

# **Network Taxonomy, Packet vs. Circuit Switching**

**Required reading:  
Kurose § 1.1, 1.2, 1.3**

**EECS 3214, Winter 2020  
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# Network Basics

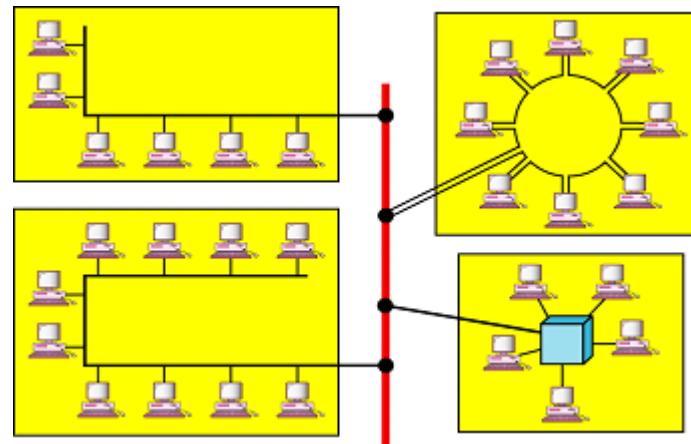
**Network** – set of devices (i.e. **nodes**) connected by **communication links**

- network uses a **combination of both hardware and software** to send data from one location to another

**Nodes** – desktop PC, UNIX-workstation, printer, PDA, cell phone, sensor or any other device capable of sending and/or receiving data

**Communication Links** – direct communication pathway between two or more devices

- communication links made of different physical media transmit data at different rates

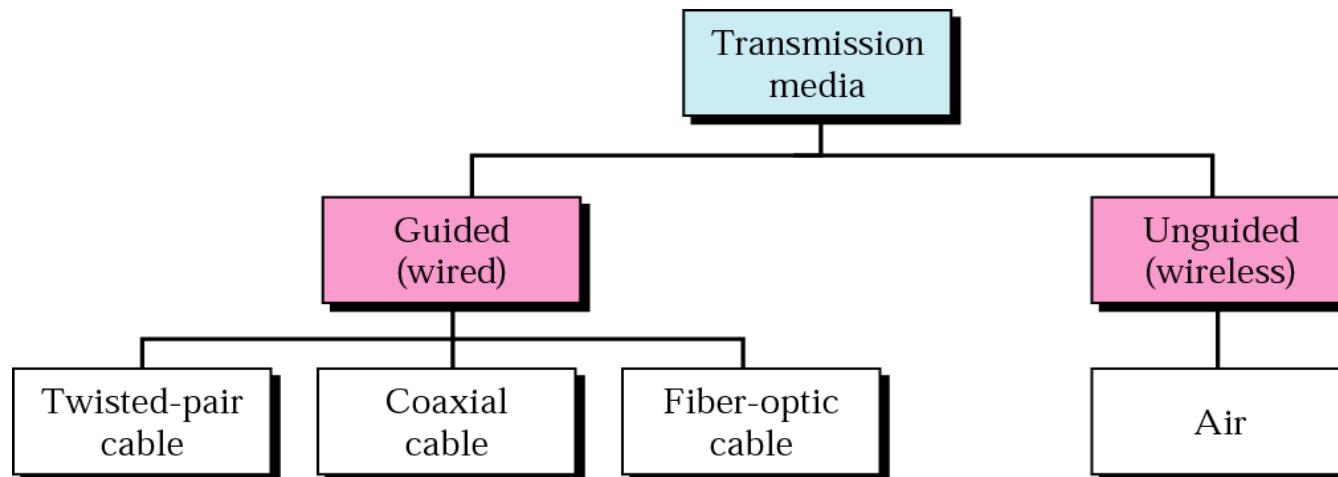


# Communication Links

**Transmission Media** – can be divided into two categories:



- **unguided (wireless) media** – signal is broadcast openly, transmission and reception are achieved by means of an antenna – **easy to set up, but low security and prone to interference**
- **guided media** – characteristics and quality of transmitted signal are constrained by physical limits of the medium
  - typically provides higher data rates than unguided media

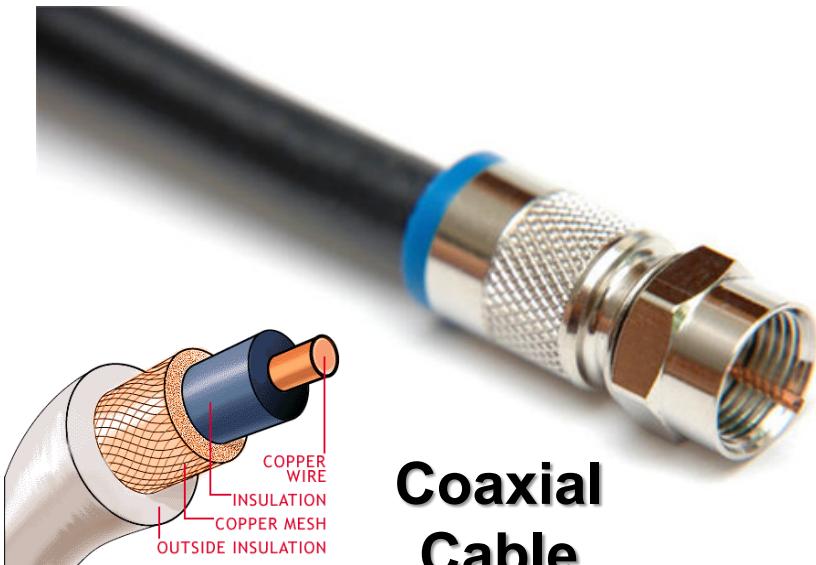


from <100 kbps  
up to 100 Mbps  
(and higher)

$\geq$  100 Mbps  
(up to 100 Gbps)

from 100 Gbps  
up to 100 Tbps

WLAN: up to 54 - 600 Mbps  
Cellular: up to 2 - 100 Mbps  
Satellite: up to 50 Mbps



# Communication Links (cont.)

## Wired vs. Wireless Transmission: Pros and Cons

<b>Wired vs. Wireless</b> [Consumer / Personal use applications]		
	<b>Wired</b>	<b>Wireless</b>
<b>Convenience</b>	★ ★	★ ★ ★ ★ ★
<b>Reliability</b>	★ ★ ★ ★	★ ★ ★
<b>Speed</b>	★ ★ ★ ★	★ ★ ★ ▾
<b>Security</b>	★ ★ ★	★ ★ ▾
<b>Ease of initial Setup</b>	★ ★ ★ ★	★ ★ ★

# Communication Links (cont.)

## Wired vs. Wireless Comm. Networks



**Ethernet**  
**Cable TV**  
**Wired Phone**

**WiFi**   
**Bluetooth**   
**Mobile/Cell Phone**  
**Satellite**

# Network Topologies (cont.)

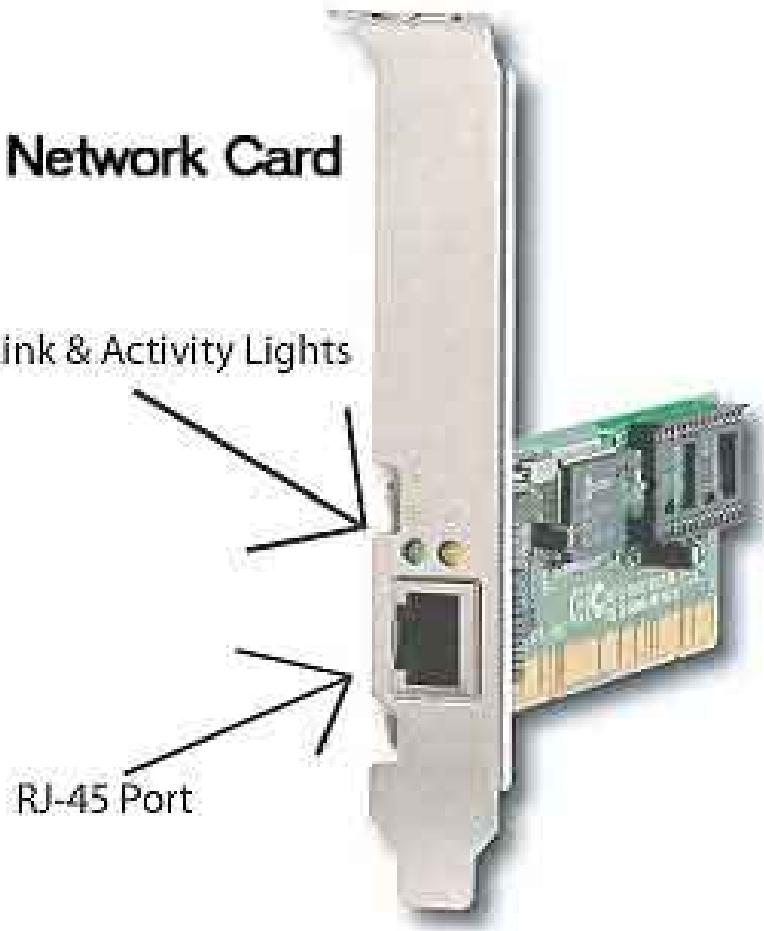
## NIC (Network Interface Card)

