Department of software engineering
Embedded Systems

Chapter one :
Introduction to Embedded Systems

❖ Definition of Embedded Systems

❖ Embedded Systems Characteristics

❖ Application area of Embedded Systems

❖ Contrast Between Embedded Systems and Other Computer **Systems**

Embedded System

- System is combination of equipment's and rules to perform some task.

- It is an arrangement in which all its units are assembled and work together according to set of rules

     Example: watch time display system

- Embedded system is an Electronic/Electro-mechanical system which is designed to perform a specific function.

- It is a combination of both **hardware** and **Software**.

- The task has to be completed in a given time.

E.g. Electronic Toys, Mobile Handsets, Washing Machines, Air Conditioners, etc…

Embedded System is: a computer system that is designed to serve for dedicated purpose.

❖ Complexity is embedded inside the device- the user doesn't have to deal with the complexity

❖ IEEE defines Embedded Systems as: "the devices used to control, monitor or assist the operation of equipment, machinery or plant".

❖ "Embedded" reflects the fact that they are an integral part of the system.

General Purpose Computer v/s Embedded System

Parameters	General Purpose Computer	Embedded System
1) Purpose	➢Multipurpose	➢Single Functioned
2) Size of System	➢Big	➢Small
3) Power Consume	➢More	➢Very Less
4) Cost of System	➢Costly	➢Cheap
5) Memory	➢Higher Memory	➢Lower Memory
6) Performance	➢Faster & Better	➢Fixed Runtime Required
7) User Interfaces	➢Keyboard, Display, Mouse, Touch Screen	➢Button, Sensors

Block Diagram of Embedded System
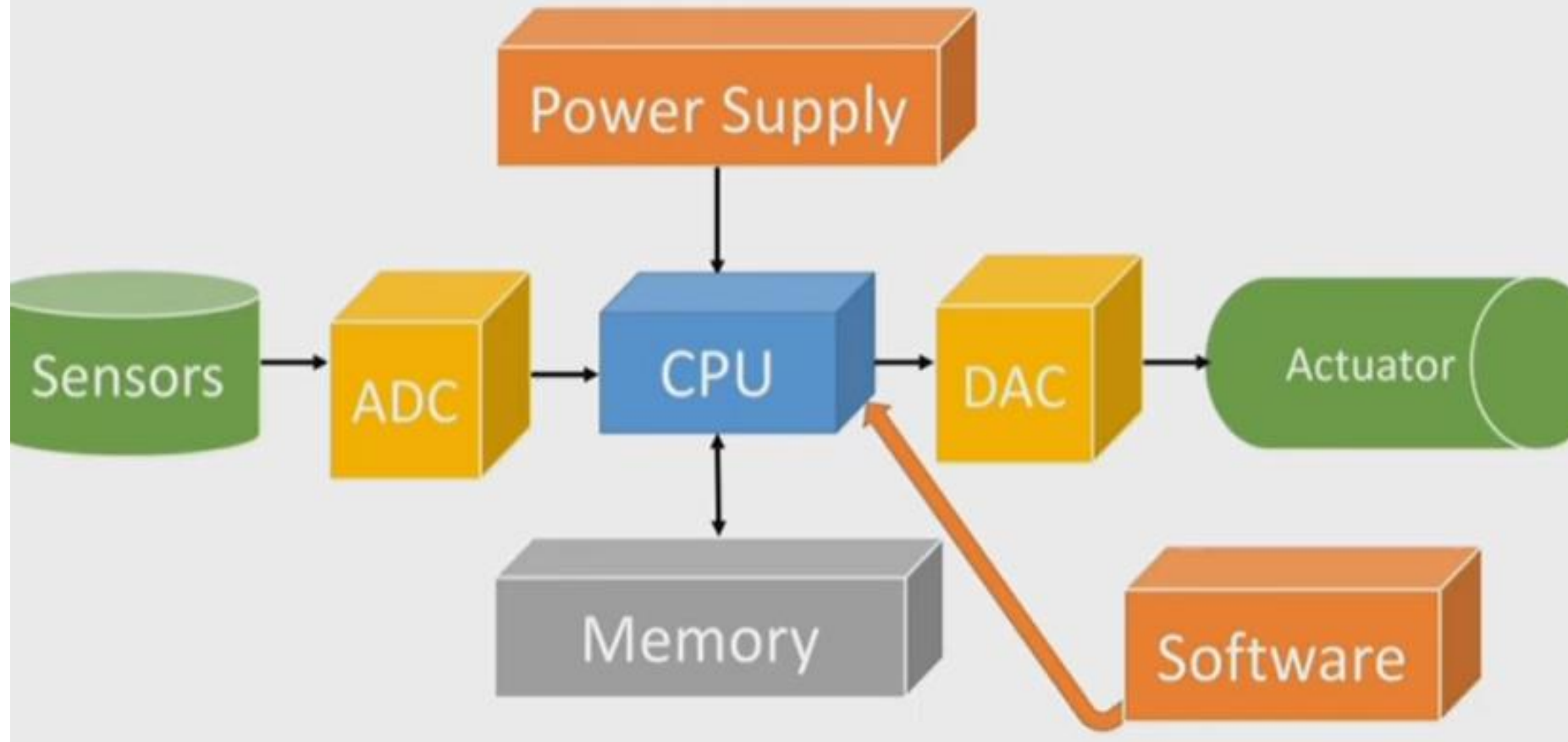
Components of embedded system

a) **Hardware** :The hardware of embedded systems is based around microprocessors and microcontrollers.

