Chapter One

Data Communication Basics

Data Communication and Computer Networks

(InTc 2112)

Communication Basics

- **Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- It includes :
  - Writing and talking
  - Nonverbal communication (such as facial expressions, body language or gestures)
  - Visual communication (the use of images or pictures such as painting, photography, video or film)
  - Electronic Communication such as telephone calls, electronic mail, cable television, satellite broadcasts.
- For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

Five components of data communication

1. **Message:** is the information (data) to be communicated. Popular forms of information include **text, numbers, pictures, audio, and video**.
2. **Sender:** is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. **Receiver:** is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. **Transmission medium:** is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiberoptic cable, and radio waves.
5. **Protocol:** is a set of rules that govern data communications. It represents an agreement between the communicating devices. **Without a protocol, two devices may be connected but not communicating,** just as a person speaking French cannot be understood by a person who speaks only Japanese.

Serial vs. parallel communications

- In serial communications
  - **A single bit will be transferred at a time** using the communication channel
  - Bits will be reassembled at the destination
  - Mostly used by computer peripherals like printers,
- In parallel communications
  - **Multiple bits (eg. Eight bits)** will be transferred at a time
  - Needs multiple (parallel) communication channels

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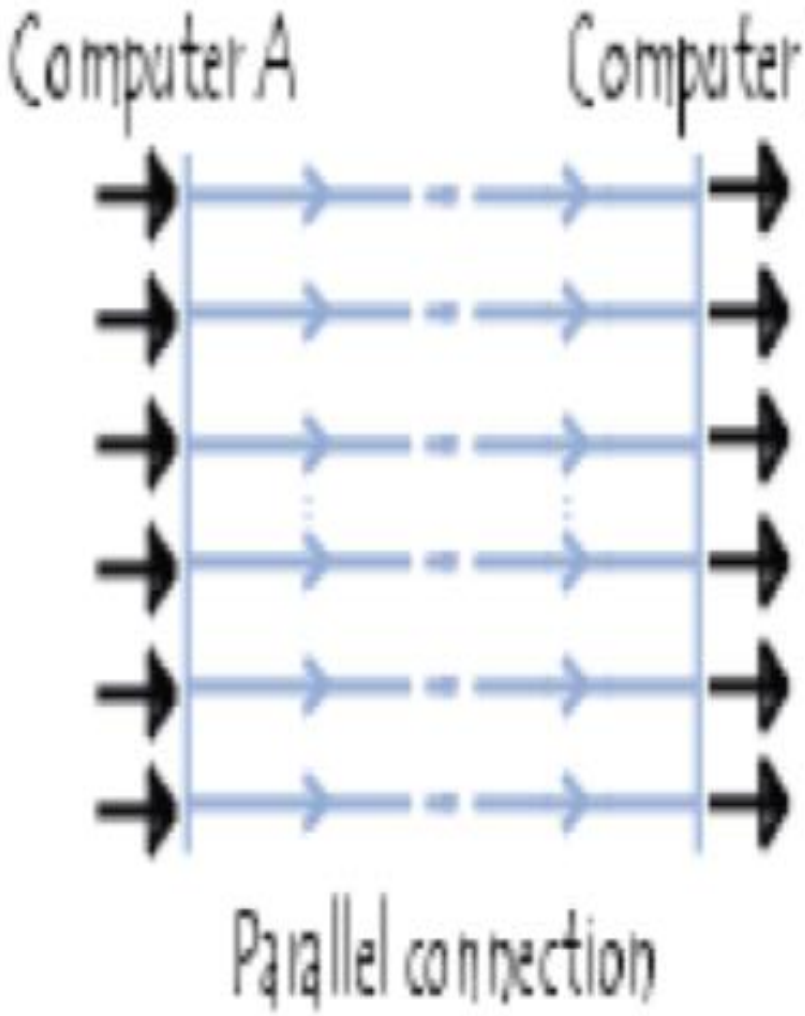
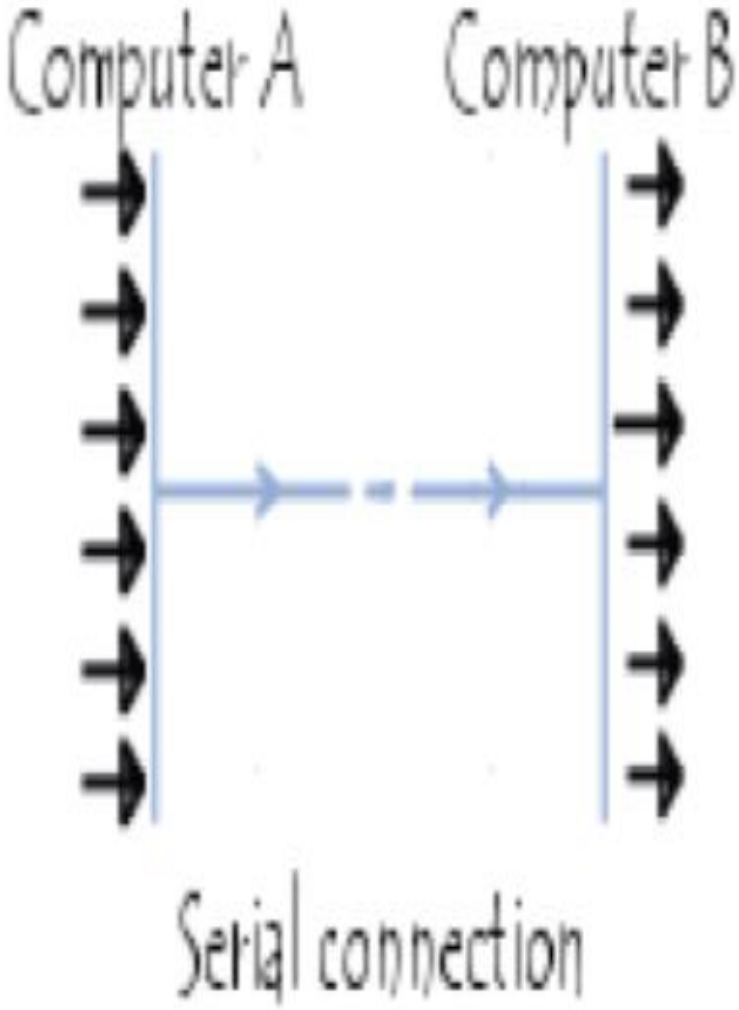