- piece of hardware that allows a computer to ‘communicate’ with other computers over a network



Network Card

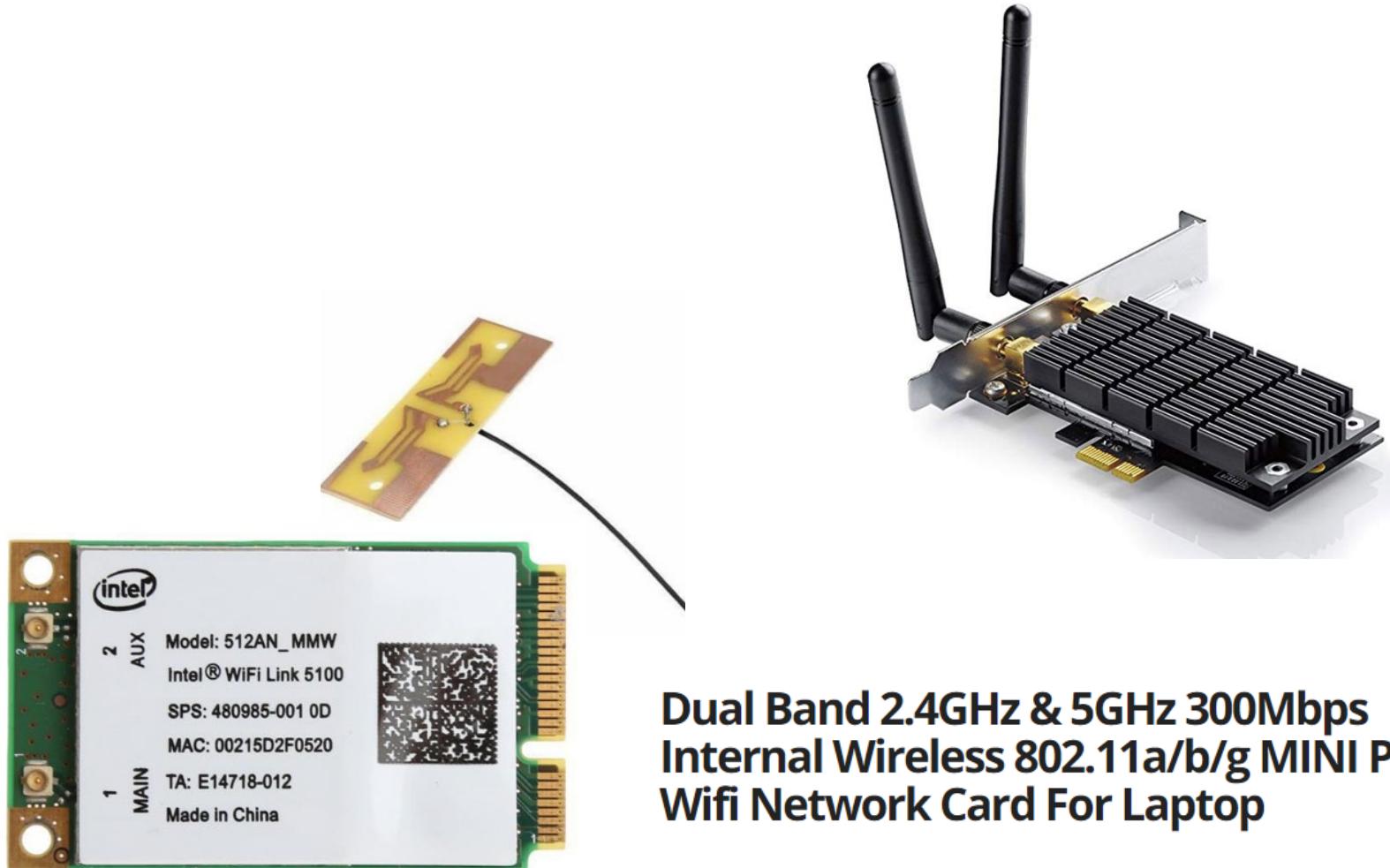
Link & Activity Lights



RJ-45 Port

# Network Topologies (cont.)

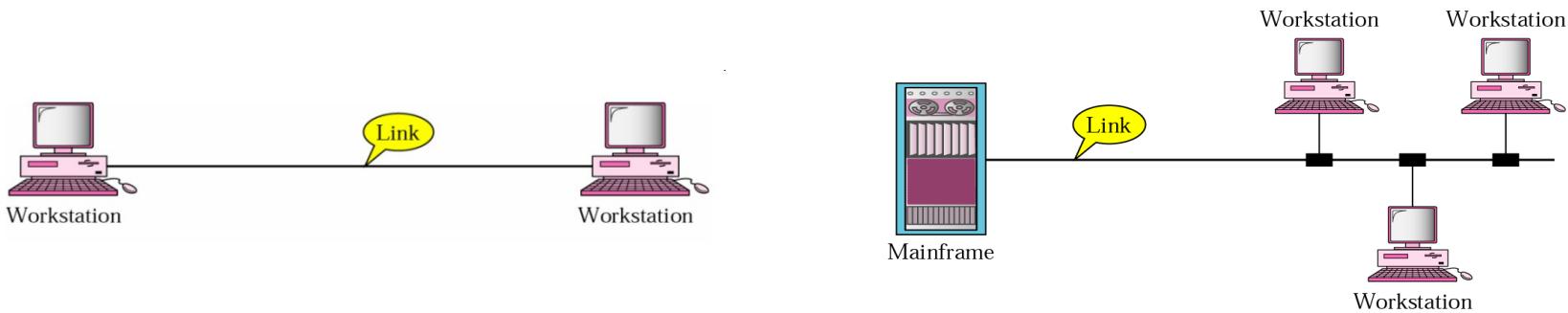
## Wireless NICs – Internal vs. External Antenna



# Network Topologies

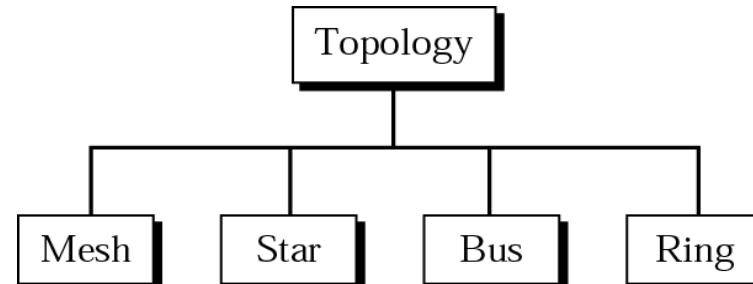
## Link Configuration

- **point-to-point**: dedicated connection between 2 devices
  - entire link capacity is reserved for the 2 devices
- **multipoint**: channel capacity is shared between 3 or more devices



## Network Topology

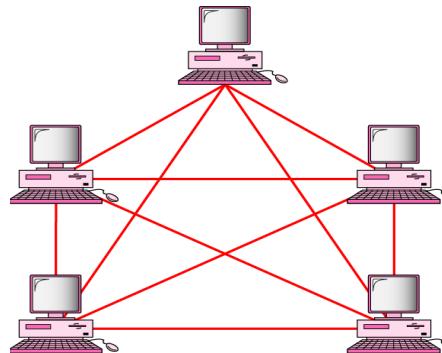
- geometric representation of the relationship of all links and linking devices to one another



# Network Topologies (cont.)

**Mesh Topology** – every device has a dedicated point-to-point connection to every other device

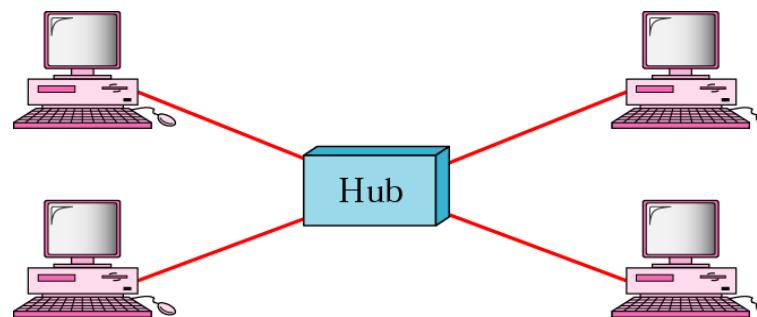
- fully connected mesh with  $n$  nodes has  $n(n-1)/2$  links
- **advantages:** 1) dedicated links  $\Rightarrow$  no need for load balancing  
2) ensured privacy and security – only intended recipient sees data  
3) robustness to link failure – many 2-hop routes
- **disadvantages:** 1) complex installation – every device must be connected to every other device  
2) expensive hardware – each device must have multiple I/O ports



Mesh topology is implemented mostly in backbone/core networks.

