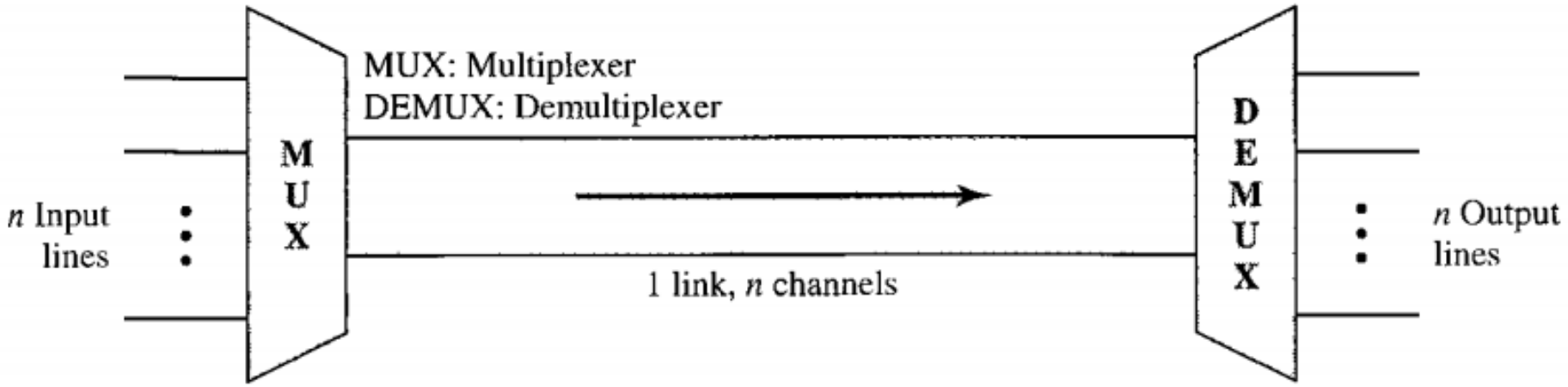
Multiplexing

- **Many to one/one to many**
- **Types of multiplexing**
- **Telephone system**

Multiplexing

- It is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link.
- Multiplexing is done using a device called Multiplexer (MUX) that combine *n* input lines to generate one output line i.e. (*many to one).*
- At the receiving end a device called Demultiplexer (DEMUX) is used that separate signal into its component signals i.e. one input and several outputs *(one to many).*

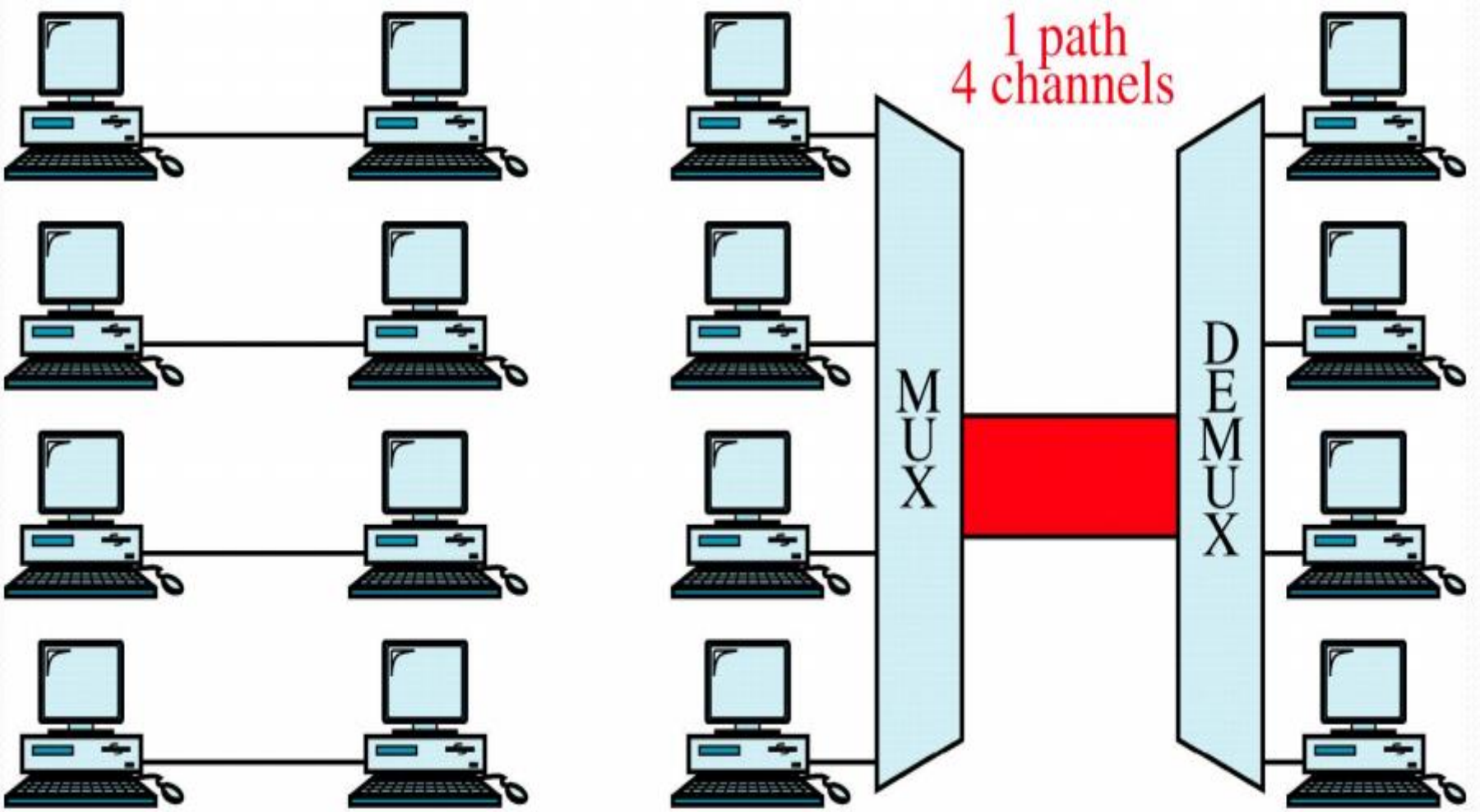
Multiplexing…



Advantages of Multiplexing

- More than one signals can be sent over single medium or link
- Effective use of the bandwidth of medium

