COMPUTER NETWORKS- (20MCA23C)
UNIT-II
'THE PHYSICAL LAYER'

FACULTY:

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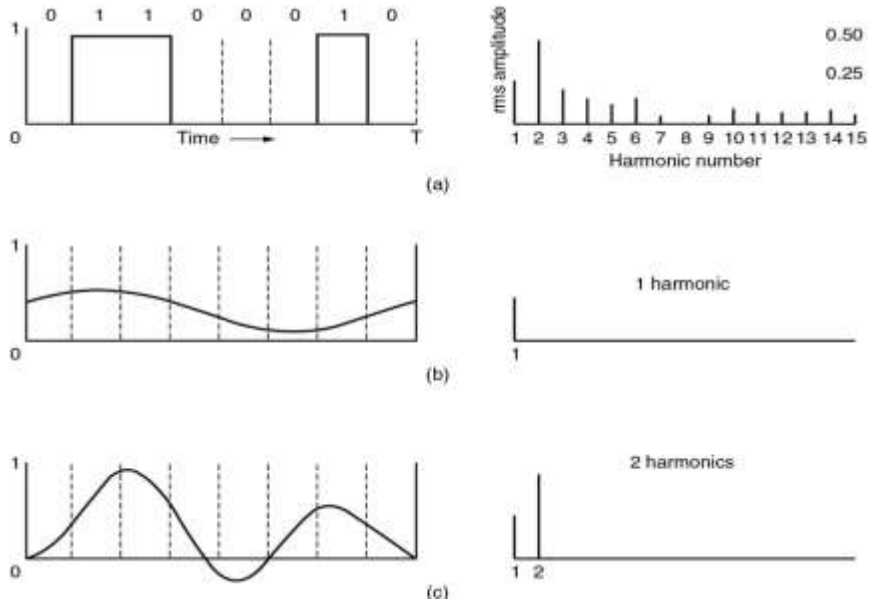
THE THEORETICAL BASIS FOR DATA COMMUNICATION

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

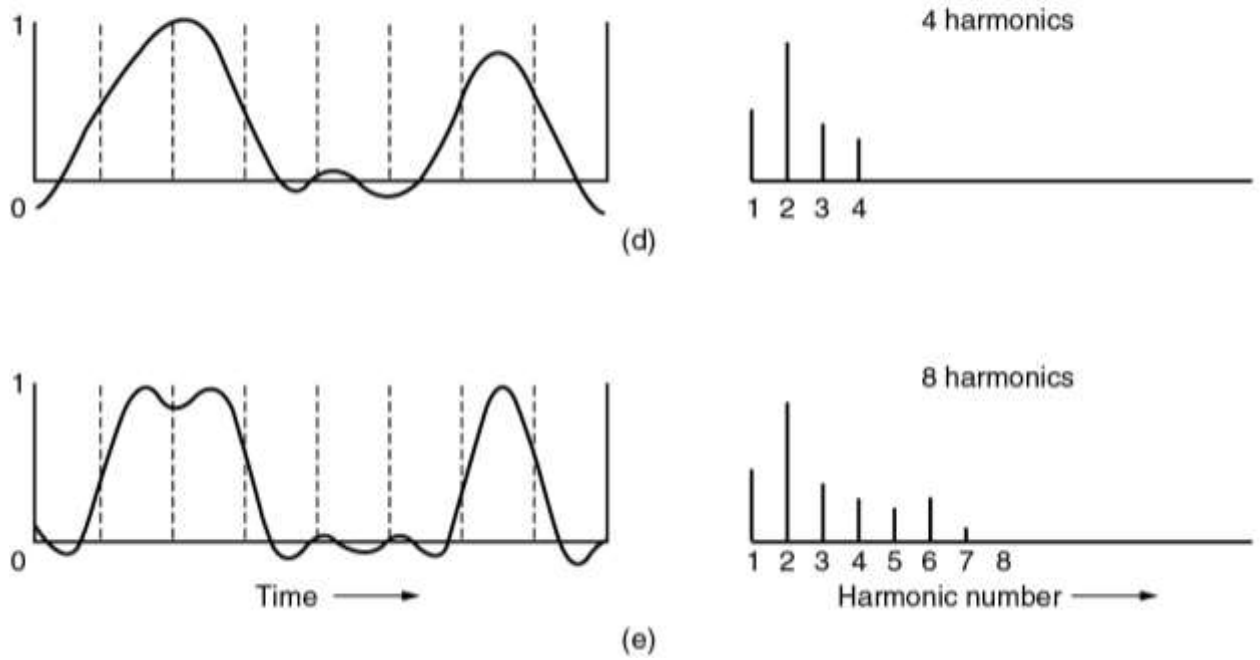
BANDWIDTH-LIMITED SIGNALS

- A binary signal and its root-mean-square Fourier amplitudes.
- (b) – (c) Successive approximations to the original signal.



BANDWIDTH-LIMITED SIGNALS (2)

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



BANDWIDTH-LIMITED SIGNALS (3)

- Relation between data rate and harmonics.

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 MEDIA

- Magnetic Media
- Twisted Pair
- Coaxial Cable
- Fiber Optics

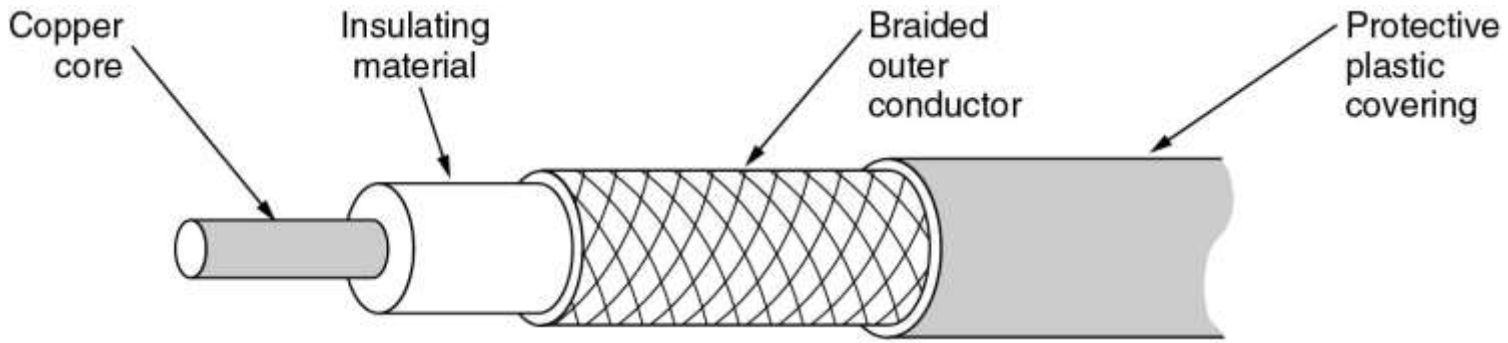
TWISTED PAIR

- (a) Category 3 UTP.

(a) (b)

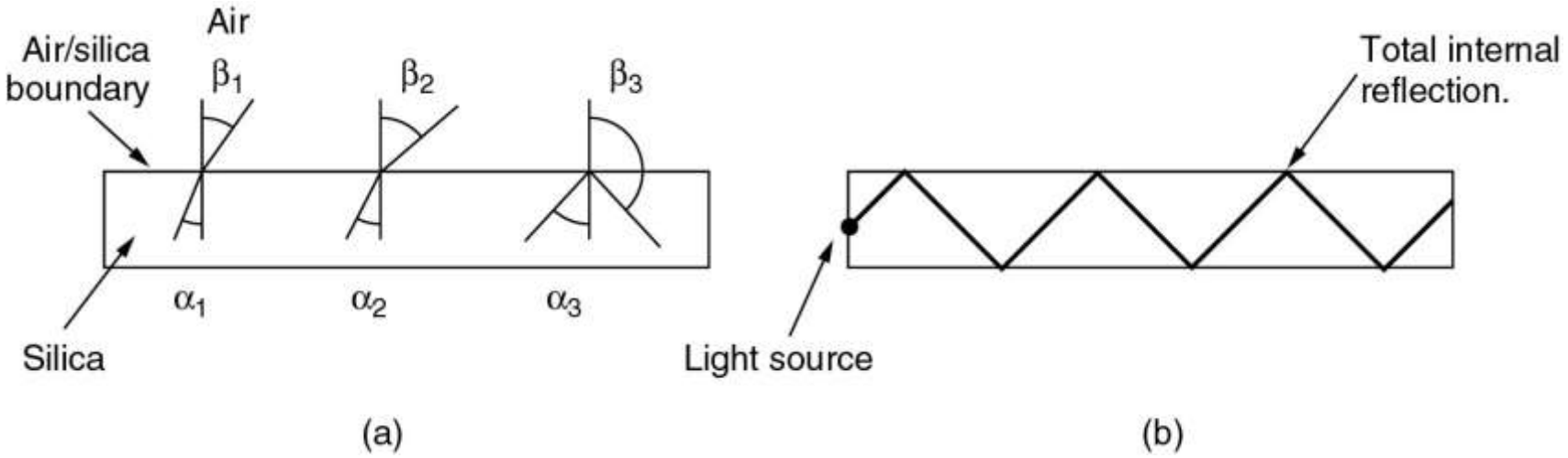
COAXIAL CABLE

- A coaxial cable.



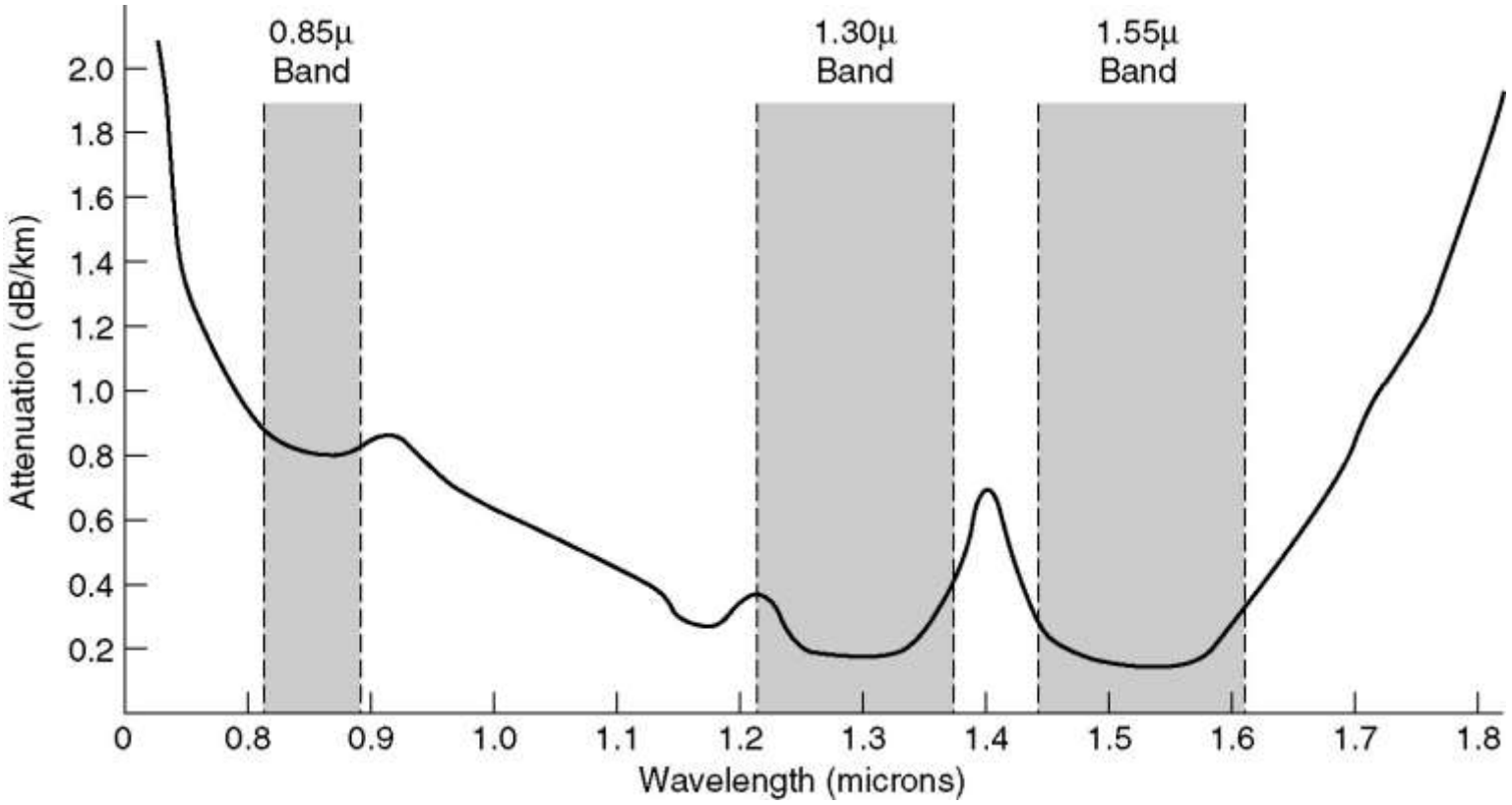
FIBER OPTICS

- (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.

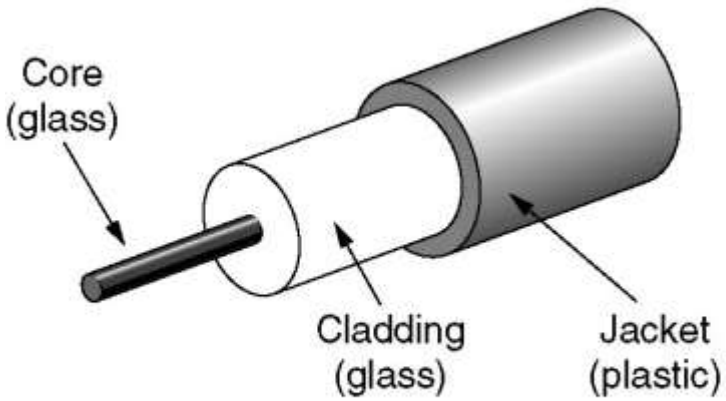


TRANSMISSION OF LIGHT THROUGH FIBER

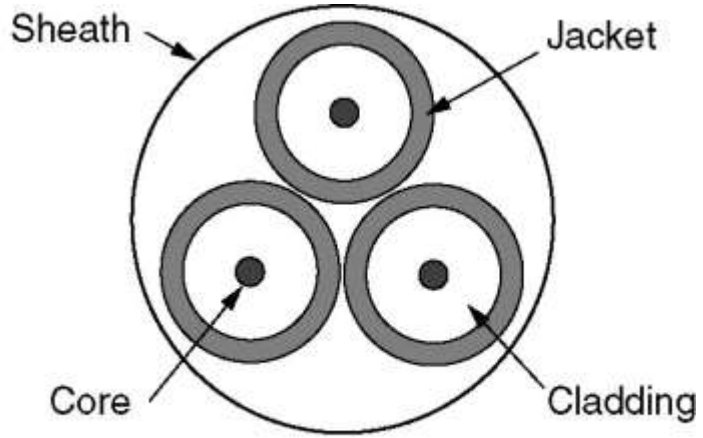
- Attenuation of light through fiber in the infrared region.



