Misr University for Science & Technology
Faculty Of Information Technology
Department of Computer Science

Embedded System

AI 230 / AI 302

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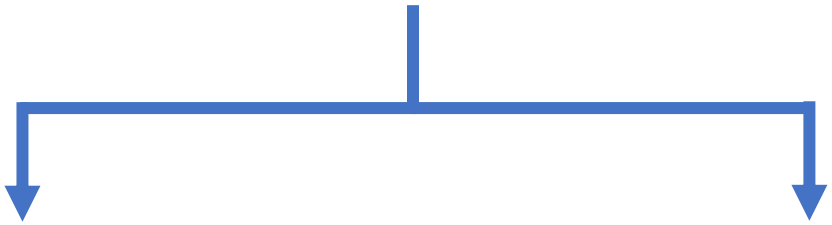
Introduction to Embedded System

Classification of Embedded System



Embedded System

Evolving Time

- 1st generation
- 2nd generation
- 3rd generation
- 4th generation

Performance and Functional Requirements

- Stand-alone
- Real-time
- Networked
- Mobile

Embedded System (Evolving Time)

1- First generation:

- Embedded systems comprising of 8-bit microprocessors or 4-bit microcontrollers belong to the first generation.
- They have hardware circuits and software that includes 8085 microprocessor and programming in machine language.

2- Second generation:

- Embedded systems comprising of 16-bit microprocessors or 8- to 16-bit microcontrollers like SCADA systems

Embedded System (Evolving Time)

3- Third generation:

- Embedded systems comprising of 32-bit processors or 16-bit microcontrollers
- Digital Signal Processors, ASICs, Intel, Pentium, etc.

4- Fourth:

- Embedded systems comprising of 64-bit processors or 32-bit microcontrollers.
- These are powerful in terms of faster computation and higher memory.
- they are built on the concept of System on Chips and multi-core processors.
- Smartphone devices and mobile internet devices.

Embedded System (Performance and Functional Requirements)

1- Stand-alone:

- This category of embedded systems works alone and does not need a host system
- e.g., digital cameras, microwave ovens, and video game consoles.
- Systems like automobile engine control units are non-stand-alone embedded systems.
- they also communicate with other systems such as transmission control units (TCU) and anti-lock braking systems (ABS)

Embedded System (Performance and Functional Requirements)

2- Real-time embedded systems:

- This category of embedded systems completes a task in a particular time as instructed by the system.
- e.g., flight control systems, set-top boxes, and missile guidance systems.
- The systems in MP3 players, digital cameras, microwave ovens, washing machines, and refrigerators are not real-time embedded system.

Embedded System (Performance and Functional Requirements)

3- Networked embedded systems:

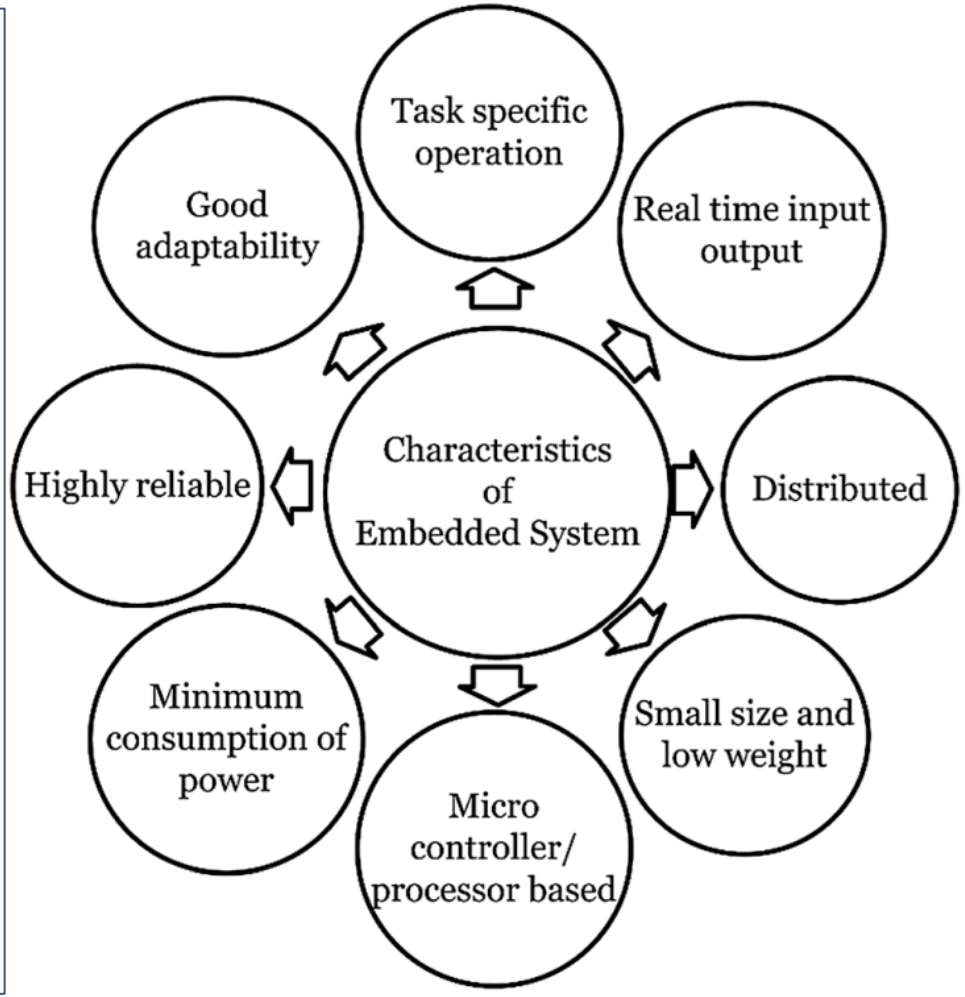
- This category of embedded systems is connected to a network to avail the resources.
- Local area network (LAN), wide area network (WAN), and internet are the connected networks.
- e.g., home security system in LAN embedded system.

4- Mobile embedded systems

- This category of embedded systems is used in mobile embedded devices, and sometimes merges with stand-alone embedded systems,
- e.g., smartphone devices, digital cameras, and MP3 players.