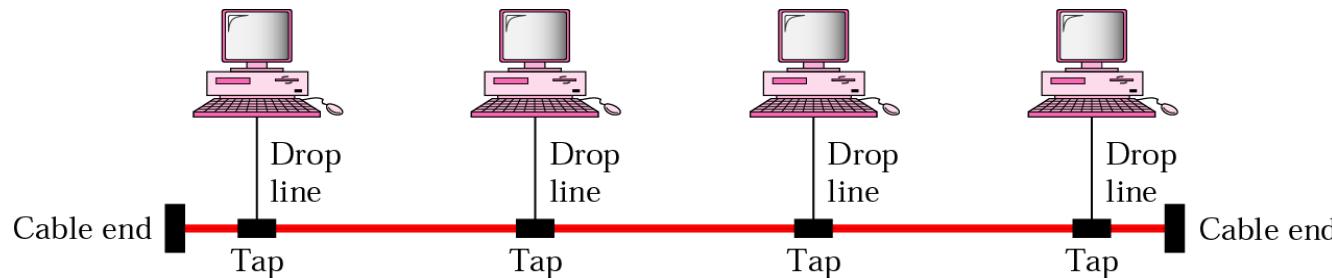
# Network Topologies (cont.)

- Star Topology** – each device has a dedicated point-to-point link only to a central controller, so-called hub
- no direct traffic between devices
  - **advantages:** 1) simpler and less expensive installation than in mesh topology – each device needs only one link and one I/O port
  - **disadvantages:** hub = single point of network failure



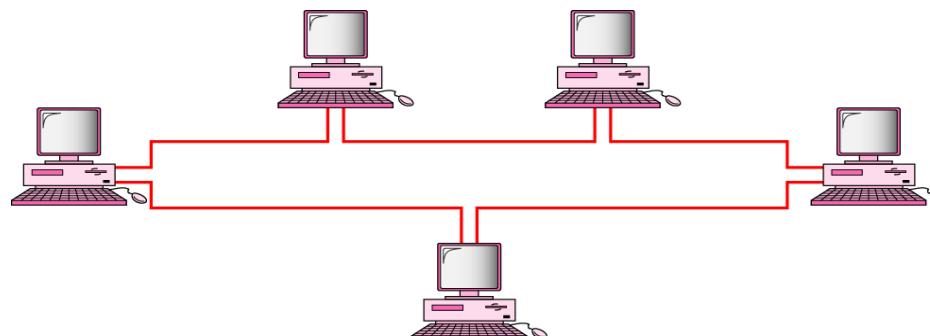
# Network Topologies (cont.)

- Bus Topology** – one long cable, so-called **backbone**, links all devices in the network ⇒ **multipoint** connection / link
- **advantages:** 1) simple installation
  - 2) less cabling than in mesh or star topologies – one cable stretches through entire facility
  - **disadvantages:** 1) backbone = single point of network failure
  - 2) collisions ⇒ diminishing capacity
    - if two or more devices transmit simultaneously their signals will interfere
- collision control:** MAC control, scheduling or channelization



# Network Topologies (cont.)

- Ring Topology** – each device has a dedicated point-to-point connection only with the two devices on either side of it
- signal is passed along the ring in one direction, from device to device, until it reaches its destination
  - **advantages:** 1) fairness in access – token-passing provides each station with a turn to transmit  
2) relatively easy to install and reconfigure – each device is linked only to its immediate neighbors
  - **disadvantages:** 1) entire network will fail if there is a failure in any transmission link or in the mechanism that relays the token



# Categories of Networks

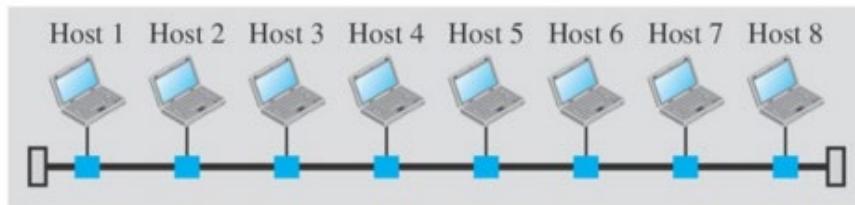
## Categories of Networks

(based on geographic coverage)

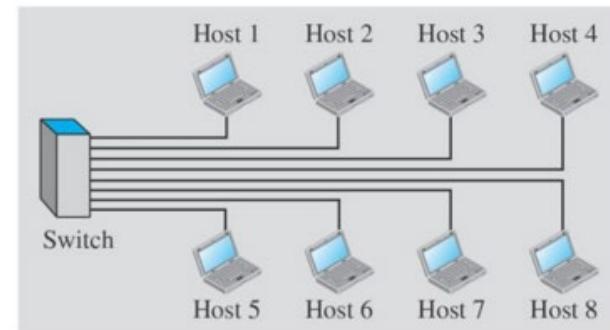
- (1) **Local Area Network (LAN)**
- (2) **Metropolitan Area Network (MAN)**
- (3) **Wide Area Network (WAN)**

### LAN

- computer network concentrated in a smaller geographic area ( $d < 5 \text{ km}$ ), such as an office, building, or campus
  - entire LAN infrastructure owned by the same organization (lines, switches, servers, hosts ...)
  - main goal: sharing of resources among the hosts (servers, printers, ...)
  - LANs typically employ only one type of transmission medium (wired or wireless), and provides low-delay, relatively error-free communication
  - internal data rates of LANs: 100 Mbps, 1 or 10 Gbps
  - most common LAN-segment topologies: star, bus, ring



a. LAN with a common cable (past)

