Introduction to LAN/WAN

Physical Layer (contd)

Modulation Modes

- amplitude-shift
- frequency-shift
- phase-shift modulation
  - shift by 45, 135, 225, 315 degree(2 bits/interval).

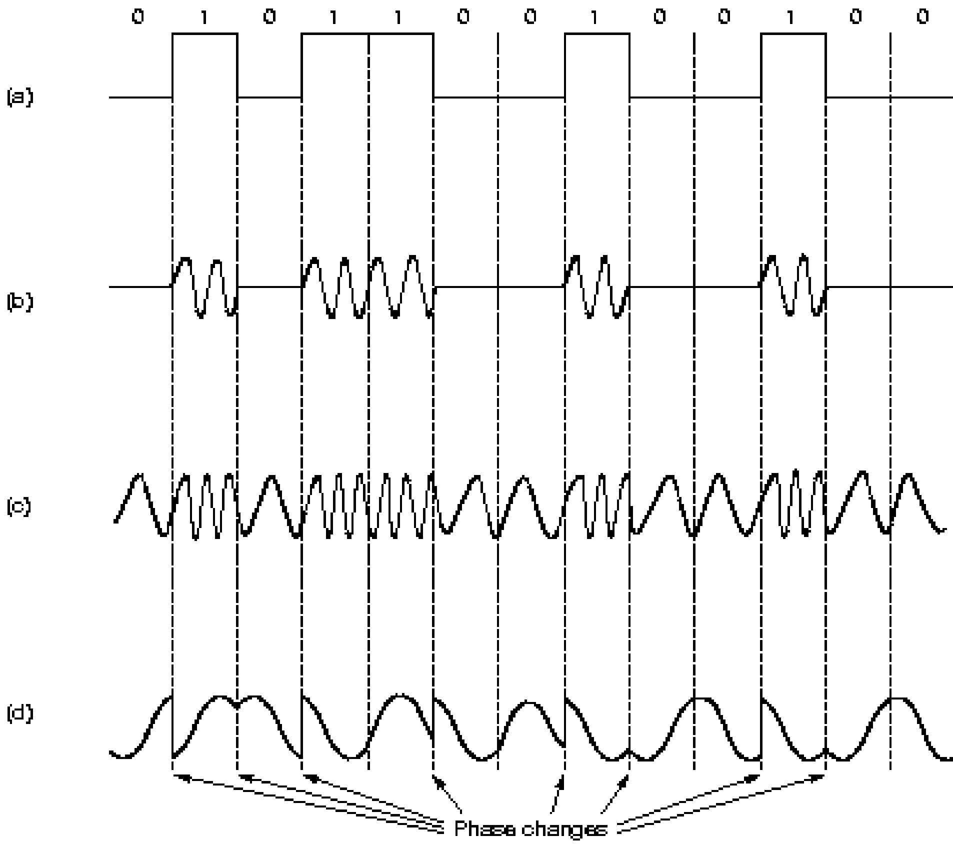


Fig. 2-18. (a) A binary signal. (b) Amplitude modulation. (c) Frequency modulation. (d) Phase modulation.

Constellation Diagrams: An example of modulation

- Different valid points: constellations
- Each point is a symbol
- 2-19 (a) has 8 valid symbols $= 2^3 = 3$ x speedup
- 2-19 (b) has 16 valid symbols $= 2^4 = 4$ x speedup
- Symbols/sec = baud
- For example if 2400 baud using 2-19(b) = 2400*4=9600bps