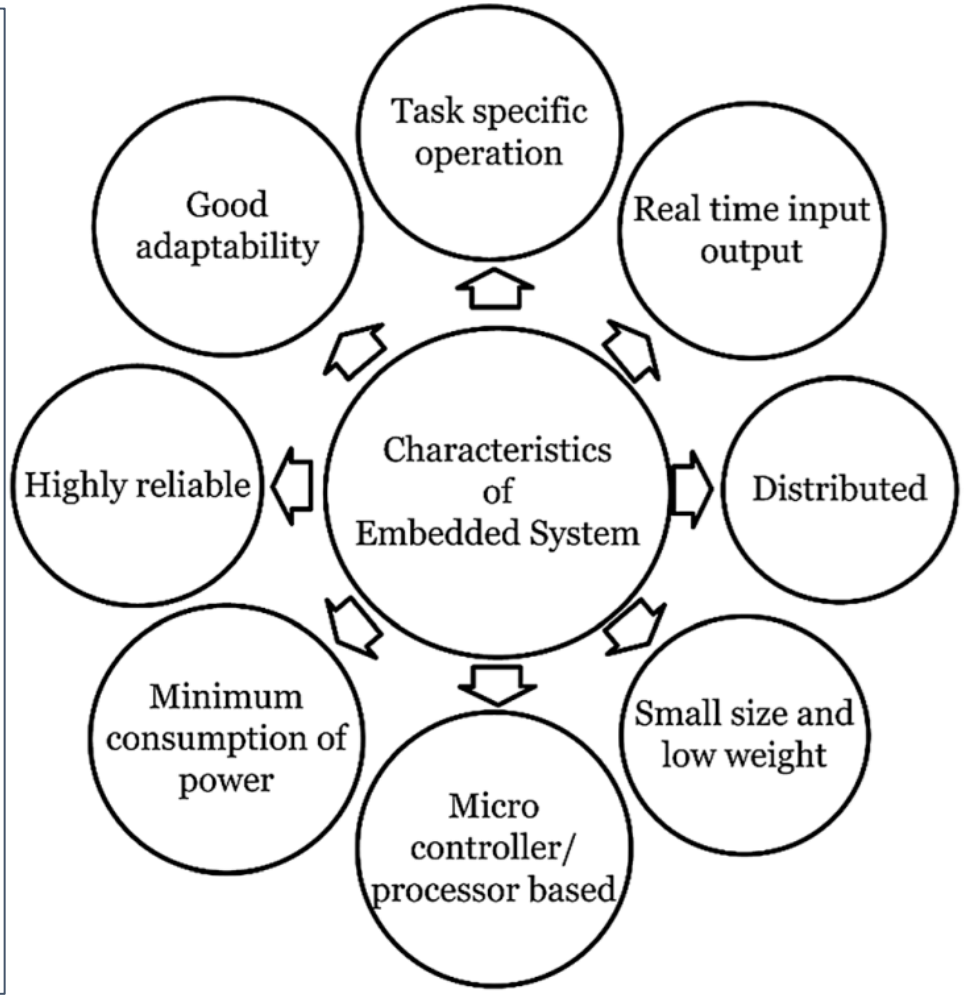
Characteristics of Embedded Systems

- Dedicated Functionality: Designed for a specific task (e.g., washing machines, medical devices, automotive control).
- Real-time Operation: Many embedded systems have real-time constraints, meaning they must respond within strict time limits.
- Low Power Consumption: Often optimized for efficiency since they may run on batteries or limited power.



Characteristics of Embedded Systems

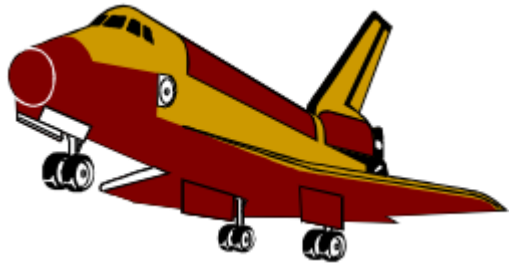
- Compact and Lightweight: Designed to fit within the physical constraints of the device.
- Firmware-Based: Runs a fixed software program (firmware) stored in non-volatile memory (e.g., ROM, Flash).
- High Reliability: Must operate consistently under varying environmental conditions.



Application of embedded system

Aerospace Spacecrafts

- Navigation systems, automatic landing systems, flight attitude controls, engine controls, space exploration (e.g., the Mars Pathfinder).



