Overview

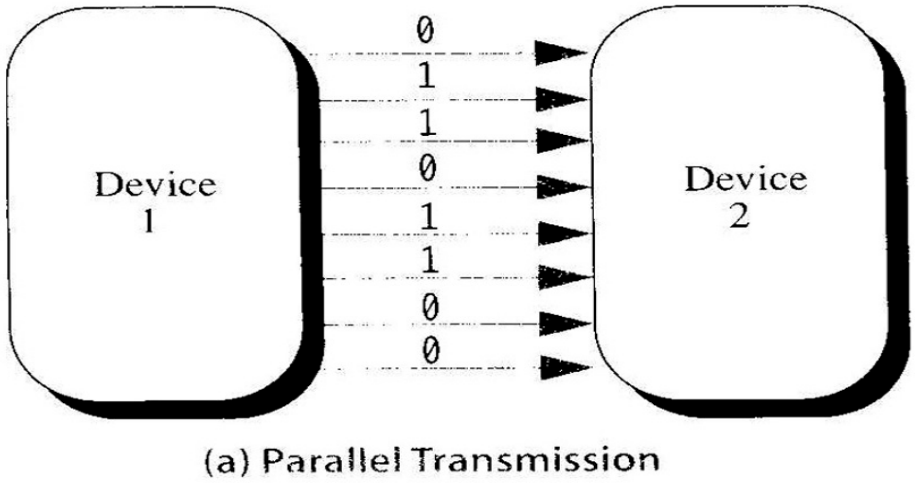
- Last Lecture
  - Signals and Encoding
- This Lecture
  - Data Transmission
  - Source: Sections 1.1, 4.3, 6.1
- Next Lecture
  - Data Compression
  - Source : Lecture notes

Data Transmission

http://onwardsoftware.com/

Parallel Transmission

- Parallel transmission (e.g. printer)
  - Transmits a group of bits simultaneously through several paths (usually wires)



(a) Parallel Transmission

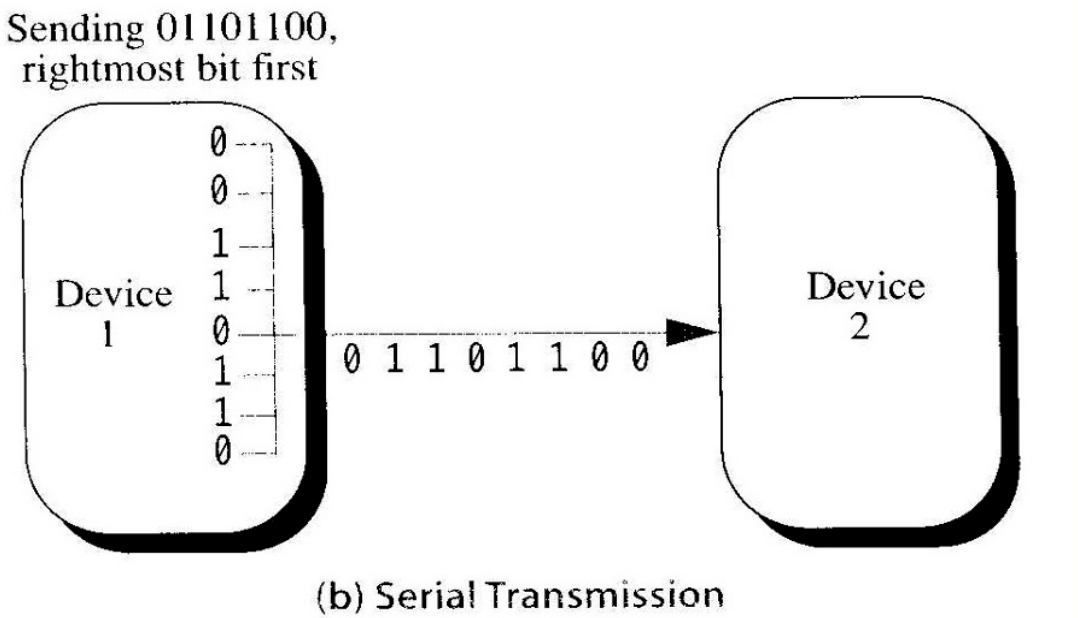

computingforpsychologists.wordpress.com

Parallel Transmission(cont.)

