Chapter 1

Introduction to Data Communications

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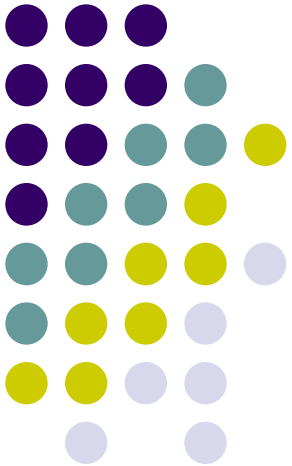
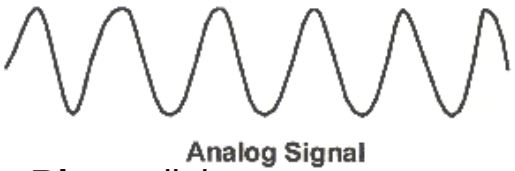


Chapter 1- Part 1
Digital vs. Analog Concepts

- **Digital vs. Analog Signals** الاشارات الرقمية والتناظرية

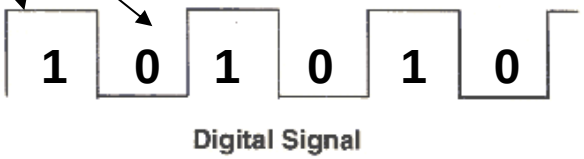
Analog: → Continuous values



Analog Signal

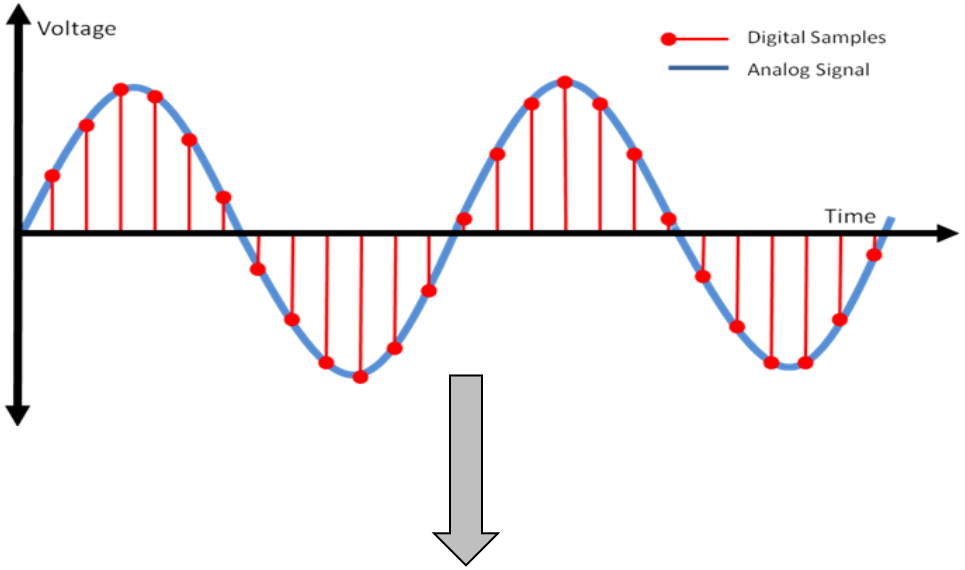
Bit= Binary digit

High= 1 **Low= 0 → +ve logic**



Digital Signal

Digital: → A discrete set of values



Digital System:

(1) Sampling → (2) Quantization → (3) Digital Coding (0's and 1's)

- In **Computer System**, **Data** represented by **binary information units in the form of 0s and 1s.**

Digital Applications:

- Wide Range of Applications Such as: Computers, Satellite TV, Military Systems, Medical Systems, Navigation GPS, Industrial Control,..etc.

Example: Digital/Analog System نظام تناظري/رقمي

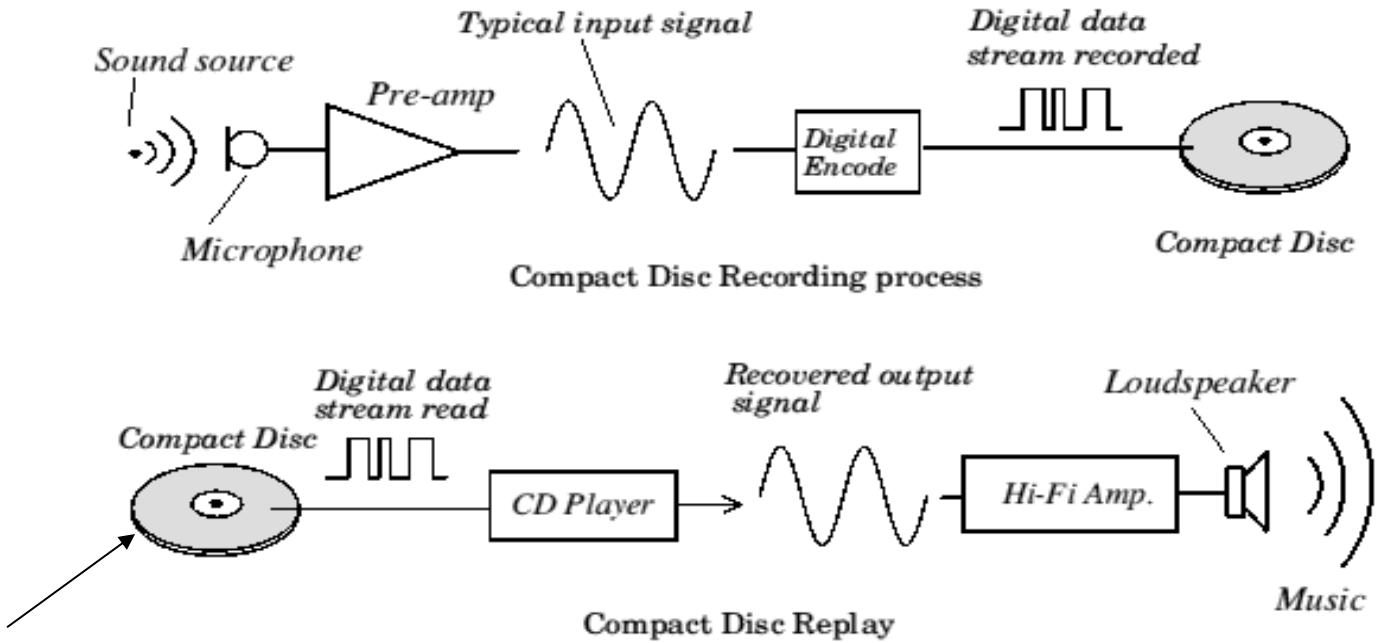
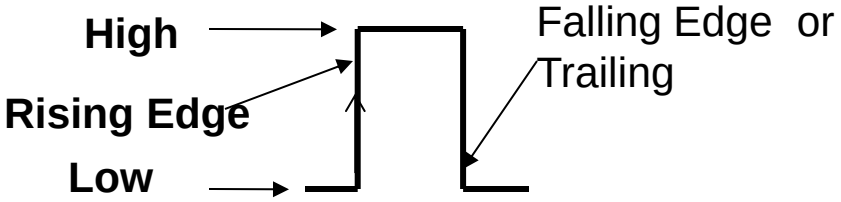
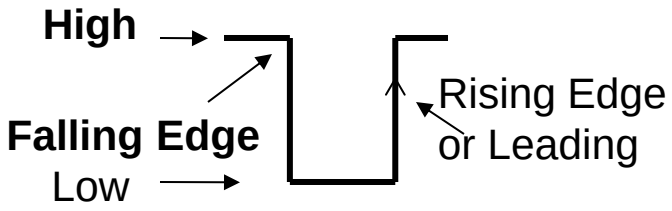


Figure 1.1 Compact Disc Hi-Fi Audio System (only one channel shown).

