AMERICAN INTERNATIONAL UNIVERSITY – BANGLADESH(AIUB)

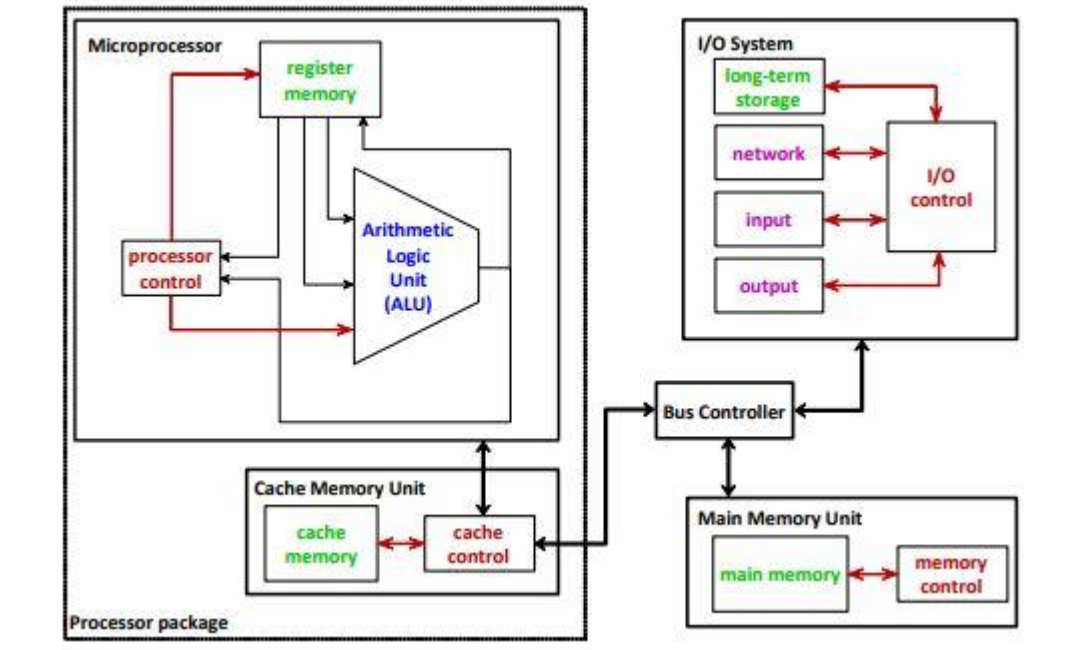
Where leaders are created

FUNDAMENTALS OF MICROPROCESSOR AND EMBEDDED SYSTEM

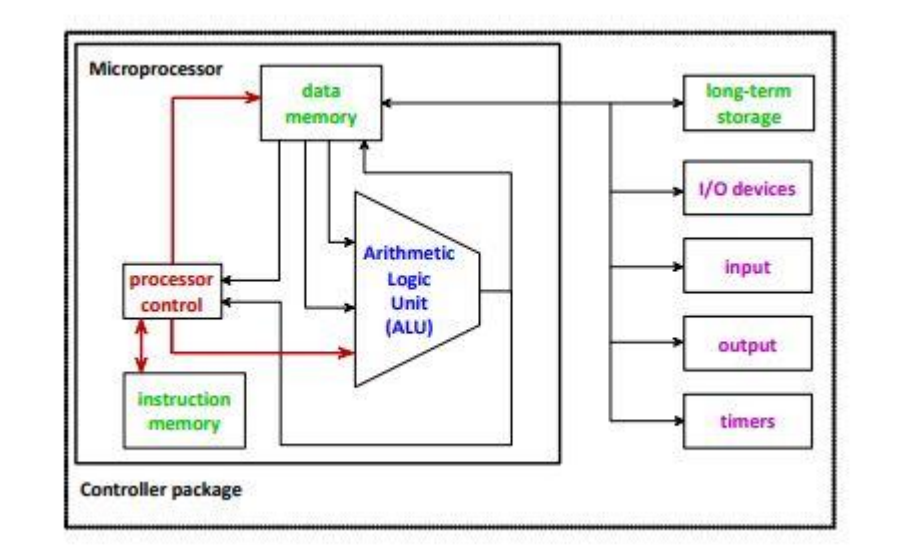
BY TAHSEEN ASMA MEEM

SOME IMPORTANT DIFFERENCES :

Microprocessor



Microcontroller.