- Parallel transmission
  - High bit rate
  - Good for short distances only
  - Synchronisation problems over longer distances.
  - Large wire bundles (in a cable)

Serial Transmission

- Serial transmission
  - Transmits bits one after another along the medium



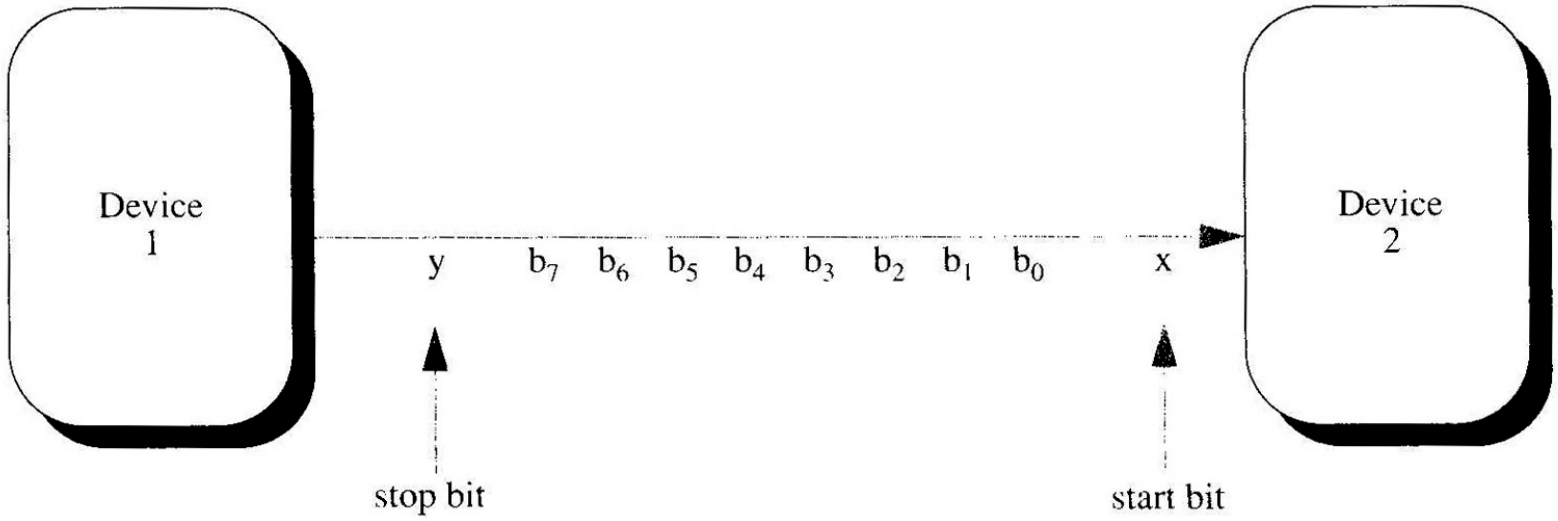
(b) Serial Transmission

Serial Transmission (cont.)

- Serial transmission
  - Slower than parallel
  - More reliable and less expensive for longer distances
  - Additional complexity for sending and receiving devices
  - How to order the bit
    - Asynchronous Transmission
    - Synchronous Transmission

