MULTIPLEXING & MULTIPLE ACCESS

Multiplexing

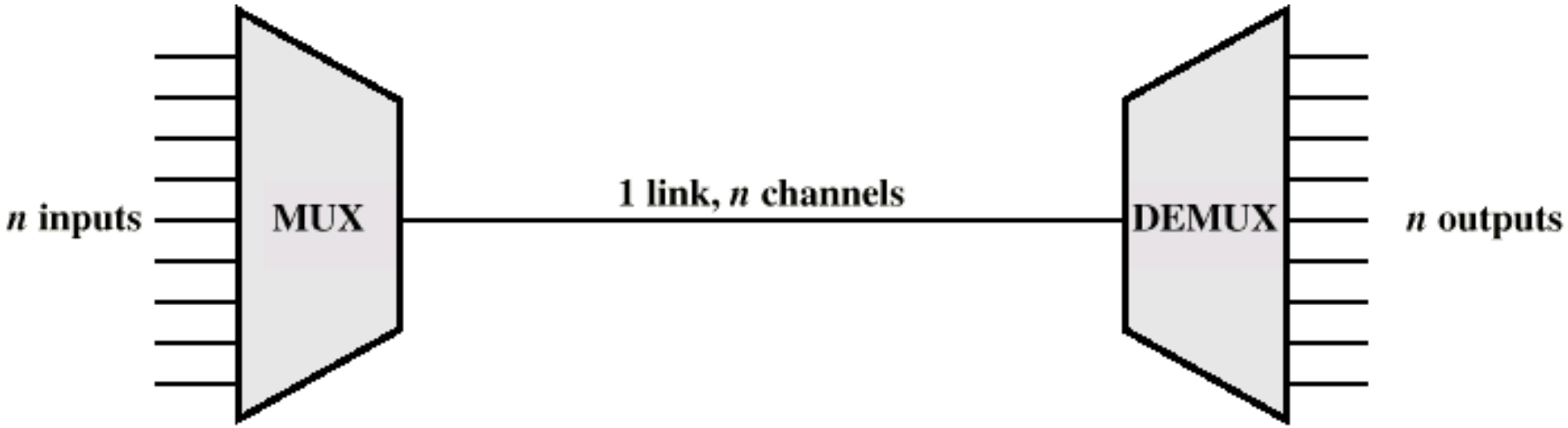
- Multiplexing is a technique by which several low bandwidth channels are combined into one channel with a larger bandwidth.
- It is a technique(s) that makes efficient use of transmission medium by allowing multiple signals to be carried on a single medium.

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

- Two or more simultaneous transmissions on a single circuit.
  - **Transparent to end user.**
- *Multiplexing costs less*.



