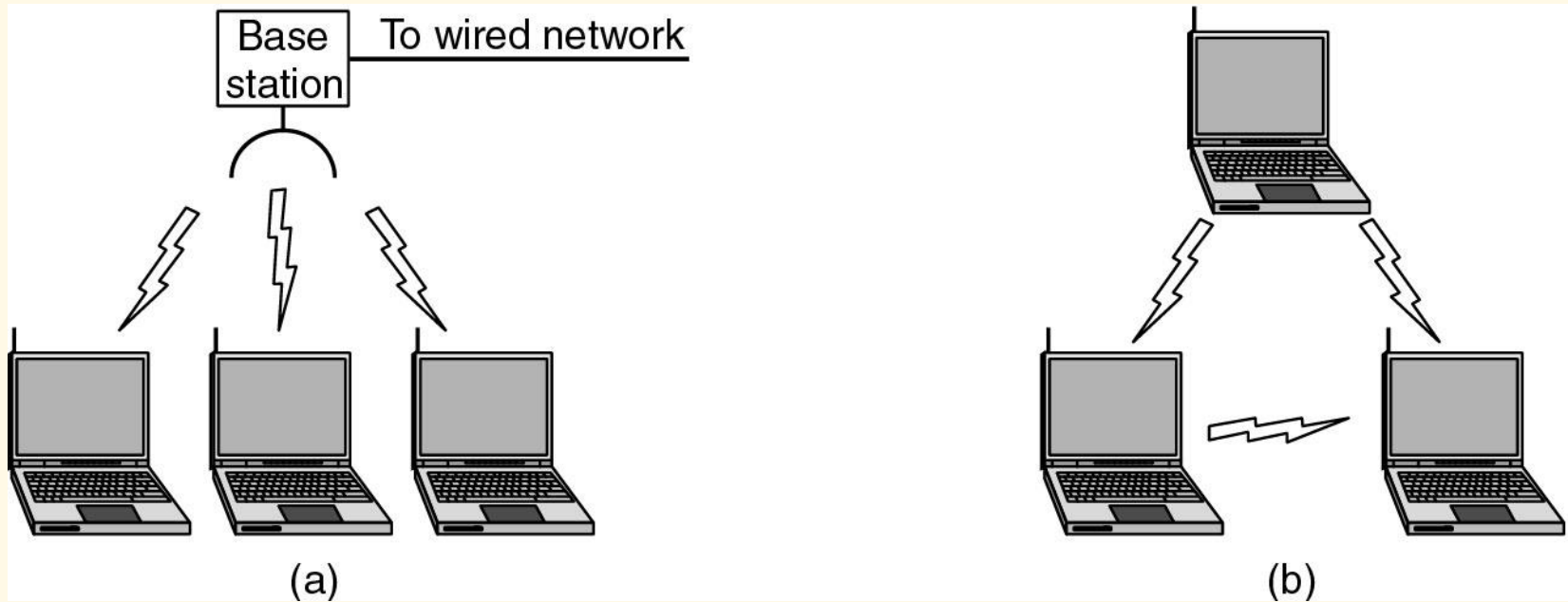


Figure 1-35. (a) Wireless networking with a base station. (b) Ad hoc networking.

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Wireless Sensor Networks (WSNs)

