Embedded Systems CSEN701

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Outline :

- **Embedded systems Introduction**
- Embedded Systems industry & applications
- Embedded Systems characteristics
- Embedded Systems Challenges
- Microprocessor vs microcontroller
- ES

What defines an embedded system?

- ES is a microprocessor-based system that is built to control and perform a dedicated Function (special-purpose-system) or range of functions and is not designed to be programmed by the end user, Unlike the PC which is considered as a programmable general-purpose-computer .
- ES is application-dependent as it contains computer hardware, software and perhaps additional parts, either mechanical or electronic—designed as LEDs, ADC, sensors, etc.… depending on the application .
- Embedded Systems are Application-specific systems which contain hardware and software tailored for a particular task and are generally part of a larger system as the word “Embedded” reflects such a fact .

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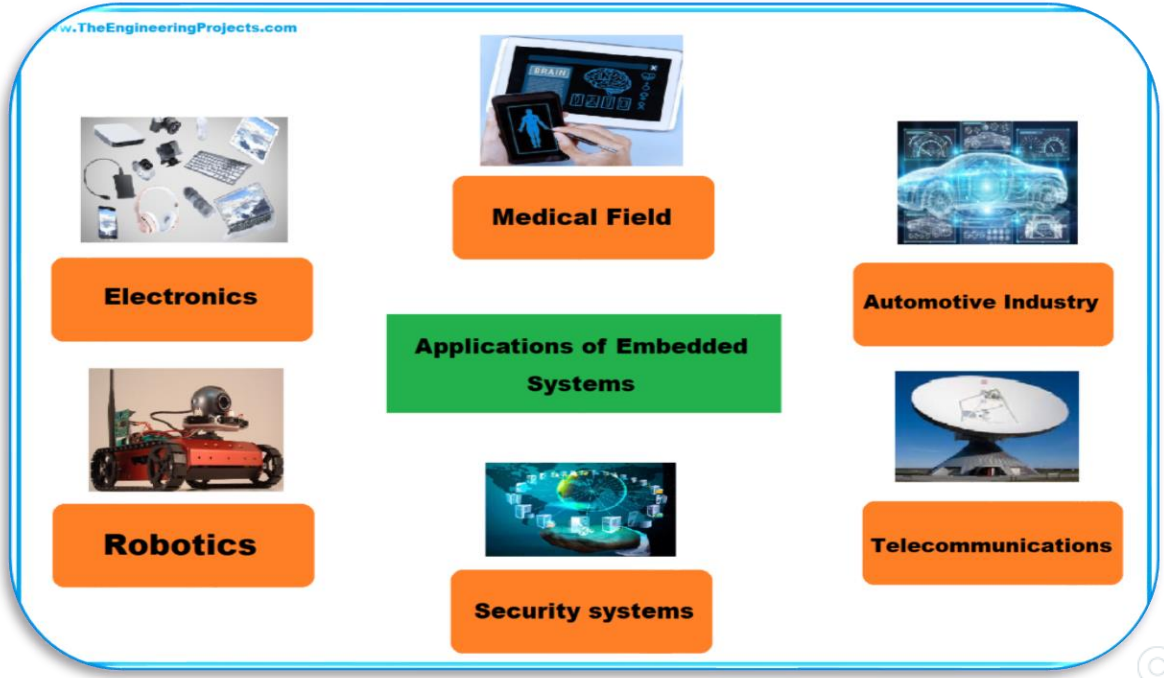
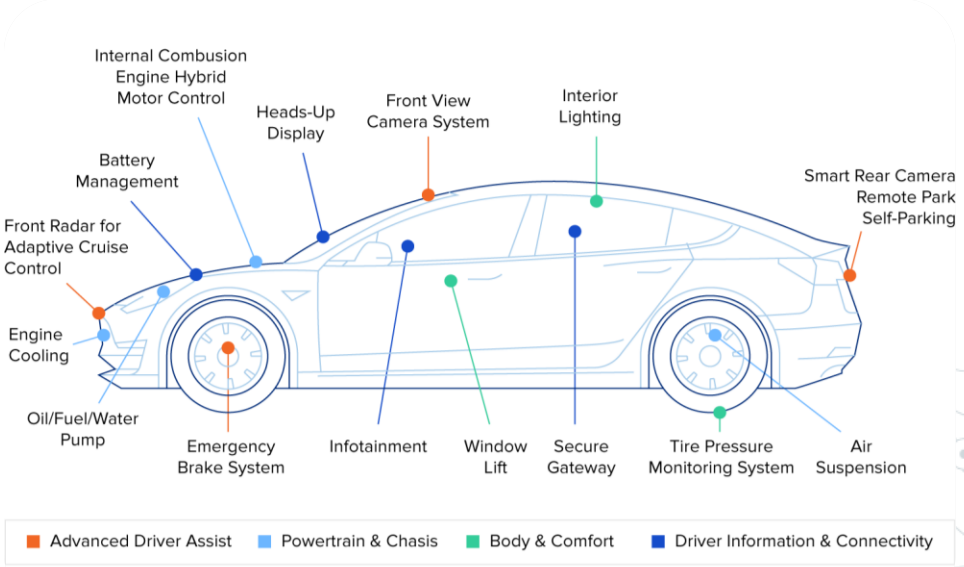
Embedded Systems industry & applications



