COMPUTER NETWORKS

- Chapter 2. The Physical Layer 2

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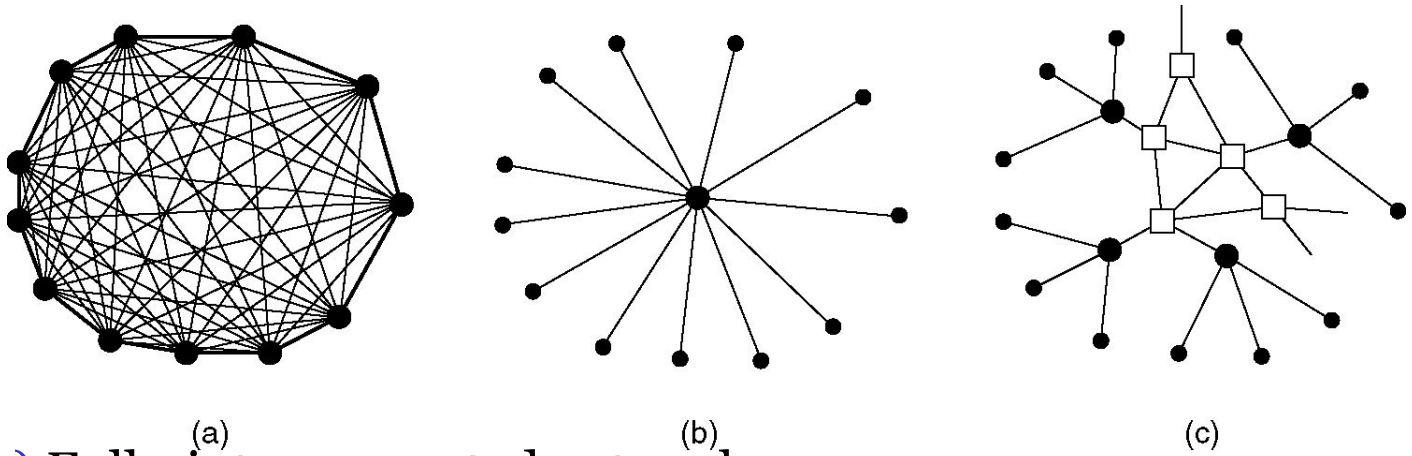
- Development of telephone system

Outline

- Structure of the Telephone System
- The Local Loop: Modems, ADSL and Wireless
- Trunks and Multiplexing 中继&多路复用
- Switching

Structure of the Telephone System

- The **PSTN** (Public Switched Telephone Network) is the world's collection of interconnected voice-oriented public telephone networks. It's also referred to as the **POTS** (Plain Old Telephone Service).



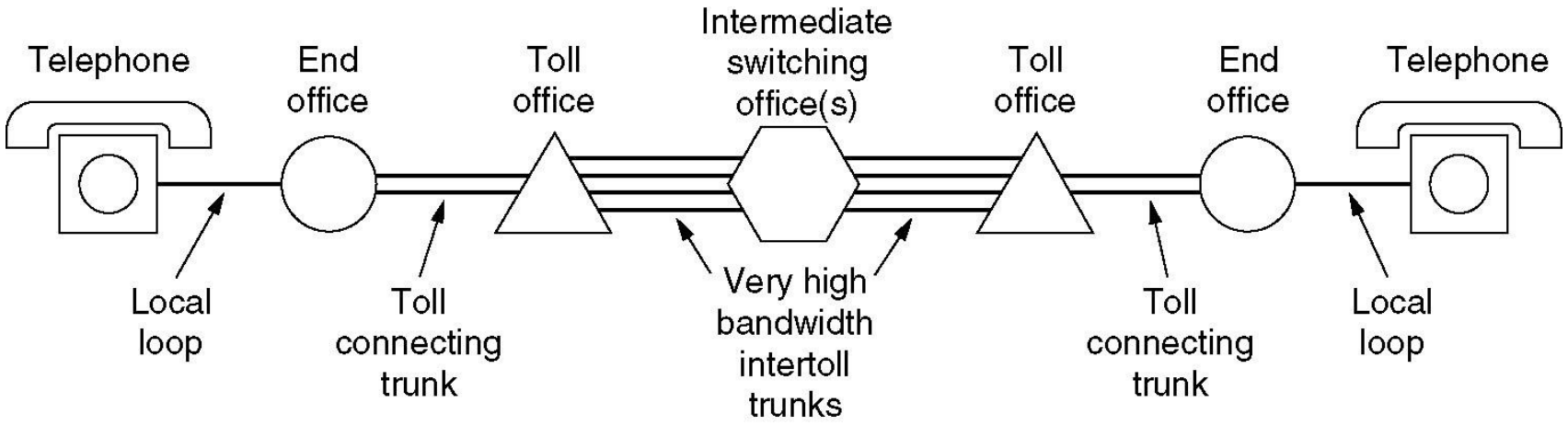
(a) Fully-interconnected network.