SOME IMPORTANT DIFFERENCES :

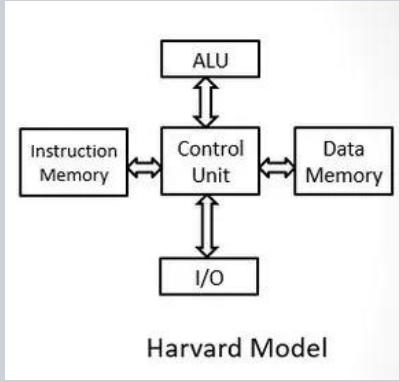
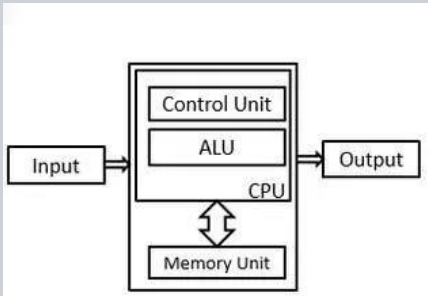
Microprocessor

- Microprocessor is considered to be the heart of the computer system.
- Used in personal computers or laptops.
- Von Neumann architecture is used.
- Circuit is large and complex.
- More expensive than microcontrollers.
- Power consumption is high as clock speed is low.

Microcontroller

- Microcontroller is considered to be the heart of the embedded systems.
- Used in home appliances like refrigerator, washing machine, etc. along with PC.
- Harvard architecture and Princeton architecture is used.
- Circuit is small.
- Less expensive than microprocessors.
- Power consumption is lower as clock speed is high.

SOME IMPORTANT DIFFERENCES :

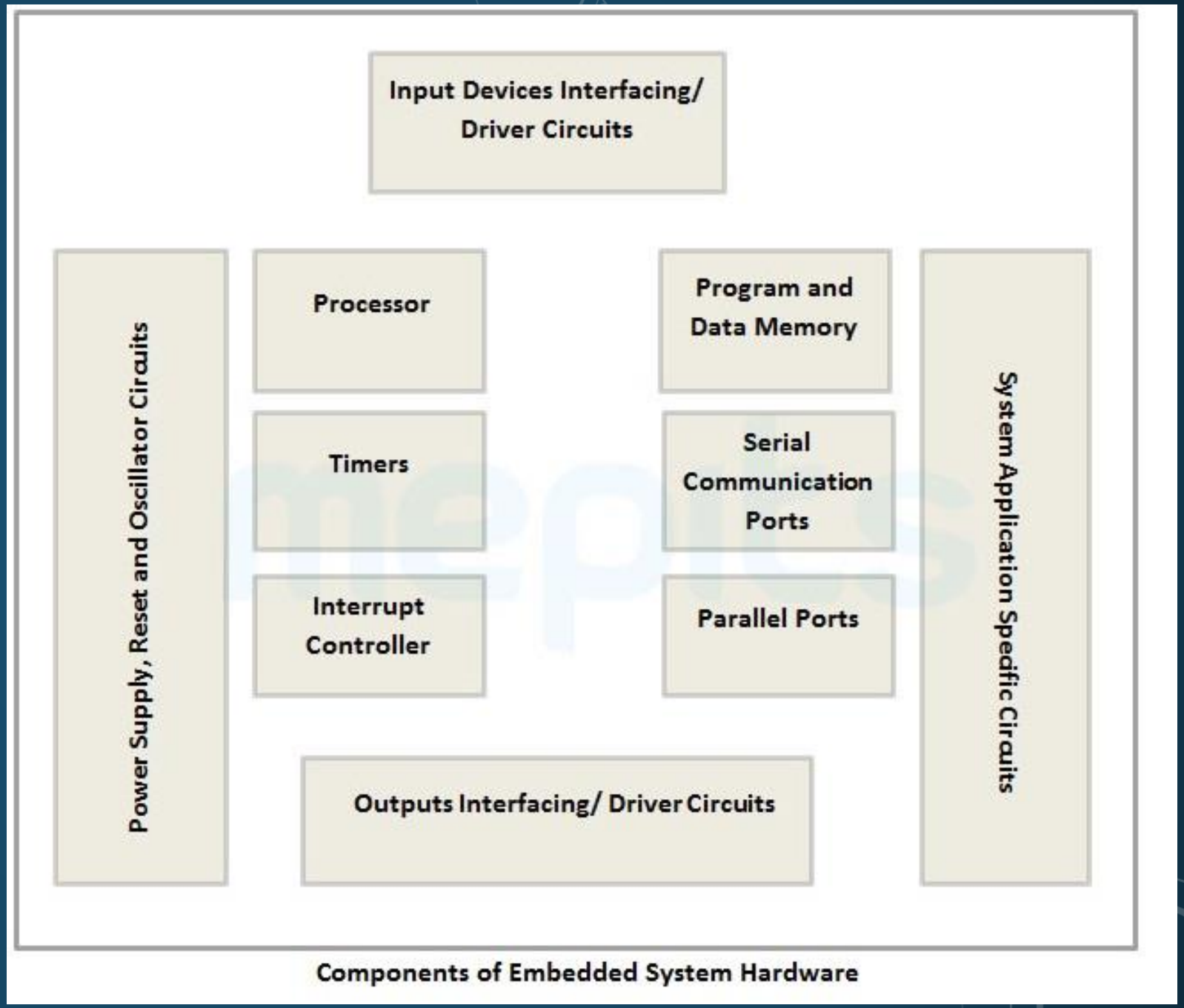
Point of Comparison	Harvard Architecture	Von Neumann Architecture
Arrangement	In Harvard architecture, the CPU is connected with both the data memory (RAM) and program memory (ROM), separately.  Harvard Model	In Von-Neumann architecture, there is no separate data and program memory. Instead, a single memory connection is given to the CPU.  Von Neumann Model
Hardware requirements	It requires more hardware since it will be requiring separate data and address bus for each memory.	In contrast to the Harvard architecture, this requires less hardware since only a common memory needs to be reached.