Digital Signal (Ideal Pulse)

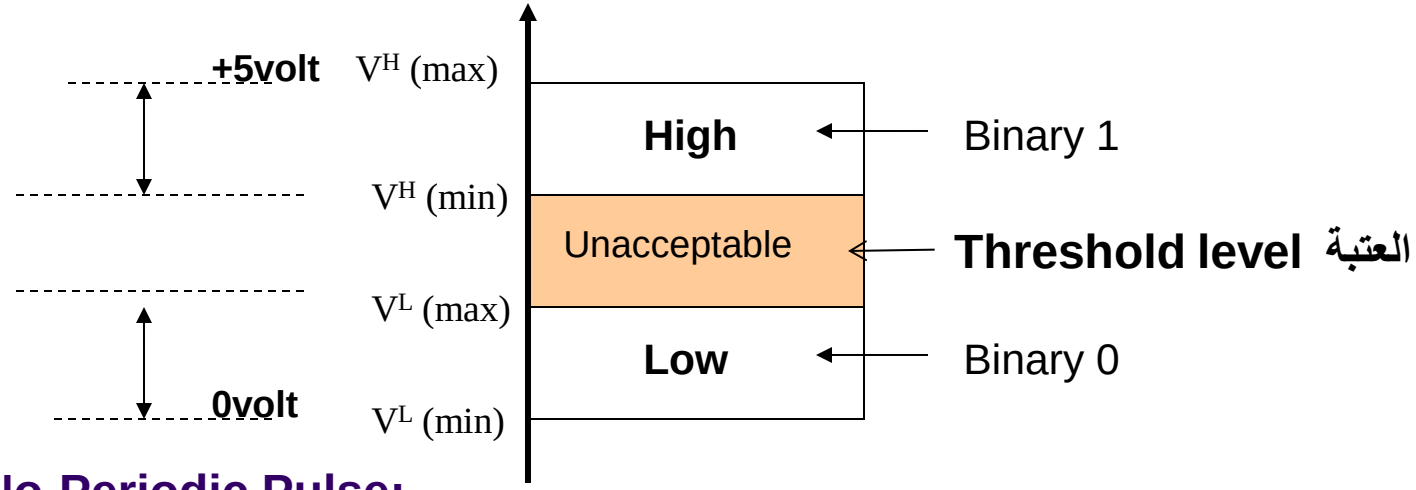


Positive-going Pulse (+ve)

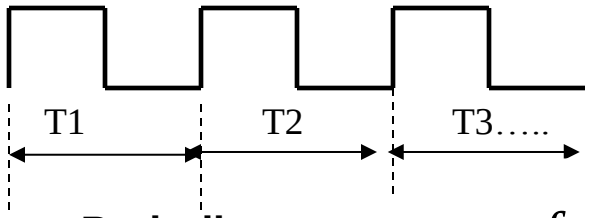


Negative-going Pulse (-ve)

Logic Levels



Periodic and No-Periodic Pulse:

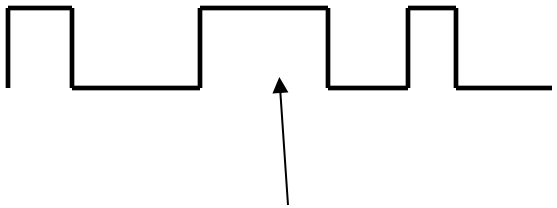


Period= T1 = T2 = T3…..

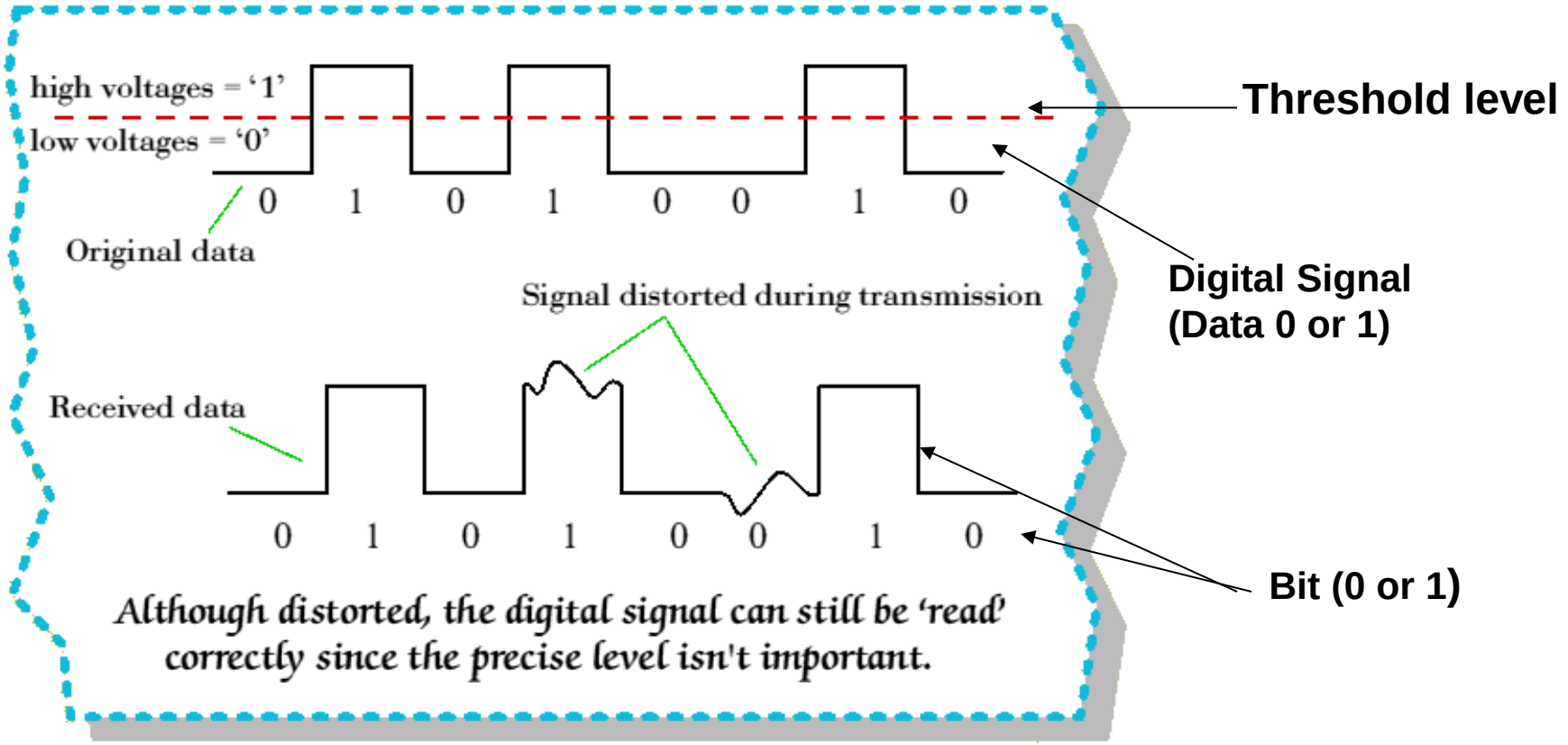
Periodic

$$f = \frac{1}{T} = \frac{1}{T_{bit}} = Bit\ Rate\ [bps]$$

Frequency=Clock [Hz]