Computer A
Computer B
Parallel connection


Computer A
Computer B
Serial connection

Definitions

- The word ***data*** refers to **information presented in whatever form** is agreed upon by the parties creating and using the data.
- ***Signal: the electrical wave that is used to represent the data.***
  - It Can be analog or digital signal
- ***Data communications (Transmission)*** are the **exchange of data** between two devices **via some form of transmission medium** such as a wire cable or wireless media using appropriate signal.
- ***Network*** is a system in which a number of independent computers are linked together to share data and peripherals, such as hard disks and printers (more in the next chapters)

Data Representation Techniques

- The type of data to be transmitted can be in the form of **text, audio, and video** in the form of electrical signal, radio, laser, or other radiated energy source.
- Data can be analog or digital
- The term **analog** data refers to information that is continuous; **digital** data refers to information that has discrete states.
- Example: **analog clock** (with second, minute and hour hands) and digital clock

Analog and digital signals

- An analog signal has infinitely **many levels of intensity** over a period of time.
  - As the wave moves from value A to value B, it passes through and includes an infinite number of values along its path.
- A digital signal, on the other hand, can have only a **limited number** of defined values.
  - Although each value can be any number, it is often as simple as 1 and 0.

Analog Signals

- Are Continuous wave that carries information by altering the characteristics of waves.
- Analogue means that the original information is retransmitted to the receiver/listener **without any manipulation**.
- Here the signal can take on **any value** (within the limits set by the recording equipment and the transmitter)**.**
- It measures rather than counts
- For instance, Voice and all sounds are analog, traveling to human ears in the forms of waves.

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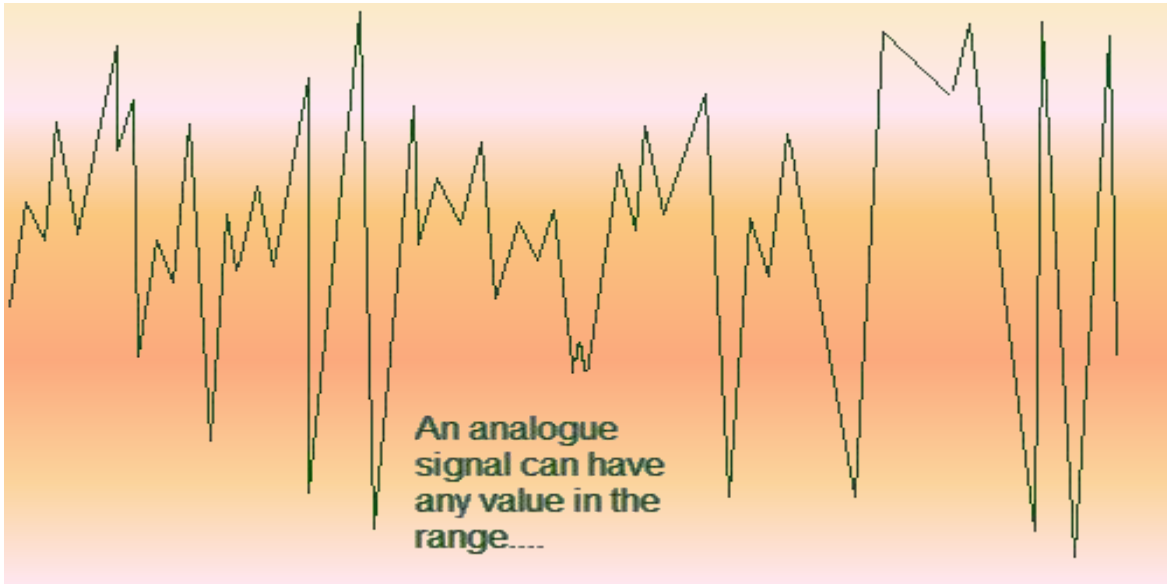

- Radio, telephone and recording equipment historically have been analog, but they are beginning to change –due to large to computers to the other types of signals-digitals
- **The disadvantage of analogue signals** is that any '**noise**', interference, added to the signal at any point cannot be removed from the audio signal and this degrades the audio quality of the signal or causes 'hiss'.

Digital Signals

- are a discrete series of pulses - either **high or low - on or off** - sometimes expressed as binary code 1s and 0s.
- It counts but not measures
- Discrete pluses of data transmission rather than continues wave
- More prevalent in computer based devices
- **Flashing light and telegraph message** are traditional examples of on-off pluses, although not in binary code.

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The advantage of digital signals is that

1. they are much less likely to be degraded by interference (noise).
2. also it is possible to send a lot more information digitally (e.g. more television channels) than using analogue technology.
3. They can be transmitted effectively along fibreoptic cables. (on - light signal, off - no light signal) and these are cheaper to manufacture than copper wiring and can cope with multiple signals without interference between them.
4. They can be sent directly to computers which use digital systems themselves.

