DATA COMMUNICATION CONCEPTS

CHAPTER 7

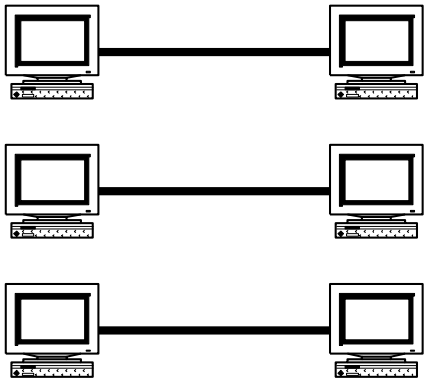
MULTIPLEXING

7.0 OBJECTIVES

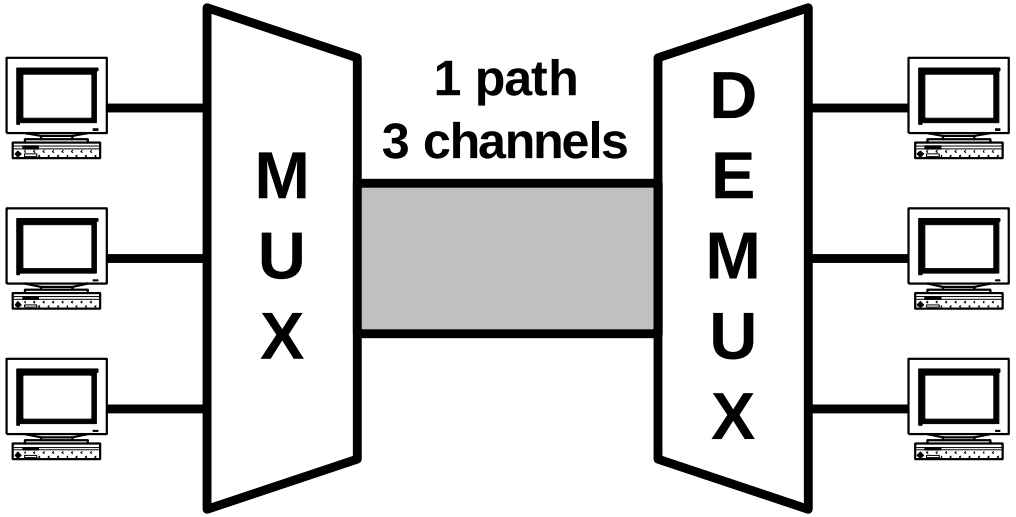
- At the end of this chapter, you should be able to:
  1. Understand the concepts of multiplexing.
  2. Identify devices used in multiplexing.
  3. Understand the terms in multiplexing.
  4. Analyze and apply the categories of multiplexing.

7.1 MULTIPLEXER (MUX) AND DEMULTIPLEXER (DEMUX)

- Multiplexing : set of techniques that allows the simultaneous transmission of multiple signals across a single data link.