Non-Periodic



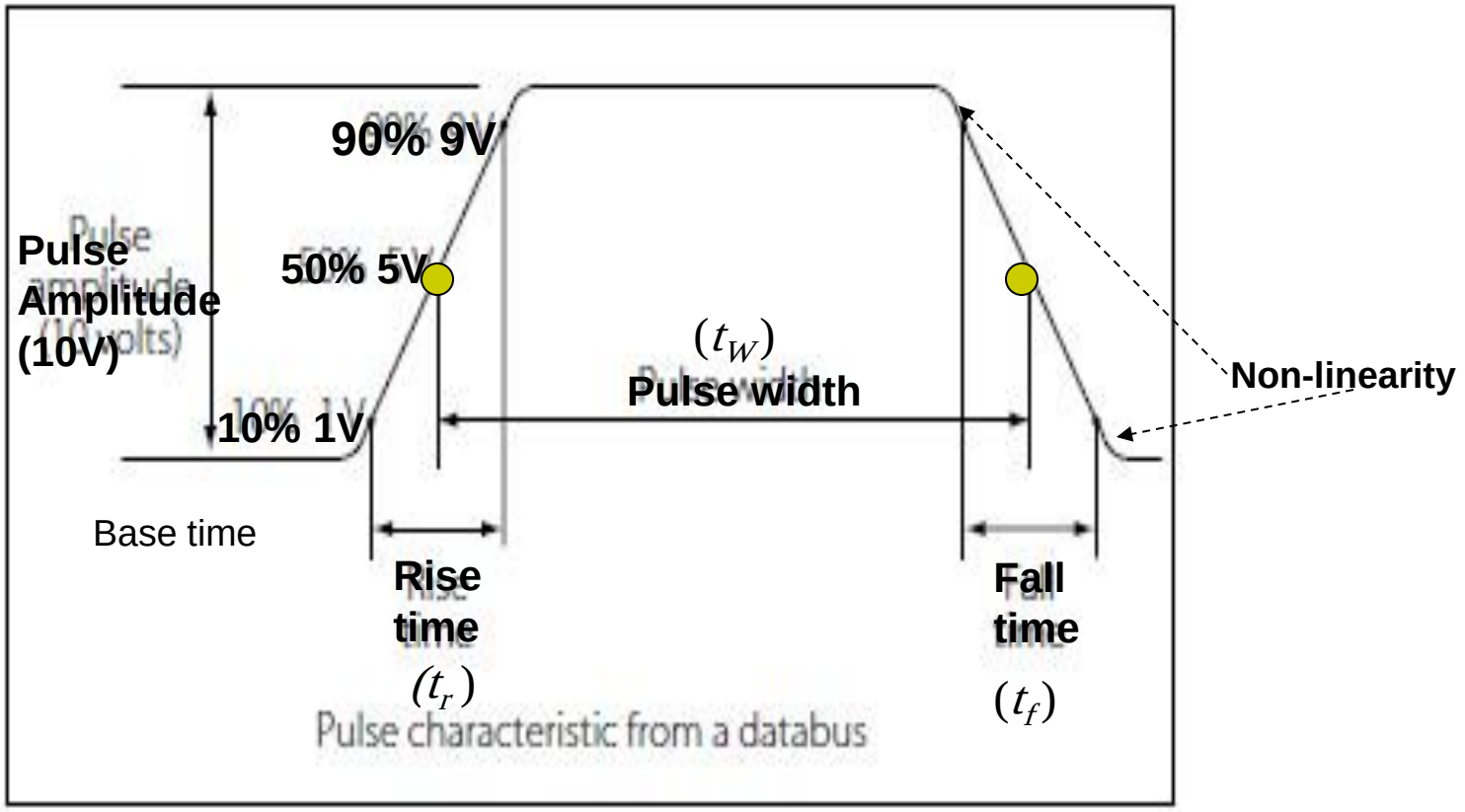
Digital Advantages

- **Digital data** can be processed and transmitted more efficiently بكفاءة عالية and reliably وثوقية ودقة عالية than analog.
- **Store** Data (if necessary). - ممكن خزنها عند الحاجة والضرورة

  (e.g. Music is converted to digital form and stored on CD)
- **Less effect to Noise (compared to Analog)** -اقل تأثر بالضوضاء

Signal (Waveform) Characteristics:

Non-Ideal Pulse

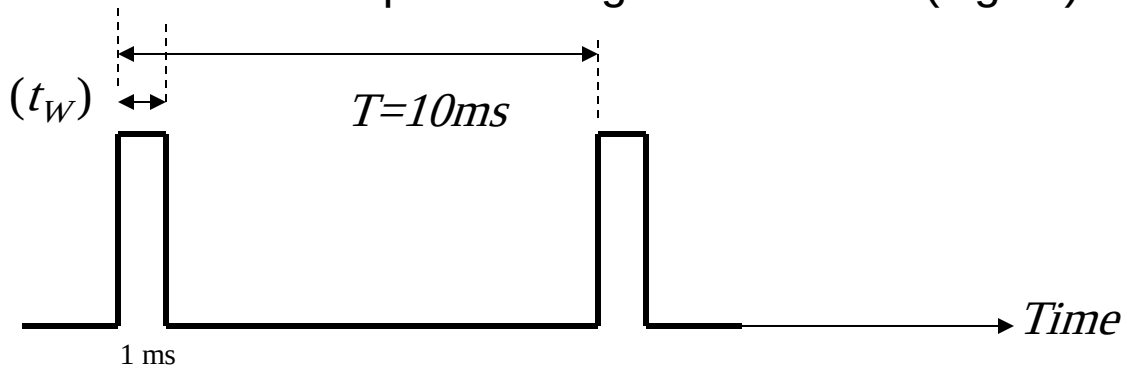


. Non-ideal pulse and its characteristics.

$$T = \frac{1}{f}$$

$$\text{Duty Cycle} = \left(\frac{t_W}{T}\right) \times 100\% \quad \rightarrow \textbf{For Periodic Pulse}$$

Example: Consider a periodic digital waveform (signal) :



Determine: (a) Period (b) Frequency (c) Duty cycle

Solution:

(a) The Period→ T=10 ms

(b) The Frequency→ $$f = \frac{1}{T} = \frac{1}{10ms} = 100\text{Hz}$$

(c) The Duty Cycle → $$\text{Duty Cycle} = \left(\frac{t_W}{T}\right) \times 100\%$$

