Computer Science 1: IT and web

coefficient: 2
credit: 3
continuous control weight: 50%
exam weight: 50%

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Course 4: Embedded system

Goals

- What is an embedded system?

- What is embedded?

1-Introduction

1. Introduction

- Every morning, you are woken up by your alarm clock; it is an embedded system.
- You program your coffee machine to have a good, strong coffee; it is an embedded system.
- You turn on the television and use your remote control; These are embedded systems.

1. Introduction

- You call your friend with your cell phone to say that you will be late; it is an embedded system.
- You get in your car and the computer's voice tells you that you haven't worn your seat belt; it is an embedded system.

1. Introduction

1. Introduction

- Every day we use products that contain computer chips that are made up of CPUs, memories and programs.
  - Television, Automobiles,
  - iPod, cell phones, GPS,
  - Microwaves, alarms,
  - Router, game consoles, etc.

1. Introduction

- Specific tools:
  - Digital Machines, Diagnostic Tools,
  - ATM ticket machine.
  - Medical Instrumentation, Aeronautical Industry, Satellites,

2-Definition

2. Embedded system definition

- An embedded system is defined as an autonomous electronic and computer system, often real-time, specialized in a very specific task. Its resources are generally limited.
- The system includes a hardware part and a software part.

2. Embedded system definition

- An embedded system is a complex system that integrates software and hardware designed together to provide given functionality. It generally contains one or more microprocessors intended to execute a set of programs defined during design and stored in memories.

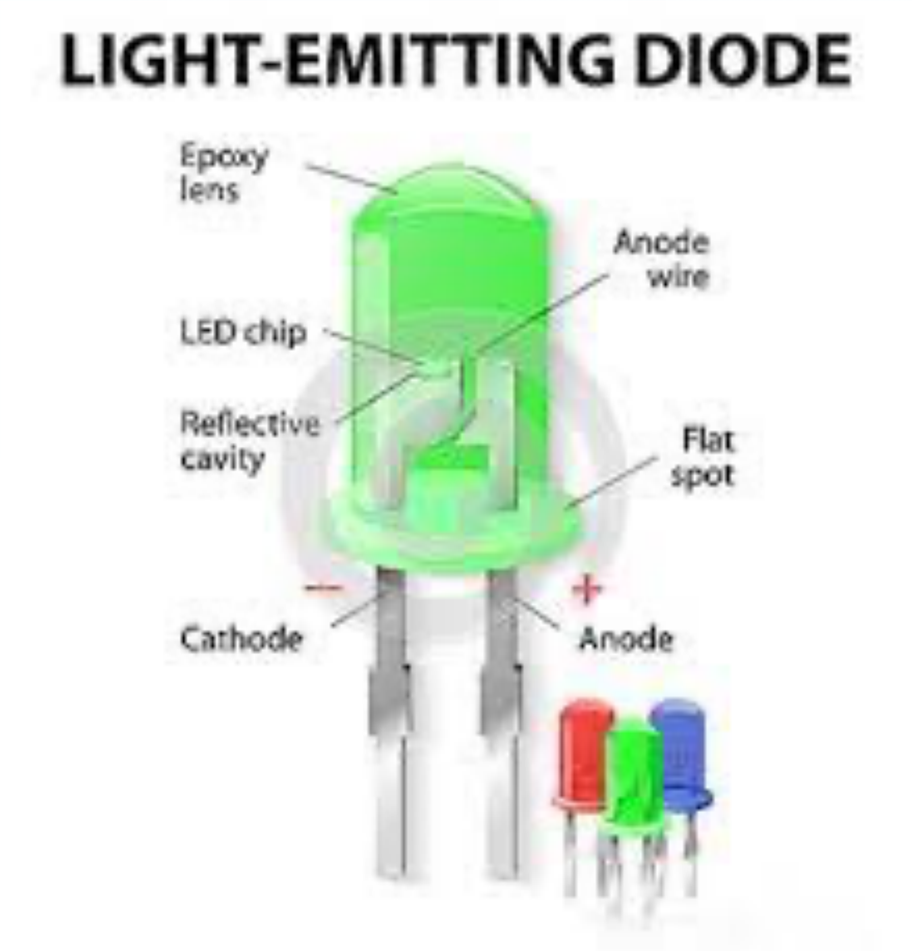
2. Embedded system definition

- The hardware system and the application (software) are intertwined and immersed in the hardware and are not as easily discernible as in a typical desktop PC (Personal Computer) work environment.