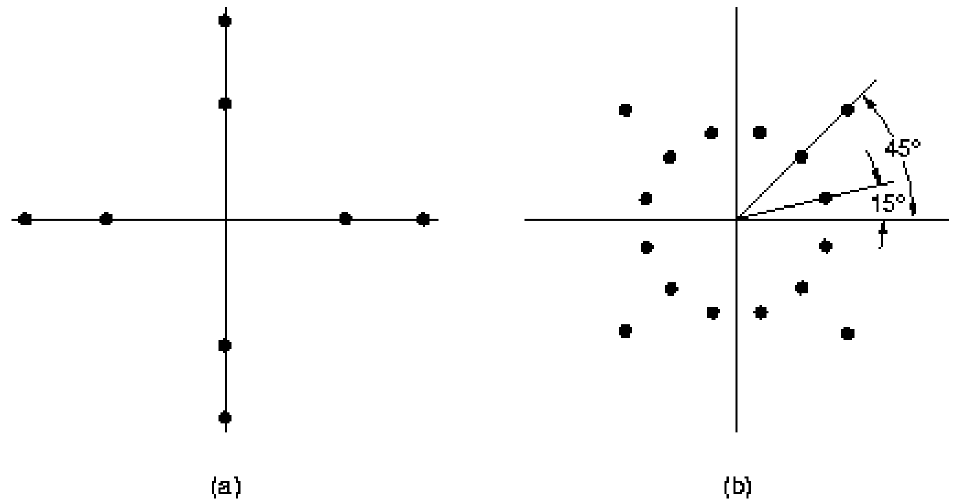
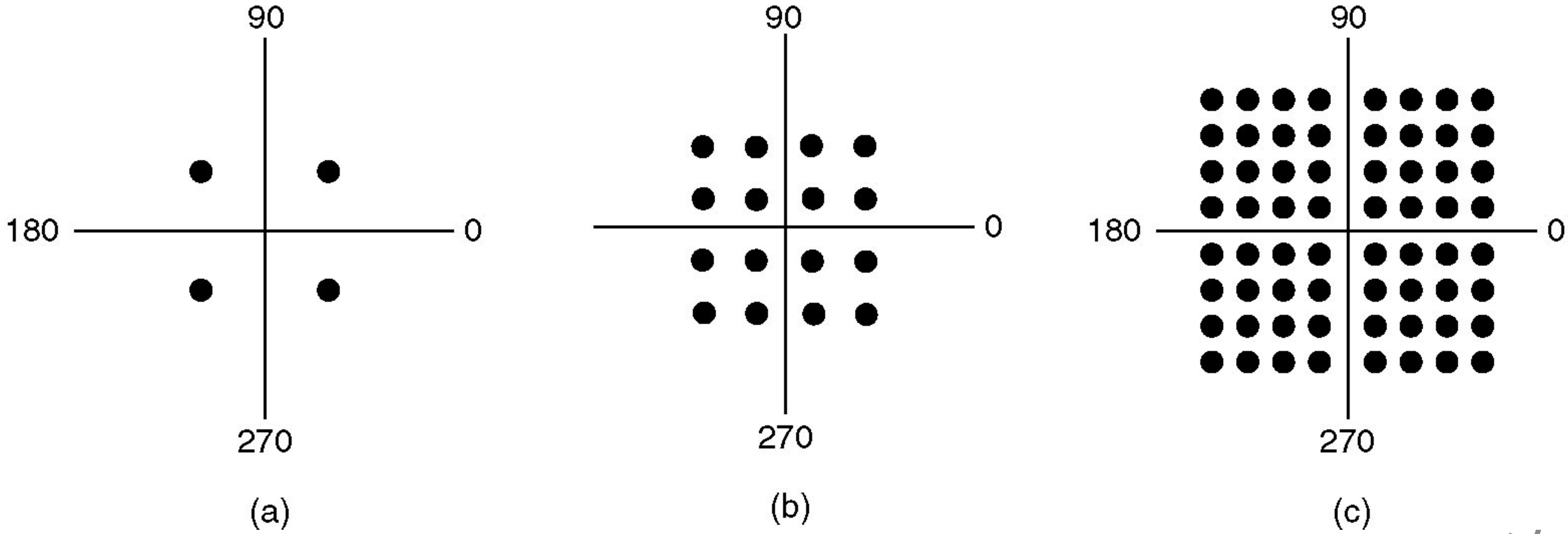


Fig. 2-19. (a) 3 bits/baud modulation. (b) 4 bits/baud modulation.

Modems: Constellation diagrams



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

Digital Transmission

- Analog circuits require amplifiers, and each amplifier adds distortion and noise to the signal.
- Digital amplifiers regenerate an exact signal
- Integrate all traffic

Clock synchronization

- ☞ With digital transmission, one problem that continually arises is clock synchronization.
- ☞ Possibilities:
  - – use a separate channel to transmit timing info.
  - – include timing information in the data signal
    - ◆ Manchester encoding

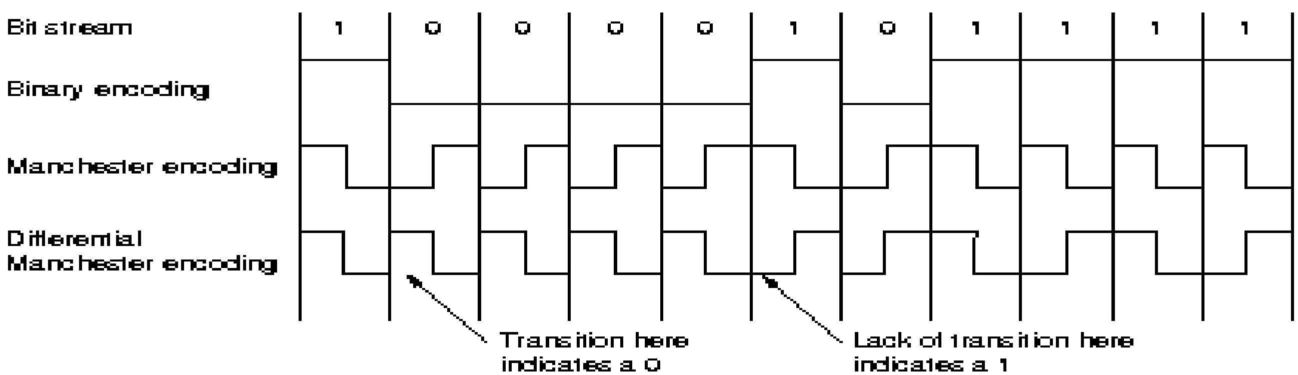
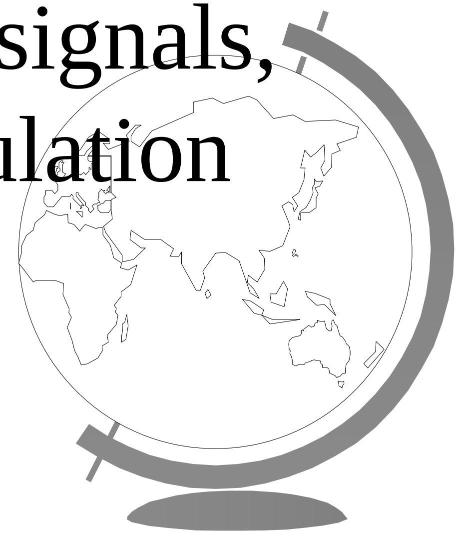


