임베디드컴퓨팅

Embedded Computing
(0009488)

Introduction

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정보기술대학 정보통신공학과

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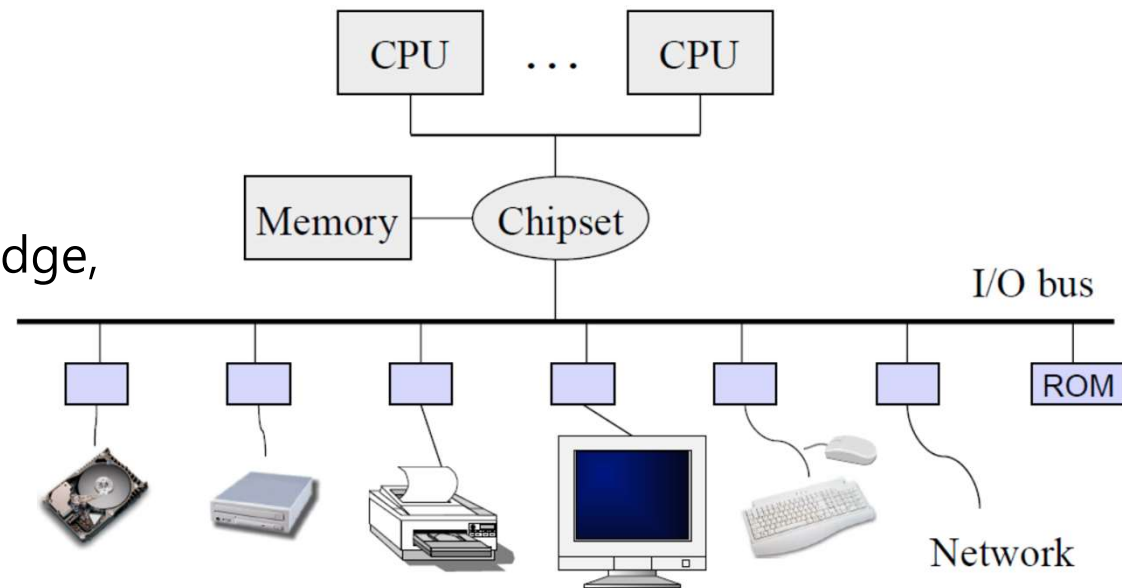
Contents

- What is embedded system?
- Embedded system classification and examples
- Embedded system pros. and cons.

A typical modern computer

- CPU
  - Intel i5, i7, AMD, ARM,...
- Memory
  - RAM (DDR..)
- Chipset
  - Northbridge, Southbridge, others
- I/O bus
  - IDE, SATA, AMBA,..
- Peripheral devices
  - HDD, SSD, CD-ROM, Printers, monitors, keyboard, mouse, tablet, Wired or wireless NIC,