➢ Microprocessors are very similar to microcontrollers and, typically, refer to a CPU (central processing unit) that is integrated with other basic computing components such as memory chips and digital signal processors (DSPs).

➢ Microcontrollers have those components built into one chip.

➢ In terms of hardware, a basic embedded system would consist of the following elements:

✓ **Sensors:** convert physical sense data into an electrical signal.

✓ **Analog-to-digital (A-D) converters:** change an analog electrical signal into a digital one.

✓ **Processors:** process digital signals and store them in memory.

✓ **Digital-to-analog (D-A) converters:** change the digital data from the processor into analog data.

✓ **Actuators:** compare actual output to memory-stored output and choose the correct one.

Component of embedded system cont….

b). Real times operating system: These are not always included in embedded systems, especially smaller-scale systems.

➢RTOSes define how the system works by supervising the software and setting rules during program execution.

c). Application specific software: Software for embedded systems can vary in complexity.

Embedded Systems Characteristics

❖ **The important characteristics of an embedded system are**

- Speed (bytes/sec) : should be high speed

- Restricted memory:

- Task specific:

- Cost: low manufacturing cost since designed to perform particular task.

- Power (watts): low power dissipation

- Size and weight: as far as possible small in size and low weight

- Percentage error: must be very accurate

- Adaptability: high adaptability and

- Reliability: must be reliable over a long period of time

Embedded Systems Characteristics cont....

Embedded Systems Examples

Smart buildings: Information processing can be used to increase the comfort level in buildings, can reduce the energy consumption within buildings, and can improve safety and security.

Robotics: Robotics is also a traditional area in which embedded systems have been used. Mechanical aspects are very important for robots.
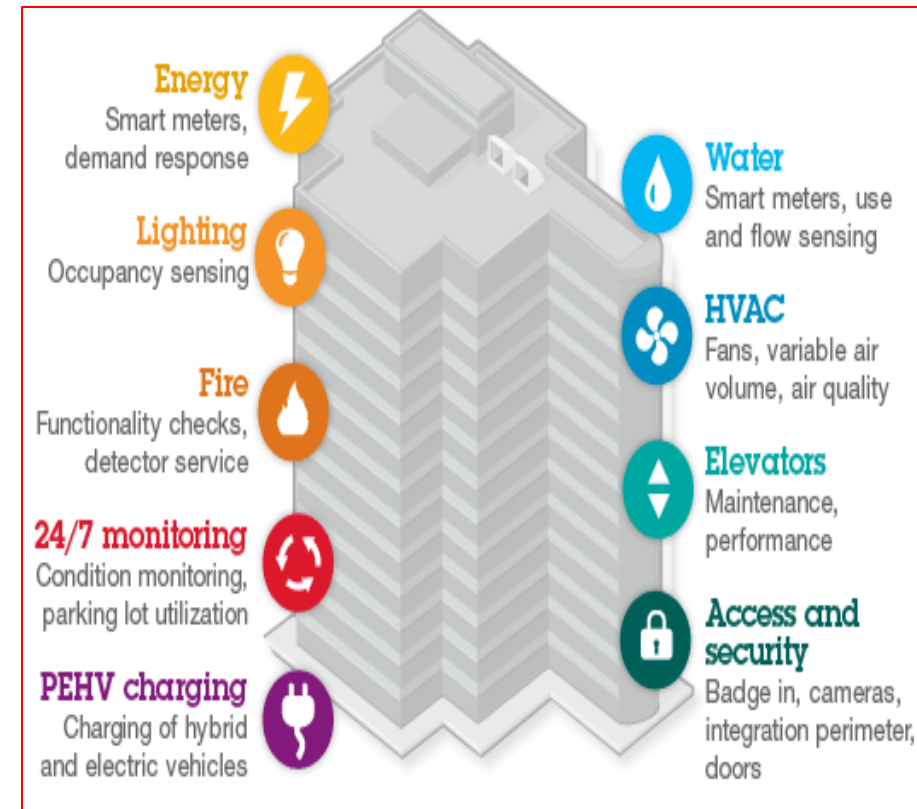
Components of Embedded Systems

❖ **Microcontroller:** Integrated circuit that executes a program
- ■ Connected to other hardware components
- ■ Sends commands and receives data