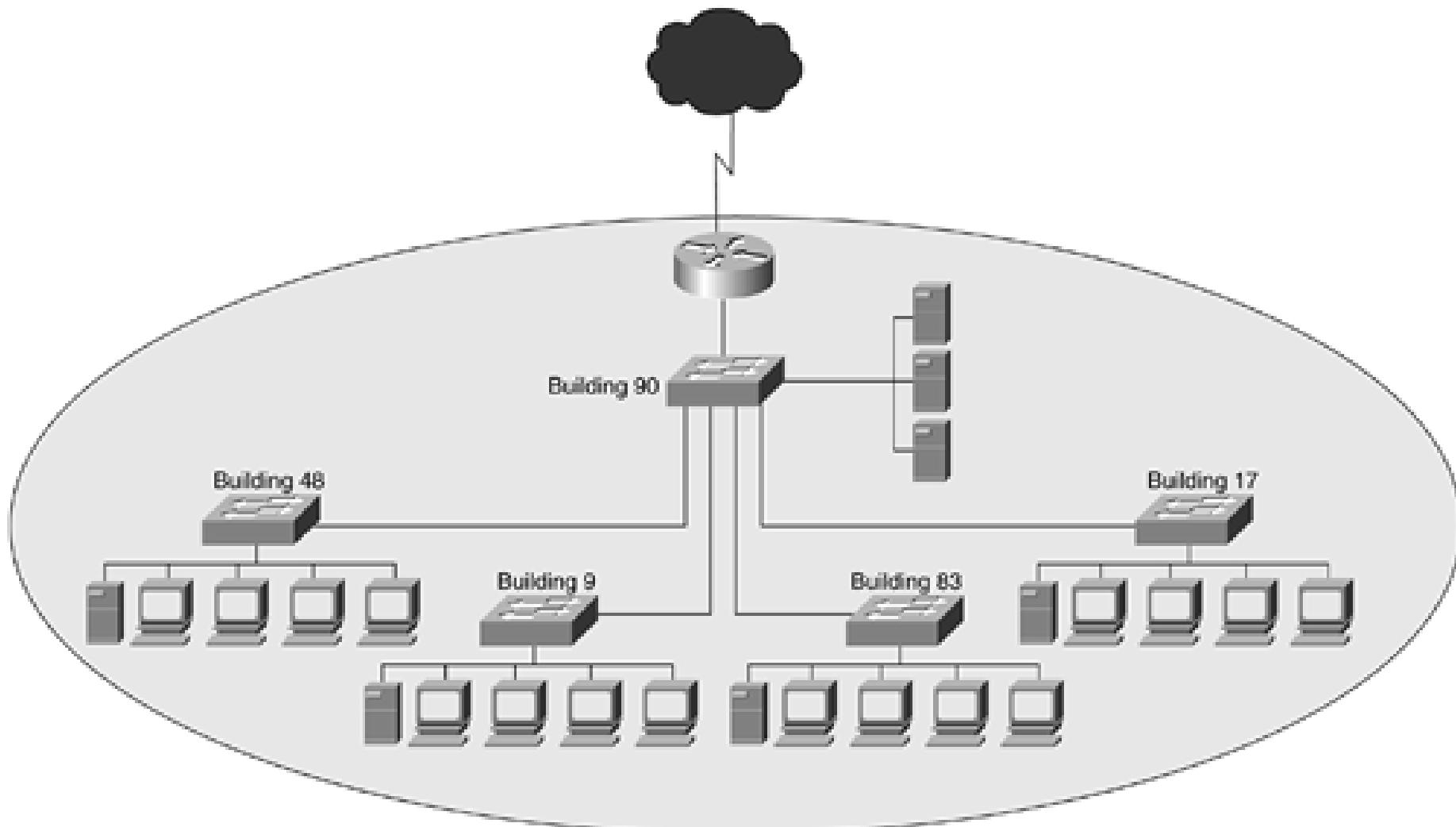


b. LAN with a switch (today)

# Categories of Networks (cont.)

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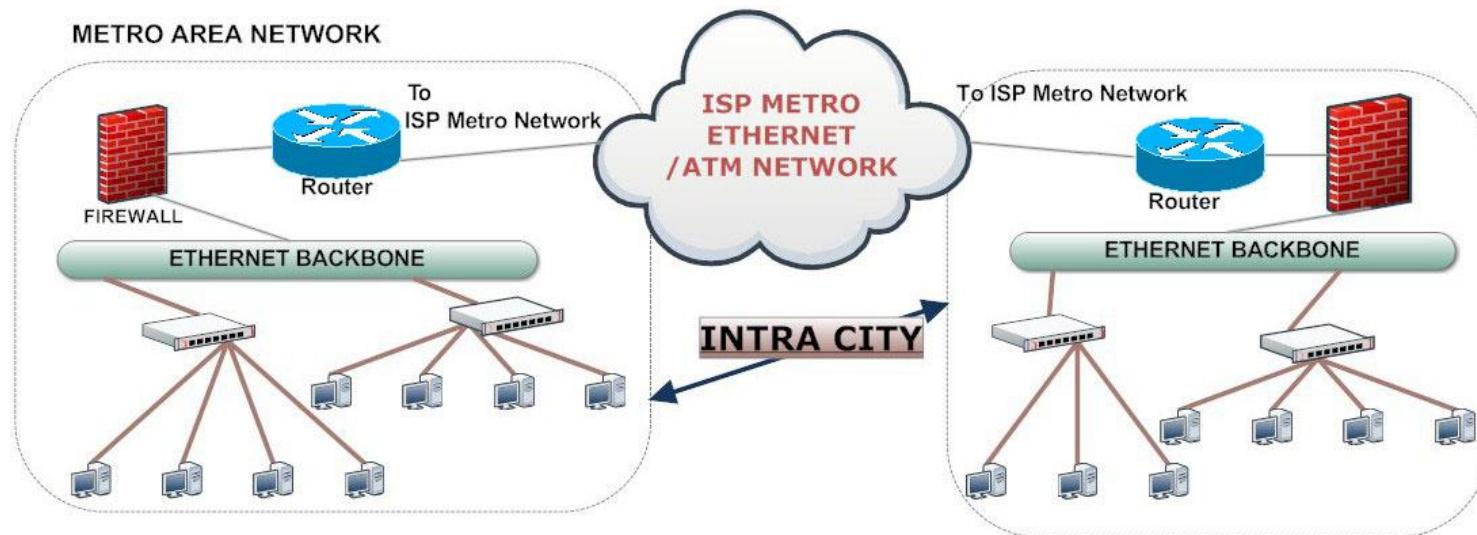
## Example [ complex LAN ]



# Categories of Networks (cont.)

## MAN

- a number of distant LANs connected into a larger network so that resources can be further shared
  - MAN extends over a larger geographic area (5 to 50 km), e.g. entire city
  - MAN can be wholly owned and operated by a private company, or it may include point-to-point links provided by a public company (e.g. local telephone company) to connect its remote sites

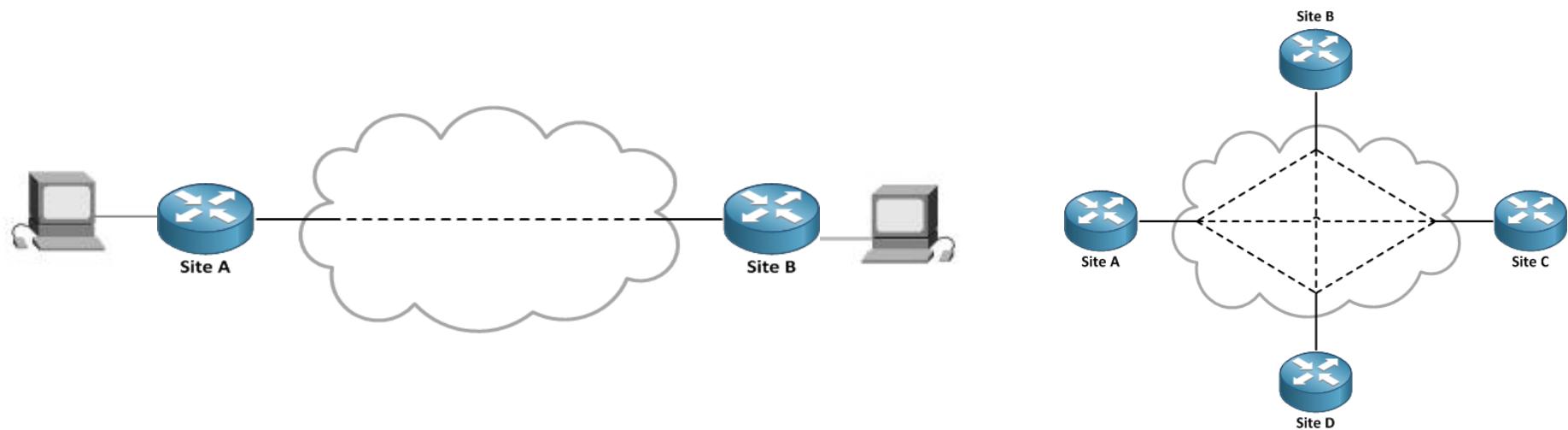


# Categories of Networks (cont.)

**WAN** – computer network that extends over large geographic area (>100 km), such as a country, continent, or even the whole world

**Point-to-Point WAN** – connects (only) two remote end LANs

- point-to-point line is usually leased from a carrier and is reserved for exclusive use by the WAN-customer
- advantage: best performance / QoS
- drawbacks: high cost & poor scalability



multipoint-to-multipoint =  
 $n(n-1)/2$  point-to-point links !!!