A modern embedded device: ATmega328p

- ALU (Arithmetic logic unit)
  - arithmetic, logical, bit-functions
  - with 32 general purpose registers
- Memory and storage
  - SRAM
    - Store data fast but small (2KB)
    - Main memory role
  - Flash memory
    - Slow but large (32KB) and cheap
    - Main storage role
  - EEPROM
    - Slow and small (1KB) but store data permanently (firmware)
- I/O lines
  - Connect to sensors, actuators, etc.
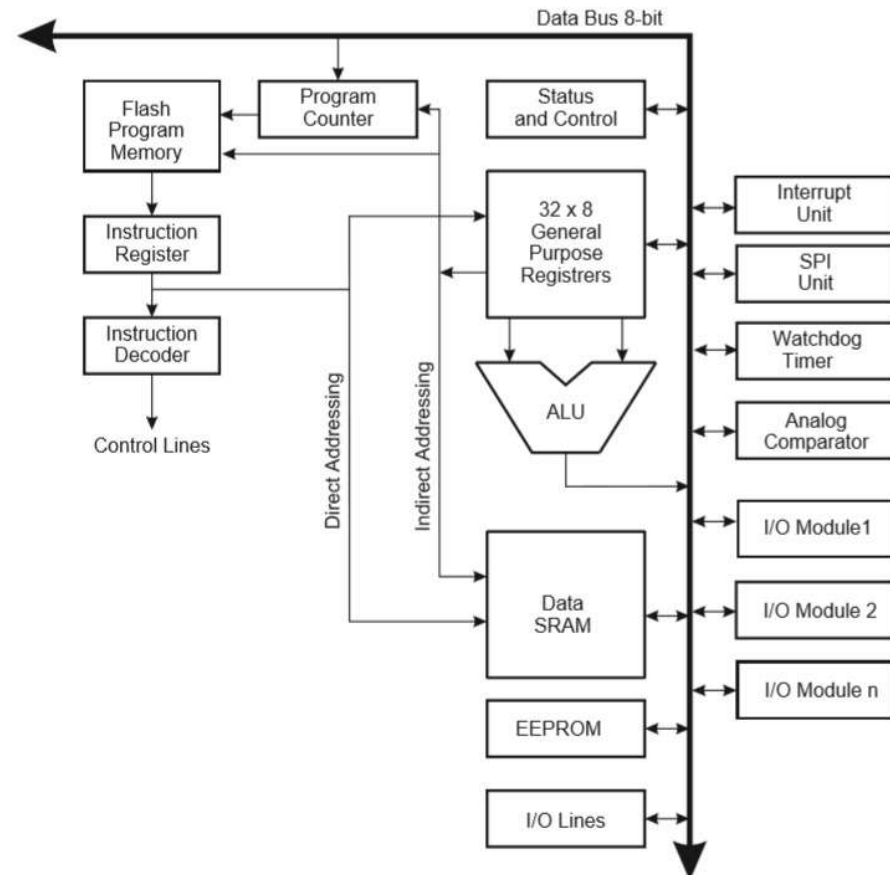
Computer vs. Embedded devices

- **Computer**
  - A combination of hardware and software resources which integrate together
  - Can be

- **Embedded devices**
  - A device part of an integrated system which is formed as an combination of computer hardware and software

  - Can operate without human interaction
  - Made

Architectures

Computer

- Analog / digital computer
- Hybrid computer
- Harvard architecture
- Von Neumann architecture
- Reduced instruction set computer
- Complex instruction set computer

Embedded device

- Small Scale Embedded System
- Medium Scale Embedded Systems
- Sophisticated or Complex Embedded Systems

Peripherals

Computer

- Keyboard

- Mouse

- Display

- Printer

- Wireless / Ethernet network card

- Hard disk drives

- Solid state drives

- Optical disc drives

- Serial interfaces, USB drives, etc

Embedded device

- Serial Communication Interfaces (SCI)

- Synchronous Serial Communication Interface

- Universal Serial Bus (USB)

- Multi Media Cards (SD cards, Compact Flash) etc.

Size

Computer

- Physical
  - Usually bigger in size with larger hardware and input output devices attached to it

- Memory
  - Have larger memory requirement due to a lot of storage of data

Embedded device

- Physical
  - Embedded Devices are smaller in size than computers, with limited hardware.

- Memory
  - Need lesser Memory.

A typical computer system

- A computer system consists of

  - Hardware

    - Computing resources: CPU, Memory, …
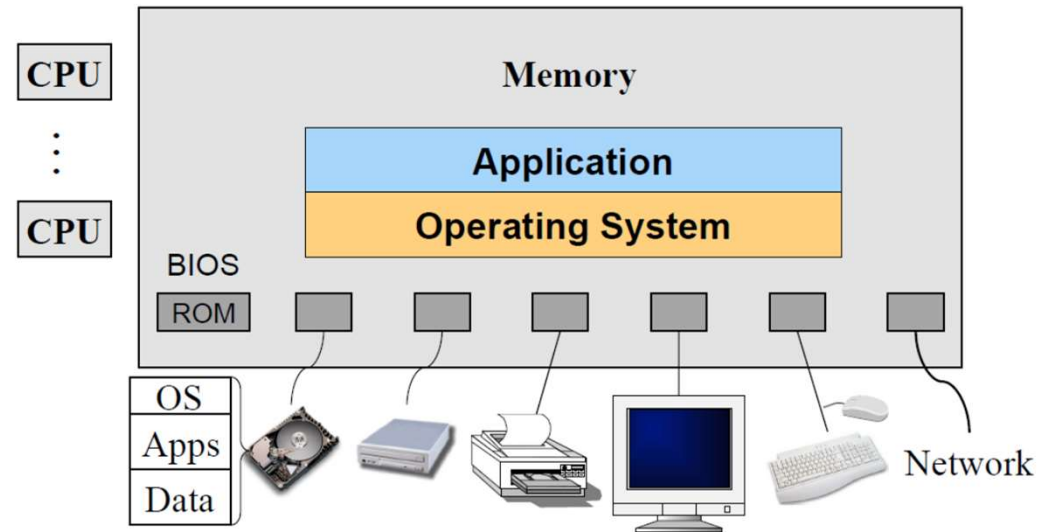
  - System software (S/W)