a) No multiplexing



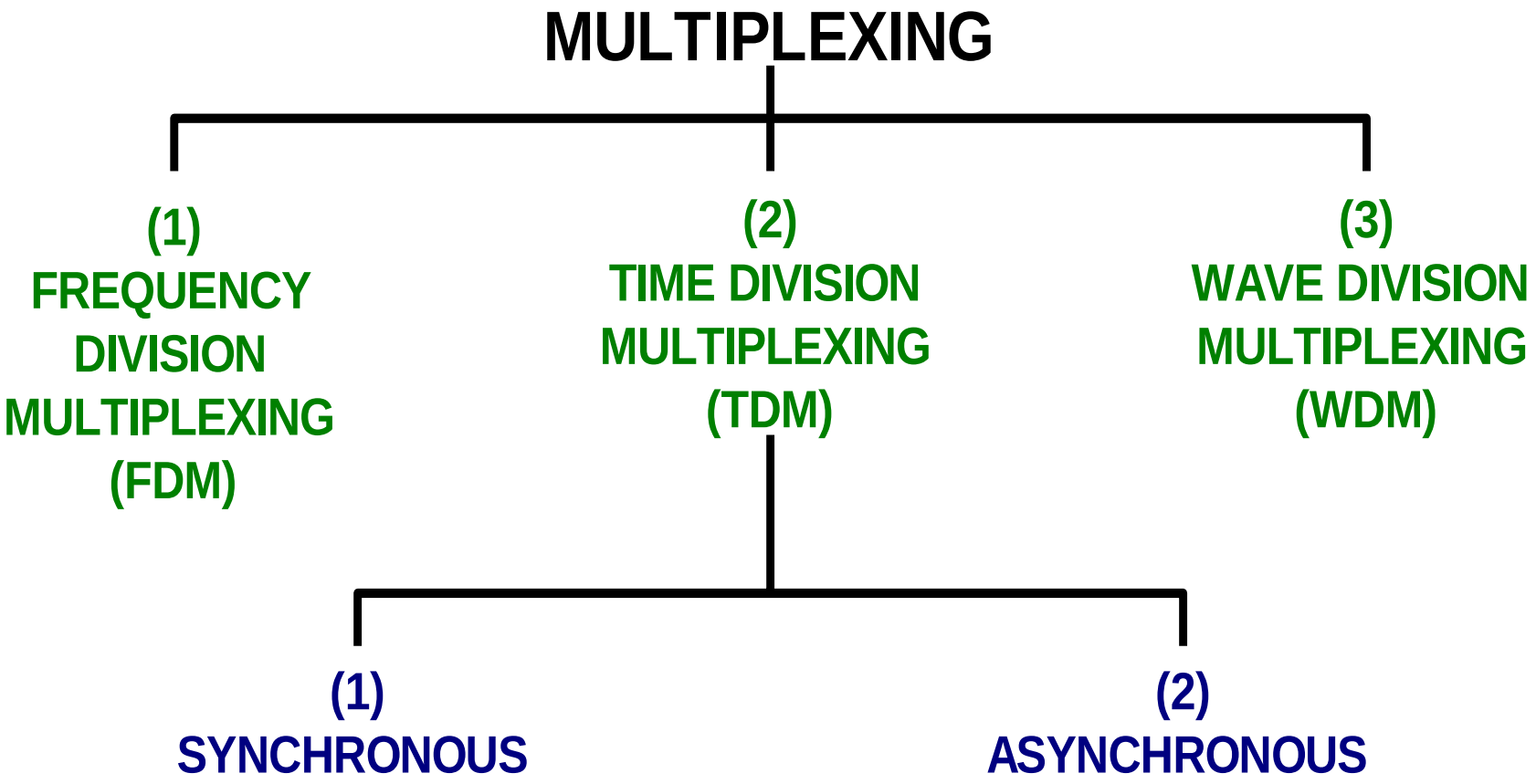
b) Multiplexing

Many to One/One to Many:

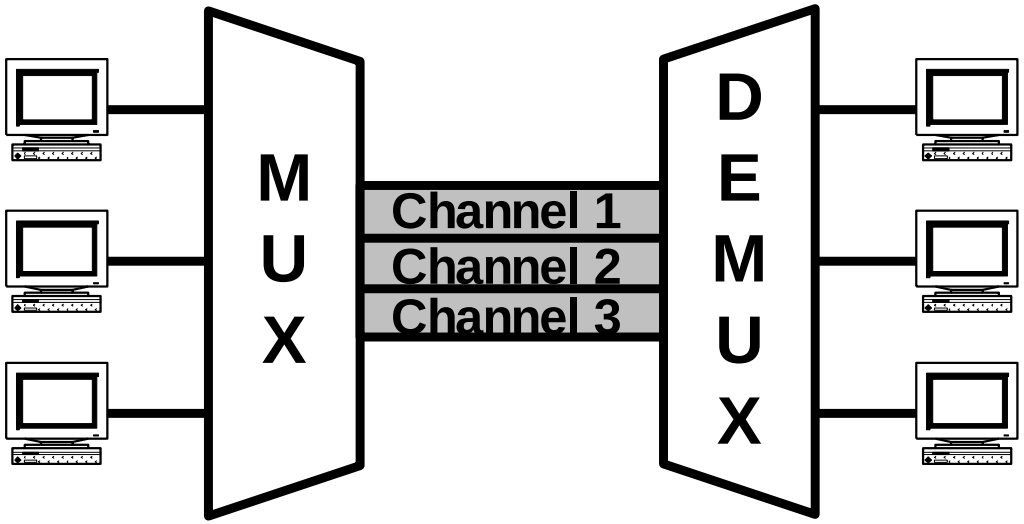
- *Many-to-one* : many devices (multiple devices) on the left, direct their transmission streams to a multiplexer (MUX), which combines them into a single stream.
- ***One-to-many*** : at the receiving end, that stream is fed into a demultiplexer (DEMUX) which separates the stream back into its component transmission and direct them to their intended receiving devices.
- ***Multiplexer (MUX)*** :
  - A device used for multiplexing.
  - Modulates/combines signal.

- ***Demultiplexer (DEMUX)*** :
  - A device that separates a multiplexed signal into its original components.
  - Decompose/demodulate signals.
- ***Path*** : - the channel through which a signal travels.
  - the physical link.
- ***Channel*** : a portion of a path that carries a transmission between a given pair of devices.