2. Embedded system definition

- An embedded system is **self-contained (autonome)** and does not have standard inputs/outputs such as a keyboard or computer screen.
- Unlike a PC, the HMI (Human Machine Interface) interface of an embedded system can be as simple as a flashing LED (Light Emitter Diode) or as complex as a real-time night vision system. ; Liquid Crystal Displays (LCDs) of generally simple structure are commonly used.

2. Embedded system definition



2. Embedded system definition

- In order to optimize the performance and reliability of these systems we use:
  - programmable digital circuits FPGA (Fild Programmable Gate Array),
  - circuits dedicated to specific applications ASIC (Application Specific Integrated Circuits)
  - or analog modules.

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3-Characteristic of embedded system

3 Characteristic of embedded system

- Embedded systems process certain specific features and these features are unique in each embedded system.

3 Characteristic of embedded system

- **Scope specification**
- An embedded system performs certain functions that are intended but cannot be used for any other purpose. Specifications are usually assigned and contribute to reducing the overall price of the embedded system.

3 Characteristic of embedded system

- **Real-time**
- A real-time system is a system that responds to temporal constraints and is not necessarily a system that goes quickly. To do this, it must guarantee logical and temporal determinism. It must also be reliable

3 Characteristic of embedded system

- **Reactivity**
- An embedded system must by definition monitor and control an environment. If the latter itself presents changing or event-type behavior.

3 Characteristic of embedded system

- **Criticality, Reliability**
- Due to their portability and the mobility of the products in which they are incorporated, embedded systems generally operate in non-deterministic and often uncontrolled environmental conditions.
- They are exposed to variations and other environmental constraints likely to cause failures.

3 Characteristic of embedded system

- **Criticality, Reliability**
- At the same time as their sophistication increases, embedded systems are used in increasingly critical applications in which their malfunction can cause nuisance.
- This type of system must guarantee very high reliability and must be able to react in the event of a breakdown of one of its components

3 Characteristic of embedded system

- **Autonomy**
- Embedded systems must generally be autonomous, that is to say, fulfill their mission for long periods without human intervention.
- This autonomy is necessary when human intervention is impossible, but also when human reaction is too slow or insufficiently reliableels or even fuel cells for certain prototypes.

3 Characteristic of embedded system

- **Energy consumption**
- Power management is another important factor that must be considered when designing embedded systems.
- The processors used in embedded systems are 2 to 3 decades less powerful than a PC computer processor.
- Energy consumption is very low, due to the use of batteries and/or solar panels or even fuel cells for certain prototypes is necessary when human intervention is impossible, but also when human reaction is too slow or insufficient. reliable

4-Complexity

4. Complexity

- Embedded systems often require a small footprint (low weight)
- Their technology then uses electronics and portable applications where both space and electricity consumption must be minimized.

4. Complexity

- Consequently, creating packaging in order to allow analog electronics, digital electronics and RF (Radio Frequency) components to coexist on a small surface area without interference is a difficult task.
- In current design strategies, an embedded system is generally integrated on a single silicon support, thus constituting a complete system integrated on an SoC (System on a Chip).

4. Complexity

4. Complexity

- The memories (ROM and RAM) are integrated for storing data and programs.
- These digital components generally coexist on the same silicon support with various analog and mixed components such as radio frequency components for communication, components for high-speed data transfer, MEMS (Micro Electro Mechanical System) for interfacing. with the external world.

5- Constraints of embedded systems: criticality and reliability

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- Due to their portability and the mobility of the products in which they are incorporated, embedded systems generally evolve in non-deterministic and often uncontrolled environmental conditions.
- They are exposed to variations and other environmental constraints likely to cause failures: vibrations, shocks, temperature variations, power supply variations, RF interference, humidity, etc.

5. Constraints of embedded systems: criticality and reliability

- Hence the need to take into account changes in the characteristics of components depending on environmental conditions.
- At the same time as their sophistication increases, embedded systems are used in increasingly critical applications in which their malfunction can generate nuisance, economic losses or unacceptable consequences which can go as far as the loss of human lives.