# Categories of Networks (cont.)

[Solutions by Sector](#)[Solutions by Category](#)[Our Network](#)[Team](#) Find your Solution

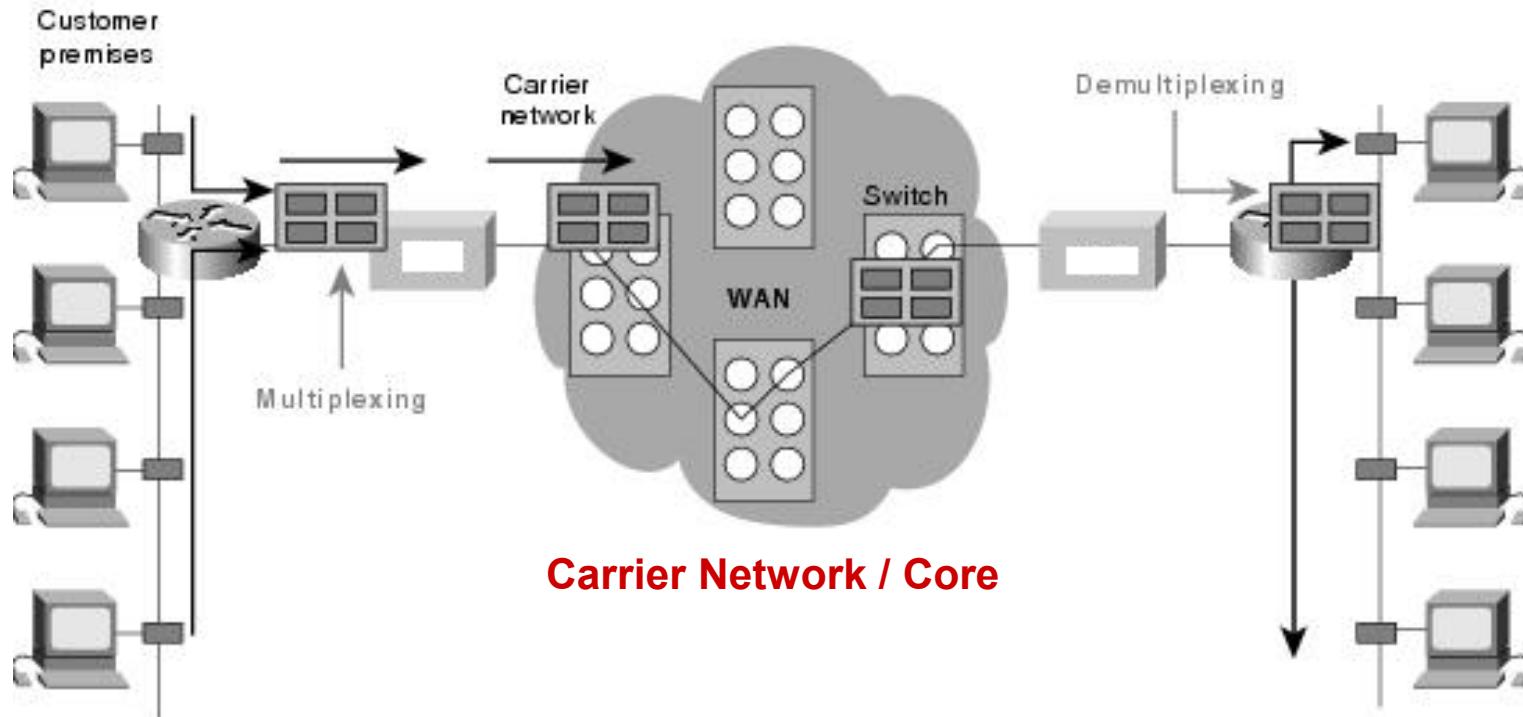
TELUS Digital Private Line (DPL) Services offers a fast and cost-effective solution to extend reach and service a broad customer base with voice, data and video communications. TELUS DPL Services provides the bandwidth and flexibility to create a backbone network, manage a 24x7 private voice and wireless network, exponentially grow e-business applications or extend reach for enhanced data services with speeds of up to OC192.

**10 Gbps**

# Categories of Networks (cont.)

## Switched WAN – avoids the use of reserved lines / full-mesh topology

- carrier deploys switches/routers to interconnect various sites/customers and to better utilize link resources

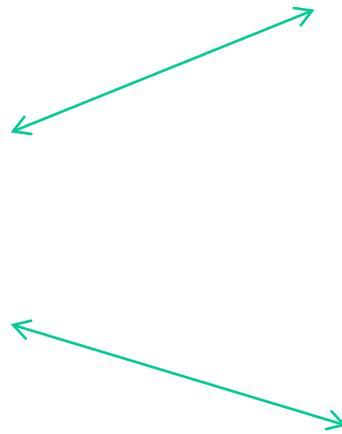


## Switches (Routers) – connecting devices whose purpose is to route (i.e switch) data/packets to their final destination