The Concept of Multiplexing

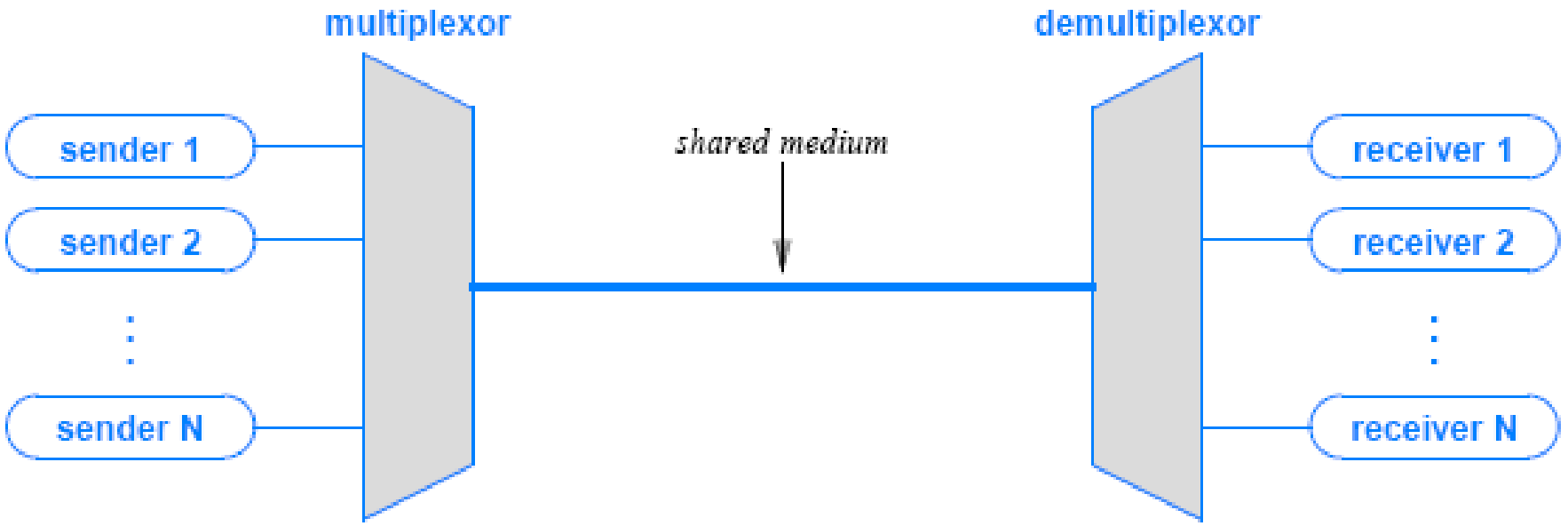
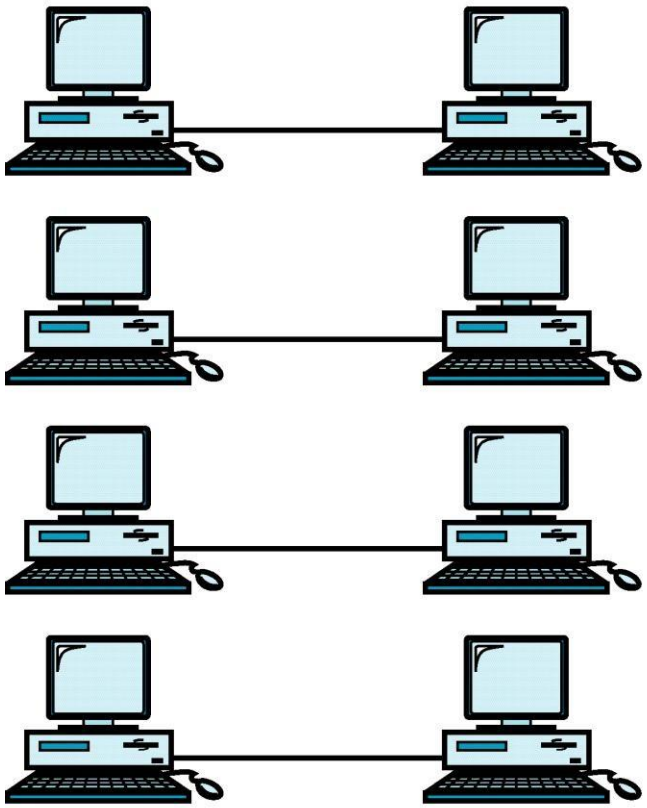
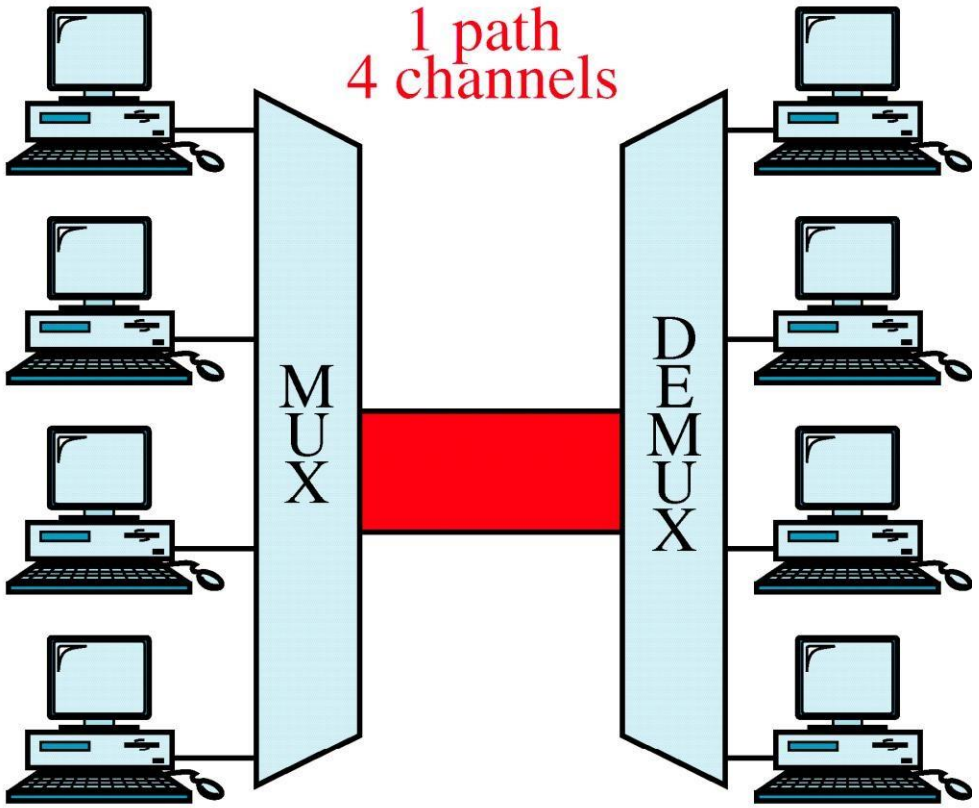


Figure 11.1 The concept of multiplexing in which independent pairs of senders and receivers share a transmission medium.

Multiplexing vs. No Multiplexing



a. No multiplexing



b. Multiplexing

Why Need Multiplexing

- Multiplexing can be used :
    - To send a large number of signals simultaneously.
    - Reduce the cost of transmission
    - To make effective use of the available bandwidth