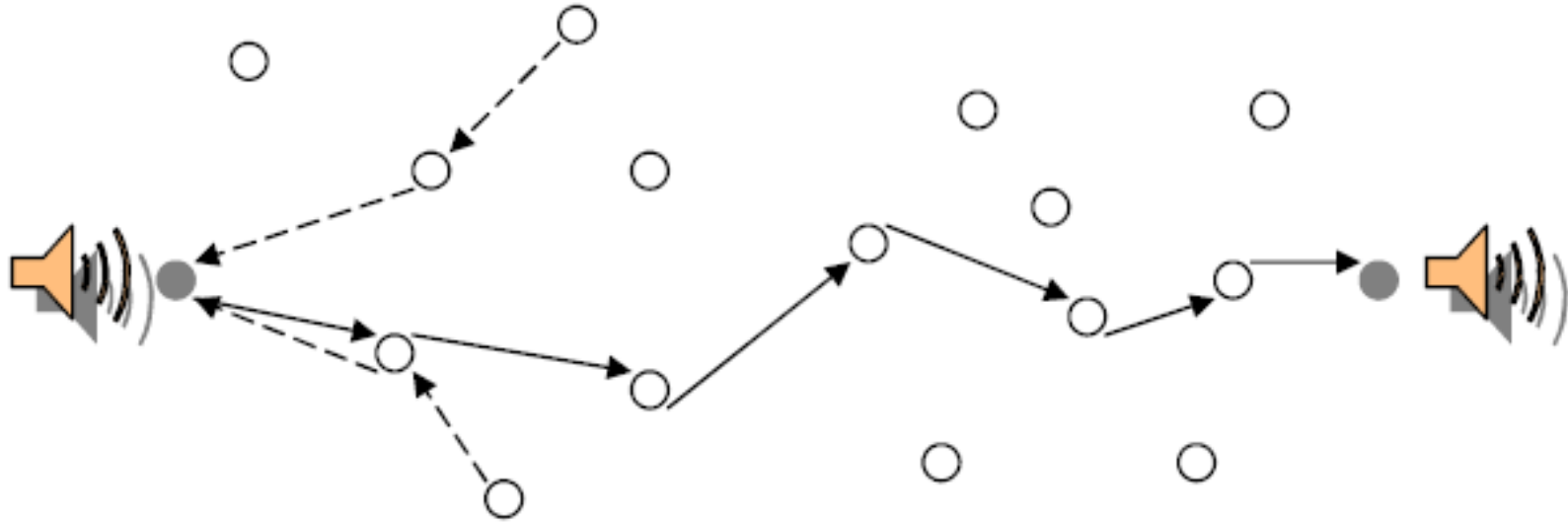


Figure 1: Routing paths for end to end and mote-to-sink.

N. Chohan

WSNs can have mobile or fixed nodes but require a routing algorithm and normally have power concerns.

Metropolitan Area Networks (MANs)

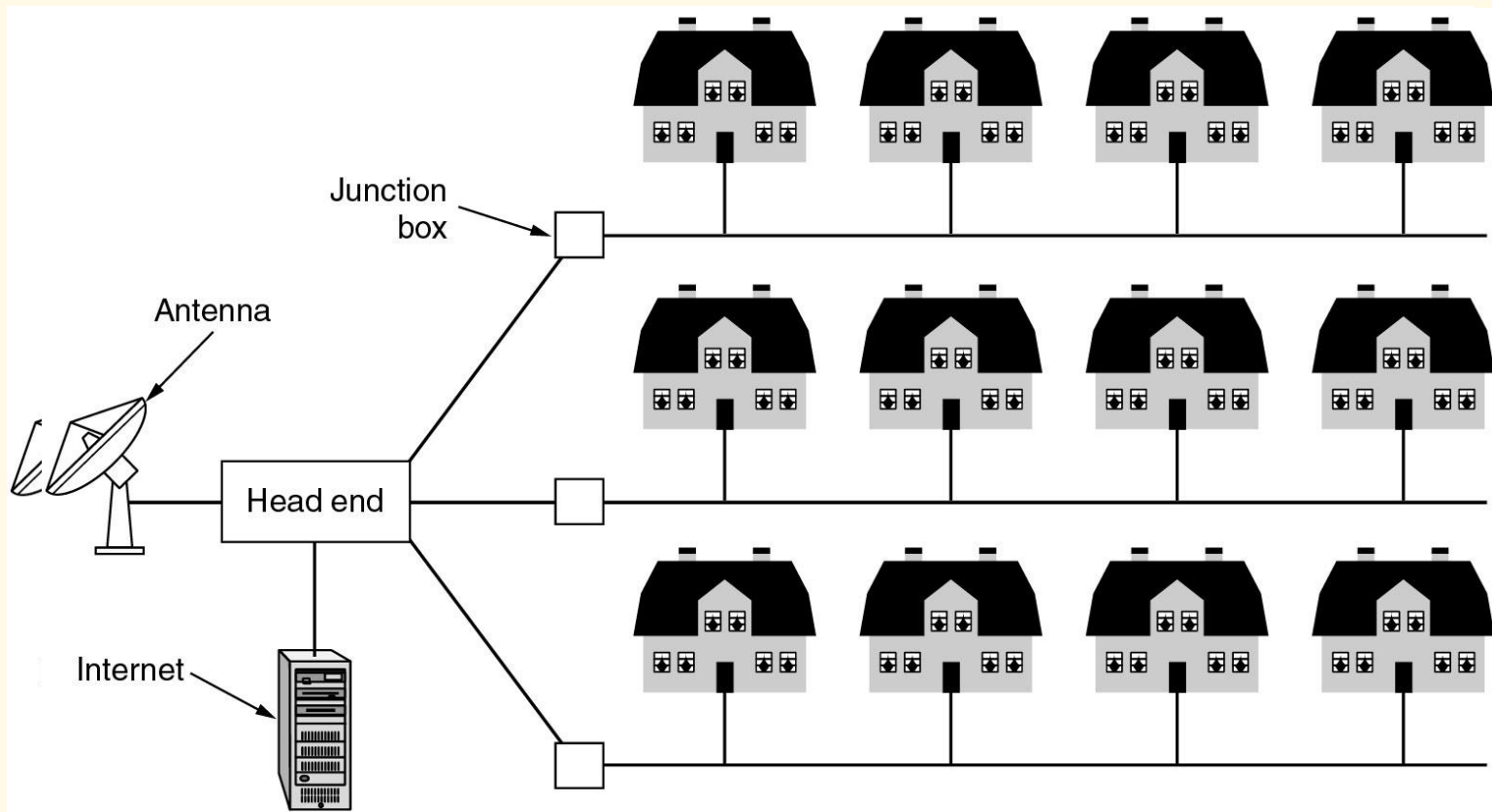
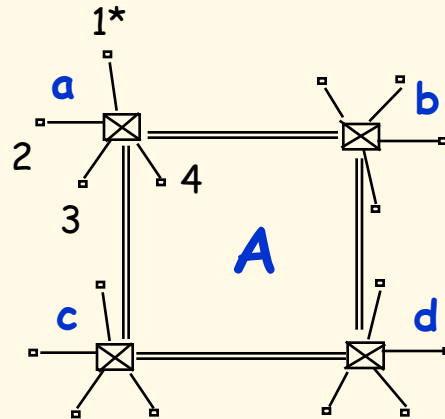


