

## chapter 7



# Wide Area Networks

# CHAPTER OBJECTIVES

- Define circuit switching, describe circuit-switched architecture, and identify and describe different types of circuit-switched carrier services.
- Define dedicated circuit, and list and describe dedicated-circuit carrier services.
- Discuss packet-switched networks, and list and describe different types of packet-switched carrier services.
- List and describe other high-speed carrier services.
- Identify and describe different types of multiplexing.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

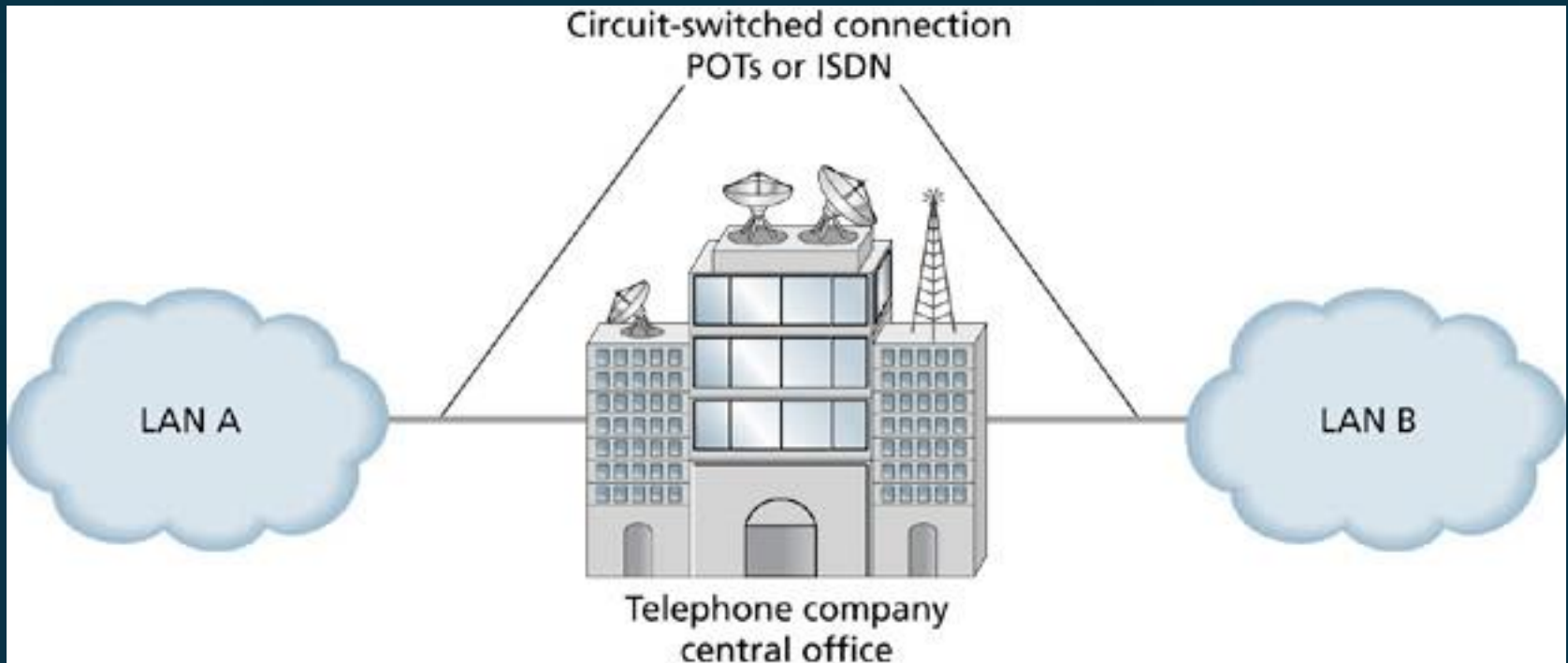
- **Circuit-Switched Carrier Services**
  - Circuit switching is a communications method that creates a dedicated communications path between points A and B for the exclusive use of the end nodes for the duration of the connection.
  - Data rates for circuit-switched carrier services range from modem dial-up speeds of 28.8 Kbps to 56 Kbps, to low-end broadband data rates of 1.544 Mbps.
  - Businesses implement circuit-switched carrier services if data transmission requirements between remote locations are mostly text-based and don't require a continuous connection.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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- Circuit-Switched Carrier Services (cont'd)
  - All circuit-switched services use the PSTN, which provides the carrier-service infrastructure between remote locations.
  - Circuit-switched connections provide flexibility in connecting to remote locations – you dial a number to connect to a remote computer or network, and the connection is maintained until you hang up.
  - Circuit-switched connections charge for every minute of connection time.