Advantages of Multiplexing

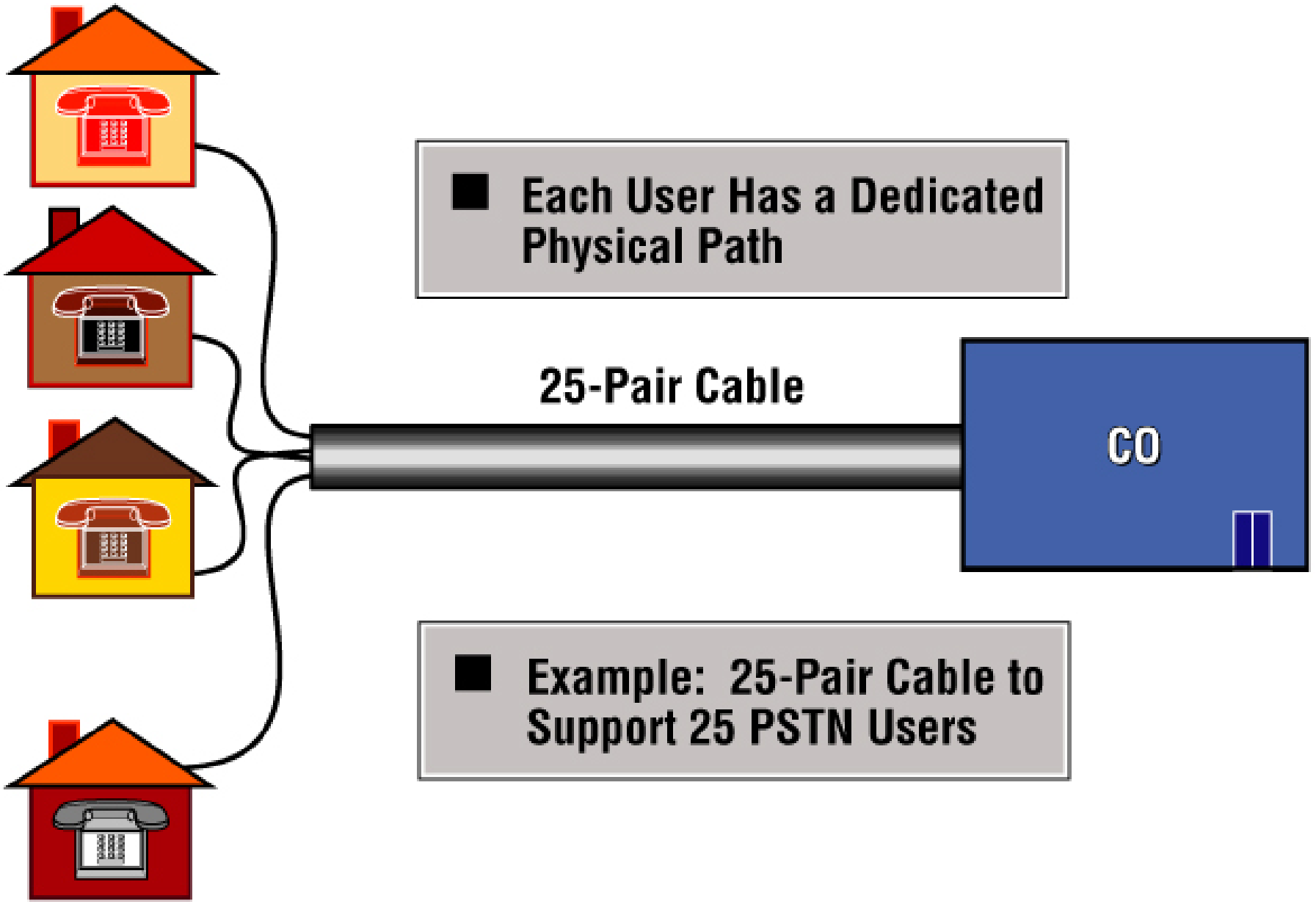
- More than one signals can be sent over single medium or link
- Effective use of the bandwidth of medium

Space Division Multiplexing

- The earliest multiplexing technique in which separate pair of wires used for the source to destination end is called Space-division multiplexing.
- In the early telephone days, each conversation was carried on a separate pairs of wires this approach is known as space division multiplexing.

Space division multiplexing (SDM)

- **Space division multiplexing** (SDM) is nothing more than the provision of multiple fixed bandwidth channels by multiple physical paths (i.e., pairs of wires or optical fibers).
- A good example of SDM is the use of a 25-pair cable to carry the conversations of 25 individual users from the customer's premises to the local telephone company’s central office location.


Each User Has a Dedicated Physical Path
25-Pair Cable
CO
Example: 25-Pair Cable to Support 25 PSTN Users

- Suppose that if you want to see two television channels like Discovery and ARY using Space-division multiplexing you would need two television set, each connected to a separate wire. On one set you could see Discovery on the other ARY. You cannot see both channels in one one set because space division multiplexing requires a separate physical path for each signal.

ADVANTAGES AND DISADVANTAGES

Space Division Multiplexing has three advantages.

- Simple and straightforward.
- Can be very economical over short physical distances, because no physical equipment is needed other than the wires.
- Using separate circuits minimizes the interference among signals being carried between the same two points.

Disadvantages

- Cost and waste.
- It can be very expensive, because lots of wires and poles are required.
- Maintaining space-division multiplex systems is often costly because of the number and length of circuits.
- Wasteful of available bandwidth.

Multiplexing process

Each source generates a signal of a similar frequency range. Inside the multiplexer, these similar signals modulates different frequencies (f1, f2, and f3). The resulting modulated signals are then combined into a composite signal that is sent out over a media link that has enough bandwidth to accommodate it.

Multiplexor

- A device that combines n input lines into one single line (many to one).

Demultiplexing

- The demultiplexer uses a series of filters to decompose the multiplexed signal. The individual signals are then passed to demodulator that separates them from their carriers and passes them to the output lines.
- **Demultiplexor**
- A device that separates one single line into n output lines (one to many).