Asynchronous Transmission

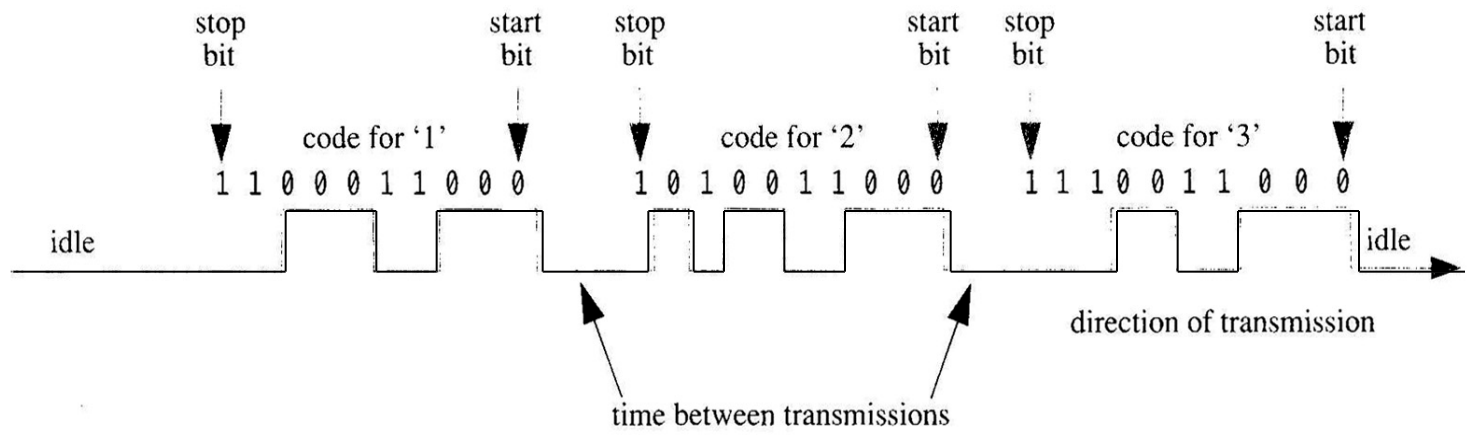
- Bits are collected into groups, usually bytes
- Bytes are sent as available at any time.
- Uses start and stop bits so receiver knows when data starts. (e.g. keyboard)



Asynchronous Transmission (cont.)

- Example: Send 321 using NRZ encoding
  - '1' 0011 0001, '2' 0011 0010, '3' 0011 0011