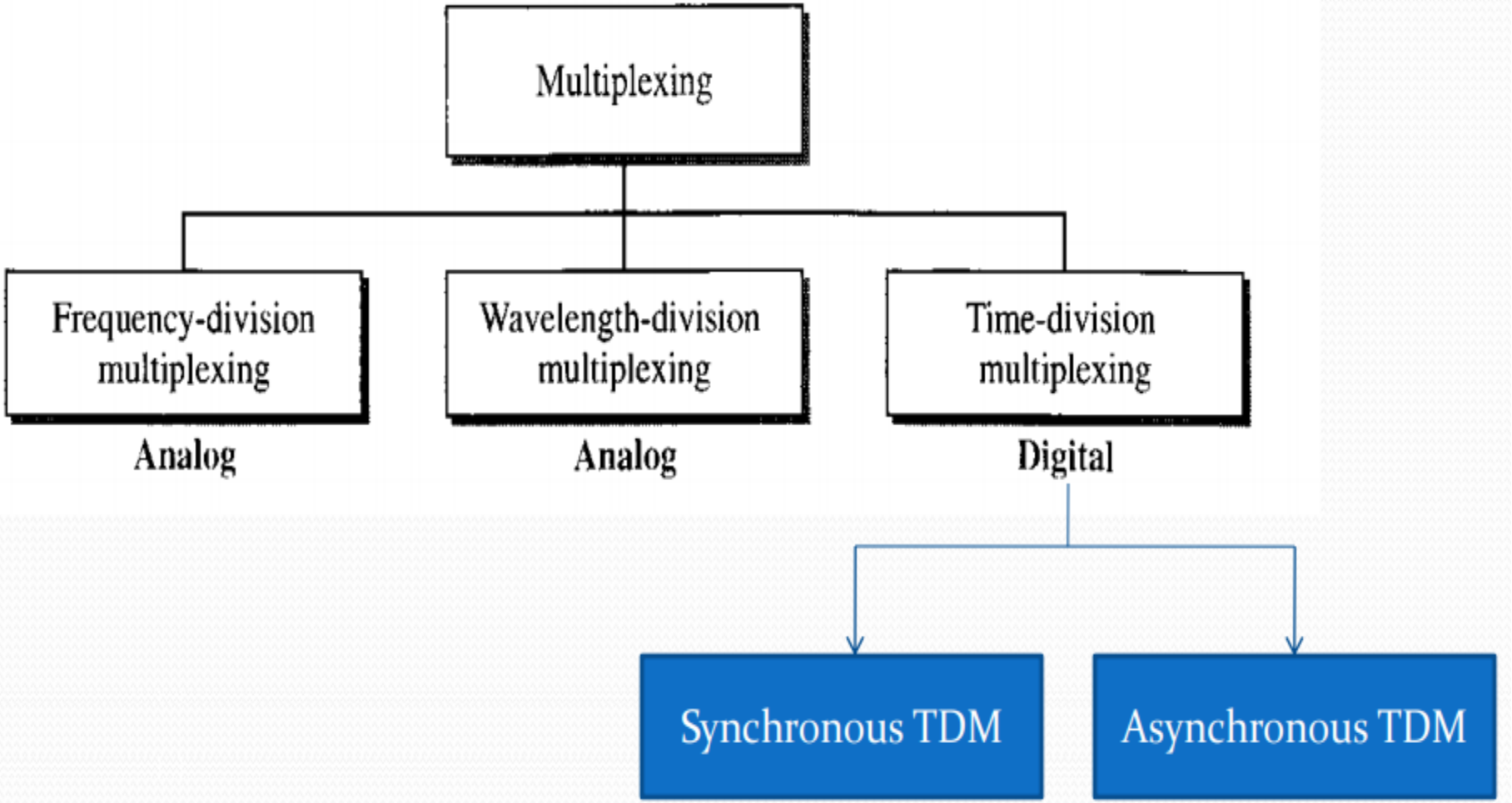
Multiplexing vs. No Multiplexing



a. No multiplexing

b. Multiplexing

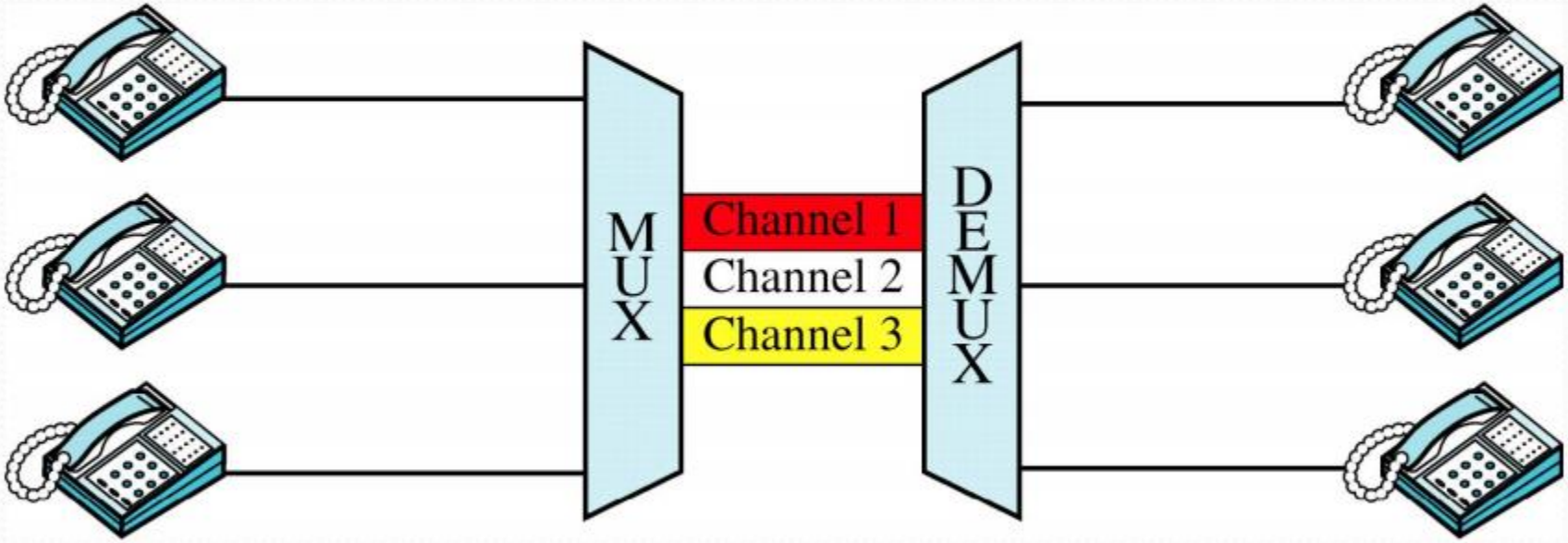
Types of Multiplexing



Frequency Division Multiplexing

- It is an analog technique.
- Signals of different frequencies are combined into a composite signal and is transmitted on the single link.
- Bandwidth of a link should be greater than the combined bandwidths of the various channels.
- Each signal is having different frequency.
- Channels are separated by the strips of unused bandwidth called *Guard Bands* (to prevent overlapping).