    - Managing/Operating computing resources
      - OS, DBMS, Hypervisor
    - Software development
      - Compiler, Linker, Assembler

  - Applications

System?
  A set of interrelated parts/components which are designed/developed to perform a common tasks or specific work

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Embedded system

- **Embedded?**
  - ██████ something with anything for a reason, or ████████████████████ with another thing.

- **Embedded Systems?**
  - An integrated system which is formed as an combination of computer hardware and software ████████████████.
  - A ████████████████████ which has been developed for some ████████████.
  - Can **work independently or attached to a larger system** to work on few specific functions.
  - Can work **without** human intervention or **with** a little **human intervention**

Application areas of Embedded System

- Mostly present everywhere, and use it in our everyday life unknowingly

- In most of the cases, it is integrated insides the larger systems

- Application areas of Embedded System
  - Home appliances
  - Transportation
  - Health care
  - Business sector & offices
  - Defense sector
  - Aerospace
  - Agricultural Sector

General characteristics of an embedded system

- Performs
- Low Cost
-
-
- High Efficiency
- Minimal User interface
- Less
- Highly Stable
- High Reliability
- Use microprocessors or micro controllers

Embedded Programming Languages

- Embedded systems can be programmed using different programming languages
    - Embedded C
    - Embedded C++
    - Embedded Java
    - Embedded Python

- Depends on the developer to use which programming language for the development

Architecture of Embedded systems

- **Hardware**

  - Microprocessors (CPU), memory, bus, digital signal processors (DSP)

  - Microcontrollers

    - Built into one chip

- **Software and firmware**

  - Embedded operating systems, different applications, device drivers..

- **Basic H/W components**

  - Sensors, Analog to Digital Converter (ADC), Memory, Processor, Digital to Analog Converter (DAC), and Actuators etc.

Embedded Product Development Life Cycle

- Four parts and 7 steps
    - Analysis part
        - Step 1. Requirement analysis
        - Step 2. Examine
    - Design part
        - Step 3. Design
    - Implementation part
        - Step 4. Develop
        - Step 5. Test
    - Operational part
        - Step 6. Deploy
        - Step 7. Maintenance

- Desktop computer, workstation or laptop with high-performance, sufficient memory, large storage, and fast communication speed.
- Some programming languages can do interactive debugging
- Processors often have CPU debuggers via JTAG or similar debugging port

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Advantages of Embedded System

- Fast in performance.

- Consumes less power

- Small in shape and size

- Scalable and reliable.

- Works on wide variety of sectors and environments

- Improve product quality and enhance performance
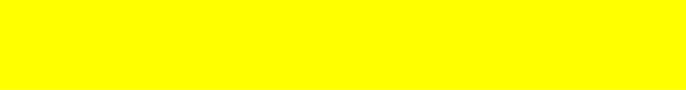
- Performs specific tasks without error

Disadvantages of Embedded System

- Difficult to backup of embedded files

- Sometimes complex to develop

- Integration may be a problem

- Offer very limited resources for processing

- Troubleshooting may be difficult

- Maintenance may be a problem

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Classification of Embedded system

- Criteria
  - Performance and Functional Requirements
    - Real-time embedded system
    - Standalone embedded system
    - Networked embedded system
    - Mobile embedded system

  - Performance of Micro-controllers
    - Small-scale embedded system
    - Medium-scale embedded system
    - Sophisticated or Complex Embedded Systems

Real-time embedded systems

- Soft real-time
  - Deadline miss produces
  - Examples
    - Video streaming player
    - Internet radio player

- Hard real-time
  - Deadline miss produces
  - Examples
    - Traffic control system
    - Military usage in defense sector
    - Medical usage in health sector

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Standalone Embedded systems

- Independent systems which can work by themselves
  - Do not ▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓
  - It takes input in digital or analog form and provides the output.