Embedded Systems industry & applications

Embedded Systems in Automotive Industry

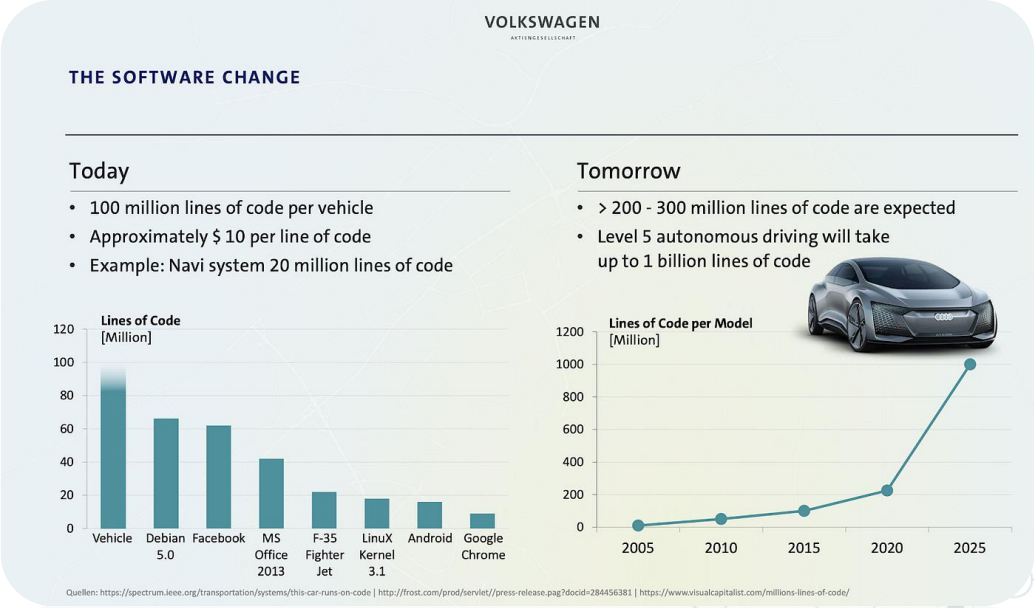
- Electronics represents 40% of the total cost of the car
- 80% of the car features require software
- modern car now contains around 100 million lines of software code, and is expected to have around 300 million lines of code by 2030



Embedded Systems industry & applications

Embedded Systems in Automotive Industry

Modern Luxury cars contain from 70+ microcontrollers and around 100 millions lines of code !



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Embedded Systems characteristics

- **Reliable and Safe** : Ensuring that the system is safe and reliable is a priority as An error in Embedded system application such as an Antilock Braking System(ABS) or Breaking Assistant(BA) or autopilot could be fatal.
- **Reactive and Efficient** : it must respond efficiently and rapidly in real-time applications (airbag) .
- **Maintainable :** The ability to modify the system after its initial release and enhance its performance like execution time, code and memory size .
- **Heterogeneous Integrity** : Strong association between the Hardware and Software.

Embedded Systems characteristics

- **Dynamic :** interacts with physical processes through sensors and actuators
- **Networked :** concurrent and distributed. Cars contain more than 50+ MCU working concurrently and communicating with each other .
- **Computational complexity :** Complex functionality Often have to run sophisticated algorithms or multiple algorithms Cell phone, laser printer, automotive, etc.