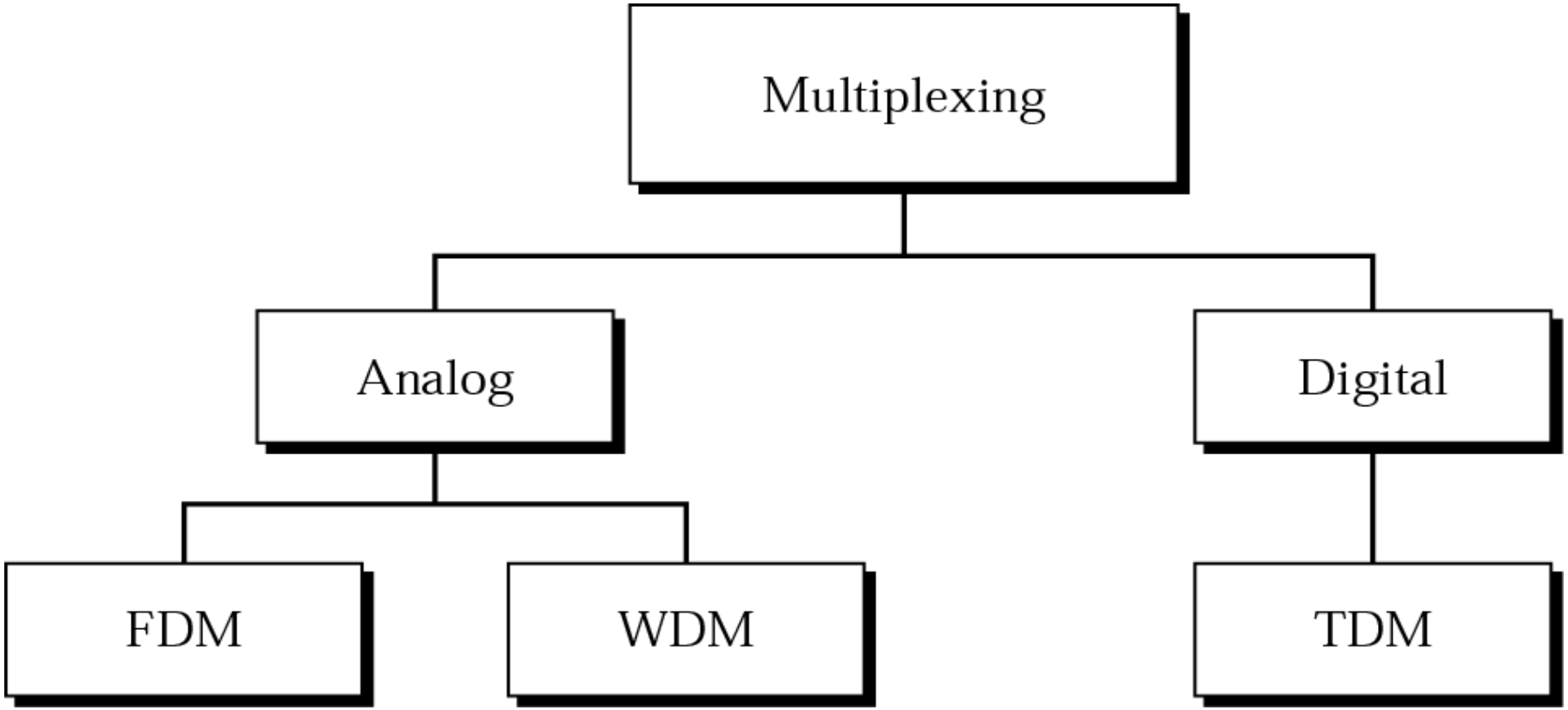
Advantages

- It does not need synchronization between its transmitter and receiver.
- Frequency division multiplexing (FDM) is simpler and easy demodulation.
- Due to slow narrow band fading only one channel gets affected.
- It is used for analog signals.
- A large number of signals (channels) can be transmitted simultaneously.

Disadvantages

- It suffers problem of cross-talk.
- It is used only when a few low speed channels are desired.
- Intermodulation distortion takes place.

Categories of multiplexing



Frequency Division Multiplexing (FDM)

In analog multiplexing, the most used technique is Frequency Division Multiplexing FDM. This technique uses various frequencies to combine streams of data, for sending them on a communication medium, as a single signal.

- **Example:** A traditional television transmitter, which sends a number of channels through a single cable, uses FDM.

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).

