

# زكاة التبع العجايب والبعث العليمي



## جامعة الانبار كلية علوم الحاسوب وتكنولوجيا المعلومات قسم علوم الحاسبات

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# Lecture One

## Digital Concepts

### Objectives:

- Introduction (digital system design concepts and definitions).
- Advantages and drawbacks of digital techniques compared with analog.
- Digital Abstraction.
- Synchronous and Asynchronous Systems.
- Specification of Digital Systems.
- Implementation of Digital Systems.
- Switching Networks Types: Combinational and Sequential.
- Digital System examples.

## Introduction (concepts and definitions)

**System:** A set of related components work together to achieve a goal.

A system contains (see figure 1):

- ✓ **Input**
- ✓ **Behavior**
- ✓ **Output**



Figure 1: System Architecture

**Behavior** is a function that translates input to output.

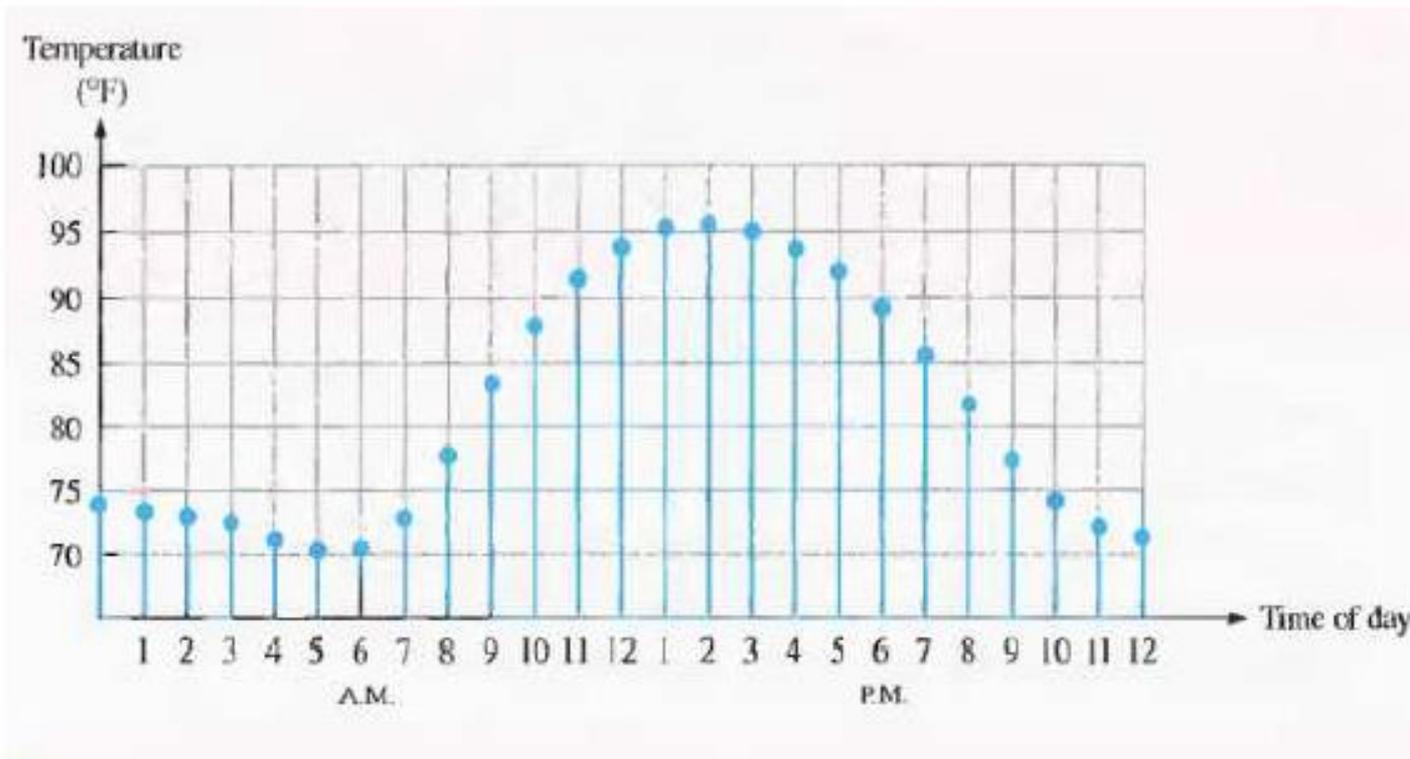
**Components** are electronic components: *digital*, *analog* and *mixed* signals.