Figure 3.3 Asynchronous Transmission of the Digits 1, 2, and 3 Using NRZ Coding

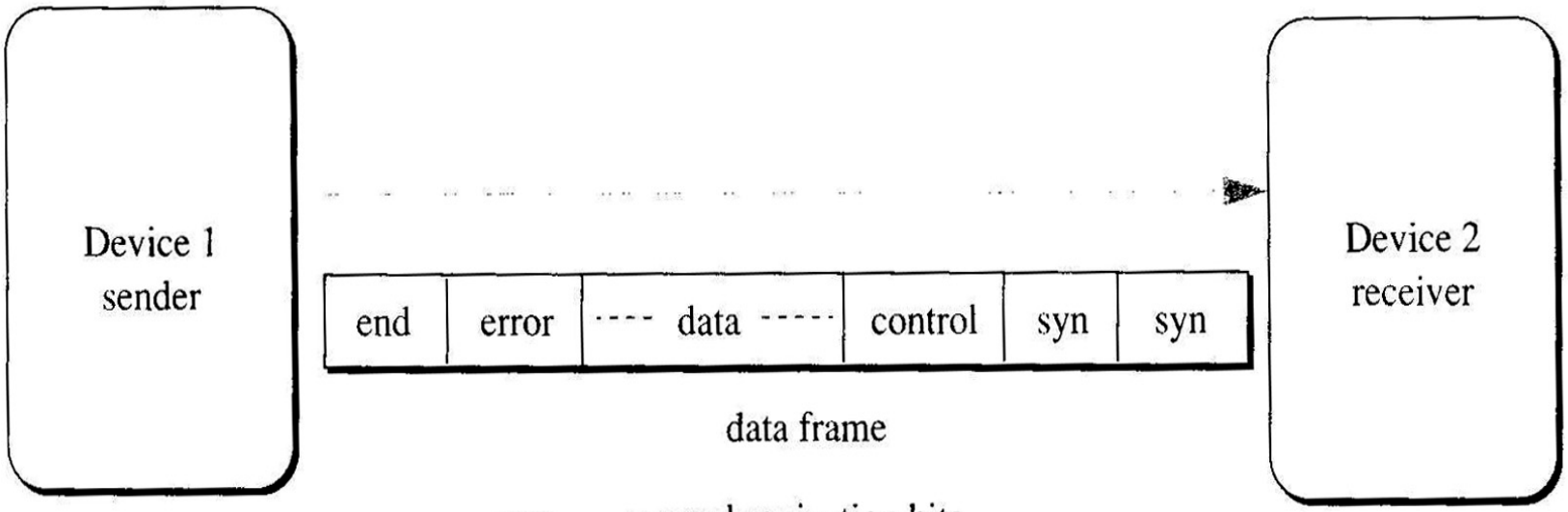


Synchronous Transmission

- A larger group of bits or bytes are sent.
- A group is organized into a data frame.
- Beginning contains SYN characters to alert the receiver to the frame and to allow the receiver to synchronize to the bit rate.
- A Typical frame may have 500 bytes (4000 bits, 100bits overhead, 2.5%)

Synchronous Transmission (cont.)

Figure 3.4 Synchronous Transmission



Synchronous Transmission (cont.)

- Controls bits can include
  - Source address
  - Destination address
  - Number of data bytes
  - Sequence number
  - Frame type
- Error checking bits
  - Detect or correct transmission errors
- End of frame bits
  - Indicate no more bits are arriving

Directions

- Simplex
  - Communications in one direction only
  - Printers, monitors, television

- Half-duplex
  - Bi-directional communications, but must alternate
  - Police radio phone, only one can talk at a time.
- Full-duplex
  - Simultaneous bi-directional communications
  - opposite directions in different channels (lines, wires, or frequency bands).

Directions (cont.)

