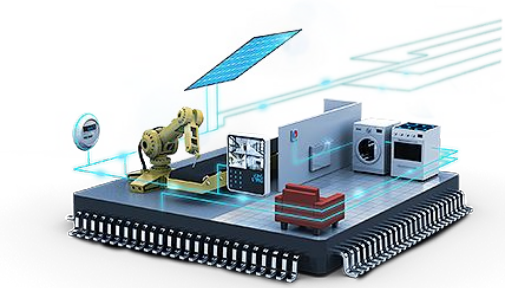
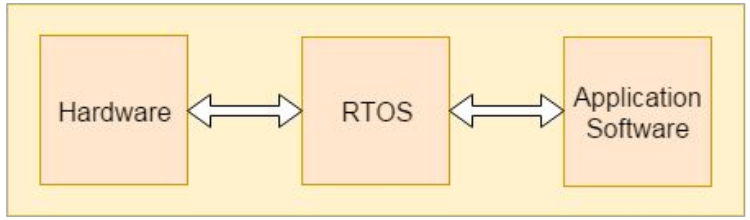
Introduction

Programming and Development of Embedded Systems

Embedded Systems

- System
  - An arrangement where all its assembled components work according to some specific defined rules
- Embedded System (A computer system embedded into a larger system)
  - A microcontroller or microprocessor based control system which is designed to perform a specific task
  - Usually has three components
    - Hardware
    - Application Software
    - Real Time Operating system (RTOS)
      - Not always required. E.g. a simple application

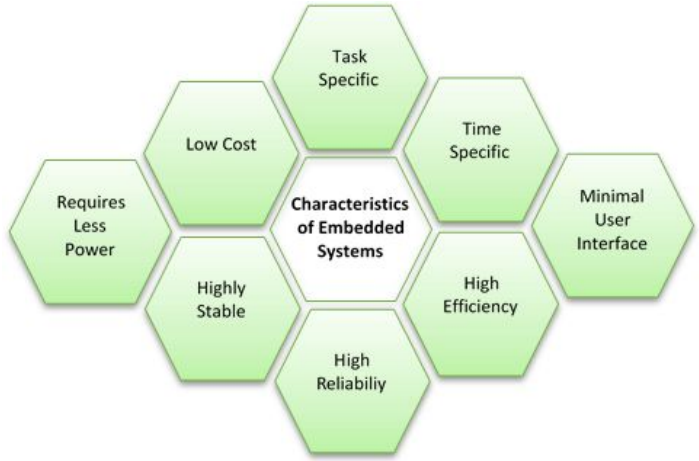




  - Examples: Smartphones, Routers, Toys, Rockets, Robotics, Parking Assistant System and etc.

Embedded Systems (Characteristics)

- Dedicated and designed for a specific task
  - Usually performs a specific operation repeatedly
  - Unlike general purpose computers which run general purpose softwares like browsers, games and etc.
- Real time computation ability
  - Continually reacts to changes in the system's environment and computes certain results in real time without any delay
  - For example a car cruise controller
    - It continually monitors and reacts to speed and brake sensors
    - It computes acceleration or deceleration repeatedly within a limited time
    - A delayed computation can result in failure to control of the car



Embedded Systems (Characteristics)

- Highly available, stable and reliable
  - The less failure probability of a system means more reliability
  - A Failure can possibly lead a self-driving car to an accident
- Flexible
  - A built-in debugging opportunity that allows for remote maintenance
  - For some systems flexibility is absolutely necessary; e.g. a spacecraft
- Portable
  - Using the same embedded software in various environments
  - By abstractions between the application logic itself and the low-level system interfaces
- Connected
  - Must be connected to peripheral devices (input and output devices)

Embedded Systems (Characteristics)