**Digital system** is a system in which signals have a *finite number* of discrete values (see figure 2).

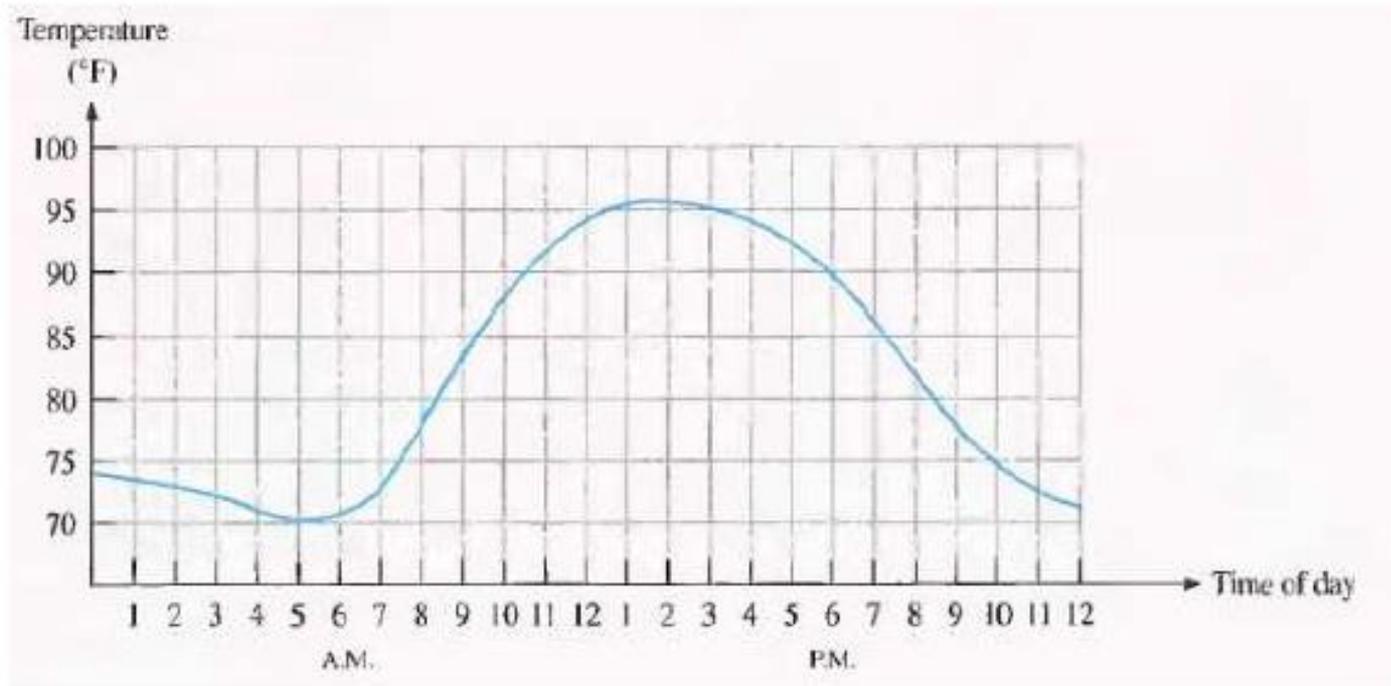
**Analog system** contains devices that manipulate *continuous set* of values (Analog from representation, see figure 3).

**Mixed system (hybrid)** mixed systems can manipulate both signals (digital and analog forms).

- ✓ In analog systems, for any input value, the set of infinite output values can be obtained.
- ✓ In mixed systems, they can contain both finite and infinite values for inputs and/ or outputs.



**Figure 2: digital signal**



**Figure 3: Analog signal**

## Advantages and Drawbacks of digital techniques compared with analog

### Advantages:

- Digital systems are generally *easier to design* (automated design and fabrication on IC chips).
- Information storage is *easy*.