  ❖ Need to be programmed
  - • Write a program in a language, such as C
  - • Place the program in the mctrlr memory
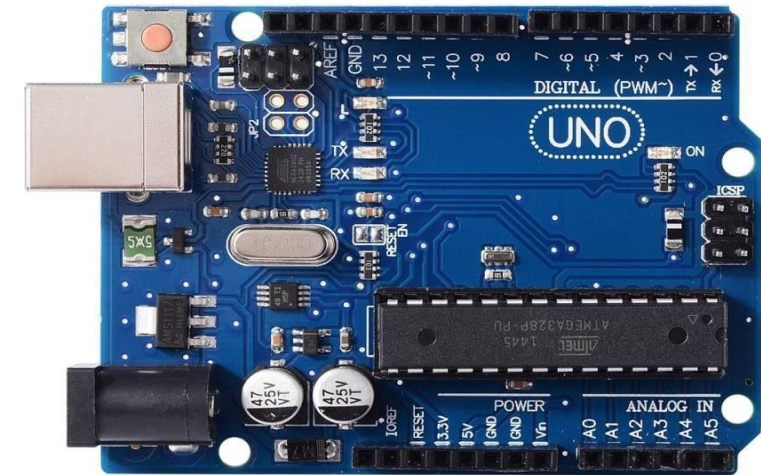
Programming microcontrollers
- • Write code on a machine– regular desktop or laptop
- • Programming the microcontroller– transferring the program from computer to microcontroller
- • Programming hardware can be used to place program in microcontroller memory

Components of Embedded Systems

- ❖ **Sensors:** Receives information from the environment
  - ▪ Provide simple information
    - • Thermistor: reports temperature
    - • Photoresistor: reports light intensity
- ❖ **Actuators:** Cause events to occur in the environment
  - ▪ Simple actuators
    - • Light emitting diodes(LEDs)– Small lights
    - • LCD display– simple display
  - ▪ Complex actuators
    - • Servo motor: moves something

Categories of Embedded Systems

❖ Embedded systems are classified based on performance and functional requirements, as well as the performance of microcontrollers.

❖ These classifications can be further divided into categories and subcategories.

❖ When classifying embedded systems based on performance and functional requirements, embedded systems are divided into four categories:

1. Real-time embedded systems

2. Standalone embedded systems

3. Network, or networked, embedded systems

4. Mobile embedded systems

Categories of Embedded Systems

Real-time embedded systems

➢ Real-time embedded systems must provide results or outputs promptly(fastly).

➢ Priority is assigned to output generation speed, as real-time embedded systems are often used in mission-critical sectors, such as defense, that need important data,

Examples of real-time embedded systems include:

- Aircraft controls

- Missile defense system controls

- Autonomous and semi-autonomous vehicle controls

Categories of Embedded Systems

Standalone embedded systems

➢ Standalone embedded systems don't require a computer to function. They can produce outputs independently.

Examples of standalone embedded systems include:
- Digital cameras
- Appliances, such as refrigerators, washing machines, and microwave ovens
- Temperature measurement systems
- Calculators

Categories of Embedded Systems

Networked embedded systems

➢ Network, or networked, embedded systems rely on wired or wireless networks and communication with web servers for output generation.

Frequently cited examples of network embedded systems include:

- Home and office security systems

- Automated teller machines (ATMs)

Mobile embedded systems

▪ Mobile embedded systems refer specifically to small, portable embedded devices.

▪ All mobile embedded systems are standalone embedded systems, but not all standalone embedded systems are mobile embedded

Categories of Embedded Systems

➢ When classifying embedded system based on the performance of microcontrollers, it is divided into three categories:

- Small-scale embedded systems
- Medium-scale embedded systems
- Sophisticated embedded systems

❖ Small-scale embedded systems have an 8-bit or 16-bit microcontroller.

❖ Medium-scale embedded systems have a 16-bit or 32-bit microcontroller.

❖ Sophisticated embedded systems have multiple 32-bit or 62-bit microcontrollers.

➢ processing speed improves as the number of microcontroller bits increase.

Major Application Areas of Embedded Systems

❖ Automotive electronics: Modern cars can be sold only if they contain a significant amount of electronics. These include engine control systems, anti-braking systems (ABS), air-conditioning, GPS systems, safety features, and many more.

❖ Aircraft electronics: A significant amount of the total value of airplanes is due to the information processing equipment, including flight control systems, anti-collision systems, pilot information systems, and others.

❖ Trains: Again, safety features contribute significantly to the total value of trains, and dependability is extremely important..

❖ Medical systems: There is a huge potential for improving the medical service by taking advantage of information processing taking place within medical equipment.

❖ Military applications: Information processing has been used in military equipment for many years. In fact, some of the very first computers analyzed military radar signals.

- **Fabrication equipment**: Fabrication equipment is a very traditional area in which embedded systems have been employed for decades.

- **Telecom**: Cellular Telephones, Telephone switches etc

- **Computer Networking Systems**: Network Routers, Switches etc.

- **Health Care:** Different Kinds of Scanners, ECG Machines etc

- **Banking** : Automatic Teller Machines (ATM).