FIBER CABLES



(a)

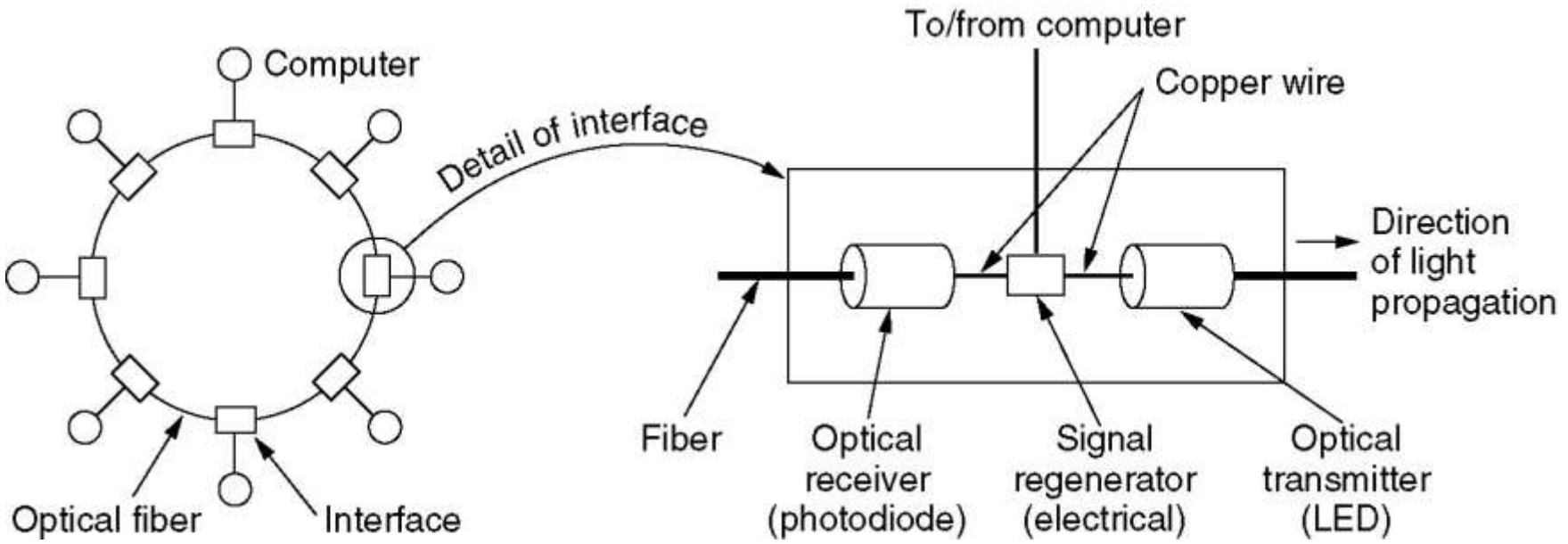


(b)

FIBER CABLES (2)

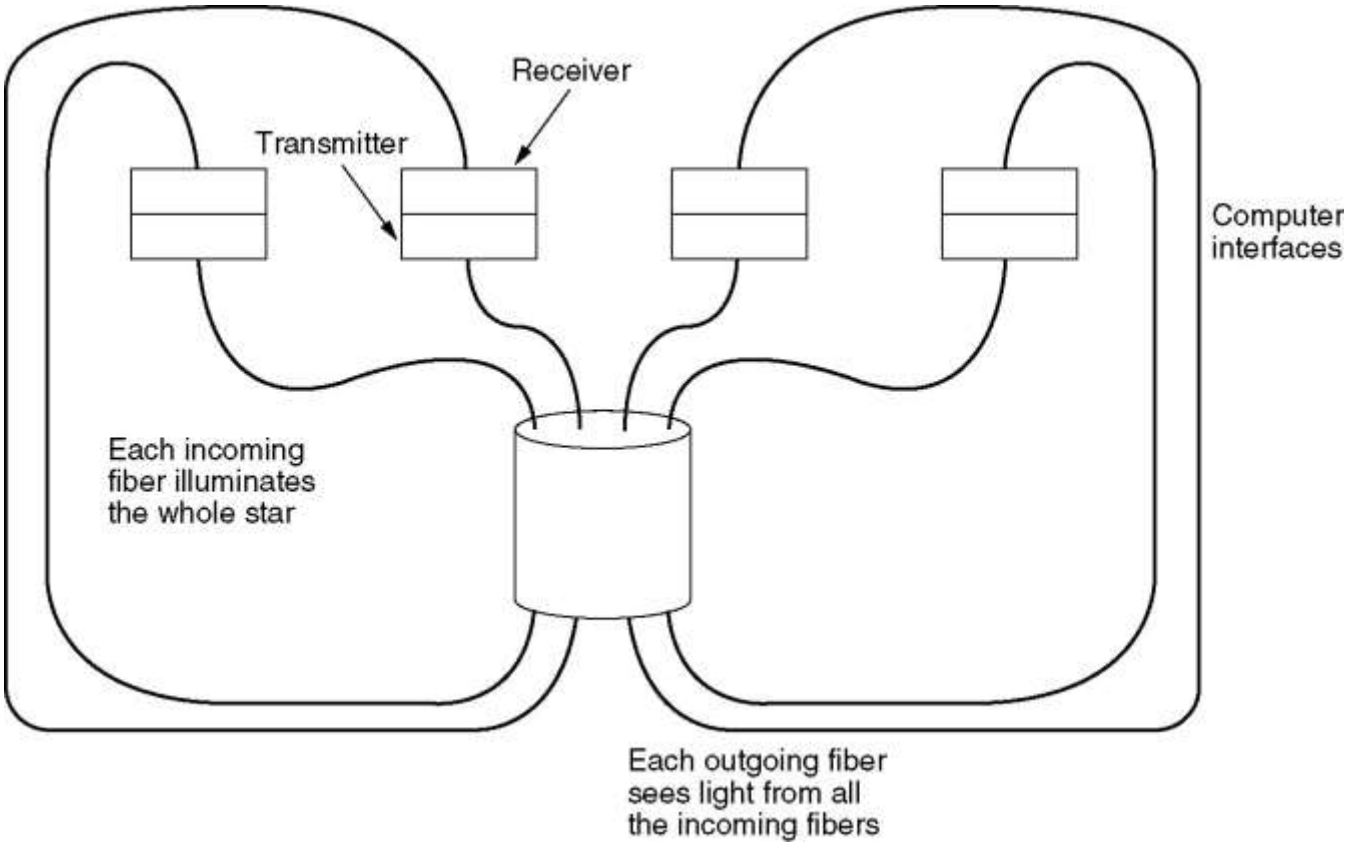
Item	LED	Semiconductor laser
Data rate	Low	High
Fiber type	Multimode	Multimode or single mode
Distance	Short	Long
Lifetime	Long life	Short life
Temperature sensitivity	Minor	Substantial
Cost	Low cost	Expensive

FIBER OPTIC NETWORKS



FIBER OPTIC NETWORKS (2)

- A passive star connection in a fiber optics network.

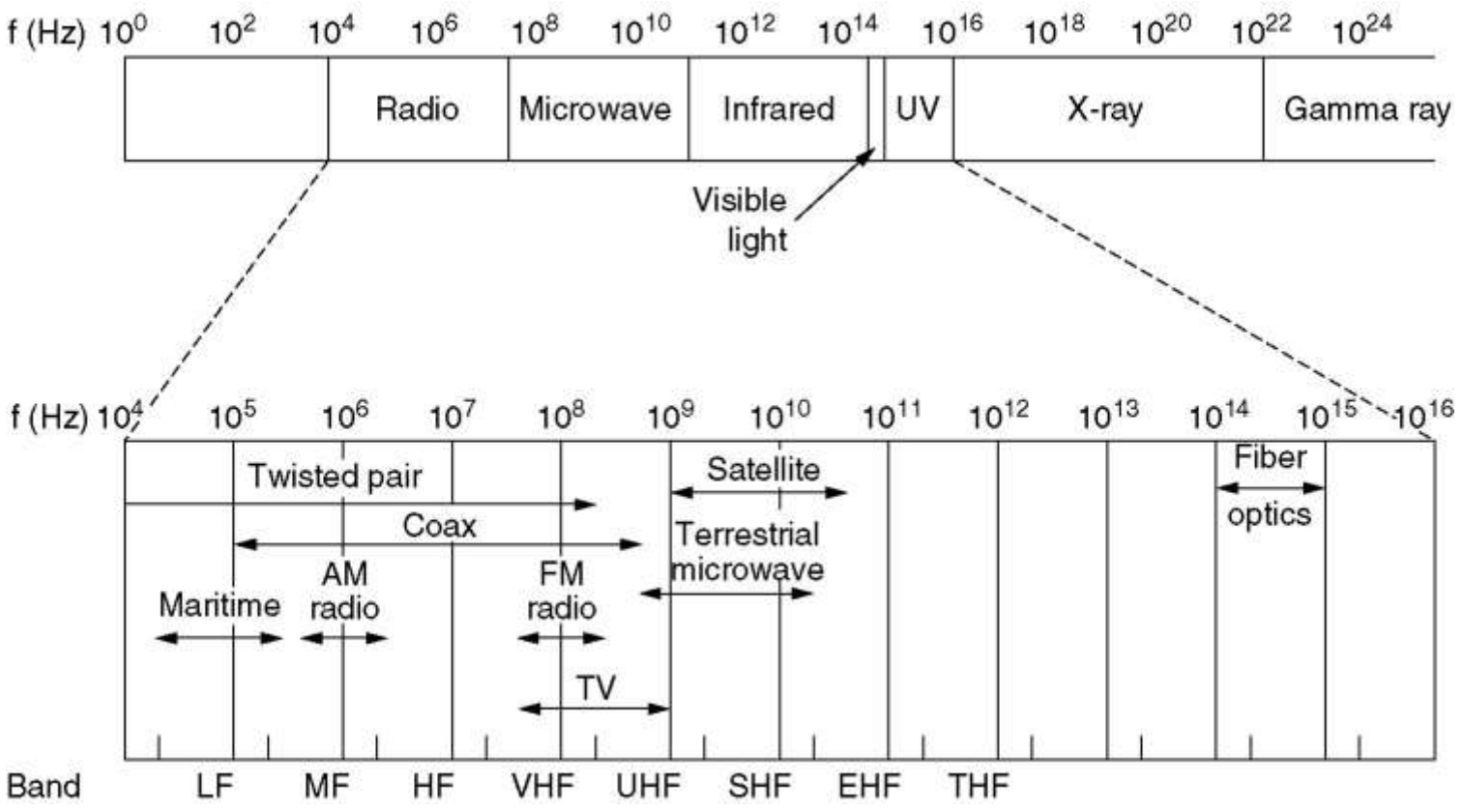


WIRELESS TRANSMISSION

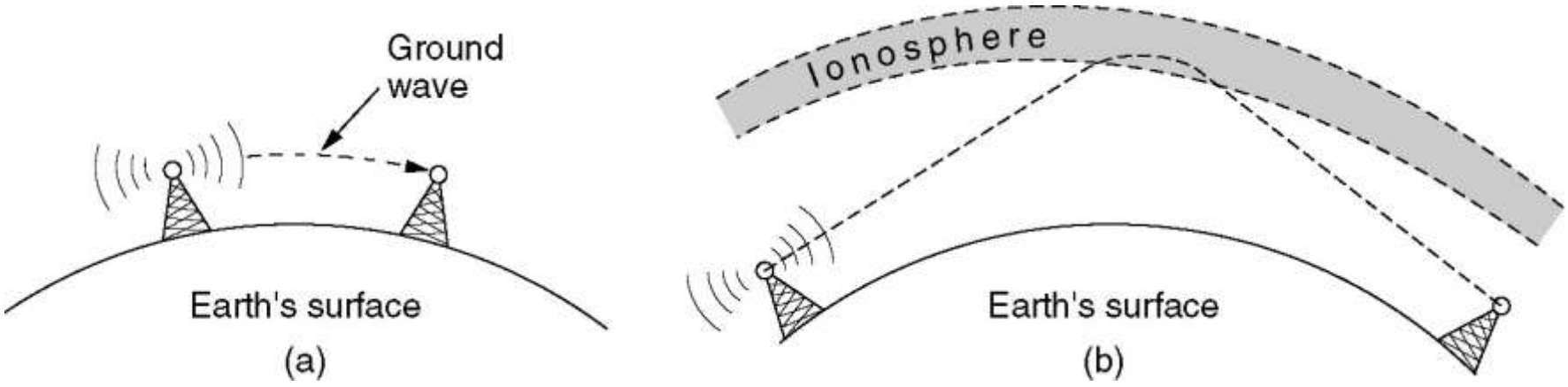
- The Electromagnetic Spectrum
- Radio Transmission
- Microwave Transmission
- Infrared and Millimeter Waves
- Lightwave Transmission

THE ELECTROMAGNETIC SPECTRUM

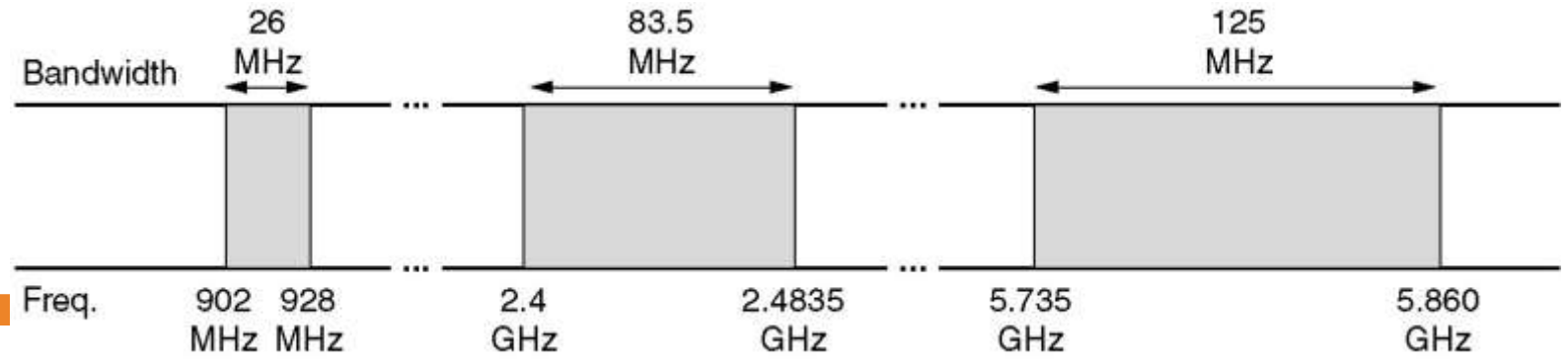
- The electromagnetic spectrum and its uses for communication.



RADIO TRANSMISSION

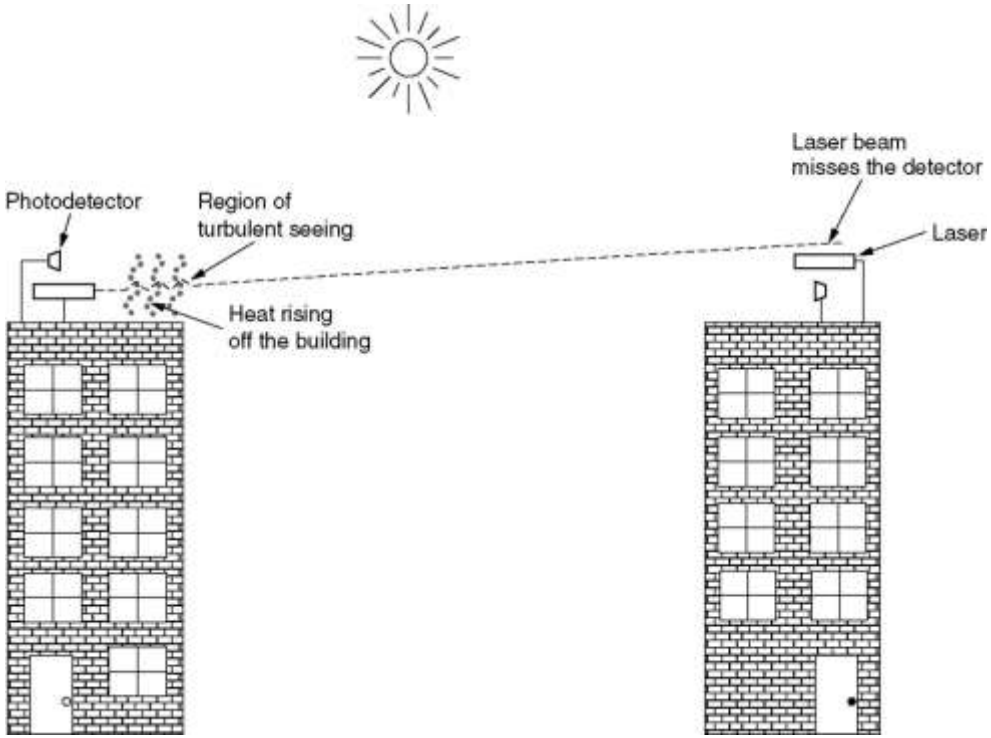


POLITICS OF THE ELECTROMAGNETIC SPECTRUM



LIGHTWAVE TRANSMISSION

- Convection currents can interfere with laser communication systems.
- A bidirectional system with two lasers is pictured here.

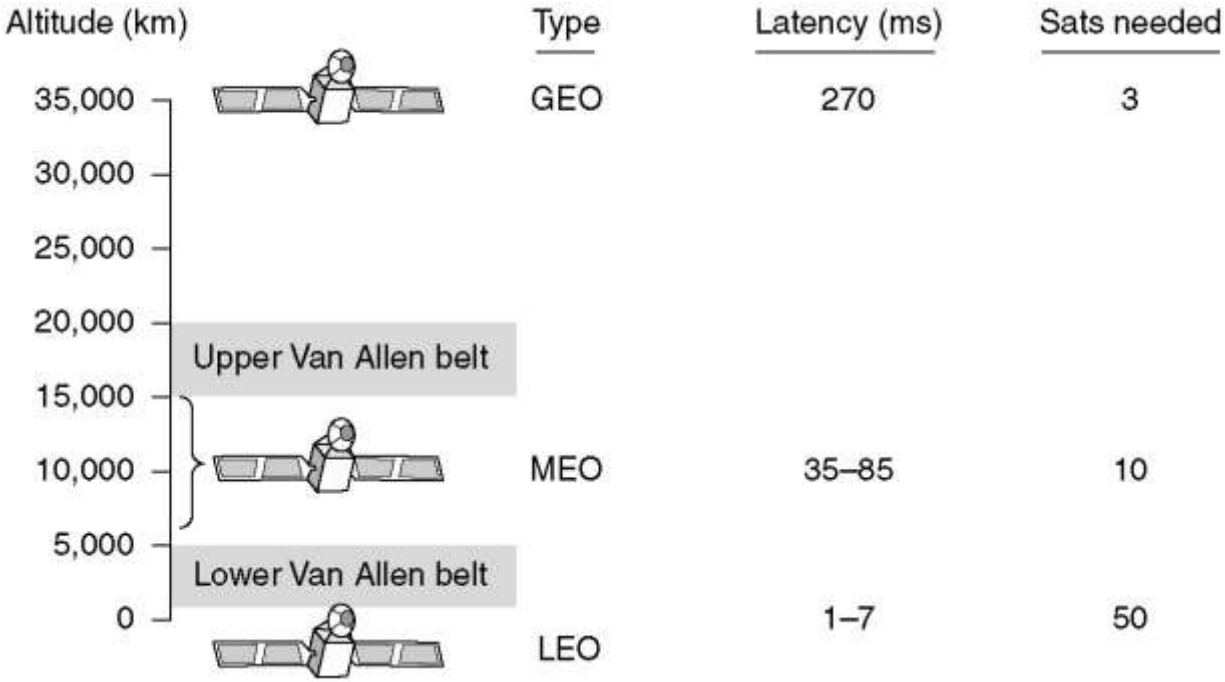


COMMUNICATION SATELLITES

- 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.