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Embedded Systems Challenges & constraints

- Processing(speed)
- Storage & Memory(limits the code size and affects the cost)
- Most of the time it targets real time objectives, this means :
  - ➢ It needs to be fast and efficient(Response Time).
  - ➢ It needs to be predictable (execution time known ahead, and almost constant)
- Power Limited (Limited battery resources)
- Cost
- Size

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General Purpose Systems vs Embedded Systems

characteristics	General Purpose System	Embedded System
Programmable by the user	Flexible and can be programmed and adjusted for various software configurations	No it is only programmed by the developer and not easily adaptable
Main Purpose	Computing a lot of applications (i.e. general purpose).	Perform ONLY Few applications that are known at design-time (i.e. special purpose)
Required Performance	Relatively fast and flexible	Performance Faster and better Fixed runtime requirement
Constraints	Low or no resource constraints	High constraints in Size, power, cost, memory, Hardware , real-time
User Interface	External Interface Can have keyboard, display, mouse, touch screen as it is configurable by the user	Minimal or no interface (buttons , LCD)

General Purpose Systems vs Embedded Systems

General purpose systems run full-fledged operating systems like Windows, Linux , Android , MAC OS, However ES run specialized, lightweight operating systems, or they run directly from the firmware without any OS .

Mobile phones and personal computers are considered general purpose systems.

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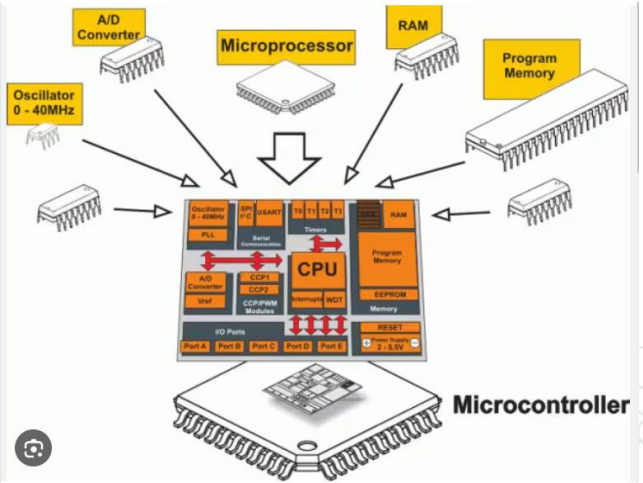
- Embedded Systems

Microprocessor vs microcontroller

Microcontroller (MC)

- Basically a microcontroller can be described as a computer on a chip designed with specific purpose.
- MC is a single chip containing a CPU, non-volatile memory (ROM), volatile memory(RAM), a timer and an I/O control unit and usually also include serial communication capabilities, interrupt controls and analog I/O capabilities .
- Micro controller May include a processing unit(CPU) of 8-bits, 16-bits or 32-bits .



Microprocessor vs microcontroller

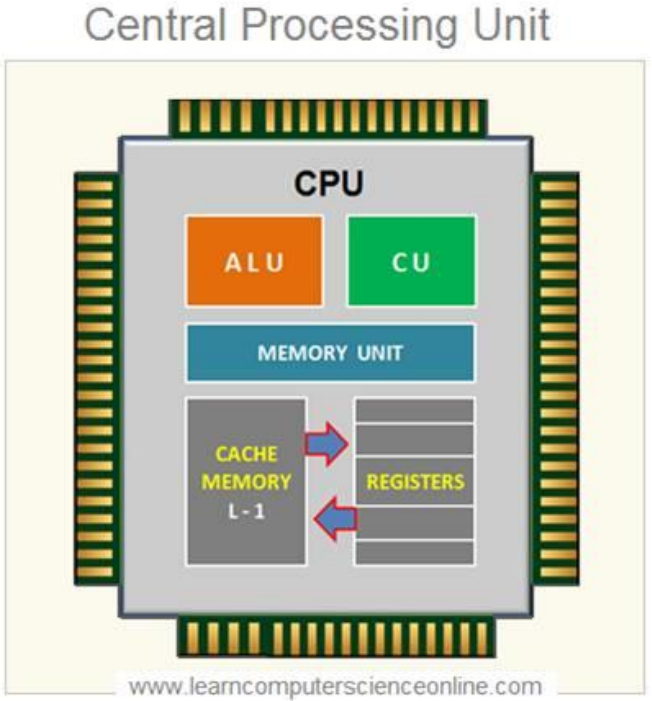
Microcontroller (MC)