7.2 MULTIPLEXING TECHNIQUES



7.2.1 FDM (Frequency Division Multiplexing)



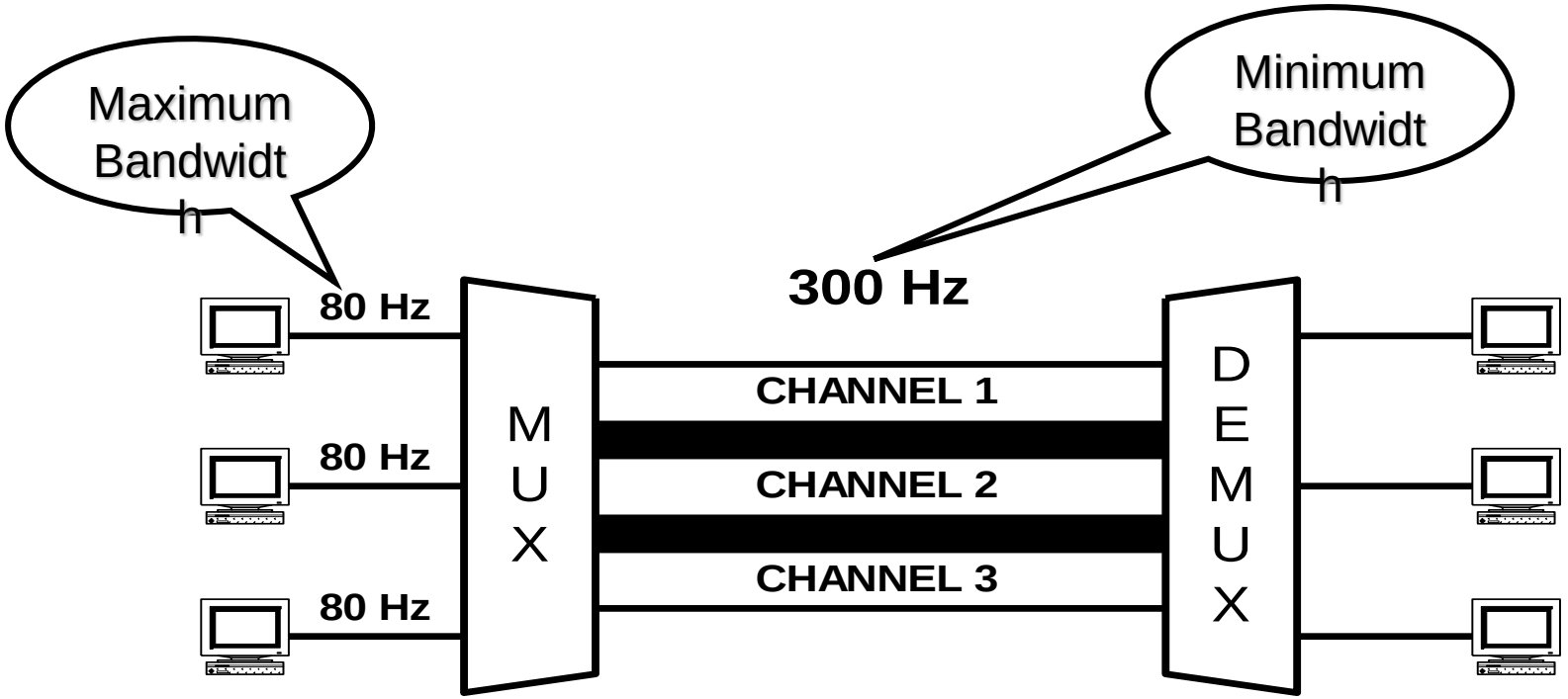
- **Definition** - the combining of analog signals into a single signals.
  - bandwidth of a *link* > the combined bandwidth of the signals to be transmitted.
  - the **link** is sectioned by **frequency/channel**

- **Guard band**
  - a bandwidth separating 2 signals.
  - function: keep the modulated signals from overlapping & interfering with one another.
  - channels are separated by guard bands.

- **Characteristics**
  - (1) Each signal modulates in different carrier frequency.
  - (2) The modulated carriers are combined to form a new signal that is then sent across the link.
  - (3) - Multiplexers modulates & combine signals.
    - Demultiplexers decompose & demodulate.

- **Purpose of FDM:**
  - Find minimum bandwidth (bandwidth of the path)
  - Find maximum bandwidth (bandwidth for each devices)

EXAMPLE:


Maximum Bandwidth
Minimum Bandwidth
300 Hz
80 Hz
80 Hz
80 Hz
MUX
CHANNEL 1
CHANNEL 2
CHANNEL 3
DEMUX

Q1 : Given the following information, find the minimum bandwidth for the path:

FDM Multiplexing

5 devices, each requiring 4000 Hz

200 Hz guard band for each device.

A1 :

Min bandwidth = 5 * 4000 + (5-1)*200

= 20000 + 800

= 20800 Hz

= **20.8 KHz**

Q2 : Given the following information, find the **maximum** bandwidth for each signal source:

FDM Multiplexing

Total available bandwidth = 7900 Hz

3 signal sources

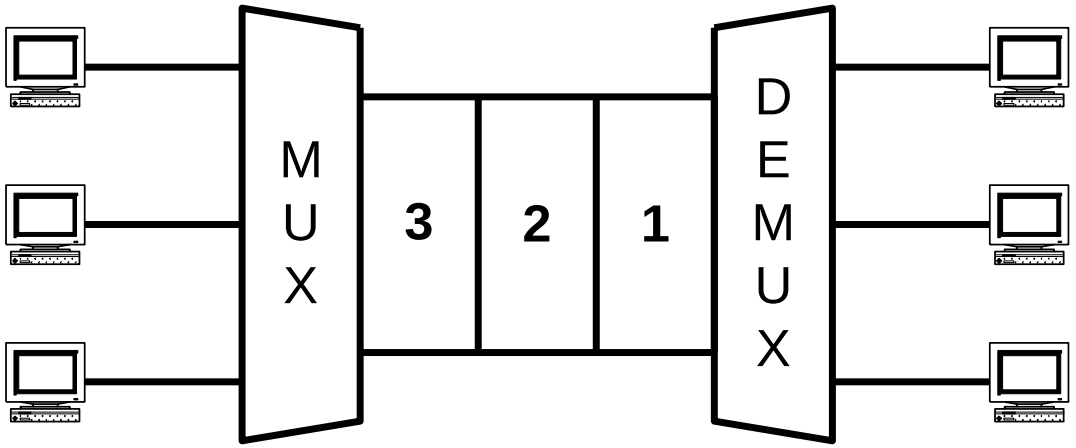
A 200 Hz guard band for each device

A1 :

Bandwidth without guard bands = 7900 – (3-1)*200 = 7500 Hz
Bandwidth for each station = 7500/3
= 2500 Hz
= **2.5 KHz**