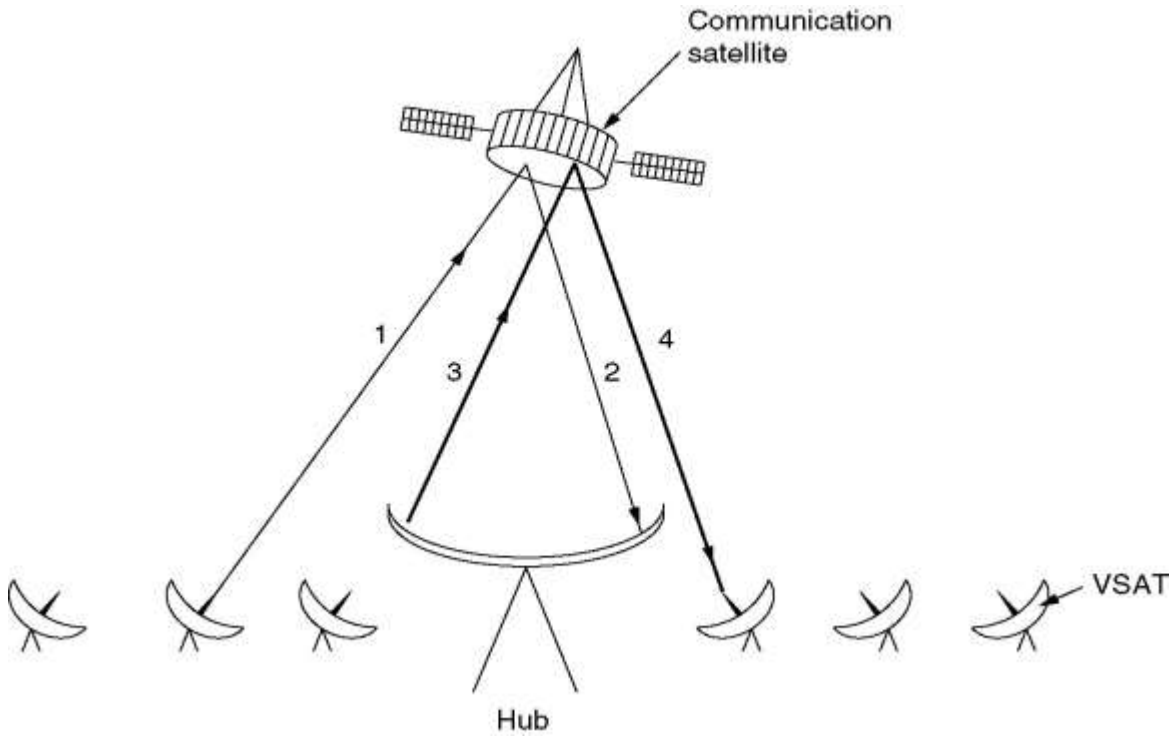


COMMUNICATION SATELLITES (2)

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

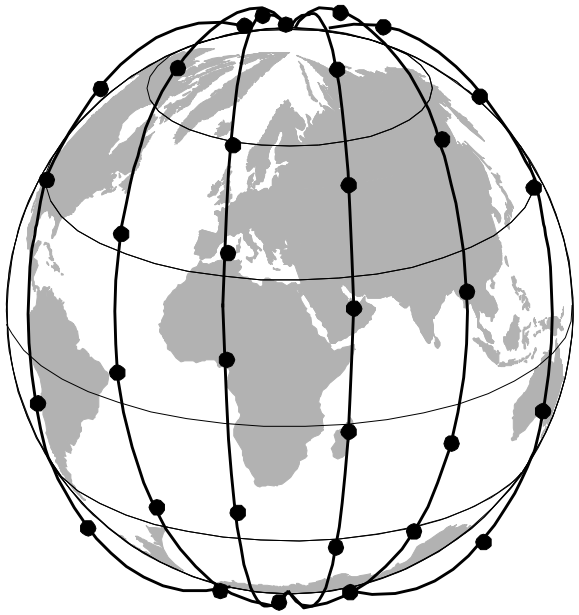
COMMUNICATION SATELLITES (3)

- VSATs using a hub.

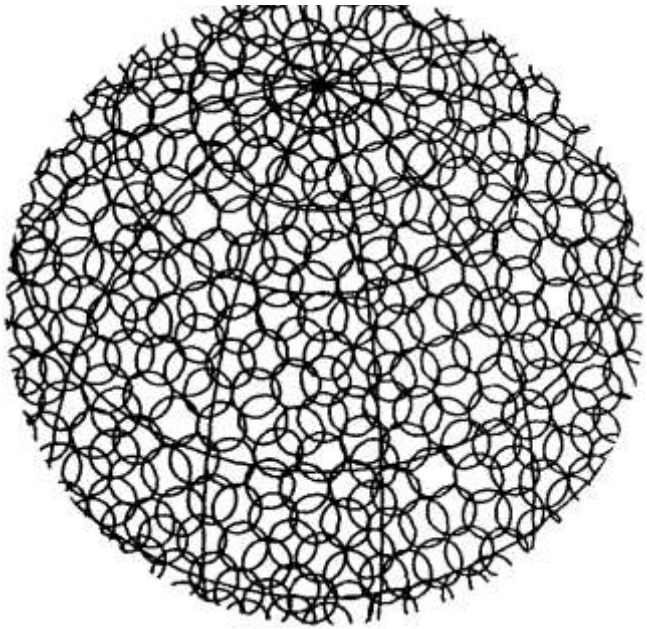


LOW-EARTH ORBIT SATELLITES IRIDIUM

- (a) The Iridium satellites from six necklaces around the earth.
- (b) 1628 moving cells cover the earth.

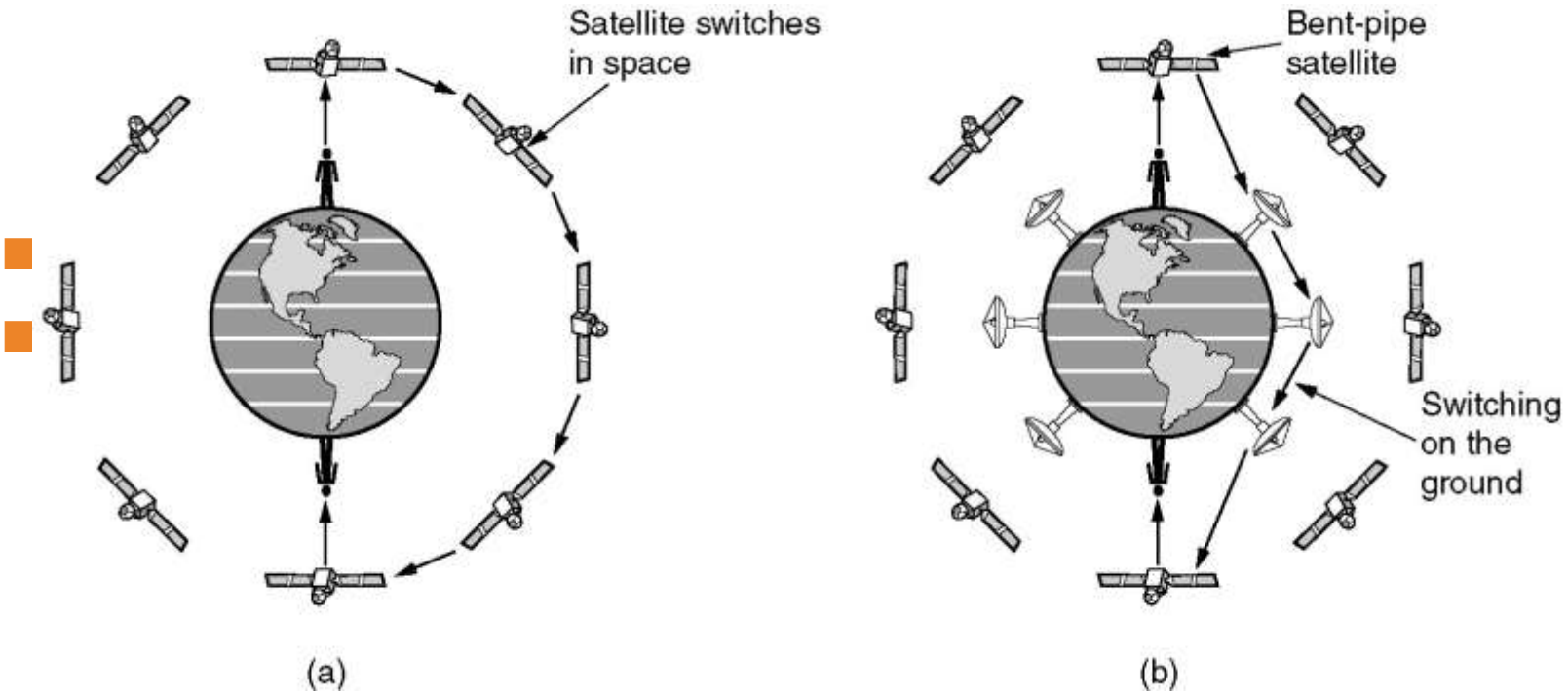


(a)



(b)

GLOBALSTAR


Satellite switches
in space
(a)
Bent-pipe
satellite
Switching
on the
ground
(b)

PUBLIC SWITCHED TELEPHONE NETWORK

- The public switched telephone network (PSTN) refers to the **international telephone system that uses copper wires to carry analog voice data**. It consists of a collection of individual telephones that are hardwired to a public exchange.

PROPERTIES OF PSTN

- It is also known as Plain Old Telephone Service (POTS)
- It has evolved from the invention of telephone by Alexander Graham Bell.
- The individual networks can be owned by national government, regional government or private telephone operators.
- Its main objective is to transmit human voice in a recognizable form.
- It is an aggregation of circuit-switched networks of the world.
- Originally, it was an entirely analog network laid with copper cables and switches.

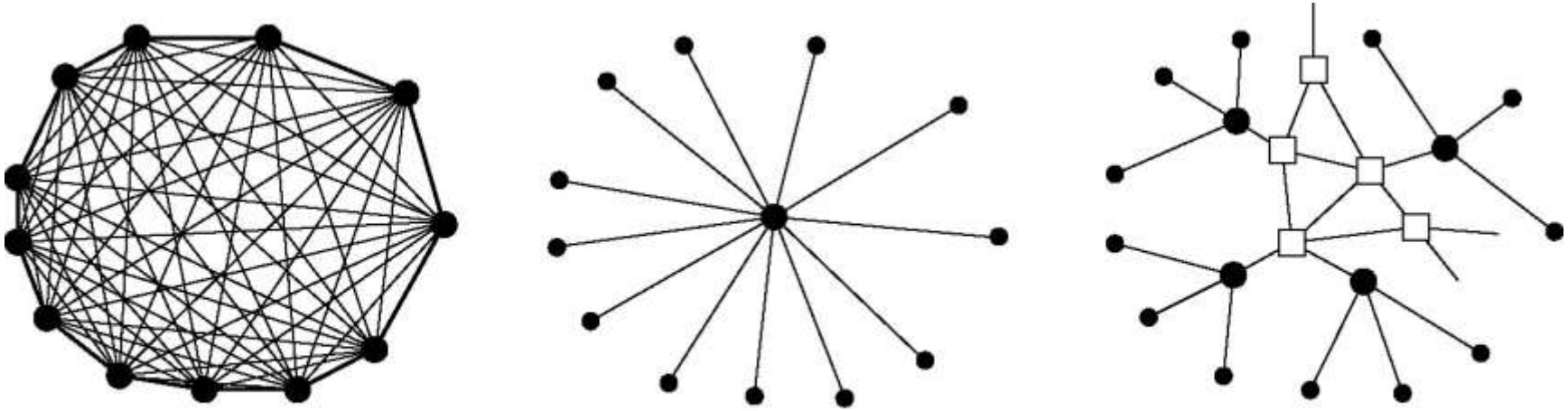
- Presently, most part of PSTN networks is digitized and comprises of a wide variety communicating devices.
- The present PSTNs comprises of copper telephone lines, fibre optic cables, communication satellites, microwave transmission links and undersea telephone lines. It is also linked to the cellular networks.
- The interconnection between the different parts of the telephone system is done by switching centres. This allows multiple telephone and cellular networks to communicate with each other.
- Present telephone systems are tightly coupled with WANs (wide area networks) and are used for both data and voice communications.
- The operation of PSTN networks follows the ITU-T standards.

PUBLIC SWITCHED TELEPHONE SYSTEM

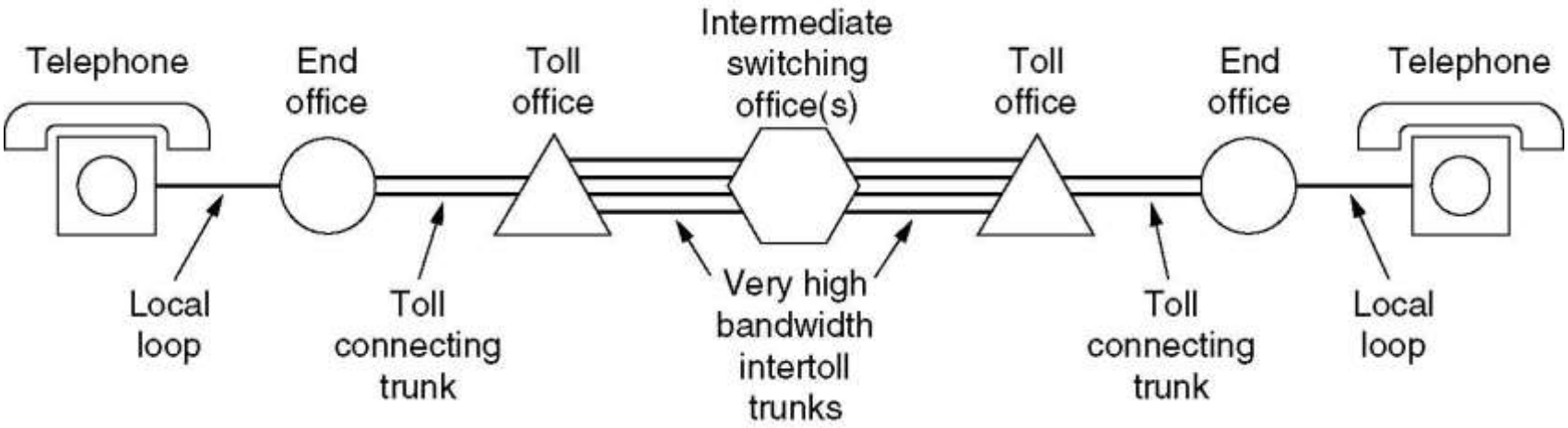
- Structure of the Telephone System
- The Politics of Telephones
- The Local Loop: Modems, ADSL and Wireless
- Trunks and Multiplexing
- Switching

STRUCTURE OF THE TELEPHONE SYSTEM

- (a) Fully-interconnected network.
- (b) Centralized switch.
- (c) Two-level hierarchy.



