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Module No : 03

Contents

- ✓ Components of embedded systems
- ✓ Classification of Embedded system
  - Based on performance and functional Requirements
  - Based on complexity and performance
- ✓ Characteristics of Embedded system

Components of Embedded systems :

Hardware details of an Embedded System

The hardware blocks of an embedded system are as shown in Fig. 1.2

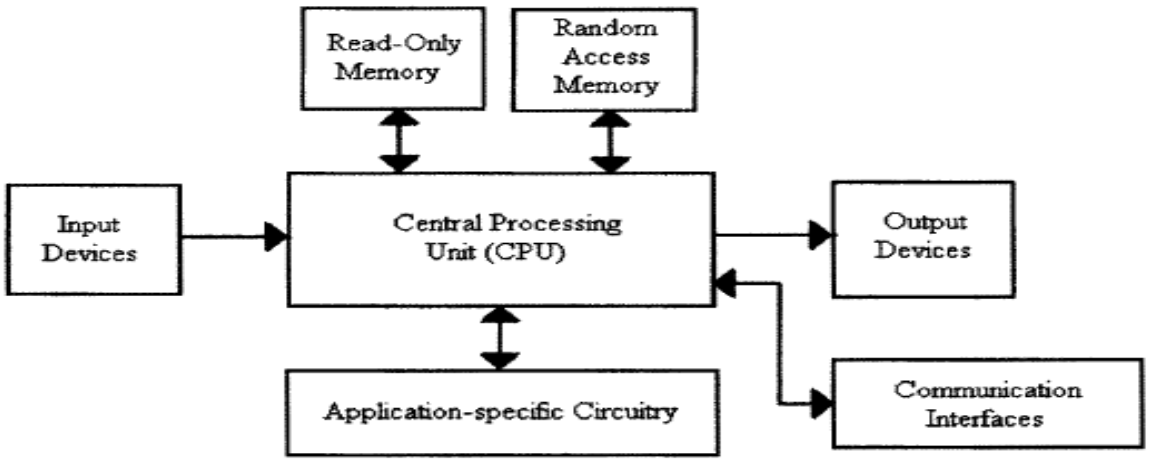


Fig. 1.2: Simplified Hardware Architecture of an Embedded System

entral Processing Unit (CPU)

(i) Central Processing Unit (CPU)
(ii) Memory (Read only memory and Random access memory)
(iii) Input Devices
(iv) Output Devices
(v) Communication interfaces
(vi) Application specific circuitry

(i) Central Processing Unit (CPU)

The Central Processing Unit (Processor, in short) can be any of the following: Microcontroller, microprocessor or Digital signal processor (DSP).

A microcontroller: is a low-cost processor. Its main attraction is that on the chip itself, there will be many other components such as memory, serial communication interface, analog to digital converter etc. So, for small applications, a microcontroller is the best choice as the number of external components required will be very less.
A microcontroller is the best choice for small embedded systems because it has memory and peripherals in the same chip as the CPU. And hence very few extra components are required.On the other hand, **microprocessors** are more powerful, but you need to use many external components with them.

DSP is used mainly for applications in which signal processing is involved such as audio and video processing.

(ii) Memory

The memory is categorized as Random access memory (RAM) and Read only memory (ROM). The contents of the RAM will be erased if power is switched off to the chip, whereas ROM retains the contents even if the power is switched off. So, the firmware is stored in the ROM. When power is switched on, the processor reads the ROM, the program is transferred to RAM and the program is executed.

(iii) Input Devices

Unlike desktops, the input devices to an embedded system have very limited capability. There will be no keyboard or a mouse, and hence interacting with the embedded system is no easy task. Many embedded systems will have a small keypad you press one key to give a specific command. A keypad may be used to input only the digits.

Many embedded systems used in process control do not have any input device for user interaction; they take inputs from sensors or transducers and produce electrical signals that are in turn fed to other systems.

(iv) Output Devices

The Output devices of the embedded systems also have very limited capability. Some embedded systems will have a few Light Emitting Diodes (LEDs) to indicate the health status of the system modules, or for visual indication alarms. A small Liquid crystal display (LCD) may also be used to display some important parameters.

(v) Communication Interfaces

The embedded systems may need to interact with other embedded systems or they may have to transmit data to a desktop. To facilitate this, the embedded systems are provided with one or a few communication interfaces such as RS232, RS422, RS485, Universal Serial Bus (USB), IEEE 1394, Ethernet etc.