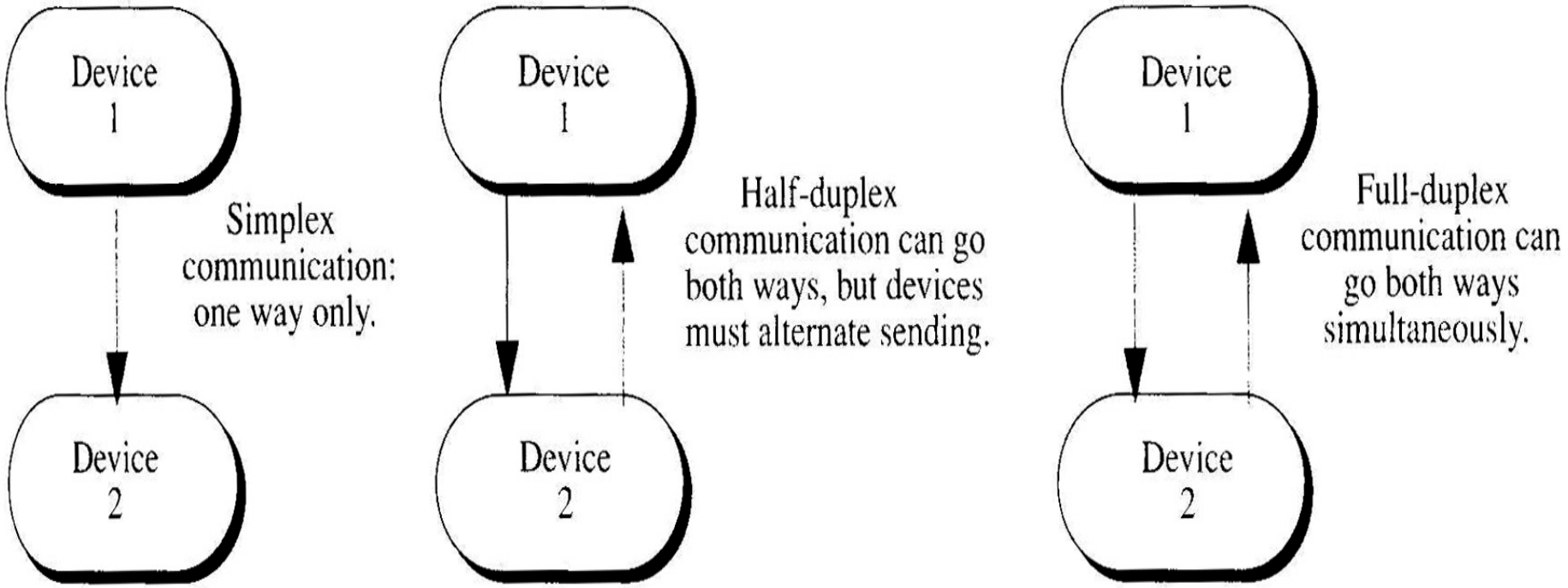


Figure 3.5 Simplex, Half-Duplex, and Full-Duplex Communication

Multiplexing

- Techniques that allows the simultaneous transmission of multiple signals over a single link.
  - Allocate the total capacity of a transmission medium among a number of users.
- Reasons behind multiplexing
  - High speed data channels
  - Relatively slow devices
  - Maximum utilisation
  - reduction in the number of links and the overall cost.

Multiplexing

- Multiplexer
  - transmission streams combine into a single stream (many into one)
- Demultiplexer
  - stream separates into its component transmission (one into many) and directs them to their intended receiving devices
- analog: FDM/WDM; digital: TDM

