



Computer Networks 1

(Mạng Máy Tính 1)

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Lecture 2: Communication Media

Reference:

Chapter 2 - “*Computer Networks*”,
Andrew S. Tanenbaum, 4th Edition, Prentice Hall, 2003.



Content

- Theoretical basis for data communication
- Guided transmission media
- Wireless transmission
- Digital subscriber lines
- Internet over TV cables



The Theoretical Basis for Data Communication

- Fourier Analysis
- Bandwidth
- Bandwidth-Limited Signals
- Maximum Data Rate of a Channel



Fourier Series

$$g(t) = \frac{1}{2}c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$



Bandwidth

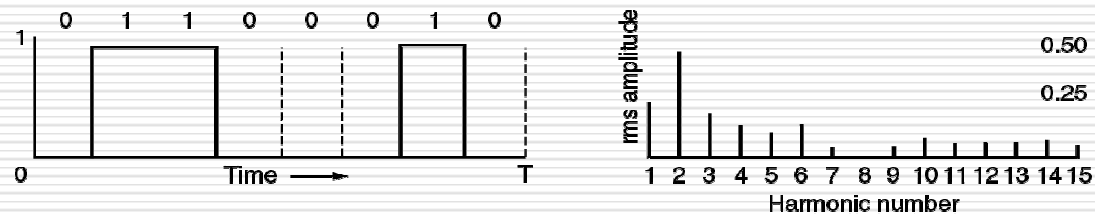
- ❑ Signals lose power during transmission
- ❑ Different transmission facilities diminish different Fourier components with different amounts -> distortion of signals
- ❑ Usually, high frequency components will be diminished
- ❑ **Bandwidth:** range of frequencies can be transmitted without being strongly attenuated



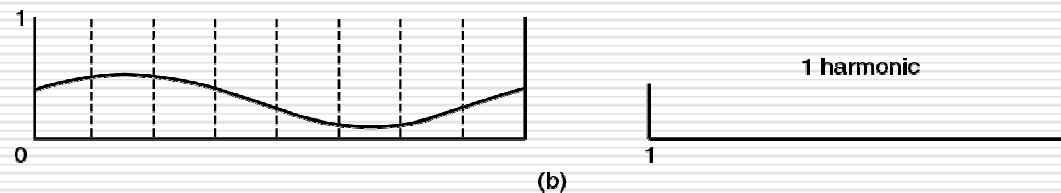
Bandwidth-Limited Signals (1)

A binary signal and its root-mean-square Fourier amplitudes.

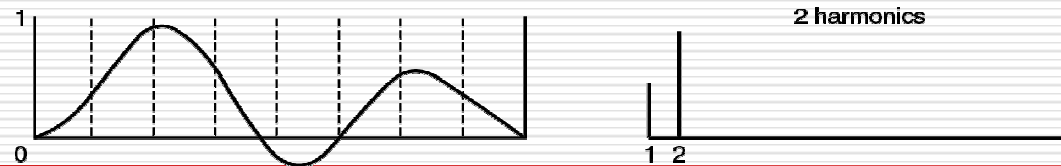
(b) – (c) Successive approximations to the original signal.



(a)



(b)

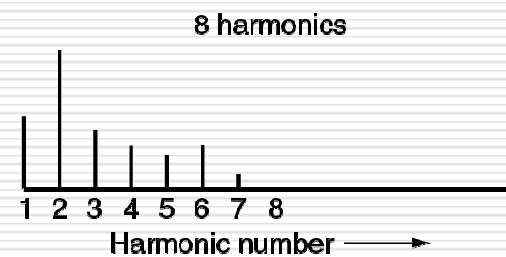
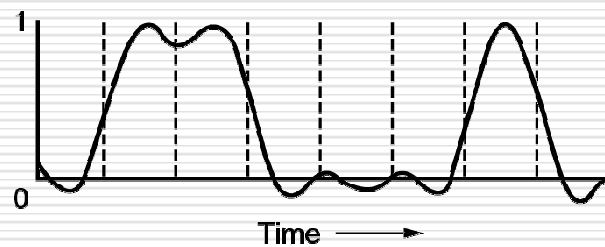
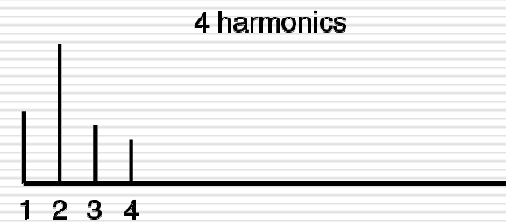
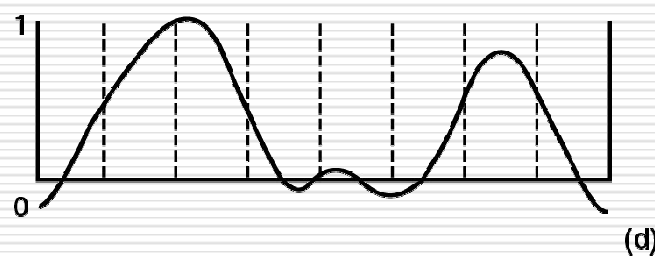


(c)



Bandwidth-Limited Signals (2)

(d) – (e) Successive approximations to the original signal.



(e)



Bandwidth-Limited Signals (3)

Relation between data rate and harmonics for a voice telephone line

Bps	T (msec)	First harmonic (Hz)	# Harmonics sent
300	26.67	37.5	80
600	13.33	75	40
1200	6.67	150	20
2400	3.33	300	10
4800	1.67	600	5
9600	0.83	1200	2
19200	0.42	2400	1
38400	0.21	4800	0

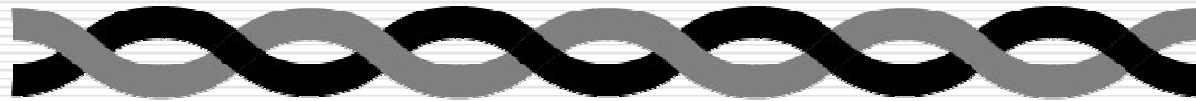


Guided Transmission Data

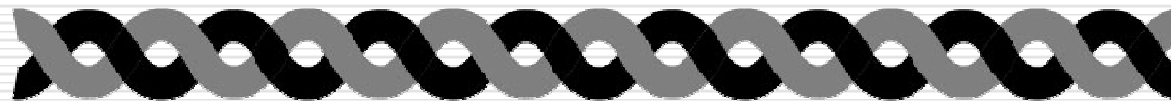
- Twisted Pair
- Coaxial Cable
- Fiber Optics



Twisted Pair



(a)



(b)

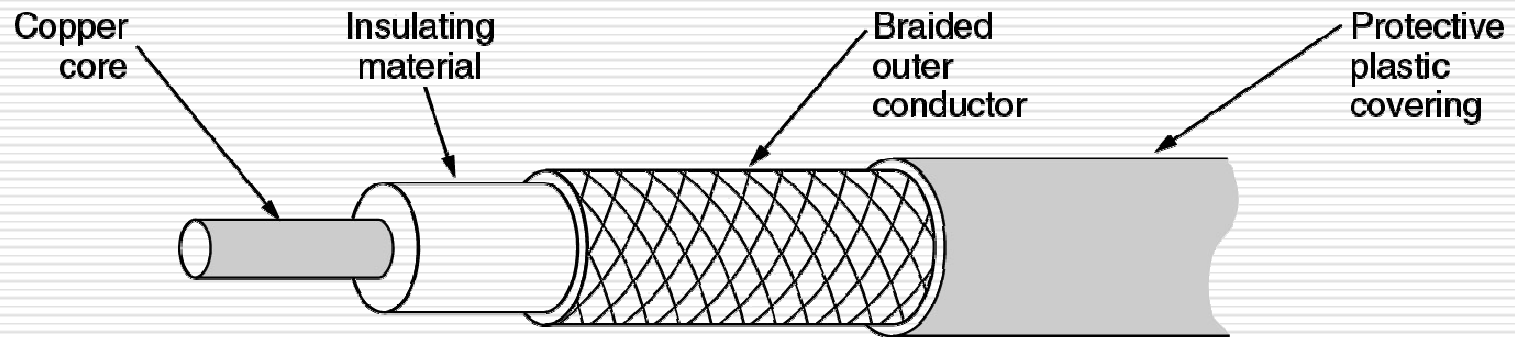
(a) Category 3 UTP.