5. Constraints of embedded systems: criticality and reliability

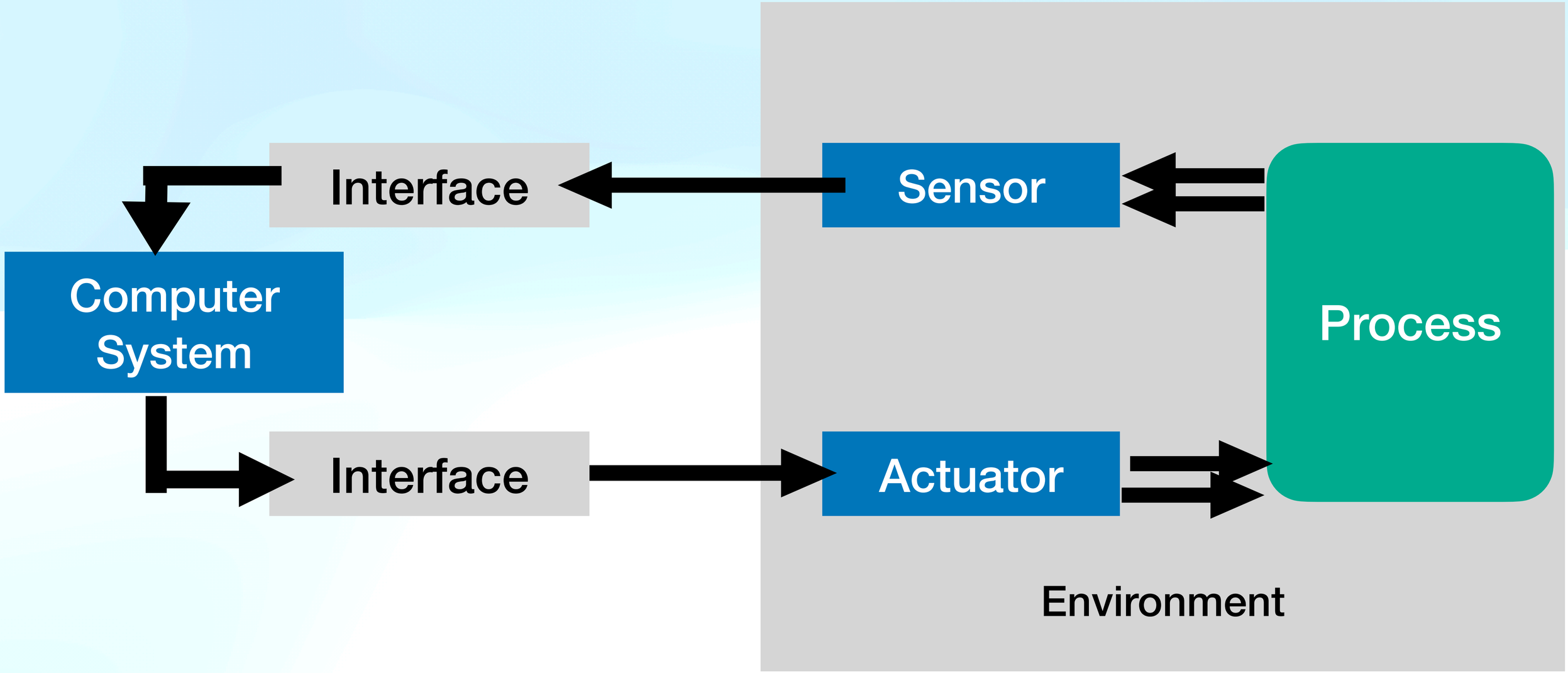
- This is the case, for example, for medical or transport applications for which a failure can have a direct impact on the lives of human beings.
- This is also the case for space, underground or underwater applications where failure can have serious consequences both in terms of safety and at an economic level.
- This type of system must guarantee very high reliability and must be able to react in the event of a breakdown of one of its components.

6-Architecture of an embedded system:

6. Architecture of an embedded system:

- Whatever the nature and complexity of the system, we decompose a embedded system in:
    - **Controlled system:** environment (process) equipped with instrumentation which interfaces with the control system.
    - **Control system:** hardware elements (microprocessors, etc.) and software whose mission is to act on the process via actuators according to the state of this process indicated by the sensors so as to maintain or drive the process in a given state.