- Digital representation is very *well suited* for *numerical* and *non-numerical* information processing.
  - *Numerical information:*  
The digital representation is simple: 0, 100, 130.53
  - *Non-numerical information:*  
The character can be represented digital in easy way.
- Accuracy and precision are *greater*:
  - Digital system can handle as many digits of precision as you need simply by adding more switching circuit.
  - In analog systems, precision is usually 3-4 digits.
- Operations can be *programmed*.
- Digital circuits are less affected by *noise*.
- Low cost.
- Easy to *duplicate* similar circuits (regular structures).
- The main advantages: *Easily controllable by computer*, the finite number of values in a digital system can be represented by a vector of signals with just two values (Binary signals) e.g. 2 is **0010** and 10 is **1010**. So the device which processes the signal is very simple say a **switch- open/close**.  
Finite values- 0 and 1 (Binary values).

## Example:

0-10 decimal numbers:

0 = 0000

1 = 0001

2 = 0010

3 = 0011

4 = 0100

....

10 = 1010

## Disadvantages of Digital Techniques:

- Lower speed (extra time required to perform conversions)
- The major drawback is

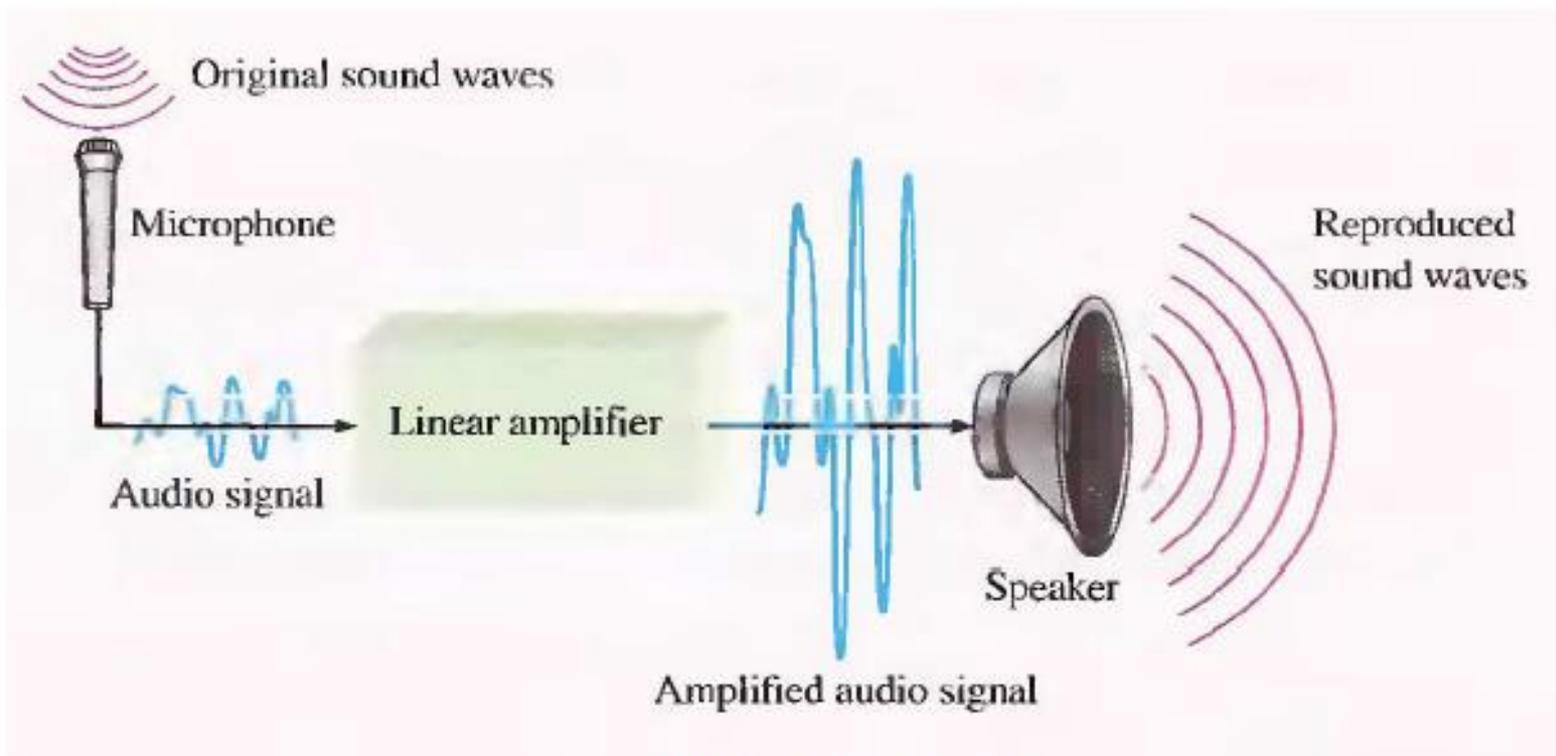
***The physical world is analog***

Such as temperature, pressure, talk, etc

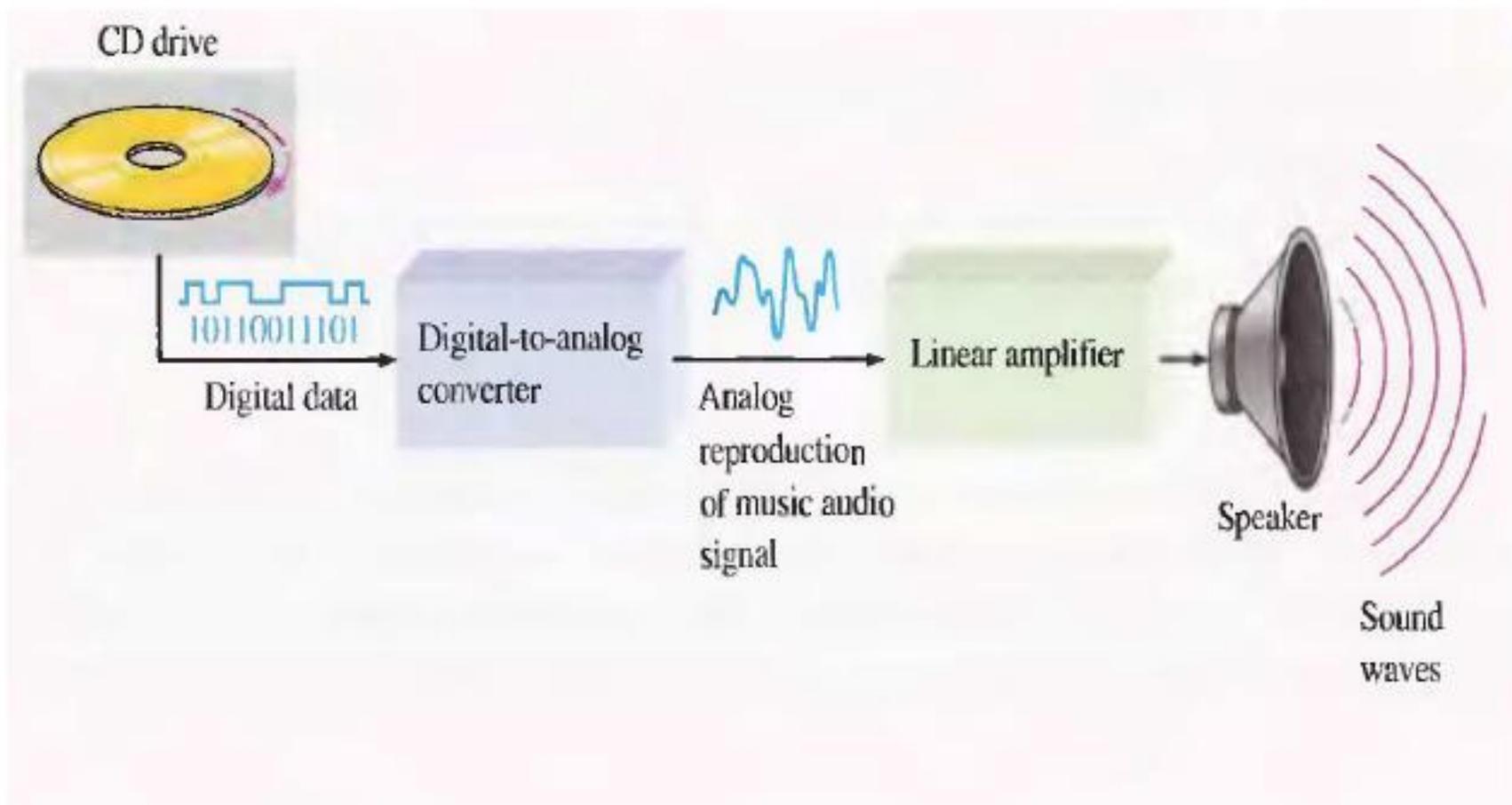
***So we need to convert digital to analog and vice versa to communicate with real world.***