(b) Centralized switch.

(c) Two-level hierarchy.

Structure of the Telephone System

A typical circuit route for a medium-distance call.



Components of the Telephone System

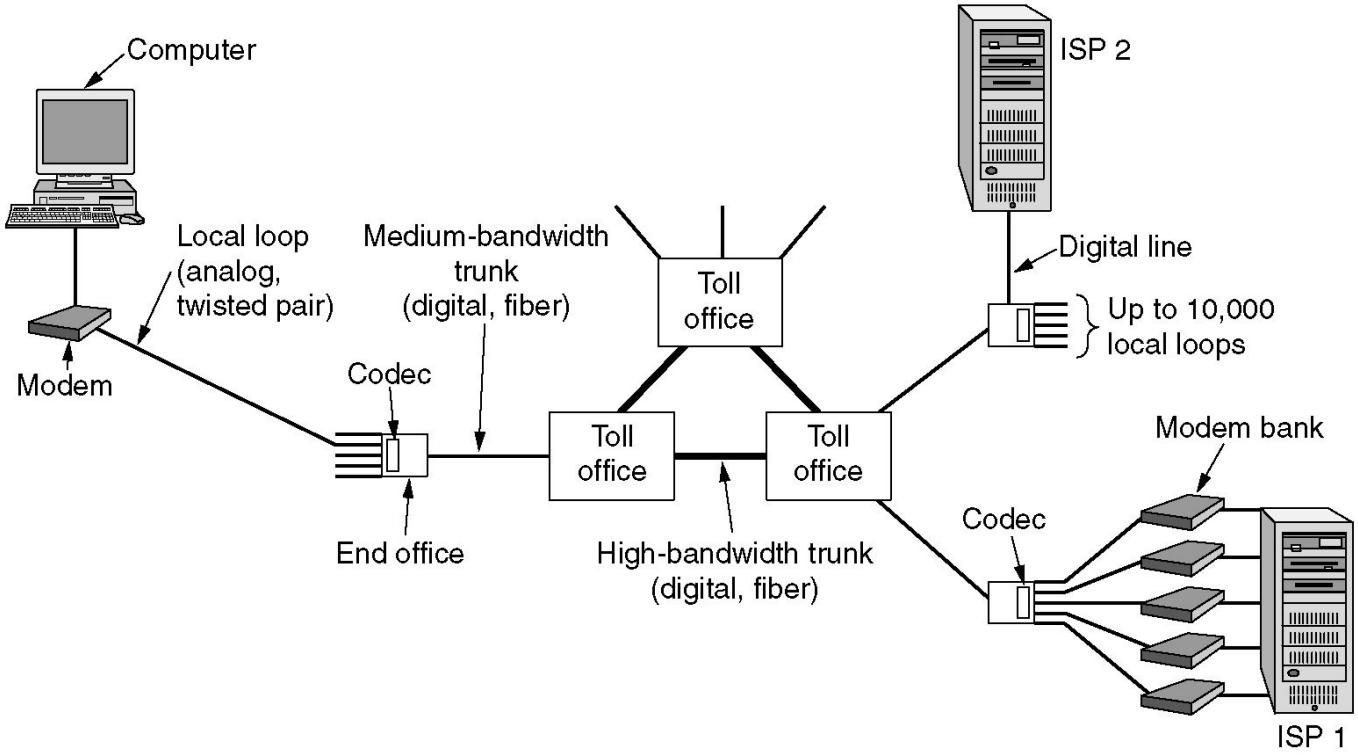
- Local loops
  - Analog twisted pairs going to houses and businesses
- Trunks
  - Digital fiber optics connecting the switching offices
- Switching offices
  - Where calls are moved from one trunk to another

The Local Loop

- Transmission lines suffer from three major problems:
  - Attenuation
  - Delay distortion
  - Noise
- The square waves used in digital signals have a wide frequency spectrum (usually, high frequency) and thus are subject to strong attenuation and delay distortion.