Automotive

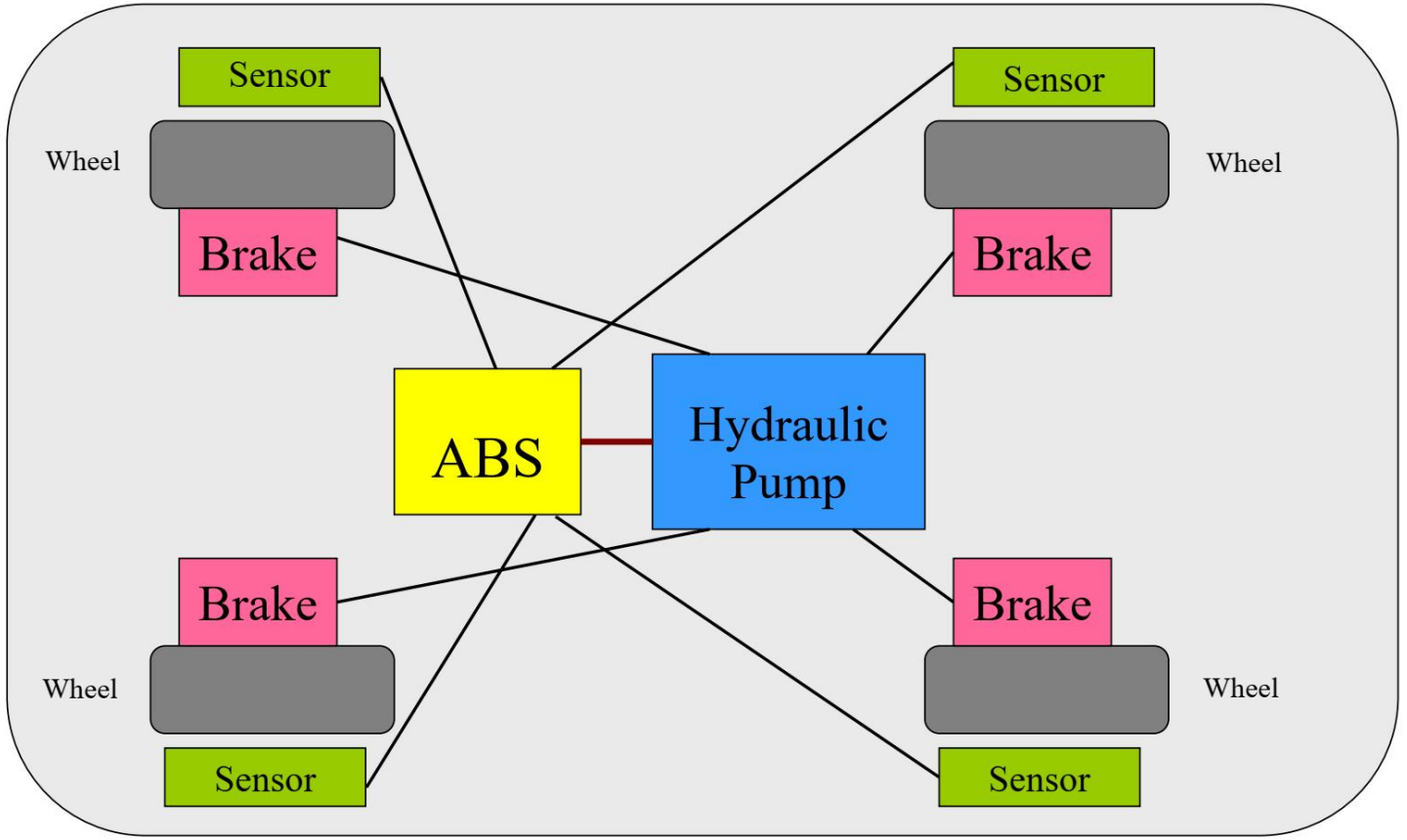
- Fuel injection control, passenger environmental controls, anti-lock braking, air bag controls, GPS mapping.

Communications

- Satellites; network routers, switches, hubs.

Application of embedded system

Anti-lock Brake System (ABS)



Application of embedded system

Computer Peripherals

- Printers, scanners, keyboards, displays, modems, hard disk drives, CD-ROM drives.

Home

- Dishwashers, microwave ovens, HDTV, sound systems, fire/security alarm systems, lawn sprinkler controls, thermostats, cameras, clock digital radios.

Industrial

- Elevator controls, surveillance systems, robots.

Application of embedded system

Instrumentation

- Data collection, oscilloscopes, signal generators, signal analyzers, power supplies.