# Categories of Networks (cont.)

## Router / Packet Switch

- dedicated device/computer that forwards data packets between computer networks



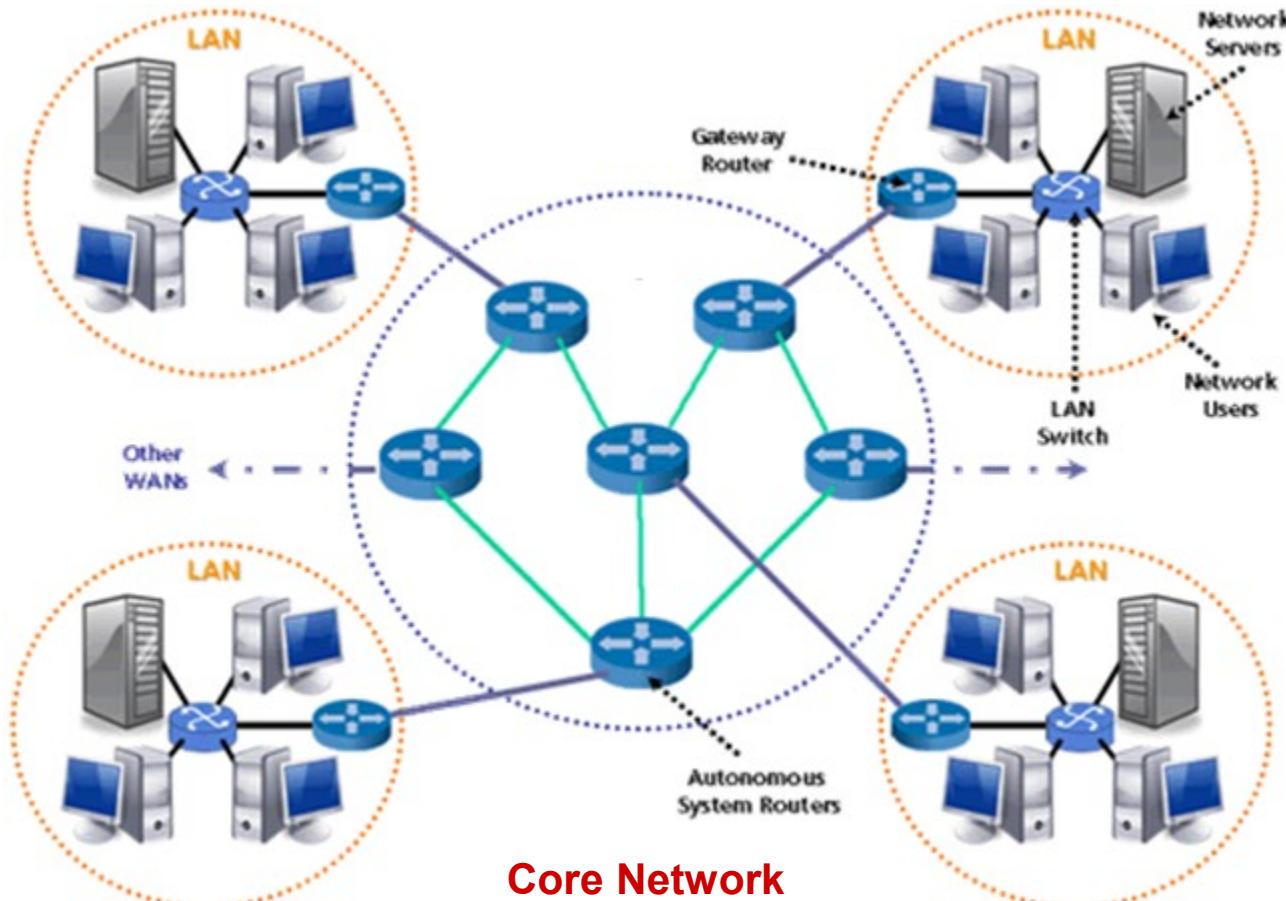
Cisco 1800



Cisco 7200

## Internet – the largest WAN in existence

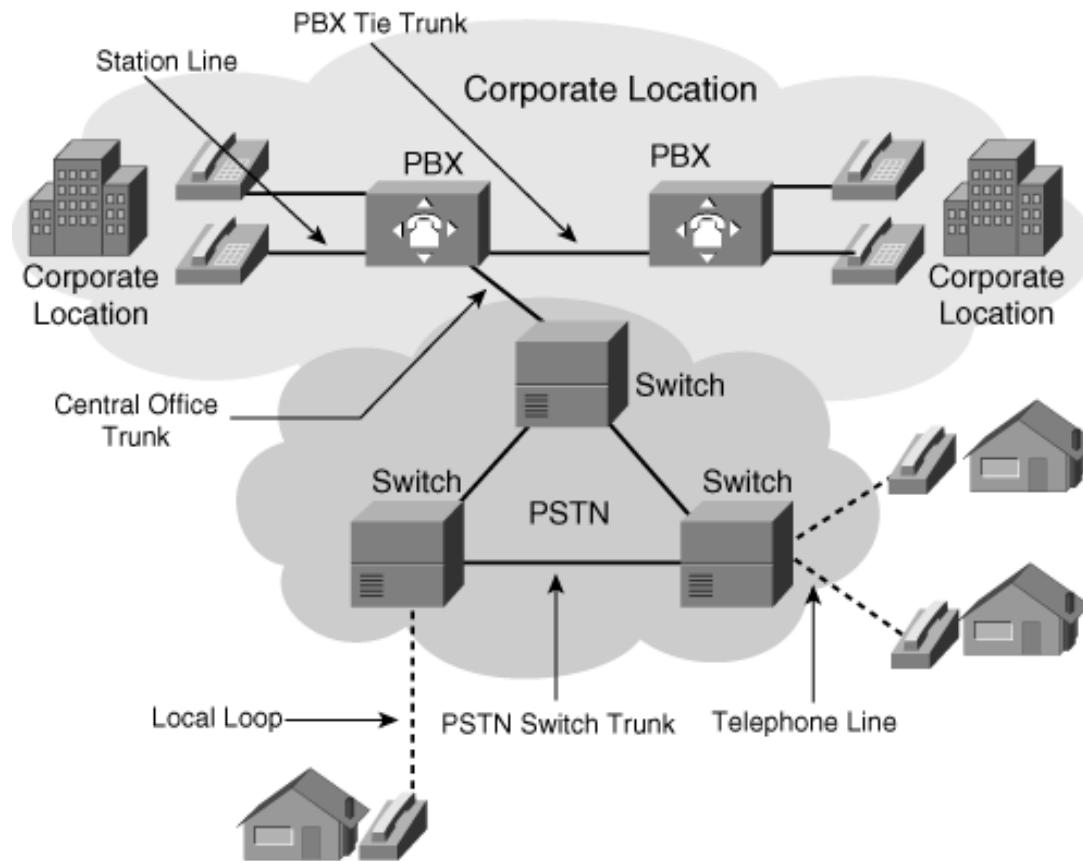
- connects all existing LANS (IP/TCP enabled devices in the world)
- core comprised of multitude of interconnected carriers



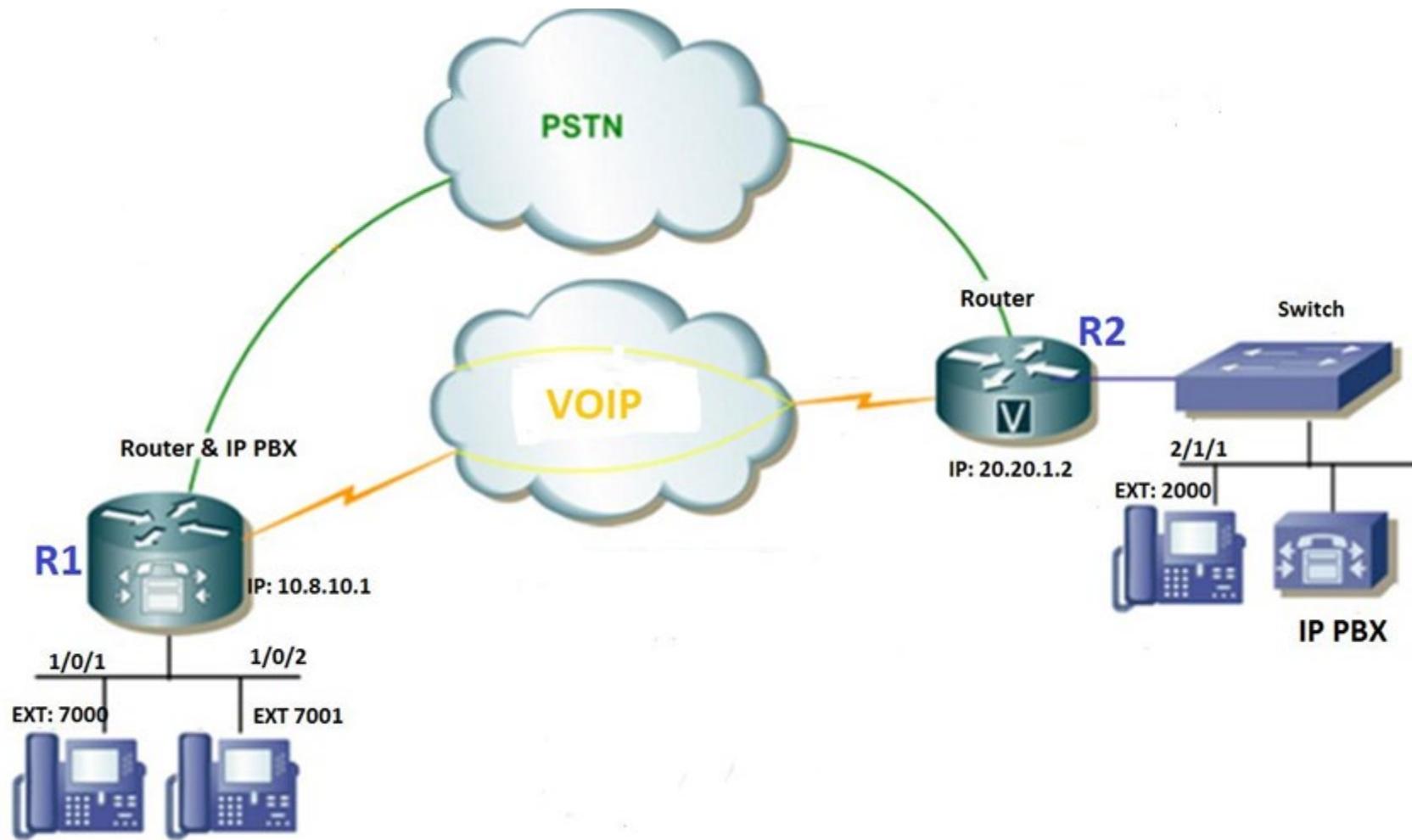
# Categories of Networks (cont.)

## PSTN Network – ‘the second’ largest WAN in existence

- connects all land-line phones
- core comprised of multitude of interconnected carriers



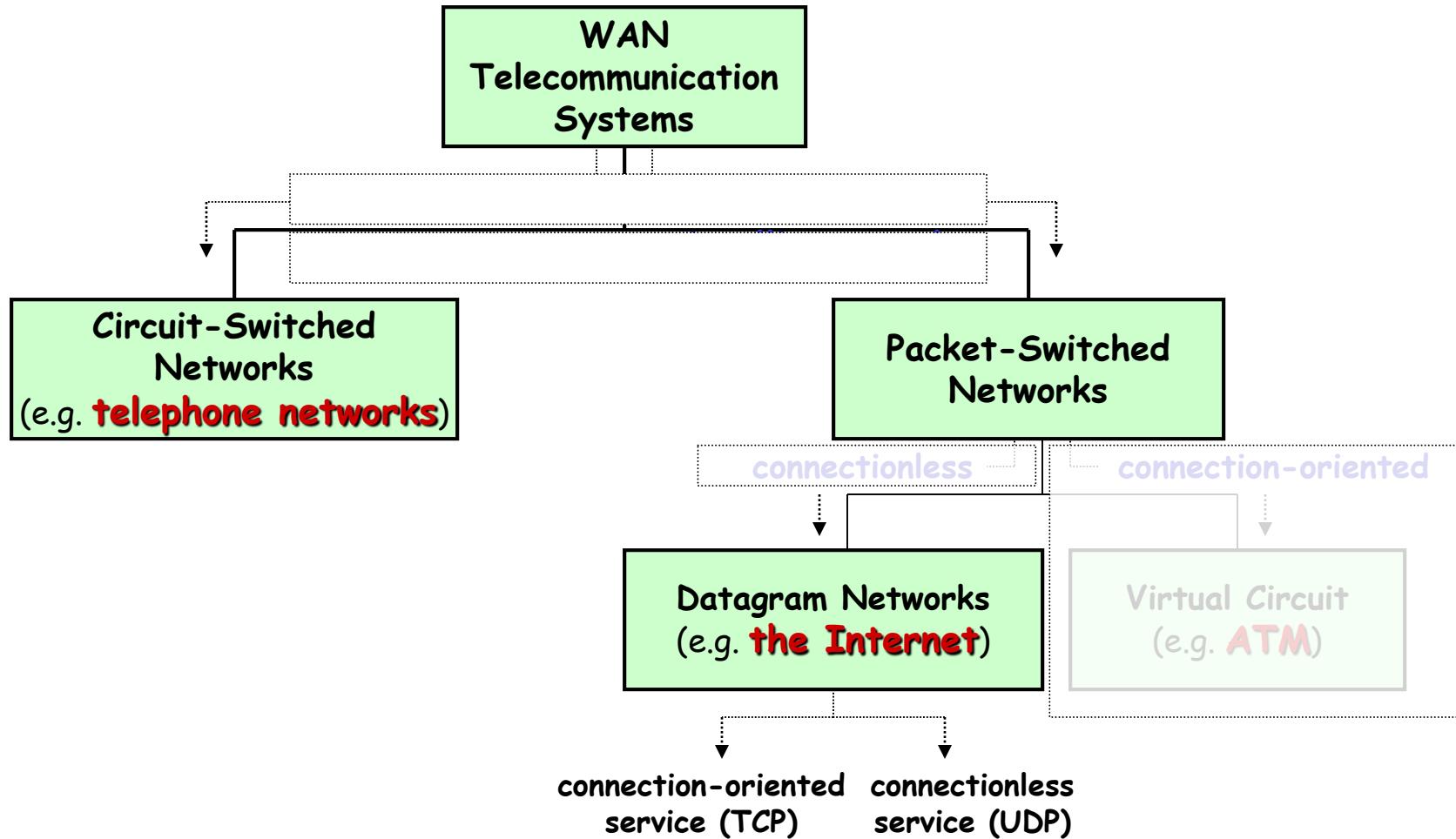
# Categories of Networks (cont.)