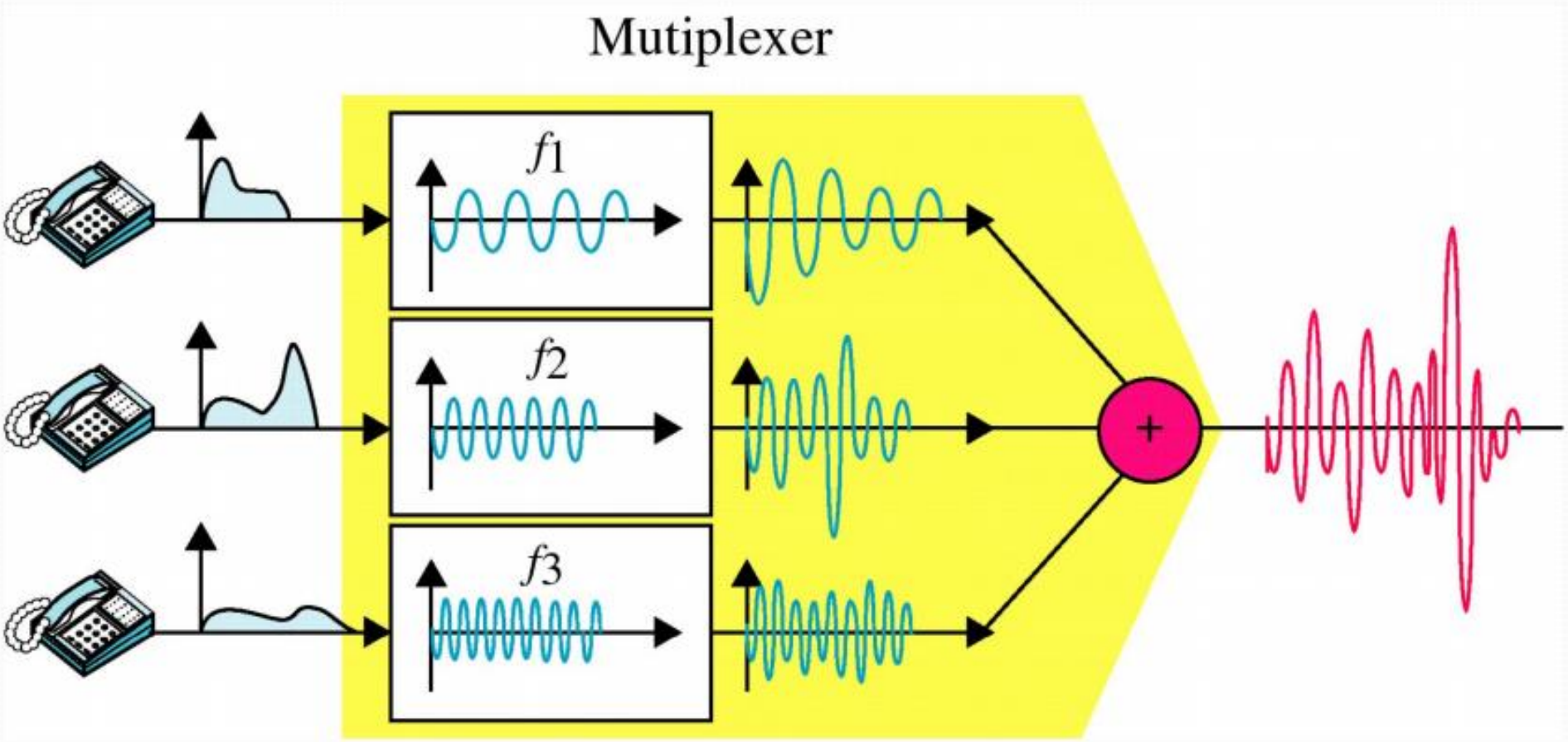
FDM



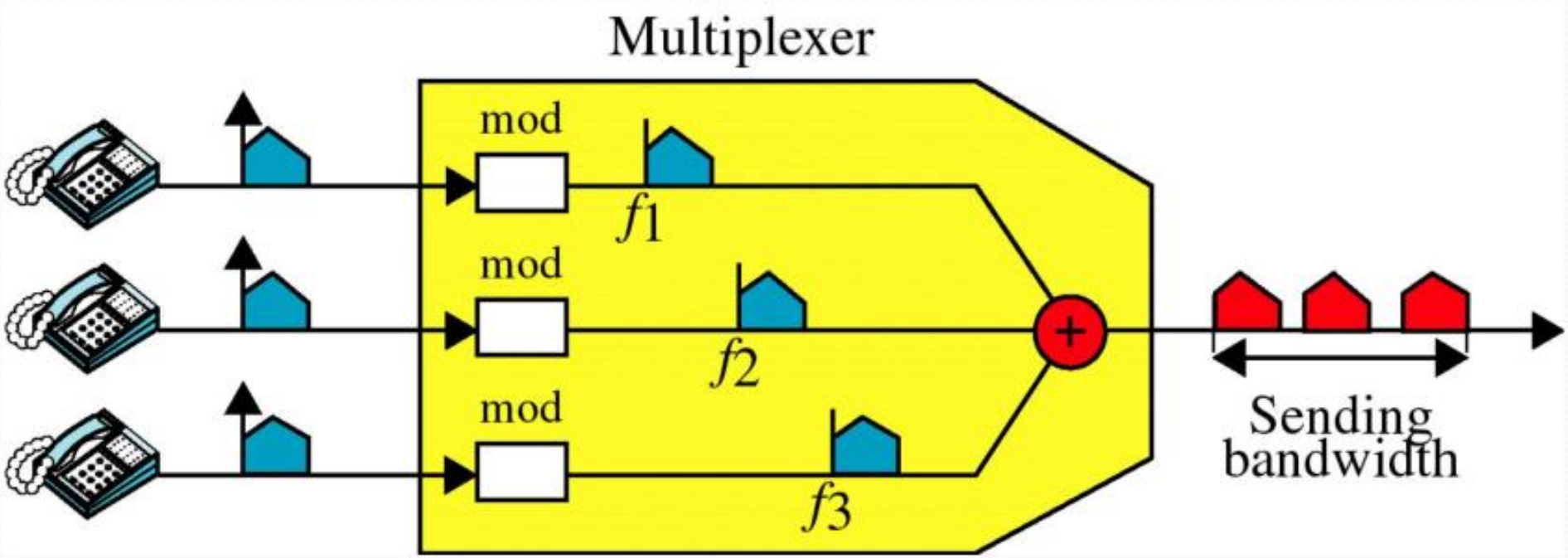
Applications of FDM

- FDM is used for FM & AM radio broadcasting.
- AM frequency = 530 to 1700 kHz.
- FM frequency = 88 to 108 MHz.
- FDM is used in television broadcasting.
- First generation cellular telephone also uses FDM.

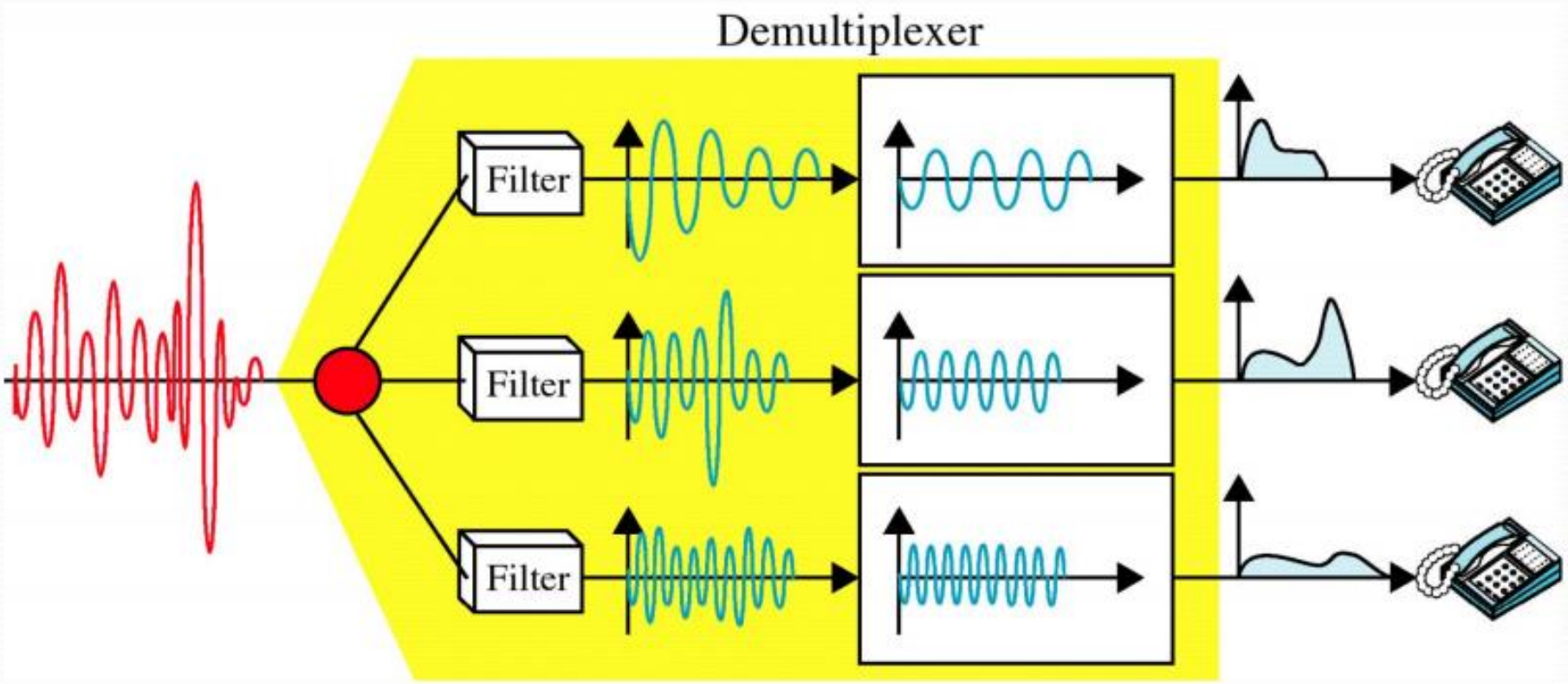
FDM, Time Domain



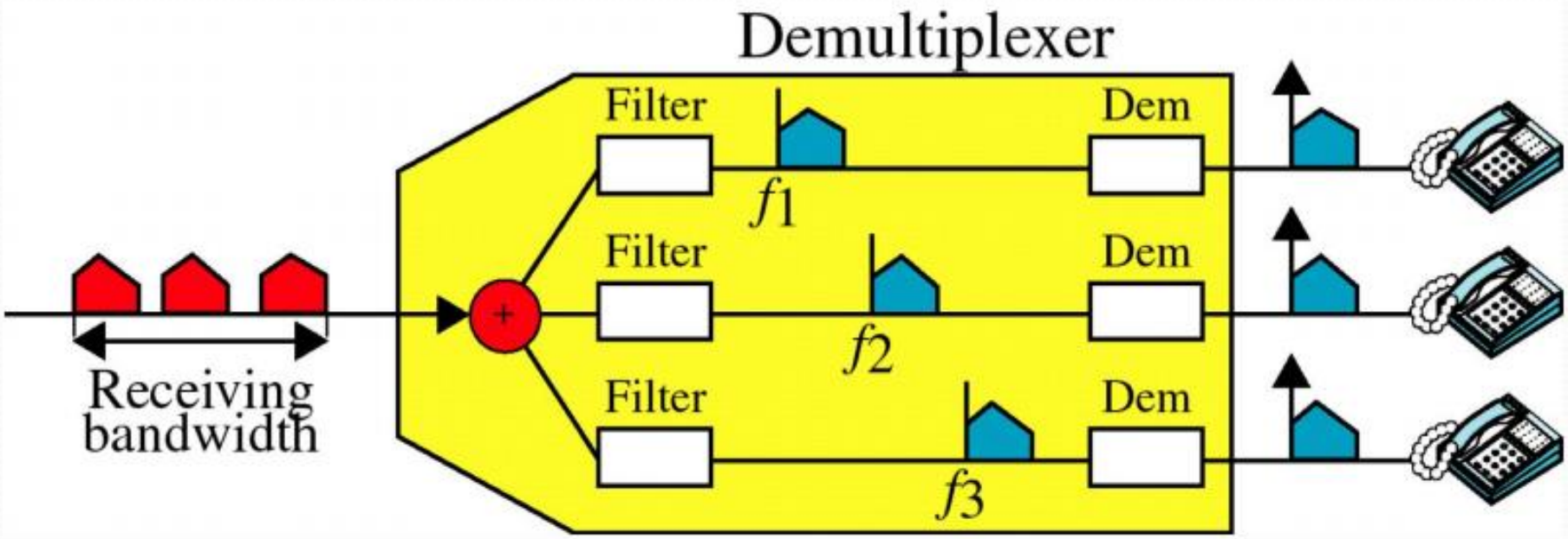
Multiplexing, Frequency Domain



Demultiplexing, Time Domain



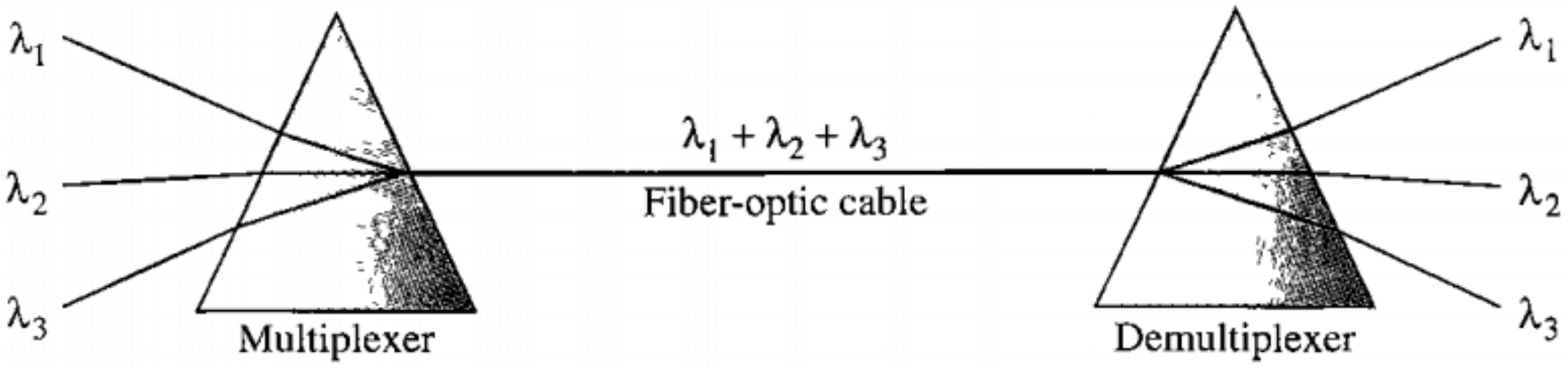
Demultiplexing, Frequency Domain



Wave Division Multiplexing

- WDM is an analog multiplexing technique.
- Working is same as FDM.
- In WDM different signals are *optical or light* signals that are transmitted through optical fiber.
- Various light waves from different sources are combined to form a composite light signal that is transmitted across the channel to the receiver.
- At the receiver side, this composite light signal is broken into different light waves by Demultiplexer.
- This Combining and the Splitting of light waves is done by using a PRISM. Prism bends beam of light based on the angle of incidence and the frequency of light wave.