SOME IMPORTANT DIFFERENCES :

Point of Comparison	Harvard Architecture	Von Neumann Architecture
Space requirements	This requires more space.	Von-Neumann Architecture requires less space.
Speed of execution	Speed of execution is faster because the processor fetches data and instructions simultaneously .	Speed of execution is slower since it cannot fetch the data and instructions at the same time.
Space usage	It results in wastage of space since if the space is left in the data memory then the instructions memory cannot use the space of the data memory and vice-versa.	Space is not wasted because the space of the data memory can be utilized by the instructions memory and vice-versa.
Controlling	Controlling becomes complex since data and instructions are to be fetched simultaneously.	Controlling becomes simpler since either data or instructions are to be fetched at a time.

EMBEDDED SYSTEM

An embedded system is **a microprocessor-based computer hardware system with software that is designed to perform a dedicated function, either as an independent system or as a part of a large system**. At the core is an integrated circuit designed to carry out computation for real-time operations.



Components of Embedded System Hardware

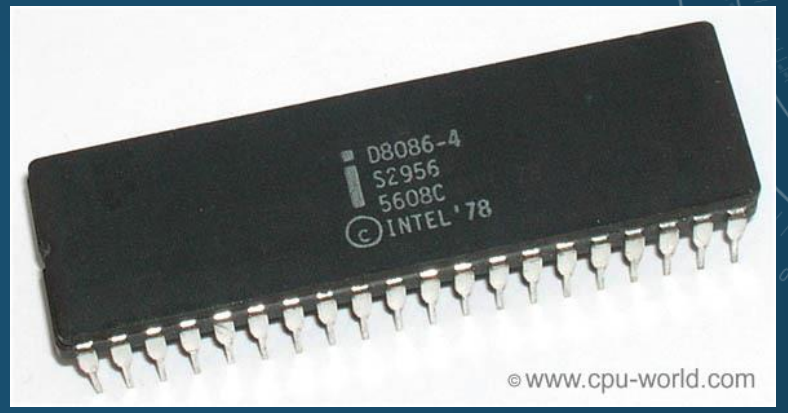
EMBEDDED SYSTEM

- An Embedded System can be best described as a system which has both the hardware and software and is designed to do a specific task.
- It should be noted that embedded systems may only have some specific range of operations or, it can be programmed to performed a wide-range of tasks.
- A good example for an Embedded System, which many households have, is a Washing Machine.
- We use washing machines almost daily but wouldn’t get the idea that it is an embedded system consisting of a Processor (and other hardware as well) and software.
- Embedded Systems can not only be stand-alone devices like Washing Machines but also be a part of a much larger system. An example for this is a Car. A modern day car has several individual embedded systems that perform their specific tasks with the aim of making a smooth and safe journey.
- Some of the embedded systems in a Car are Anti-lock Braking System (ABS), Temperature Monitoring System, Automatic Climate Control, Tyre Pressure Monitoring System, Engine Oil Level Monitor, etc.