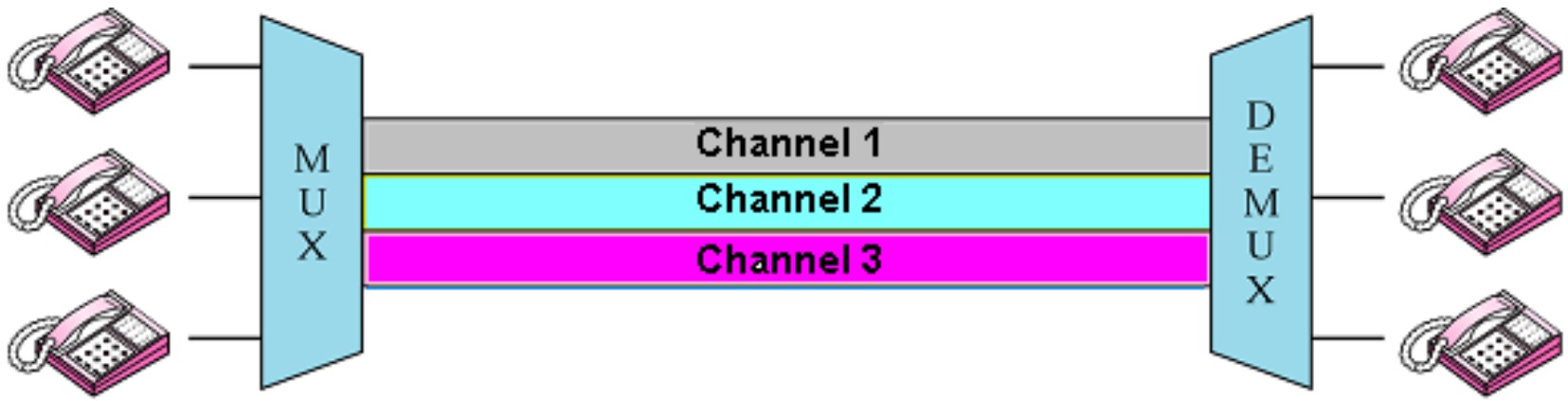
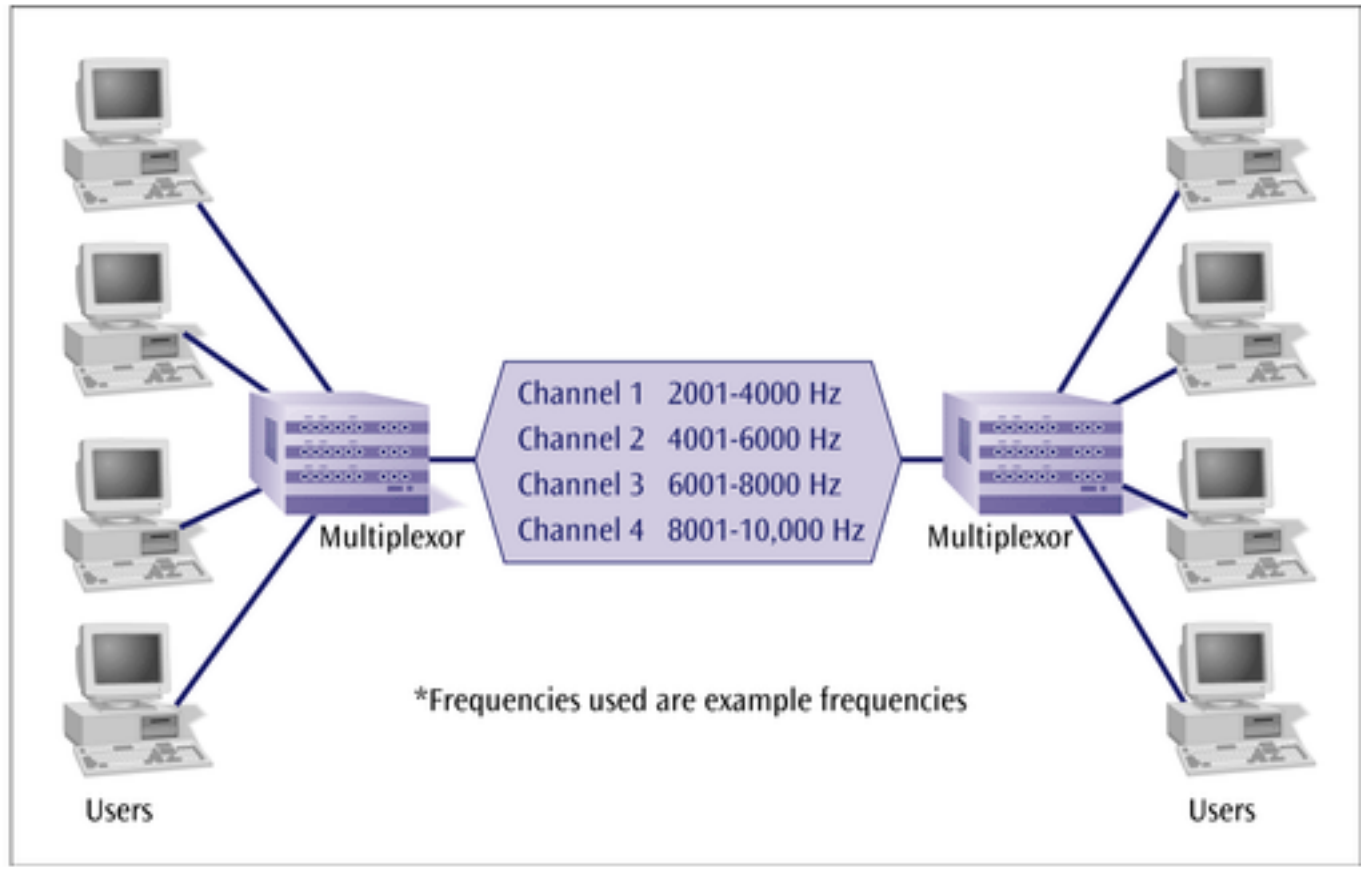
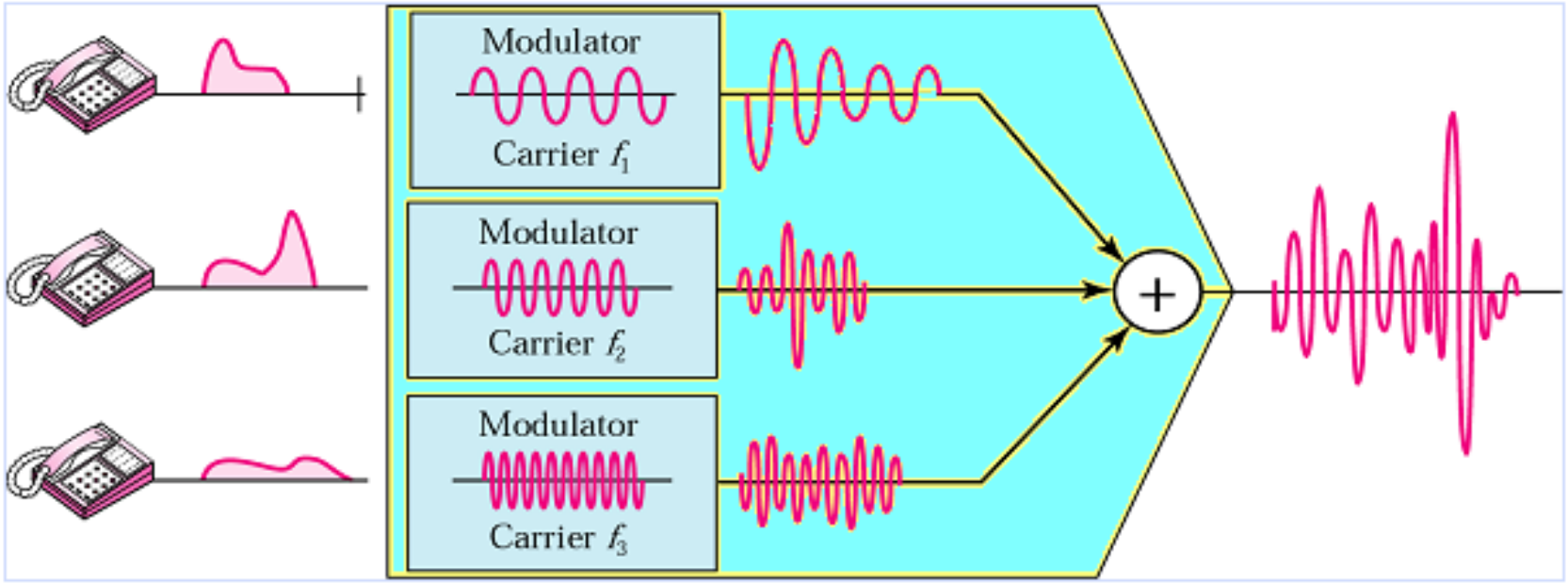