Figure 1-8. A metropolitan area network based on cable TV.

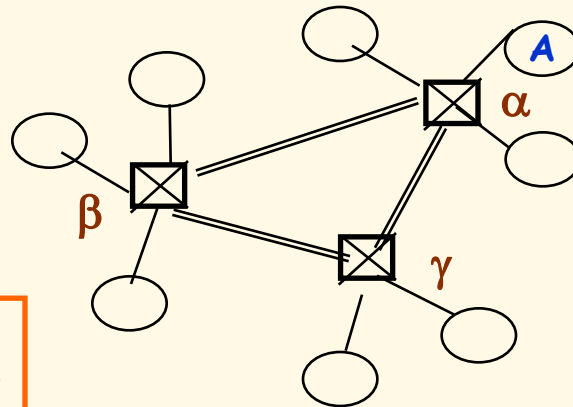
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MANs within a Hierarchical Topology



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

Hierarchical Network Topology



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

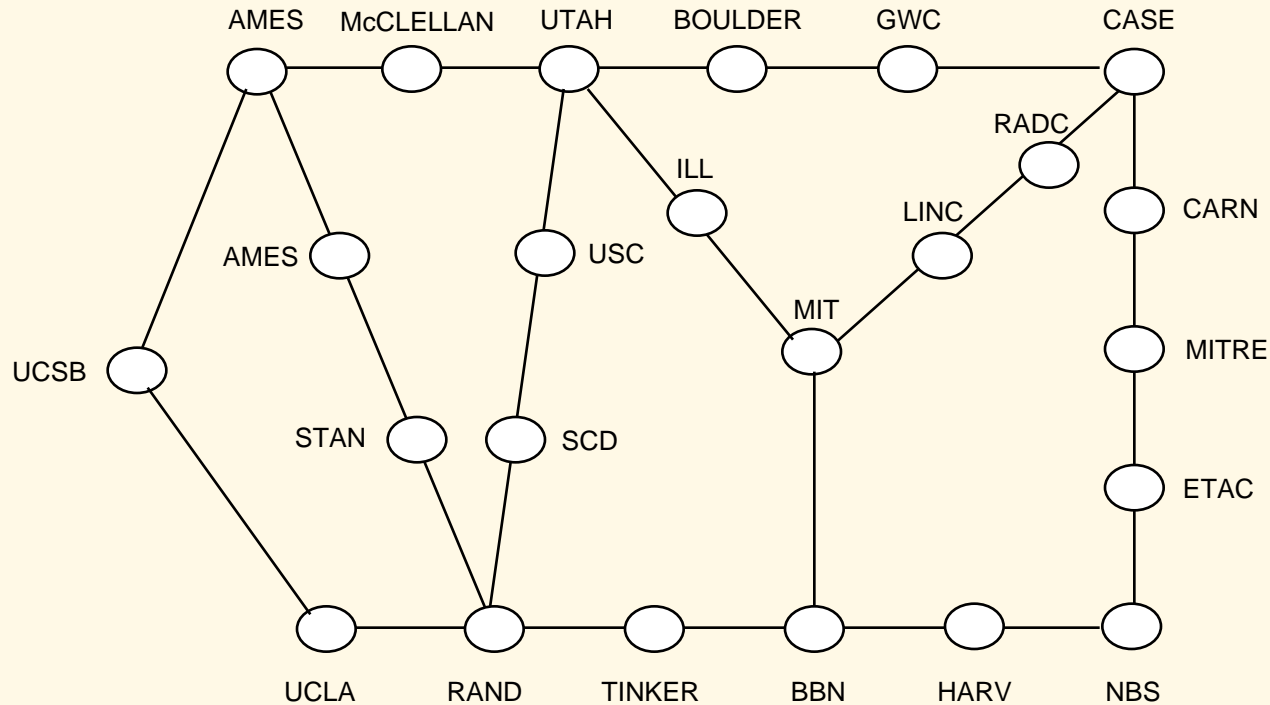
Metropolitan network **A** is part of regional subnetwork α .