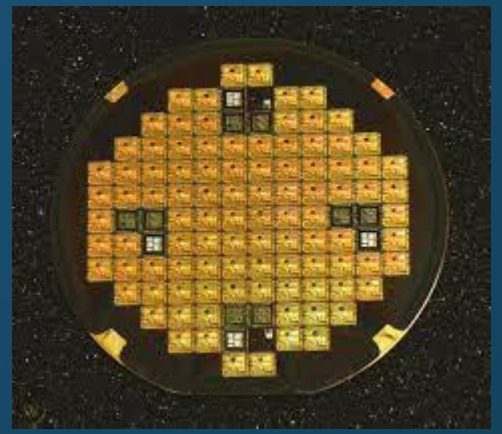
CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON GENERATIONS:

1st generation embedded systems :

- Assembly language was used to develop embedded system possessing simple hardware and firmware.
- Examples: Digital telephone keypads, stepper motor control units.



8 bit microprocessors (8085)



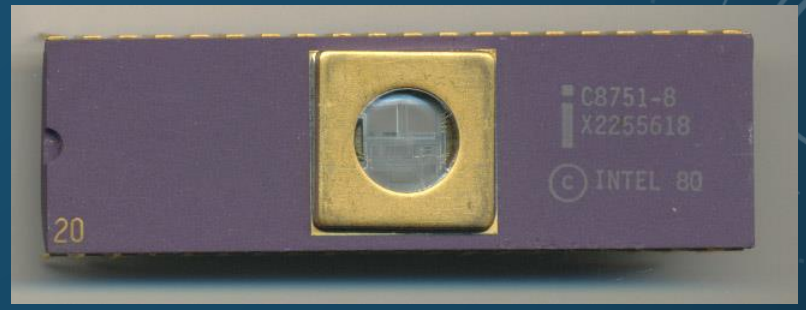
4 bit microcontrollers

CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON GENERATIONS:

2nd generation embedded systems:

- More powerful and complex to previous generation embedded systems
- Examples: Data acquisition systems, SCADA systems

16 bit microprocessor (8086)

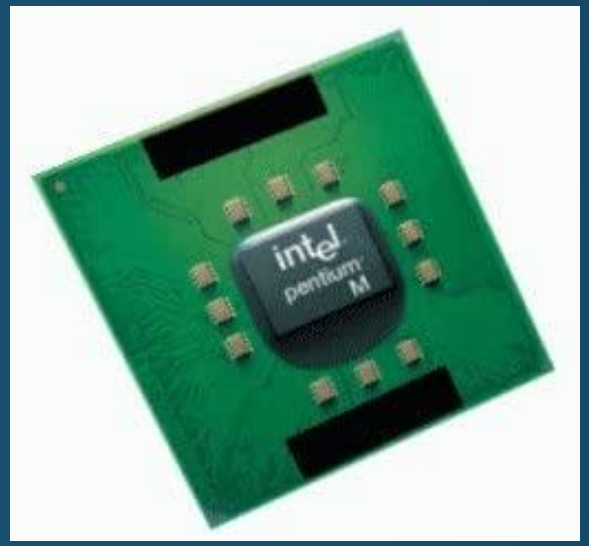


8 bit microcontrollers

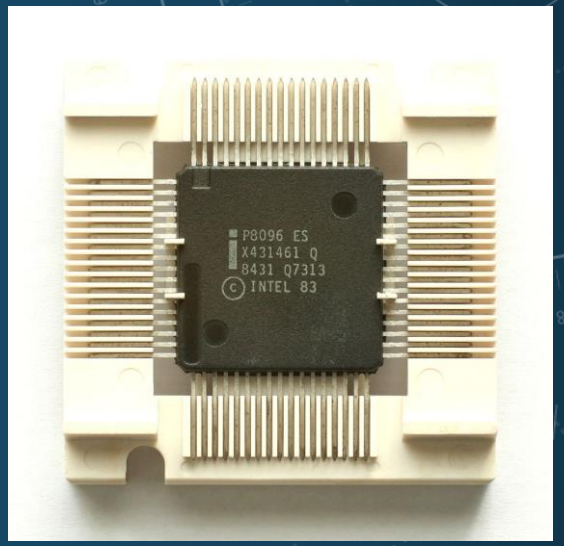
CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON GENERATIONS:

3rd generation embedded systems :

- Domain specific processors/controllers like Digital Signal Processors (DSP) , Application Specific Integrated Circuits(ASICs) and the concept of instruction pipelining evolved.
- Examples: robotics, industrial process control, embedded networking.