MUX
Channel 1
Channel 2
Channel 3
DEMUX

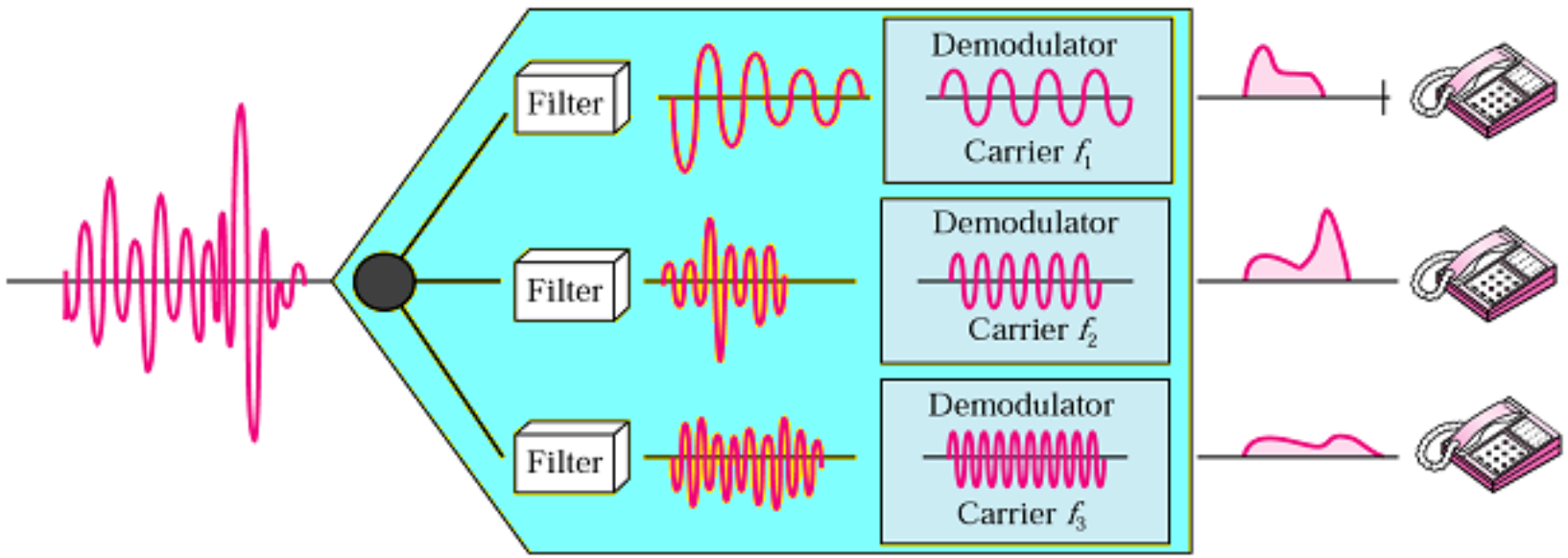
Figure 5-1
Simplified example of frequency division multiplexing



FDM process


Modulator
Carrier f_1
Modulator
Carrier f_2
Modulator
Carrier f_3
+

FDM demultiplexing example



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.