## Three steps must be followed

1. *Convert the real- world analog inputs to digital form.*
2. *Process the digital information.*
3. *Convert the digital outputs back to real-world analog form.*



**Figure 4: Analog System**



**Figure 5: Mixed System**

## Digital Abstraction

- Digital circuits actually deal with analog signals (current or voltage: 0-10 volts).
- **Example 1: analog values: 10v power supply**

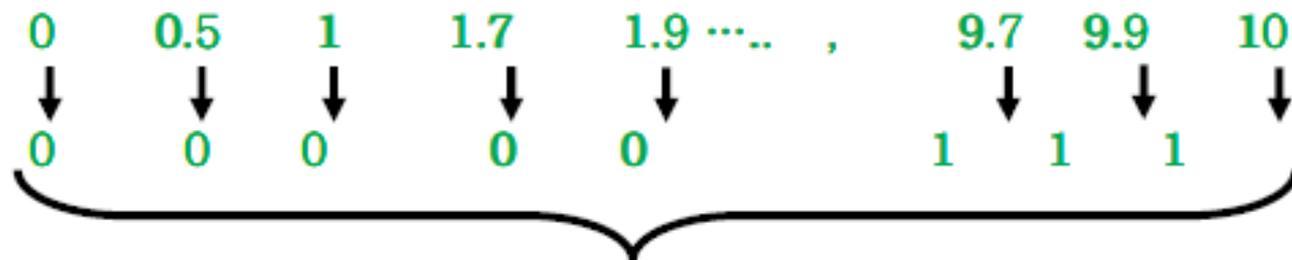
0      0.5   1      1.7            1.9            2.3, ... , 9.7,      9.9 , 10

To represent these values digitally using just two values 0 and 1, we first define one range for 0 and another range for 1:

**For example:**

range 1:            0 - 4.8 v       $\longrightarrow$       0  
range 2:            4.8 - 10 v      $\longrightarrow$       1

So the digital representation for the above sequence is:



- Digital abstraction allows analog signals to be ignored and allows some discrete values to be used.

**Example 2: Binary system, only two values are allowed: 1 and 0**

1 means high value or logic "TRUE"

0 means low value or logic "FALSE"

### Synchronous and Asynchronous Systems

Synchronous system: elements change their values at certain specified times (*clocked*).

Asynchronous system: output can change at any instant of time.

#### **Example: Digital clock**

- ✓ If a digital clock is set to alarm at every minute: **11:15, 11:16, 11:17, 11:18, etc**, then the system is *synchronous*.
- ✓ If a digital clock is set to alarm at any time: **10:10, 10:70, 13:35, 22:15, etc**, then the system is *Asynchronous*.

## Specification of Digital Systems

Specification of system is the description of the system functions and another characteristics required for designing it such as *speed, cost and power*, (requirements) they are related, when construct a system.

## Implementation of Digital System

Implementation means how the system is constructed from smaller and simpler components called modules.

- ✓ The modules can vary from simple gates to complex processors.
- ✓ Digital system follows some *hierarchical implementation*.

### Hierarchical implementation:

- *Modular design:*
  - *Divide and conquer*
  - *Modules are designed and built separately and then assembled to form the system.*
  - *Simplifies implementation and testing*