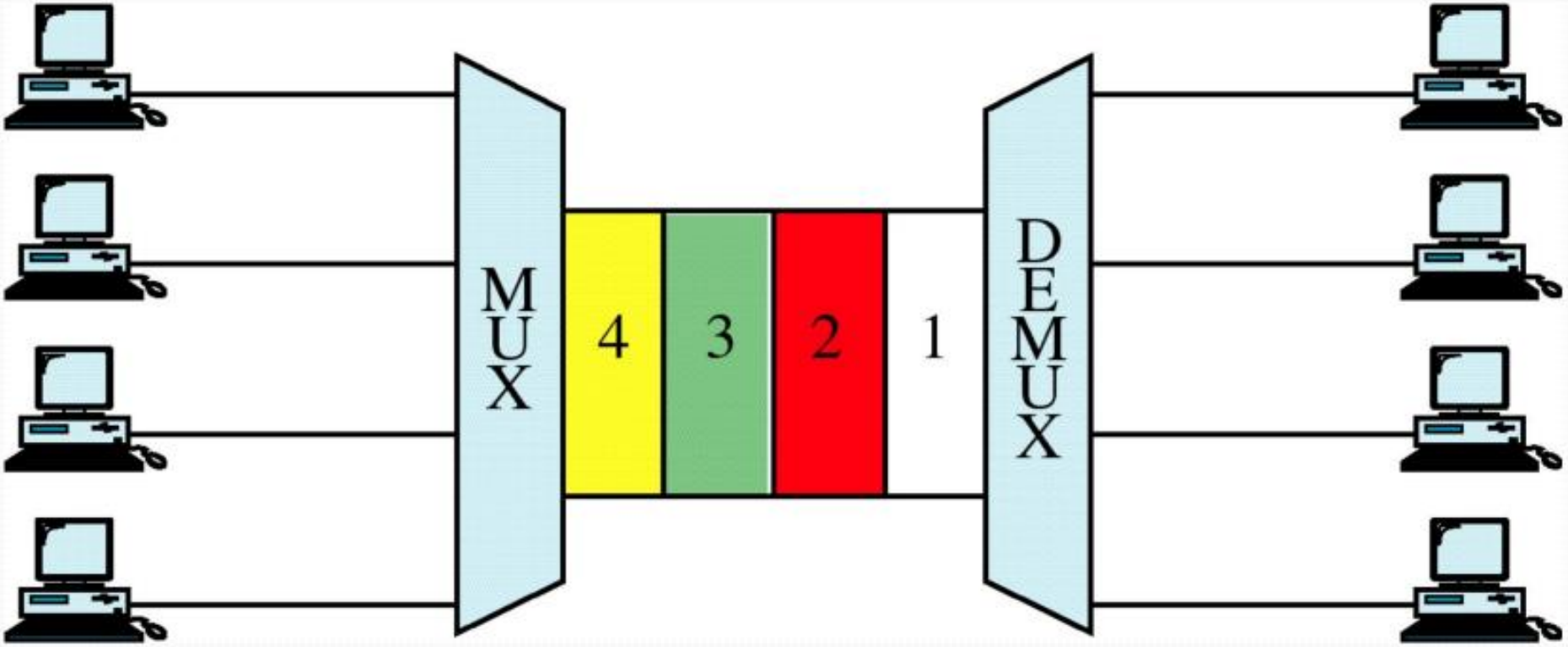
Wave Division Multiplexing…



Time Division Multiplexing

- It is the digital multiplexing technique.
- Channel/Link is not divided on the basis of *frequency* but on the *basis of time.*
- Total time available in the channel is divided between several users.
- Each user is allotted a particular time interval called *time slot* or *slice.*
- In TDM the data rate capacity of the transmission medium should be greater than the data rate required by sending of receiving devices.

TDM



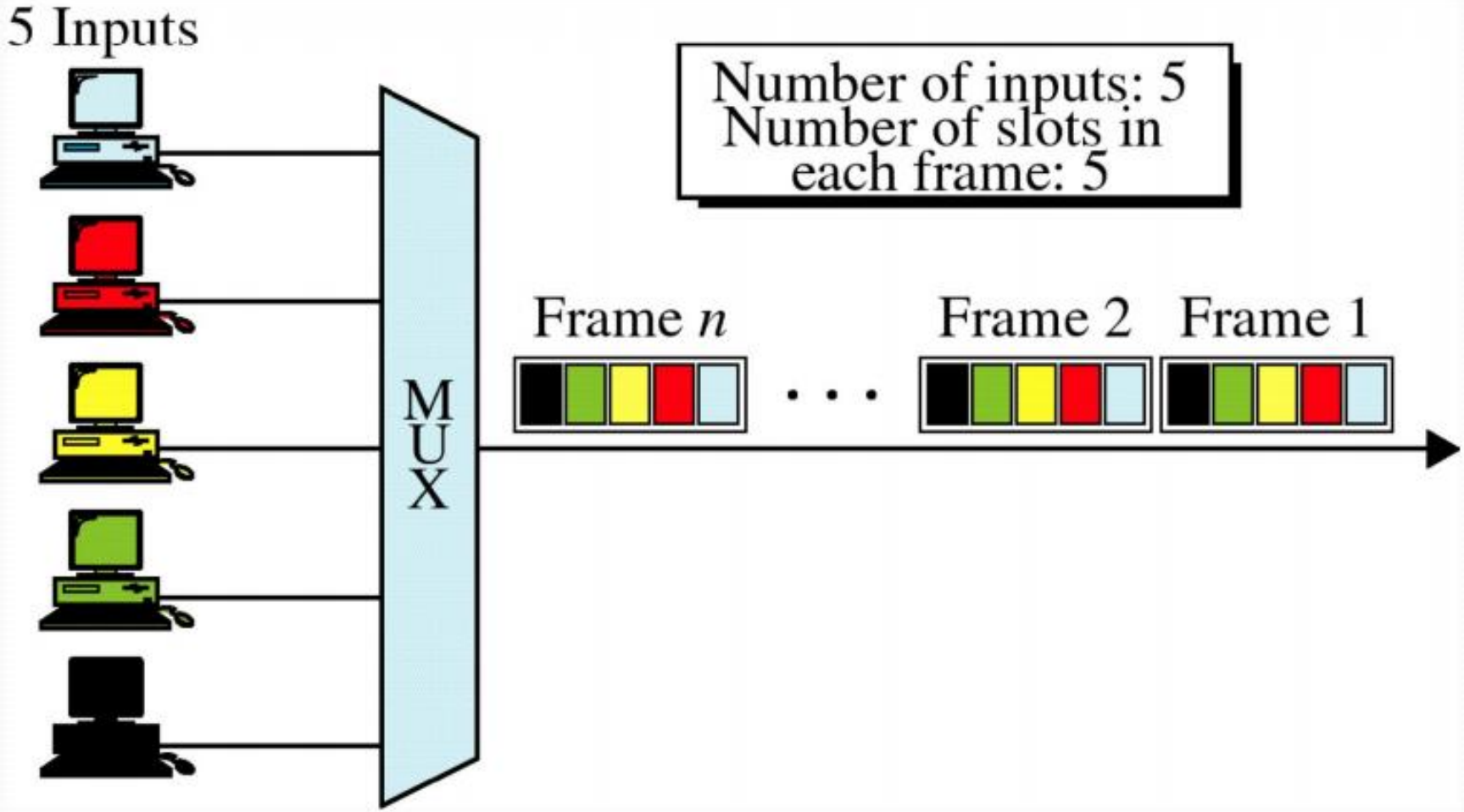
Types of TDM

- Synchronous TDM
- Asynchronous TDM

Synchronous TDM

- Each device is given same Time Slot to transmit the data over the link, whether the device has any data to transmit or not.
- Each device places its data onto the link when its *Time Slot* arrives, each device is given the possession of line turn by turn.
- If any device does not have data to send then its time slot remains empty.
- Time slots are organized into *Frames* and each frame consists of one or more time slots.
- If there are *n* sending devices there will be *n* slots in frame.