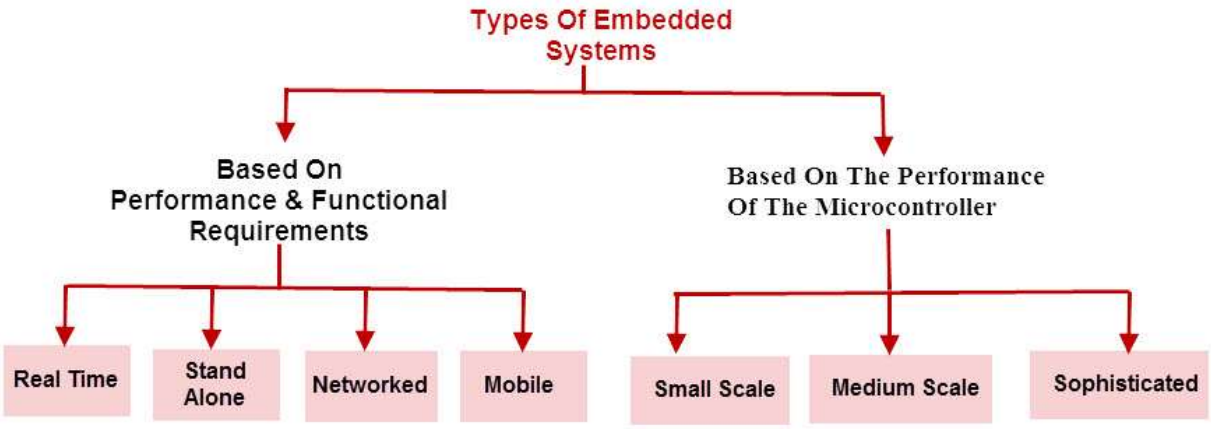
(vi) Application-specific Circuitry

Sensors, transducers, special processing and control circuitry may be required for an embedded system, depending on its application. This circuitry interacts with the processor to carry out the necessary work.

The entire hardware has to be given power supply either through the 230 volts main supply or through a battery. The hardware has to be designed in such a way that the power consumption is minimized.

Types of Embedded Systems

Embedded systems can be classified into different types based on performance, functional requirements and performance of the microcontroller.



Types of Embedded systems

Embedded systems are **classified into four categories based on their performance and functional requirements:**

1. Stand-alone embedded systems
2. Real time embedded systems
3. Networked embedded systems
4. Mobile embedded systems

Embedded Systems are **classified into three types based on the performance of the microcontroller such as**

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

- **Stand-alone Embedded systems :**
- Works by itself. It is a self-contained device which do not require any host system like a computer- EX :Temperature measurement systems, MP3 players, digital cameras, and microwave ovens
- **Real-time embedded systems :**
- Gives the required output in a specified time (deadline).

- **Soft Real-Time system:**
- Violation of time constraints will cause only the degraded quality, but the system can continue to operate. EX: Washing machine ,TV remote
- **Hard Real-Time system :**
- Violation of time constraints will cause critical failure and loss of life or property damage or catastrophe.Ex: Deadline in a missile control embedded system , Delayed alarm during a Gas leakage , car airbag control system.
- **Networked embedded systems :**
- Related to a network with network interfaces to access the resources. The connected network can be a LAN or a WAN, or the Internet. The connection can be either wired or wireless. EX : Home security system.
- **Mobile Embedded systems**
- Mobile and cellular phones , digital cameras,MP3 players, PDA .Limitation is Memory & other resources.
- **Small scaled embedded system :** Supported by a single 8–16 bit Microcontroller with on-chip RAM and ROM.
- **Medium scaled embedded system :** Supported by 16–32 bit Microcontroller /Microprocessor with external RAM and ROM.
- **Large scaled embedded system:** Supported by 32-64 bit multiple chips which can perform distributed jobs.

Stand-alone Embedded Systems

As the name implies, stand-alone systems work in stand-alone mode. They take inputs, process them and produce the desired output. The input can be electrical signals from transducers or commands from a human being such as the pressing of a button. The output can be electrical signals to drive another system, an LED display or LCD display for displaying of information to the users. Introduction to embedded systems, Microprocessors and Microcontrollers, Components of Embedded system & its classification,

characteristics of embedded system. Embedded systems used in process control, automobiles, consumer electronic items etc. fall into this category. In a process control system, the inputs are from sensors that convert a physical entity such as temperature or pressure into its equivalent electrical signal. These electrical signals are processed by the system and the appropriate electrical signals are produced using which an action is taken such as opening a valve.

Real Time Embedded Systems

A real time embedded system is defined as, a system which gives a required o/p in a particular time. These types of embedded systems follow the time deadlines for completion of a task. Real time embedded systems are **classified into two types such as soft and hard real time systems.**

Real-time Embedded Systems

Embedded systems in which some specific work has to be done in a specific time period are called real-time systems. For example, consider a system that has to open a valve within 30 milliseconds when the humidity crosses a particular threshold. If the valve is not opened within 30 milliseconds, a catastrophe may occur. Such systems with strict deadlines are called **hard real-time** systems.