Nowadays, Internet and PSTN merging into one ...

# Circuit vs. Packet Switching

## Taxonomy of Switched Wide Area Networks



# Circuit vs. Packet Switching (cont.)

**Network Core** – mesh of routers/switches that interconnect end systems

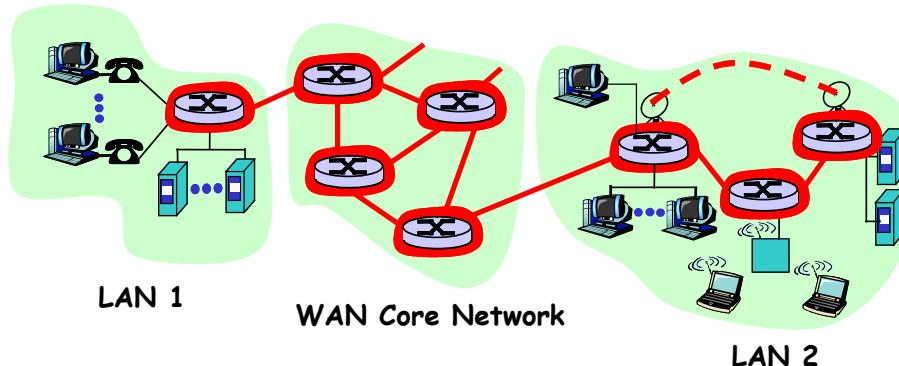
- two fundamental approaches to building a WAN core:

**(1) circuit switching (example: telephone networks)**

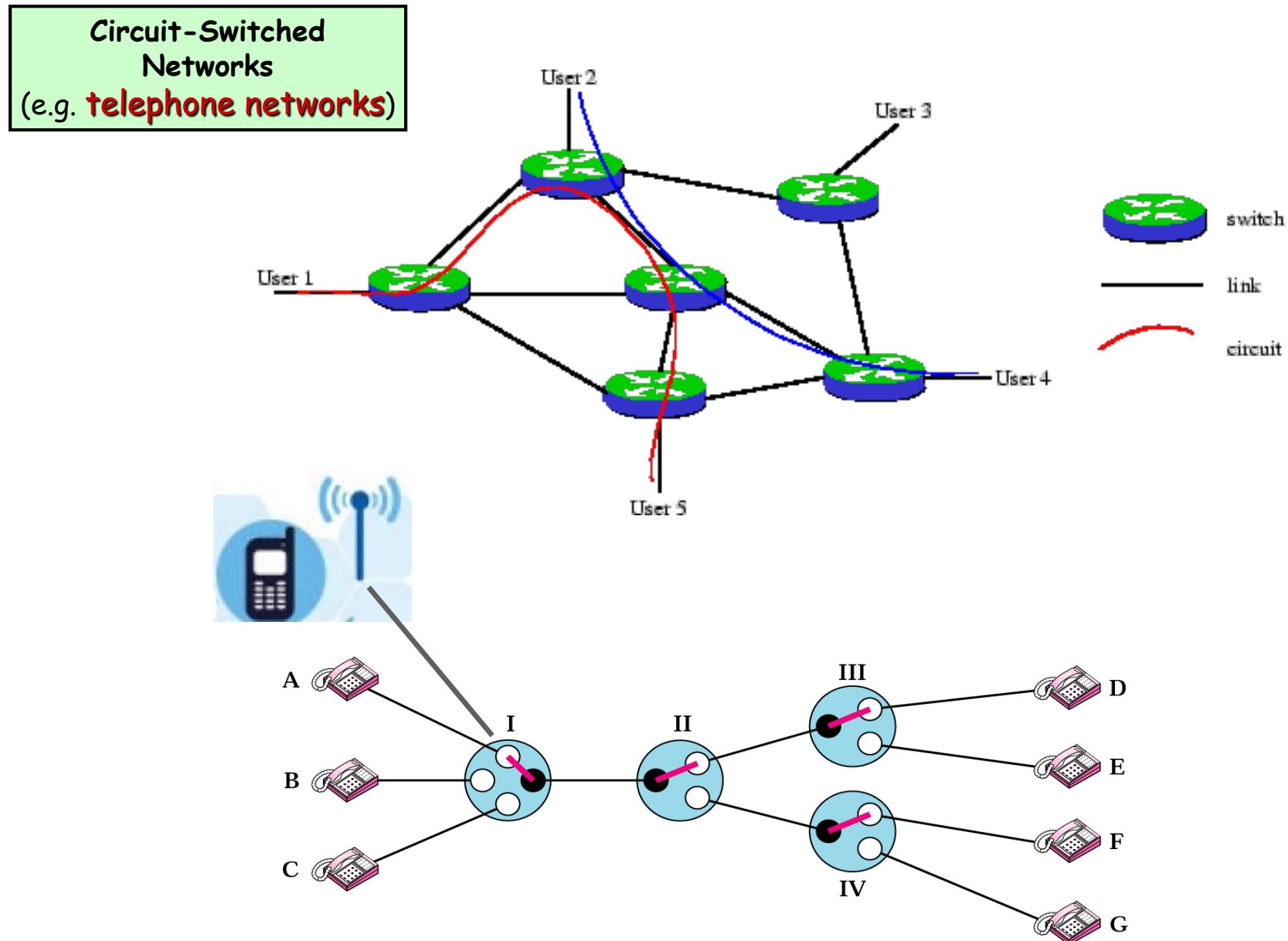
- a sequence of links (communication path) between two communicating nodes is determined ahead of the actual communication
- on each physical link, a channel is dedicated to the connection
- data is sent as a stream of bits through the network

**(2) packet switching (example: the Internet)**

- data is sent through network in short blocks – packets
- network links are dynamically shared by many packets; each packet uses full link bandwidth