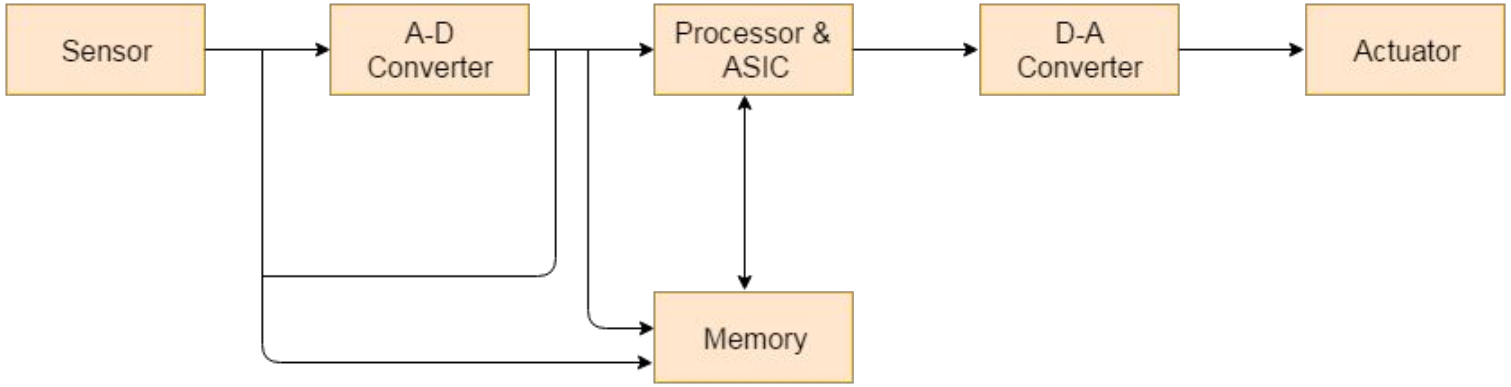
- Tightly constrained
  - Limited memory, low cost, low power, small size
  - More safety, single threaded, high performance and etc.
- Microprocessors based
  - It must be microprocessor or microcontroller based
- Memory
  - It must have a ROM, EPROM, EEPROM or Flash memory to embed the application
  - It does not need any secondary memories
- Fault-Tolerance
  - It should survive in the presence of faults
  - All environments are assumed to be noisy

Embedded Systems (Characteristics)

- Applications
  - Industrial Control, Automobiles, Home Devices, Medical, Networking and etc.
- Advantages
  - Easily Customizable
  - Low power consumption
  - Low cost
  - Enhanced performance
- Disadvantages
  - Developing a system required more time
  - Skilled engineers required
- Programming languages: C, C++, Embedded Java, Python and etc.

Embedded Systems (Basic Structure)

- Sensor: Used for sensing the change in environment conditions and generate electrical signals
- A-D Converter: Is a device to convert an analog input signal into its equivalent digital signal
- Memory: Used to store data. Embedded systems have volatile and non-volatile memories
- Processor & ASIC: It processes the data to measure the output and store it to the memory
- D-A Converter: It converts the digital data fed by the processor to analog data
- Actuator: A mechanical or electrical device which converts signals to equivalent physical actions



Programming and Development of Embedded Systems

- Microcontrollers
  - Teensy 3.5
    - Teensy 3.5 (Headers)
    - Teensy Technical Specifications
    - Manual & Datasheet
  - Adafruit Feather ESP32
    - Adafruit Feather HUZZAH32 – ESP32
    - Adafruit HUZZAH32 - ESP32 Feather Overview
    - Manual & Datasheet
    - ESP-32 Resources
- Tools: Visual Studio Code and Platformio for VSCode
- Framework: Arduino

Programming and Development of Embedded Systems

- Some useful links
  - Electronic Systems
  - Embedded Systems Tutorials
  - 5 Steps to Getting Started with Embedded Programing
  - Embedded Systems Tutorial: History, Types, Advantages, Examples
  - Embedded system
  - Introduction to the C Programming Language for Embedded Applications
  - Introduction to Embedded Systems
  - What is an Embedded System?
  - 5 Differences between Embedded Software Engineer and Software Developer
  - C Programming Exercises, Practice, Solution