Brief Introduction to Embedded Systems

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Embedded Systems

"… a computer system with a dedicated function within a larger mechanical or electrical system."

- Everywhere
- Small and cheap
  - Washing machines
  - Cars
  - Chemical plants
  - Routers
- High performance and (more) expensive
  - Digital cameras
  - Entertainment and self-driving system in cars
  - Smartphones

Architecture of embedded systems

- Often not based on traditional computer architecture (CPU, RAM, external mass storage)
  - Too big
  - Too expensive
  - Too sensitive
  - Too power consuming
- Based on
  - Microcontrollers: CPU, memory, interfaces integrated
  - Customized chips: ASICs, FPGA
  - Dedicated processors: digital signal processors (DSP)
  - System-on-Chip (SoC): Unclear term. Often used for combinations of CPU, GPU,… on one chip

Example: ATmega8

- Microcontroller by the company Atmel
- 8-bit architecture
- 4 MHz
- 512 Bytes SRAM, 8KB flash memory, 256 Bytes EEPROM (electrically erasable programmable ROM)
- Price: $1.70 (if you buy 5000 pieces)

TQFP Top View
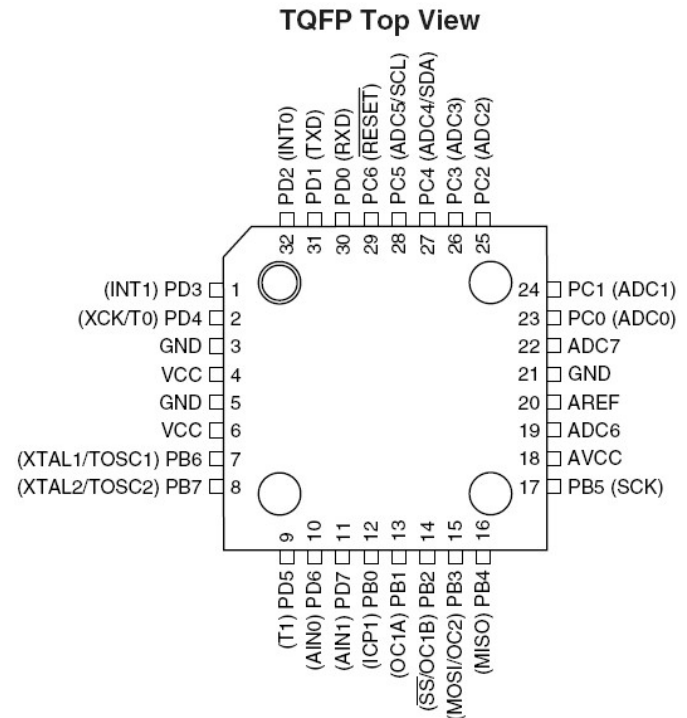
Example: BCM2711

