Embedded System

IoT and Embedded System

- IoT is a network of objects that are connected to the internet, and through the internet, **an embedded system is able to collect and exchange data**. Internet of Things works through the embedded applications that can be used to control and monitor your other devices from anywhere.

What is System?

A system is a way of working, organizing or doing one or many tasks according to a fixed plan, program or set of rules.

A system is also an arrangement in which all its units assemble and work together according to the plan or program.

System

WATCH

- **It is a time display SYSTEM**
- **Parts: Hardware, Needles,**
- **Battery, Dial,**
- **Chassis and Strap**

Rules

1.All needles move clockwise only
2.A thin needle rotates every second
3.A long needle rotates every minute
4.A short needle rotates every hour
5.All needles return to the original position after 12 hours

Embedded Systems

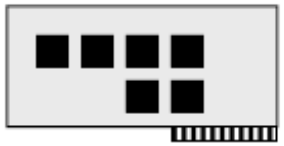
Definition :

- *A combination of hardware and software which together form a component of a larger machine.*
- *An example of an embedded system is a microprocessor that controls an automobile engine.*
- *An embedded system is designed to run on its own without human intervention, and may be required to respond to events in real time.*

Source: www.computeruser.com/resources/dictionary

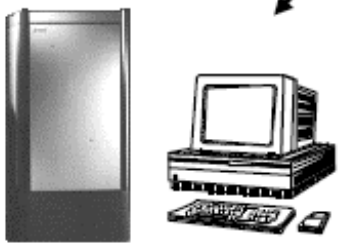
Embedded Systems *vs.* Standard Computer Systems

CPU chip



Microcomputer board (CPU, memory, interface)

- connected to sensors
- connected to actuators
- real-time operation
- programmed *once*



Microcomputer system
e.g. PC, printer, disk drive

Embedded system
e.g. automotive application

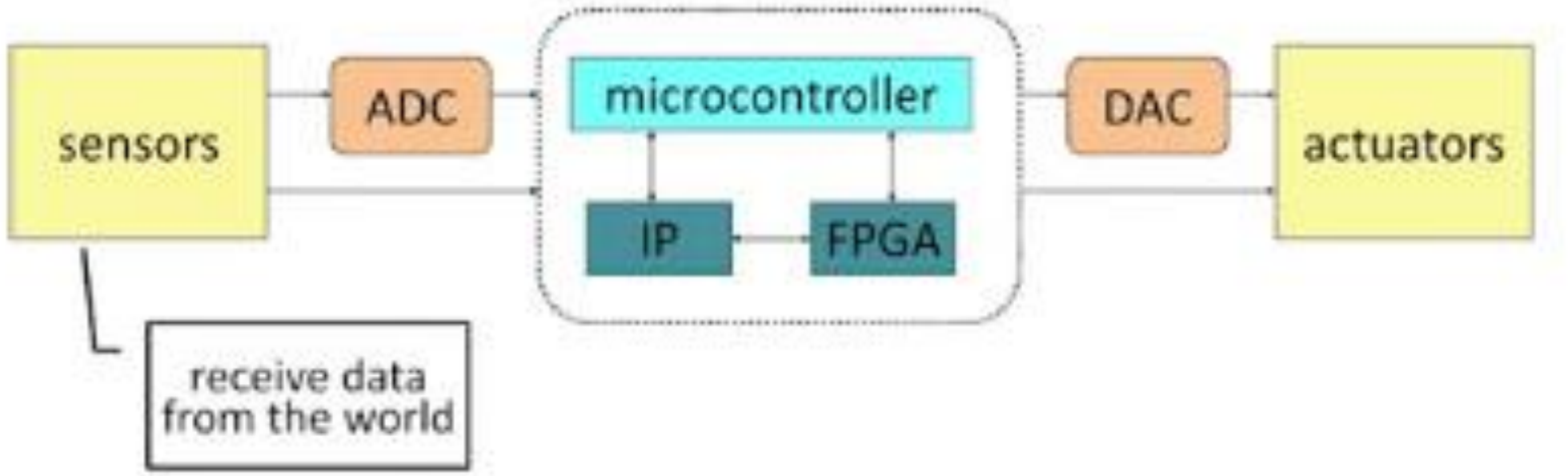
What is Embedded system ?