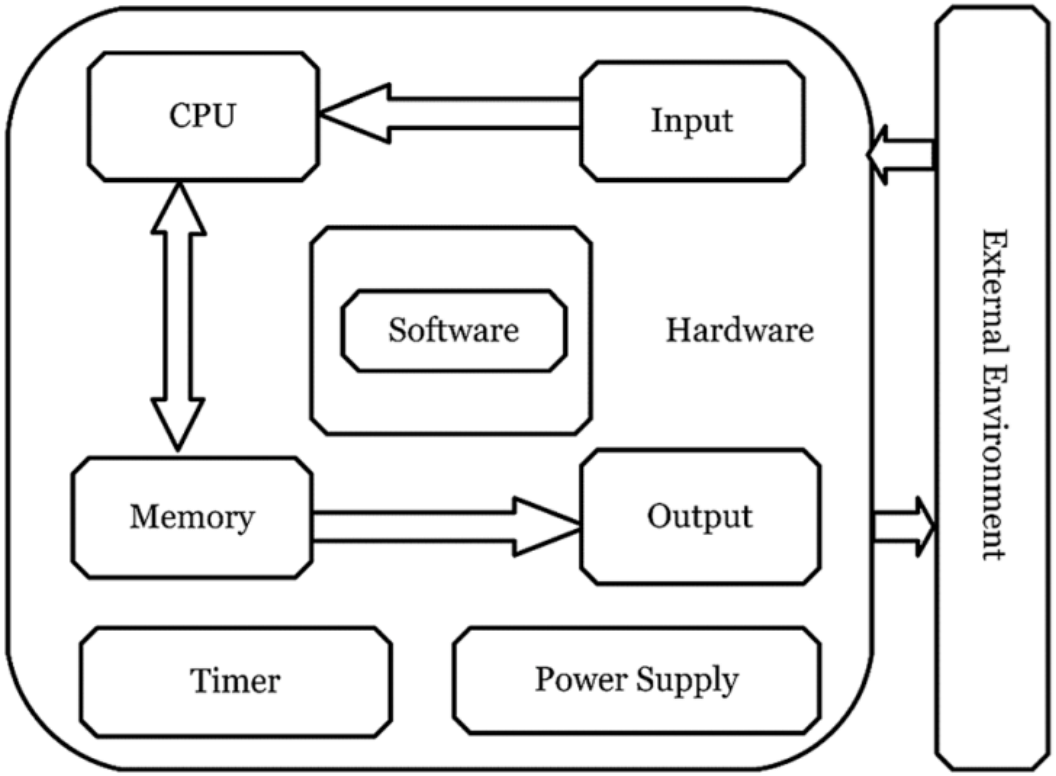
Medical

- Imaging systems (e.g., XRAY, MRI, and ultrasound), patient monitors, and heart pacers.

- **Personal**
- Tablets, ipads, cell phones, smart-watches

Basic Components of an Embedded System

- The main components of an embedded system: hardware, software, and real-time operating system (RTOS).