# LAN-to-LAN Connectivity through the PSTN



# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

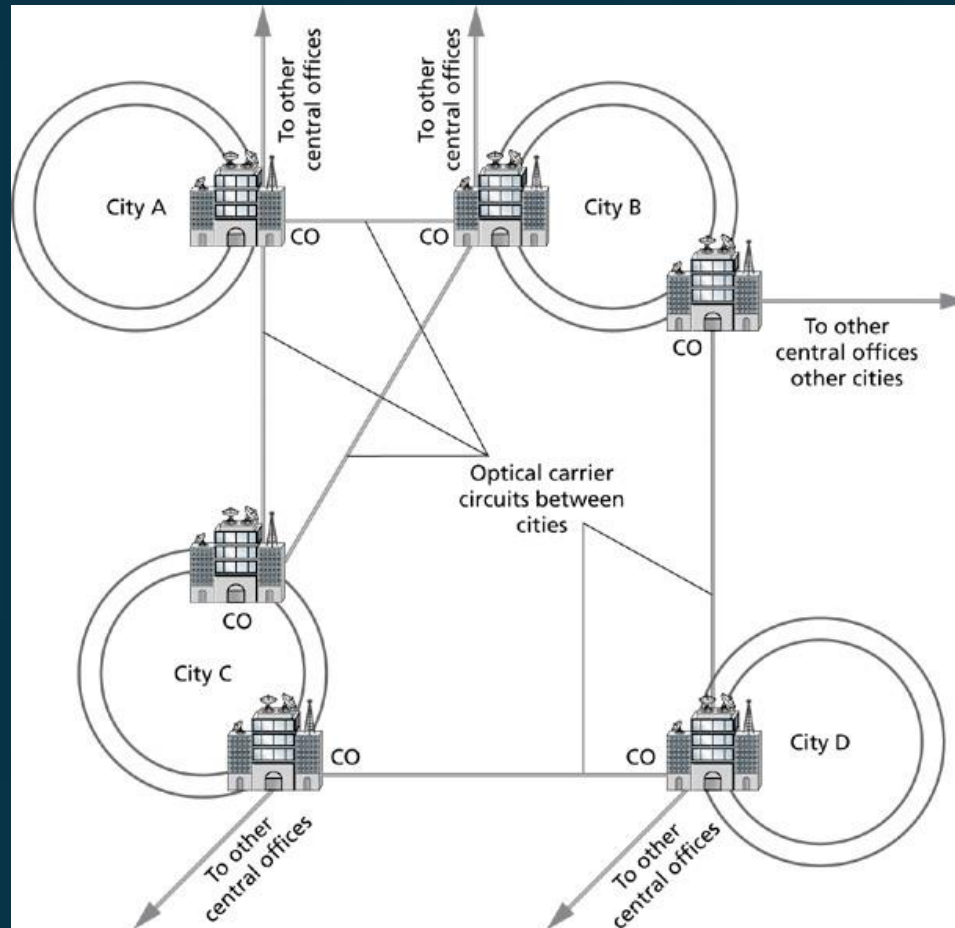
- **Integrated Services Digital Network**
  - ISDN is a digital circuit-switched service.
  - Was originally developed in the 1960s as a digital replacement for analog phone lines.
  - ISDN has many of the same features as regular analog phone lines.
  - ISDN can accommodate voice and data traffic, graphics, video, audio, and any other data that can be converted to digital.
  - It was never widely deployed because of the cost of telephone replacement at every home in the U.S. in the days when AT&T held a telephone monopoly.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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- **SONET (Synchronous Optical Network)**
  - It's an ANSI standard for high-speed data communications over fiber-optic cables.
  - It's defined in terms of optical carrier levels (OC-x).
  - SONET is deployed as redundant rings for fault tolerance.

# SONET Ring Infrastructure





# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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- **Packet-Switched Carrier Services**
  - Were developed as more efficient data and voice transmission services – packet switching reduced idle time on transmission circuits.
  - Are always on and ready to transmit.
  - There's no call setup with packet-switched services.
  - There's no wasted capacity when the connection is not in use.