- An embedded system is that system which has computer hardware with software embedded in it.
- It is a device which has a programmable computer but such a computer is not general purpose computer.
- It may be an independent system or a part connected with some other system.
- An embedded system product is controlled by an internal microprocessor or microcontroller instead of some external control unit.
- The ROM of microcontroller is burned with the program to perform specific functions of the embedded systems.
- Microcontrollers normally used to design embedded systems are Arduino, PIC Microcontroller, Atmel Microcontroller, 8051 Microcontroller etc.

Embedded Systems

- React on the environment at the speed of the environment.
- Often real time requirement
- Are designed for one single task
- Have often to be power efficient
- Are mass products and have to be cheap
- Must be reliable

Generic Structure of ES



Components of ES

- Microcontroller
  - Integrated chip that executes the program
  - Slower compared to microprocessor (16 MHz to 500Mhz)
  - Less memory, fewer features
  - Connected to other hardware devices
  - Sends commands and receives data
  - Needs to be programmed
- Development Board
  - Includes hardware required for programming
- Digital Signal Processors
- Sensors
- Actuators [LEDs, LCDs]

Digital Camera

- A digital camera is very good example of embedded systems.
- Cameras that we use today are smart and have a lot of features that were not present in early cameras all because of embedded system used in them.
- A digital camera has basically three functions, to capture image which we call data, to store image data, and to represent this data.
- Today images are stored and processed in form of digital data in bits.
- There is no need of film for storing images. This feature has increased the storage capacity and made it easy to transfer images.