STRUCTURE OF THE TELEPHONE SYSTEM (2)

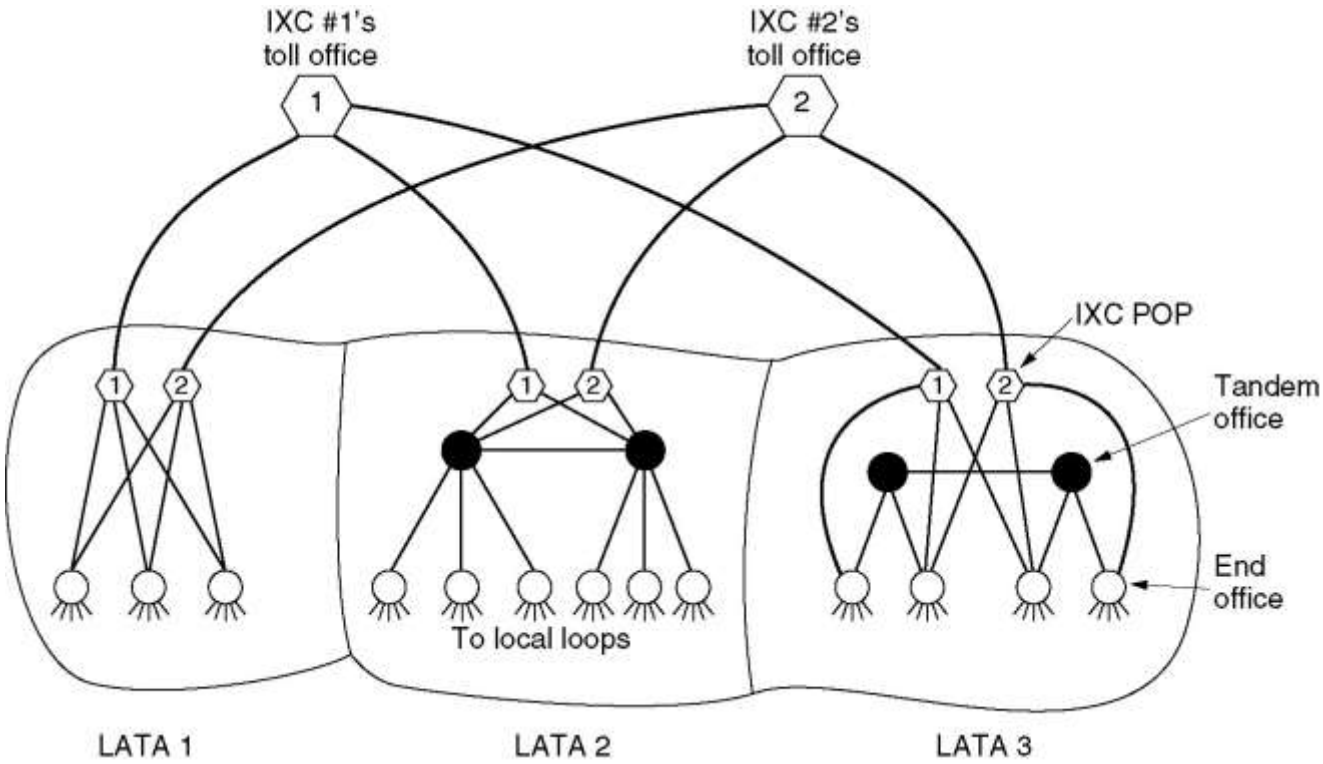


MAJOR COMPONENTS OF THE TELEPHONE SYSTEM

- 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

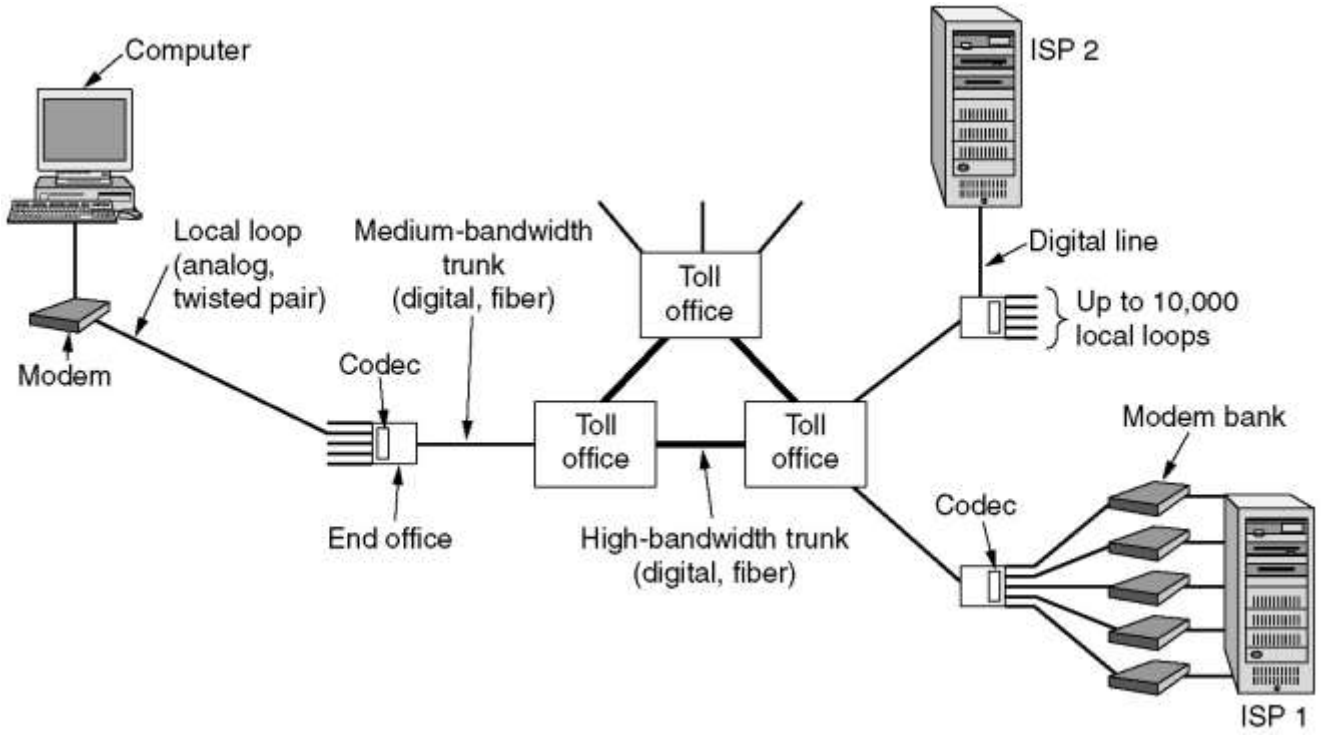
THE POLITICS OF TELEPHONES

- The relationship of LATAs, LECs, and IXCs. All the circles are LEC switching offices. Each hexagon belongs to the IXC whose number is on it.



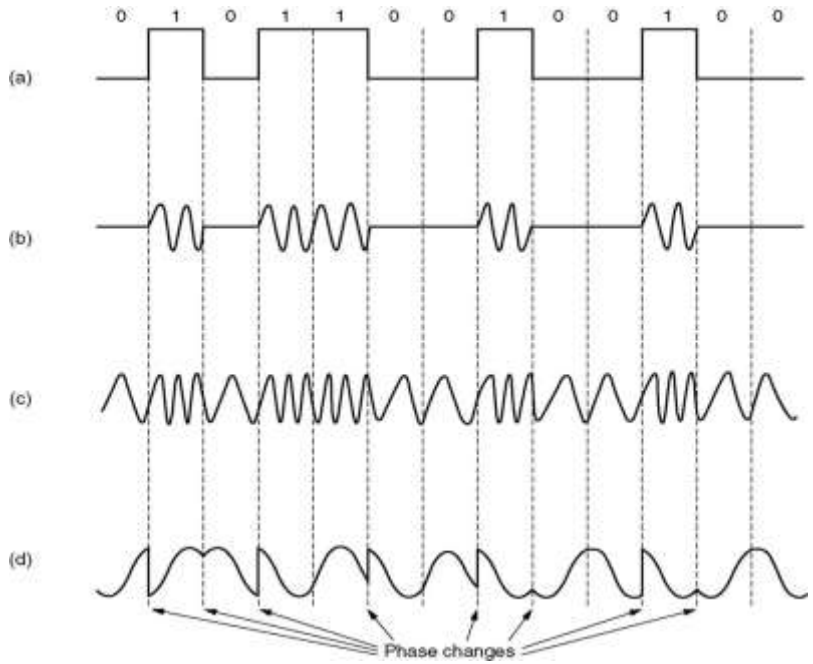
THE LOCAL LOOP: MODEMS, ADSL, AND WIRELESS

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



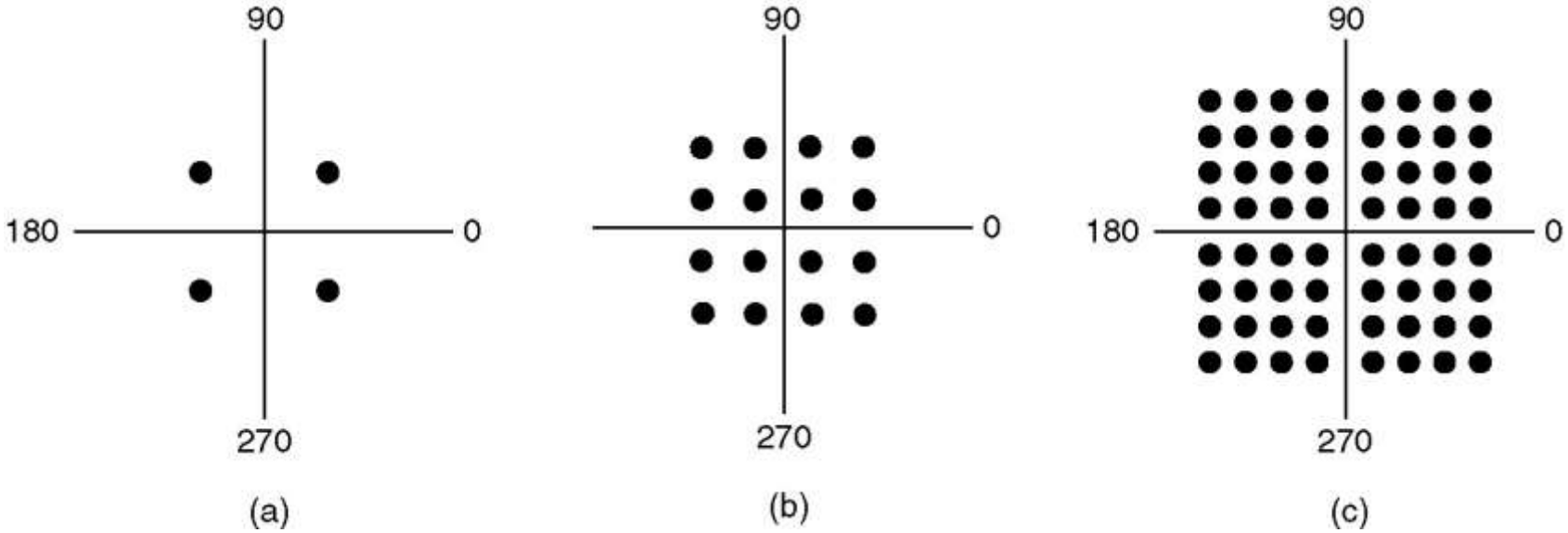
MODEMS

- (a) A binary signal
- (b) Amplitude modulation
- (c) Frequency modulation
- (d) Phase modulation



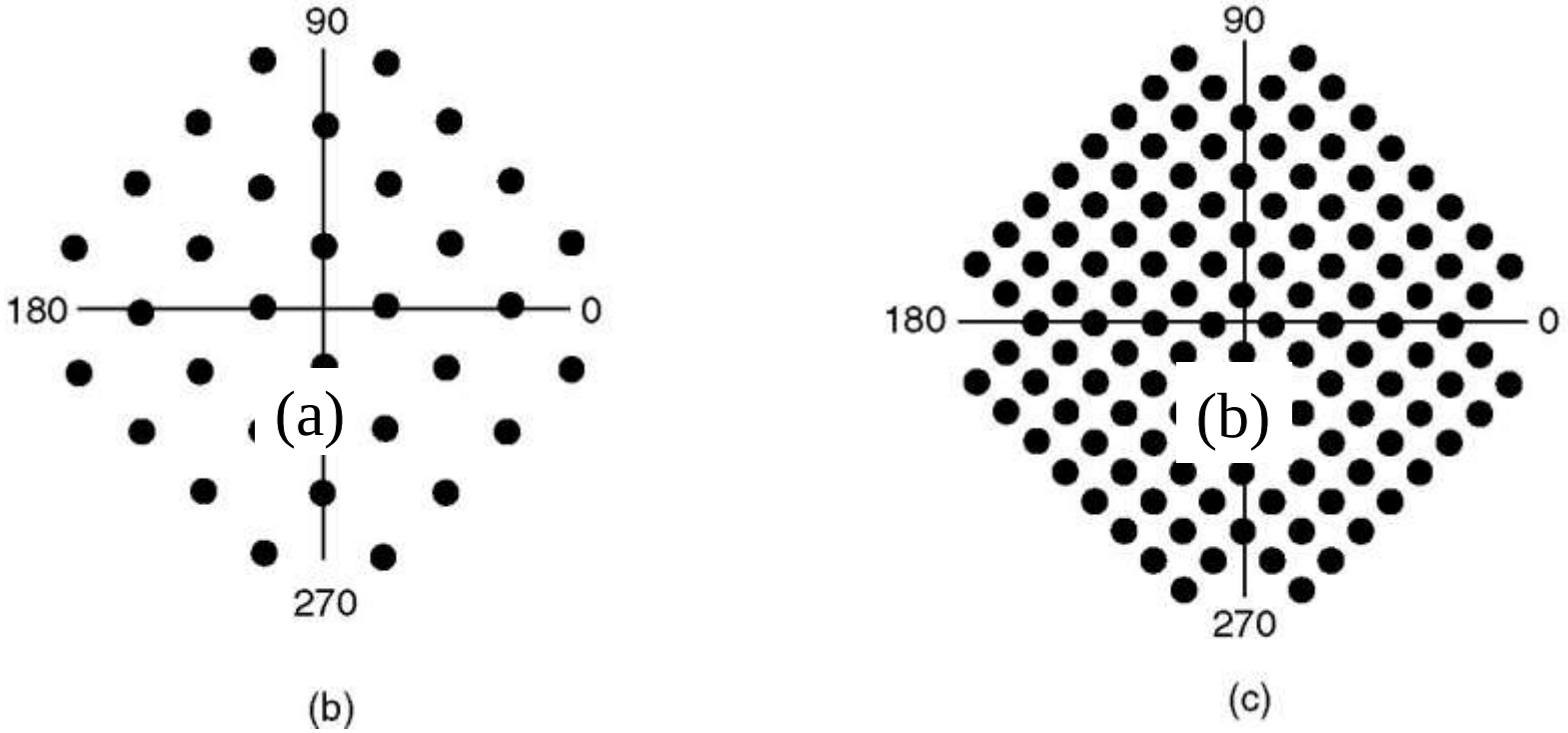
MODEMS (2)

- (a) QPSK.
- (b) QAM-16.
- (c) QAM-64.

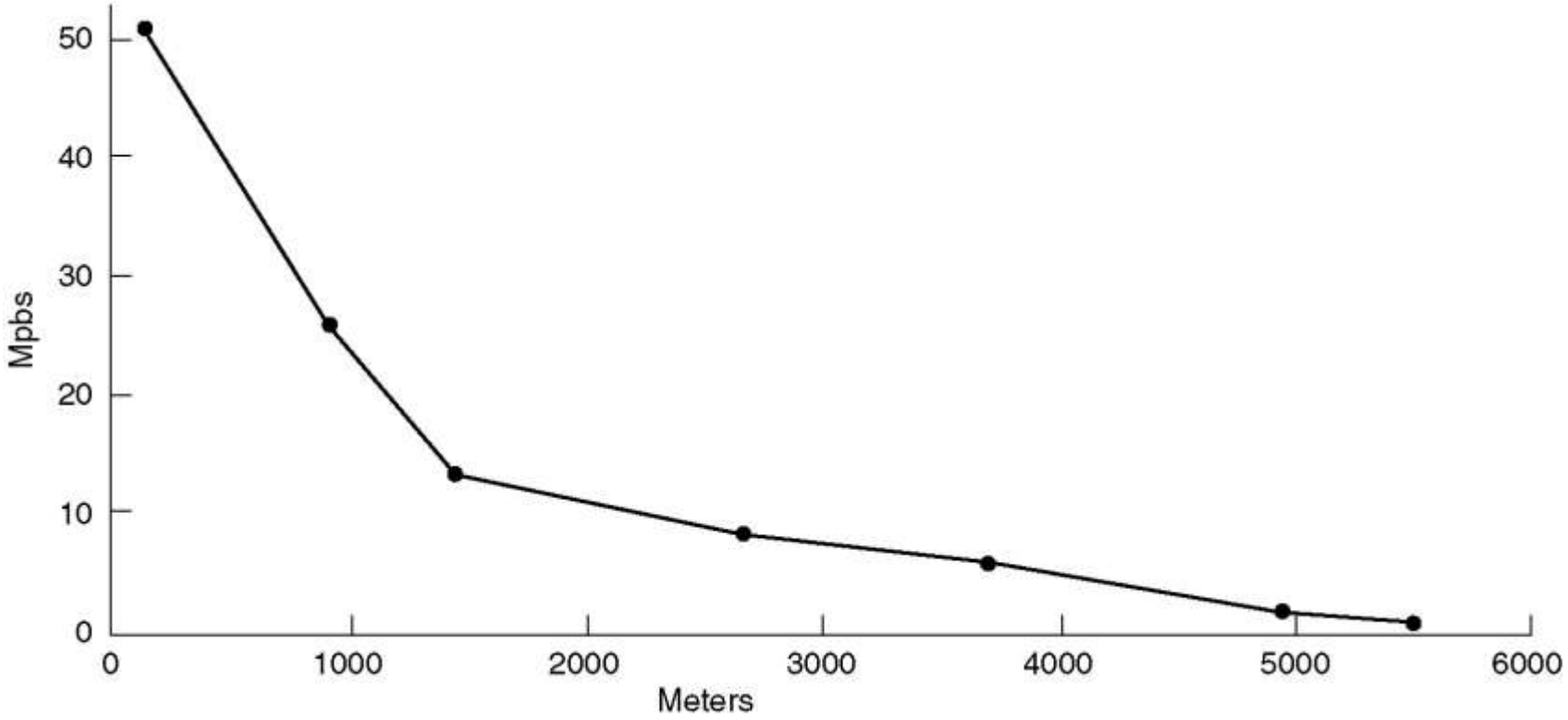


MODEMS (3)