- SoC by Broadcom, used in Raspberry Pi 4B
- Contains
  - 64-bit Quadcore CPU based on ARM A72, 1.5GHz
  - 32-bit GPU, 500MHz
  - Interfaces for audio, USB,
- Needs external RAM
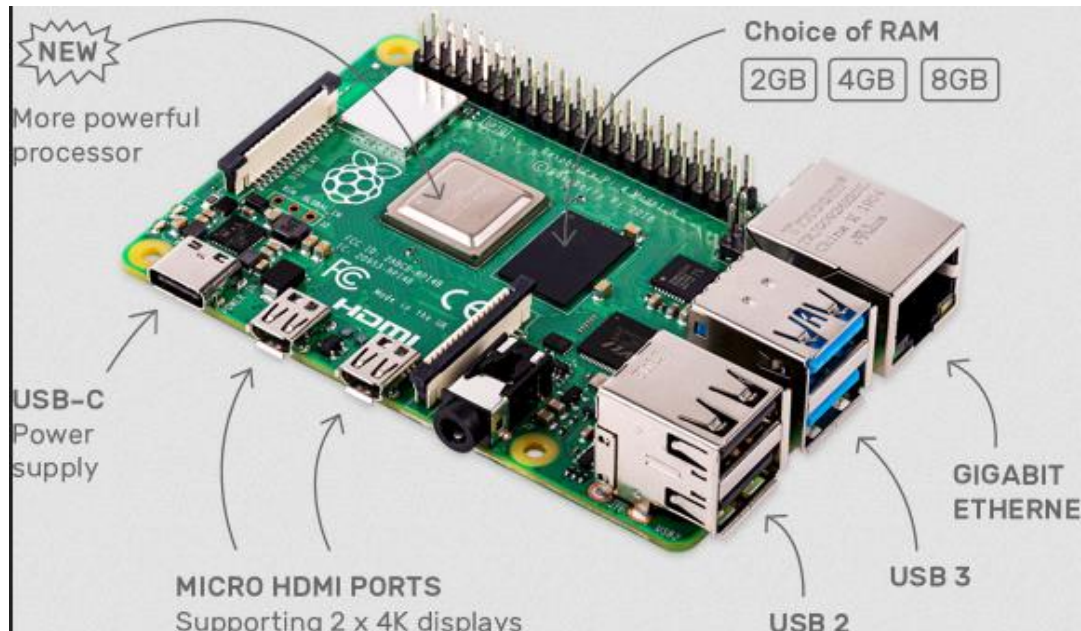
www.raspberrypi.org

Example: Cars

- ∼100 microprocessors in a car
  - Engine control
  - Airbag
  - Audio
  - Navigation
  - ABS
  - Collision warning
  - Rain detector (wipers)
  - ...

- 32/64-bit microcontrollers for complex tasks
- 8/16-bit microcontrollers for simple tasks. Estimated to be 40-50% of 8/16-bit microcontroller market
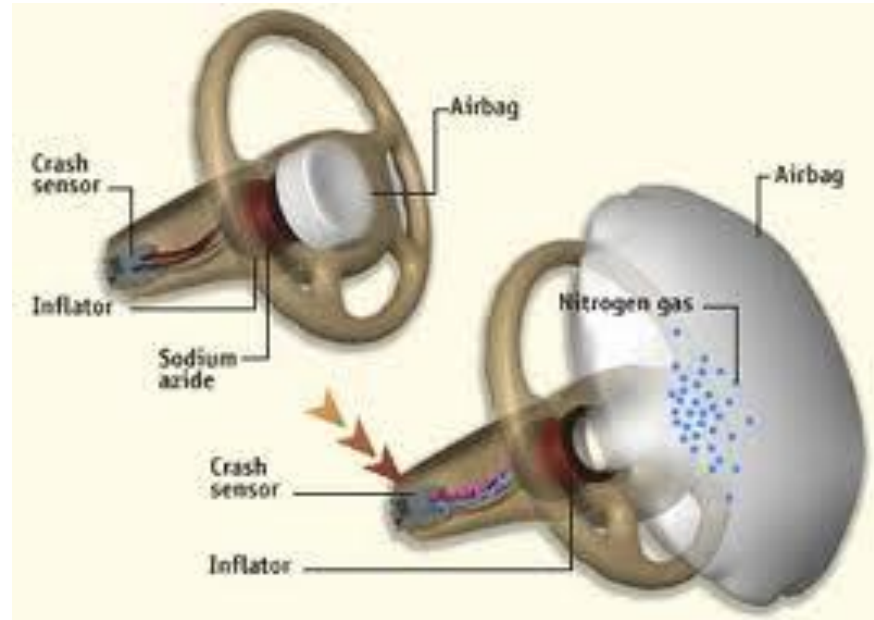
Typical characteristics of embedded systems

- Cheap and constrained resources (small RAM, slow CPU,…)
- Reduced power consumption
- More or less directly connected to the physical world
- Robust: wide temperature operation range, insensitive against unstable power supply
- Real-time capable

- Those characteristics can be only achieved with tightly coupled Hardware – OS – Application
  - OS with reduced functionality
  - Power- and context-aware applications
  - Special network technologies (low-power, real-time,…). General-purpose network technologies (Ethernet, WiFi,…) often not suitable.