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).

ARPAnet circa 1972



A point-to-point network

*Leon-Garcia & Widjaja:
Communication Networks*

Wide Area Networks (WANs)

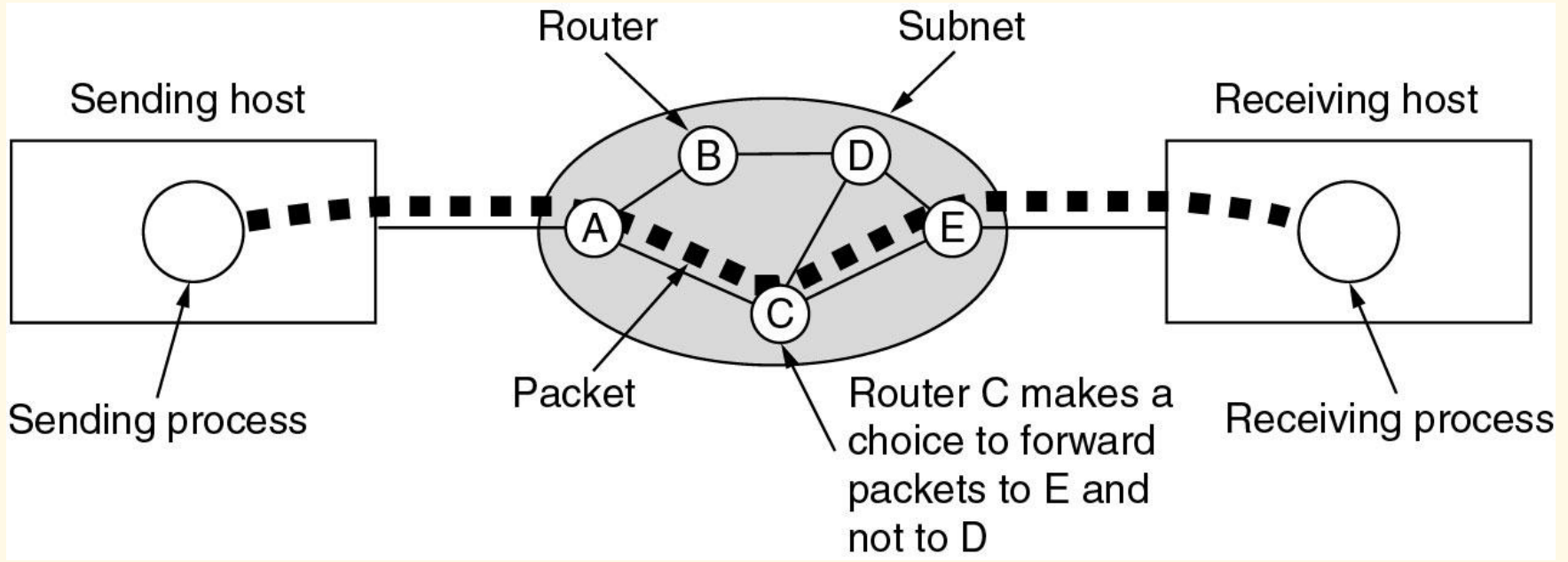
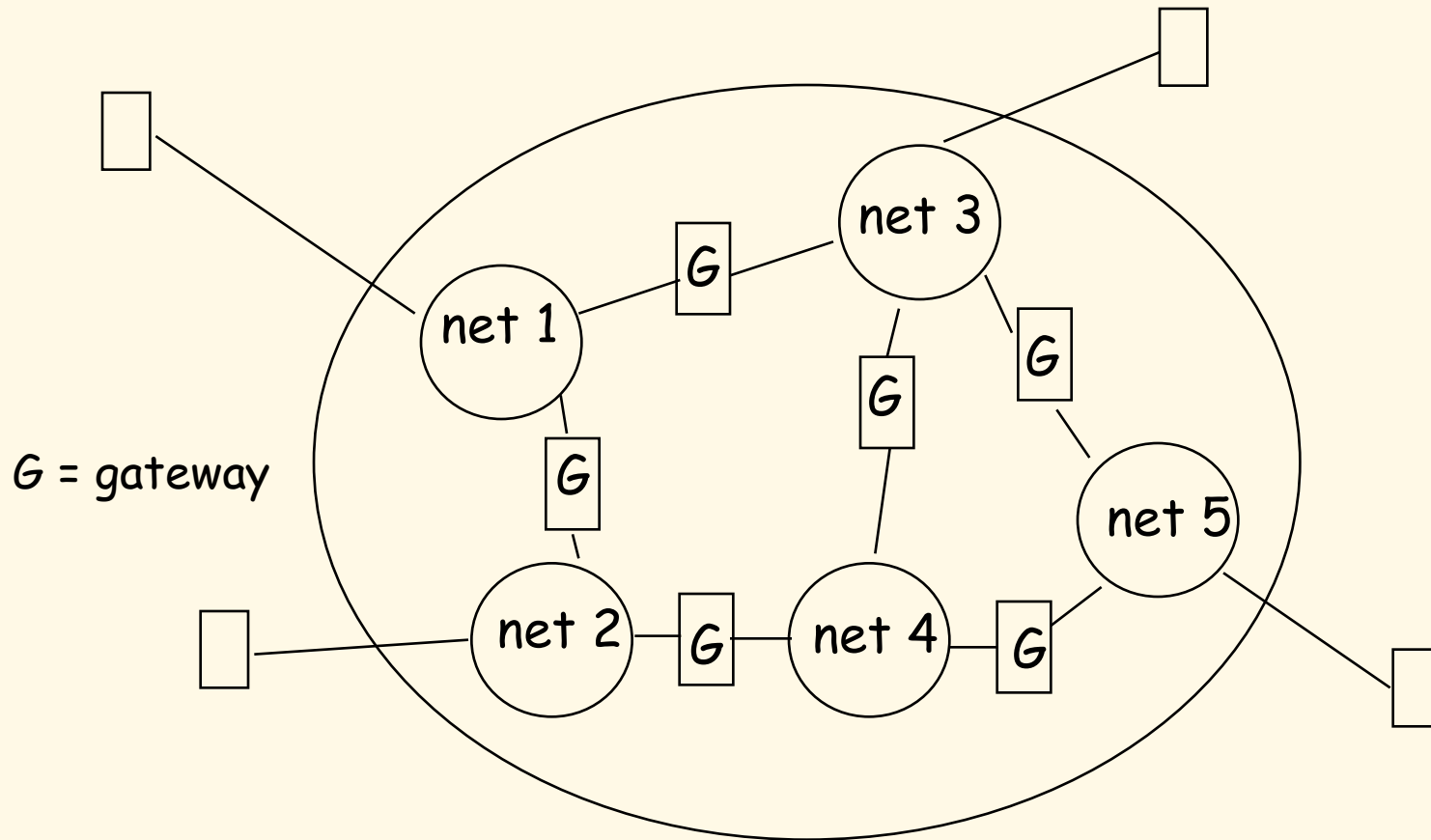