Modems

- The use of both analog and digital transmissions for a computer to computer call. Conversion is done by the modems and codecs.



Modems

- The modulation is introduced to solve this problem.
  - Amplitude: two different amplitudes are used to represent 0 and 1.
  - Frequency: different tones are used.
  - Phase: the wave is systematically shifted (45, 135, 225, or 315°).
- A **modem** (modulator-demodulator) is a device that modulates outgoing digital signals to analog signals.

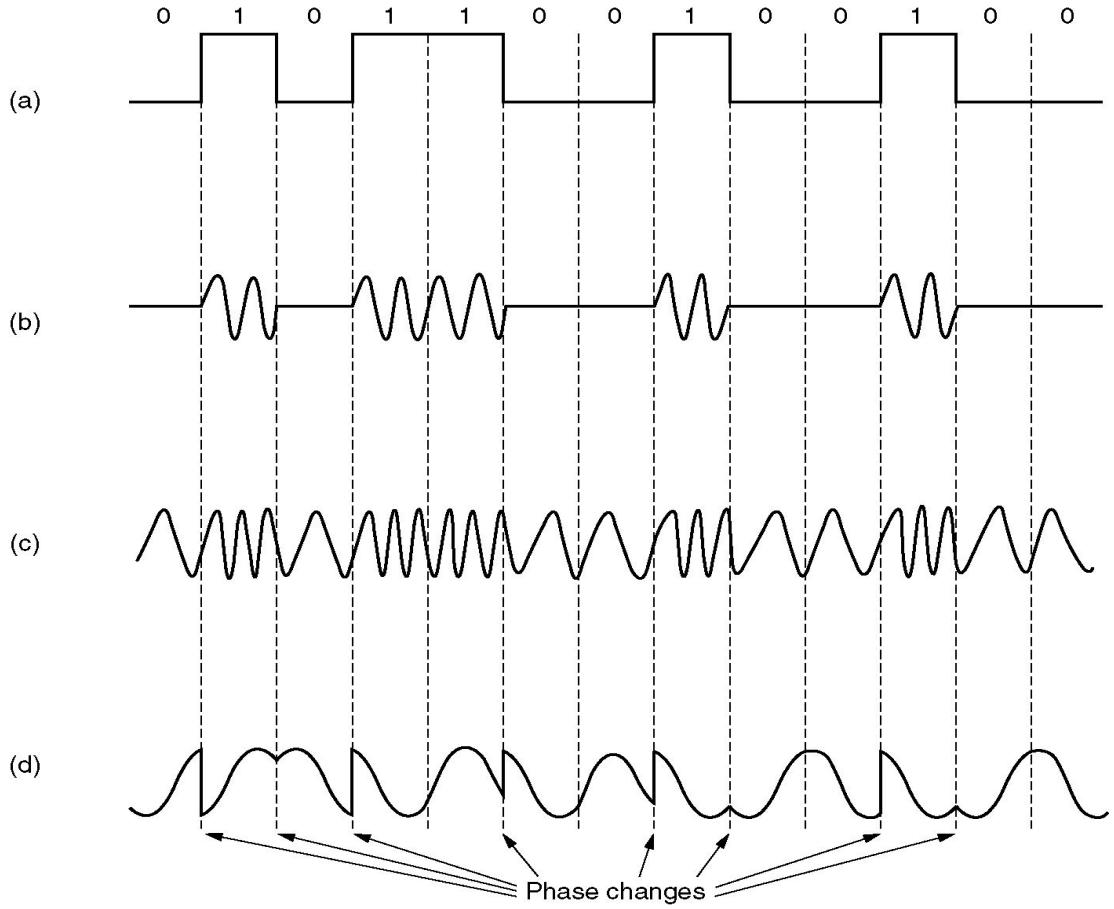
Terms

- Data element, bits, a signal binary 0 or 1
- Data rate, bits per second, the rate at which data elements are transmitted.
- Signal elements/Symbol
- Signal rate or modulation rate, signal elements per second (baud), the rate at which signal elements are transmitted.