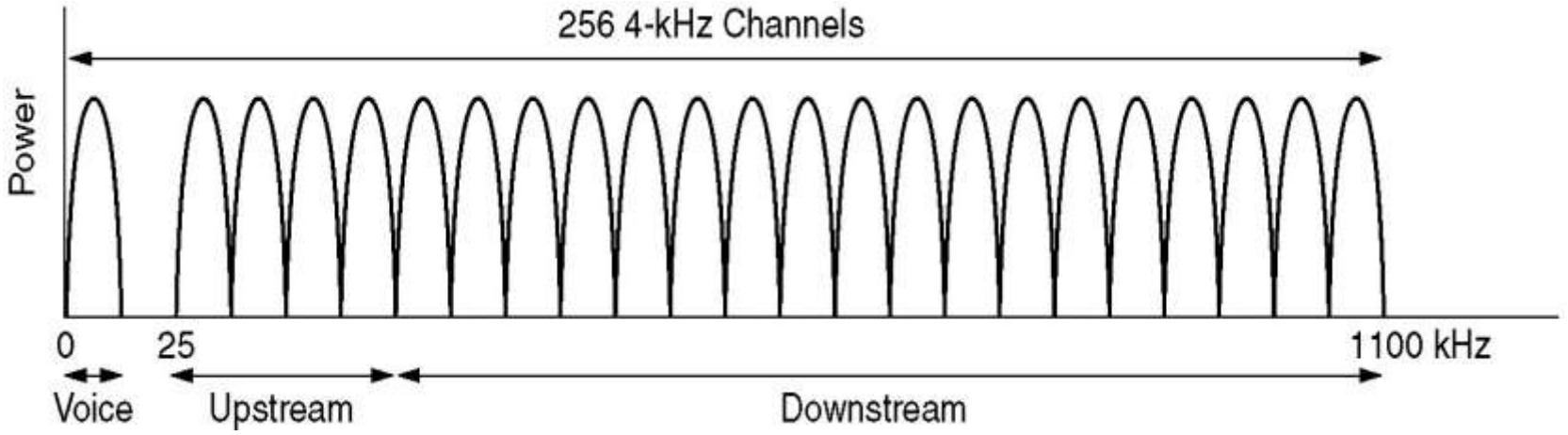
- (a) V.32 for 9600 bps.
- (b) V32 bis for 14,400 bps.



DIGITAL SUBSCRIBER LINES

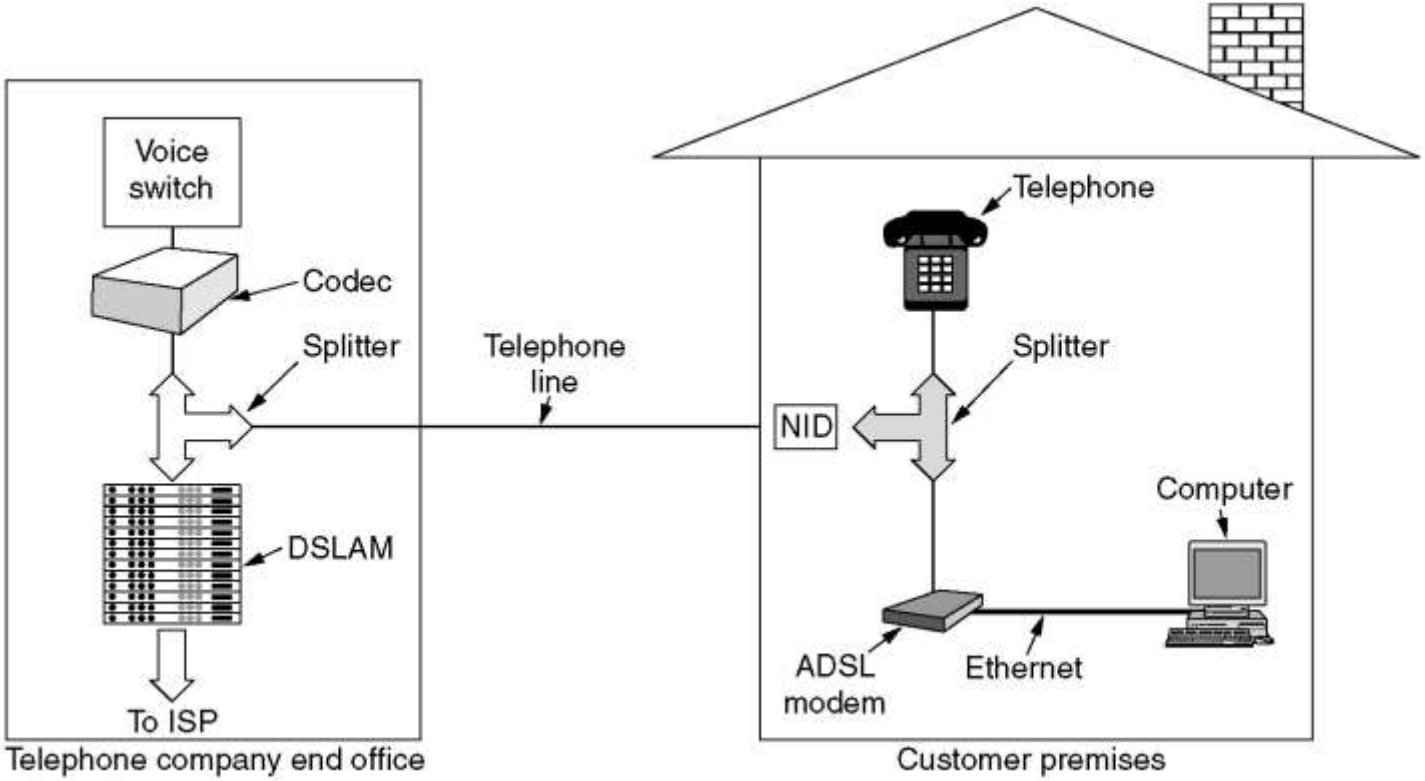


DIGITAL SUBSCRIBER LINES (2)



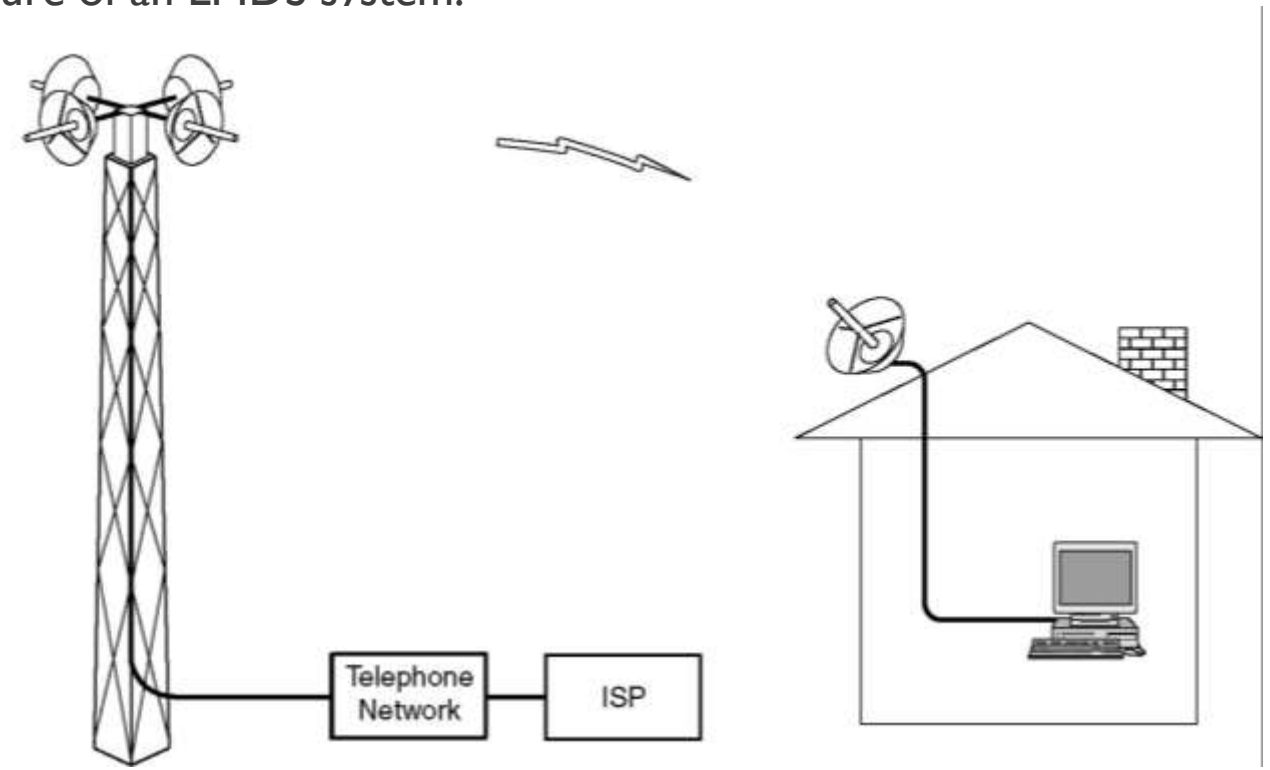
DIGITAL SUBSCRIBER LINES (3)

- A typical ADSL equipment configuration.



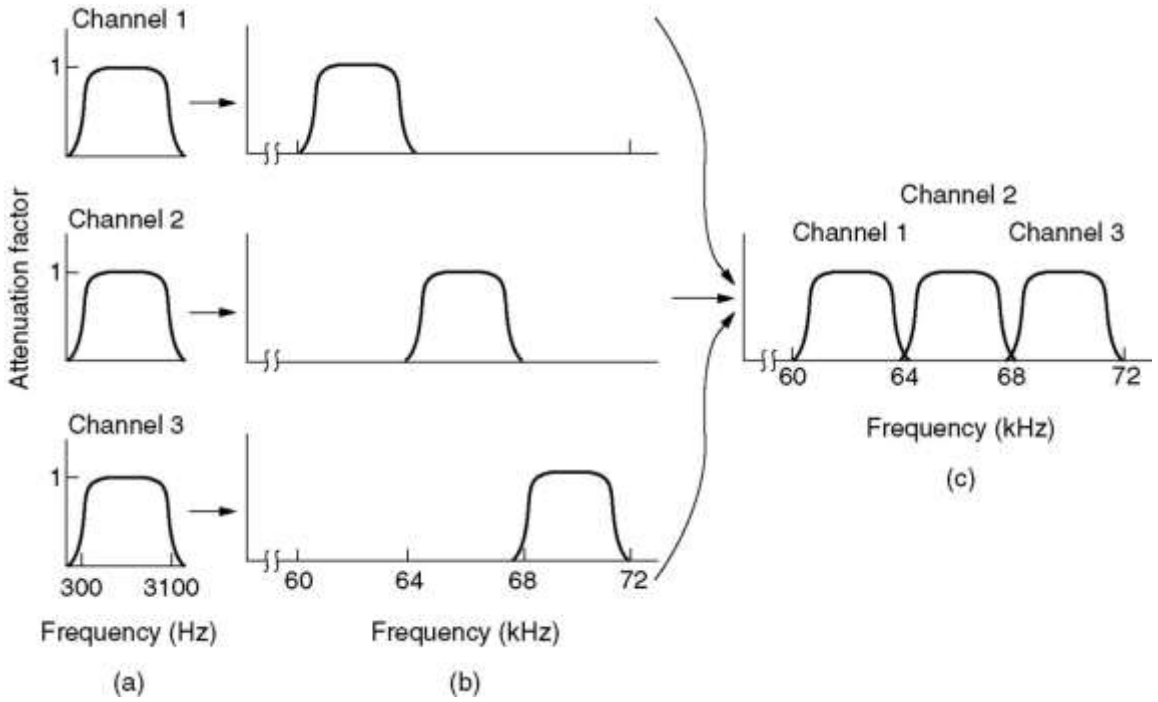
WIRELESS LOCAL LOOPS

- Architecture of an LMDS system.



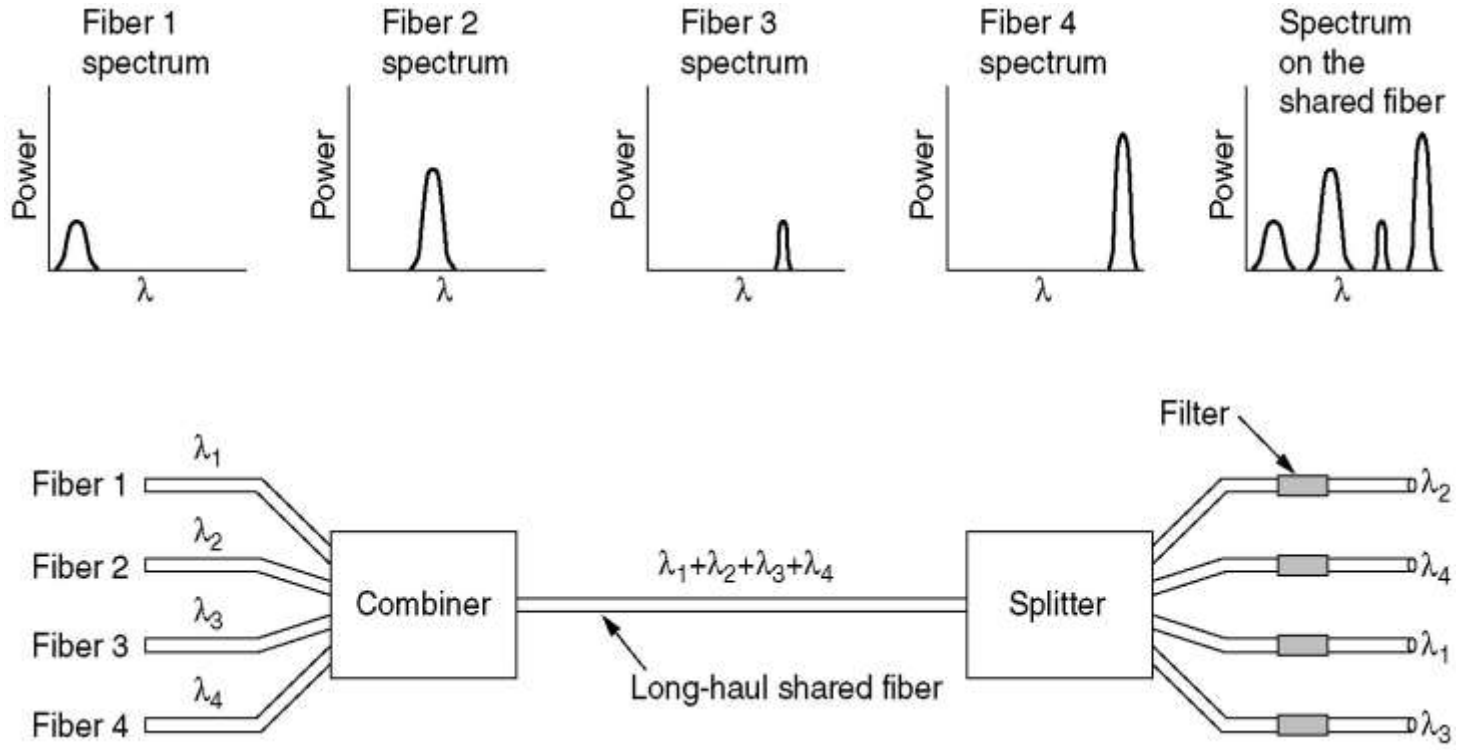
FREQUENCY DIVISION MULTIPLEXING

- (a) The original bandwidths.
- (b) The bandwidths raised in frequency.
- (b) The multiplexed channel.