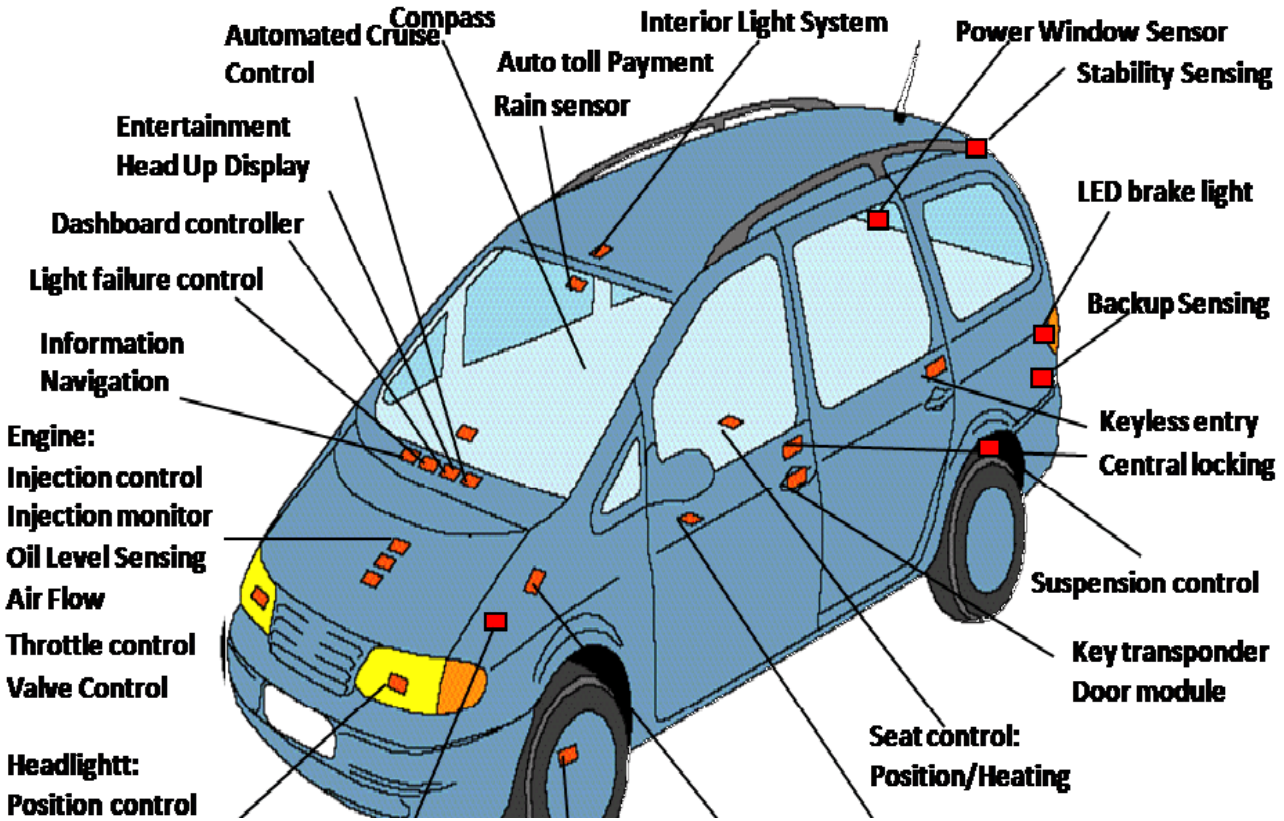
Digital Camera

- In digital cameras, first image is captured and converted to digital form.
- This digital image is stored in internal memory.
- When the camera is attached to your personal computer for uploading images, it transfers the stored data.
- Smart Camera, it has some extra features than digital cameras.
- Smart cameras are able to capture details of the scene.
- These cameras analyze the images and are able to detect humans, motion, faces etc. from the whole image.
- For detection of objects in the image, some processing is required in cameras.
- Usually, image processing includes low level processing and high level processing.
- Various algorithms are available that are employed for this purpose.

Components of a smart camera

- Components of a smart camera
  - image sensor that may be a CCD (Charge Coupled Device) or a CMOS (Complementary metal oxide semiconductor)
  - Analog to digital converter (A2D)
  - Image Processor
  - Memory
  - Lens
  - Led or other illuminating device
  - Communication Interface etc.
- So, we can say that camera is one of the important embedded systems examples. It has its own processor, sensors, actuators and also memory for storage purposes.

Automotive Embedded Systems



Application Domain of Embedded Systems

- **Medical Systems**
  - pace maker, patient monitoring systems, injection systems, intensive care units, …
- **Office Equipment**
  - printer, copier, fax, …
- **Tools**
  - multimeter, oscilloscope, line tester, GPS, …
- **Banking**
  - ATMs, statement printers, …
- **Transportation**
  - (Planes/Trains/[Automobiles] and Boats)
- radar, traffic lights, signaling systems, …

Desirable Features & General Characteristics of ES

- It should have one or small set of functions which it is expected to perform efficiently.
- Low power dissipation
- Limited memory and peripherals
- Applications are not meant to be alterable by the user
- Highly reliable
- Need to operate with time constraints.