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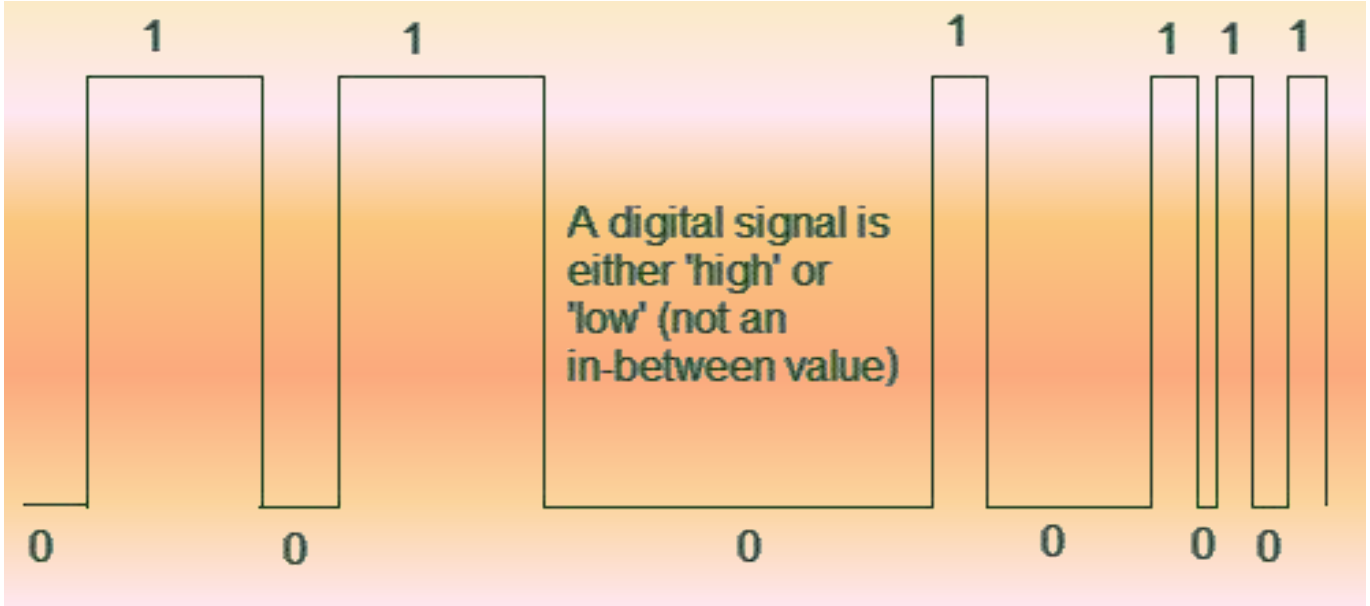

- **The signals from a satellite are digital.** They use a system called 'packet switching' which is the same as used in computer networks and for the internet. This system is particularly effective for **dealing with noise elimination**.

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Which of the following signals are Analog and which are Digital?

- Volume control on a radio
- Traffic lights
- Motor bike throttle
- Water tap
- Dimmer switch
- Light switch
- In Music on a CD
- Music on a tape

Modes of data transmission

- There are 3 different transmission modes characterized according to the direction of the exchanges:

1. **A simplex connection** is a connection in which the data flows in only **one direction**, from the transmitter to the receiver.
   - This type of connection is useful if the data do not need to flow in both directions (**for example, from your computer to the printer or from the mouse to your computer...**).

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2. **A half-duplex connection** (sometimes called an *alternating connection or semi-duplex) is a connection* in which the data flows in one direction or the other, but not both at the same time.

- With this type of connection, each end of the connection transmits in turn.
- This type of connection makes it possible to have bidirectional communications using the full capacity of the line.
- In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.
- Walkie-talkies and CB (citizens band) radios are both half-duplex systems.
- The half-duplex mode is used in cases where there is no need for communication in both directions at the same time; the entire capacity of the channel can be utilized for each direction.

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3. ***Full-Duplex:*** In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously

- The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time.
- In full-duplex mode, signals going in one direction share the capacity of the link: with signals going in the other direction.
- This sharing can occur in two ways: Either the link must contain two physically separate transmission paths, one for sending and the other for receiving; or the capacity of the channel is divided between signals travelling in both directions.
- One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.
- The full-duplex mode is used when communication in both directions is required all the time.
- The capacity of the channel, however, must be divided between the two directions.

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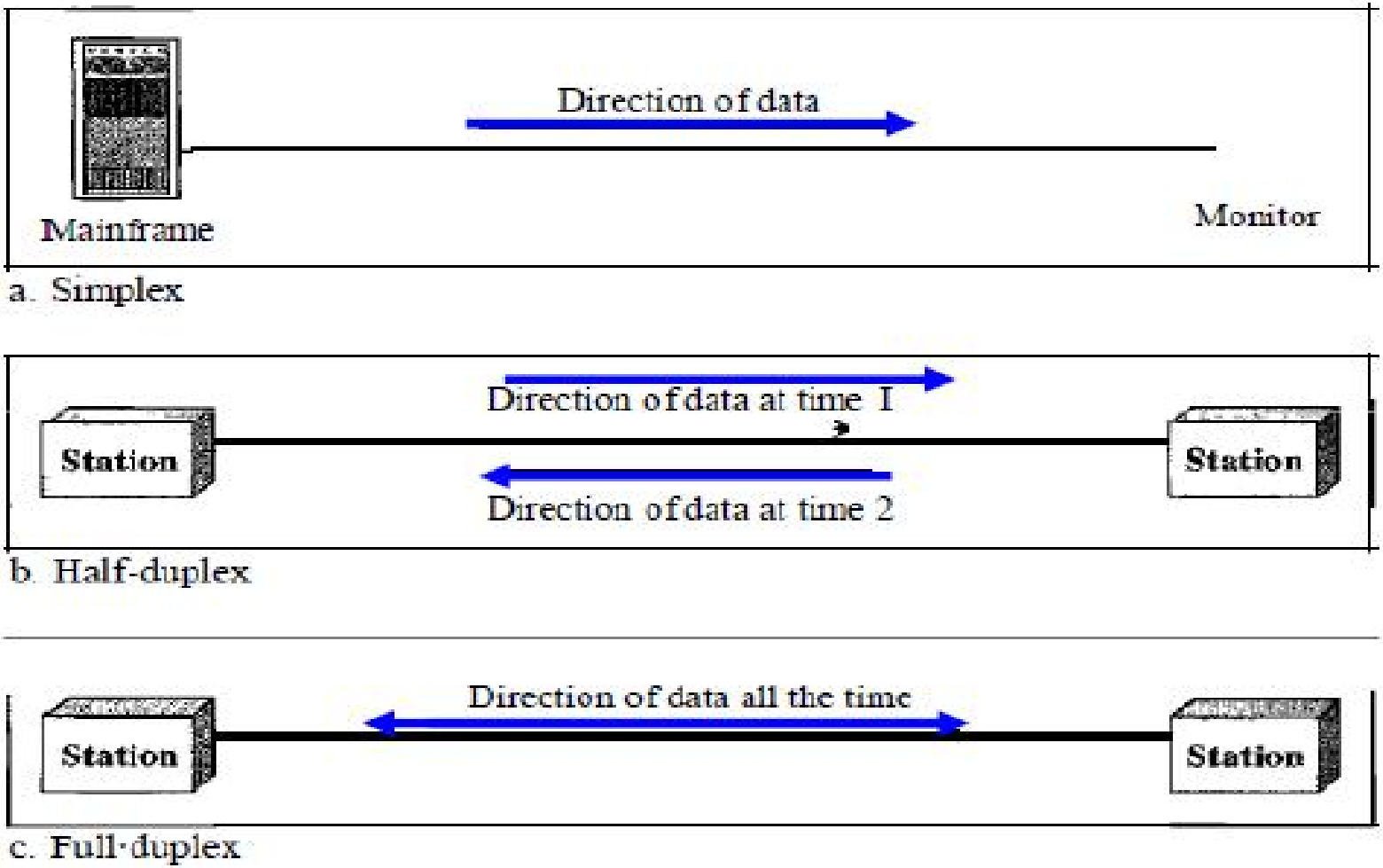
Direction of data
Mainframe
Monitor
a. Simplex
Direction of data at time 1
Station
Station
Direction of data at time 2
b. Half-duplex
Direction of data all the time
Station
Station
c. Full-duplex