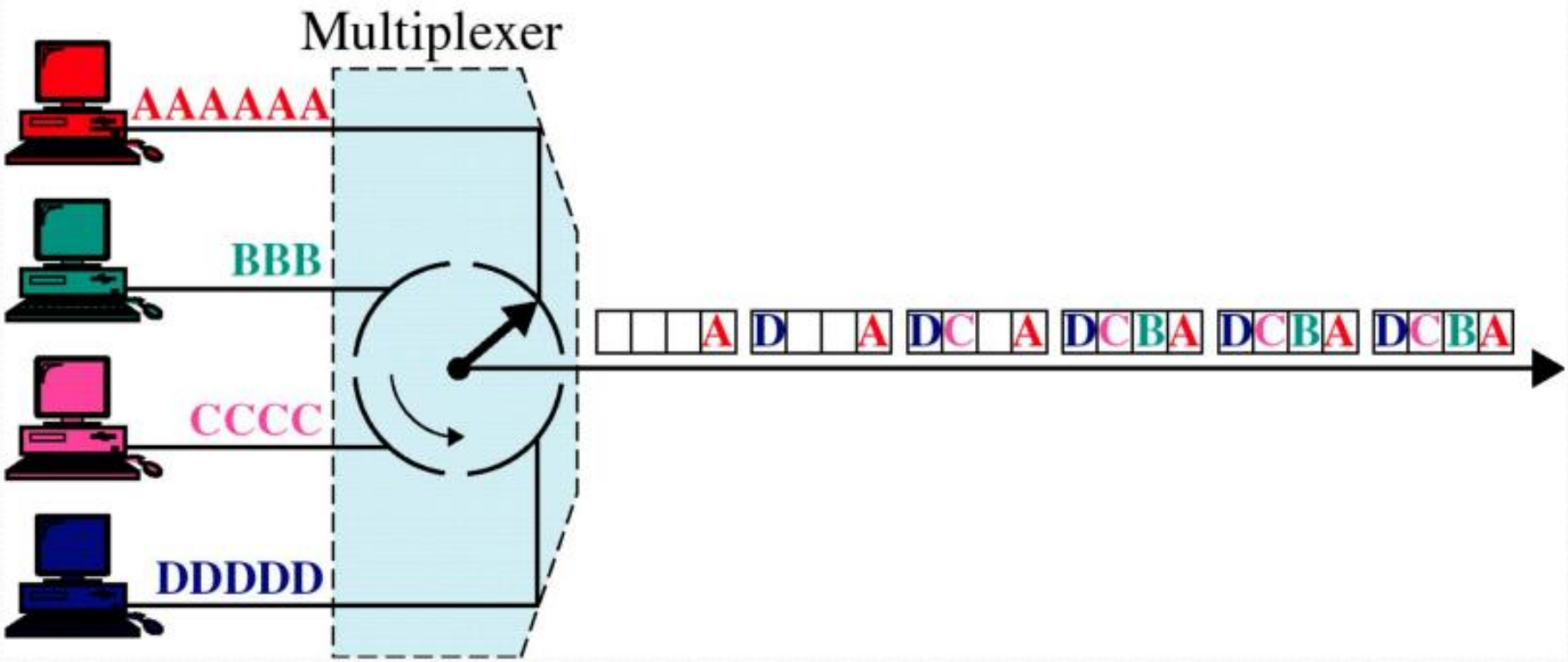
Synchronous TDM



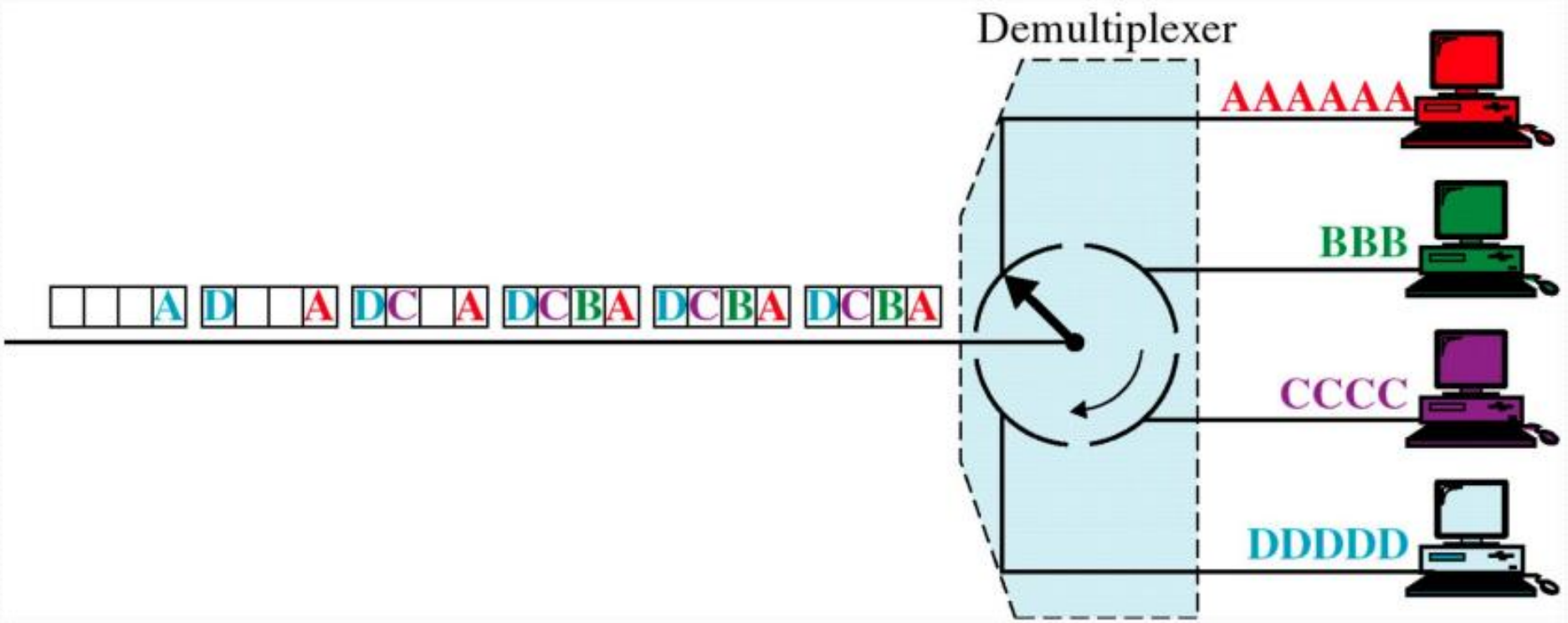
Multiplexing Process in STDM

- In STDM every device is given opportunity to transmit a specific amount of data onto the link.
- Each device gets its turn in fixed order and for fixed amount of time = INTERLEAVING.
- Interleaving is done by a character (one byte).
- Each frame consist of four slots as there are four input devices.
- Slots of some devices go empty if they do not have any data to send.

TDM, Multiplexing



TDM, Demultiplexing

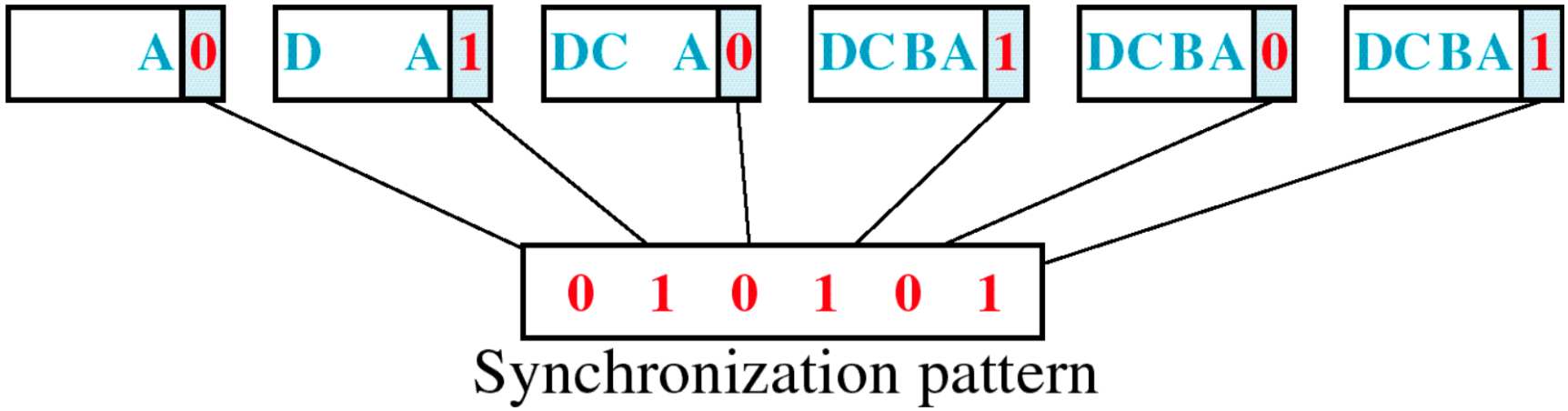


Disadvantages of STDM

- The channel capacity cannot be fully utilized. Some of the slots go empty in certain frames.