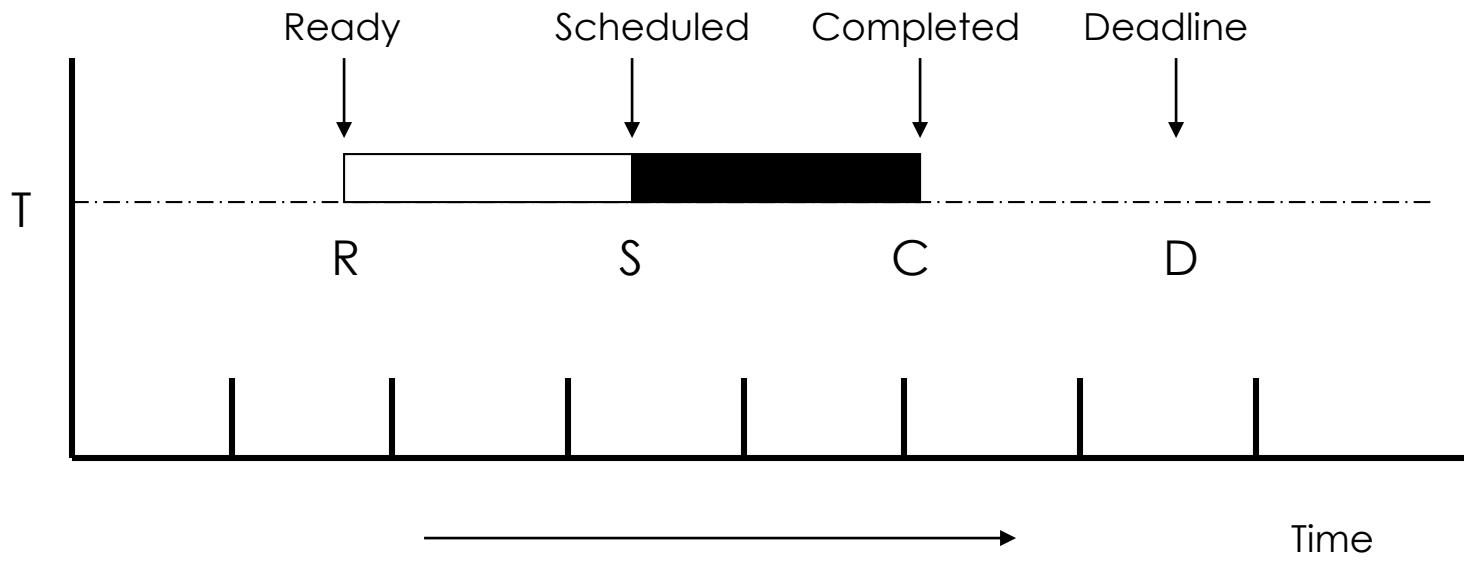
Real Time System

- **real-time task**
- A **real-time system** is a system whose specification includes both logical and temporal correctness requirements.
- **Logical Correctness:** Produces correct outputs.
- **Temporal Correctness:** Produces outputs at the right time.

Basic Definitions

- Release Time – The time instant at which a task is ready or eligible for execution.
- Scheduling Time – The instant if time at which a task gets its chance to execute.
- Completion Time – The time instant at which a task completes execution.
- Deadline - The time instant of time by which execution of the task should be completed.
- Run Time – The time taken without interruption to complete the task, after the task is released.
- Tardiness – The amount of time by which a task misses it deadline. It is equal to the difference between the completion time instant and the deadline.
- Laxity – The deadline minus the remaining computation time. The laxity of a task is the maximum amount of time it can wait, and still meet its deadline.