Signal Encoding techniques

- **Digital data:-** information that has discrete states
- **Analog Data:-** information that is continuous
- **Digital Signal:-** can have only a limited number of defined values.
  - Although each value can be any number, it is often as simple as 1 and 0.
- **Analog signal**:- has infinitely many levels of intensity over a period of time.
  - As the wave moves from value A to value B, it passes through and includes an infinite number of values along its path.

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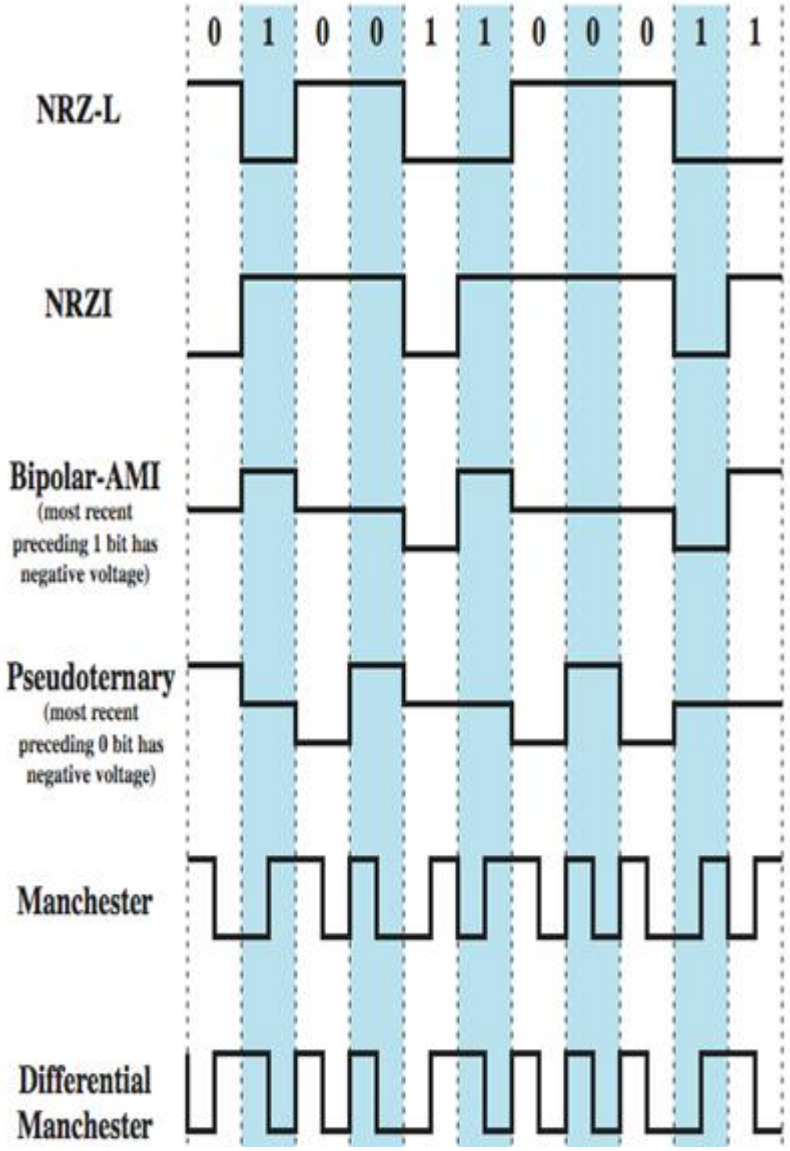
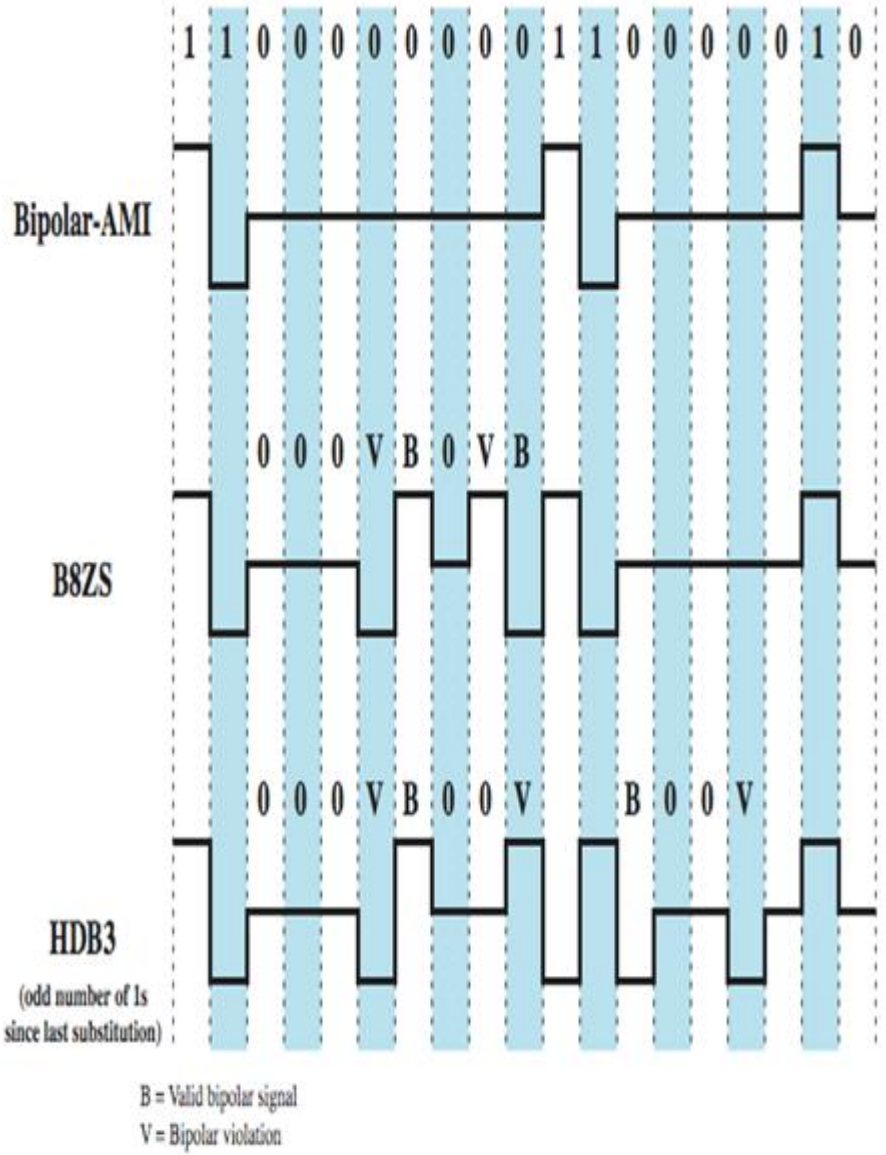
Key data transmission terms.