Figure 1-10. A stream of packets from sender to receiver.

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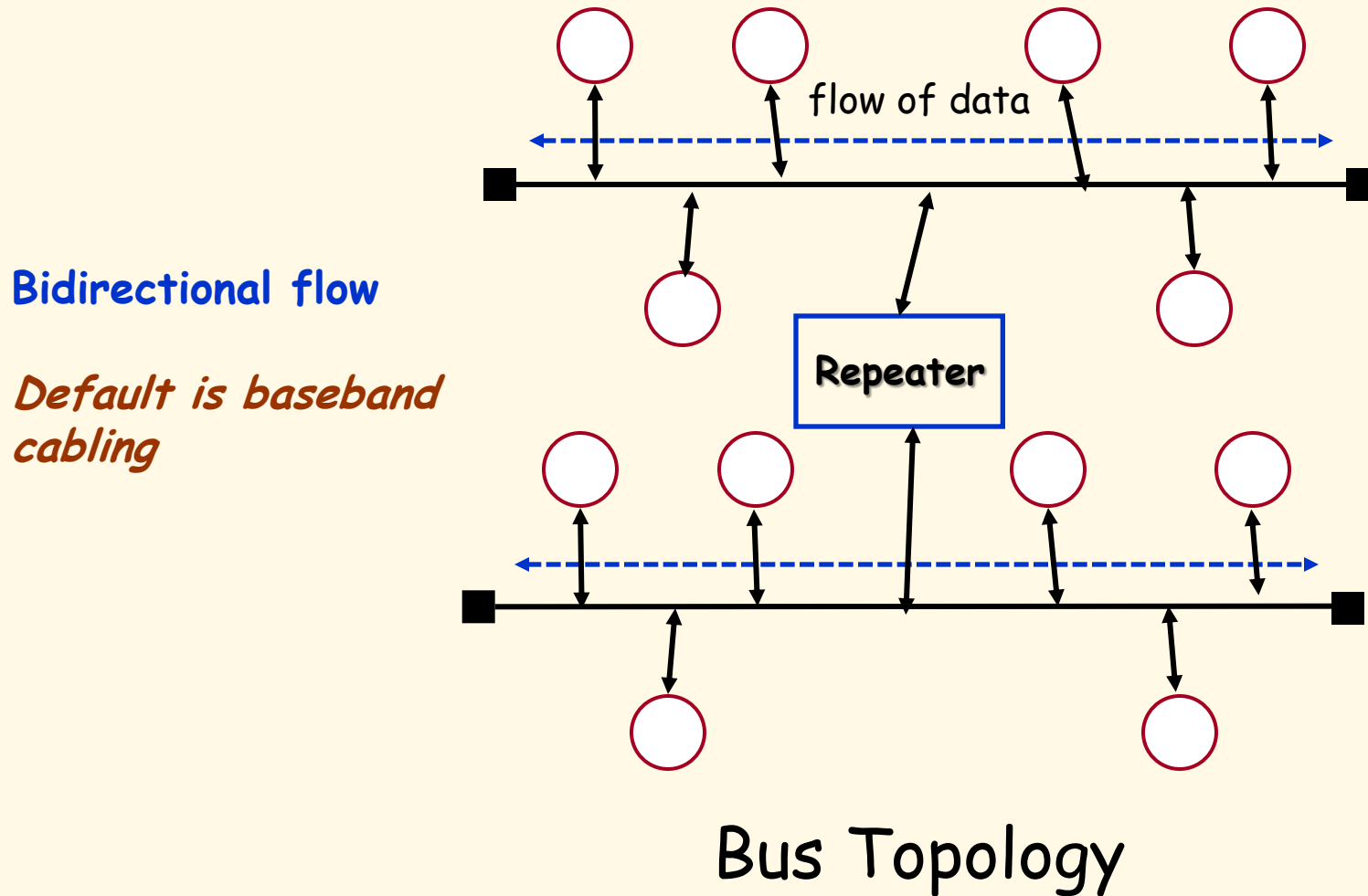
internet