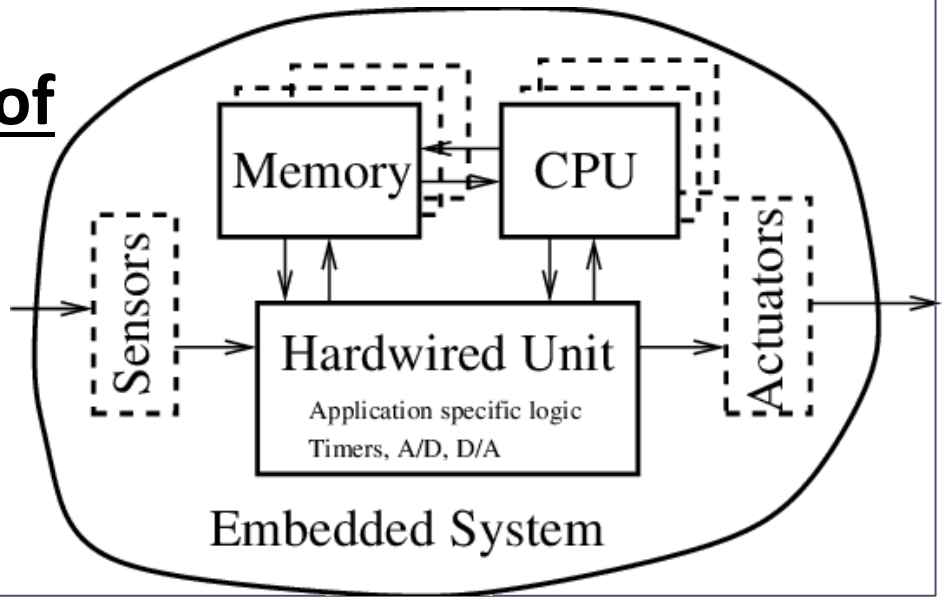
Basic Components of an Embedded System

Three specific categories of functions of these components are

- Reading the input or command from the outside world.
- Processing the information
- Generating necessary signal as output for bringing changes in the environment.

The hardware of an embedded system consists of

- System a central processing unit (CPU).
- Memory.
- a set of input/output ports.