Term	Units	Definition
Data element	bits	A single binary one or zero.
Data rate	bits per second (bps)	The rate at which data elements are transmitted.
Signal element	Digital: a voltage pulse of constant amplitude. Analog: a pulse of constant frequency, phase, and amplitude.	That part of a signal that occupies the shortest interval of a signaling code.
Signaling rate or modulation rate	Signal elements per second (baud)	The rate at which signal elements are transmitted


0 1 0 0 1 1 0 0 0 1 1
NRZ-L
NRZI
Bipolar-AMI
(most recent preceding 1 bit has negative voltage)
Pseudoternary
(most recent preceding 0 bit has negative voltage)
Manchester
Differential Manchester


1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0
Bipolar-AMI
0 0 0 V B 0 V B
B8ZS
0 0 0 V B 0 0 V B 0 0 V
HDB3
(odd number of 1s since last substitution)
B = Valid bipolar signal
V = Bipolar violation

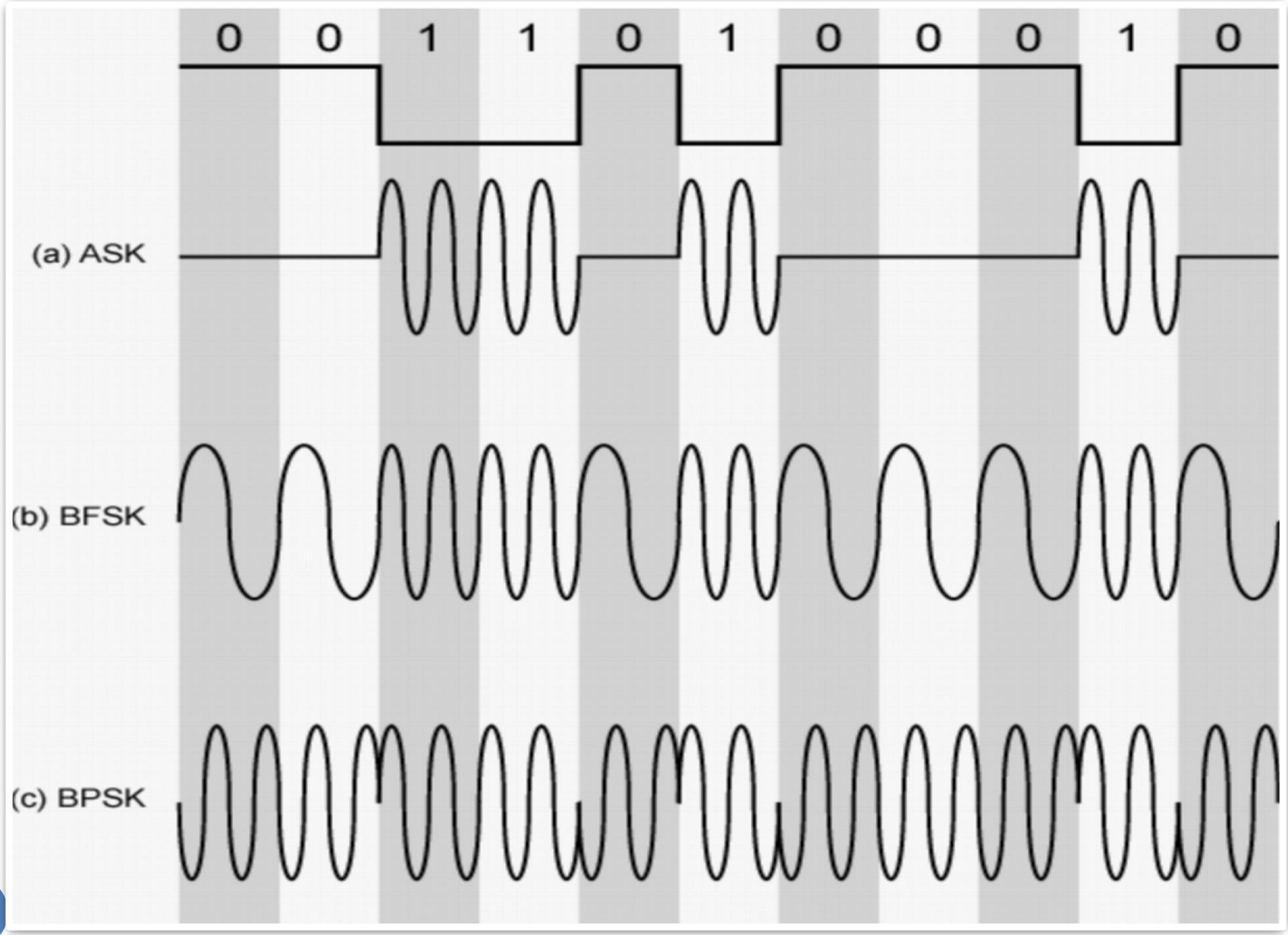
DIGITAL DATA, ANALOG SIGNALS

- The most familiar use of this transformation is for transmitting digital data through the public telephone network.
- The telephone network was designed to receive, switch, and transmit analog signals in the voice- voice frequency range of about 300 to 3400 Hz.
- digital devices are attached to the network via a modem (modulator-demodulator), which converts digital data to analog signals, and vice versa.

Digital Data to Analog Signal Encoding Techniques

- Modulation involves operation on one or more of the three characteristics of a carrier signal: **amplitude, frequency, and phase**.