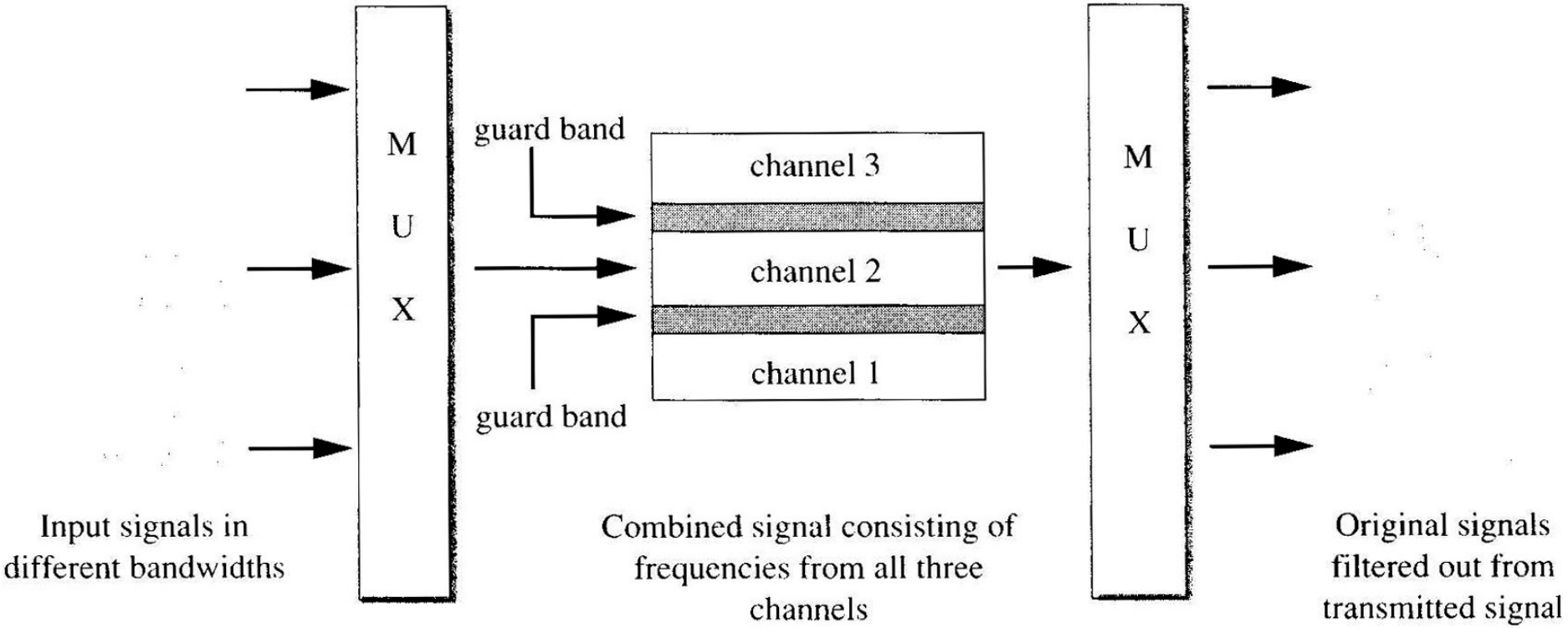
Frequency Division Multiplexing

- Used with analog signals
- The bandwidth of the media is divided into logical channels, with a given channel devoted to a specific signal.
- Broadcast radio, cable television
- TV Example:
  - 68 channels of 6 MHz each
  - 54 MHZ to 806 MHz
  - Use a coaxial cable (500+ MHz bandwidth)

Frequency Division Multiplexing (cont.)

- A carrier signal is defined for each channel (typically centred in the channel's frequency band).
- The carrier is modulated by the input signal.
- The modulated signals from all sources are combined into a single complex signal.
- The complex signal is fed into the transmission media.
- A demultiplexer uses bandpass filters to extract each channel.
- Each channel is demodulated to recover the original signal.
- Guard bands are used to prevent interference between adjacent channels.

Frequency Division Multiplexing (cont.)