(b) Category 5 UTP.



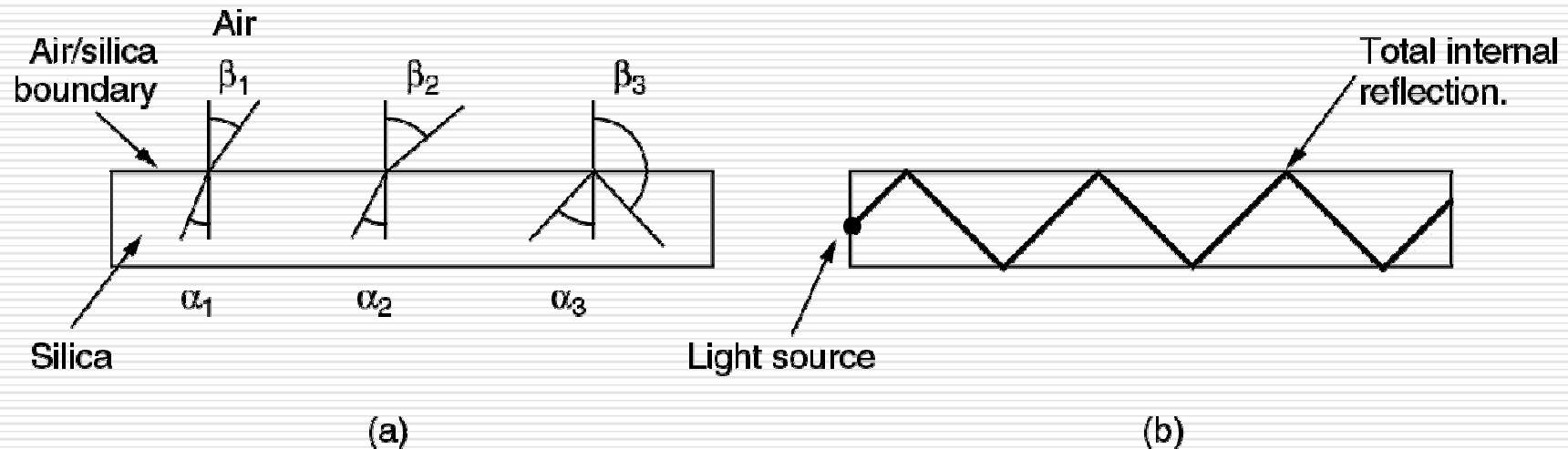
Coaxial Cable

A coaxial cable.





Fiber Optics

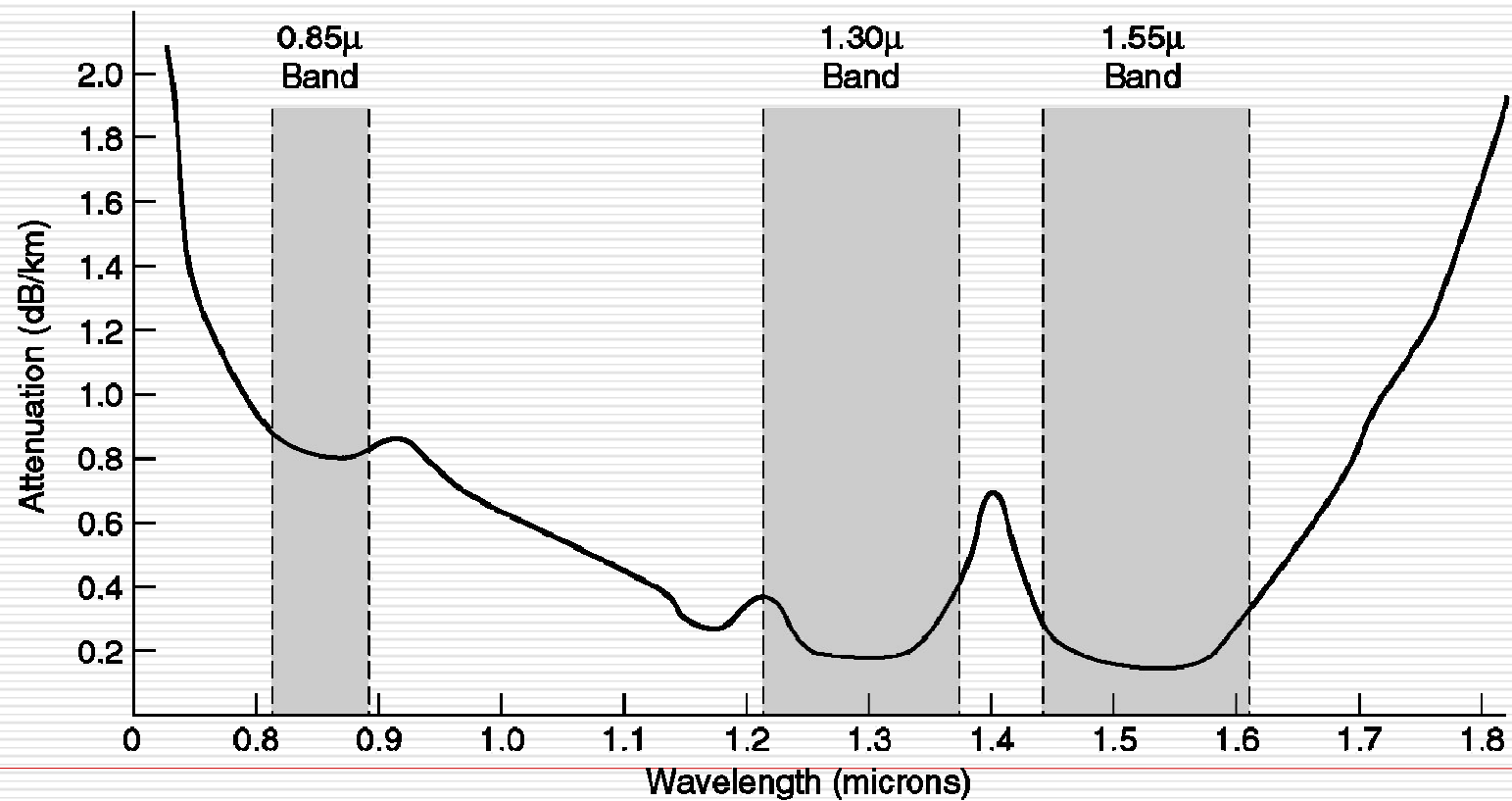


- (a) Three examples of a light ray from inside a silica fiber impinging on the air/silica boundary at different angles.
- (b) Light trapped by total internal reflection.