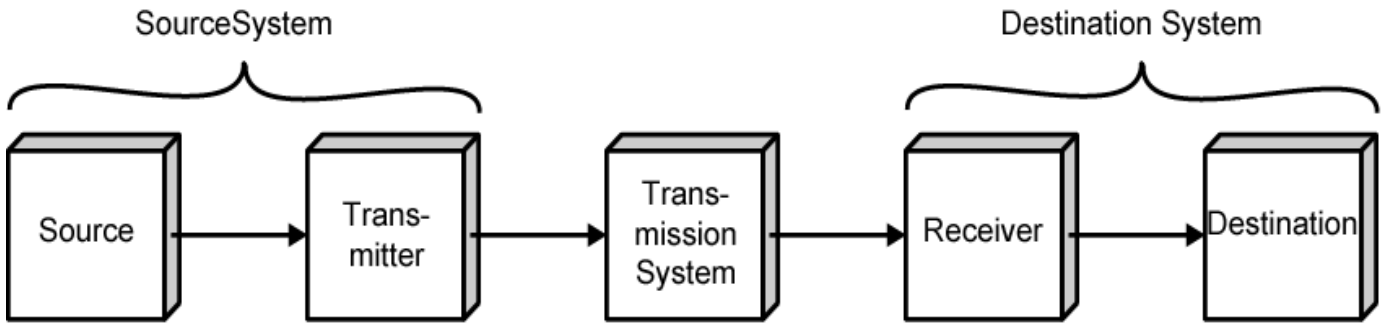
$$\text{Duty Cycle} = \left(\frac{1ms}{10ms}\right) \times 100\% = 10\%$$

Question: A period digital signal of a pulse width of 25μs and a period of 50 μs. Determine its frequency, bit rate and duty cycle.

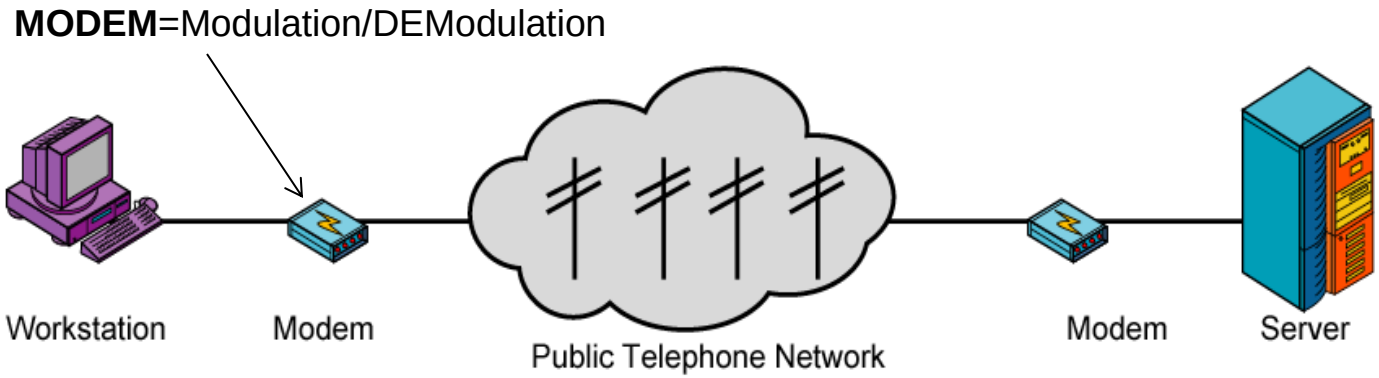
Chapter 1- Part 2
Introduction to Data Communications

- **Data Communications** is the transfer of data or information between a source and a receiver.
- The **Data** refers to facts, concepts and instruction presented in whatever form is agreed upon by the parties creating and using the data.
- **Communication Types:** - Local or Remote
  - Unicast or Multicast or Broadcast
  - Single User or Multiple Users (Sharing)
  - Serial or Parallel
  - Half-Duplex or Full-Duplex
  - Wired or Wireless ….etc.
- The term **Telecommunication** means **communication at a distance.** e.g. Telephony, Telegraphy, and television.

2.Communication System



(a) Simple Communication System

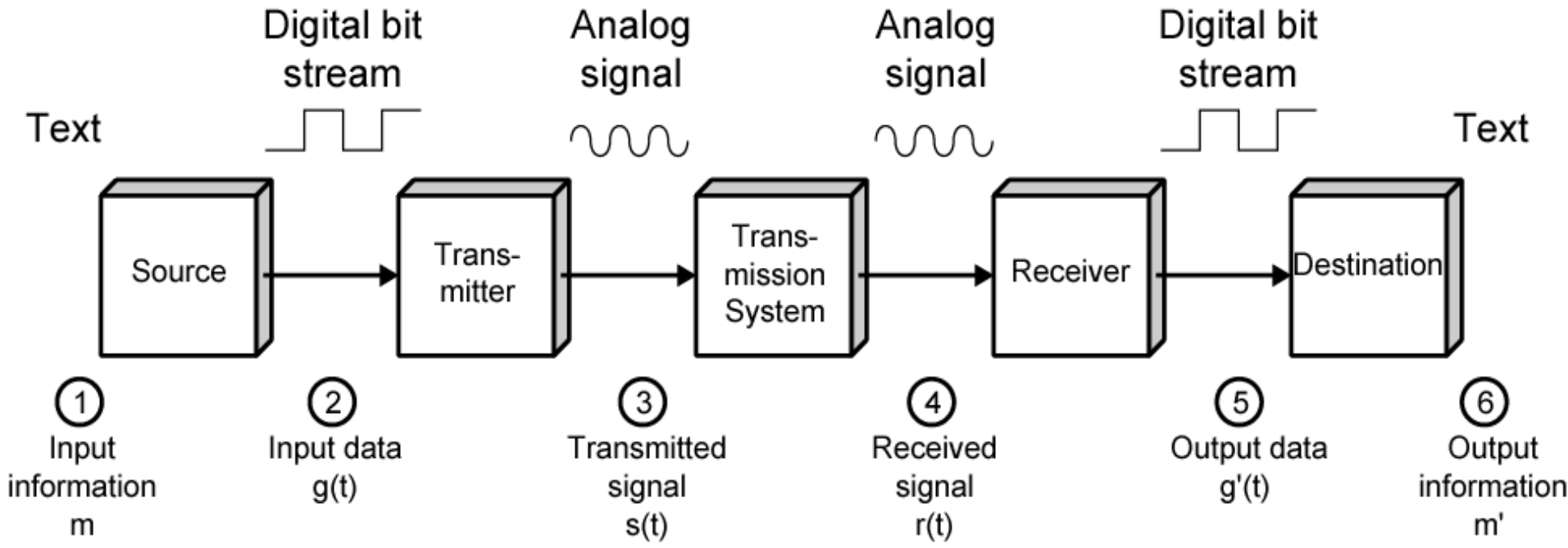


(b) Example

- Information →(**Voice, Data, Image, Video**)
- Transmission Media (Line or Network)→ Wired (guided) or Wireless (unguided Media)
- Signals→ (**Digital/Analog**)

- In Communication System → data exchange between two parties
- The **key elements of this System Model are:**

  - **Source** : generates data to be transmitted
  - **Transmitter** : converts data into transmittable signals
  - **Transmission System**: carries data from Source to Destination
  - **Receiver:** converts received signal to data
  - **Destination**: takes incoming data



3. Communications Tasks

Message formatting	Addressing
Interfacing	Routing
Signal generation	Recovery
Synchronization	Flow control
Exchange Management	Security
Error Detection and Correction	Network Management
Transmission System Utilization	

- **Data communication is** made up of a combination **of Hardware and Software. → e.g. Computer Networks**

- **Fundamental Characteristics in Data Communication System:**

1. **Delivery:** The System must deliver data to the **correct destination**.