Fig. 4-20. (a) Binary encoding. (b) Manchester encoding. (c) Differential Manchester encoding.

Analog Data/Digital Signals

- Although most local loops are analog, end offices increasingly use digital circuits for inter-trunk lines. A codec (coder/decoder) is a device that converts an analog signal into a digital signal.
- To convert analog signals to digital signals, many systems use Pulse Code Modulation (PCM)

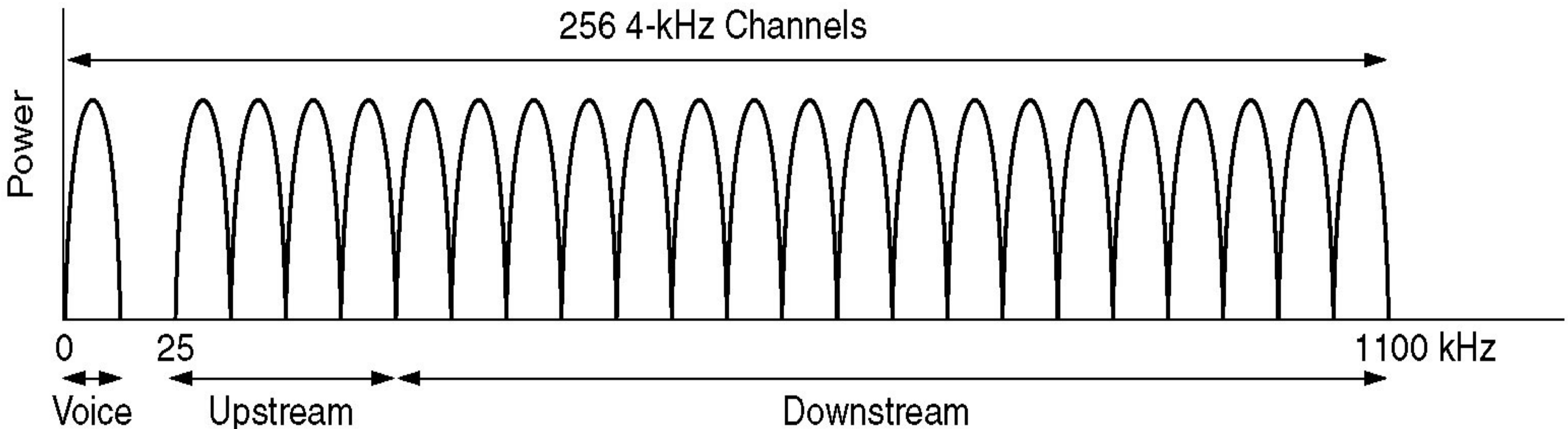


Pulse Code Modulation

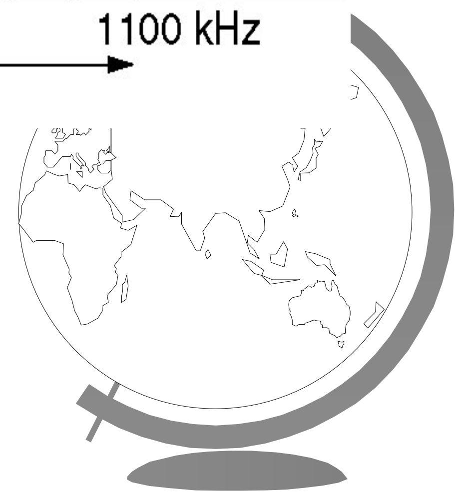
- PCM
  1. Convert analog to digital (done by codec)
  2. Uses sampling (snapshots of waveform)
  3. PCM samples the 4kHz signal 8,000 times per second. (Nyquist theorem)
  4. Each sample measures the amplitude of the signal, converting it into an n-digit integer value.
  5. The digital channel carries these n-digit encodings.

Digital Subscriber Lines

Operation of ADSL using discrete multitone modulation.