7.2.2 TDM (Time Division Multiplexing)

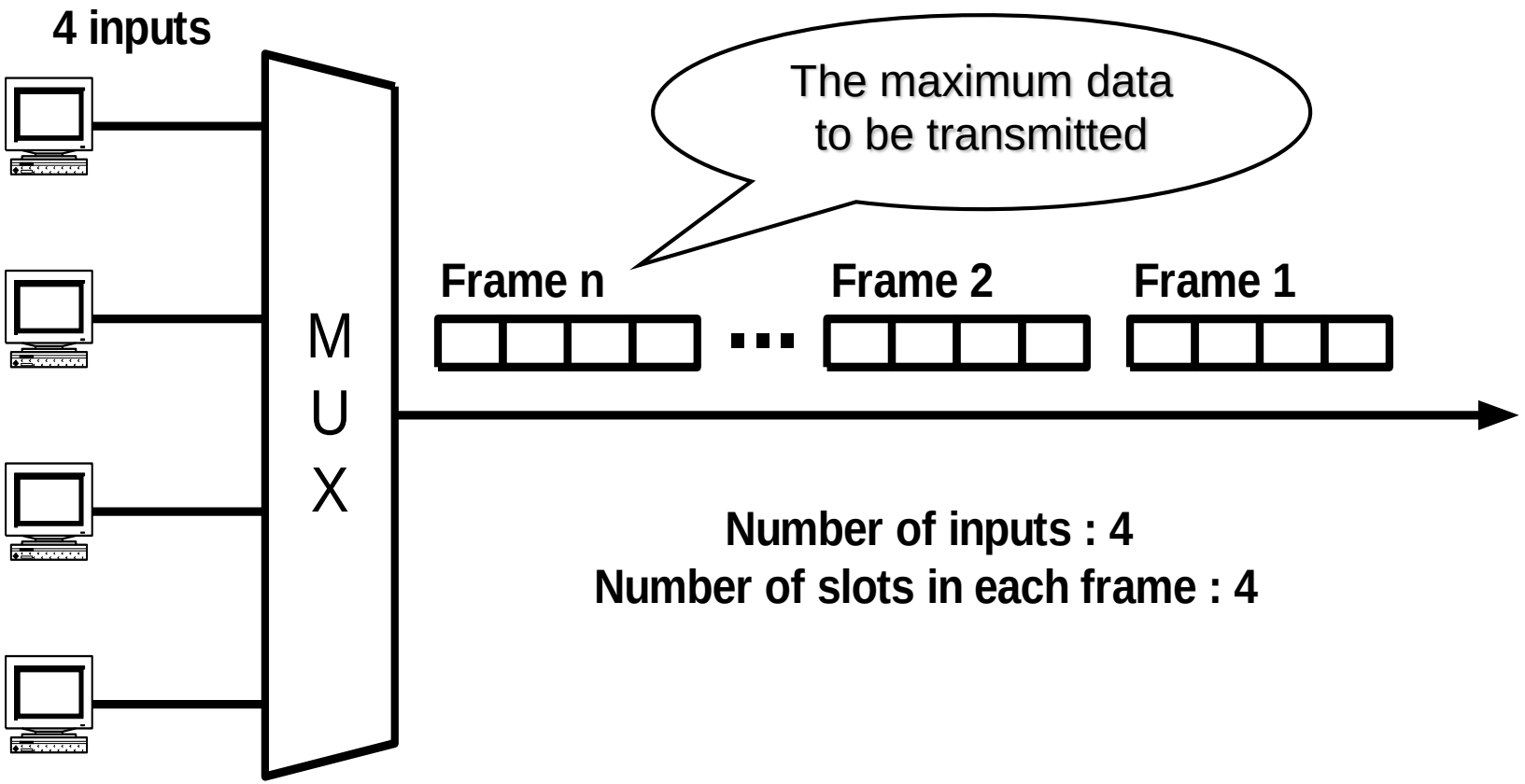
- ***Definition*** - technique of combining signals coming from low-speed channels to share time on a high-speed path.
  - data rate capacity of transmission medium > data rate required by sending & receiving devices.
- The **link** is sectioned by **time** rather than **frequency**.



Implementation of TDM:

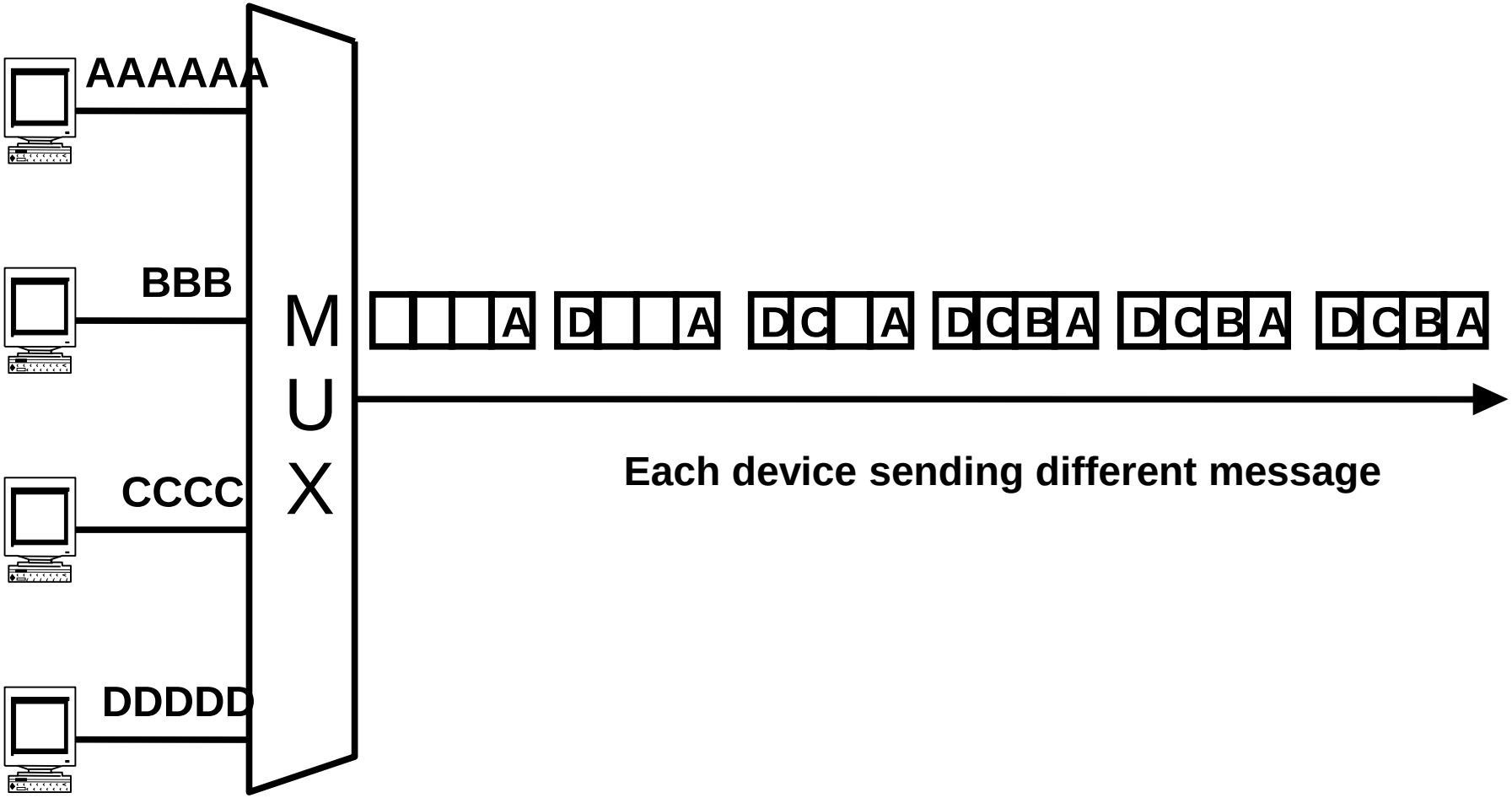
SYNCHRONOUS TDM

- Definition - a method of TDM in which multiplexing is done on a fixed, predetermined basis.
- Characteristics - (1) Multiplexer allocates exactly the same time slot to each devices at all times, whether or not a device has anything to transmit.
  - (2) If a device is unable to transmit or does not have data to send, its time slot remains empty.