Basic Encoding Techniques

- Digital data to analog signal
  - Amplitude-shift keying (ASK)
    - Amplitude difference of carrier frequency
  - Frequency-shift keying (FSK)
    - Frequency difference near carrier frequency
  - Phase-shift keying (PSK)
    - Phase of carrier signal shifted

Modulation of analog signals



(a) A binary signal

(b) Amplitude modulation

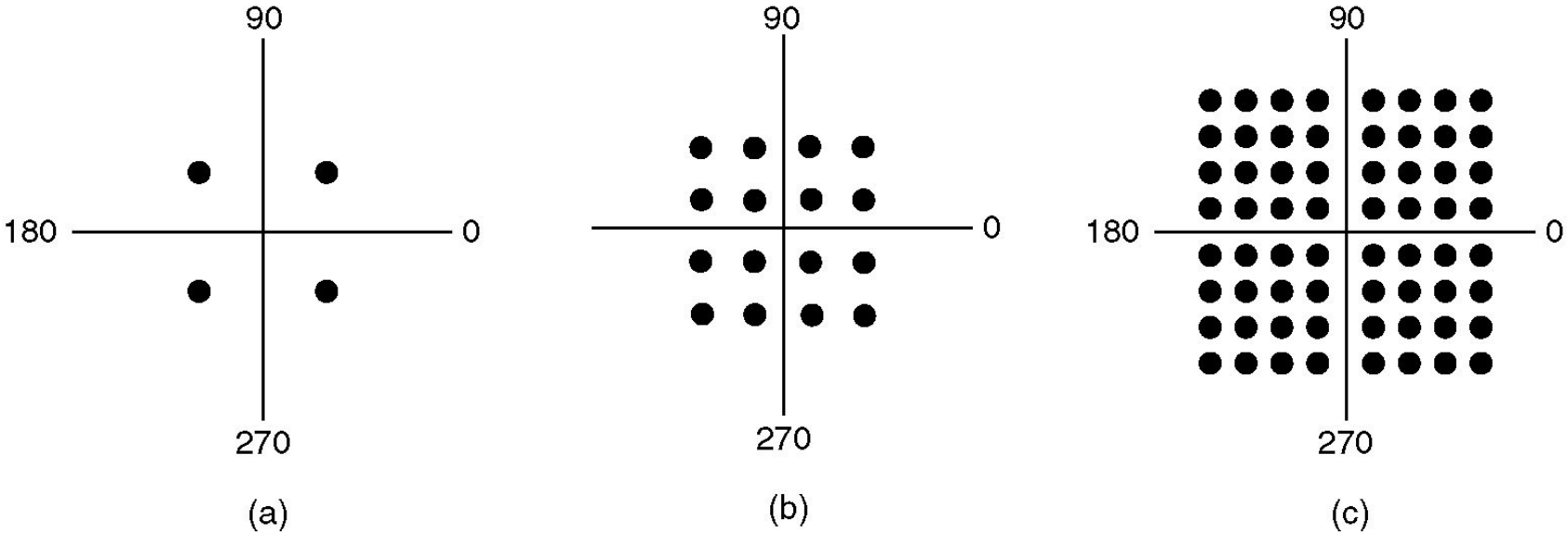
(c) Frequency modulation

(d) Phase modulation

Modems

- The number of samples/symbols per second is measured in **baud**.
- In **quadrature phase-shift keying** (**QPSK**四相/正交相移键控), the four angles, usually out of phase by 90°, are used to transmit 2 bits/symbol. The bit rate is twice the baud rate.
- **QAM-64** (Quadratrue Amplitude Modulation正交幅度调制-64) allows 64 different combinations, so 6 bits can be transmitted per symbol.

Modems



Constellation Diagrams:

(a) QPSK.

(b) QAM-16.

(c) QAM-64.