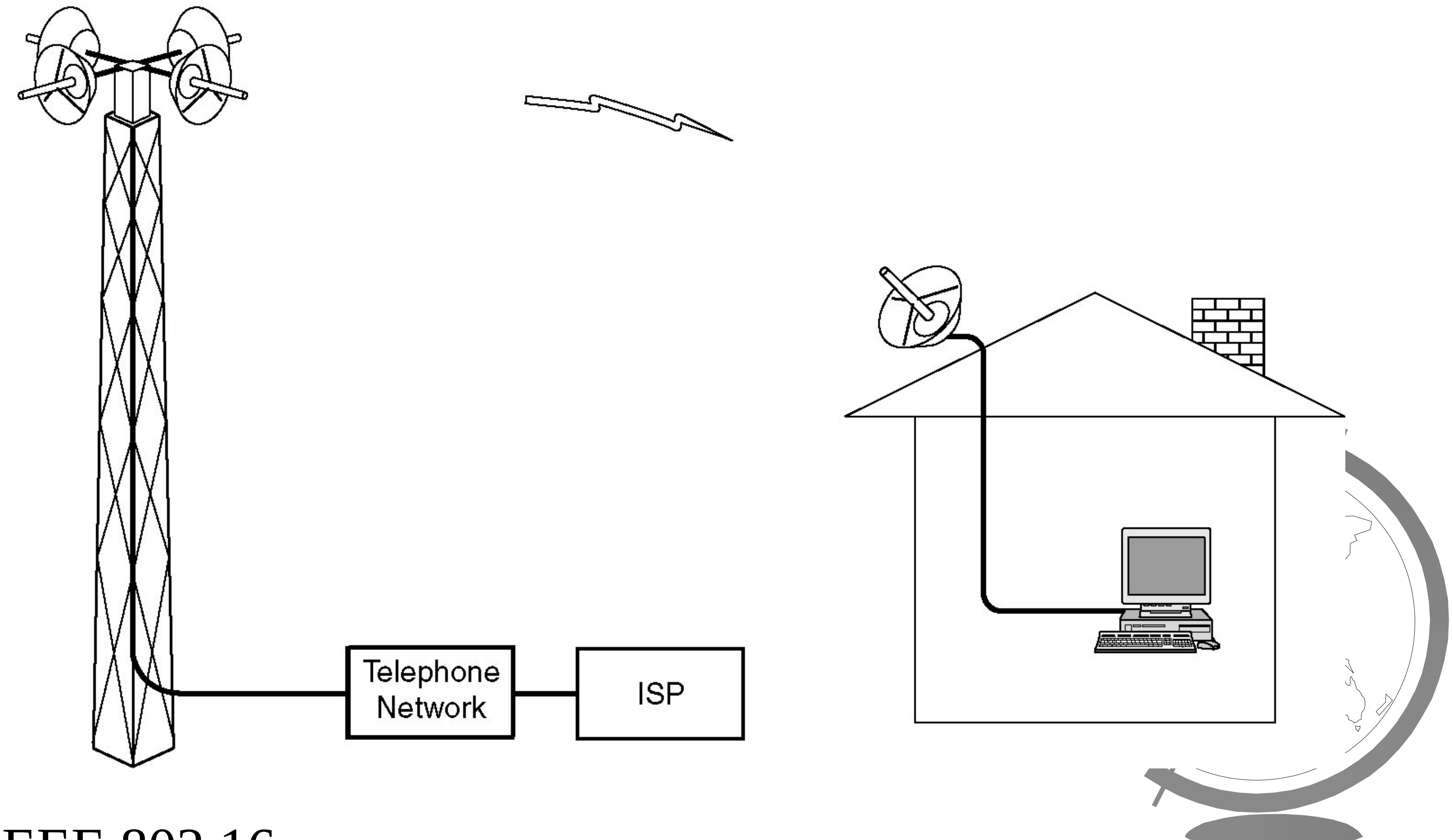


- Remove filters which limit phone line to 4Khz
- Make full 1.1 MHz available to customer
- ADSL: assymetric in upstream and downstream



Wireless Local Loops

- FCC: 1.3 GHz of spectrum for LMDS

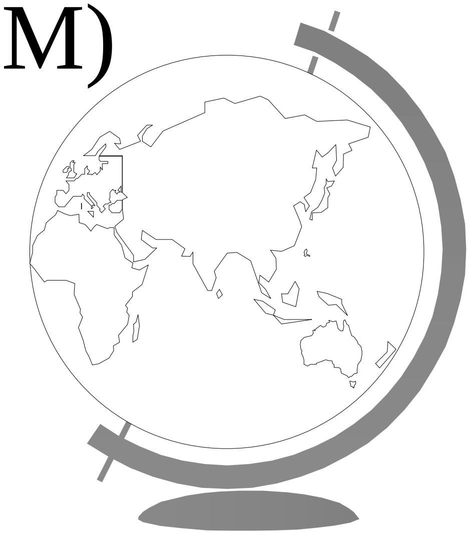


IEEE 802.16

Multiplexing

- ☞ Problem: Given a channel of large capacity, how does one subdivide the channel into smaller logical channels for individual users? Multiplex many conversations over same channel.
- ☞ Three flavors of solution:

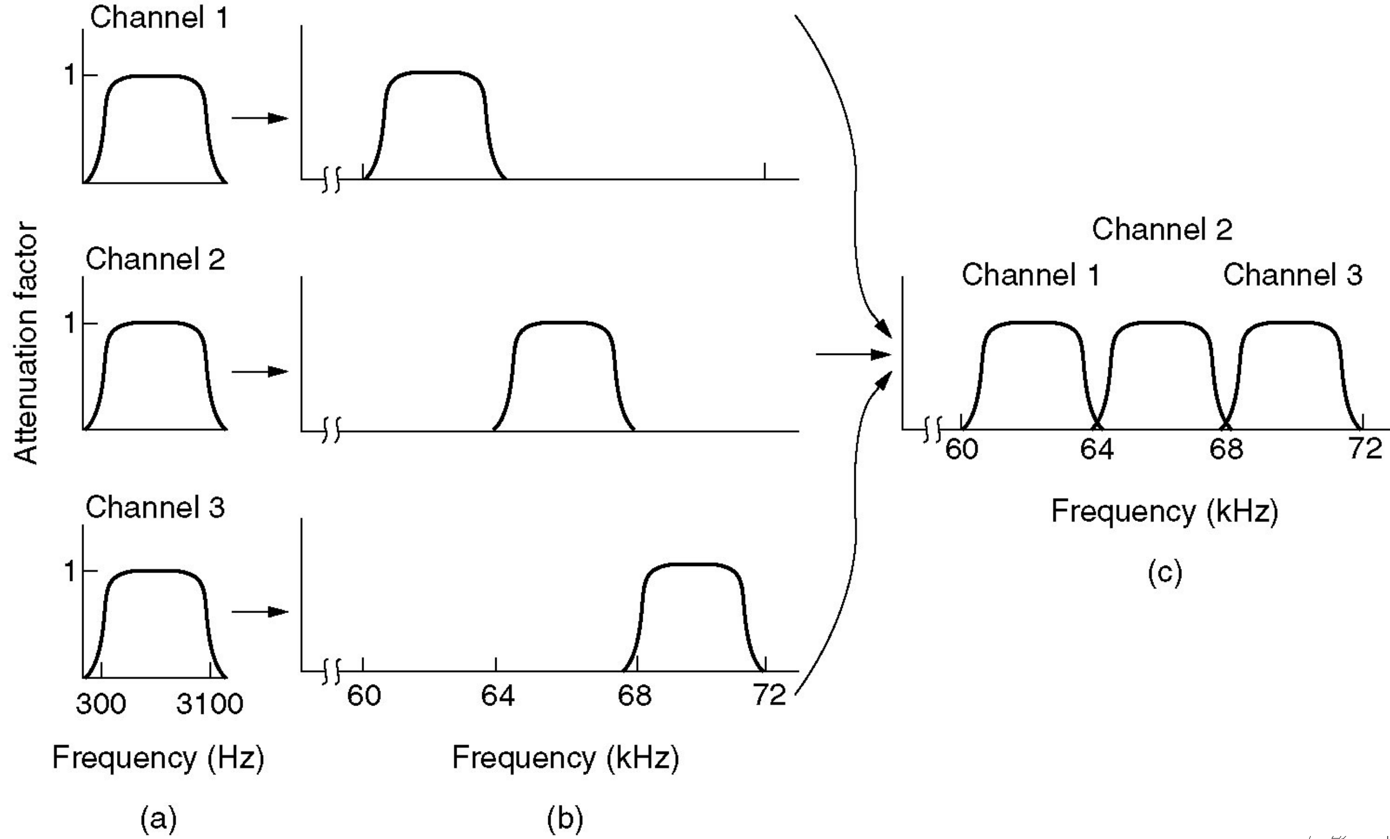
1. Frequency division multiplexing (FDM)
2. Time division multiplexing (TDM)
3. Statistical multiplexing



Frequency division multiplexing

- Divide the frequency spectrum into smaller subchannels, giving each user exclusive use of a subchannel (e.g., radio and TV).
- Problem?
  A user is given all of the frequency to use, and if the user has no data to send, bandwidth is wasted -- it cannot be used by another user.

Frequency Division Multiplexing



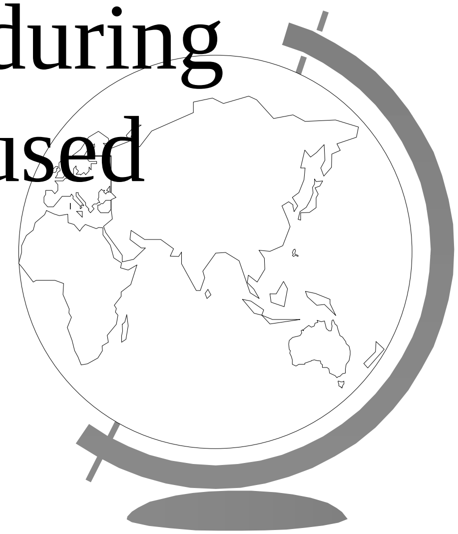
(a) The original bandwidths.

(b) The bandwidths raised in frequency.

(b) The multiplexed channel.