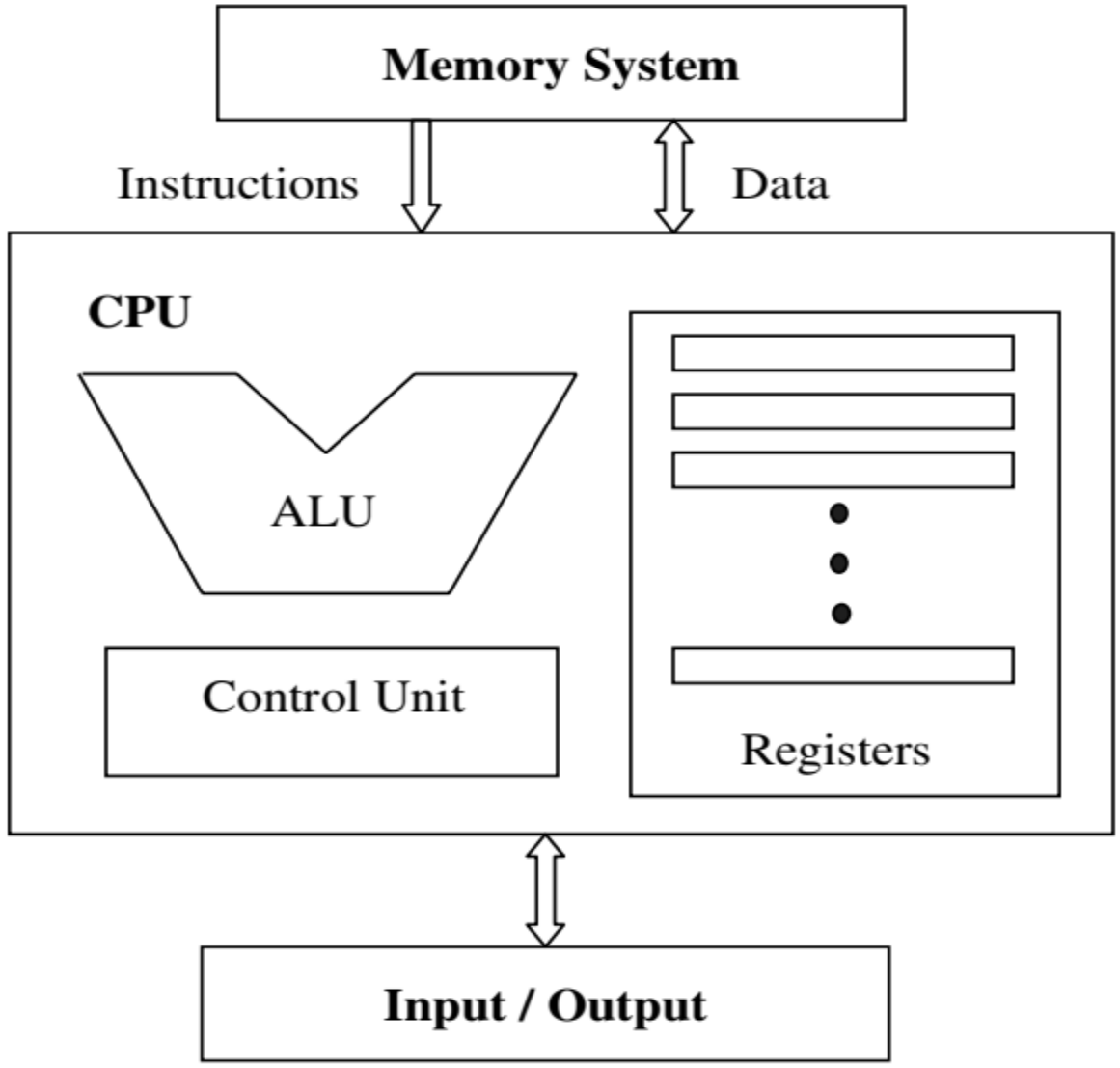
Basic Components of an Embedded System

Central Processing Unit (CPU):

- The CPU is responsible for processing the system inputs and taking decisions which guide the system operation by executing the software instructions.
- It is the main control unit of the system.
- The CPU in most embedded systems is either a microprocessor or a microcontroller.
- It can also be a digital signal processor (DSP), complex instruction set computer (CISC) processor, reduced instruction set computer (RISC) processor, or an advanced RISC machine (ARM) processor depending on the application of the system.

Basic Components of an Embedded Sy

Central Processing Unit (CPU):



Central Processing Unit (CPU)

- Now, we focus our attention on the main component of any computer system, the central processing unit (CPU).

- A typical CPU has three major components:
  - Register set.
  - Arithmetic logic unit (ALU).
  - Control unit (CU).

- The register set differs from one computer architecture to another.
- It is usually a combination of general-purpose and special purpose registers.