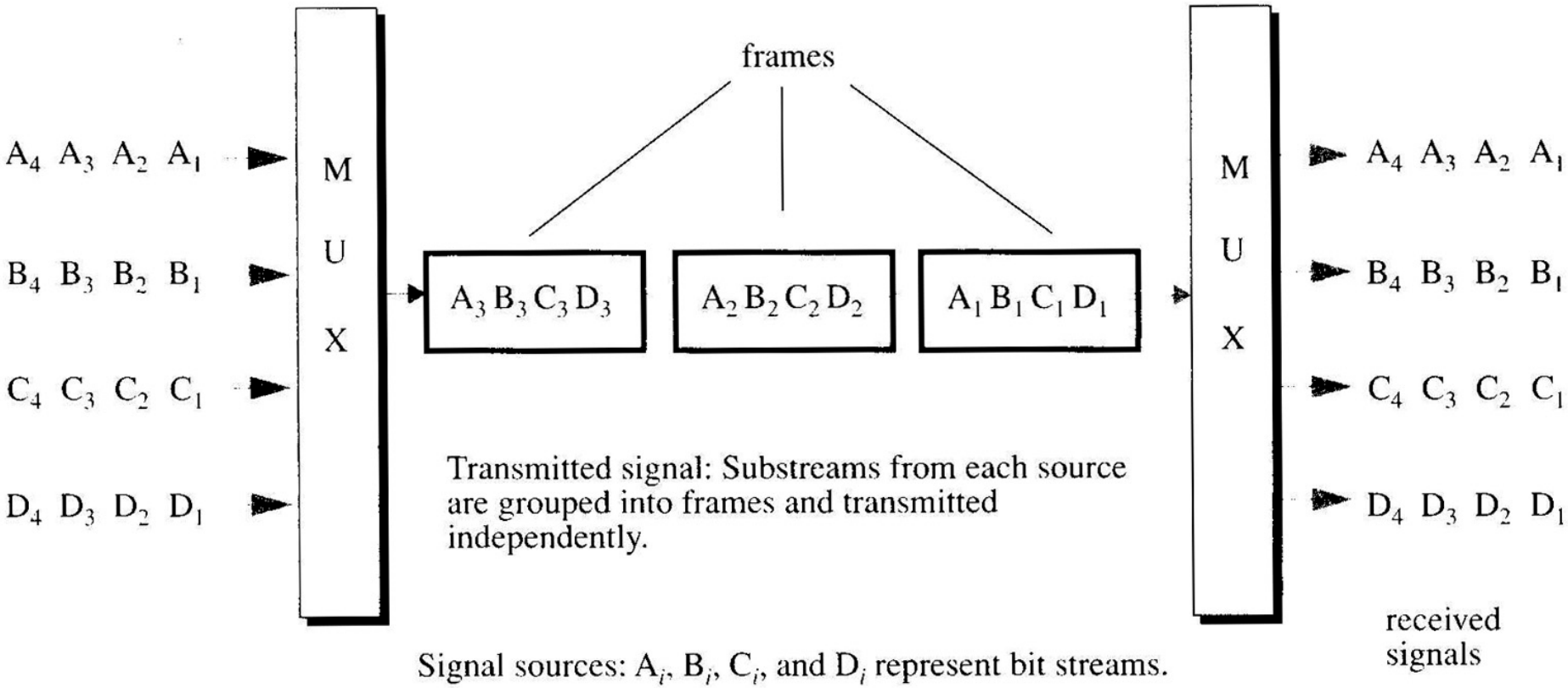


Time Division Multiplexing

- Used with digital signals
- T-1 and ISDN Telephone lines
- Data from each source is buffered.
- The multiplexer scans each buffer, taking a bit or byte from each source.
- The bits or bytes are used to construct a frame which is sent on the transmission media.
- The demultiplexer receives the frame and reverses the process.

Time Division Multiplexing (cont.)

- Frame (multiplexing): Time slots are grouped into frames. A frame consists of one complete cycle of time slots, including one or more slots dedicated to each sending device, plus framing bits.



Time Division Multiplexing (cont.)

- Example: T-1 Telephone Transmission
  - Uses time division multiplexing.
  - Voice is digitized into 8 bit samples at 8000 per second.
  - Transmission media is divided into 24 channels.
  - A frame of 24 voice signals requires 193 bits.
  - T-1 is 193 * 8000 or 1.544 Mbps.

Time Division Multiplexing (cont.)