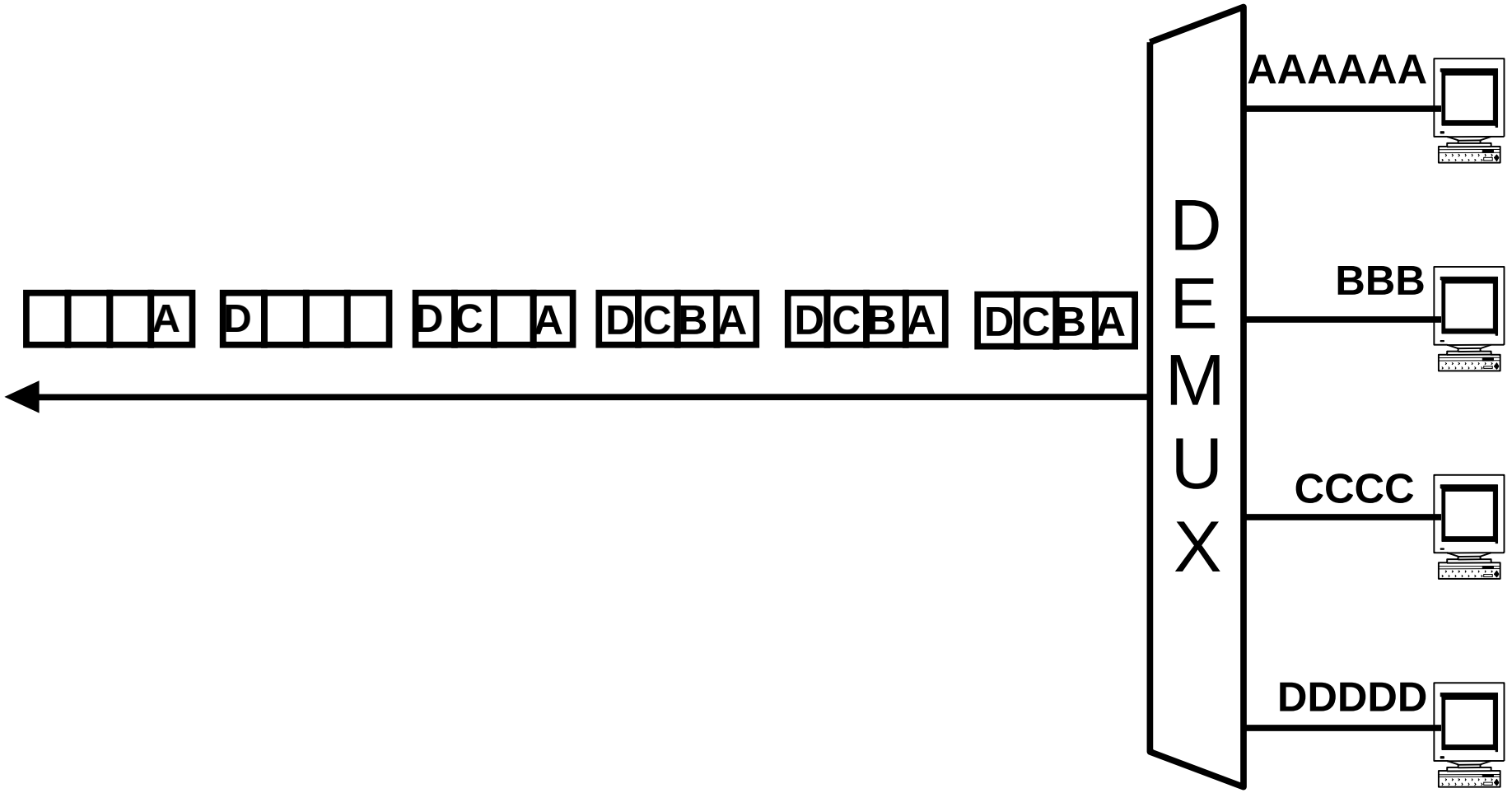


- num of slots in each frame depend on num of inputs.
- num of frame depend on the maximum num of msg/data.