*We can break to smaller blocks;  
each block has its own function.*

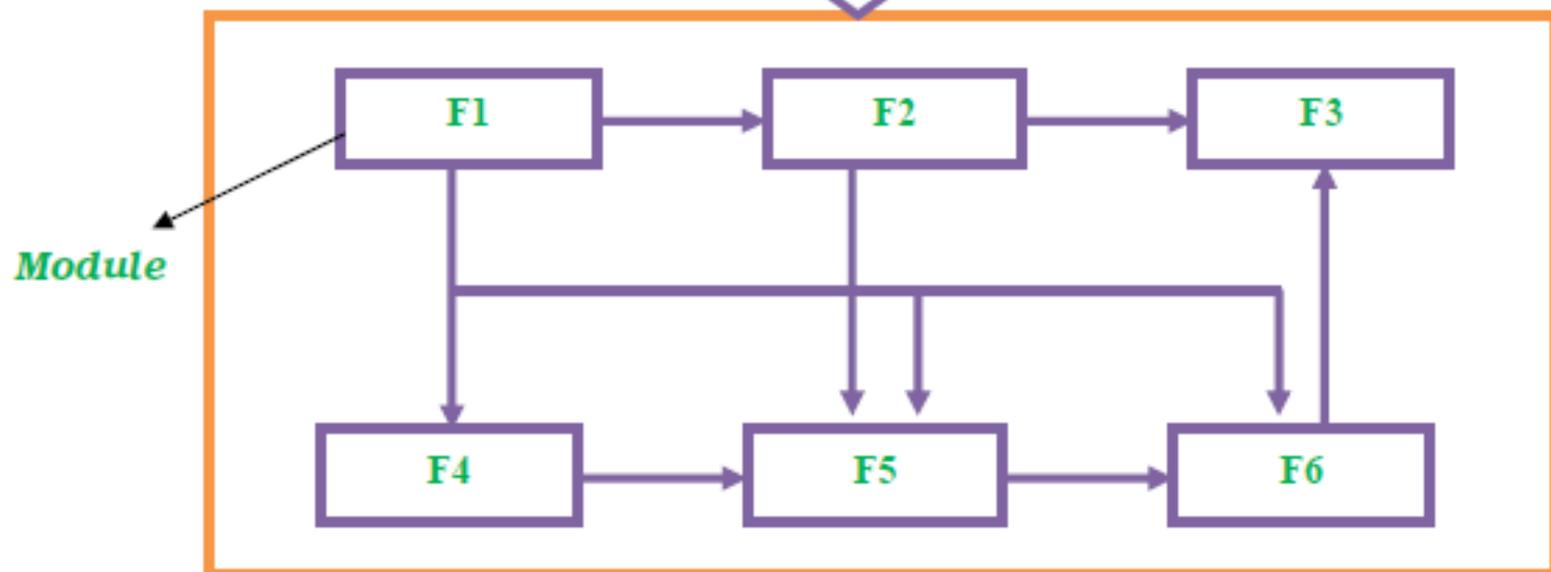


Figure 6: Modular design

➤ *Design approaches:*

○ *Top-down design:*

- Starts at the top and works down.
- Decomposes the system into subsystem and then subsystems into simpler and smaller subsystems and so on.
- Stop when subsystems can be realized by directly available module.