2. **Accuracy:** The system must deliver **data accurately (no error)**.

3. **Timeliness:** The system must deliver data in **a timely manner i.e. (without delay).**

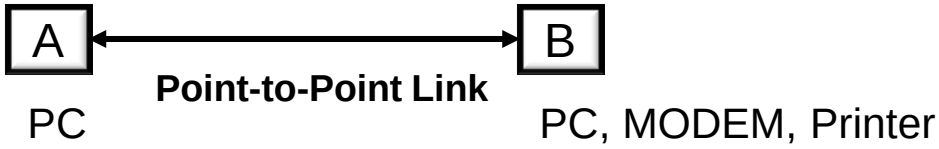
Example:

In case of video, audio, and voice data, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay.

This kind of delivery is called **Real-time transmission**.

- **Network:** is a Set of Communication links for interconnecting a collection of Stations **(Nodes)**

  e.g. Terminals, Printers, Computers, Modems, …etc.



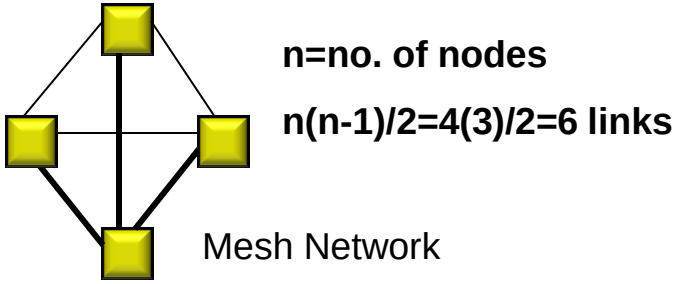
- **Type of Nodes:**

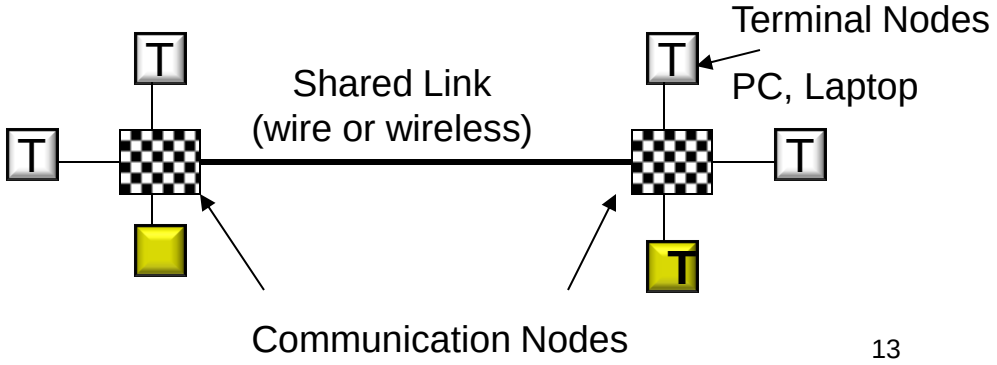
  - **Terminal Node:** generates or use information transmitted over network

    e.g. PC, Printer Video Monitor, File-Servers, (routers)→ (Processing)

  - **Communication Node:** transport information (not generate or use) → i.e. (transmit & receive)

    e.g. Switches, Hub, Repeaters, Boosters, modem, etc.



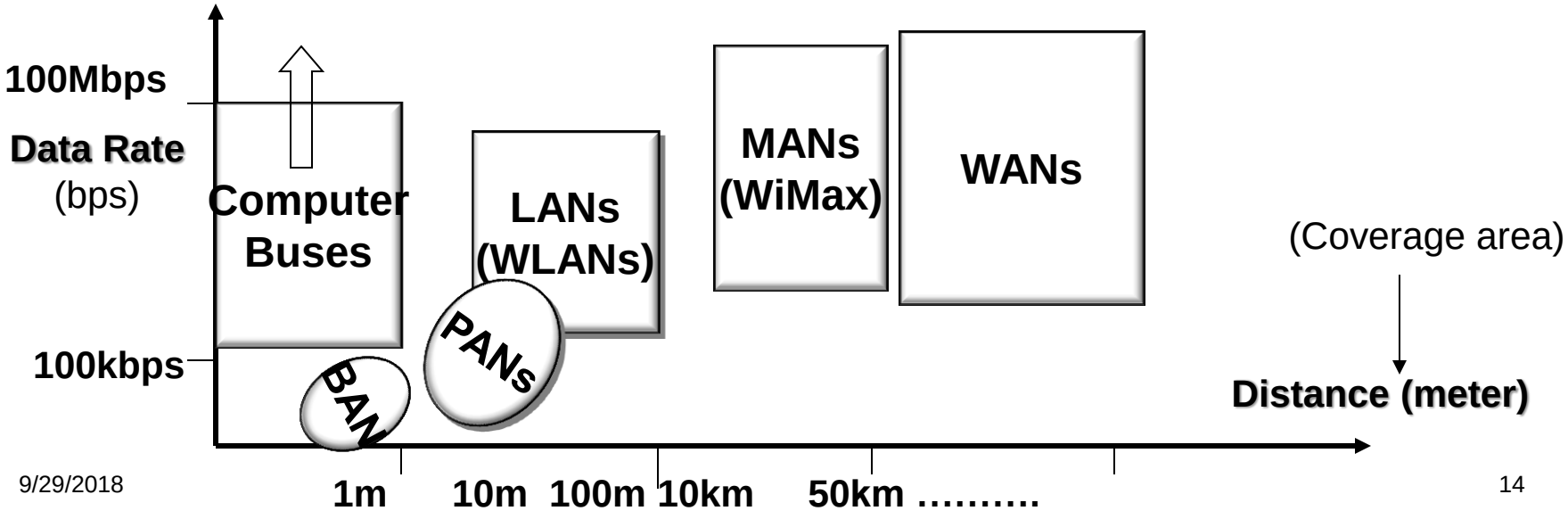


Type of Networks:

- **Computer Buses**: Cables like RS-232, RS449, etc.
- **LANS**: Local Area Networks, 1970's

  e.g. wireless LAN IEEE802.11a (54Mbps) 100-300m
- **MAN**s: Metropolitan Area Networks,

  e.g. WiMAX (IEEE802.16) up to 50km
- **WAN**s: Wide Area Networks e.g. Internet
- **BANs**: Body Area Networks (Sensors)
- **PANs**: Personal Area Networks (Bluetooth IEEE802.15.3)