- Accordingly, there are three basic encoding or modulation techniques for transforming digital data into analog signals
  1. Amplitude-shift keying (ASK)
  2. Frequency-shift keying (FSK)
  3. Phase-shift keying (PSK)

Read about these techniques


0 0 1 1 0 1 0 0 0 1 0
(a) ASK
(b) BFSK
(c) BPSK

Multiplexing

- In data communication, there might be a need to **share a single media for multiple communication** (media/bandwidth sharing) in order to utilize the available bandwidth wisely to achieve specific goals.
- Sharing of a single media (fiber, coaxial, microwave,..) is known as **multiplexing**.
- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.

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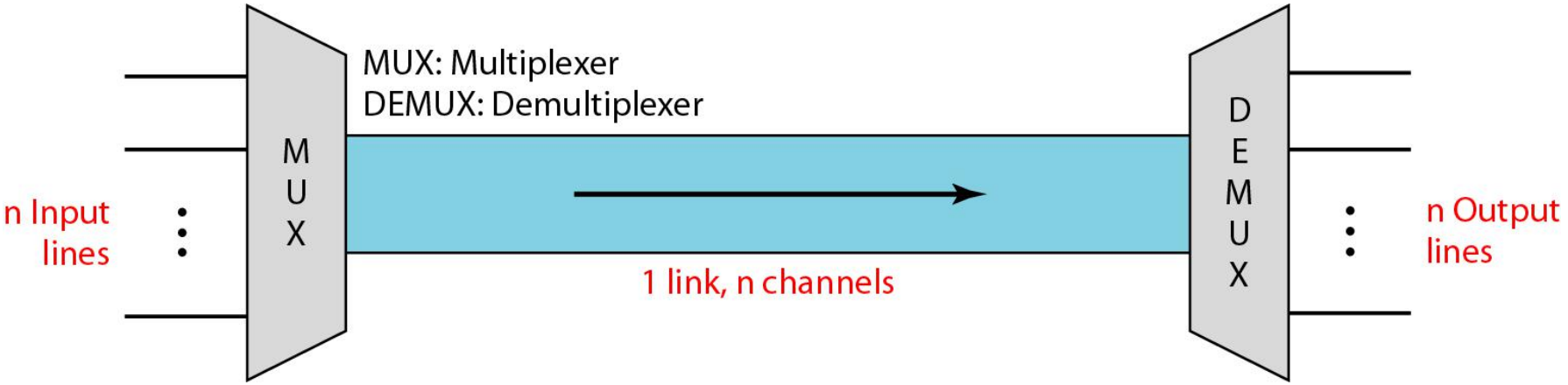
- Multiplexing is the set of techniques that allows the (simultaneous) transmission of multiple signals across a single data link.
- As data and telecommunications use increases, so does traffic.



- In the above figure, there are n inputs to a multiplexer. The multiplexer is connected by a single data link to a DE multiplexer.

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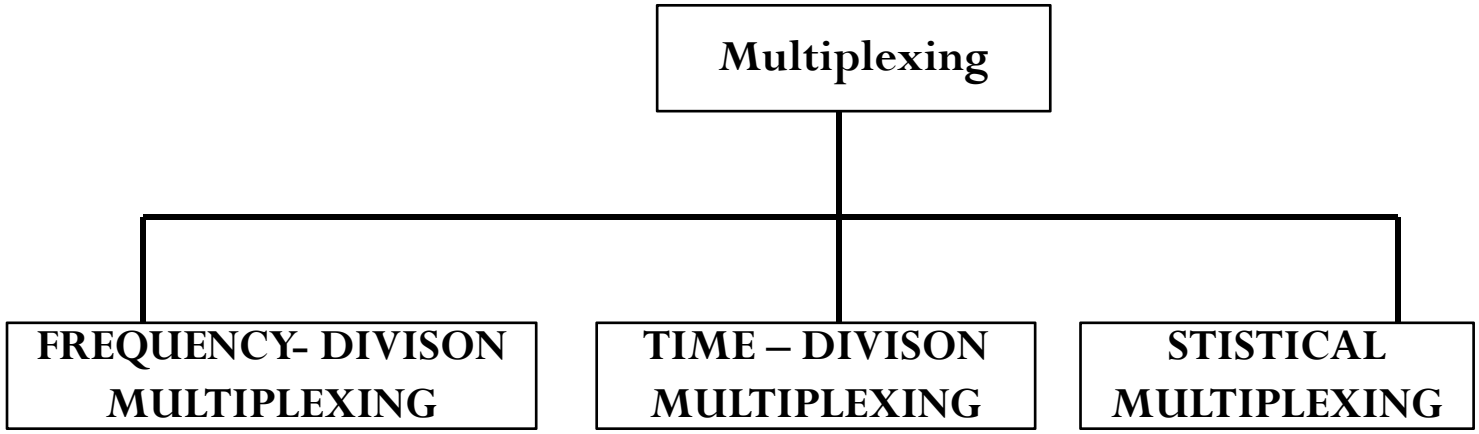
- The link is able to carry n separate channels of data.
- The multiplexer combines (multiplexes) data from the *n input lines and transmits over a* ***higher capacity*** data link.
- The de multiplexer accepts the multiplexed data stream, separates (de multiplexes) the data according to channel, and delivers them to the appropriate output lines.
- There are three types of Multiplexing