A network of networks

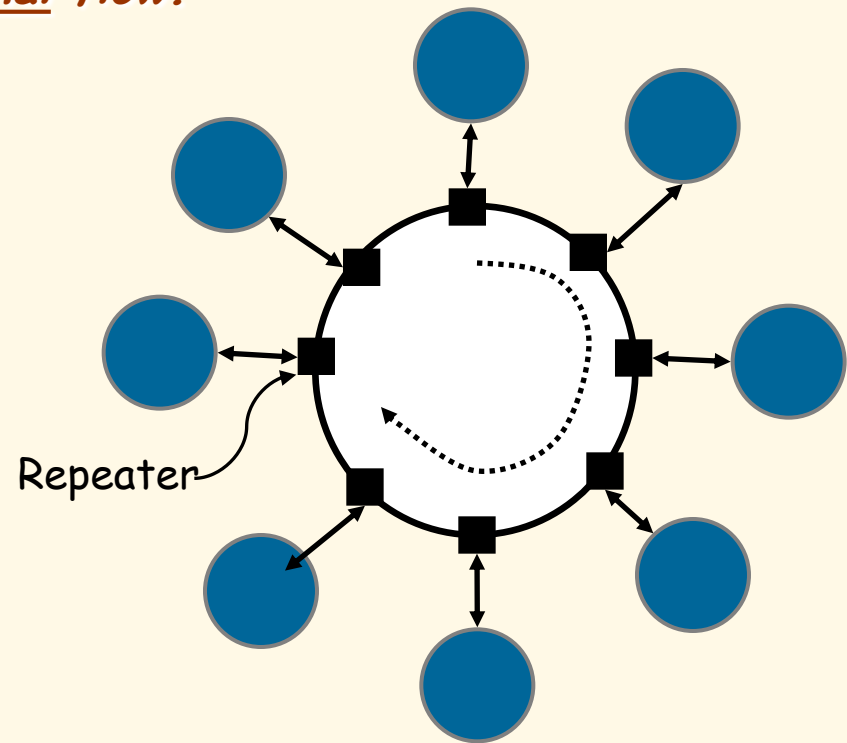
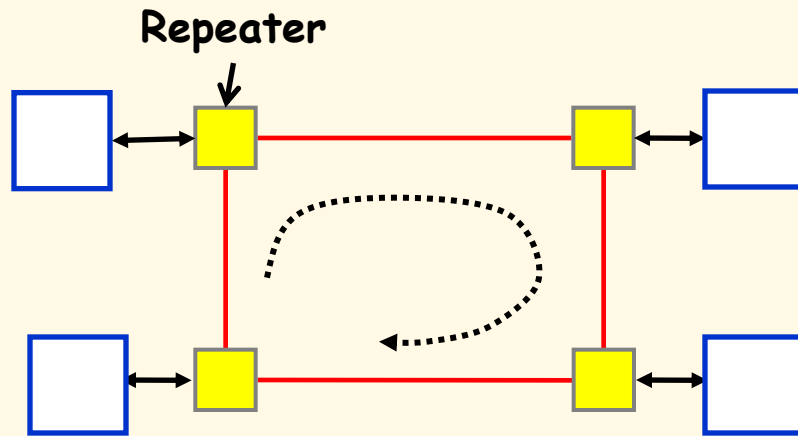
Leon-Garcia & Widjaja:
Communication Networks