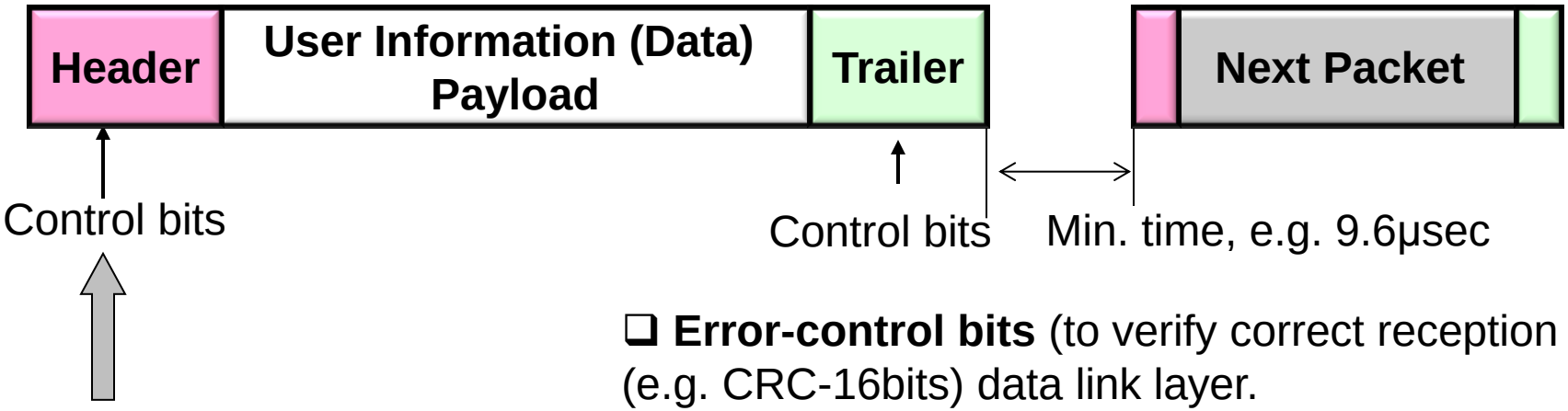


Messages and Packets

- **Message**: Binary Symbols=Stream of bits
- Messages needs **Control bits** (reliable communication, e.g. **CRC in data link layer**
- The long message is **broken** (decompose) up into shorter bit strings called →**Packets**.
- The **Packets** are sent through network and are **reassembled** into a complete message at the destination.

Packet Format:

- Header + Data (Payload) + Trailer



❑ **Error-control bits** (to verify correct reception (e.g. CRC-16bits) data link layer.

❑ Destination Address

❑ Source Address

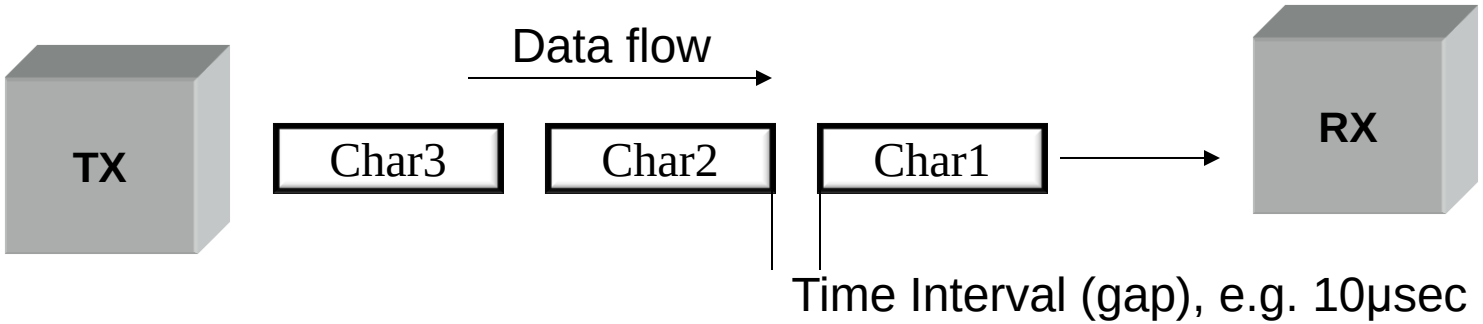
❑ Sequence Number ⟹ (is used by destination to verify that all packets are received)

Example: HDLC= High-Level Data Link Control

Note:

There is a minimum separation between successive packets instead of successive characters in (Asynchronous Transmission mode). This time is **smaller in Synch**. mode than Asynch. mode.

- **Example**: Transmission speed 38 kbps, 15 meters distance (cable), data transmission char-by-char ASCII(7bit) or EBCDIC(8bit) (Asynch Mode)

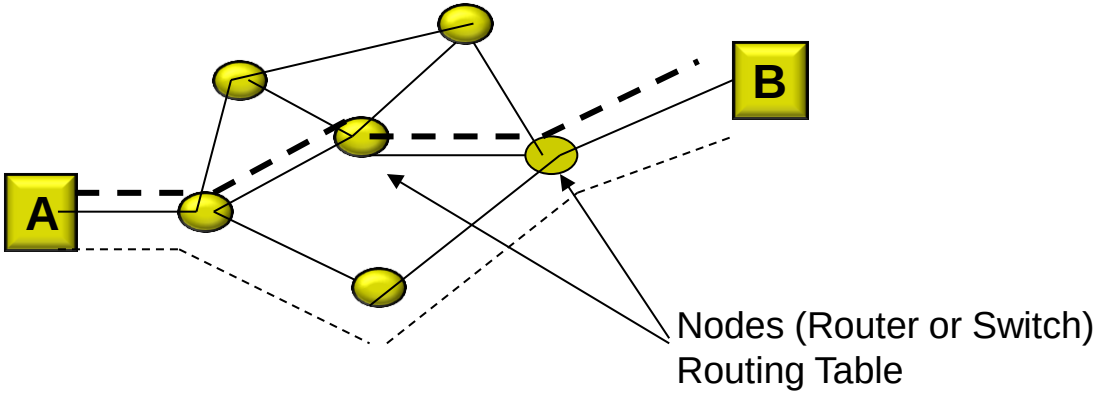


H.W: Consider Bit rate 100kbps Packet size 1000bit, what is the time required to send one packet (i.e., transmission time) if the time interval is 10μsec?