Schematic of a Time Constrained Computation



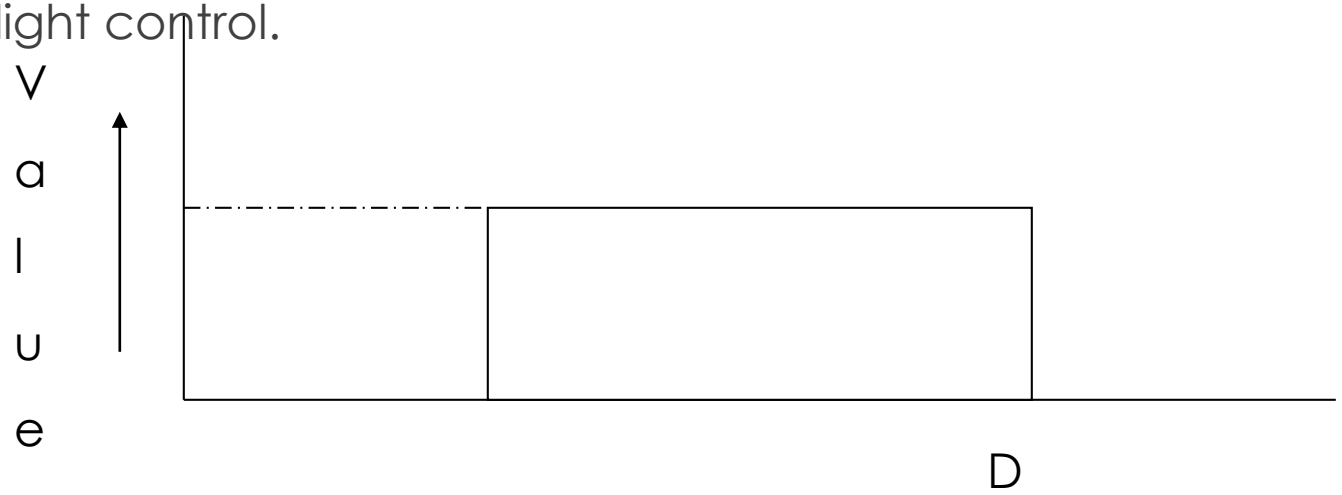
Types of Real time task

- HRT
- SRT
- FRT

Hard Real-Time Task

- A **hard deadline** *must* be met.
  - If *any* hard deadline is *ever* missed, then the system is **incorrect**.
  - Requires a means for **validating** that deadlines are met.
- **Hard real-time system:** A real-time system in which all deadlines are hard.

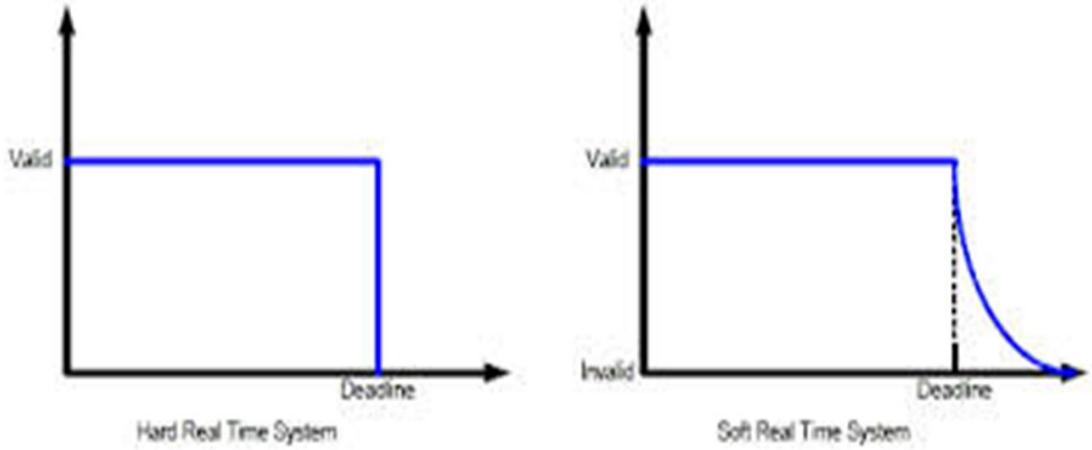
- **Examples:** Nuclear power plant control, flight control.
- If c<=D then Q=1
- If c>D then Q=0



Soft Real-Time Task

- A **soft deadline** may *occasionally* be missed.
  - **Question:** How to define "occasionally"?
- **Soft real-time system:** A real-time system in which some deadlines are soft.
- No catastrophic effects or loss of human lives
- **Examples:** Multimedia Applications, Online gaming

- If c<=D then Q=1
- If c>D then Q lowers and move till Q=0



Firm Real-Time Task

- Task T_i is a firm real time task, if its value reduces to zero if the stipulated deadline is not met.
- This is slightly different from a 'hard' real-time task, in the sense that here, missing the deadline is not catastrophic, it simply is that the output of delayed execution is dropped.

Real Time Tasks

- Process control in industrial plants
- Robotics
- Air Traffic control
- Telecommunications
- Weapon guidance system
- Medical diagnostic and life support system
- Automatic engine control system
- Anti-lock braking systems
- Real time data bases

Real Time Operating System

•The ability of the operating system to provide a required level of service in a bounded response time.

•It responds to inputs immediately (Real-Time).

•The task is completed within a specified time delay.

•In real life situations like controlling traffic signal or a nuclear reactor or an aircraft,

•The operating system has to respond quickly.

Characteristic of Real time in operating systems

- Consistency
- Reliability
- Predictability
- Performance
- Manageability
- Scalability

Functions of Real time in operating systems

- Task management
- Scheduling.
- Resource Allocation.
- Interrupt Handling.

Thank you!