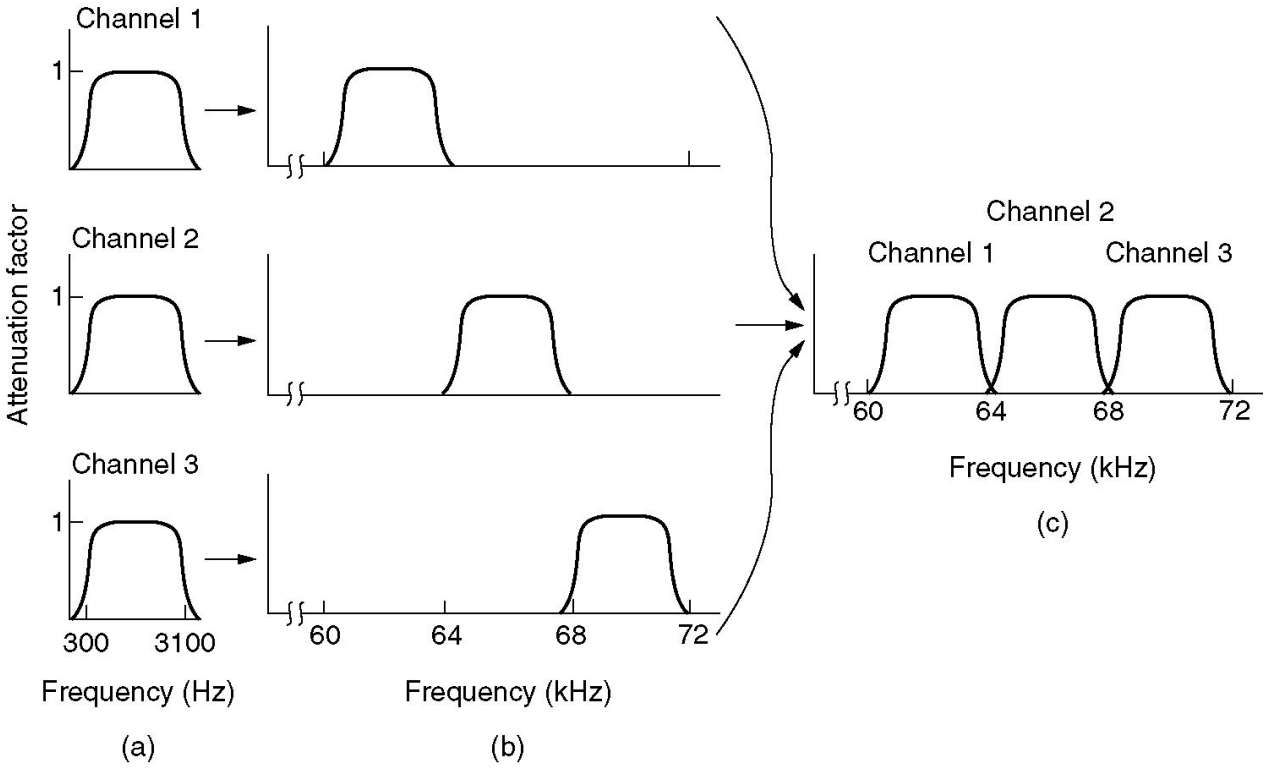
Modems

- A connection that allows traffic in both directions simultaneously is called **full duplex**.
- A connection that allows traffic either way, but only one way at a time is called **half duplex**.
- A connection that allows traffic only one way is called **simplex**.

Trunks and Multiplexing

- Two categories of multiplexing schemes are used to multiplex many conversations over a single physical trunk:
  - In **FDM** (**Frequency Division multiplexing**), the frequency spectrum is divided into frequency bands. For fiber optic channels, **WDM** (**Wavelength Division Multiplexing**) is used.
  - In **TDM** (**Time Division Multiplexing**), the entire bandwidth is used for a chunk of time period.