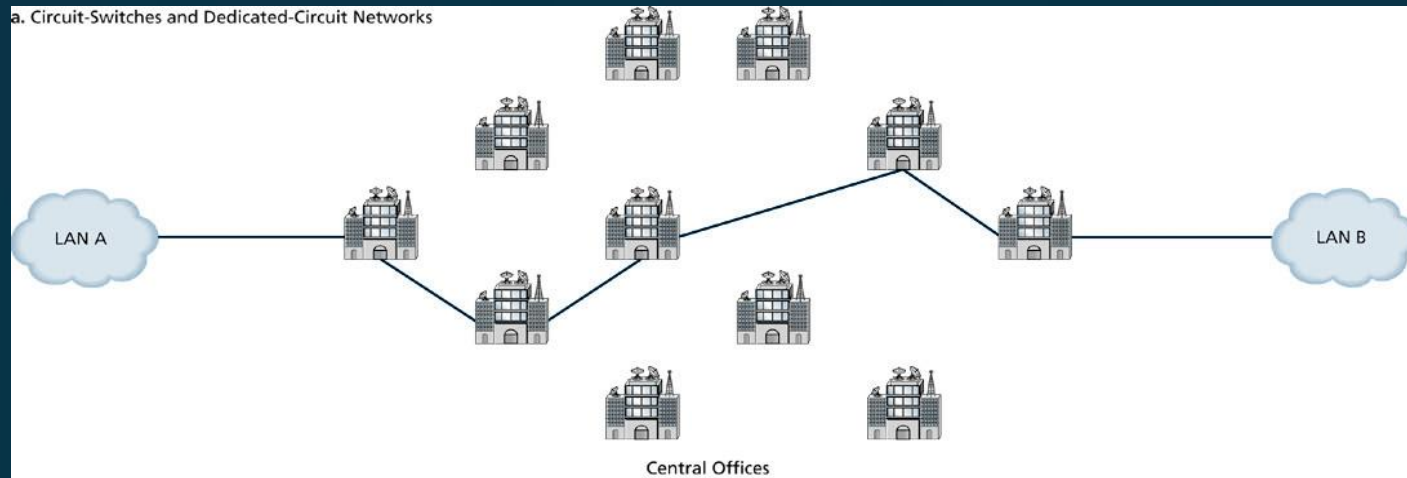
# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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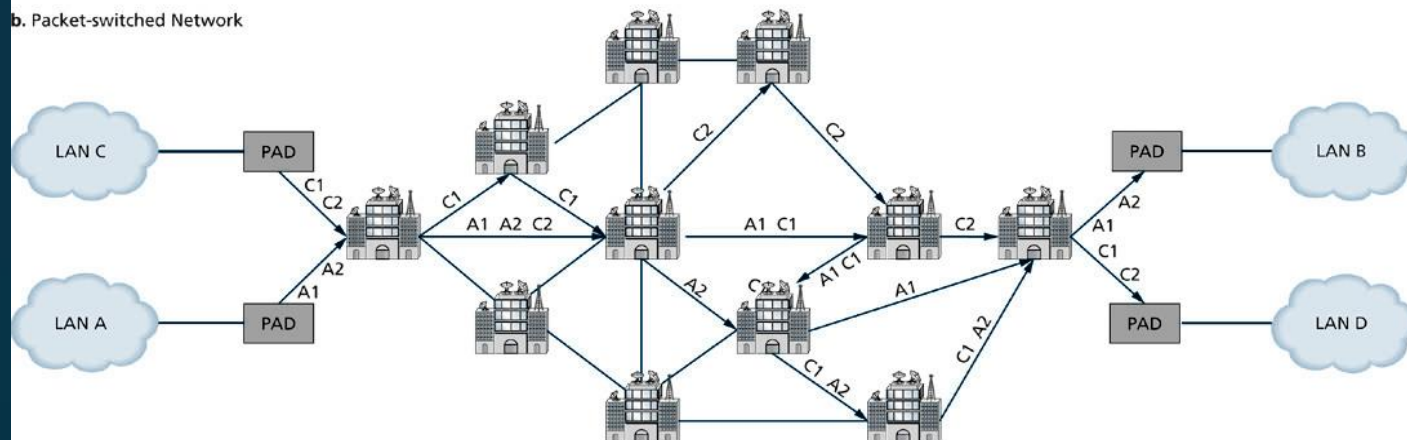
- Packet-Switched Carrier Services (cont'd)
  - Are represented as a cloud in diagrams.
  - Are referred to as the Public Data Network (PDN).
  - Packets must pass through a packet assembler/disassembler (PAD) to reach the PDN.