Example : Synchronous TDM, multiplexing process

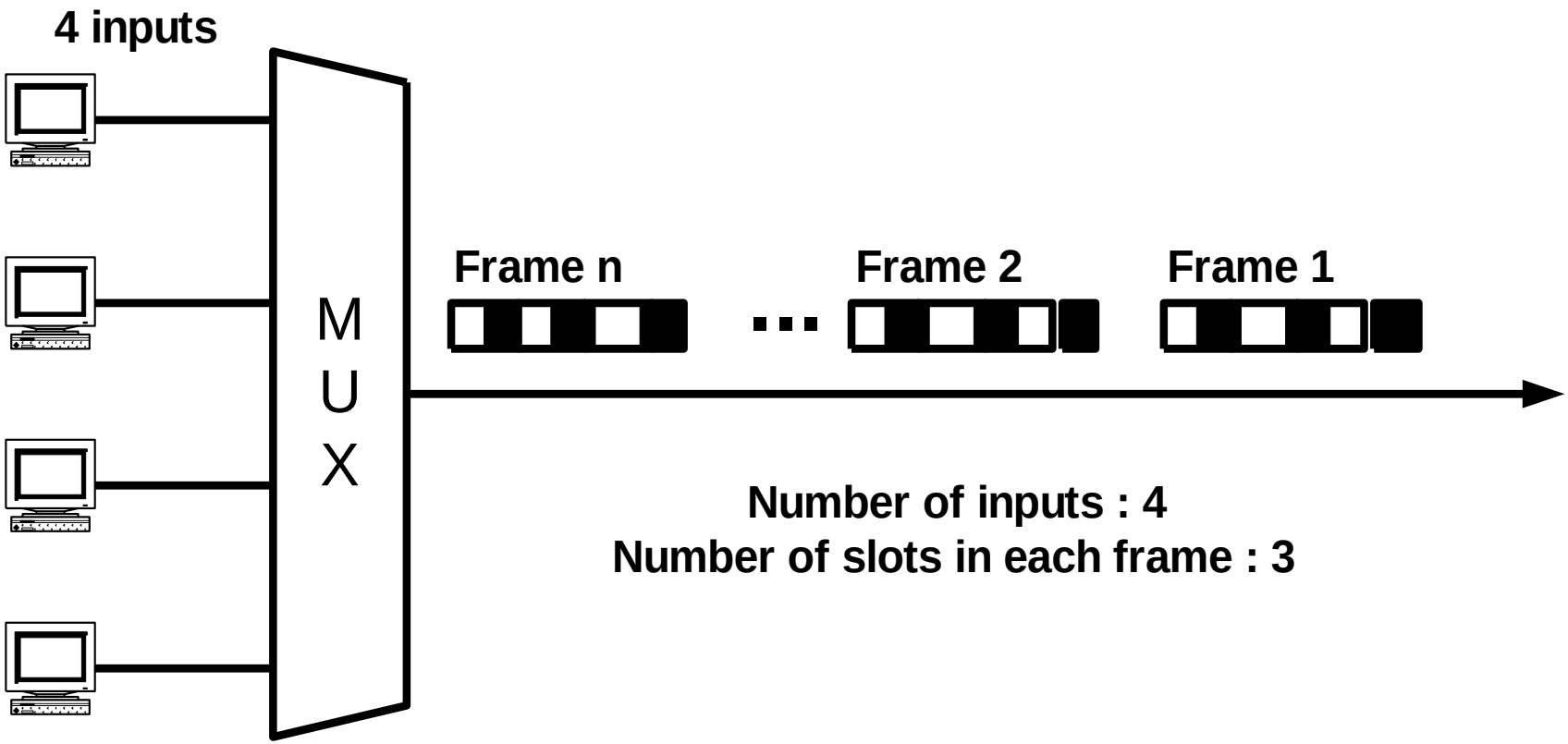


Example : Synchronous TDM, demultiplexing process

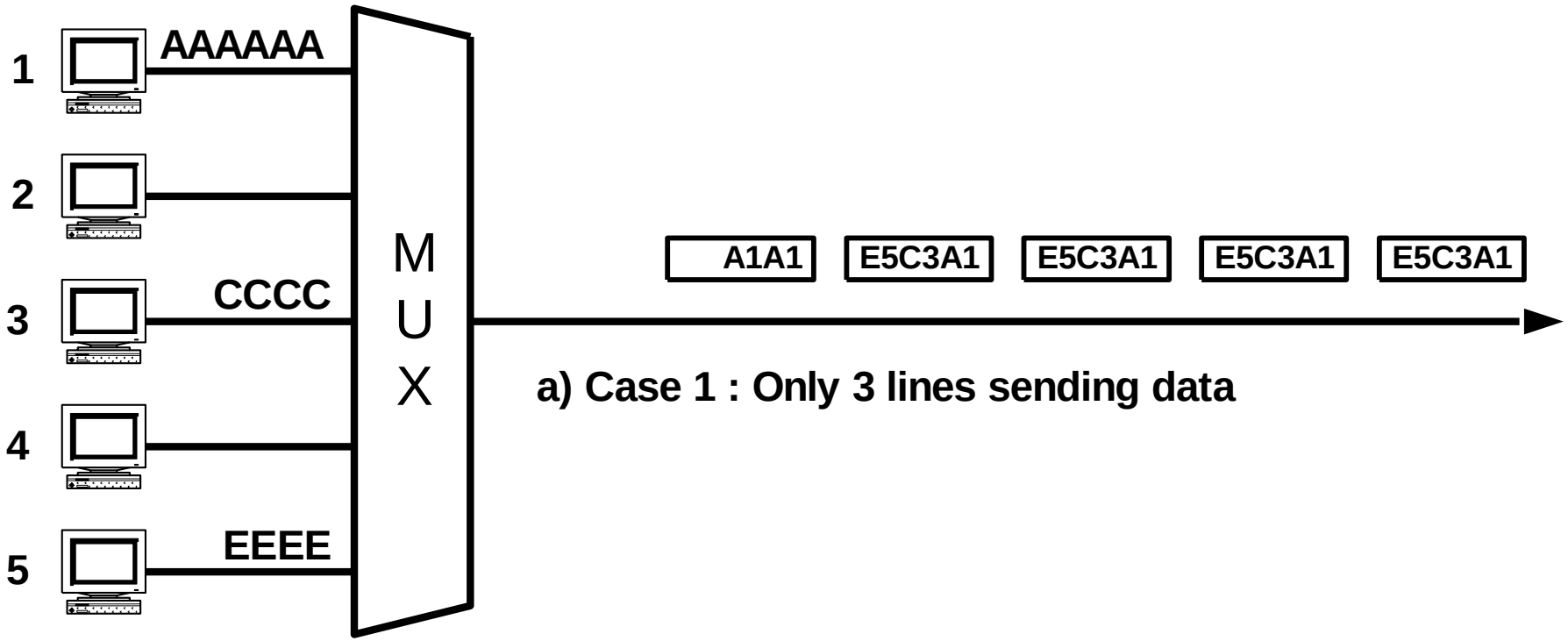


ASYNCHRONOUS TDM

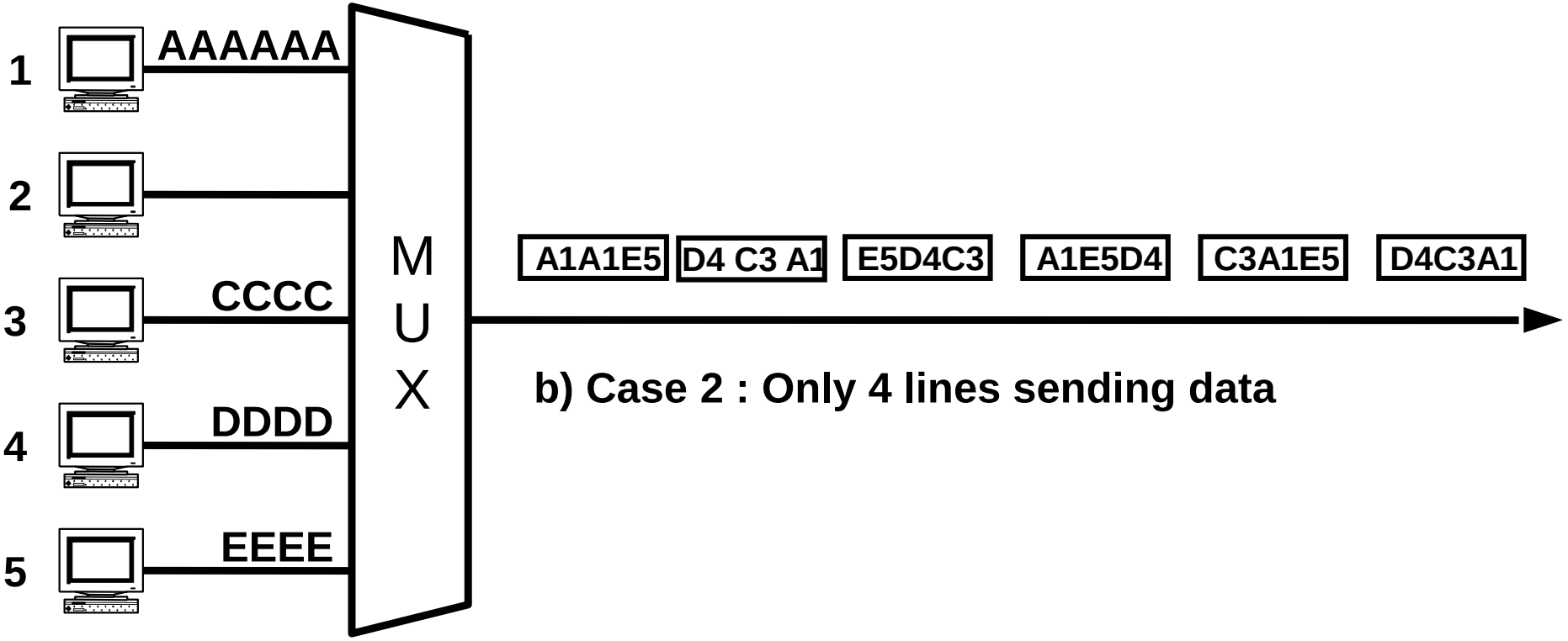
- Definition - A TDM in which link time is allocated dynamically according to whether a terminal is active or not.
- Characteristics - (1) The total speed of the input lines can be greater than the capacity of the path.
  - (2) Flexible or not fixed.