Wavelength Division Multiplexing (WDM)

Wavelength Division Multiplexing is an analog technique, in which many data streams of different wavelengths are transmitted in the light spectrum. If the wavelength increases, the frequency of the signal decreases.

- **Example:** Optical fibre Communications use the WDM technique, to merge different wavelengths into a single light for the communication.

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.

Time Division Multiplexing (TDM)

In TDM, the time frame is divided into slots. This technique is used to transmit a signal over a single communication channel, with allotting one slot for each message. Of all the types of TDM, the main ones are Synchronous and Asynchronous TDM.

Synchronous TDM

- In Synchronous TDM, the input is connected to a frame. If there are ‘n’ number of connections, then the frame is divided into ‘n’ time slots. One slot is allocated for each input line.

Asynchronous TDM

- In Asynchronous TDM, the sampling rate is different for each of the signals and the clock signal is also not in common. If the allotted device, for a time-slot, transmits nothing and sits idle, then that slot is allotted to another device, unlike synchronous.

Time Division Multiplexing

Sharing of the signal is accomplished by dividing available transmission time on a medium among users.

Digital signaling is used exclusively.

Time division multiplexing comes in two basic forms:

1. Synchronous time division multiplexing, and
2. Statistical, or asynchronous time division multiplexing.

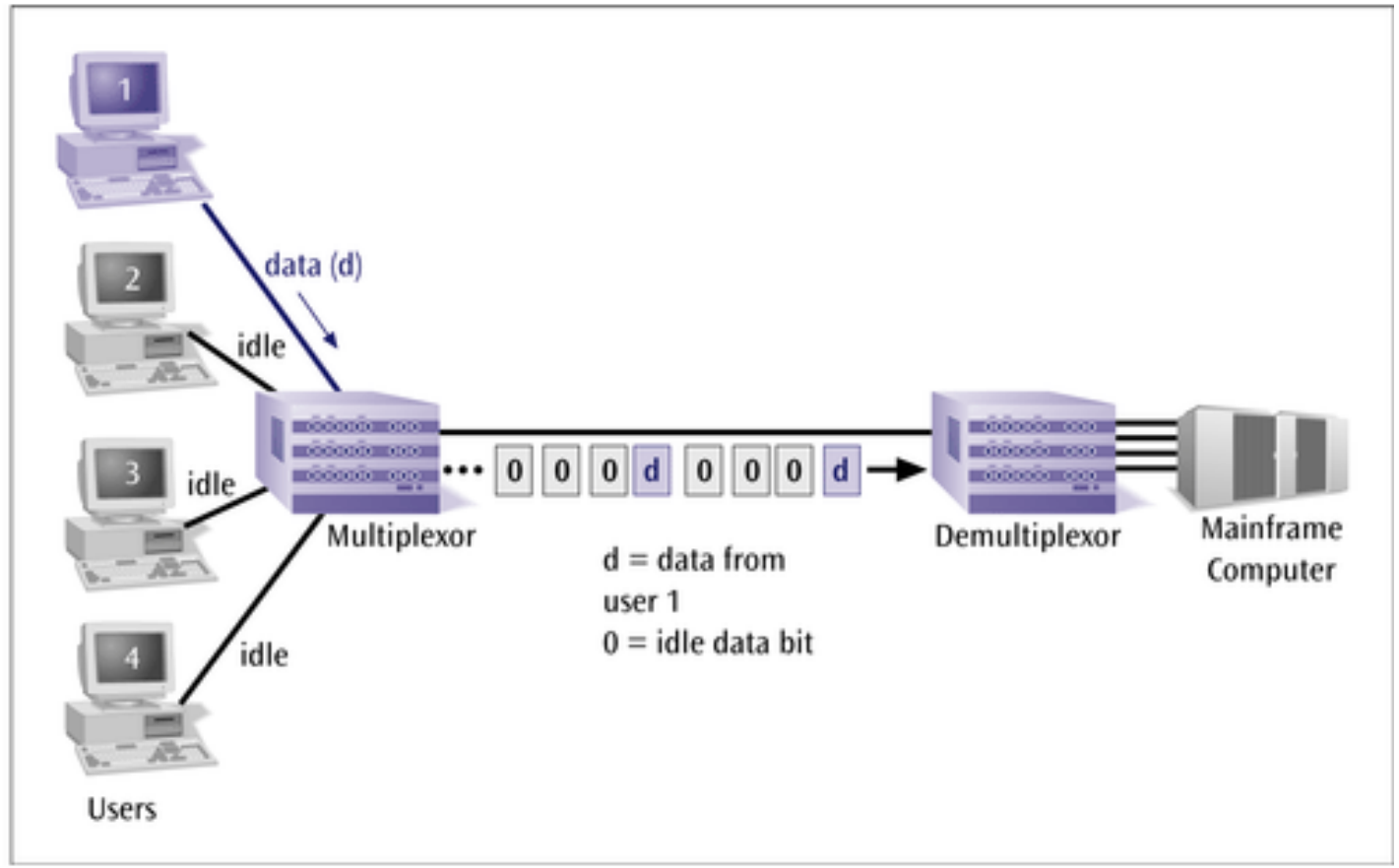
Synchronous Time Division Multiplexing

The original time division multiplexing.