# Circuit-Switched and Dedicated-Circuit Networks vs. Packet-Switched Networks

a. Circuit-Switches and Dedicated-Circuit Networks



b. Packet-switched Network



# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

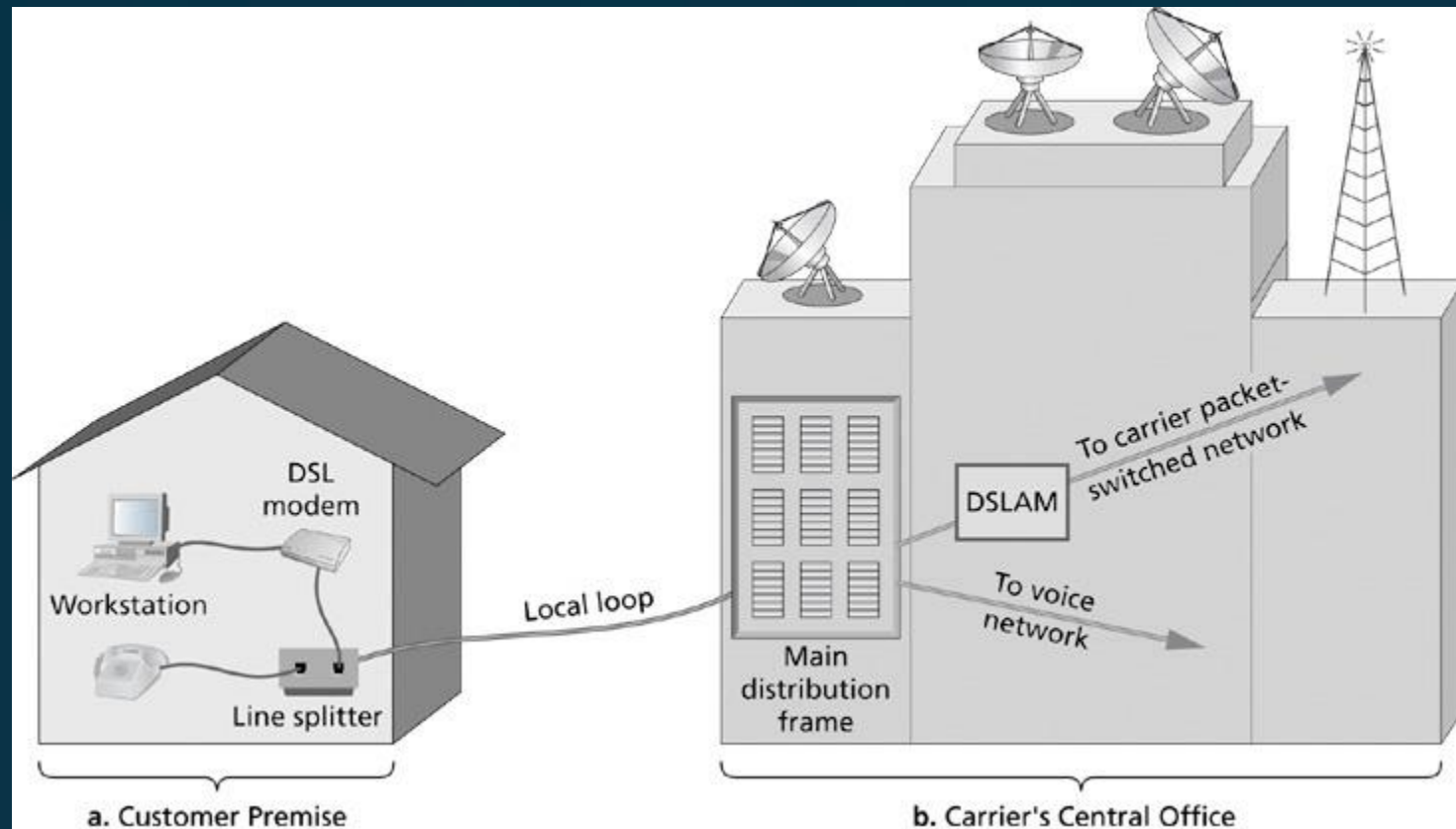
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- **Packet-Switched Services**
  - **X.25** specifies data communications across the PSTN between remote computers with a maximum data rate of 64 Kbps.
  - **Frame Relay** provides data rates ranging from 56 Kbps to 45 Mbps
  - **Asynchronous Transfer Mode (ATM)** is the widely accepted standard of cell relay technology.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