Frequency-division Multiplexing (FDM)

- FDM is a signal transmission technology in which **multiple signals can simultaneously be transmitted over the same line or channel**.
- Frequency-division multiplexing (FDM) can be used in both **wired and wireless networking** for transmitting **large amounts of data at high speeds**.
- FDM is the **simplest** and **oldest** form of multiplexing in wireless networking technology.
- Frequency division multiplexing involves simultaneously transmitting multiple signals on different frequencies.

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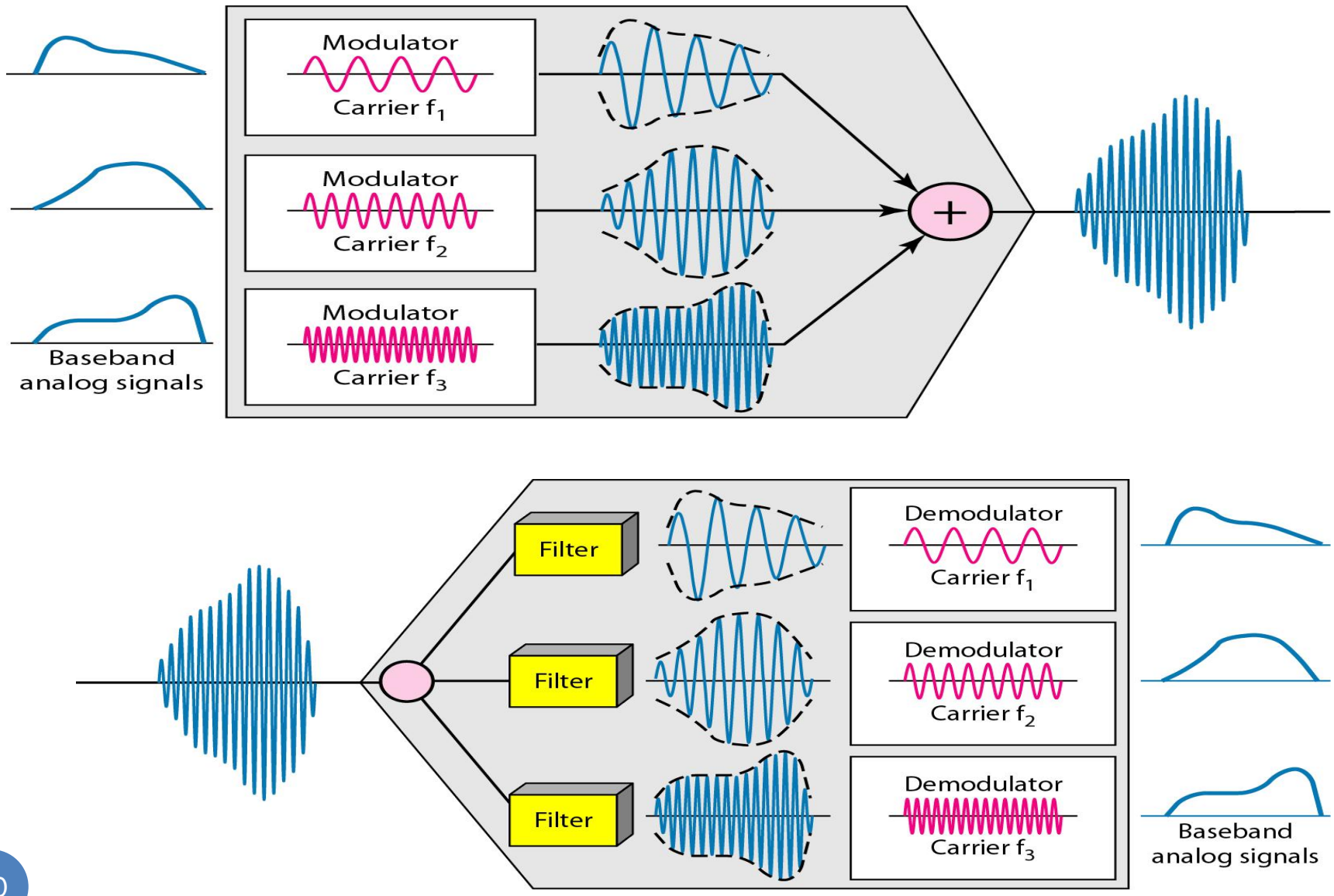
- These different frequencies, called channels, share **non-overlapping** portions of the total frequency band being used.
- Signals from different data sources are fed into a multiplexer that modulates each signal and transmits them at **different frequencies**.
- These signals are then transmitted over the wire or through wireless communication and are separated at the destination into individual data signals using a demultiplexer.

FD Multiplexing Vs. FD Demultiplexing Example



Time-division multiplexing (TDM)

- A multiplexing method for transmitting multiple data streams in **a single communication path**.
- In TDM, the data from different input channels is divided into **fixed-length segments** and then combined in **round-robin fashion** into a single output data stream, which can then be transmitted over a single channel transmission system and demultiplexed at the destination location.
- The segments can be created by the multiplexer itself or can be inherent in the input channel signals, such as fixed-length frames.