Transmission of Light through Fiber

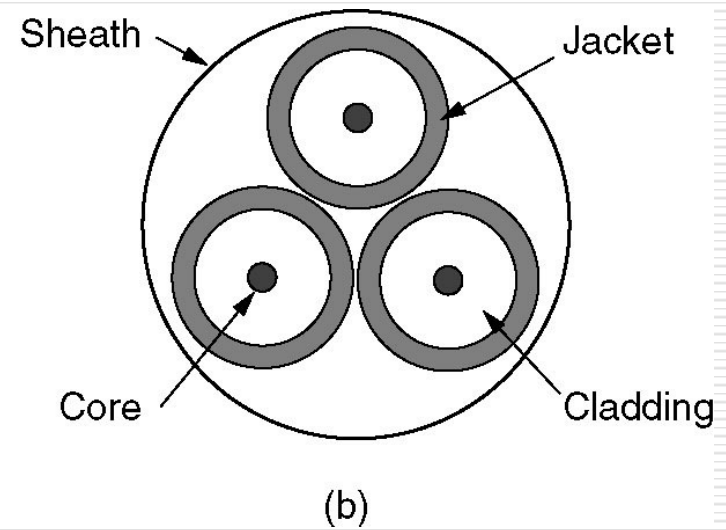
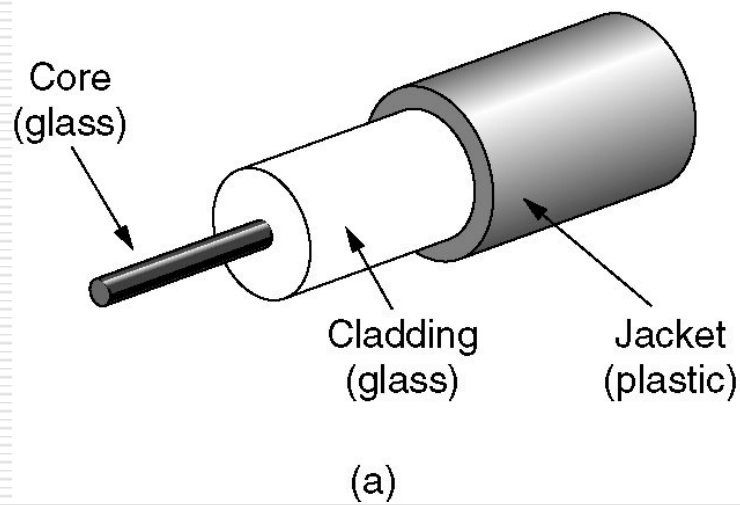
Attenuation of light through fiber in the infrared region.





Fiber Cables

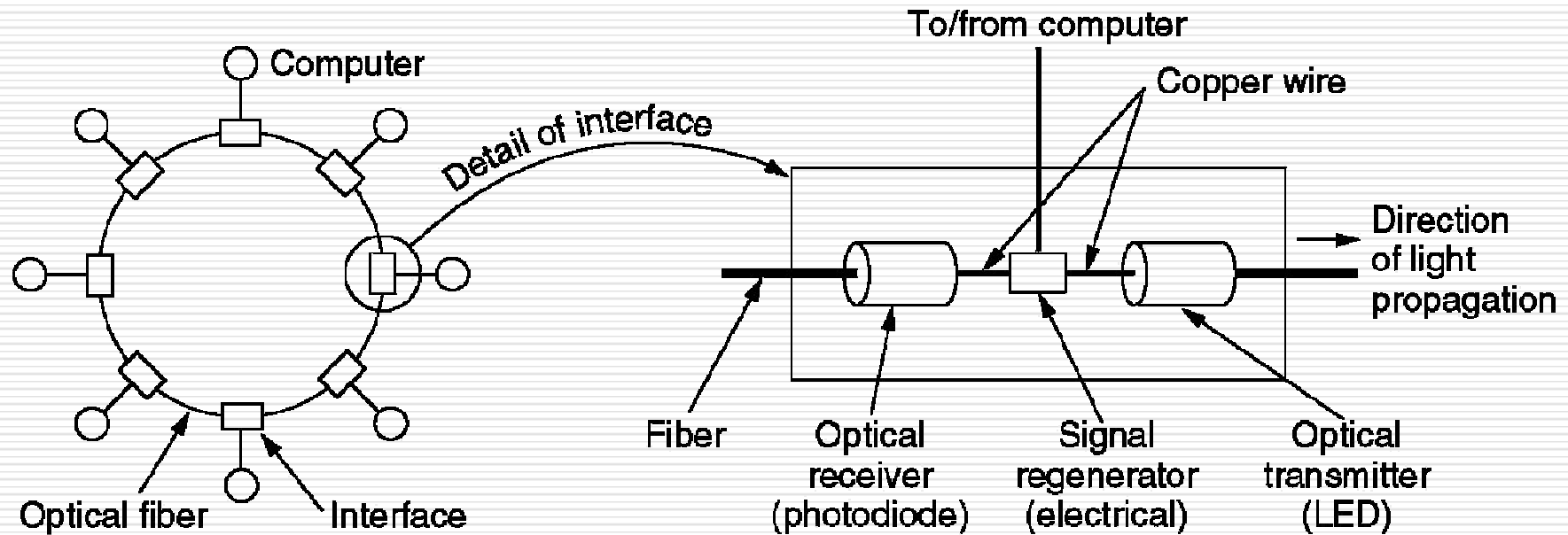
- (a) Side view of a single fiber.
- (b) End view of a sheath with three fibers.





Fiber Optic Networks

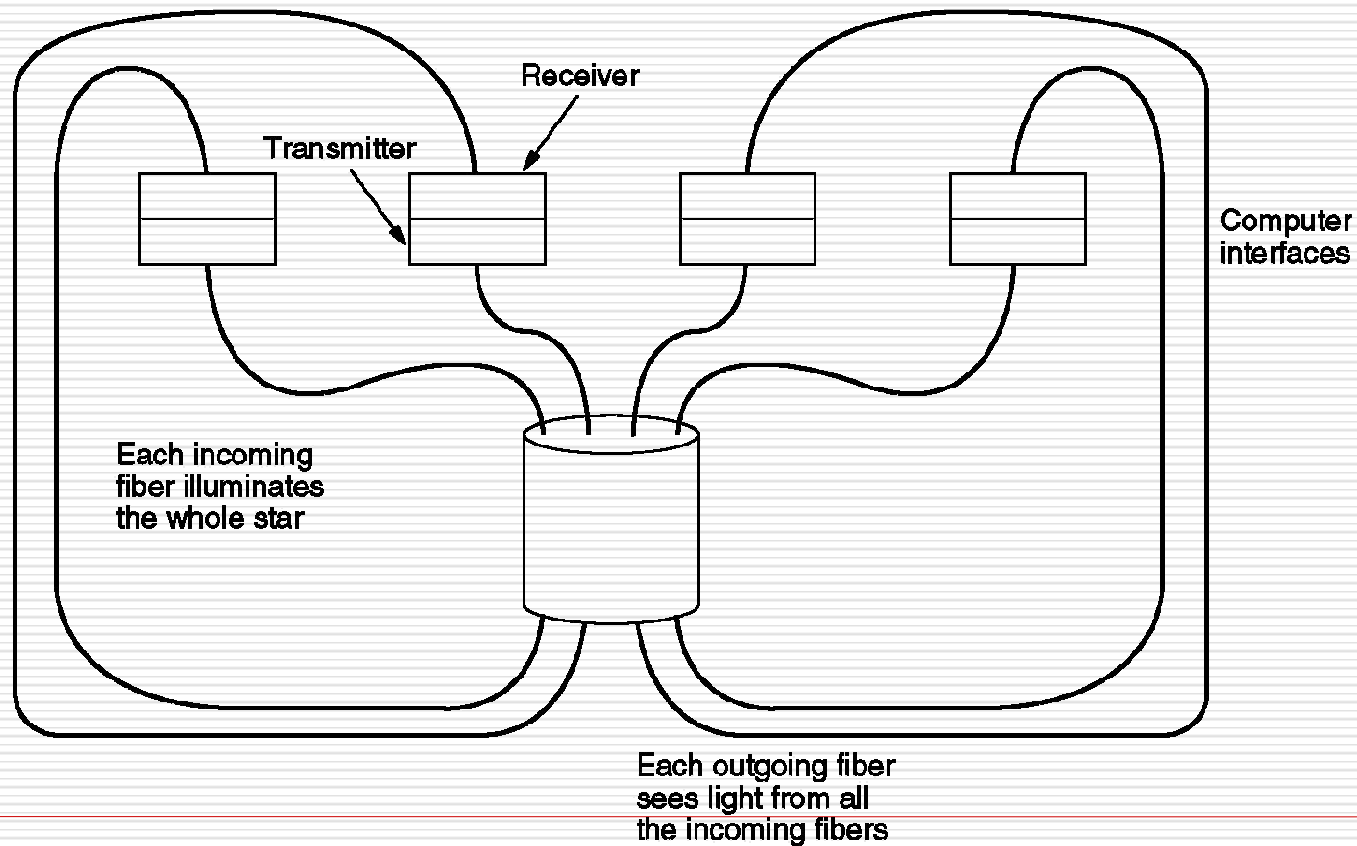
A fiber optic ring with active repeaters.