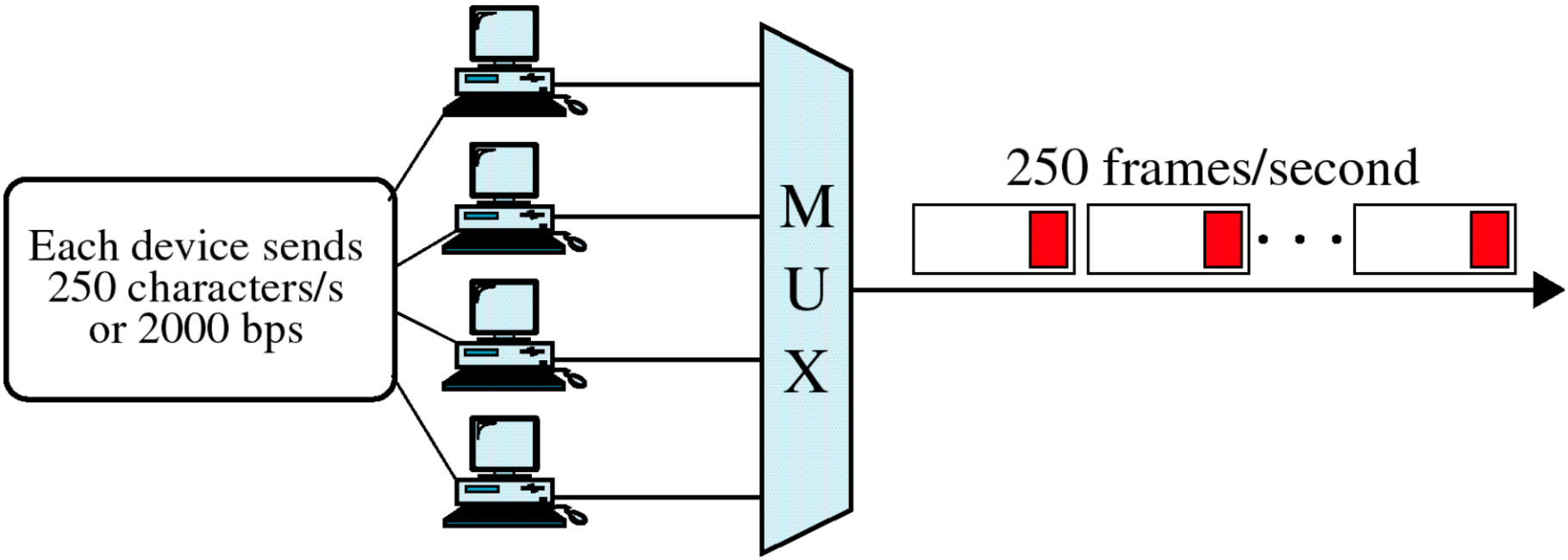
Framing Bits

The implementation of TDM is not as simple as that of FDM. Synchronization between the multiplexer and demultiplexer is a major issue. If the multiplexer and the demultiplexer are not synchronized, a bit belonging to one channel may be received by the wrong channel. For this reason, one or more synchronization bits are usually added to the beginning of each frame. These bits, called **framing bits,** follow a pattern, frame to frame, that allows the demultiplexer to synchronize with the incoming stream so that it can separate the time slots accurately. In most cases, this synchronization information consists of 1 bit per frame, alternating between 0 and 1, as shown in Figure 6.22.



Data Rate

8250 bps = 250 frames/second x 33 bits/frame
or
8250 bps = 4 x 2000 bps + 250 synchronization bps

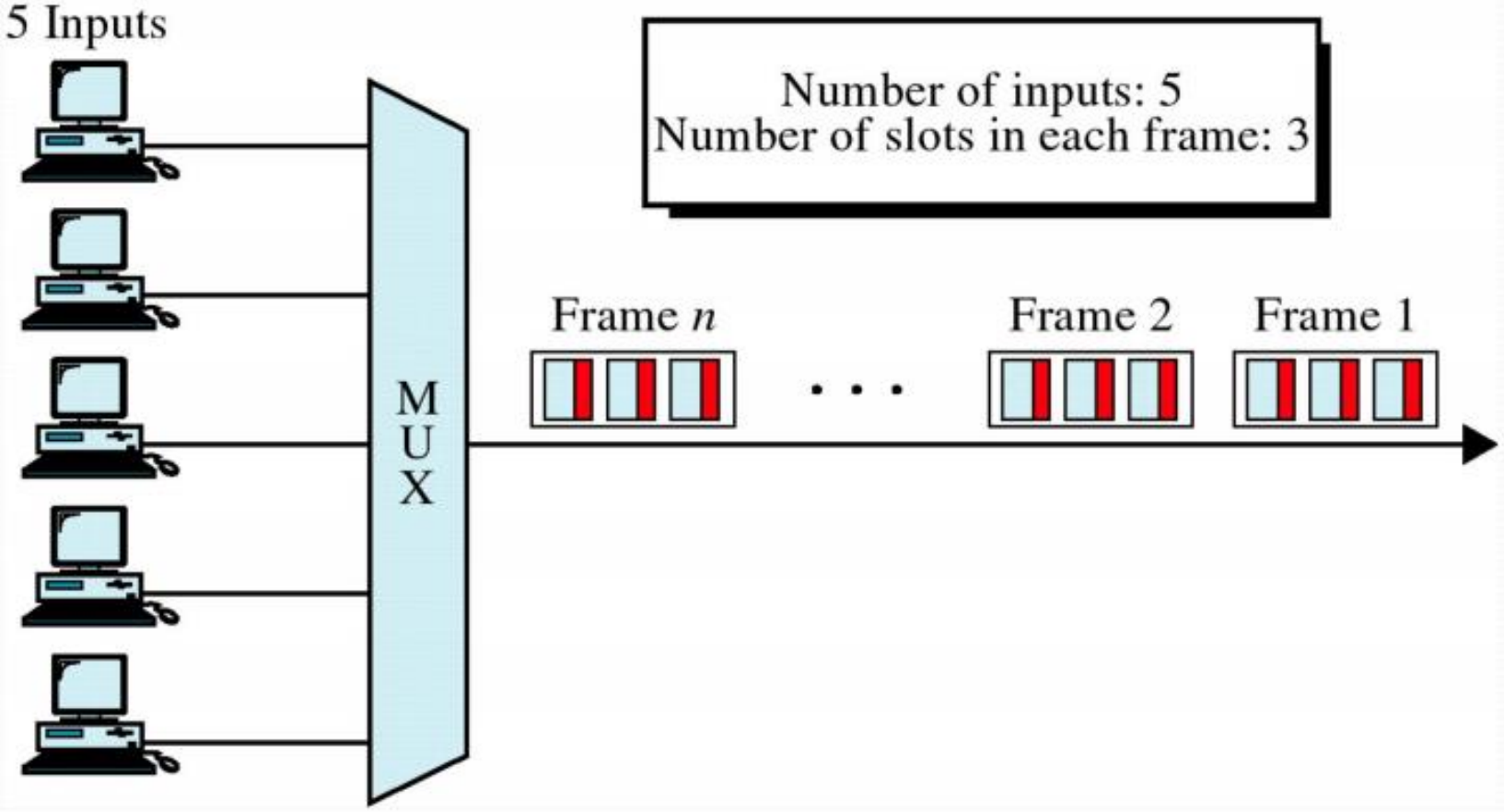


In synchronous TDM, the data rate of the link is *n* times faster, and the unit duration is *n* times shorter.

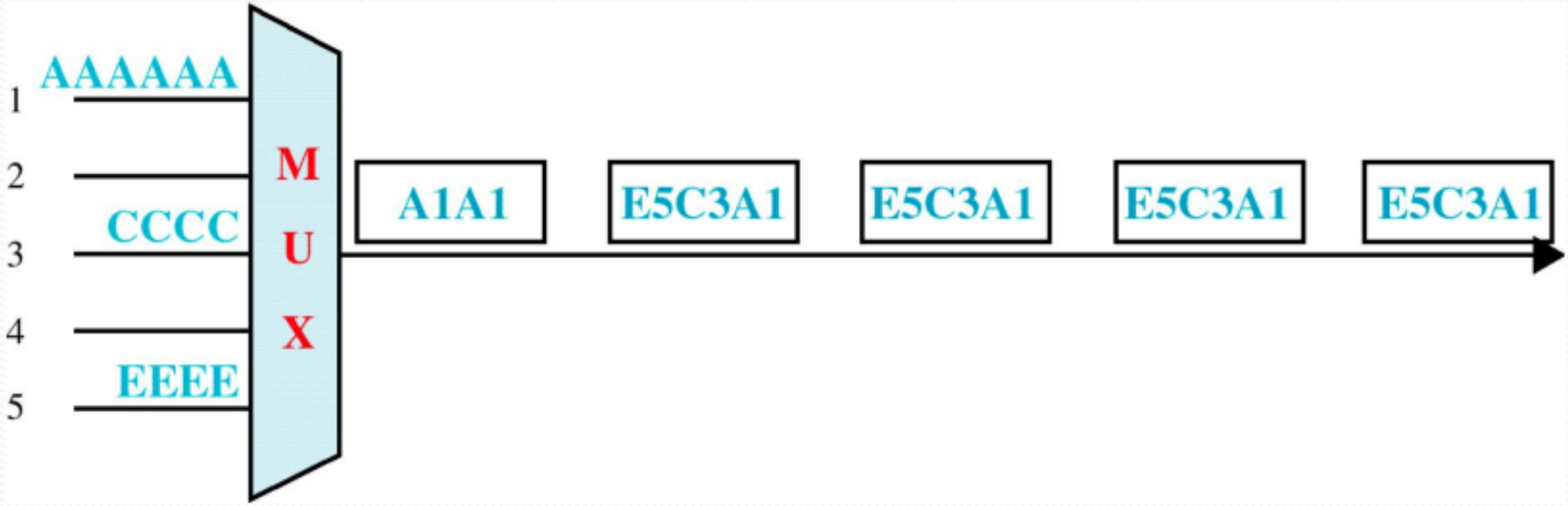
Asynchronous TDM

- Also known as Statistical Time Division *multiplexing*.
- In this time slots are not *Fixed* i.e. slots are Flexible.
- Total speed of the input lines can be greater than the capacity of the path.
- In ASTDM we have *n* input lines and *m* slots i.e. *m* less than *n* (*m*<*n*).
- Slots are not predefined rather slots are allocated to any of the device that has data to send.