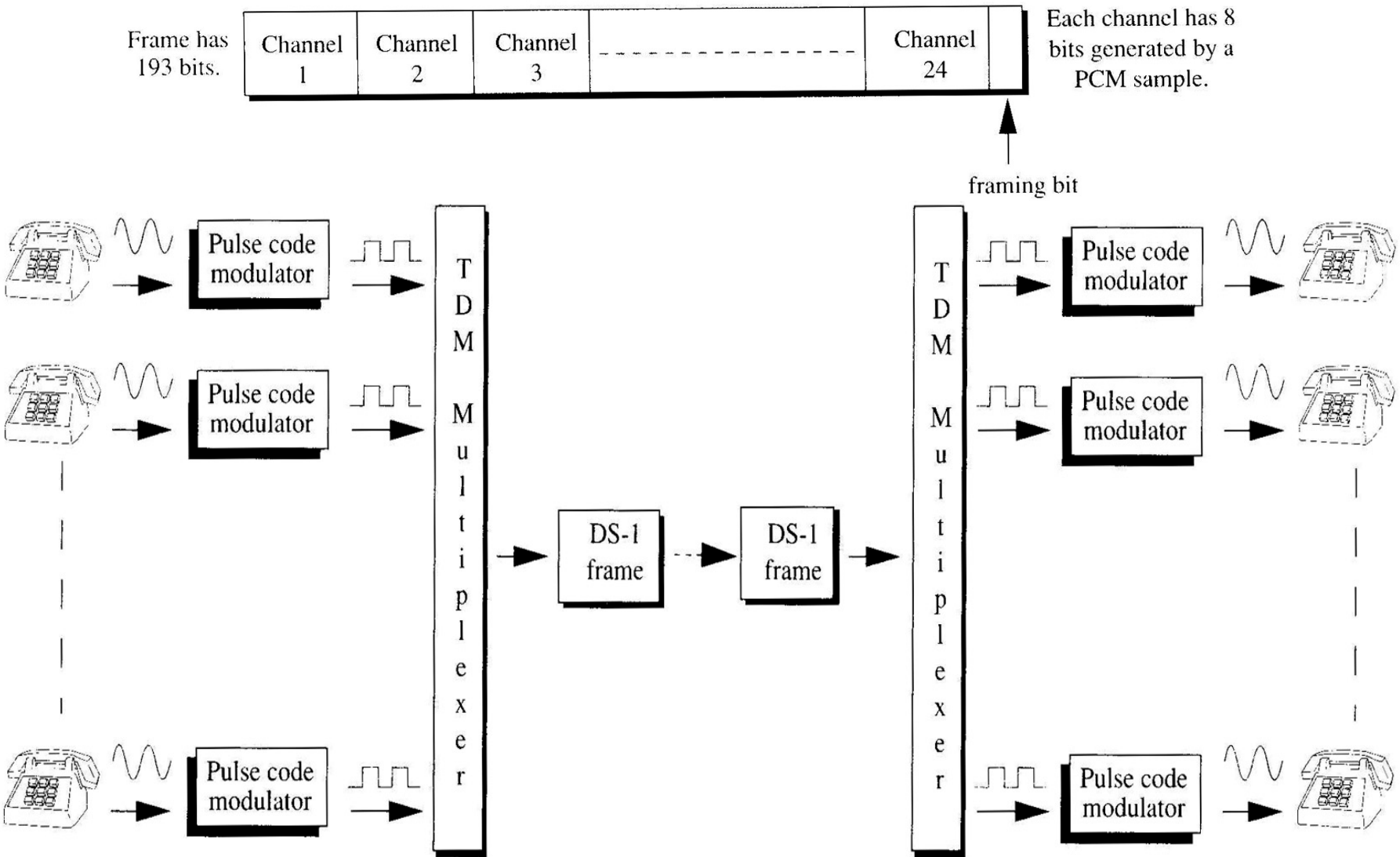
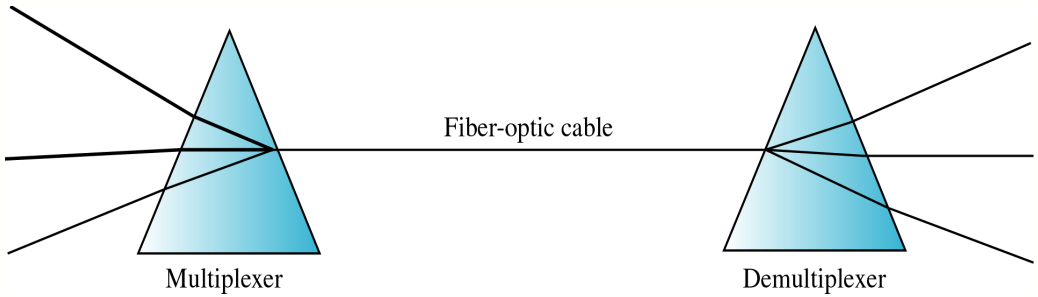
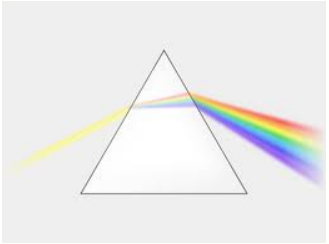


Figure 3.20 T-1 Carrier System

Wavelength-Division Multiplexing

- Conceptually same as FDM except that the multiplexing and demultiplexing involve light signals transmitted through fiber-optic channels
- Combines different optical signals with different wavelengths (frequencies)
- Combining and splitting of light sources are easily handled by a prism





en.wikipedia.org

Summary

- Serial/parallel transmission (one to one)
  - Asynchronous/synchronous serial transmission
- Directions
- Multiplexing (many into one, one into many)
  - FDM
  - TDM
  - WDM