Fiber Optic Networks (2)

A passive star connection in a fiber optics network.





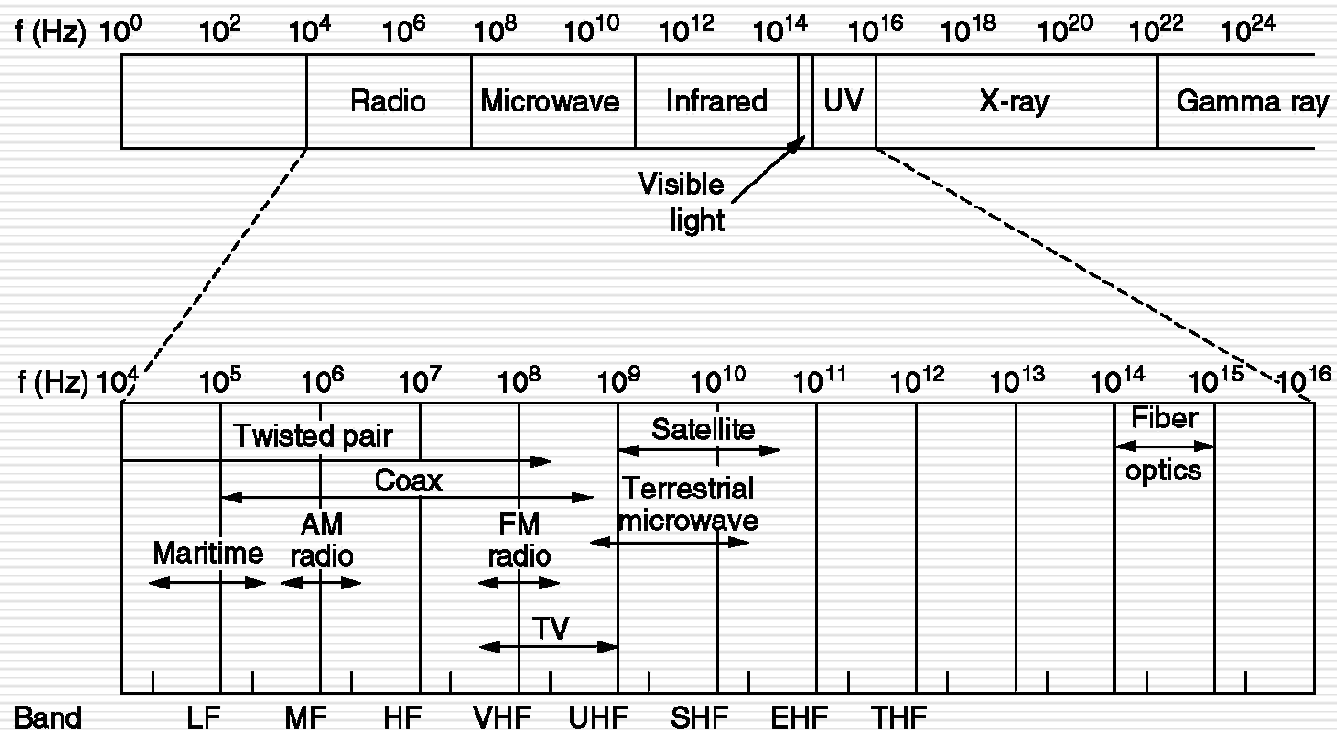
Wireless Transmission

- The Electromagnetic Spectrum
- Radio Transmission
- Microwave Transmission
- Infrared and Millimeter Waves
- Lightwave Transmission



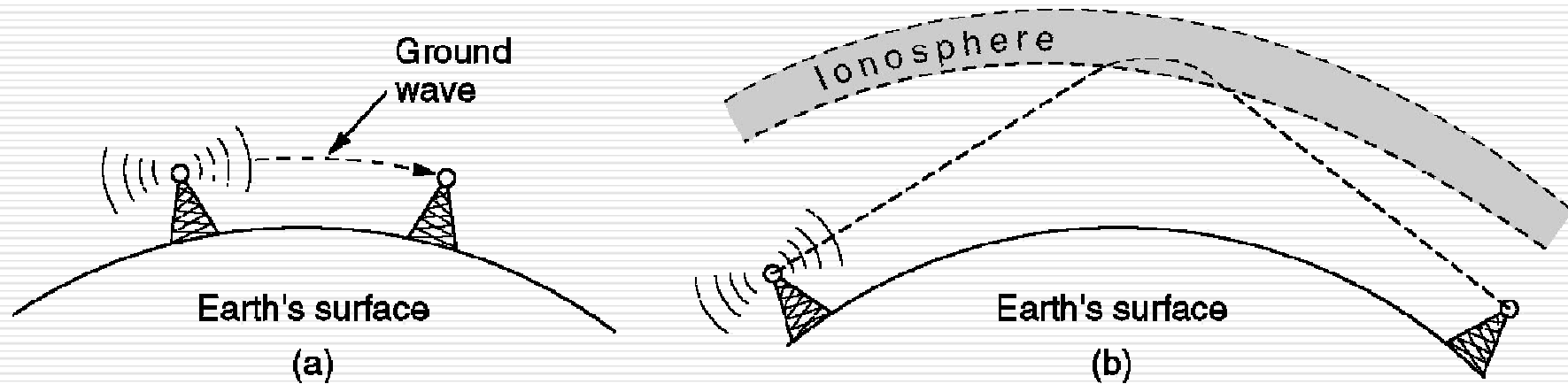
The Electromagnetic Spectrum

The electromagnetic spectrum and its uses for communication.