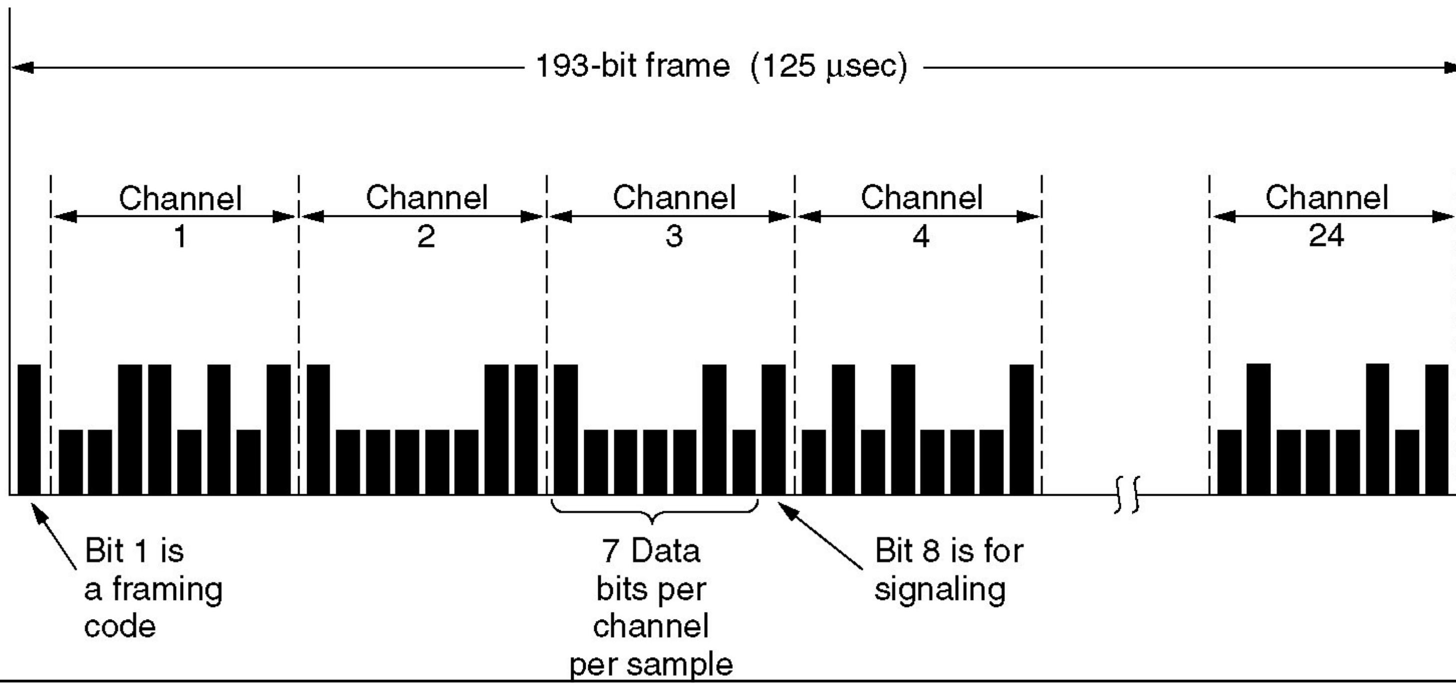
Time division multiplexing

- Use time slicing to give each user the full bandwidth, but for only a fraction of a second at a time (analogous to time sharing in operating systems).
- Problem?
  if the user doesn't have data to sent during his time slice, the bandwidth is not used (e.g., wasted).



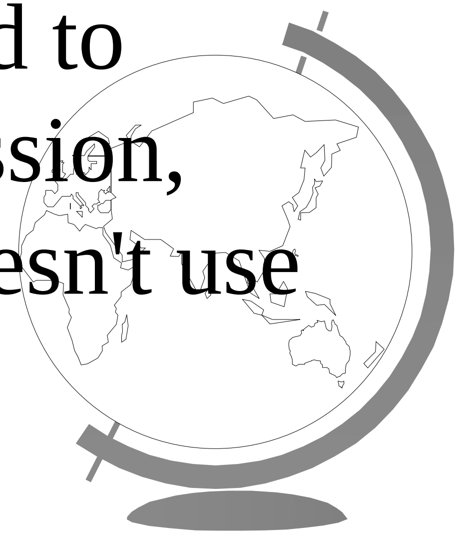
TDM example: T1 carrier(fig 2-33)

- Multiplexes 24 voice channels over one digital channel.
- Sample 24 analog inputs in round-robin.
- Each encoding = 7 bits sampled data + 1 bit signaling info
- Each subchannel carries (7 bits X 8000 samples) = 56kbps data + 8000 bps signaling info(digital data rate: 64kbps).
- Sample are 193 bits =24 X 8 +1 (extra bit for synch. info)
- Gross data rate: 1.544 Mbps