The multiplexor accepts input from attached devices in a round-robin fashion and transmit the data in a never ending pattern.

T-1 and ISDN telephone lines are common examples of synchronous time division multiplexing.

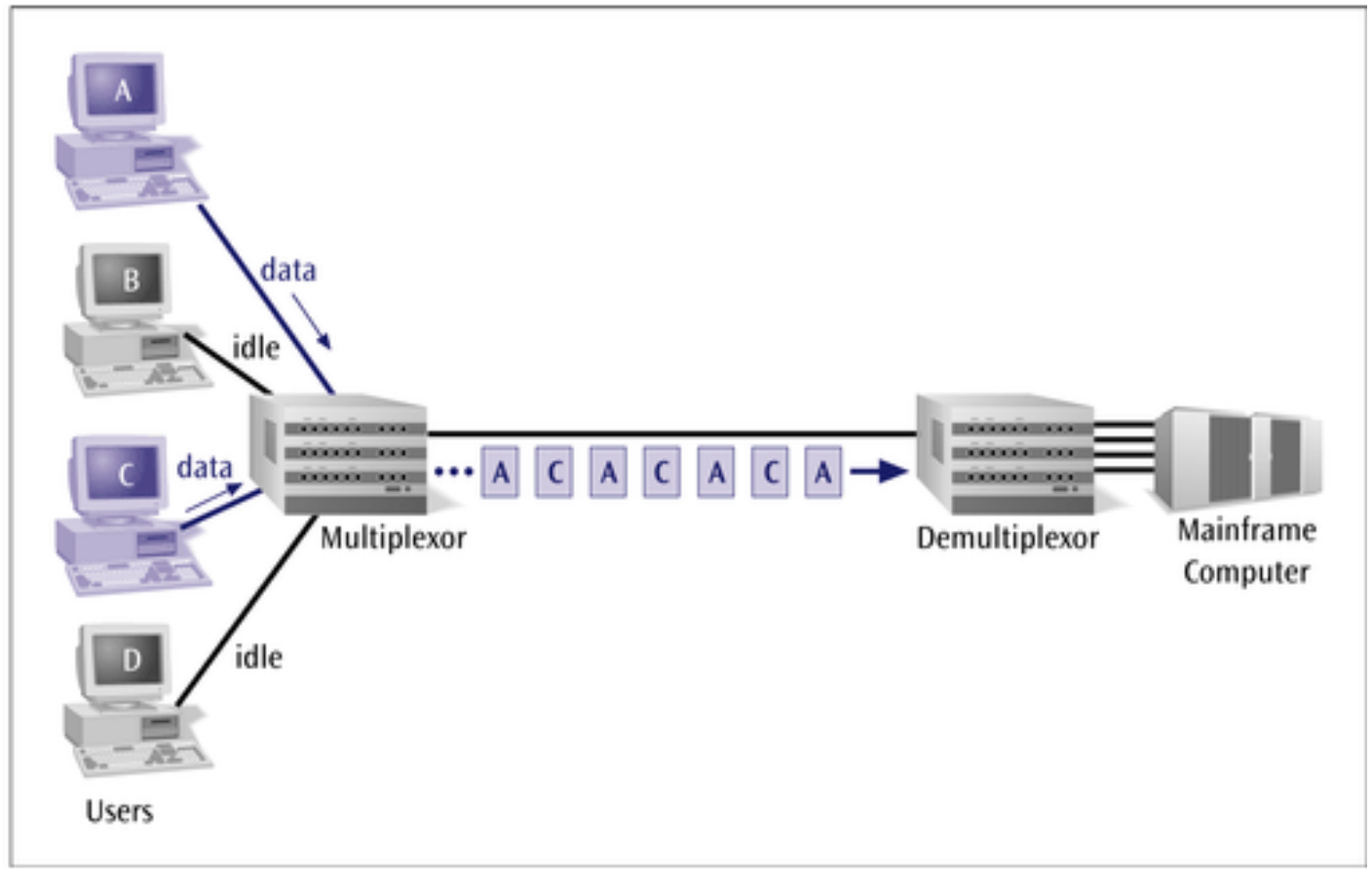
Figure 5-4
Multiplexor transmission stream with only one input device transmitting data



Statistical Time Division Multiplexing

- A statistical multiplexor transmits only the data from active workstations.
- If a workstation is not active, no space is wasted on the multiplexed stream.
- A statistical multiplexor accepts the incoming data streams and creates a frame containing only the data to be transmitted.

Figure 5-9
Two stations out of four transmitting via a statistical multiplexor



Applications

- The common use of FDM is in television broadcasting. Each TV channel has its own bandwidth.
- The first generation of cellular telephones (AMPS) also uses FDM.
- It is used in AM and FM broadcasting

COMMON MULTIPLE ACCESS TECHNOLOGIES

- FDMA (FREQUENCY DIVISION MULTIPLE ACCESS)
- OFDMA (ORTHOGONAL FREQUENCY DIVISION MULTIPLE ACCESS)
- TDMA (TIME DIVISION MULTIPLE ACCESS)
- CDMA (CODE DIVISON MULTIPLE ACCESS)
- Difference between FDM and FDMA
- Difference between TDMA and TDM