Frequency Division Multiplexing



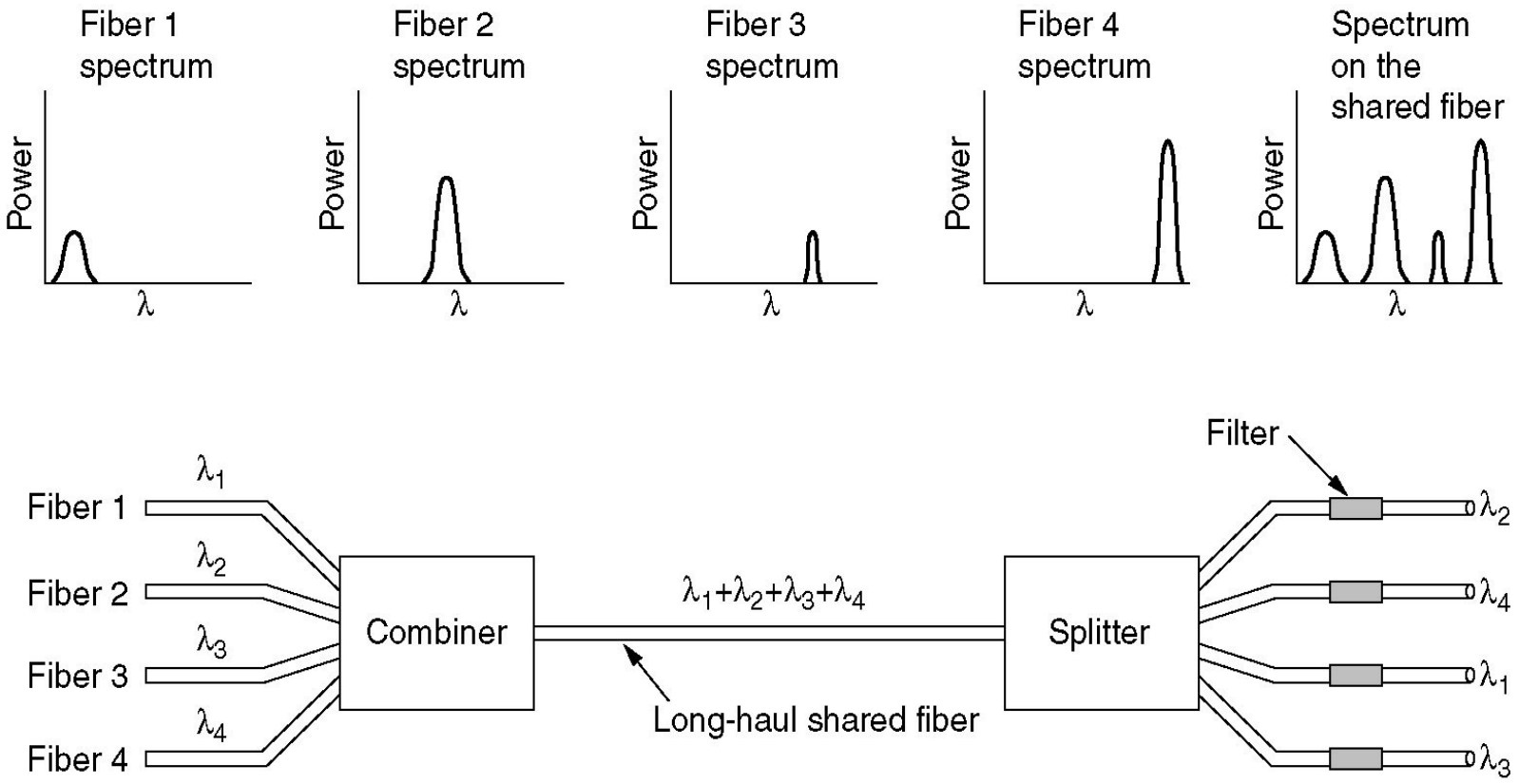
(a) The original bandwidths.

(b) The bandwidths raised in frequency.

(b) The multiplexed channel.

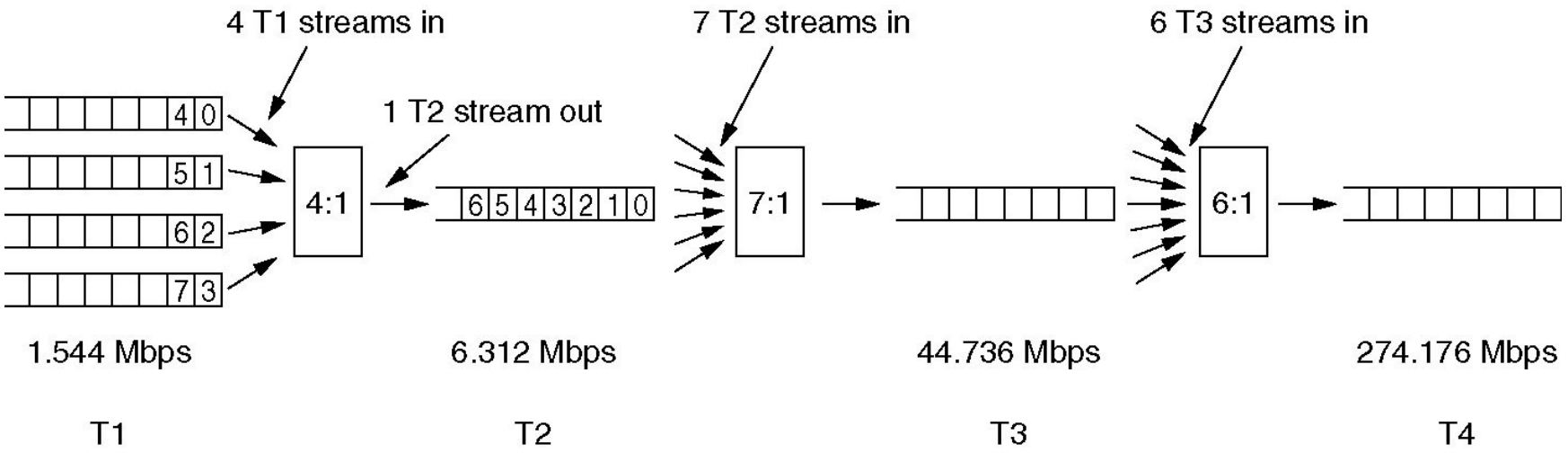
Wavelength Division Multiplexing

Wavelength division multiplexing.