Statistical multiplexing

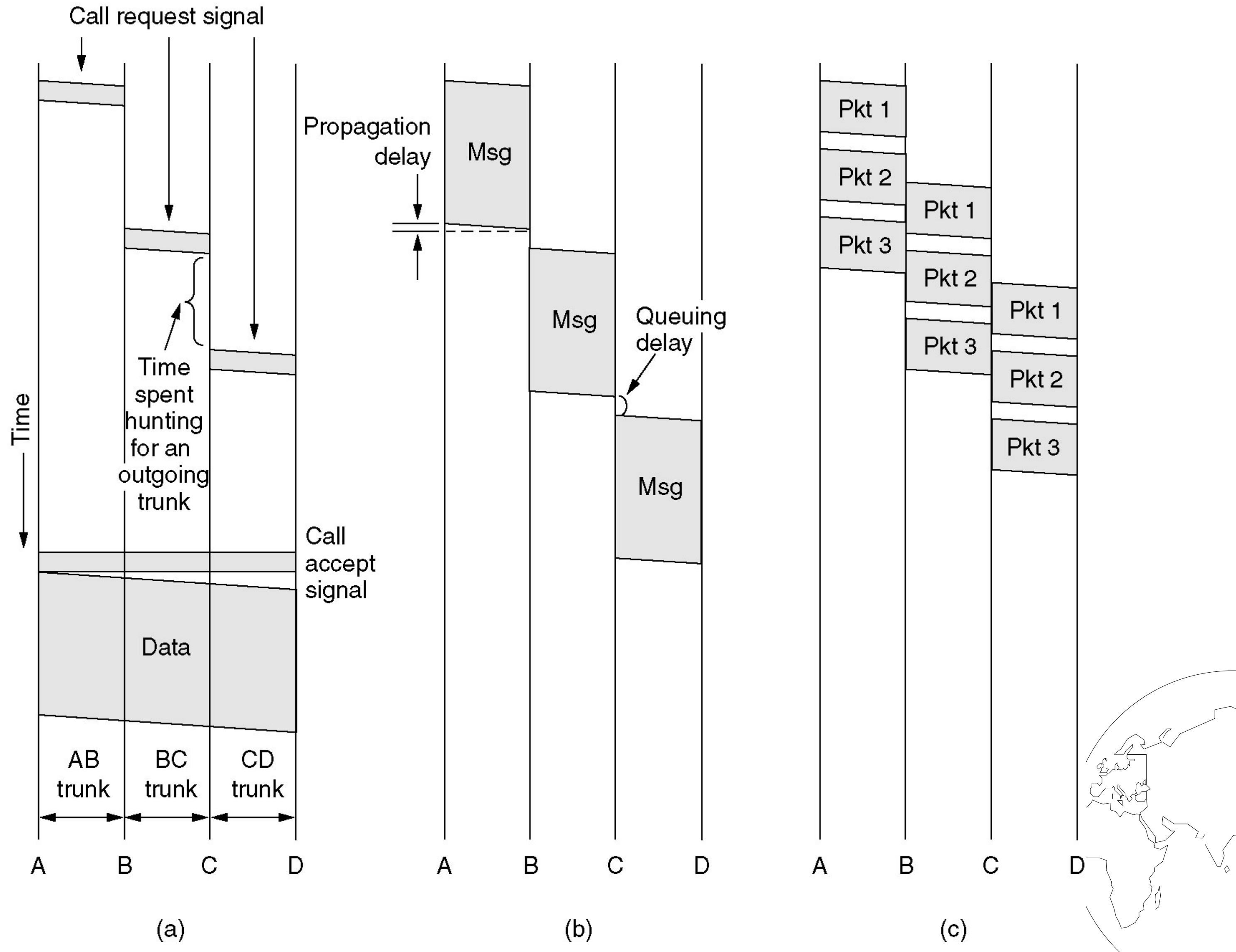
- Allocate bandwidth to arriving packets on demand.
- Advantage:
  leads to the most efficient use of channel bandwidth because it only carries useful data. Channel bandwidth is allocated to packets that are waiting for transmission, and a user generating no packets doesn't use any of the channel resources.



Switching

- Circuit Switching
  Used in current telephone system
- Message Switching
- Packet Switching
  Used in the next generation telephone system--broadband ISDN system

Switching



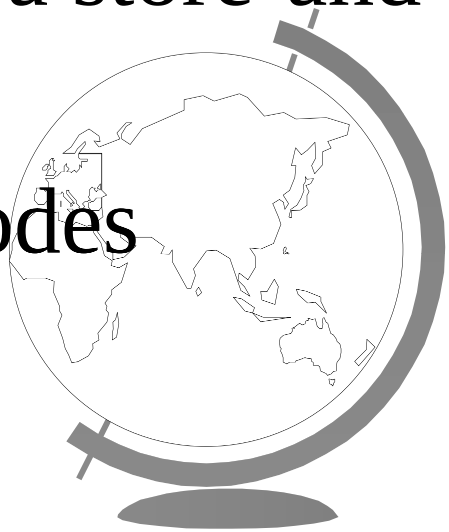
(a) Circuit switching (b) Message switching (c) Packet switching

Circuit Switching
(Fig2-35)

- 1.Once a call setup has been completed, the user sees a set of virtual wires between communicating endpoints.
- 2.The user sends a continuous stream of data, which the channel guarantees to deliver at a known rate.
- 3.Data transmission handled elegantly using TDM or FDM.
- 4.Call setup required before any data can be sent.
- 5.Call termination required when parties complete call.