32 bit microprocessors
intel Pentium M



16 bit microcontrollers

CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON GENERATIONS:

- 4th generation embedded systems were built on recent developing microprocessors and microcontrollers.
- New concepts (SoC, multicore processors, coprocessors emerged to add more powerful performance.
- Examples: Smart devices, digital cameras.

System on chip (SoC)

Multicore processors

CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON SCALES:

Small scale embedded systems are built with a single 8 or 16 bit microprocessor/controller.

- The main programming tools are an editor, assembler and integrated development environment (IDE).
- The hardware and software complexities here are very low and may or may not contain an operating system for its functioning.
- Examples: An electric toy.

Medium scale embedded systems are built with 16 or 32 bit microprocessor/controller (ASICS or DSPs)

- The hardware and software complexities here exists.
- Main programming tools are C,C++, JAVA, Visual C++, RTOS, debugger, source code engineering tool, simulator and IDE.

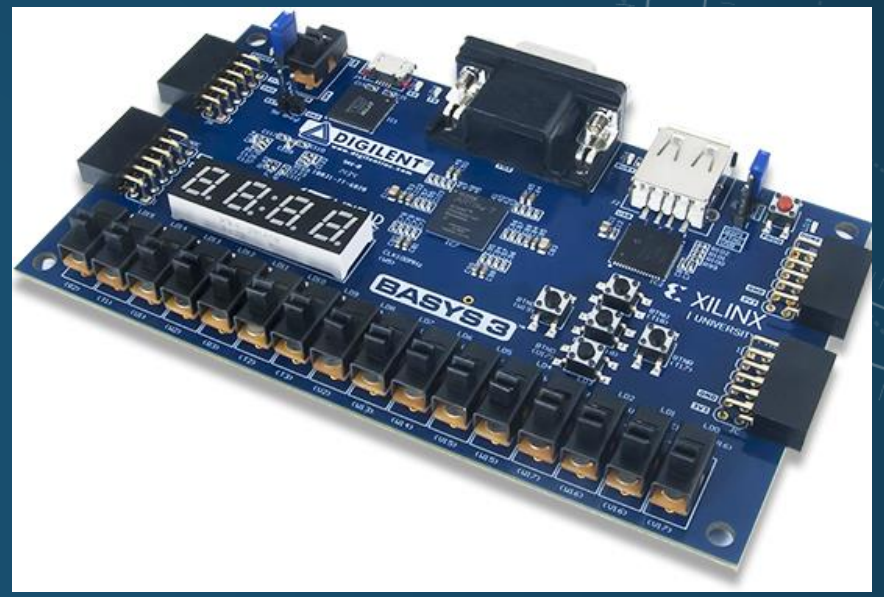
CLASSIFICATION OF EMBEDDED SYSTEMS BASED ON SCALES:

Large scale embedded systems are built with a single 32 or 64 bit microprocessor/controller, having high complex hardware and software, RISC processors, SoC, scalable and configurable processors.

- These are also known as sophisticated embedded systems.
- Used for cutting –edge applications containing high performance real time operating system for task scheduling, prioritization and management.

BASED ON HARDWARE PROPERTIES EMBEDDED SYSTEMS CAN BE GROUPED AS FOLLOWS:

Field –programmable gate arrays(FPGA) form custom embedded systems at gate level. Therefore it cannot be programmed rather FPGA system has to be constructed by a hardware description language such as Verilog and VHDL.