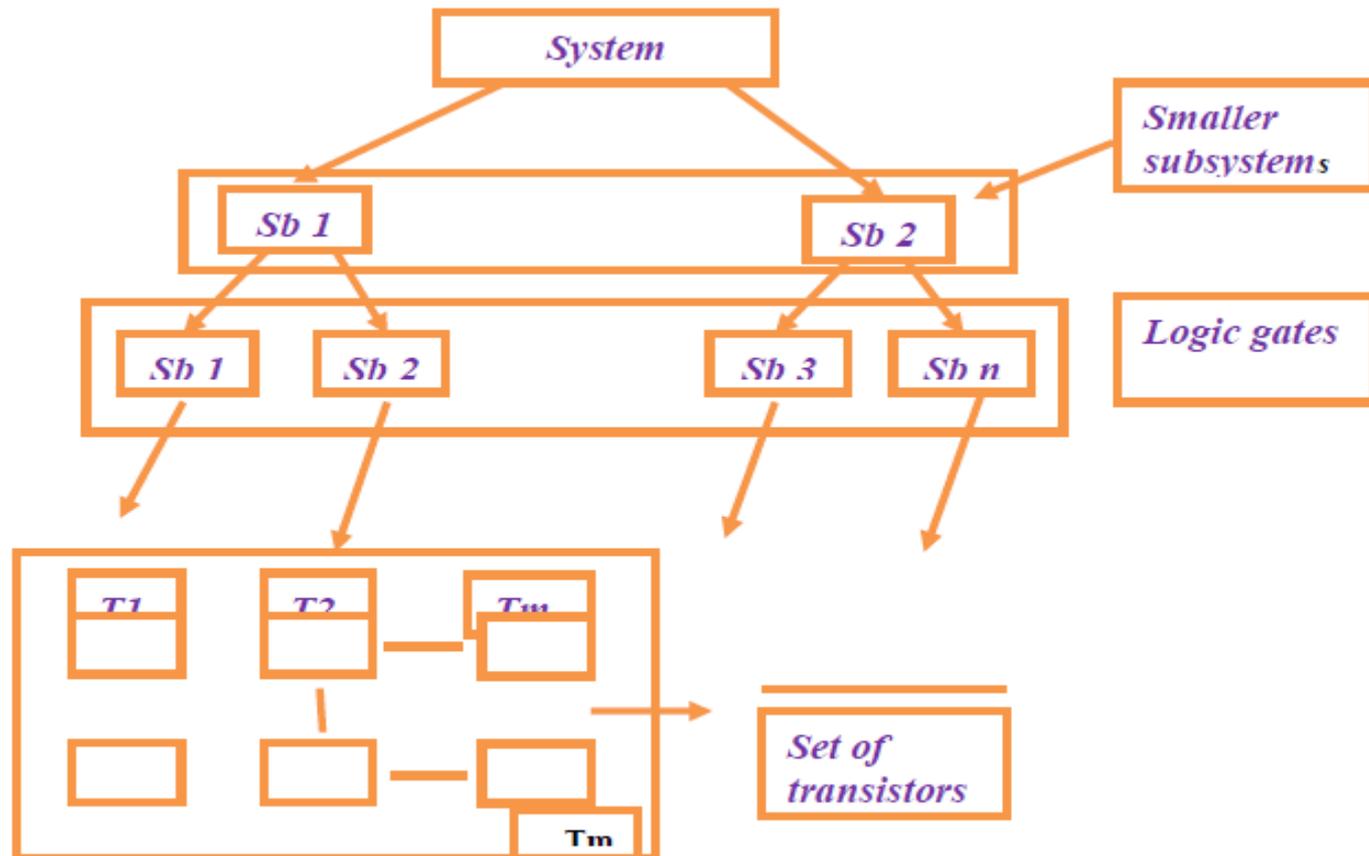


Figure 7: Top-down design

○ *Bottom-up Design*

- Starts at the leaves and put pieces together to build up the design.
- Subsystems are assembled to form a bigger subsystem.
- Stop when required functional specification is achieved.

**Switching Networks Types: Combinational and Sequential**

**Switching network:** Many of the subsystems of a digital system take the form of switching network.

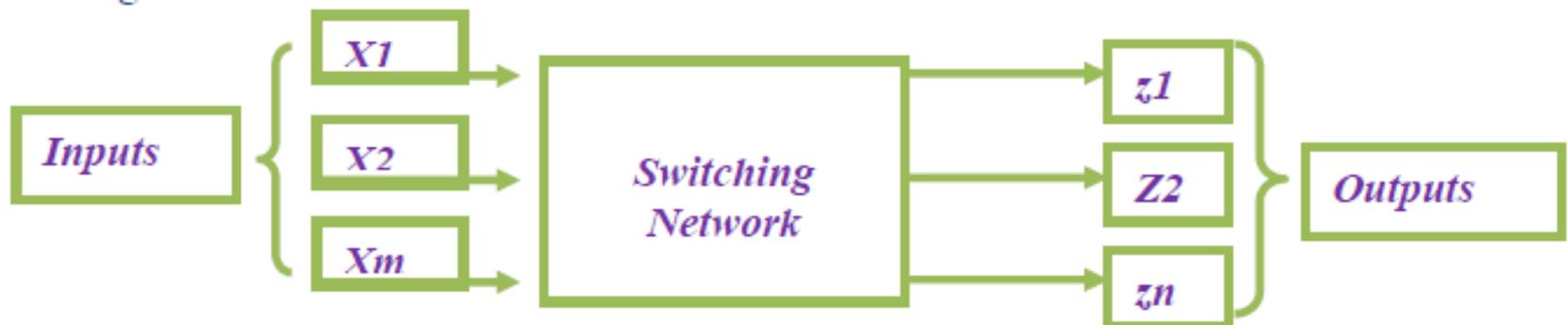


Figure 8: Switching network

- *Switching networks types*
  - *Combinational*
  - *Sequential*

In **combinational network**: the output values depend only on the present value of the inputs and not on past values.