Network Classification by Topology



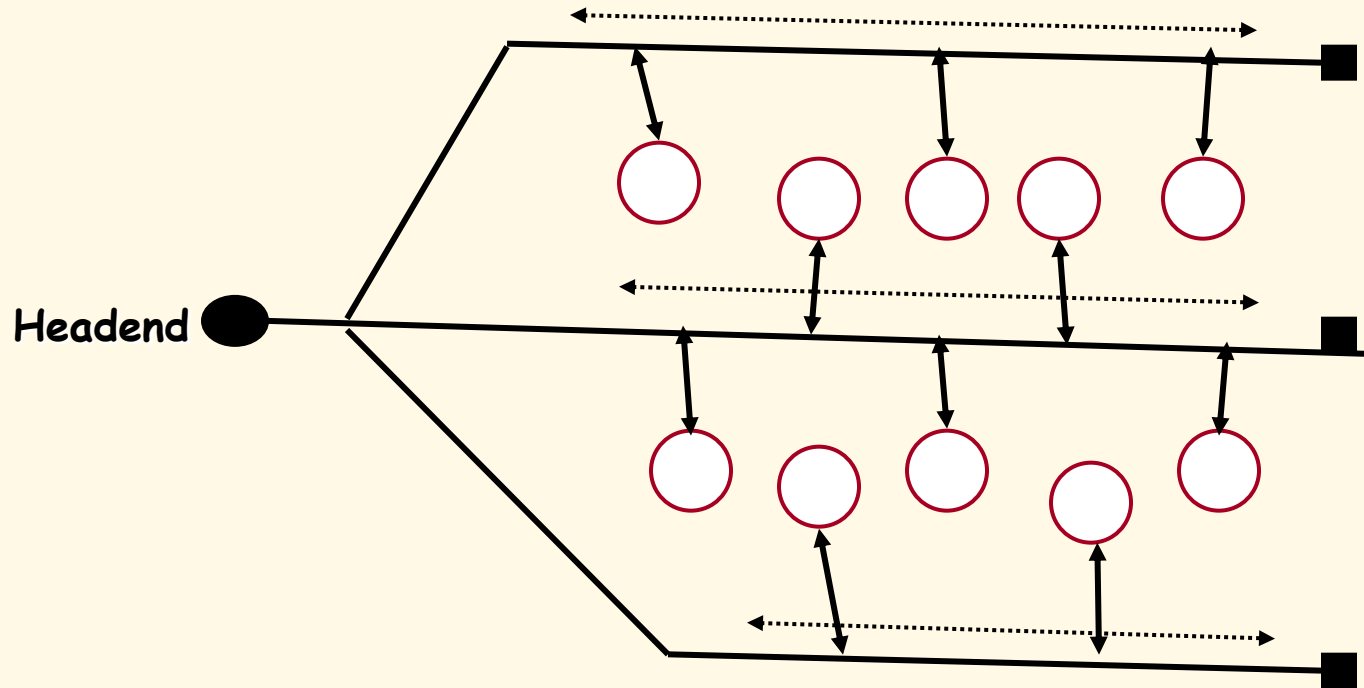
Network Classification by Topology

Note - A ring implies unidirectional flow.