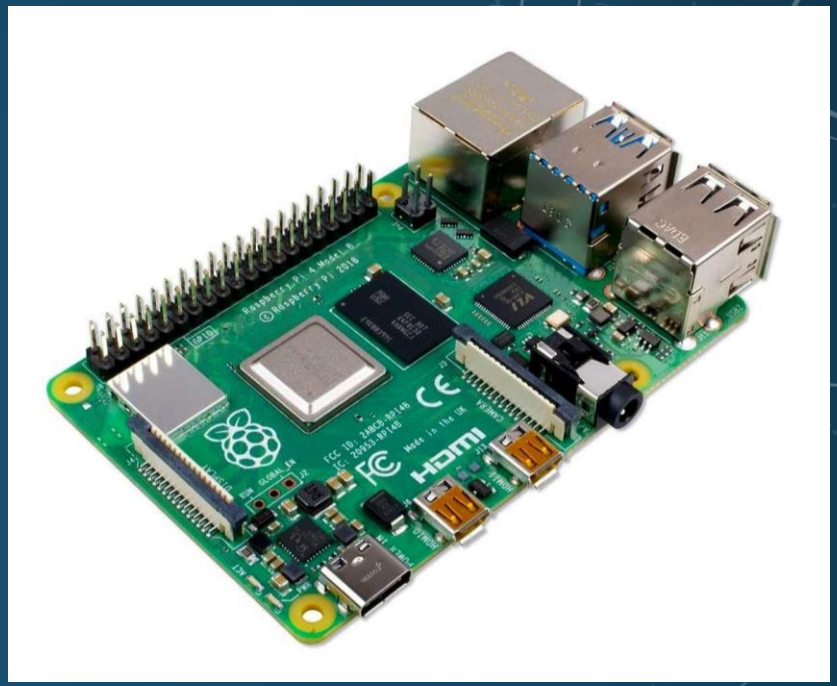
Microcontrollers form embedded systems as those can be programmed in assembly or high level language to perform operations. Most well known microcontrollers are Arduino and Arm Cortex M based ones having limited computation power and memory .

BASED ON HARDWARE PROPERTIES EMBEDDED SYSTEMS CAN BE GROUPED AS FOLLOWS:

Microprocessors form embedded systems where Linux operating system can control and organize operations . This also leads to Graphical User Interface (GUI) usage as well. Microprocessors have fairly high memory and computation power compared to microcontrollers. Popular microprocessor based embedded systems are Raspberry Pi family.

System on chip (SoC) form embedded systems as they have FPGA and microprocessor modules . Thus SoC programming and usage is still not easy when compared to microcontroller or microprocessor.

The four mentioned groups have their dedicated development boards which use cross compilers so that code is written and debugged on PC.



NEW HARDWARE OPTIONS EMERGED FOR EMBEDDED SYSTEMS ARE AS FOLLOWS:

1) STMicroelectronics offered joint usage of microcontroller (Arm Cortex A) and microprocessor (Cortex M CPUs.
2) Development boards consisting of graphical processing units (GPU) allow parallel processing via high-level programming languages.
3) Recents advances in deep learning and neural networks also led to devices consisting of neural processing units (NPU or TPU) dedicated to neural network implementations.

NEW HARDWARE OPTIONS EMERGED FOR EMBEDDED SYSTEMS ARE AS FOLLOWS:

- At present, some of the popular microcontroller families in the market are:
  - ATMega family: ATMega328P, ATMega32
  - Pic-chips: Pic24, Pic33 etc
  - ARM processors: Raspberry Pi, TM4C chips, STM32 F401

- In Bangladesh, ATMega based Arduino boards have gained wide popularity due to easy availability and low price

- We are going to mostly focus on the ATMega328P chip during midterm and then on the Arm processors in final term.

REAL-LIFE EXAMPLES OF EMBEDDED SYSTEMS:

Exceptionally versatile and adaptable, embedded systems can be found in all smart devices today. It is difficult to find a single portion of modern life that doesn't involve this technology. Here are some of the real-life examples of embedded system applications.

Central heating systems

GPS systems

Fitness trackers

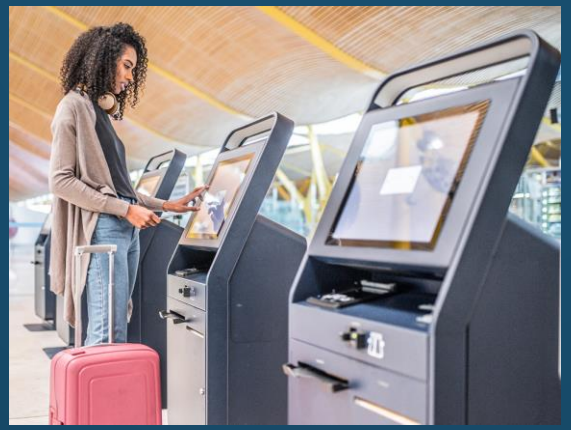
REAL-LIFE EXAMPLES OF EMBEDDED SYSTEMS:

Automatic fare collection(AFC)

ATM systems

Factory robots

Medical devices



Self-service kiosks

Electric vehicle charging stations

REFERENCES:

1. Embedded System Design with ARM Cortex-M Microcontrollers: Applications with C, C++ and MicroPython by Cem Unsalan
2. https://www.digi.com/blog/post/examples-of-embedded-systems