- Microcontrollers don’t work alone in the circuit it must interfaces with other on chip devices like Sensors, Switches, LEDs, LCD, Keypad and DC Motor.
- Differences in requirements, make the manufacturers produce different microcontrollers with different memory sizes, number of I/O lines and number of integrated peripheral devices. Other wise they are all similar to use
- Arduino , Tiva-C are famous MCs

Microprocessor vs microcontroller

Microprocessor

- A Microprocessor is basically a standalone CPU with all of its elements; CU, ALU, and registers.
- The µP is connected to the other peripherals externally such as externally memory, clock, input/output interfaces, timer and all other needed peripheral. This is the reason a microprocessor has so many pins
- µP can be used in complex embedded systems
- they are commonly used in laptops, computer gaming, laser printers, modem, digital telephone, and others



Microprocessor vs microcontroller

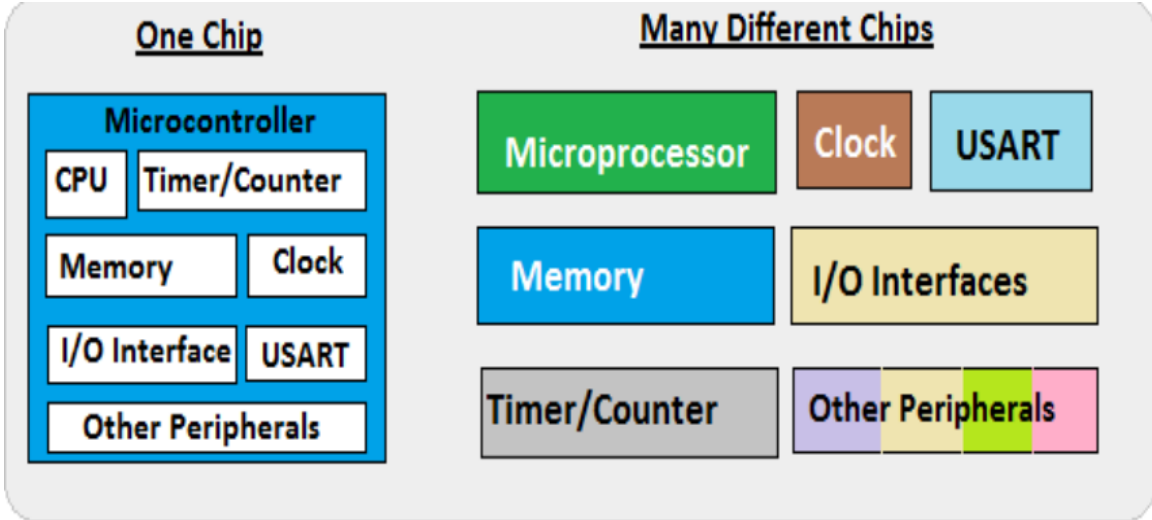
Microprocessor

- The µP is characterized by: Flexible, needs more energy, expensive, OS-based, faster
- It has three types:
- ➢Complex Instruction Set Computer (CISC)
- ➢Reduced Instruction Set Computer (RISC)
- ➢Explicitly Parallel Instruction Computing

Microprocessor vs microcontroller

The difference between a microcontroller and a microprocessor is that the microprocessor is a general purpose computer while a microcontroller is a computer dedicated to one or just a few tasks .

Microcontroller contains the circuitry of the microprocessor in addition it has in-built ROM, RAM, I/O devices, timers and counters.



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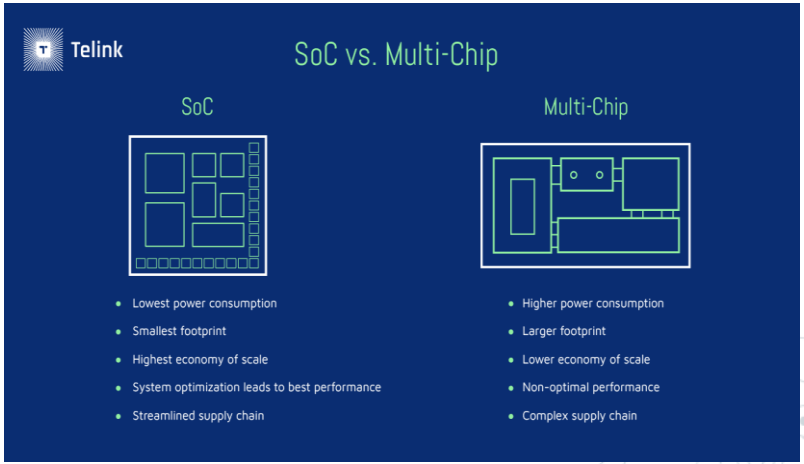
Embedded Systems