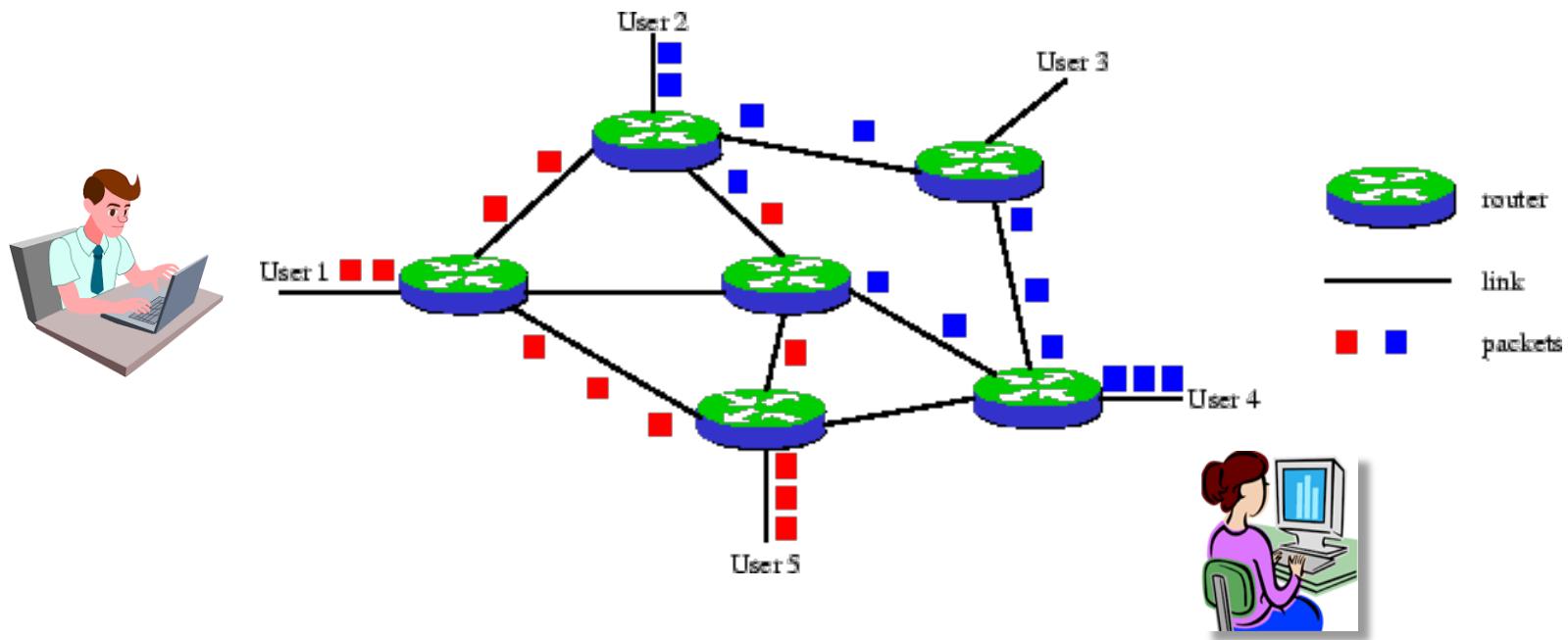
# Circuit vs. Packet Switching (cont.)



# Circuit vs. Packet Switching (cont.)

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Packet Switching:  
Datagram Networks  
(e.g. the Internet)



# Circuit Switching

**Communication via Circuit Switching** – involves three phases:

**(1) circuit establishment**

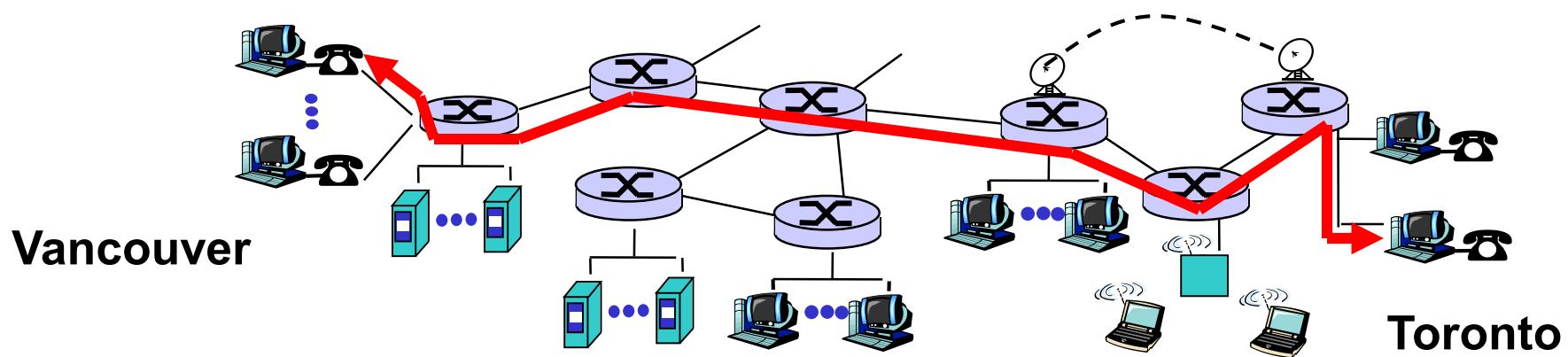
- before any data is transmitted, an end-to-end circuit must be established, i.e. network resources on path/links between end-devices must be reserved

**(2) data transfer**

- data transmission and signaling may each be digital or analog

**(3) circuit disconnect**

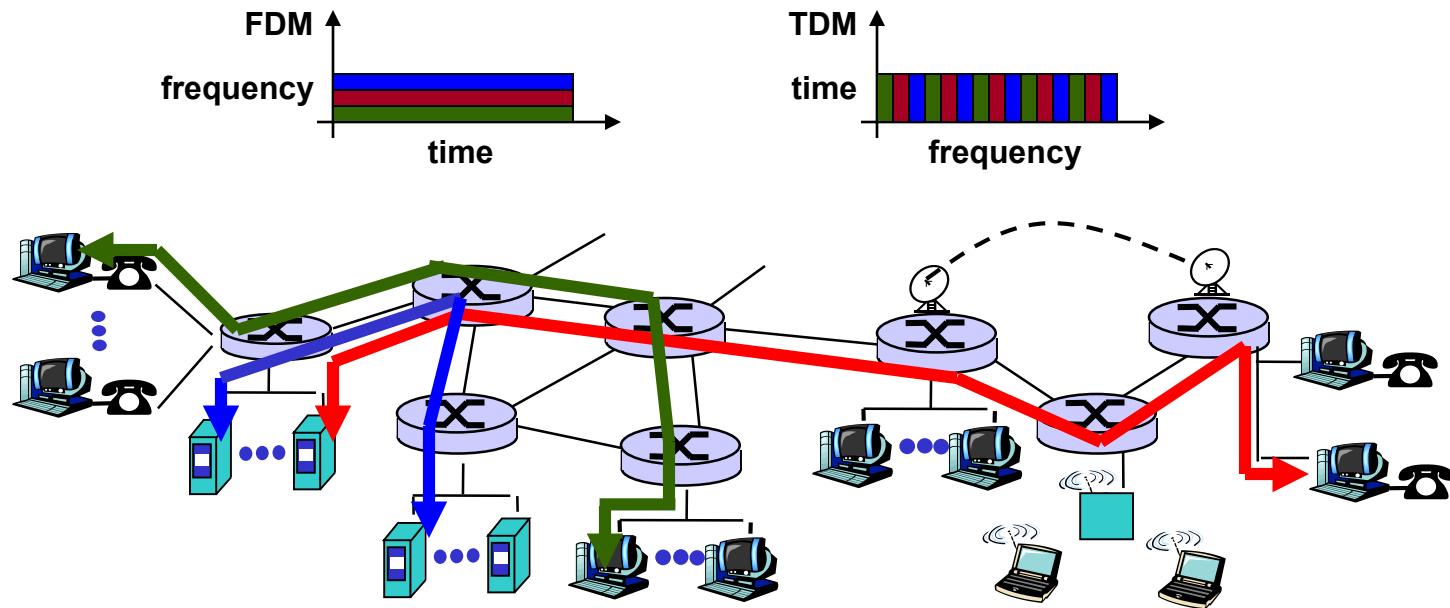
- after some period of data transfer, the connection is terminated, by action of one of two stations, and dedicated resources are released



# Circuit Switching (cont.)

## Multiplexing in Circuit-Switched Networks

- each link can be shared among (up to) n “circuits” ⇒ each circuit gets a fraction 1/n of the link’s bandwidth
  - **multiplexing** = set of techniques that allows simultaneous transmission of multiple signals across a single data link
  - **frequency division multiplexing (FDM)** = each circuit continuously gets a fraction of the link’s bandwidth
  - **time division multiplexing (TDM)** = each circuit gets all of the bandwidth periodically during brief intervals of time



## Advantages of Circuit Switching

- **guaranteed Quality of Service** – data are transmitted at fixed (guaranteed) rate; delay at nodes is negligible

## Disadvantages of Circuit Switching

- **inefficient use of capacity** – channel capacity is dedicated for the duration of a connection, even if no data is being transferred  
(example: silent periods in a phone call)
- **circuit establishment delay** – circuit establishment introduces ‘initial delay’
- **network complexity** – end-to-end circuit establishment and end-to-end bandwidth allocation is complicated and requires complex signaling software to coordinate operation of switches