Ring Topology

Network Classification by Topology



Tree Topology

Tree Topology

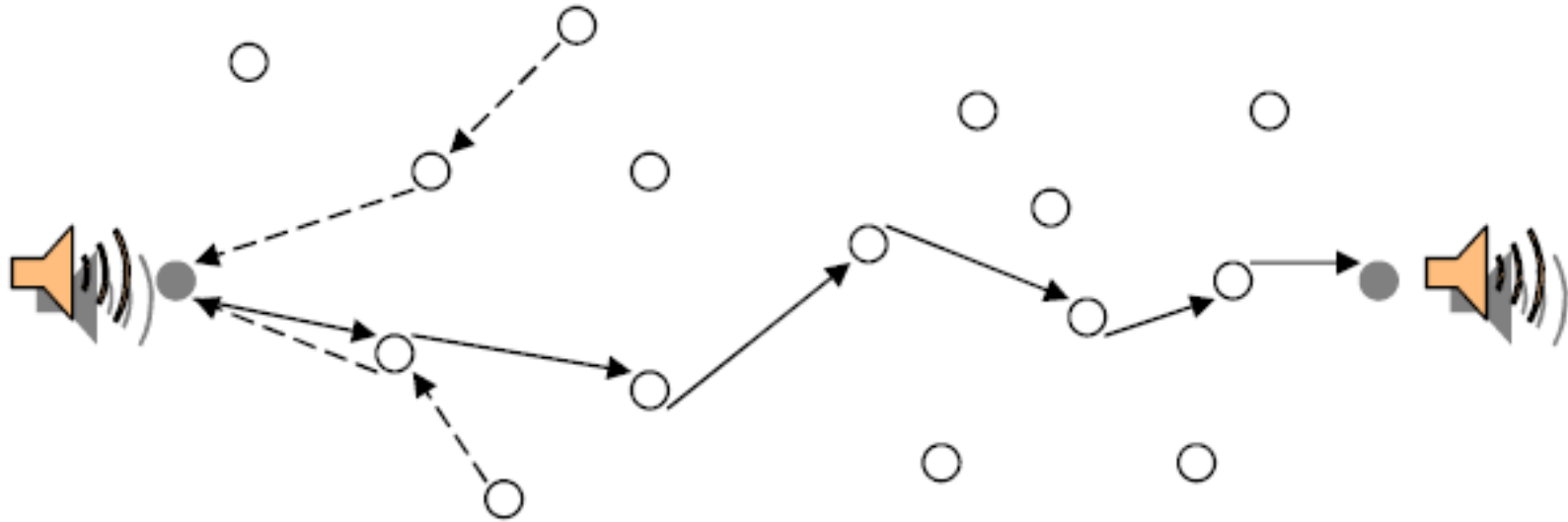
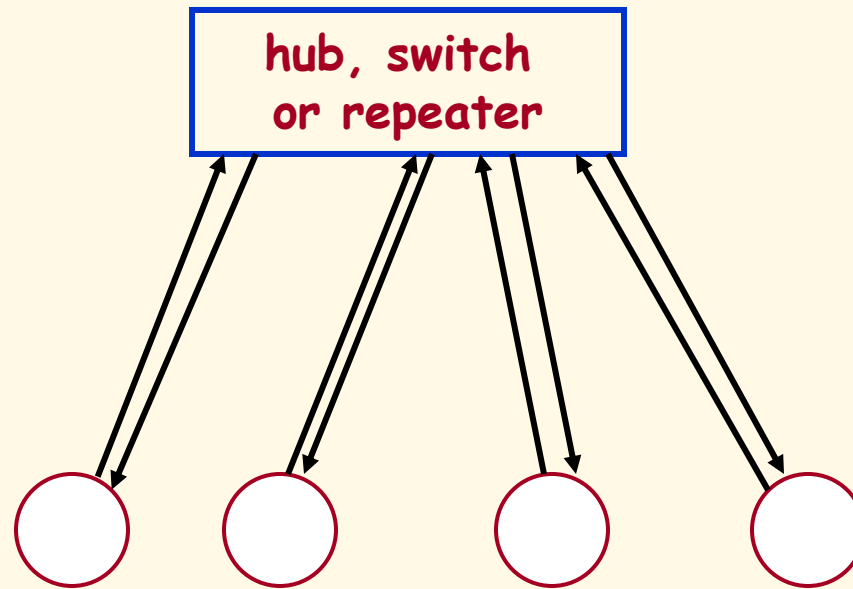


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N. Chohan

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

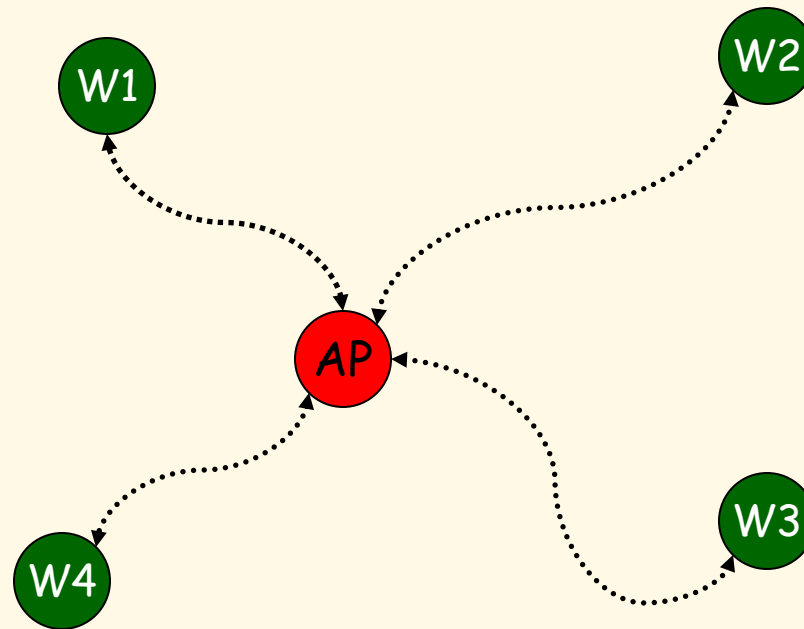
Network Classification by Topology



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