- Examples
  - MP3 players
  - Microwave ovens
  - Calculator

Networked Embedded Systems

- Connected to a [   ] via wired or wireless to provide output to the attached device.
    - Communicate with a server through network.

- Examples
    - Home security systems
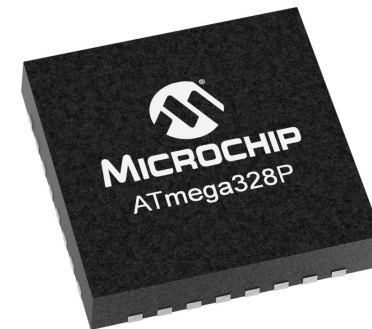   - ATM machine
    - Card swipe machine

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Mobile Embedded Systems

- Small and easy to use and requires less resources.

- They are the most preferred embedded systems.

- In _____ point of view mobile embedded systems are also best

- Examples
  - MP3 player
  - Smart / Mobile phones
  - Digital Camera

Small Scale Embedded Systems

- Designed using an   micro-controller.

- Powered by a battery.

- The processor uses very less/limited resources of memory and processing speed.

- Mainly, not act as an independent system; instead, act as any component of computer system for a small and specific task.

ATmega328P 8-bit AVR® processor
https://www.microchip.com/en-us/product/ATmega328P

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Medium Scale Embedded Systems

- Designed using an   micro-controller.

- Faster than that of small Scale Embedded Systems.

- Integration of hardware and software is complex in these systems.

- Higher level programming languages (e.g. Java, C, C++) and software tools (e.g. compiler, debugger, simulators) are used well

ARM Cortex-M0 and Cortex-M3 microcontroller ICs from NXP and Silicon Labs (Energy Micro) https://en.wikipedia.org/wiki/ARM_Cortex-M

Sophisticated or Complex Embedded Systems

- Designed using multiple �▮ micro-controller.

- Developed to perform large scale complex functions.

- Have high hardware and software complexities
  - Configurable processor, programmable logic array, etc.

- Use both hardware and software components to design final systems or hardware products
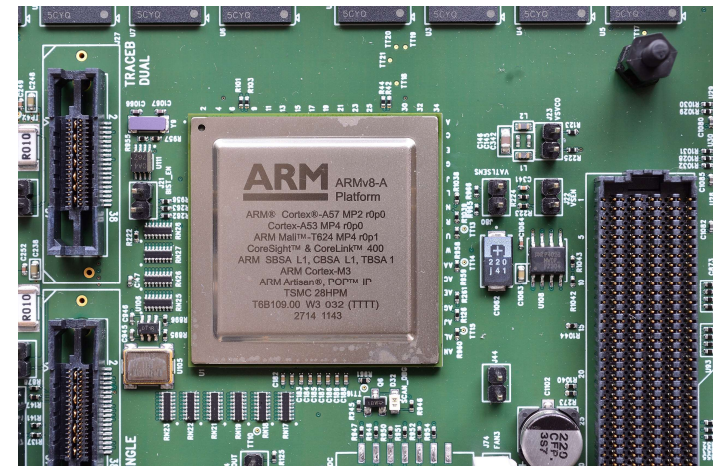
ARMv8-A Platform with Cortex A57/A53 MPCore big.LITTLE CPU chip
https://en.wikipedia.org/wiki/ARM_architecture#ARMv8-A

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Embedded system trends

- Some embedded systems can be relatively simple, they are becoming more complex
    - Supplant ▮▮▮▮▮▮▮▮▮▮ or offer capabilities beyond human
    - E.g. fast acting drones with integrate sensor data

- Expected to continue growing rapidly, driven in large part by the ▮▮▮▮▮▮▮▮▮▮▮.
    - Recent computing paradigms such as cloud computing, edge computing expands IoT applications
    - E.g. Wearables, drones, smart homes, smart buildings, video surveillance, 3D printers and smart transportation