Time Division Multiplexing

Multiplexing T1 streams into higher carriers.

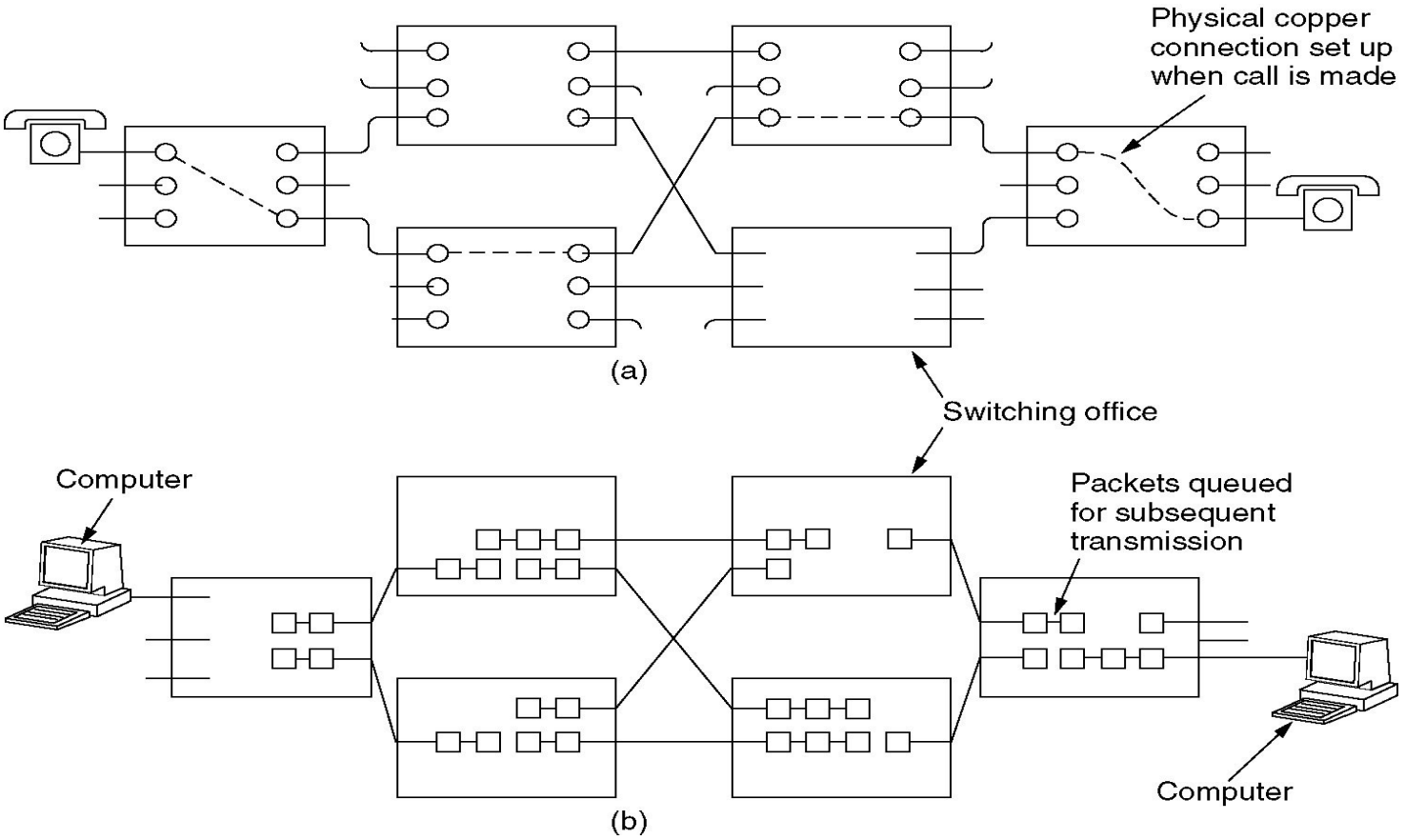


Switching

- **Circuit switching** – seek out a physical path from sender to receiver. An end-to-end path must be (conceptually) established before data is sent.
- **Message switching** – no path is established in advance. The message is stored in the first switching office and forwarded later one hop at a time.
  - Example: store-and-forward network
  - Problem: No restriction of block size
- **Packet switching** – place a restriction on block size, to allow packets to be buffered in main memory at the switching office.
  - Advantages:

    Well-suited for interactive traffic
    - Improved response time and throughput

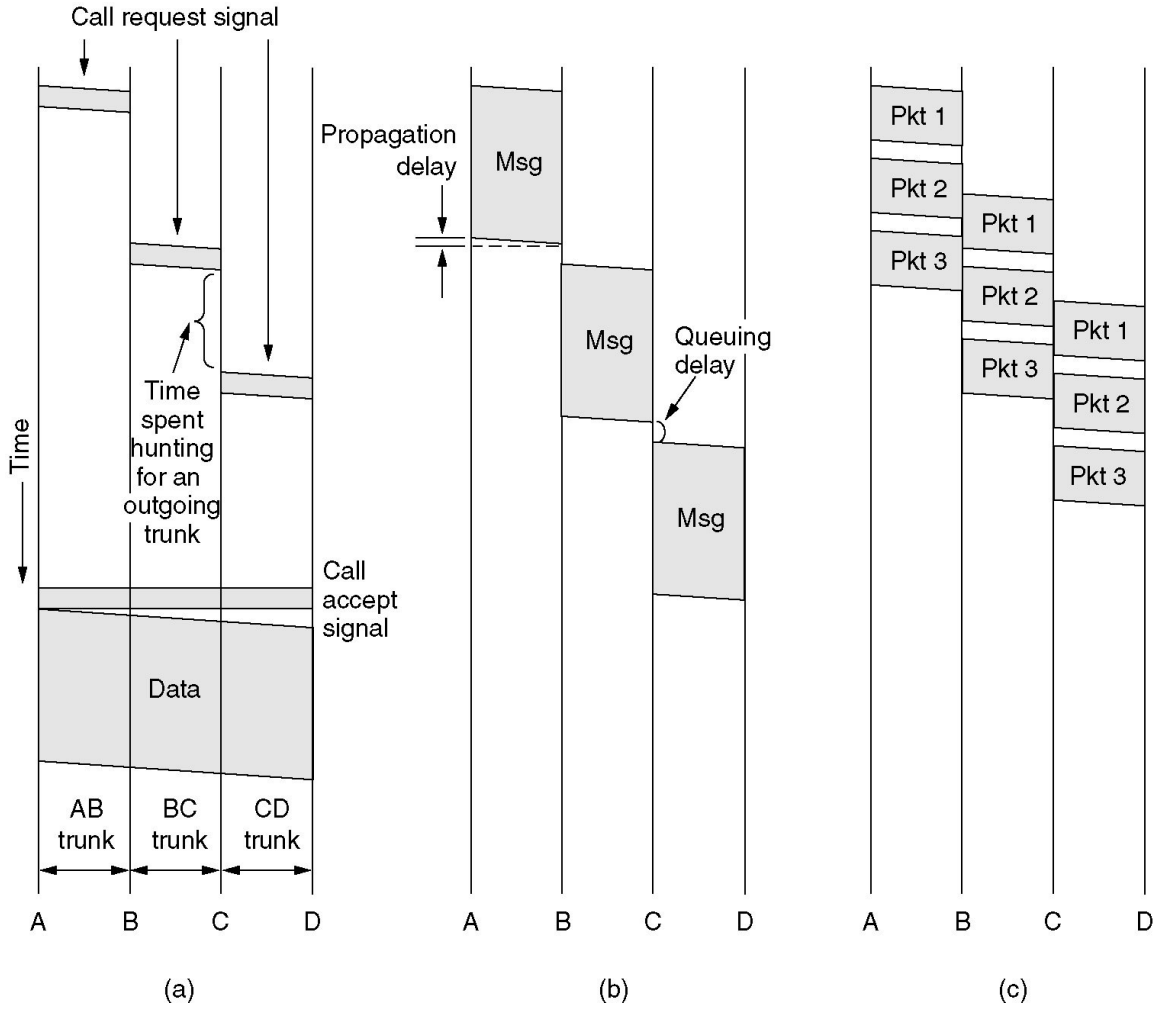
Circuit Switching



(a) Circuit switching.

(b) Packet switching.

Message Switching



(a) Circuit switching (b) Message switching (c) Packet switching

Packet Switching

Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

A comparison of circuit switched and packet-switched networks.

Presentation

- Mobile telephone system