- Other High-Speed Carrier Services
  - **Digital Subscriber Line Technologies** (DSL) use existing telephone lines for high-speed Internet access and data communications.
  - DSL requires extra equipment at both the customer location and at the carrier's central office.
  - Customers require a DSL modem and a line splitter.
  - The carrier's central office (CO) requires a main distribution frame to separate incoming voice and data traffic.
  - The carrier's CO also requires a digital subscriber line access multiplexer (DSLAM) to convert DSL data streams into ATM cells.

# DSL Configuration



# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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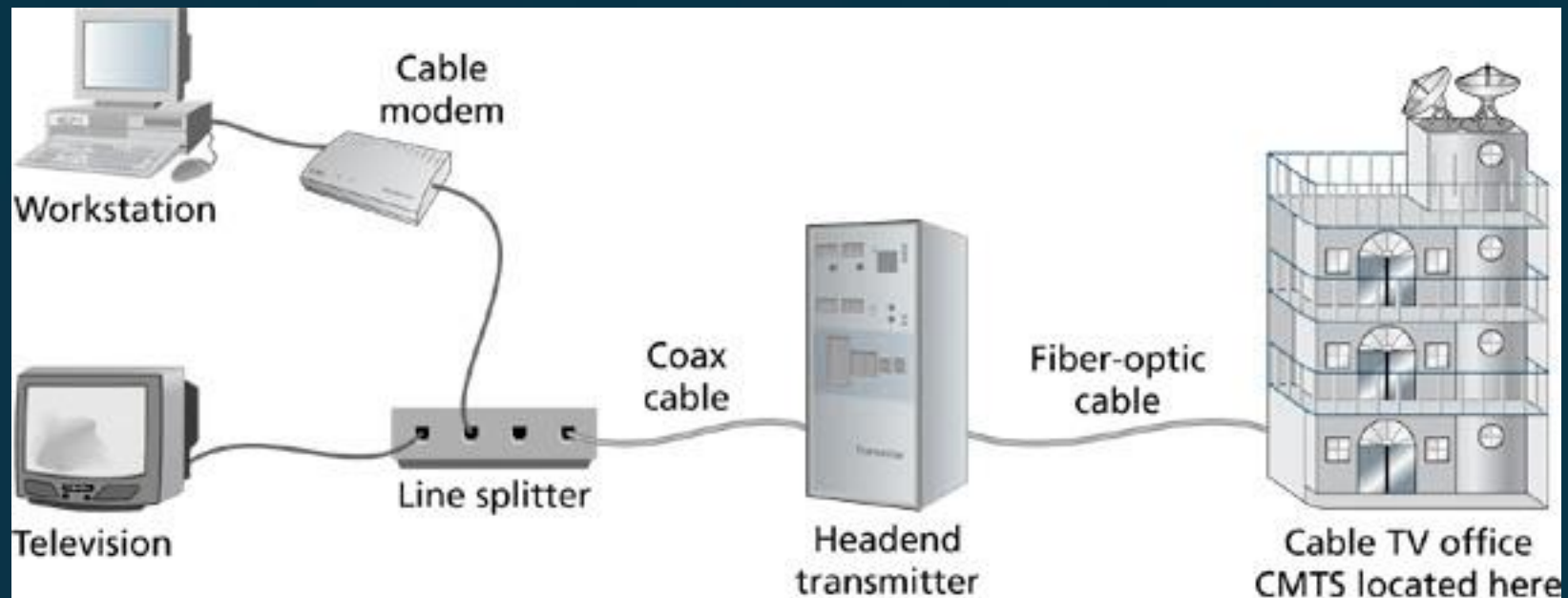
- Other High-Speed Carrier Services (cont'd)
  - **VDSL** is very-high-data-rate DSL.
  - Upload speeds approach 16 Mbps.
  - Download speeds approach 52 Mbps.
  - Distance between customer premise and central office must be 4,000 feet or less.
  - VDSL has competing standards that are not compatible with each other.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

- Other High-Speed Carrier Services (cont'd)
  - **Cable Television** (CATV) is marketed toward home users, home offices, and small businesses.
  - Upload transmission rates of 3 Mbps and download rates in the 27-56 Mbps range are achievable.
  - Customer equipment includes a cable modem and an Ethernet NIC or USB port.
  - The CATV company provides the hybrid fiber coax (HFC) network, the cable headend transmitter, and the cable modem termination system (CMTS).