Store-and-Forward Transmission

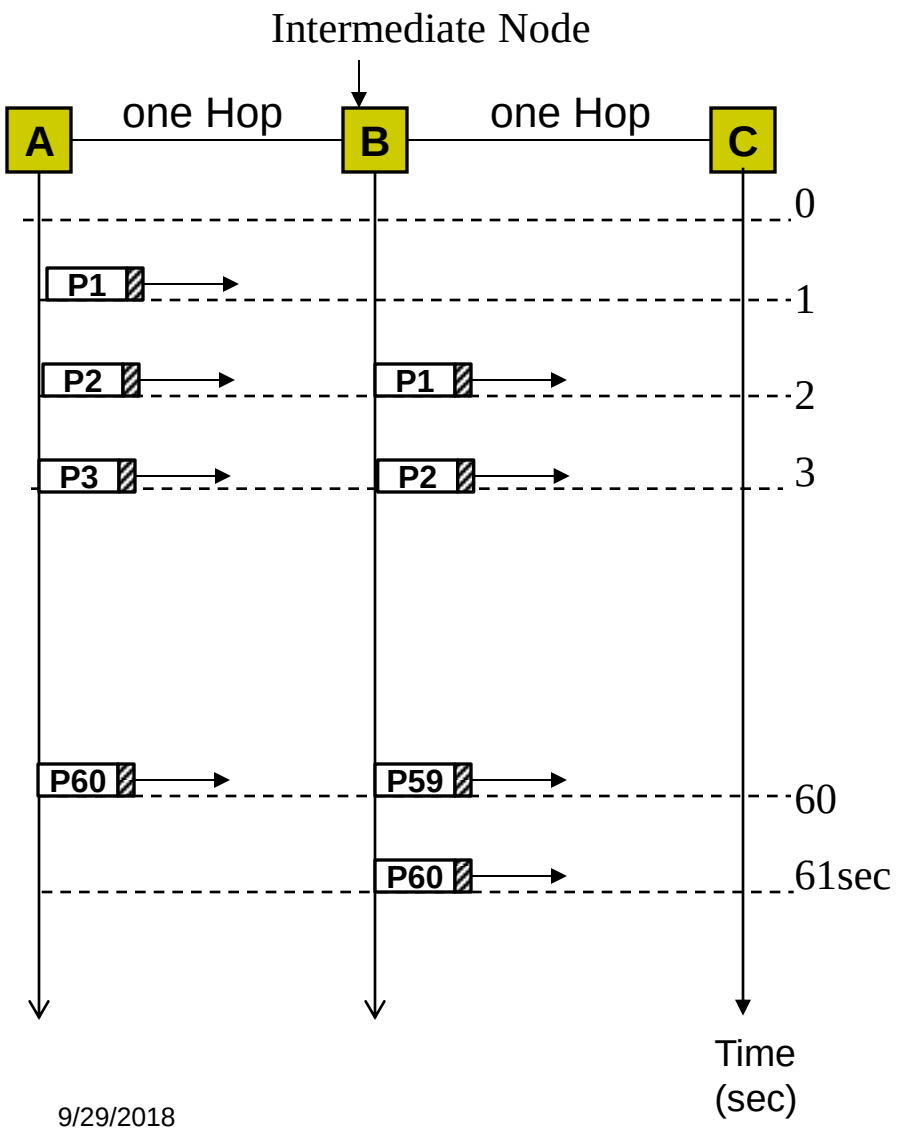
- **Message Switching**
- **Packet Switching**

- The store-and-forward mode needs the **controlle**r at each node to perform:
  - **Store** a Message
  - **Select** Appropriate Outgoing Link (**Routing table**)
  - **Transmit** the Message if the link is free.→ Post office.



An Example of 6 nodes store-and-forward network

Example: Consider Computer A is connected to Computer B and to C by two point-to-point links. Message is sent from A→B→C



Consider 1min 60 packets→1pkt/sec
T_{hop}=1sec

Message Switching:

Each hop 1min 60 packets→ Total time required=2 min to sent message of 60 pkts

Let ***N***=No. of intermediate nodes then total time required= ***N*+1 minutes**

If **N=1** then **1+1**=2min.

Packet Switching: **60s+ *N*=60+1=61s**

Note: If there are *N* intermediate nodes, we need (***N*+1)** min for message switching and (**1 min +*N***) sec in case of packet-switching

Exercise (2): Consider two intermediate nodes between A and B users, hop interval for each packet is 5sec. Determine

1- Transmission time for sending 4 packets using Packet-switching.

2- If the message consists of 4 packets, what is transmission time of message-switching.

Solution:

$$T_{Pkt-Switching} = N_n \times T_{hop} + N_P \times T_{hop}$$

$$T_{Message-switching} = (N_P \times T_{hop-Pkt}) \times (N_n + 1)$$

$$= T_{hop-message} \times (N_n + 1)$$

$N_n = No.\ of\ Intermediate\ Nodes$

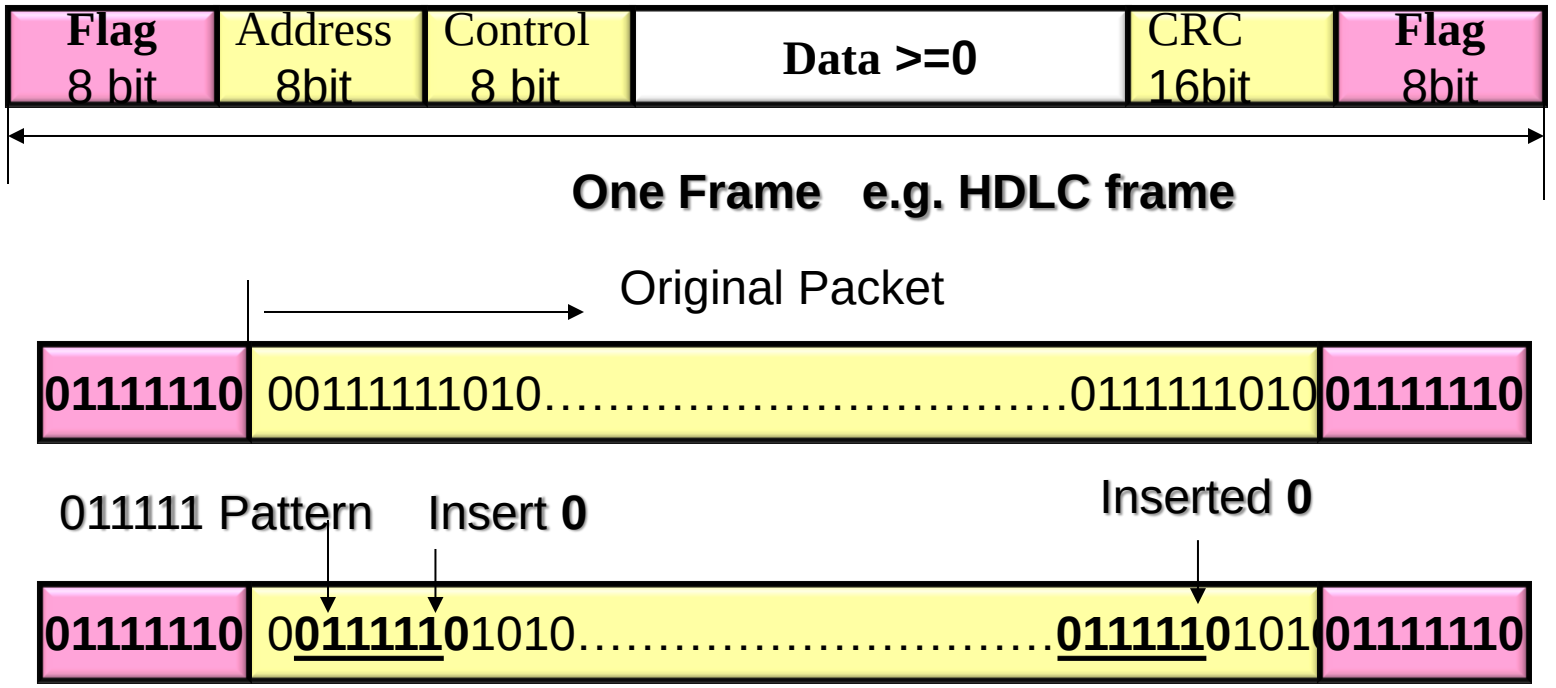
$No.\ of\ Hops = (N_n + 1)$

$N_p = No.\ of\ Packets$

$T_{hop} = Hop\ Interval\ Time$

1. Bit-oriented Transmission (Protocol): Data-Link Layer

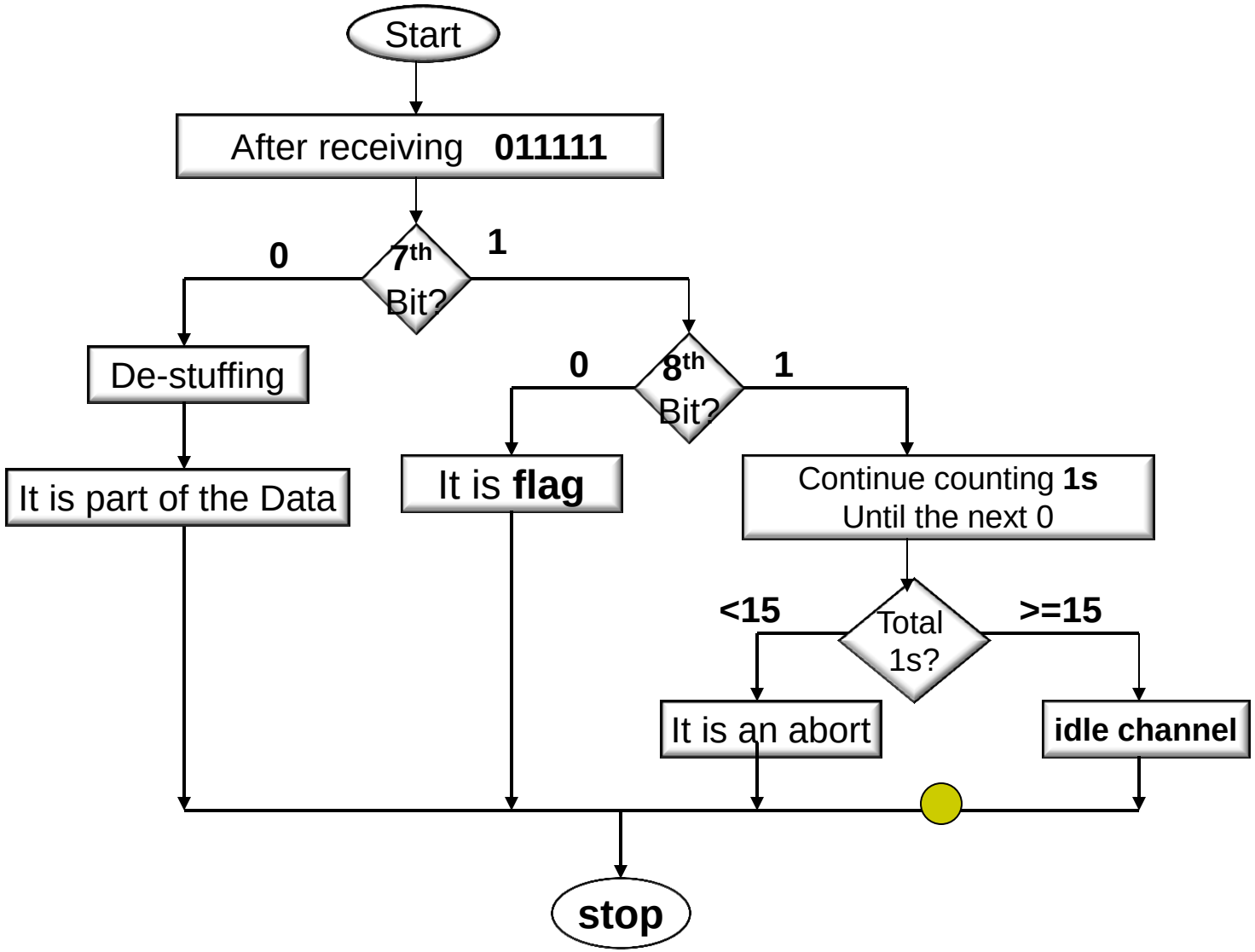
- Packet is framed by **two** special patterns called **Flags**.



Bit Stuffing (at TX): adding an extra 0 after each group of 011111 in the packet after the flag.

Bit De-stuffing (at RX): inverse operation of staffing (i.e., deleting an extra 0)

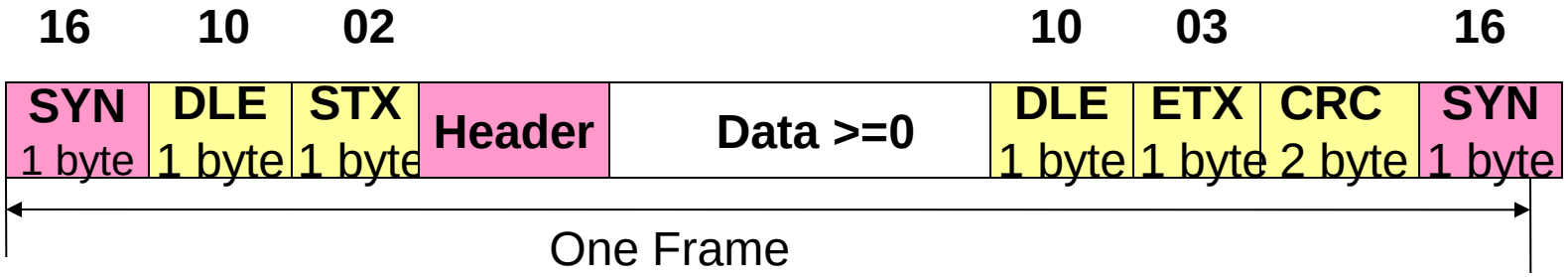
Bit-Stuffing



Bit-oriented Transmission (Protocol): (HDLC)

2. Character-oriented Transmission: Data Link Layer

Packet consists of integer no. of bytes. The string of bits is preceded by one or more special **SYN** characters *followed* by **DLE** and **STX**.



SYN= Synchronization character
DLE= Data-Link Escape
STX= Start of Text
ETX= End of Text

Note: Char-oriented protocol ASCII 7bit 3bit 4bit

Higher lower

b4 b3 b2 b1 (0 1 2…15**)** **b7 b6 b5 (0 1** 2 …..7)

Example: 2 0 → **0**2 STX **0**3 ETX **1**0 DLE

Character stuffing (at TX): replacing every occurrence of **DLE** in the string by **DLE DLE.**

Note: Inside the frame (Data field) → DLE DLE ETX DLE DLE STX as a data **but only DLE STX** means frame beginning.

Character De-stuffing (at RX): change **DLE DLE** to **DLE**

USART: Universal Synchronous /Asynchronous Receiver/Transmitter→ e.g. 8251A 16550

Exercise:

- Consider simple network shown in figure. One file of K>>1 bits must be sent from A to C. The file is decomposed into packets of P bits each. Each packet contains 16 error-control bits, 32 bits of address and sequence number, in addition to the P data bits. Each packet is first sent from A to B and then from B to C.

  a) Find the value of P that minimizes the transmission time from A to C, neglecting the propagation time.

  b) Repeat the problem when the file must go through N communication nodes between A and C.