Radio Transmission

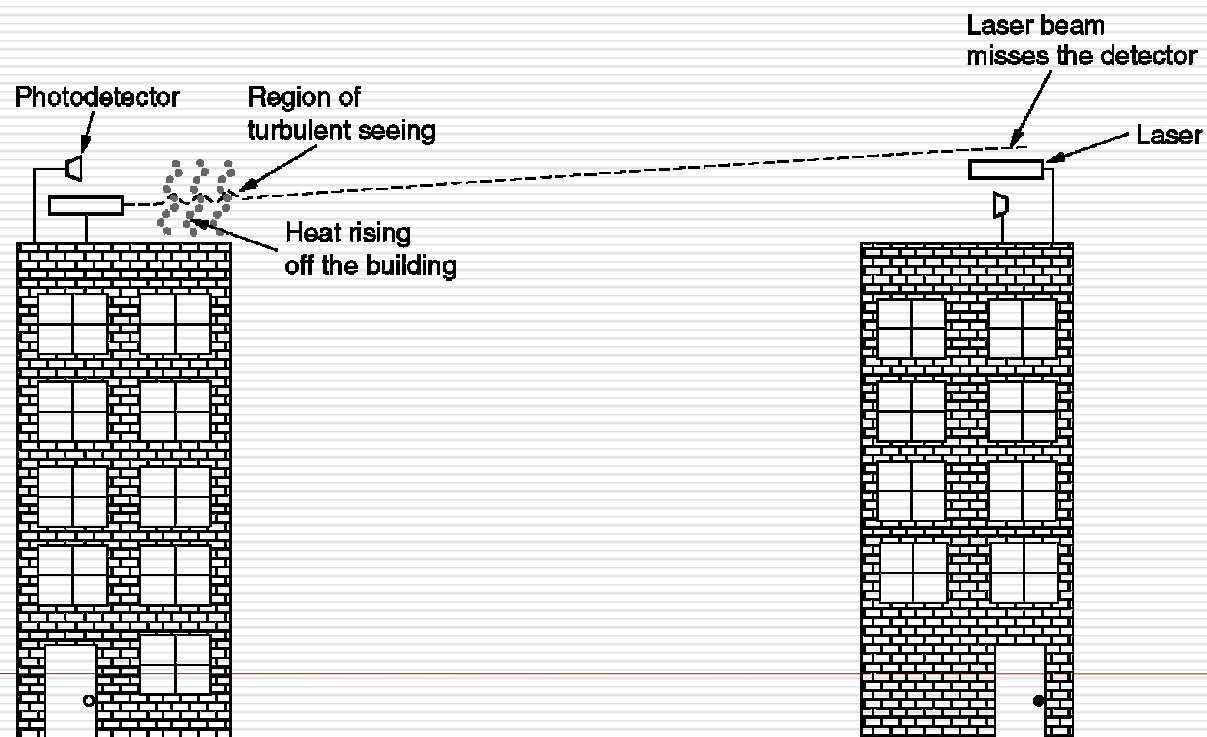
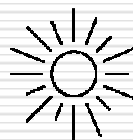


- (a) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.
- (b) In the HF band, they bounce off the ionosphere.



Lightwave Transmission

A bidirectional system with two lasers is pictured here.



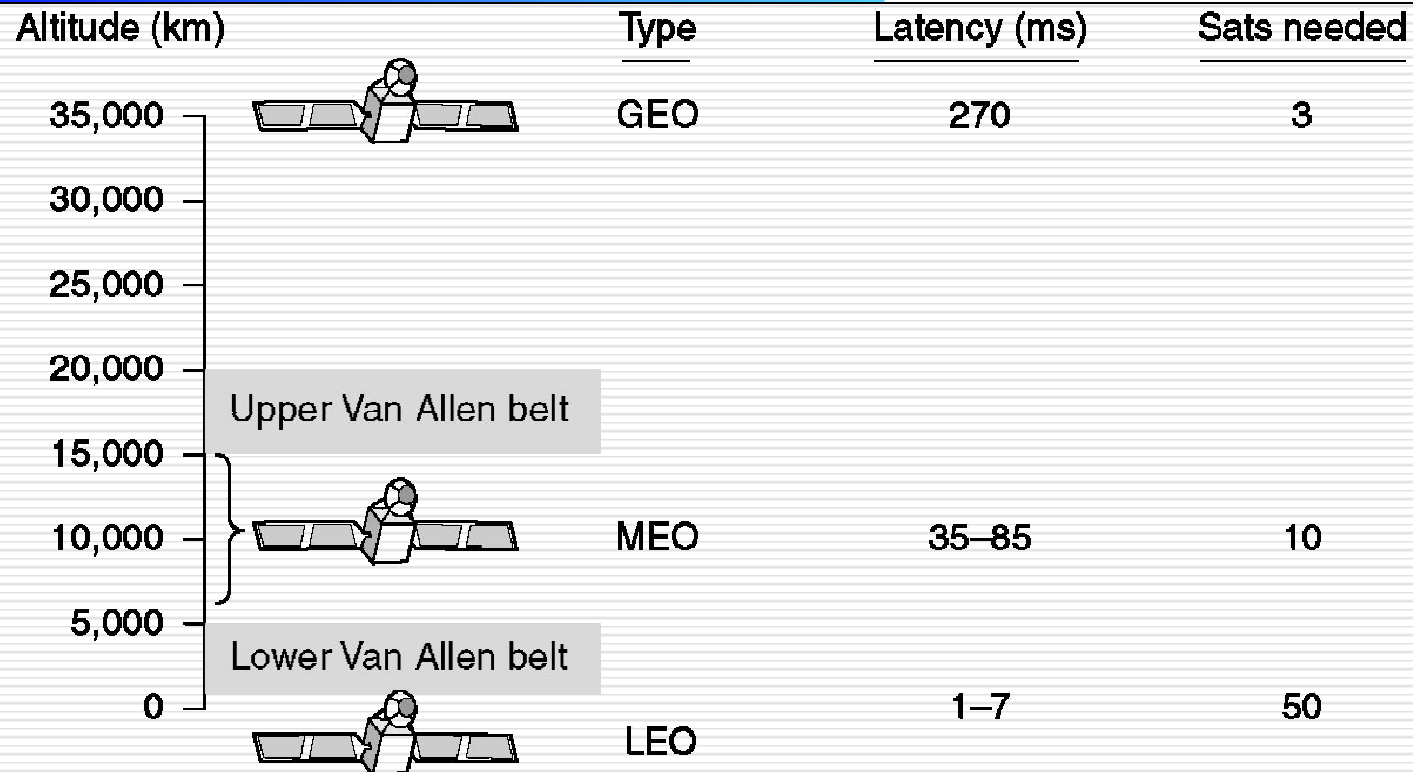


Communication Satellites

- Geostationary Satellites
- Medium-Earth Orbit Satellites
- Low-Earth Orbit Satellites
- Satellites versus Fiber



Communication Satellites



Communication satellites and some of their properties, including altitude above the earth, round-trip delay time and number of satellites needed for global coverage.