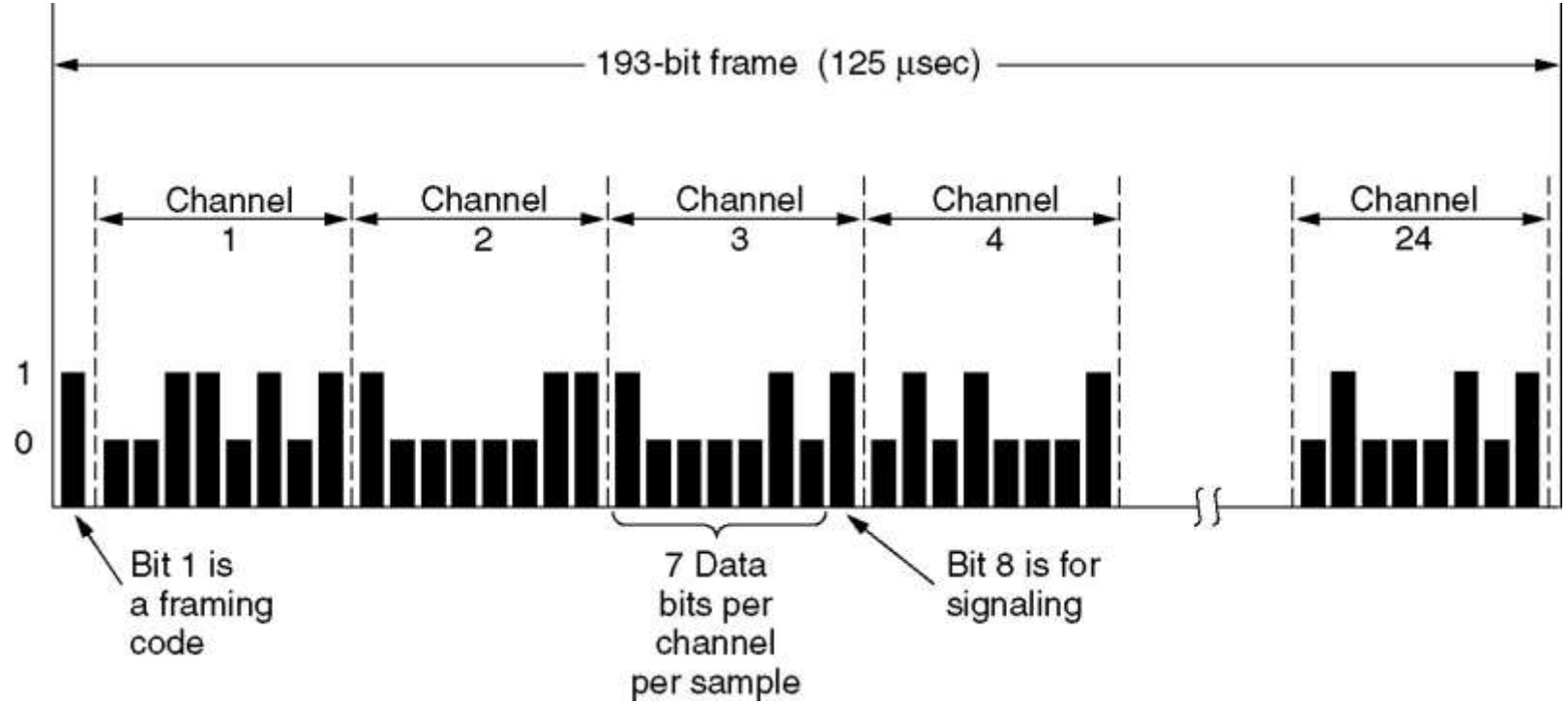
WAVELENGTH DIVISION MULTIPLEXING

- Wavelength division multiplexing.

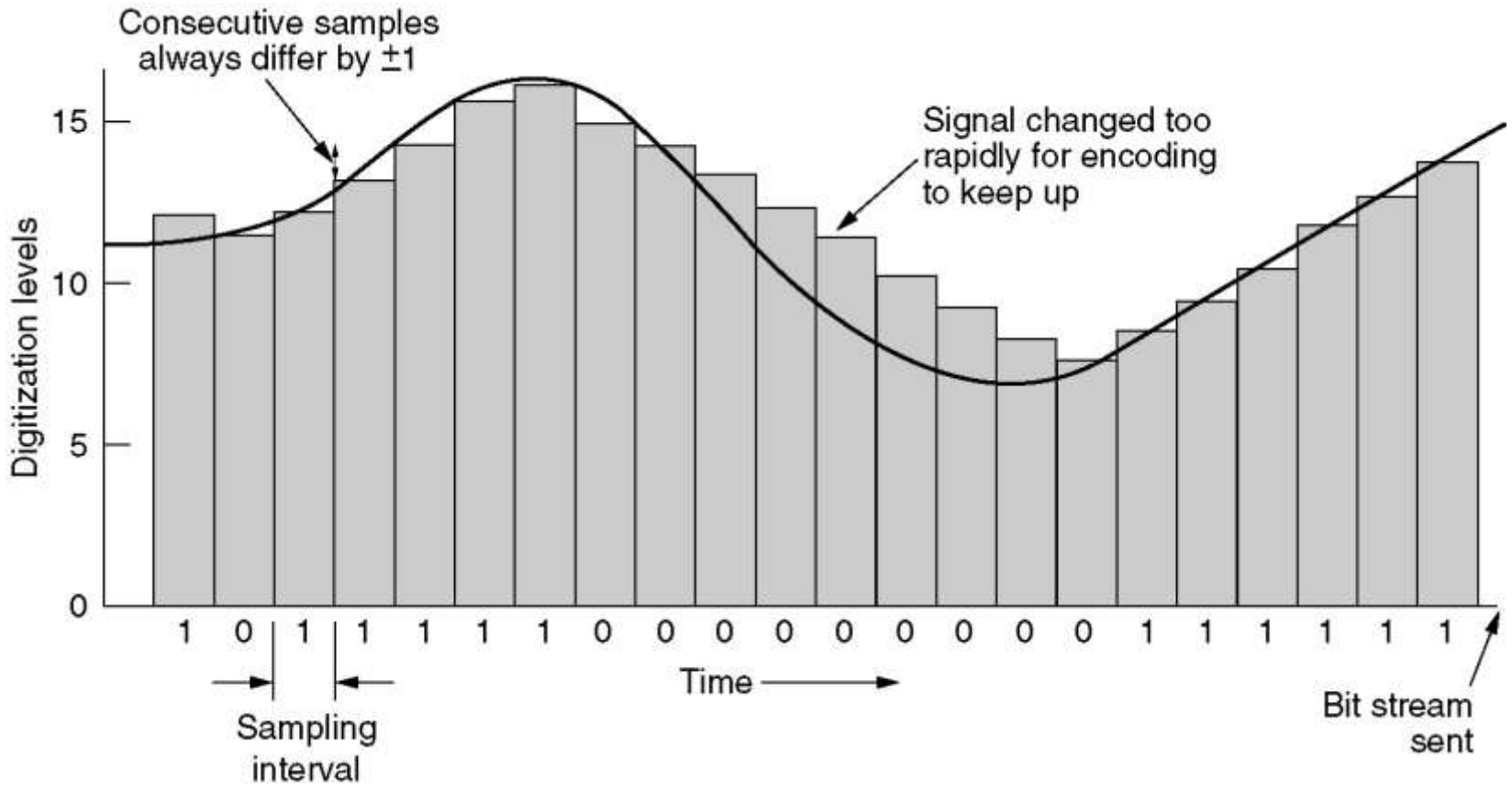


TIME DIVISION MULTIPLEXING

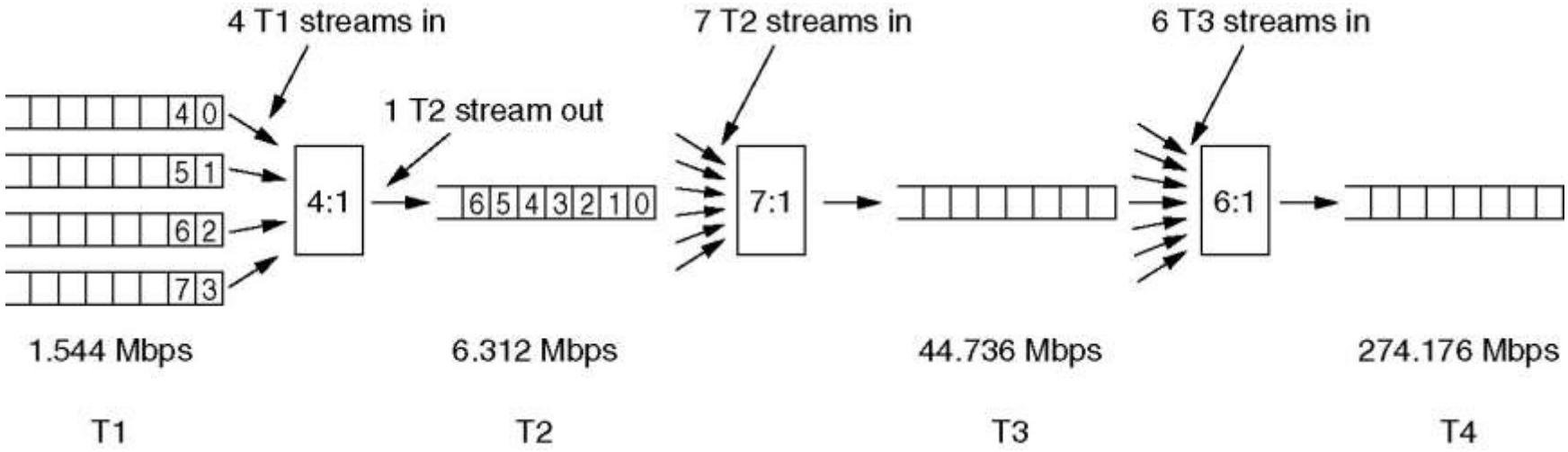
- The T1 carrier (1.544 Mbps).



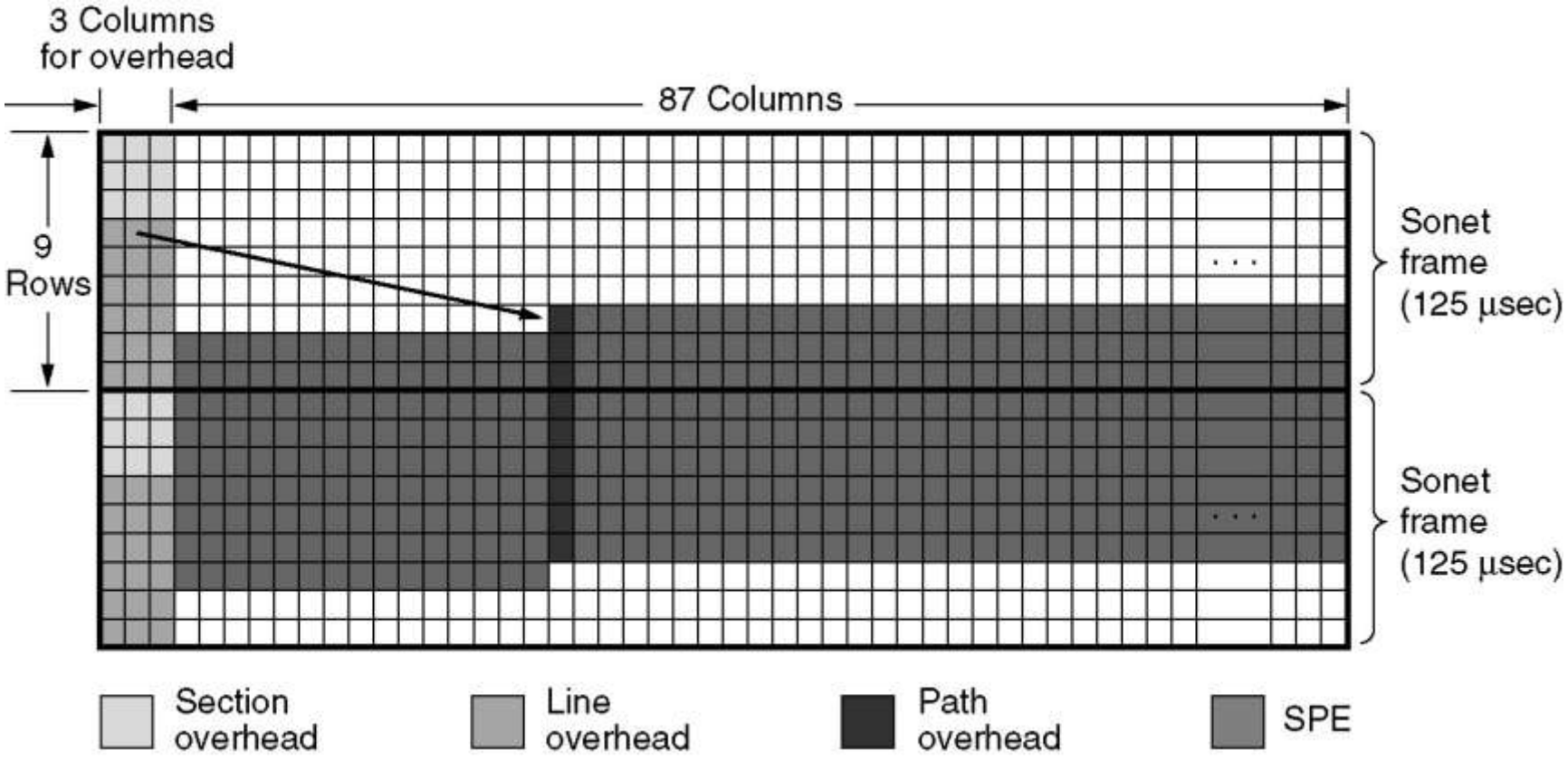
TIME DIVISION MULTIPLEXING (2)



TIME DIVISION MULTIPLEXING (3)



TIME DIVISION MULTIPLEXING (4)



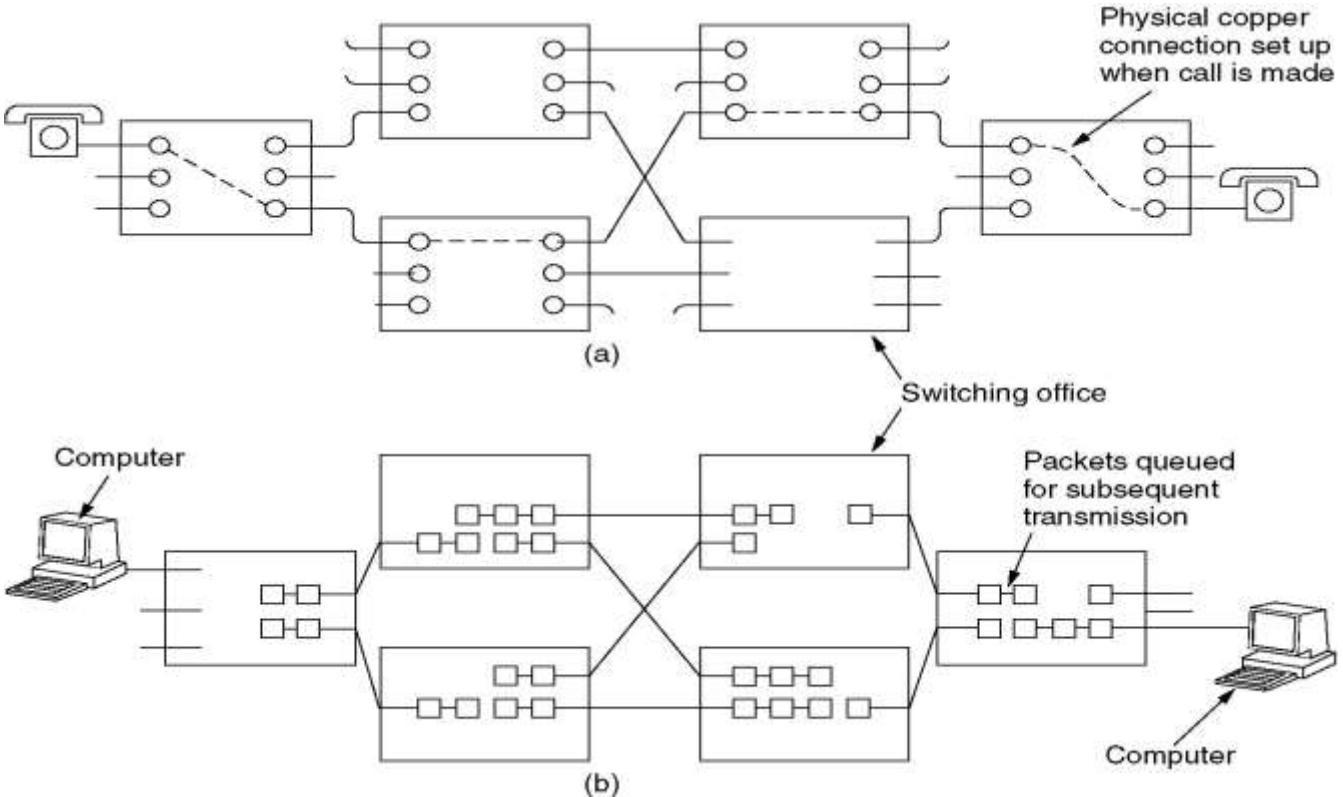
TIME DIVISION MULTIPLEXING (5)

- SONET and SDH multiplex rates.