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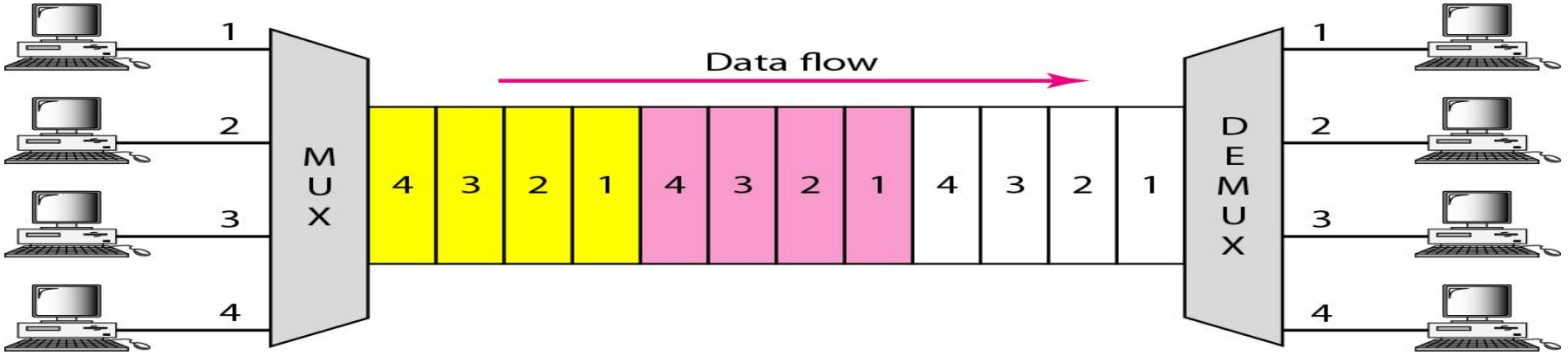
- TDM is a digital multiplexing technique for combining **several low-rate digital channels into one high-rate one**.



- **One weakness** in TDM is that if an input channel does not have anything important to carry for a time, **empty segments** are inserted into the output stream anyway. For example, if channel A is not transmitting data, one-third of the output channel is not being used. You can overcome this weakness by using a more sophisticated multiplexing technique called **statistical multiplexing**.

Contd.

- For example, if input streams A, B, and C are divided into segments as shown here:

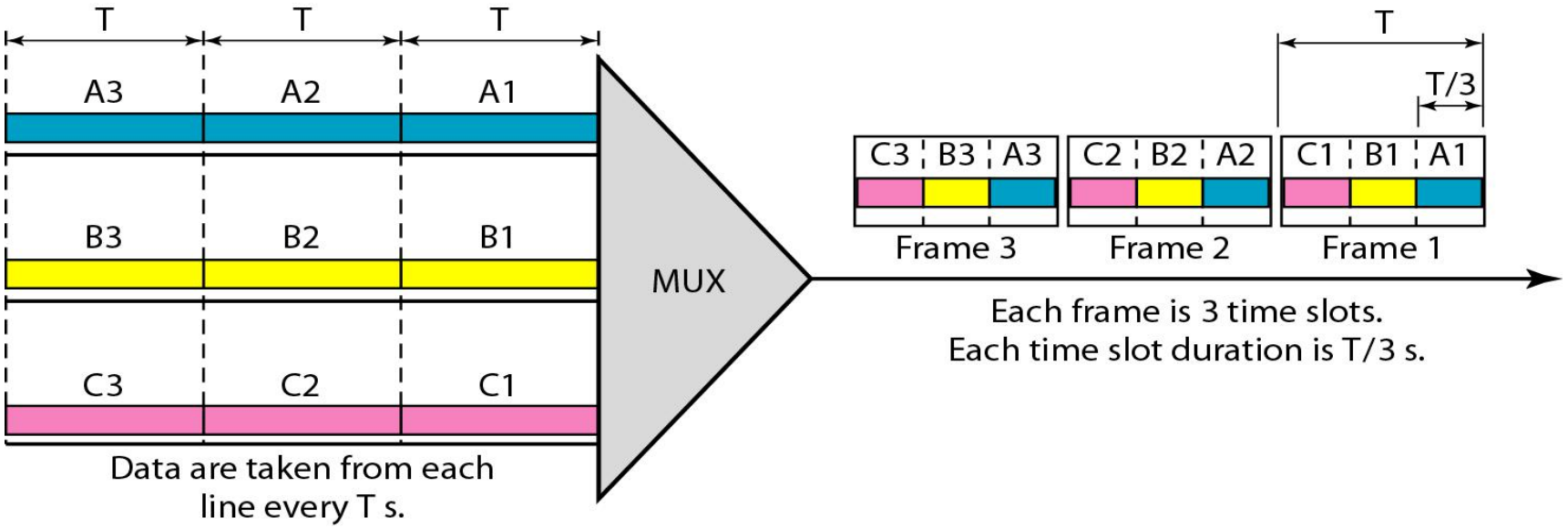
  A: A1, A2, A3,…

  B: B1, B2, B3,…

  C: C1, C2, C3,…

  the output stream will look like this:

  MUX(ABC) A1, B1, C1, A2, B2, C2, A3, B3, C3,...



Statistical Multiplexing

- It is a multiplexing technique that allows information from a number of channels to be combined for transmission over a single channel.
- Statistical multiplexing dynamically allocates bandwidth to each channel on an as-needed basis. This is in contrast to time-division multiplexing (TDM) techniques, in which quiet devices use up a portion of the multiplexed data stream, filling it with empty packets. Statistical multiplexing allocates bandwidth only to channels that are currently transmitting. It packages the data from the active channels into packets and dynamically feeds them into the output channel, usually on a FIFO (first in, first out) basis, but it's also able to allocate extra bandwidth to specific input channels.
- Statistical multiplexing is sometimes referred to as **statistical time-division multiplexing (STDM)**