6. Architecture of an embedded system:



7-Comparison between standard and embedded computing

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Standard computing	Embedded computing
Standard processor. • Standard architecture (Von Neumann) • • High speed (>GHz). • • High power consumption	Dedicated processor (Controller) • Adapted standard architecture. • Reduced speed (< 200 MHz) • Low power consumption
Large memory capacity	Low memory capacity
Standard OS	Adapted OS (RTOS)
Large number of devices •	Small number of devices

8-Conception of embedded system

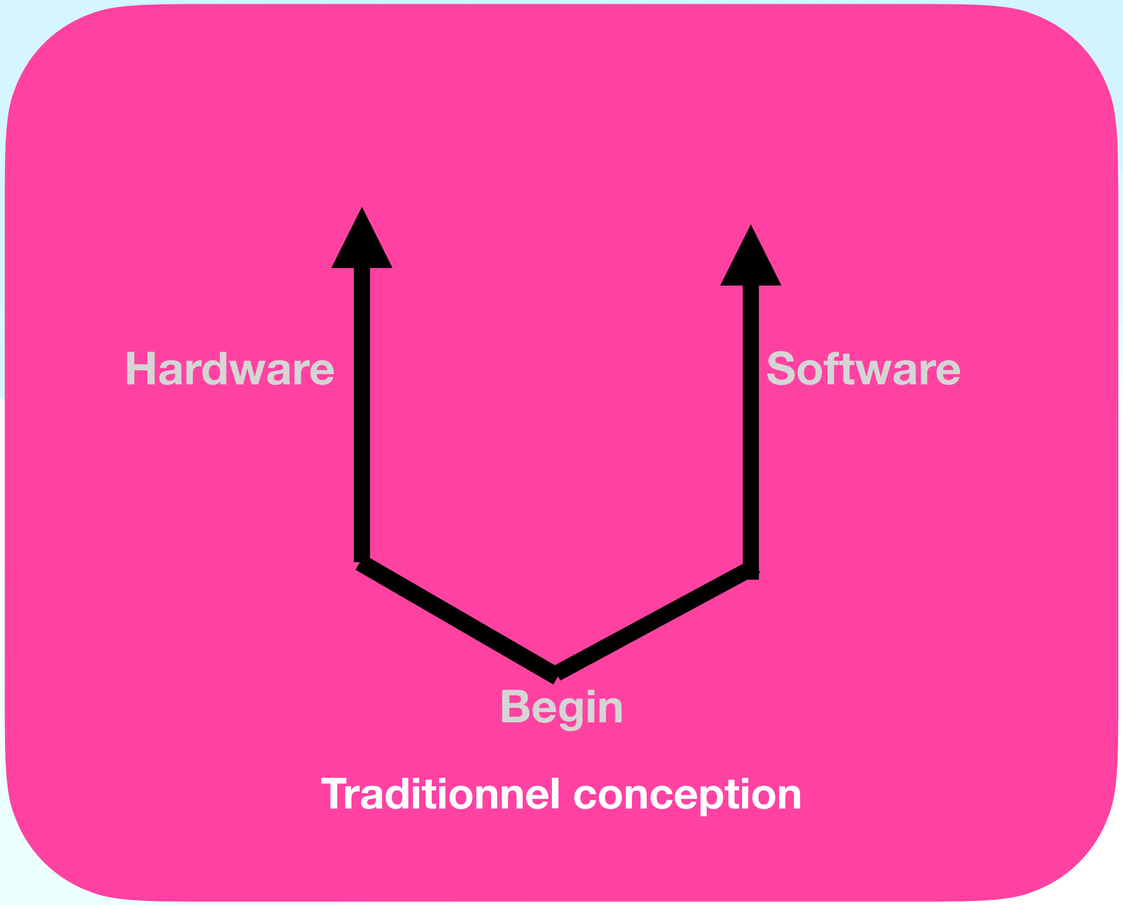
8. Conception of embedded system

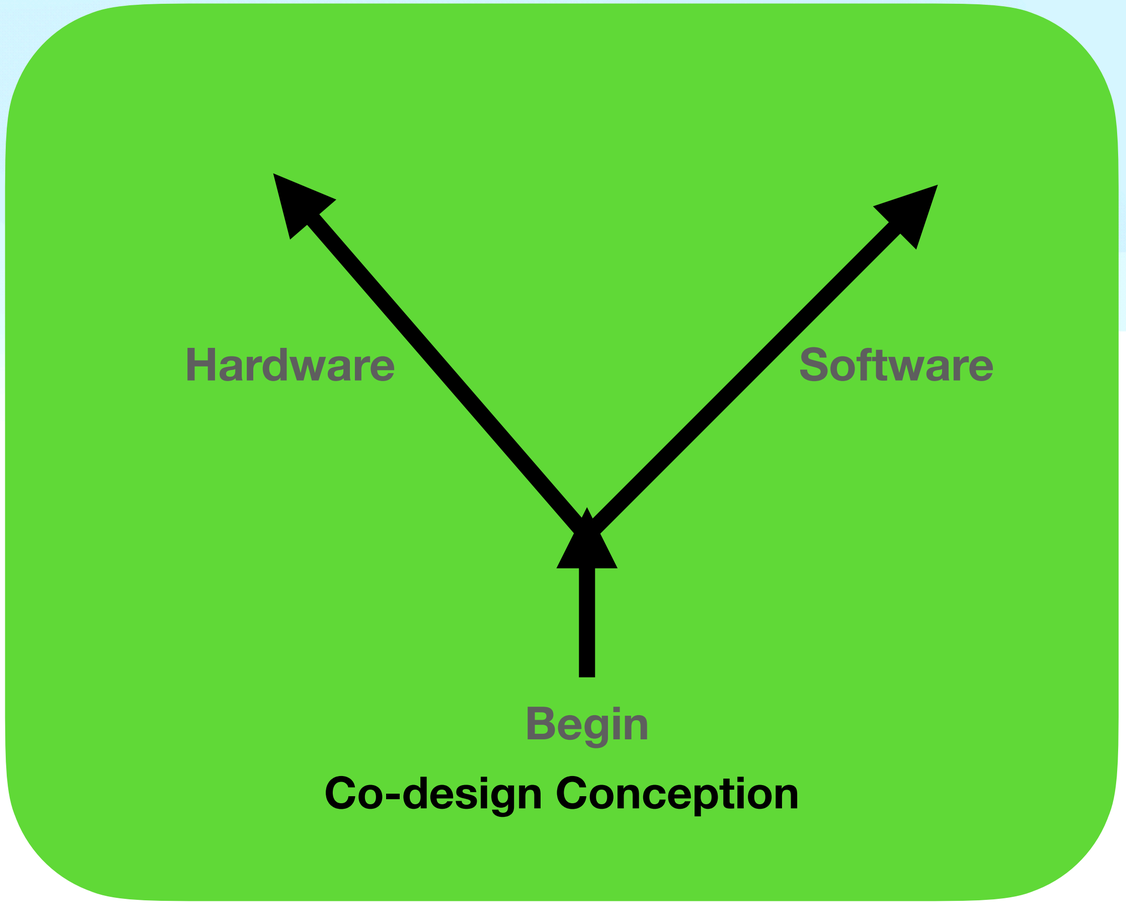
- **Objective:**
  - Integrate a system into the same component (single chip). We also speak of a silicon system SoC (System on Chip) or SoPC (System on Programmable Chip)

8. Conception of embedded system : Co-design

- Co-design is the embedded system design methodology that is increasingly used.
- Co-design allows you to design both the hardware and software at the same time for a feature to be implemented.
- Co-design allows the hardware choices to be made to be pushed back as far as possible in the design of the system, unlike the classic approach where the hardware choices are made first.

8. Conception of embedded system : Co-design





8. Conception of embedded system : Codesign

- The steps to follow:
  - **Specifications:** list of system features in abstract form.
  - **Modeling:** conceptualization and refinement of specifications producing a model of the hardware and software
  - **Partitioning**: hardware software sharing.
  - **Synthesis and optimization:** hardware synthesis and software compilation.

8. Conception of embedded system : Codesign

- **Validation**: co-simulation.
- **Integration**: bringing together the different modules.
- **Integration tests**: verification of operation.