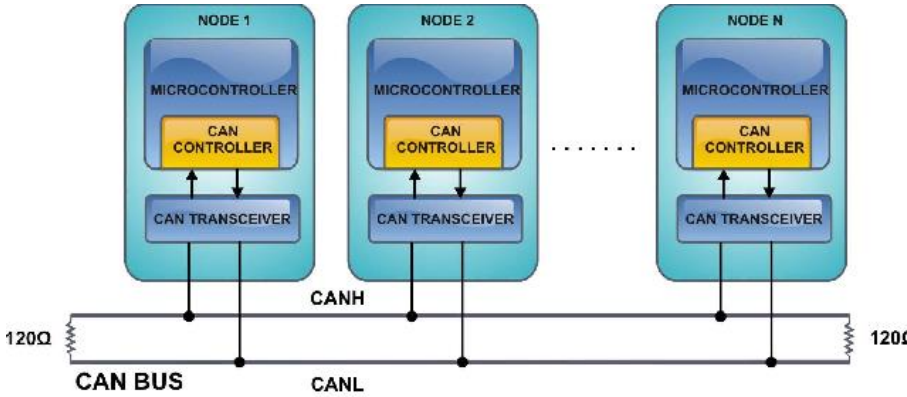
Embedded system Types:

- System on a chip (SOC) : It contains multiple functional units on one piece of silicon. Gain a low system power, size and cost , This system is unchangeable as all units exist on one chip . (Example : ATmega32 MC)
- System on Board (SOB) : Discrete units exist on the same board and it requires High power consumption, size and cost , SOB system is configurable as we can change the units on the board. (For example the mother-board)

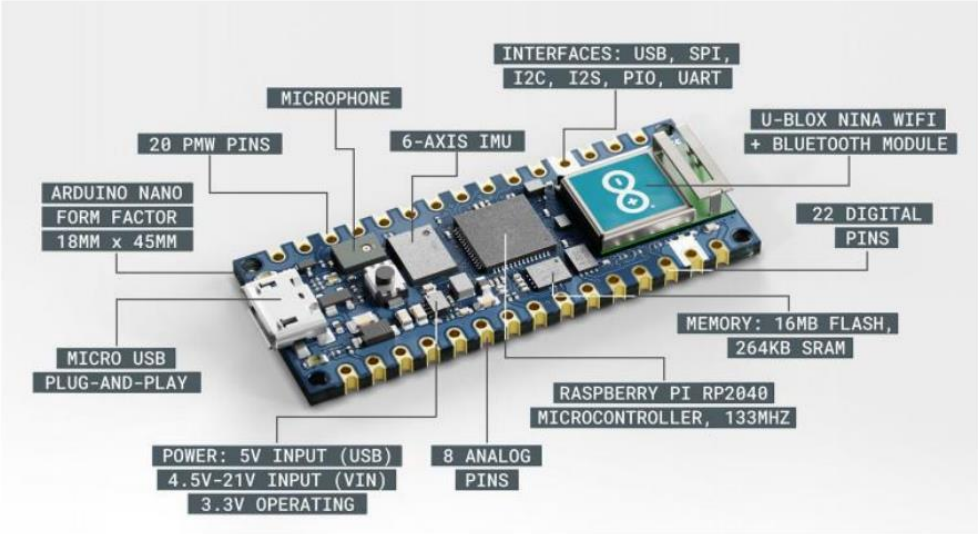


Embedded Systems

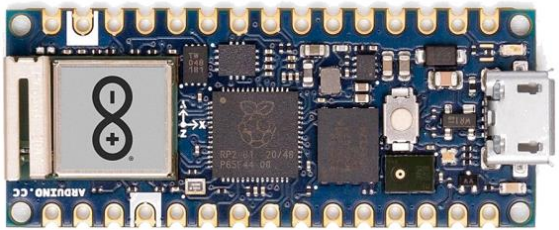
- Embedded Systems can contain a network of different micro-controllers interfacing with various peripherals , hardware components and even communicating with each other .
- Many micro-controllers on one / many board(s) communicate together through specific bus protocol like LIN bus and CAN bus (communication protocols) in automotive applications .



Exploring Arduino rp2040



Frontal View



Back View

THANK YOU