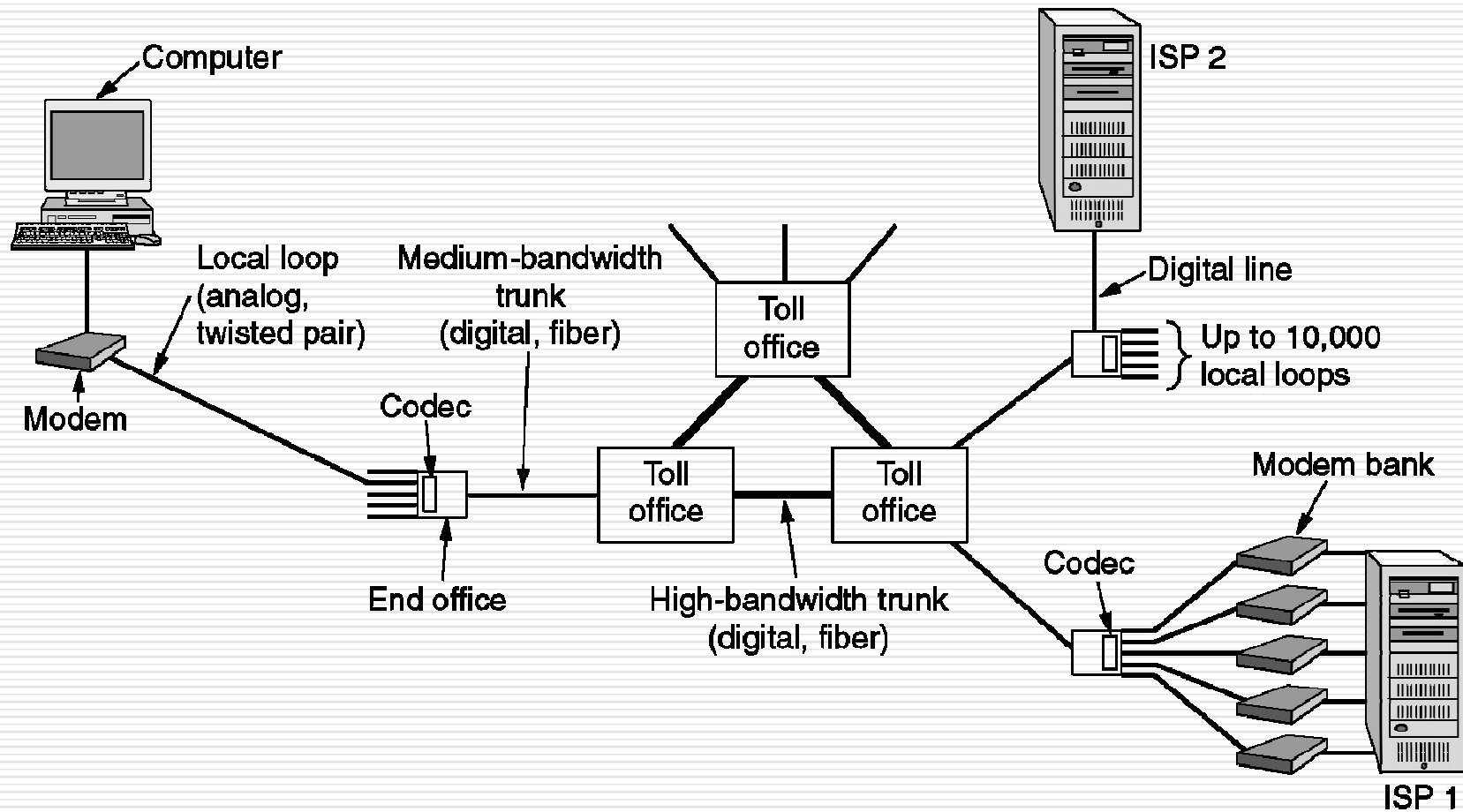
Communication Satellites (2)

The principal satellite bands.

Band	Downlink	Uplink	Bandwidth	Problems
L	1.5 GHz	1.6 GHz	15 MHz	Low bandwidth; crowded
S	1.9 GHz	2.2 GHz	70 MHz	Low bandwidth; crowded
C	4.0 GHz	6.0 GHz	500 MHz	Terrestrial interference
Ku	11 GHz	14 GHz	500 MHz	Rain
Ka	20 GHz	30 GHz	3500 MHz	Rain, equipment cost