In **sequential network** the output depend on both the present and the past input values (we need a *memory*).

***In general, a sequential network is composed of a combinational network with added memory elements.***

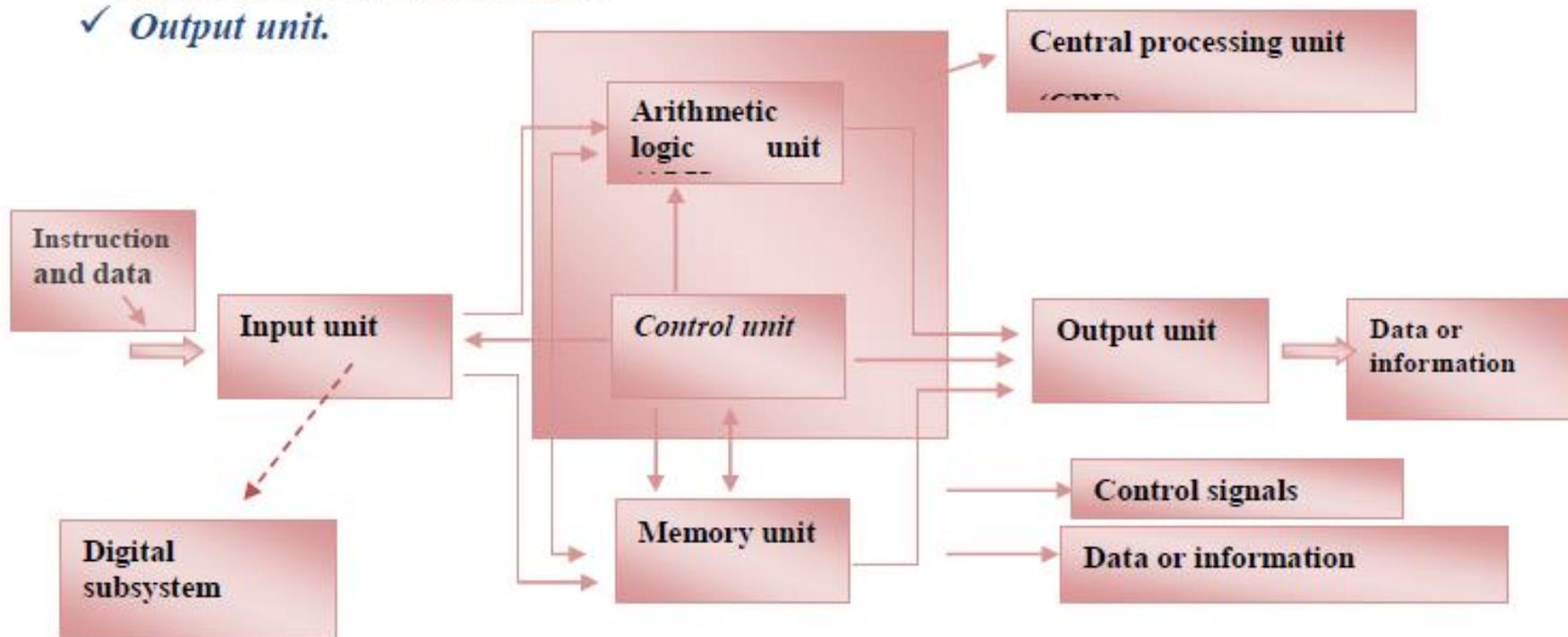
- The basic building blocks used to construct combinational network are *logic gates*
- The relationship between the input and output signal of the logic gates can be described mathematically using *Boolean algebra*

### **Digital system examples**

- *Digital calculator.*
- *Digital watch.*
- *Digital computer.*

## Functional parts of a digital computer:

- ✓ **Input unit:** enter a set of instructions and data.
- ✓ **Memory unit:** Stores the instructions and data received from the input unit.
- ✓ **Control unit:** Send appropriate signals to all the other units to cause the specific instruction to be executed.
- ✓ **Arithmetic/ logic unit (ALU).**
- ✓ **Output unit.**



*General diagram of a digital computer*

- ✓ Each component (input/ output/ memory/ CPU) is a digital subsystem.