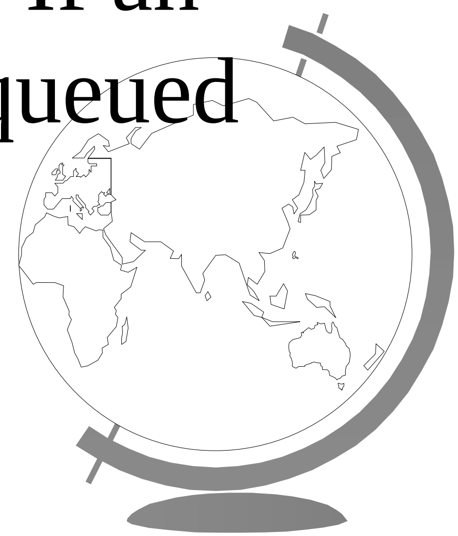
Message Switching

- No physical copper path is established in advance between communicating endpoint.
- Entire message stored at each node. Each message is received in its entirety,inspected for errors and then forwarded.
- A network using this technique is called a store-and-forward network.
- Memory requirements at intermediate nodes



Packet Switching

- Data is sent in individual messages (packets).
- Each message is forwarded from switch to switch, eventually reaching its destination.
- Each switch has a small amount of buffer space to temporarily hold messages. If an outgoing line is busy, the packet is queued until the line becomes available.



Packet vs Circuit

- No set up time
- Better channel utilization
- Less deterministic quality of service
- Billing is difficult

- Set up time
- May have quiet periods
- Known delay or capacity characteristics.
- Easy to bill for a connection

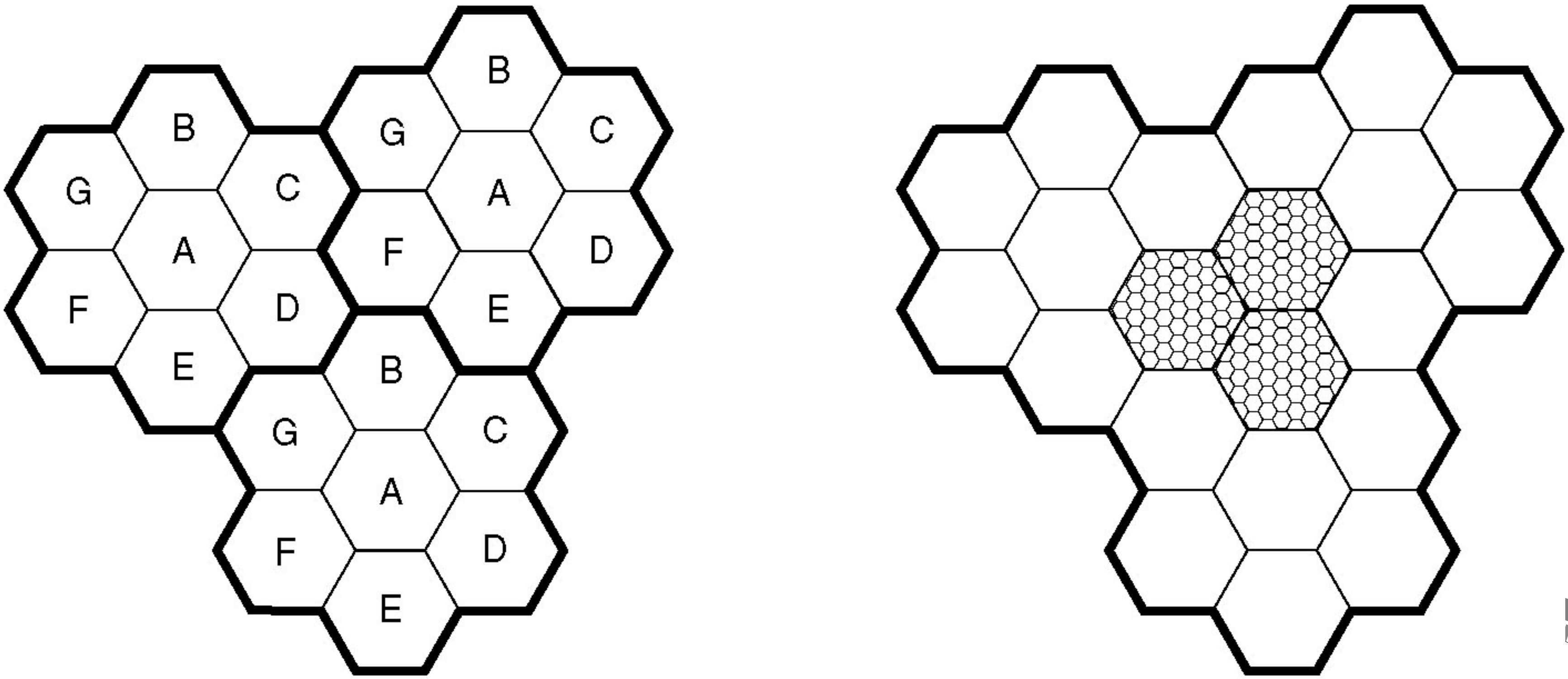
The Mobile Telephone System

- 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) (b)

(a) Frequencies are not reused in adjacent cells.

(b) To add more users, smaller cells can be used.

Specifics Not Mentioned

- Digital AMPS (D-AMPS)
- GSM
- Code Division Multiple Access (CDMA)
- Cable Television