# Cable TV Network for Data Transmission



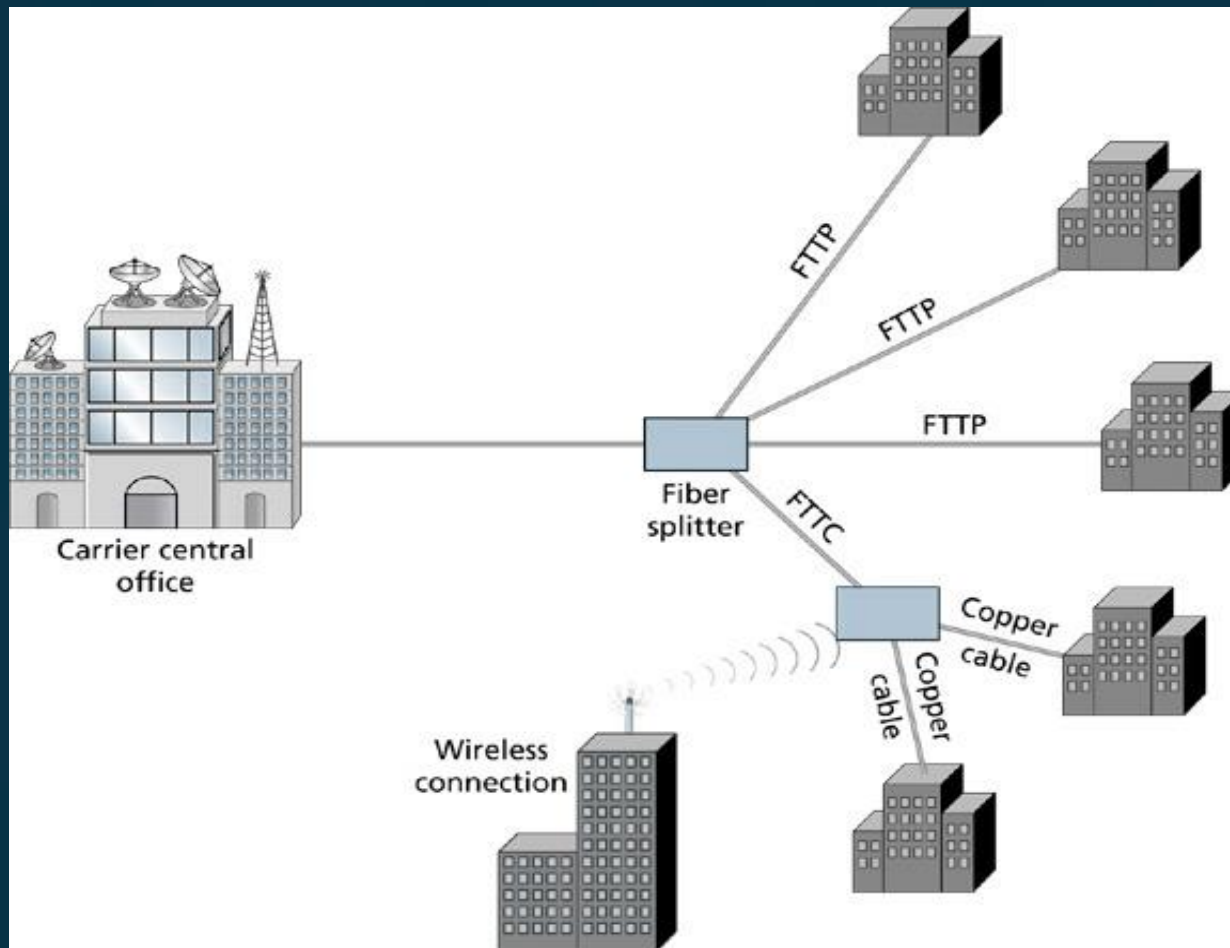
# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

- Other High-Speed Carrier Services (cont'd)
  - **Metropolitan Ethernet networks** (MENs) provide high-speed Ethernet connectivity beyond the physical boundaries of an organizations' campus.
  - 100 Mbps Ethernet, 1 Gbps Ethernet, or 10 Gbps Ethernet can be specified with the carrier.
  - **The Metro Ethernet Forum** (MEF) oversees the development of the metro Ethernet standards.

# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

- Other High-Speed Carrier Services (cont'd)
  - A **passive optical network** (PON) is a fiber optic network in which all active components have been removed between the customer and the carrier's CO.
  - **Optical splitters** distribute optical signals to multiple customers.
  - ATM-based PONs (APONs) provide 155 Mbps or 622 Mbps downstream and 155 Mbps upstream.
  - Ethernet PONs (EPONs) and Gigabit Ethernet PONs (GPONs) are in development.

# Passive Optical Network



# CONNECTIVITY TO REMOTE NETWORKS (cont'd)

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- Other High-Speed Carrier Services (cont'd)
  - **Wireless MAN/WAN services** provide shared bandwidth of up to 70 Mbps over a 30-mile non-line-of-sight range.
  - Wireless MAN/WAN services are commonly known as **WiMAX**.
  - WiMAX follows the IEEE 802.16 standards.

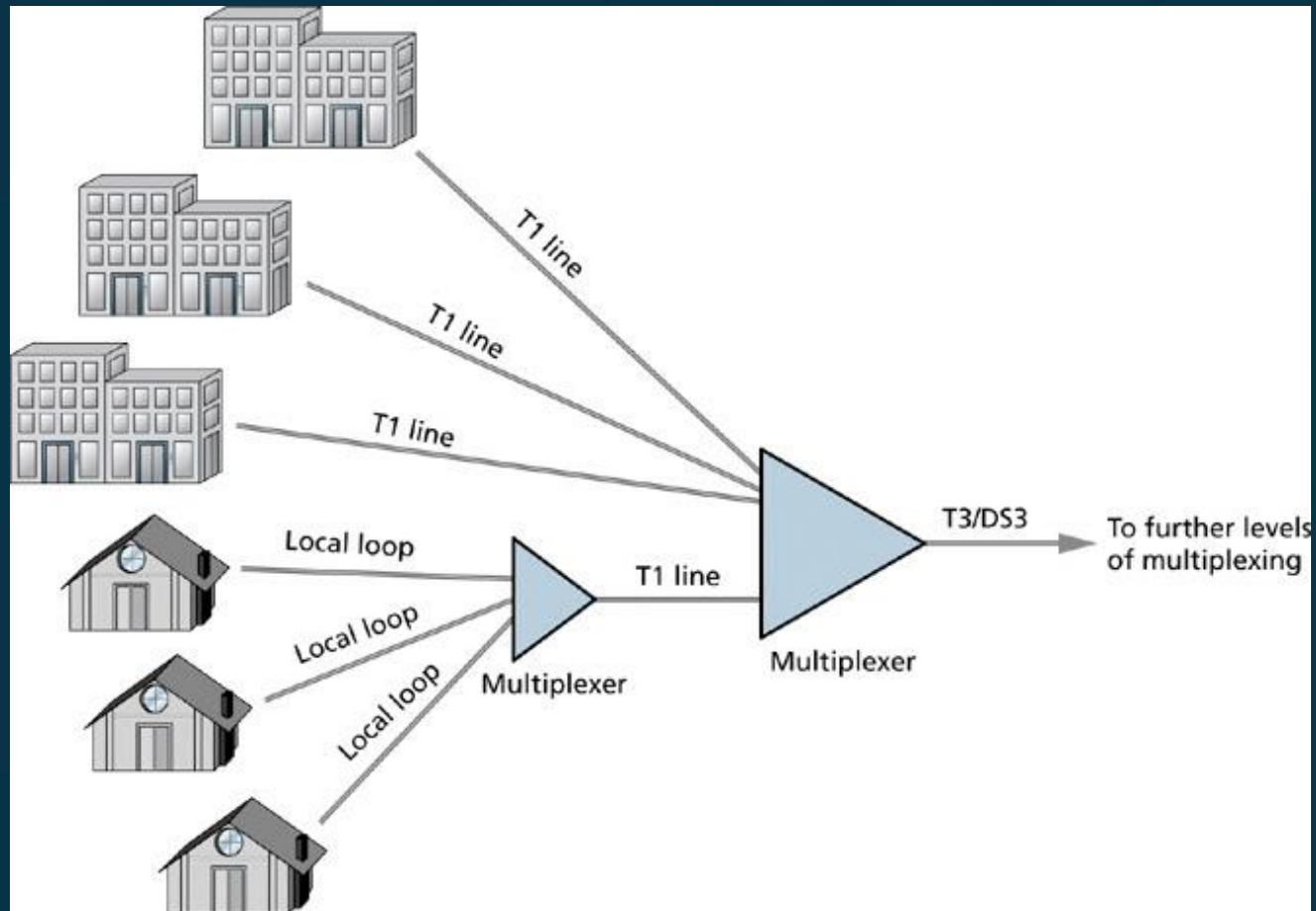