Asynchronous TDM

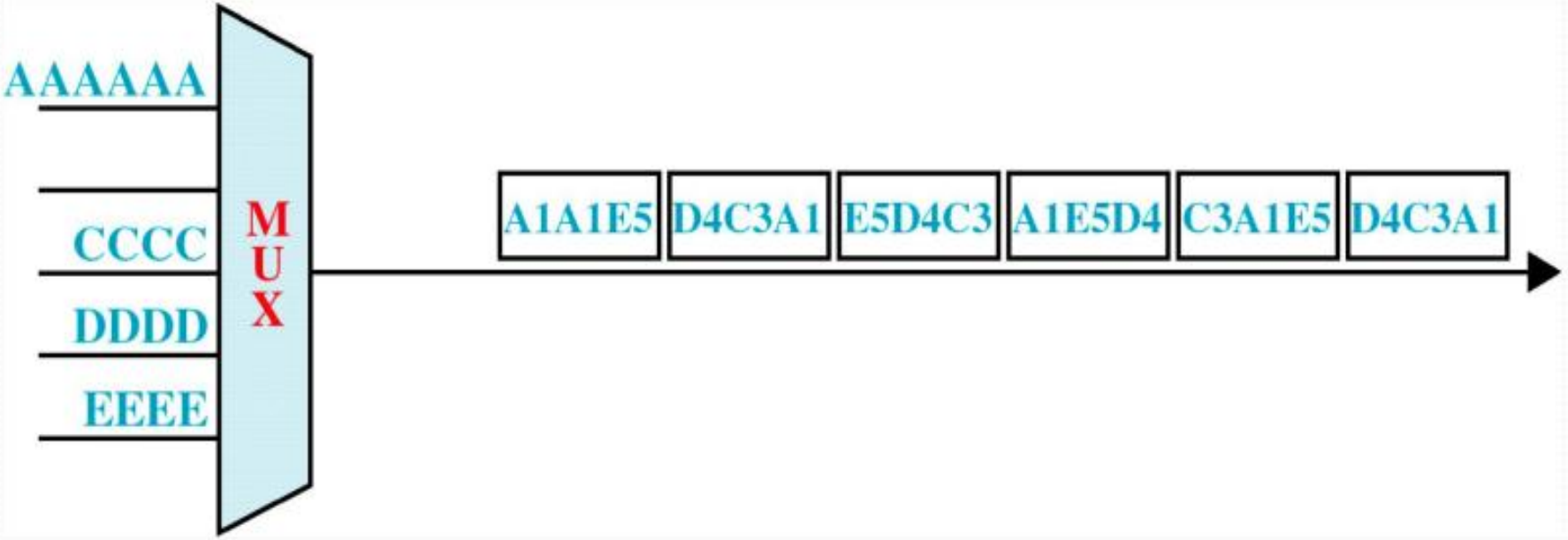


Frames and Addresses



a. Only three lines sending data

Frames and Addresses

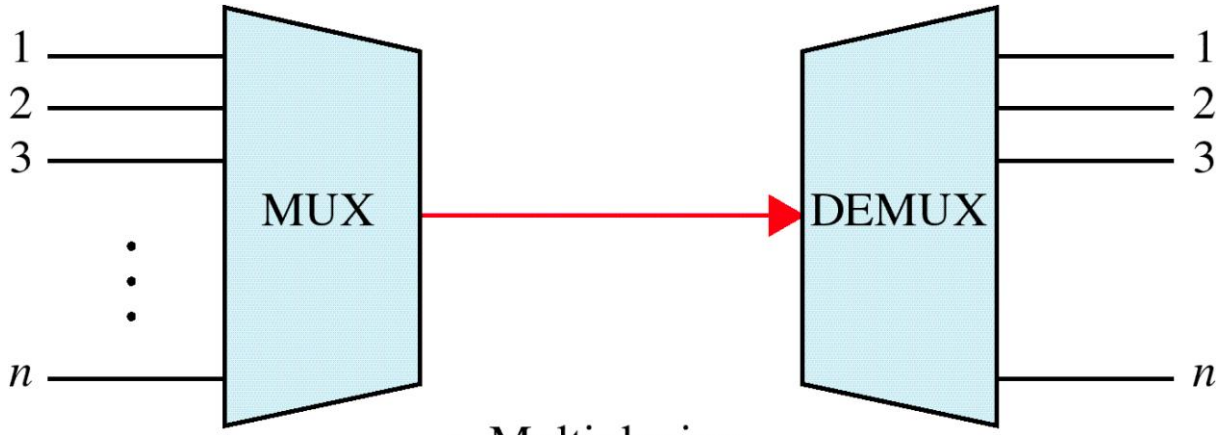


b. Only four lines sending data

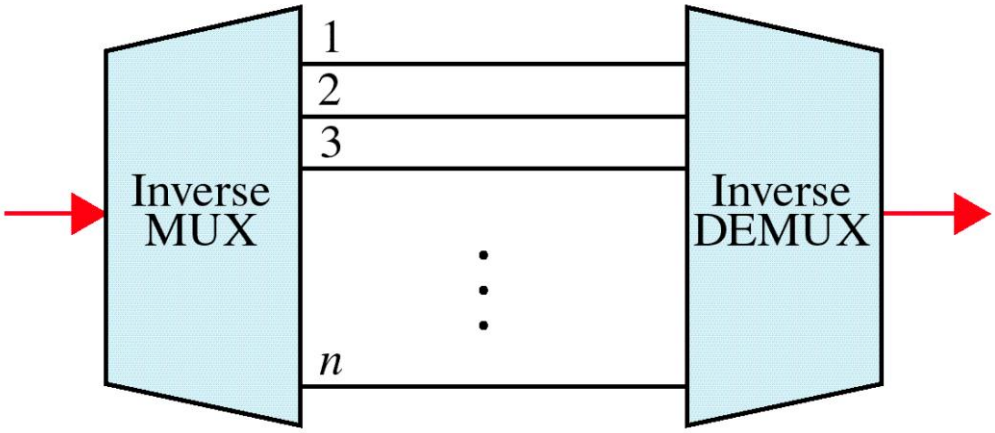
Frames and Addresses

c. All five lines sending data

Multiplexing and Inverse Multiplexing



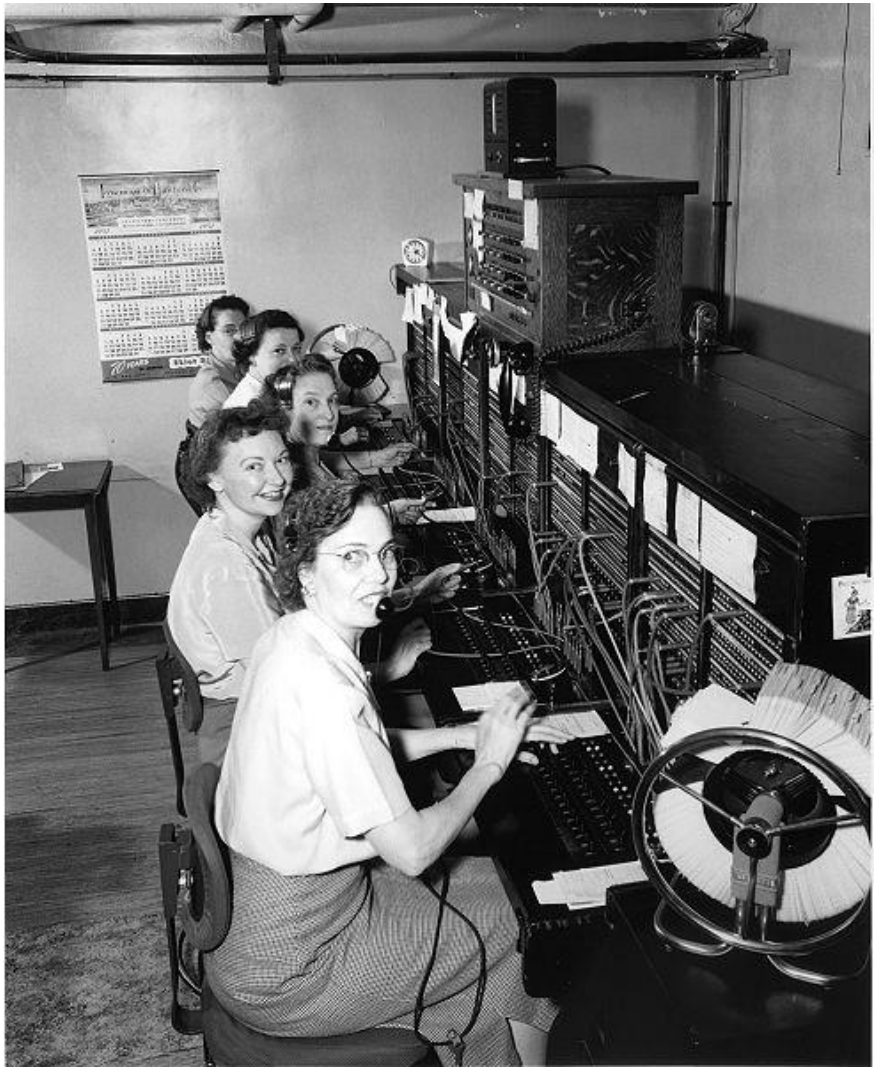
a. Multiplexing



b. Inverse multiplexing

Telephone Network

Example of Old-Style Circuit Switch



Example of Current-Style Circuit Switch

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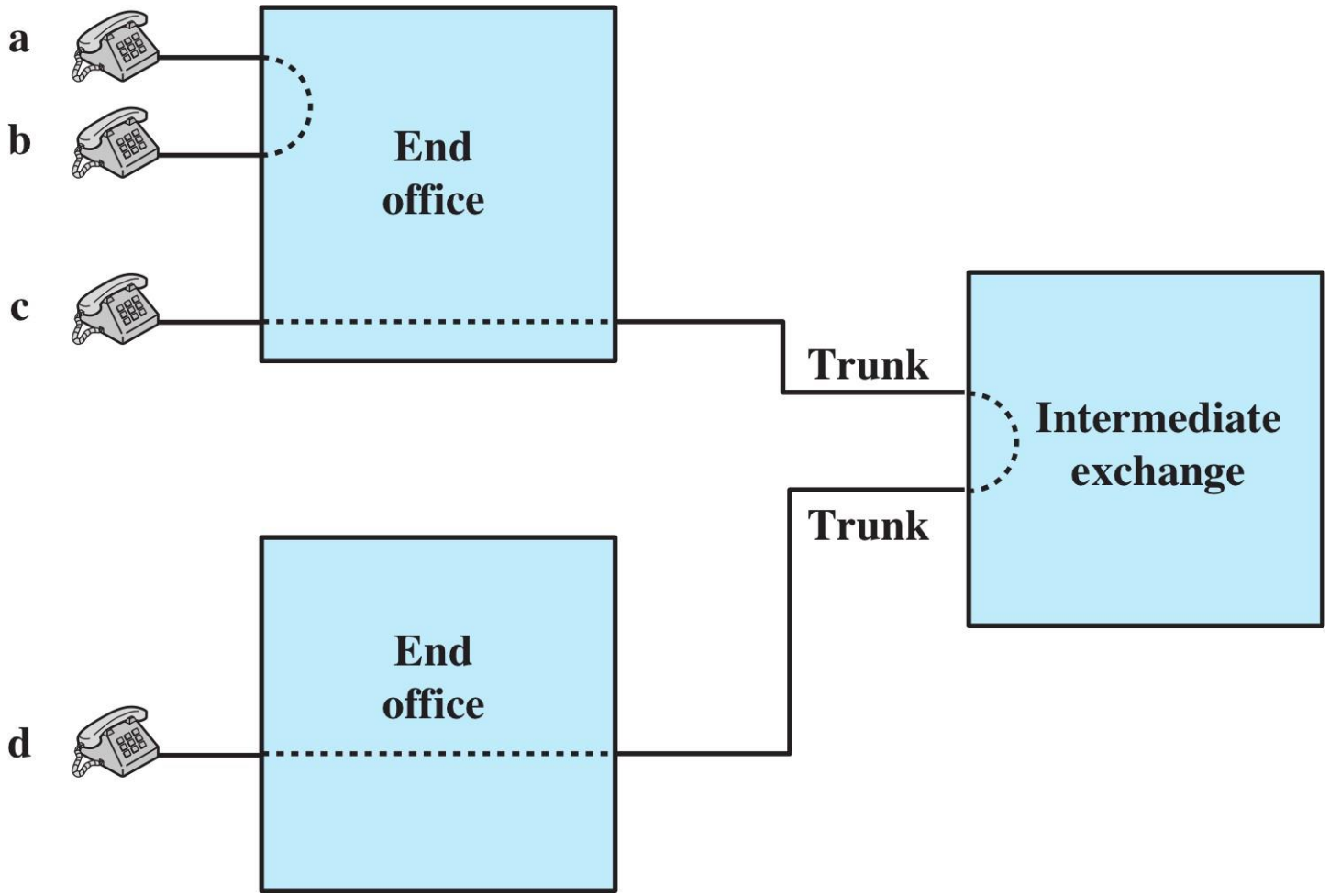
Circuit Switching Networks

- Dedicated communications path between two stations; path is sequence of links between nodes
- On each physical link, logical channel allocated to connection
- Three phases:
  1. Circuit establishment: Create station-to-station circuit, allocating resources as needed