SONET		SDH	Data rate (Mbps)		
Electrical	Optical	Optical	Gross	SPE	User
STS-1	OC-1		51.84	50.112	49.536
STS-3	OC-3	STM-1	155.52	150.336	148.608
STS-9	OC-9	STM-3	466.56	451.008	445.824
STS-12	OC-12	STM-4	622.08	601.344	594.432
STS-18	OC-18	STM-6	933.12	902.016	891.648
STS-24	OC-24	STM-8	1244.16	1202.688	1188.864
STS-36	OC-36	STM-12	1866.24	1804.032	1783.296
STS-48	OC-48	STM-16	2488.32	2405.376	2377.728
STS-192	OC-192	STM-64	9953.28	9621.504	9510.912

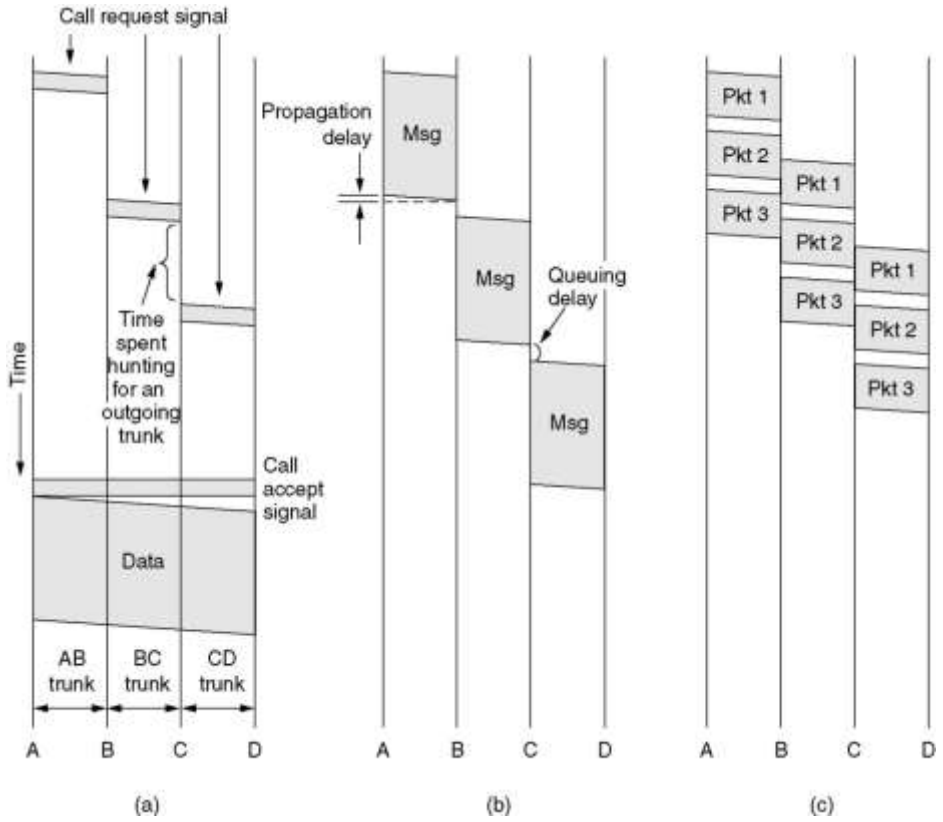
CIRCUIT SWITCHING

- (a) Circuit switching.
- (b) Packet switching.



MESSAGE SWITCHING

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



PACKET SWITCHING

- A comparison of circuit switched and packet-switched networks.

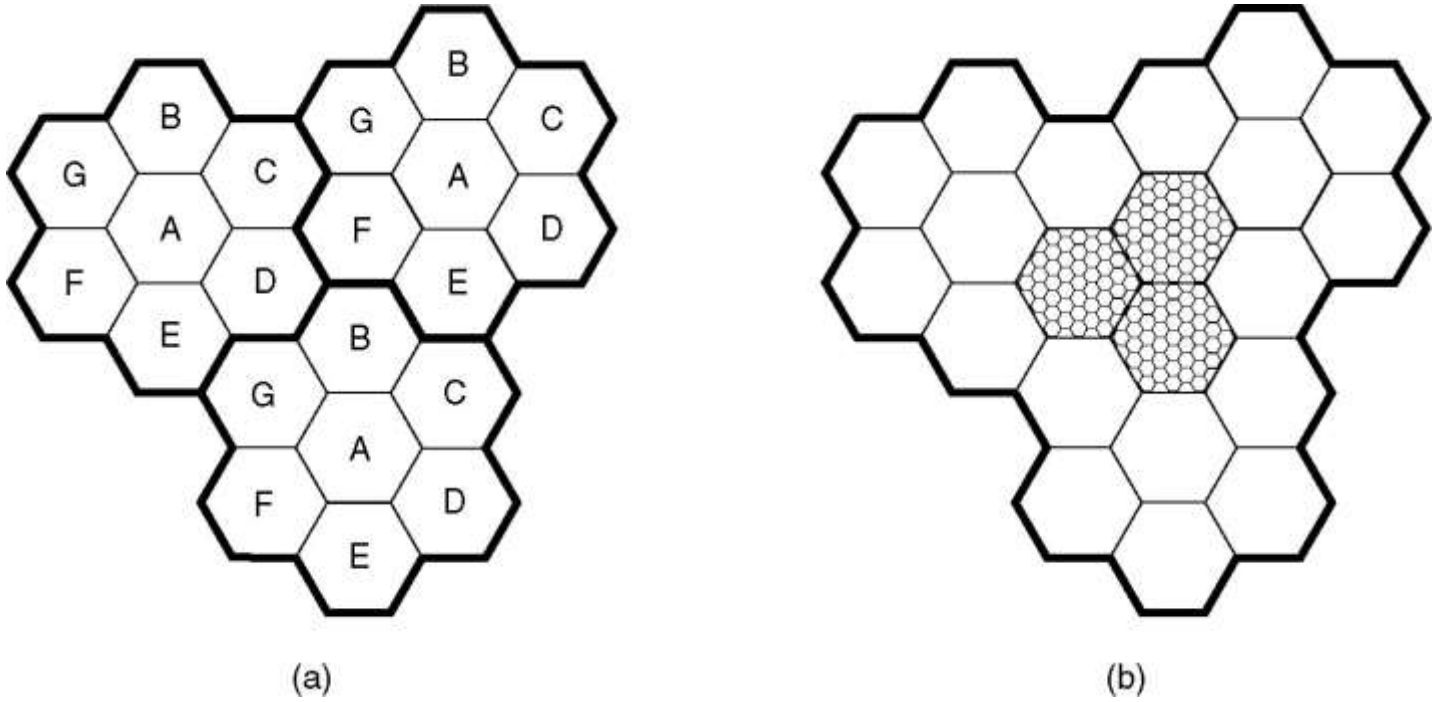
Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially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

THE MOBILE TELEPHONE SYSTEM

- First-Generation Mobile Phones: Analog Voice
- Second-Generation Mobile Phones: Digital Voice
- Third-Generation Mobile Phones: Digital Voice and Data

ADVANCED MOBILE PHONE SYSTEM

- (a) Frequencies are not reused in adjacent cells.
- (b) To add more users, smaller cells can be used.

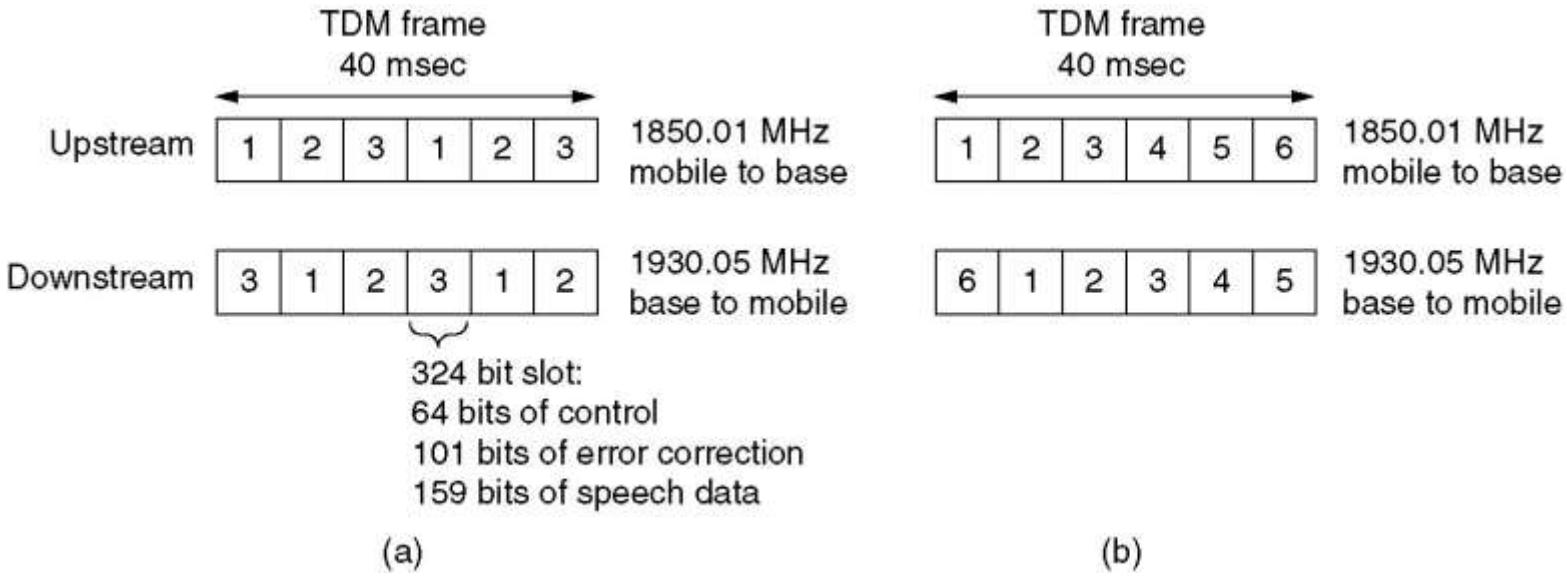


CHANNEL CATEGORIES

- The 832 channels are divided into four categories:
- Control (base to mobile) to manage the system
- Paging (base to mobile) to alert users to calls for them
- Access (bidirectional) for call setup and channel assignment
- Data (bidirectional) for voice, fax, or data

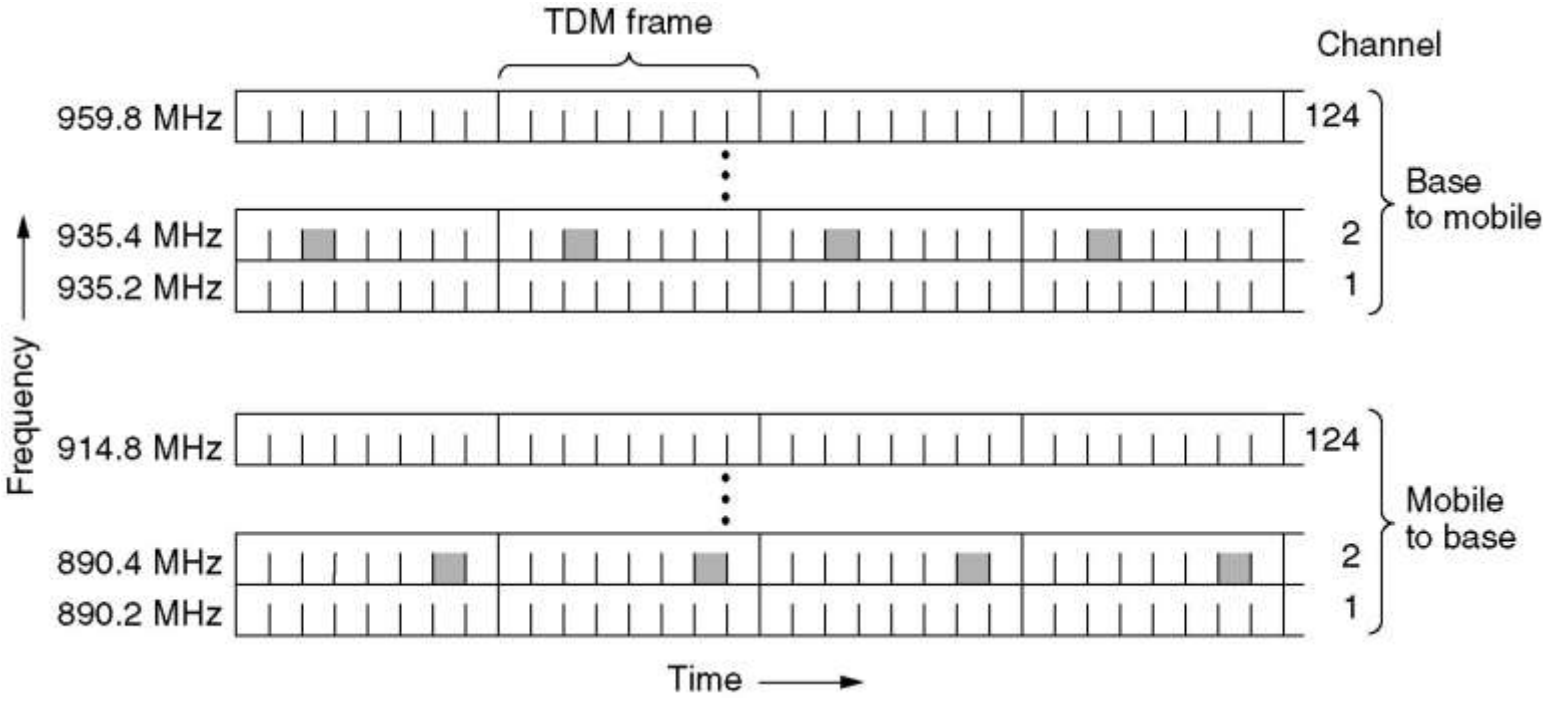
D-AMPS
DIGITAL ADVANCED MOBILE PHONE SYSTEM

- (a) A D-AMPS channel with three users.
- (b) A D-AMPS channel with six users.



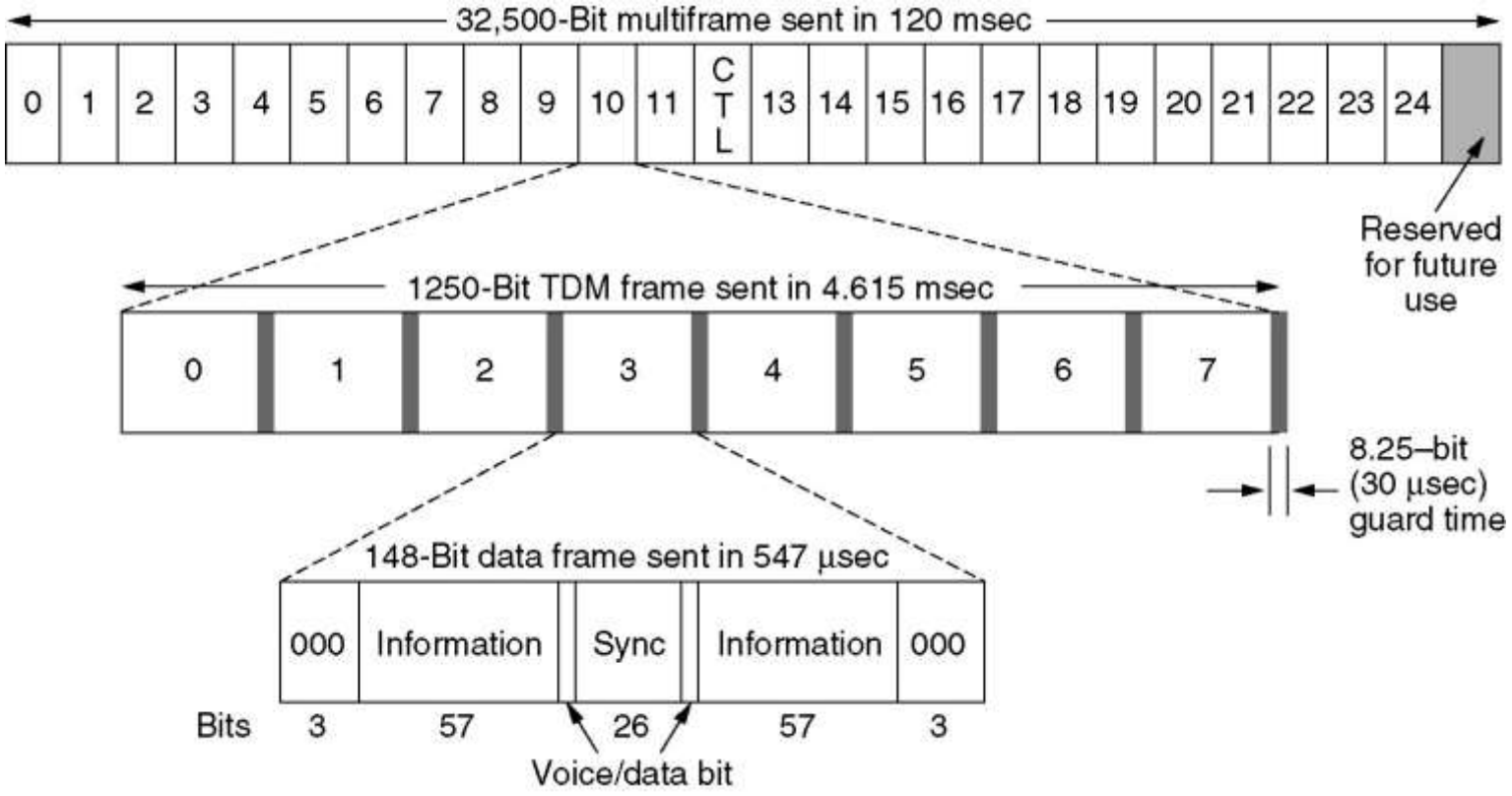
GSM
GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

- GSM uses 124 frequency channels, each of which uses an eight-slot TDM system



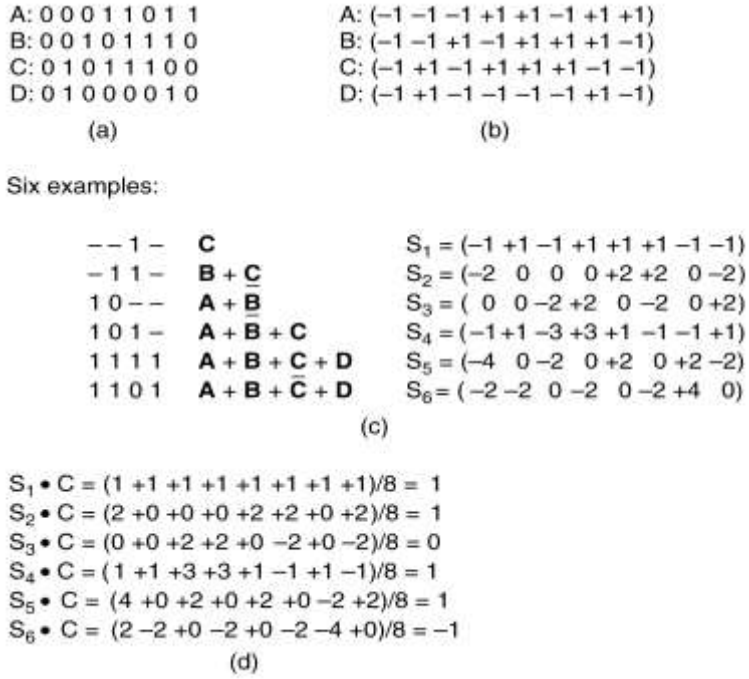
GSM (2)

- A portion of the GSM framing structure.