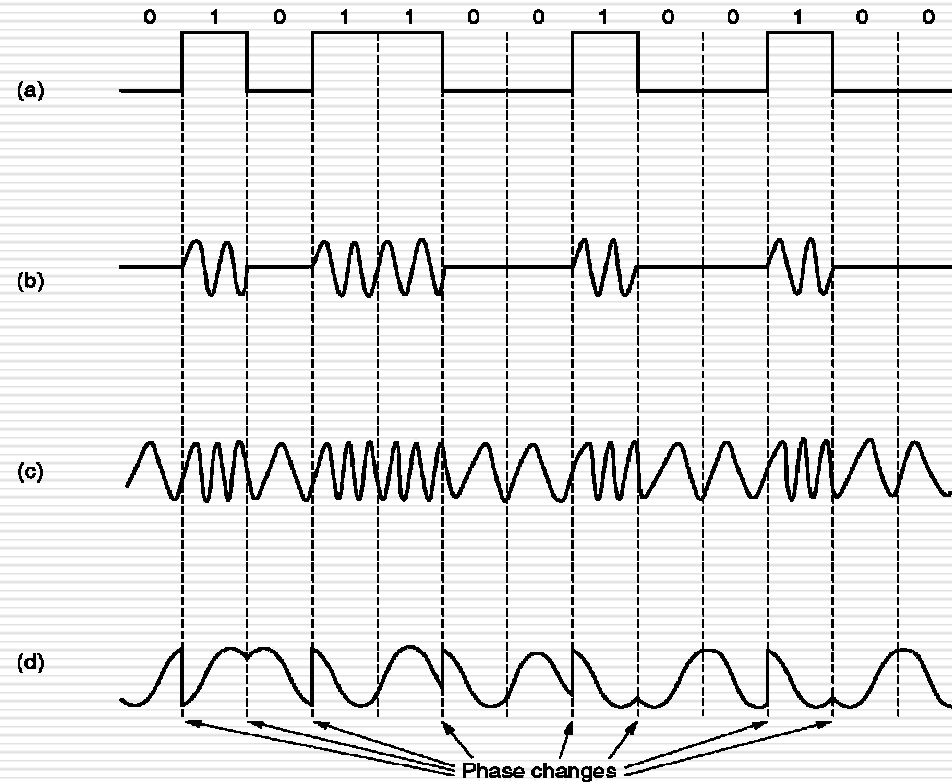


Modems, ADSL, and Wireless





Modems



(a) A binary signal

(b) Amplitude modulation

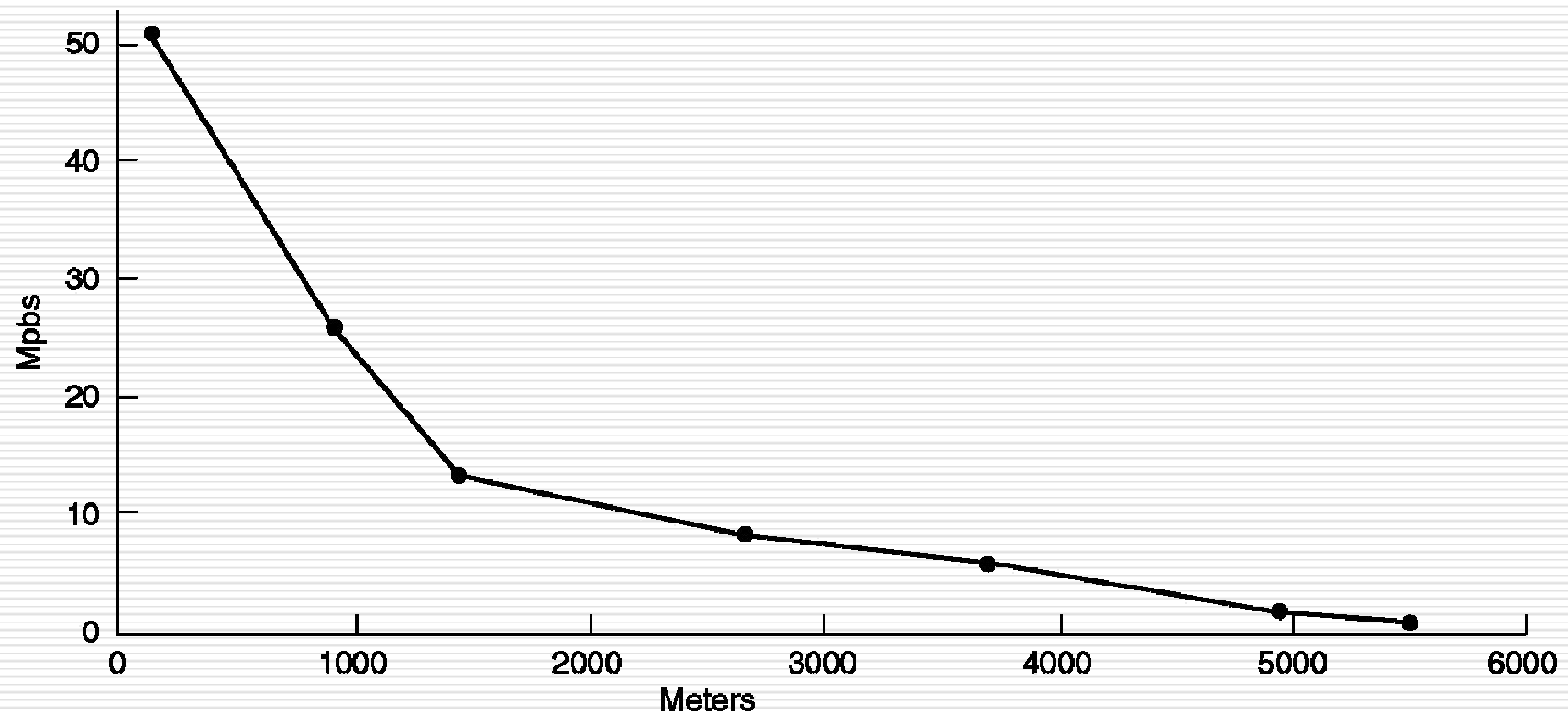
(c) Frequency modulation

(d) Phase modulation



Digital Subscriber Lines - ADSL

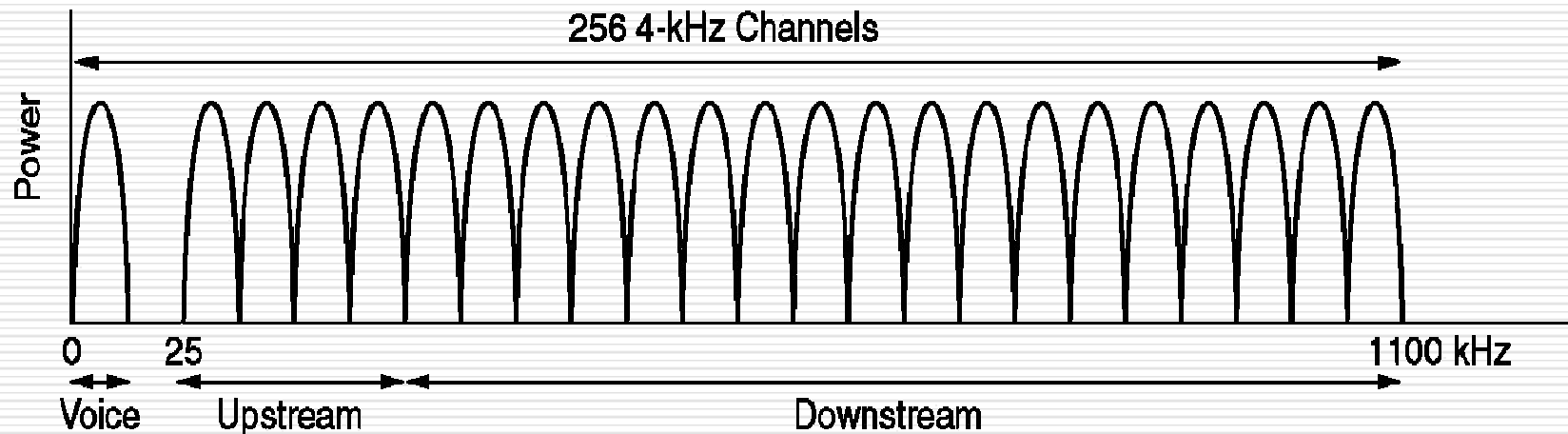
Bandwidth versus distanced over category 3 UTP for DSL.





Digital Subscriber Lines – ADSL (2)

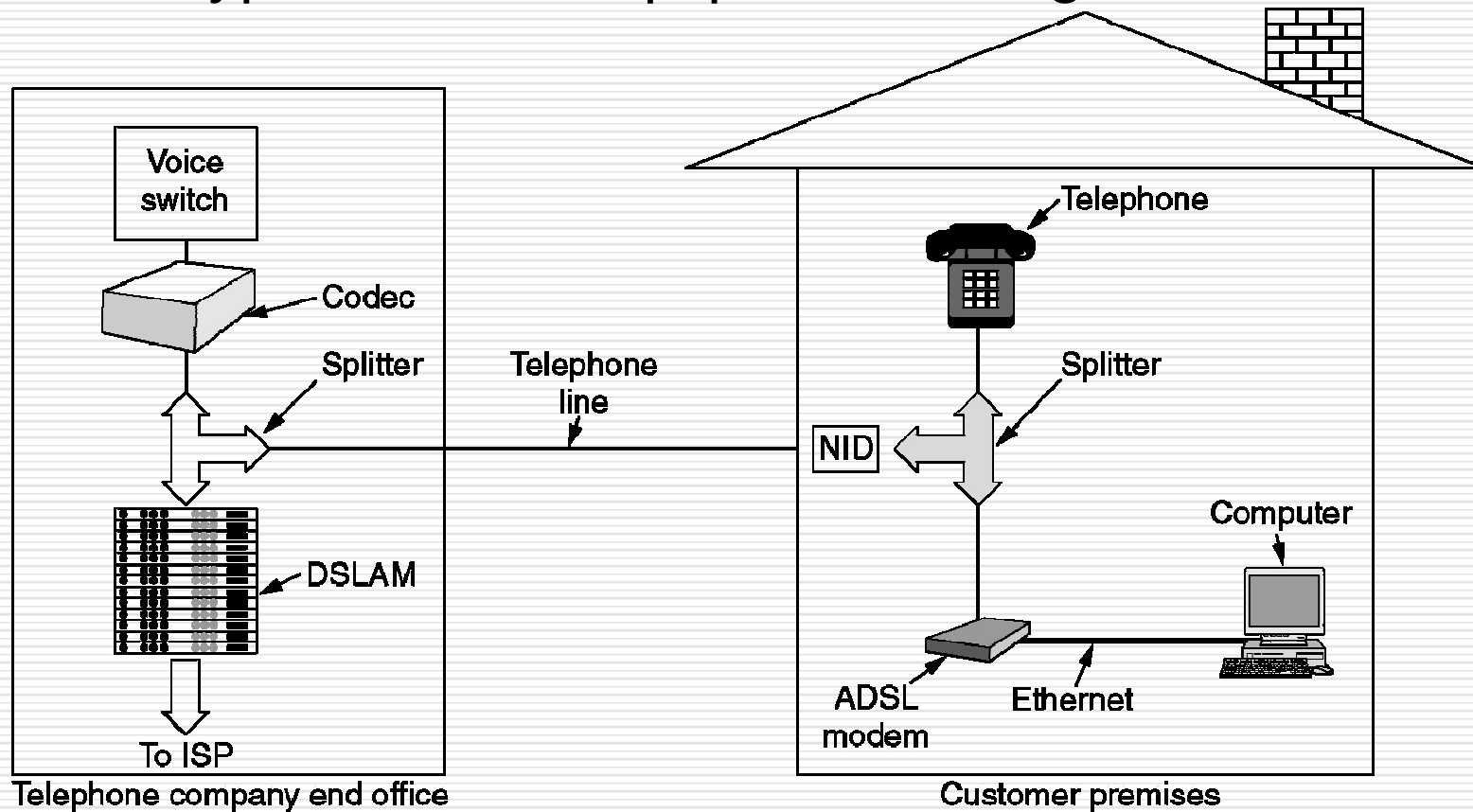
Operation of ADSL using discrete multitone modulation.