4 inputs
M
U
X
Frame n
Frame 2
Frame 1
Number of inputs : 4
Number of slots in each frame : 3

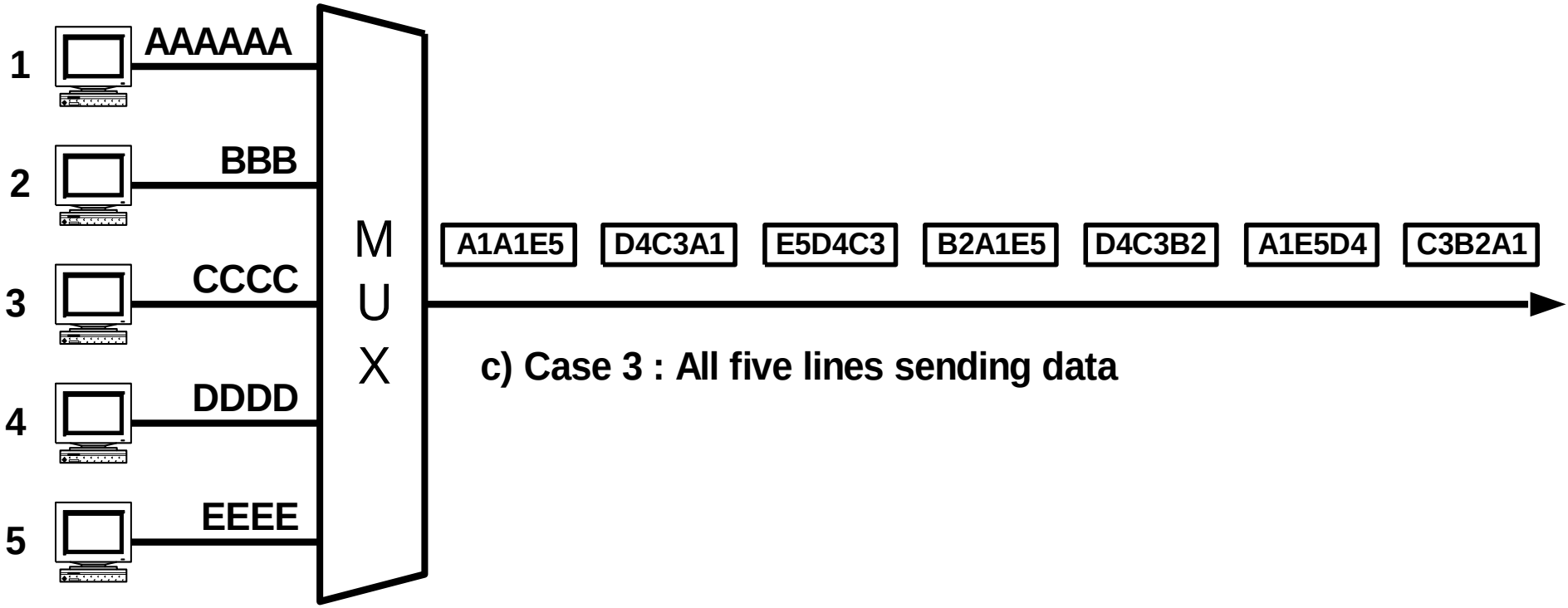
Example : Asynchronous TDM Frames



a) Case 1 : Only 3 lines sending data



b) Case 2 : Only 4 lines sending data



c) Case 3 : All five lines sending data

EXERCISES

1. Draw the synchronous TDM frames showing the character data, given the following information:

   Four signal sources:

   Source 1 message : X F I L E

   Source 2 message : I S

   Source 3 message :

   Source 4 message : F I L E

2. Draw the complete asynchronous TDM frames showing the character data, given the following information: (Frame size = 3)

Four signal sources:

Source 1 message : _ R S L

Source 2 message : M B D G

Source 3 message : O _ _ G

Source 4 message : T F N _

3. Given the following information, find the minimum bandwidth for the path:

   FDM multiplexing

   6 devices, each requiring 1500 Hz

   300 Hz guard band for each device.

4. Given the following information, find the maximum bandwidth for each signal source:

   FDM multiplexing

   Total available bandwidth = 9100 Hz

   4 signal sources

   A 100 Hz guard band for each device.

5. Given the following information, find the minimum bandwidth for the path:

   FDM multiplexing

   4 devices, each requiring 2000 Hz

   100 Hz guard band for each device.

6. Given the following information, find the maximum bandwidth for each signal source:

   FDM multiplexing

   Total available bandwidth = 5500 Hz

   3 signal sources

   A 200 Hz guard band for each device.