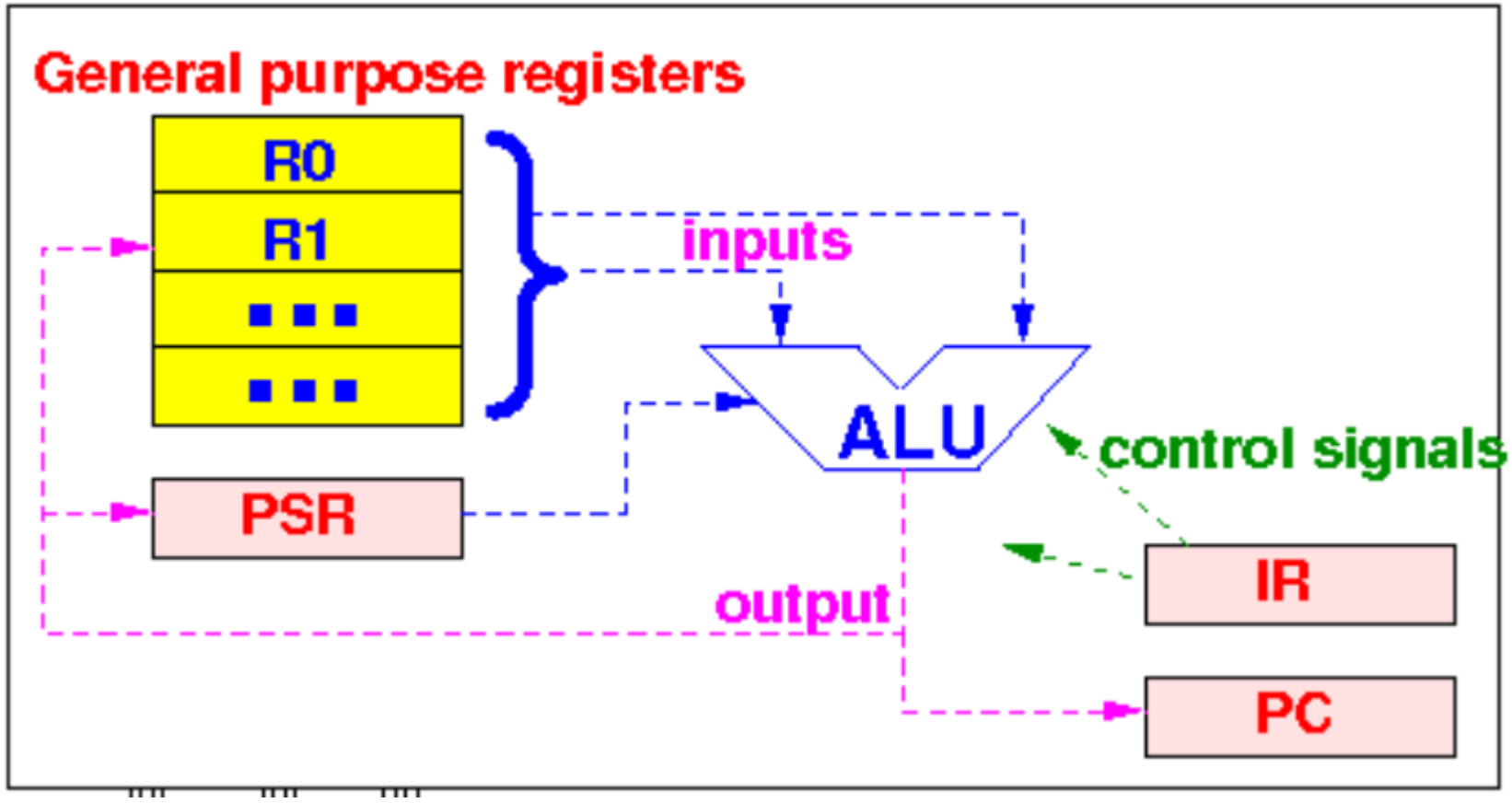
CPU Register Set

- A register is a small amount of fast storage memory within the Central Processing Unit (CPU) of a computer.
- Registers are used to store data temporarily during the execution of instructions.
- Registers are crucial for improving the efficiency and speed of the CPU.
- 8-bit register

CPU Register Set

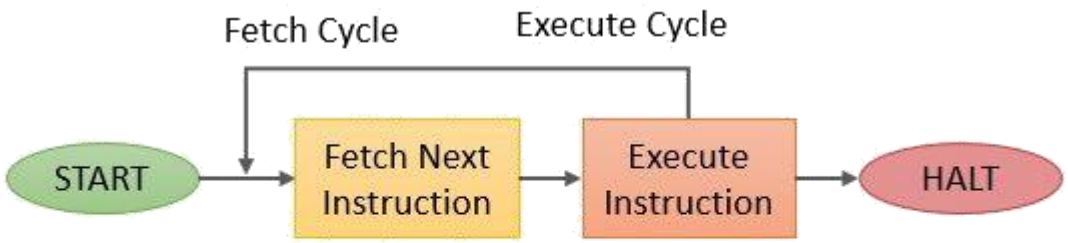
- Registers can be categorized based on their specific functions. Some common types of registers include:
  - **General-purpose** registers are used for any purpose, hence the name general purpose.
  - Used for various purposes, such as storing operands or results.
  - **Special-purpose** registers have specific functions within the CPU.
    - **Program Counter (PC):** Holds the address of the next instruction to be executed.
    - **Instruction Register (IR)**: Stores the current instruction being executed.
    - **Memory Address Register (MAR):** Holds the address of a memory location to be read from or written to.
    - **Memory Data Register (MDR):** Temporarily stores data being transferred to or from memory.
    - **Accumulator (ACC):** Stores intermediate results of arithmetic and logic operations.

CPU Register Set



CPU Register Set (Special-purpose)

- How Registers Work:
  - When the CPU executes an instruction, it fetches the instruction from memory and stores it in the Instruction Register (IR).
  - The **Program Counter** (PC) keeps track of the next instruction to be executed.
  - Data required for the operation is loaded into registers like the Accumulator (ACC) or General-Purpose Registers.
  - After processing, the result is stored back in a register or memory.



Basic Instruction Cycle

Thank You