In some embedded systems, deadlines are imposed, but not adhering to them once in a while may not lead to a catastrophe. For example, consider a DVD player. Suppose, you give a command to the DVD player from a remote control, and there is a delay of a few milliseconds in executing that command. But, this delay won't lead to a serious implication. Such systems are called **soft real-time** systems

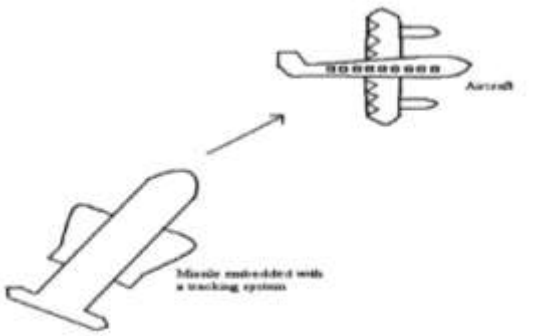


Fig. 1.3: Hard Real-Time Embedded System

Fig. 1.3 shows a missile that has to track and intercept an enemy aircraft. The missile contains an embedded system that tracks the aircraft and generates a control signal that will launch the missile. If there is a delay in tracking the aircraft and if the missile misses the deadline, the enemy aircraft may drop a bomb and cause loss of many lives. Hence, this system is *a* **hard real-time** embedded system.

Networked Embedded Systems

These types of embedded systems are related to a network to access the resources. The connected network can be LAN, WAN or the internet. The connection can be any wired or wireless. This type of embedded system is the fastest growing area in embedded system applications. The embedded web server is a type of system wherein all embedded devices are connected to a web server and accessed and controlled by a web browser. Example for the LAN networked embedded system is a home security system wherein all sensors are connected and run on the protocol TCP/IP

Here are some examples of such systems

> A networked process control system consists of a number of embedded systems connected as a local area network. Each embedded system can send real-time data to a central location from where the entire process control system can be monitored. The monitoring can be done using a web browser such as the Internet Explorer.

> A web camera can be connected to the Internet. The web camera can send pictures in real-time to any computer connected to the Internet. In such a case, the web camera has to run the HTTP server software in addition to the TCP/IP protocol stack.

> The door lock of your home can be a small embedded system with TCP/IP and HTTP server software running on it. When your children stand in front of the door lock after they return from school, the web camera in the door-lock will send an alert to your desktop over the Internet and then you can open the door lock through a click of the mouse.

Fig. 1.4 shows a weather monitoring system connected to the Internet.

- TCP/IP protocol suite and HTTP web server software will be running on this system.
- Any computer connected to the Internet can access this system to obtain real-time weather information.
- The networked information appliances need to run the complete TCP/IP protocol stack including the application layer protocols.
- If the appliance has to provide information over the Internet, HTTP web server software also needs to run on the system.

Fig. 1.4: Networked Information Appliance

Mobile Embedded Systems

Mobile embedded systems are used in portable embedded devices like cell phones, mobiles, digital cameras, mp3 players and personal digital assistants, etc.The basic limitation of these devices is the other resources and limitation of memory.

Small Scale Embedded Systems

These types of embedded systems are designed with a single 8 or 16-bit microcontroller, that may even be activated by a battery. For developing embedded software for small scale embedded systems, the main programming tools are an editor, assembler, cross assembler and integrated development environment (IDE).

Medium Scale Embedded Systems

These types of embedded systems design with a single or 16 or 32 bit microcontroller, RISCs or DSPs. These types of embedded systems have both hardware and software complexities. For developing embedded software for medium scale embedded systems, the main programming tools are C, C++, JAVA, Visual C++, RTOS, debugger, source code engineering tool, simulator and IDE.

Sophisticated Embedded Systems

These types of embedded systems have enormous hardware and software complexities, that may need ASIPs, IPs, PLAs, scalable or configurable processors. They are used for cutting-edge applications that need hardware and software Co-design and components which have to assemble in the final system.

The characteristics of Embedded system:

- **Power consumption:** This is a very important factor for all embedded system which are powered by batteries. So the amount of power will be consumed by the system, which decides the capacity or lifetime of battery.

- **Flexibility:** The flexibility is the ability to change the functionality of the system without investing additional NRE cost and hence software is typically considered very flexible as it can be updated at any time with new version.

- **Processor power:** The embedded systems are controlled by microcontrollers or digital signal processor (DSP). It can handle one or many specific task which require very powerful processor.

- **Operating system:** The embedded operating system is needed in embedded system to limit the function depending on the embedded device and may only run a single application which is crucial to the devices operation. Due to this the operating system must be reliable and able to run with tight constraints on memory, size, time and processing power.

- **Performance:** The performance of the system measures by the execution time or throughput the system.

- **Memory:** The program developed for the embedded systems are treated as firmware and stored in ROM or flash memory chips.

- **Size:** The embedded system should be small in size as possible. The software is measured in bytes and transistor or IC or gates are used for hardware.

- **Reliability:** The embedded system should be much reliable to achieve a better performance for long duration of time during its complete life cycle.

- **Safety:** During the system failure, the system should not cause harm to other.

- **Correctness:** By checking the functionality of system, it indicates the functionality of implemented system is correct or not.

- **Maintainability:** It is a most important factor of system in which system can be repaired or replaced within a certain time interval.