  2. Data transfer: Analog or digital data transmitted from station to station
  3. Circuit disconnect: Circuit is terminated, de-allocation of resources

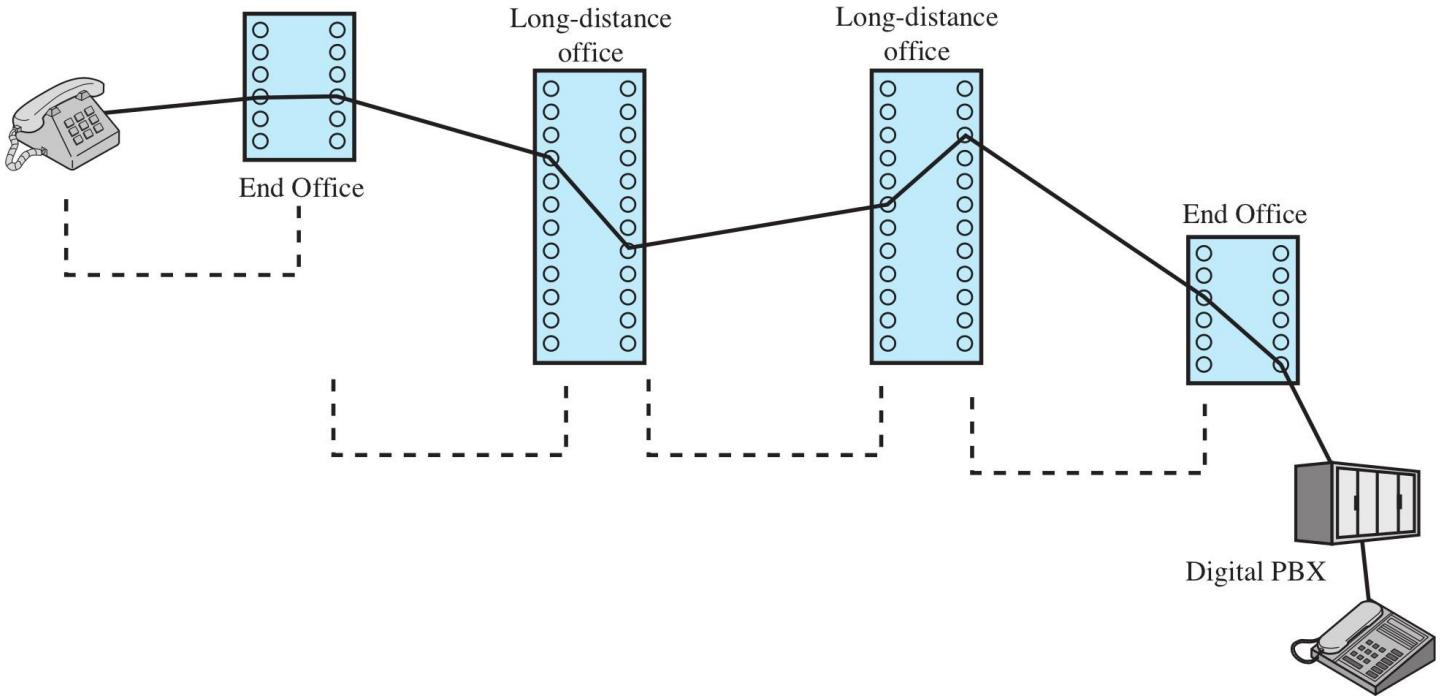
Circuit Switching Networks

- Path established before data transfer begins; channel capacity must be reserved between each pair of nodesin path, and switching capacity allocated at each switching node
- Developed to handle voice traffic, but also used for data traffic
- Examples: public telephone network, private telephone networks, prviate data networks

Circuit Establishment



Example Connection Over a Public Circuit-Switching Network



Issues in Circuit-Switching

Efficiency

- Resources reserved for duration of connection (capacity in all links, circuit in all switches)
- Inefficient if applications do not use the capacity

Quality

- Data rate, delay guaranteed for duration of connection

Link Speeds

- End devices must be the same speed