# DATA COMMUNICATION THROUGH THE CARRIER

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- **Multiplexing**

- Multiplexing combines multiple signals from multiple sources into a single, composite signal.
- The composite signal traverses the carrier's and other carriers' networks.
- Multiplexing makes more efficient use of carriers' available infrastructure and allows delivery of high-speed WAN services at affordable rates.

# Multiplexing at the Carrier



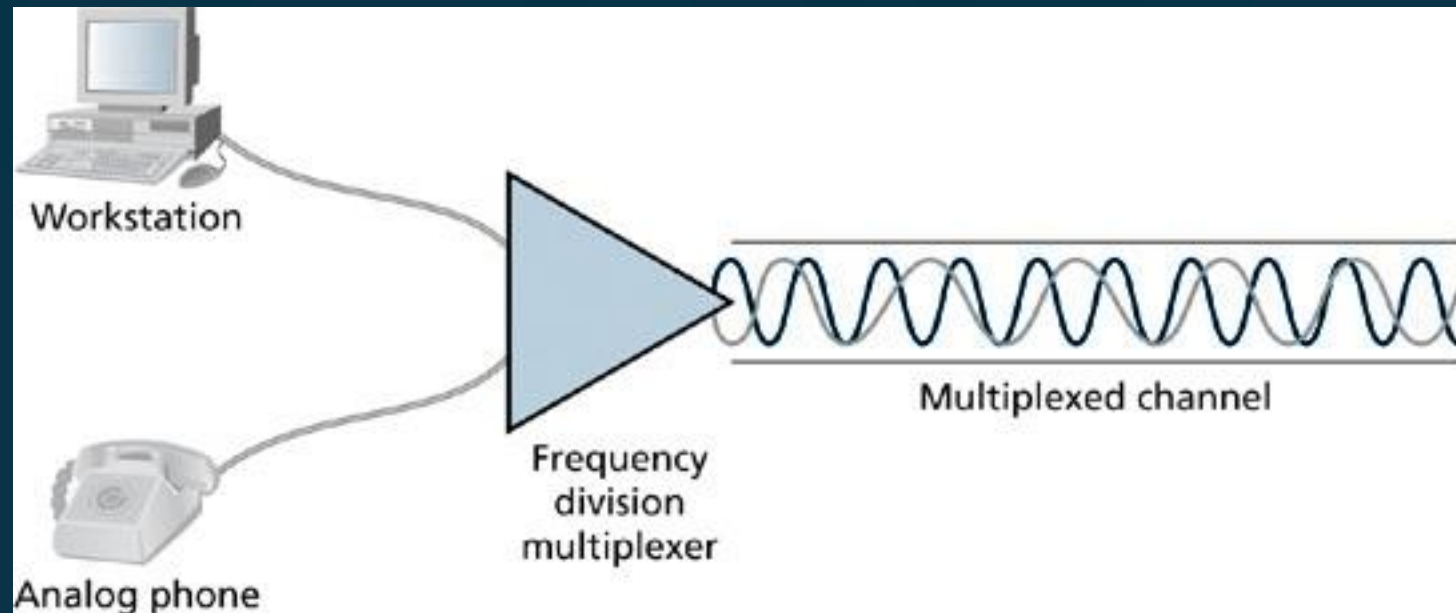
# DATA COMMUNICATION THROUGH THE CARRIER (cont'd)

## Multiplexing (cont'd)

- Several types of multiplexing are implemented by carriers to create these combined, complex signals:
  - Frequency division multiplexing (FDM)
  - Time-division multiplexing (TDM)
  - Statistical time-division multiplexing (STDM)
  - Wavelength division multiplexing (WDM)
  - Dense wavelength division multiplexing (DWDM)
  - Inverse multiplexing (IMUX)



# Frequency Division Multiplexing



# Time-Division Multiplexing