CDMA – CODE DIVISION MULTIPLE ACCESS

- (a) Binary chip sequences for four stations
- (b) Bipolar chip sequences
- (c) Six examples of transmissions
- (d) Recovery of station C's signal



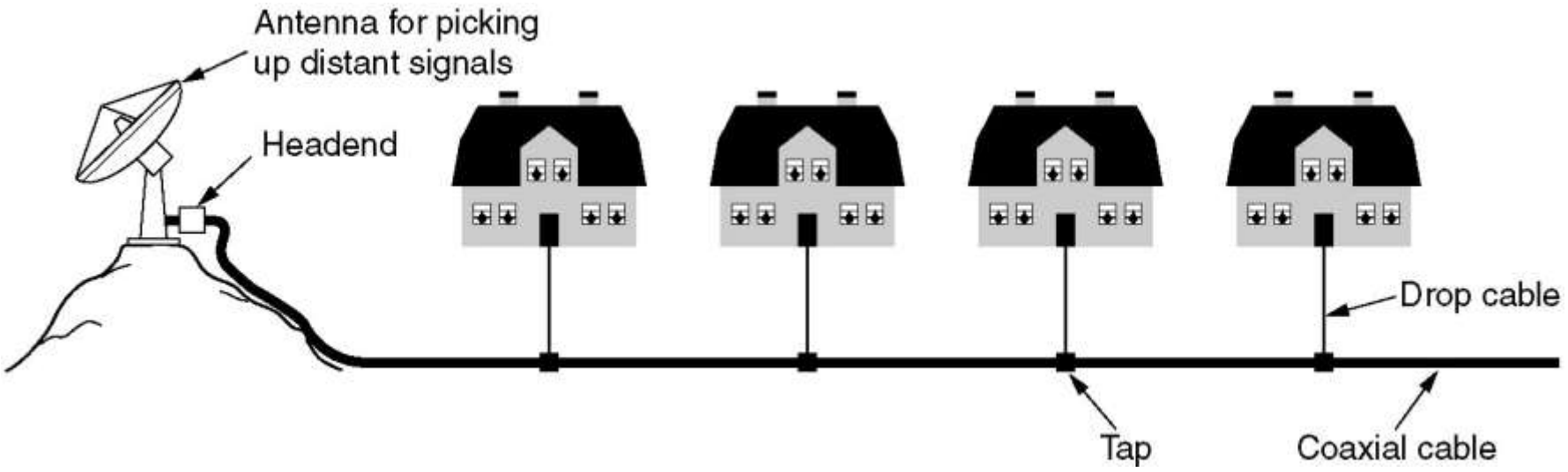
THIRD-GENERATION MOBILE PHONES: DIGITAL VOICE AND DATA

- Basic services an IMT-2000 network should provide
- High-quality voice transmission
- Messaging (replace e-mail, fax, SMS, chat, etc.)
- Multimedia (music, videos, films, TV, etc.)
- Internet access (web surfing, w/multimedia.)

CABLE TELEVISION

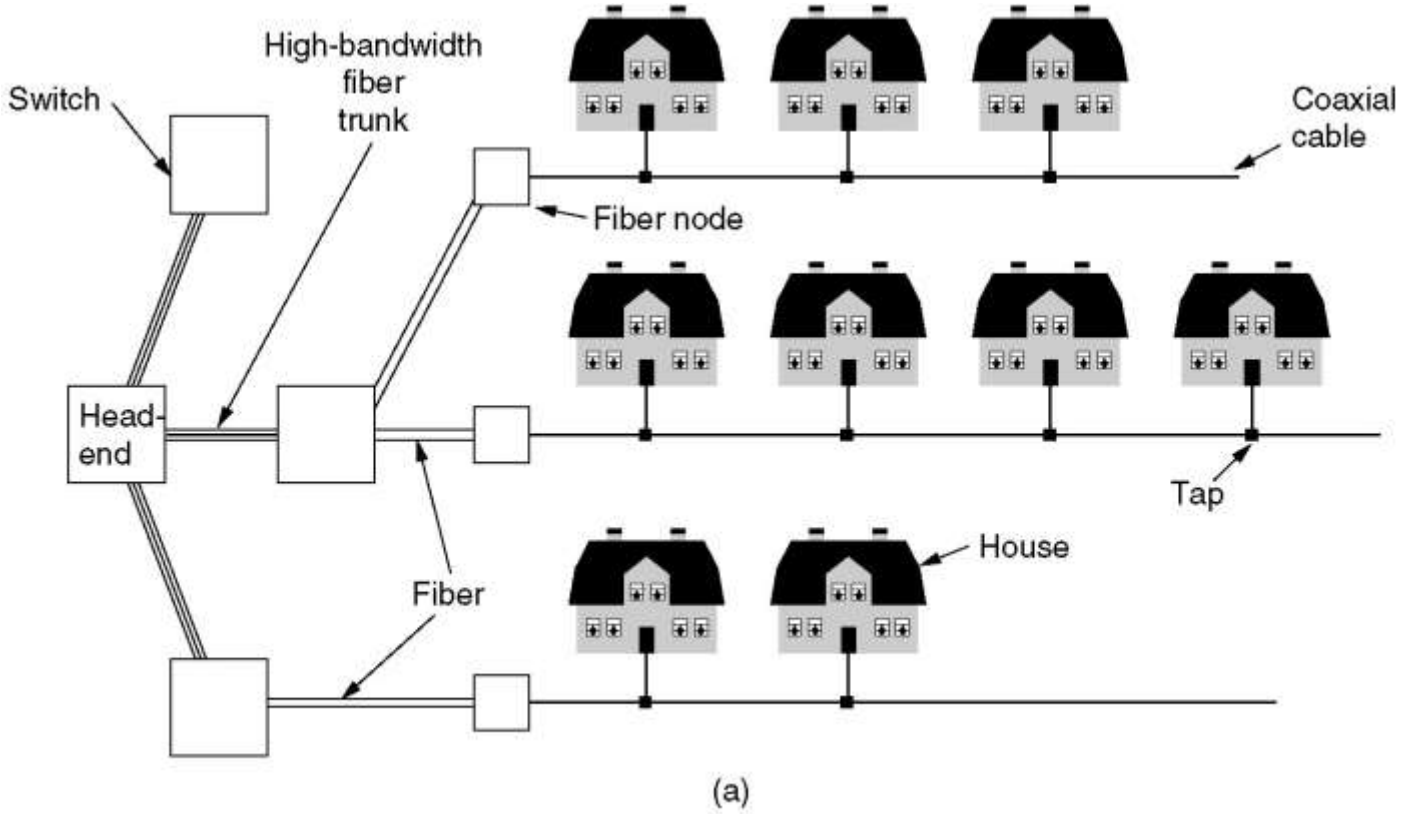
- Community Antenna Television
- Internet over Cable
- Spectrum Allocation
- Cable Modems
- ADSL versus Cable

COMMUNITY ANTENNA TELEVISION



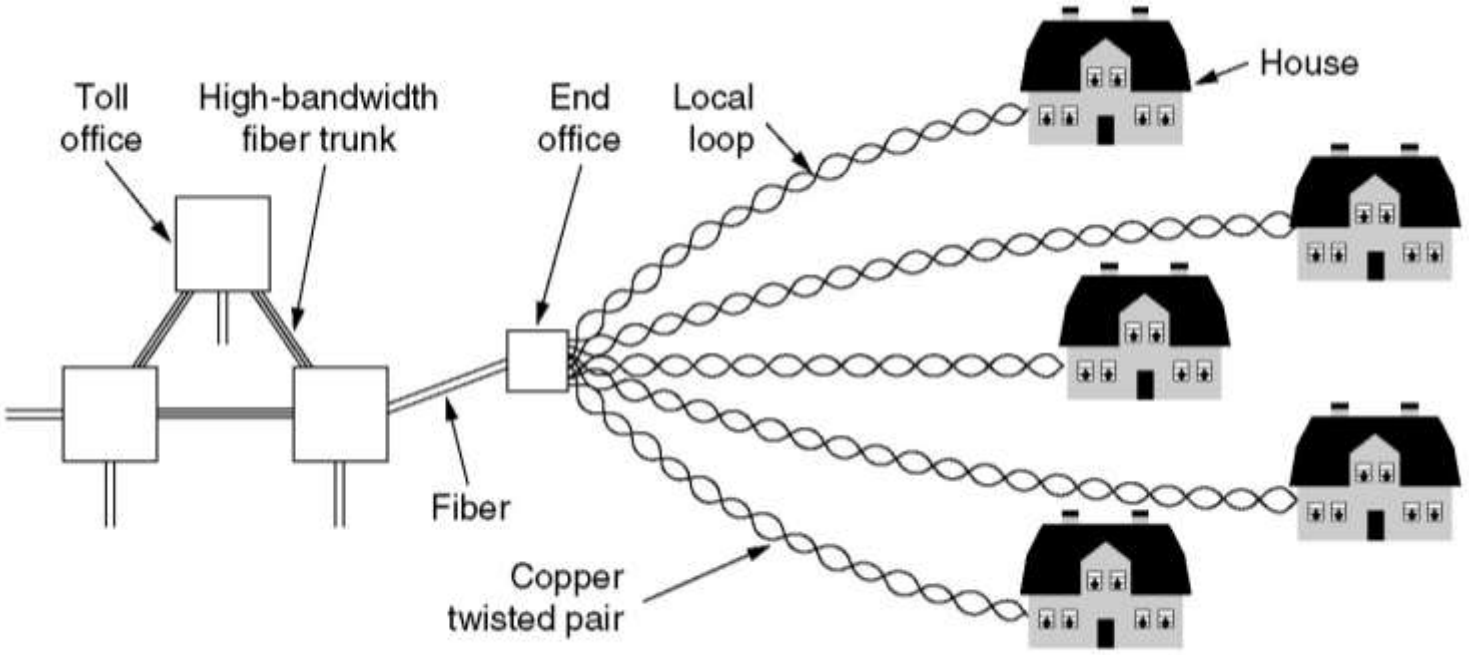
INTERNET OVER CABLE

- Cable television



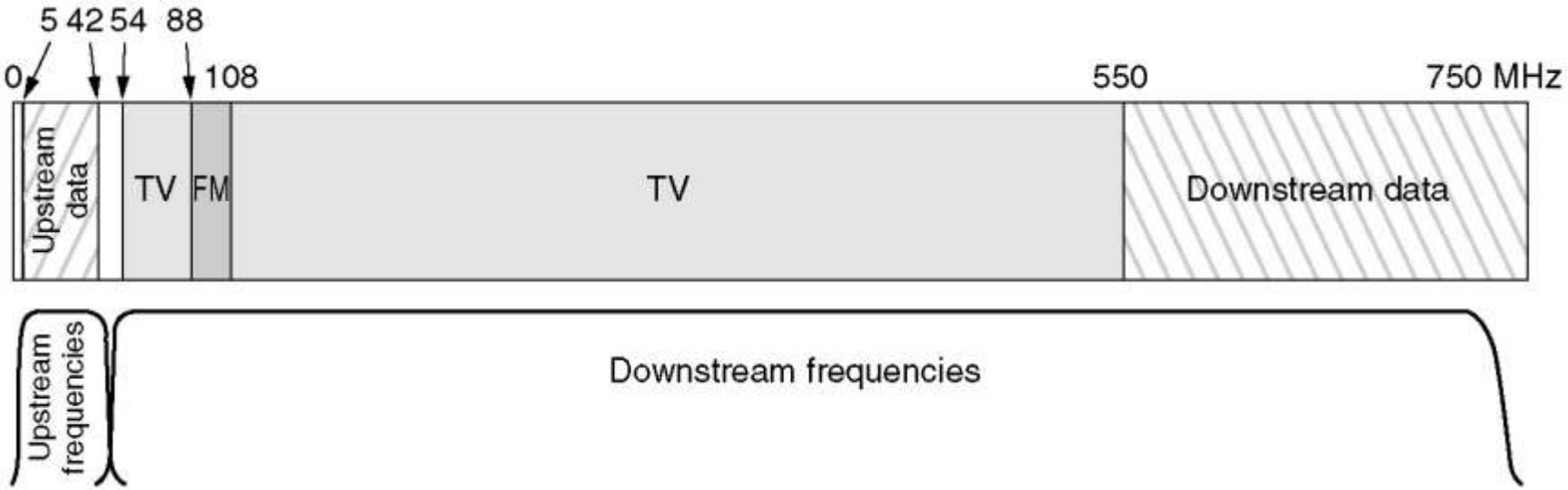
INTERNET OVER CABLE (2)

- The fixed telephone system.

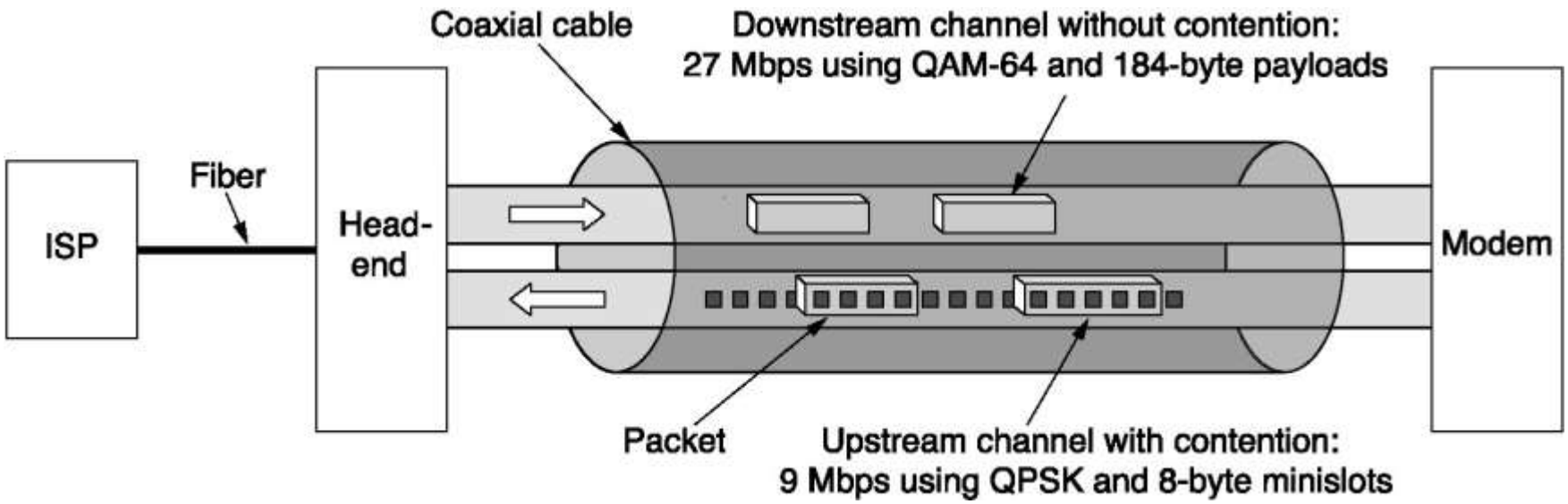


(b)

SPECTRUM ALLOCATION



CABLE MODEMS



Thank you

The content in this material are from the textbooks and reference books given in the syllabus.