Digital Subscriber Lines (3)

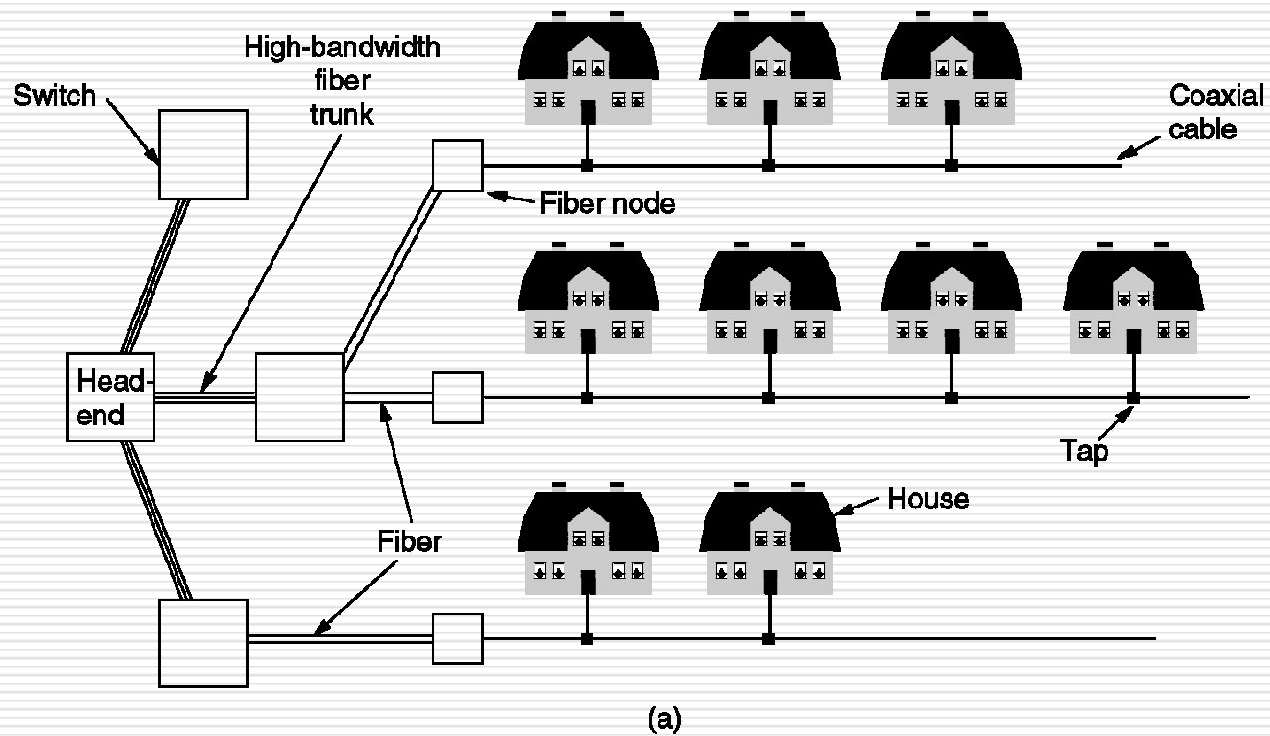
A typical ADSL equipment configuration.





Internet over Cable

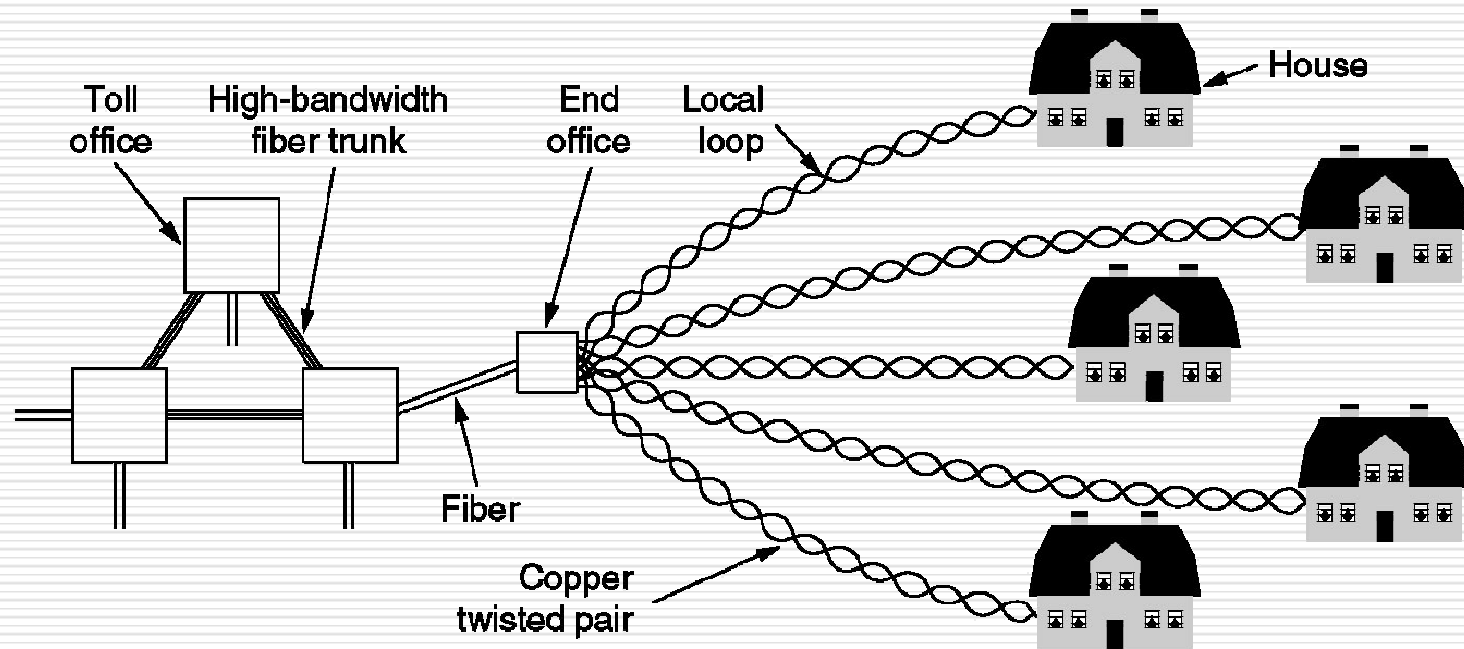
Cable television





Internet over Cable (2)

The fixed telephone system.



(b)



Spectrum Allocation

Frequency allocation in a typical cable TV system used for Internet access

