Introduction

EE5182 Microcontrollers and Embedded Systems

What is a 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 Examples: Watch

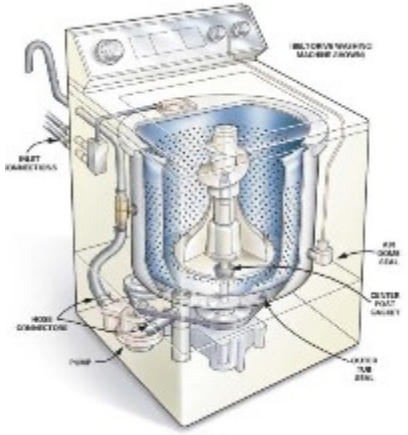
- It is a time display SYSTEM
- Parts: Hardware, Needles, Battery, Dial, Chassis and Strap

- Rules:
  - All needles move clockwise only
  - A thin needle rotates every second
  - A long needle rotates every minute
  - A short needle rotates every hour
  - All needles return to the original position after 12 hours

System Examples: Washing Machine

- It is an automatic clothes washing SYSTEM
- Parts: Status display panel, Switches & Dials, Motor, Power supply & control unit, Inner water level sensor and solenoid valve.

- Rules:
  - Wash by spinning
  - Rinse
  - Drying
  - Wash over by blinking
  - Each step display the process stage
  - In case interruption, execute only the remaining

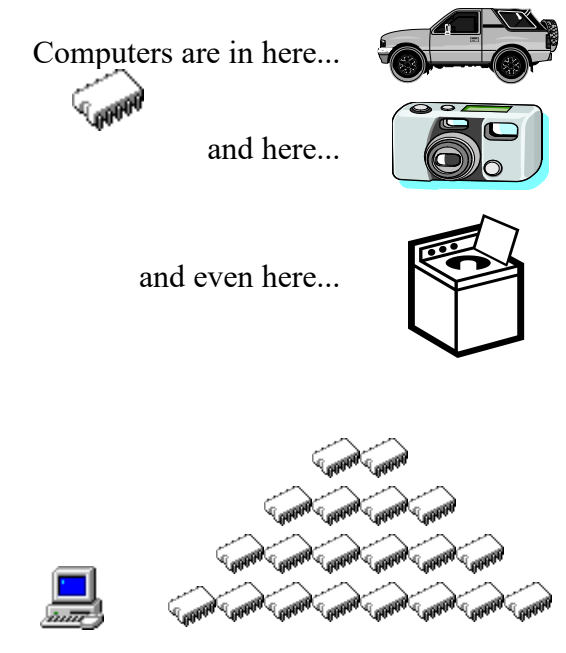


Embedded Systems Overview

- Computing systems are everywhere
- Most of us think of computers as
  - PC's
  - Laptops
  - Mainframes
  - Servers
- But there's another type of computing system that's more common

Embedded Systems Overview

- Embedded computing systems
  - Computing systems embedded within electronic devices
  - Hard to define. Nearly any computing system other than a desktop computer
  - Billions of units produced yearly, versus millions of desktop units
  - Perhaps 50 per household and per automobile



Embedded Systems Definition

- An Embedded System is one that has computer hardware with software embedded in it as one of its important components.

- Its software embeds in ROM (Read Only Memory). It does not need secondary memories as in a personal computer.

Where in our daily life do we use embedded systems?

Embedded Systems Applications

- Consumer Products
  - TV, stereo, remote control, mobile phone, refrigerator, microwave, washing machine
- Automobiles
  - engine management, trip computer, cruise control, immobilizer, car alarm,
  - airbag, ABS, ESP
- Building Systems
  - elevator, heater, air conditioning, lighting, key card entries, locks, alarm systems
- Agriculture
  - feeding systems, milking systems
- Space
  - satellite 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

Example: Automobiles

Autonomous cars:

- Electronic gas
- Electronic brake
- Electronic steering

See: *The Daimler Story*

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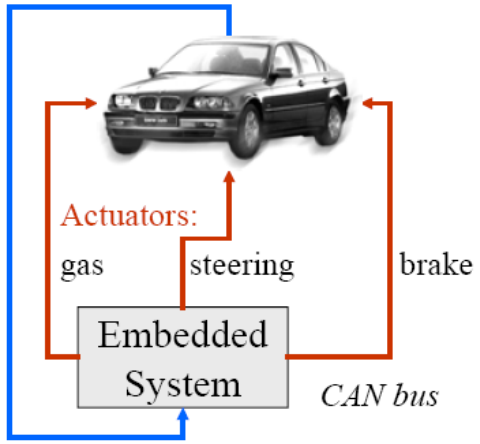

Sensors: Stereo-cameras, speedometer, accelerometers, signalling

2002: Opel Vectra has over 40 sensors (25 types)

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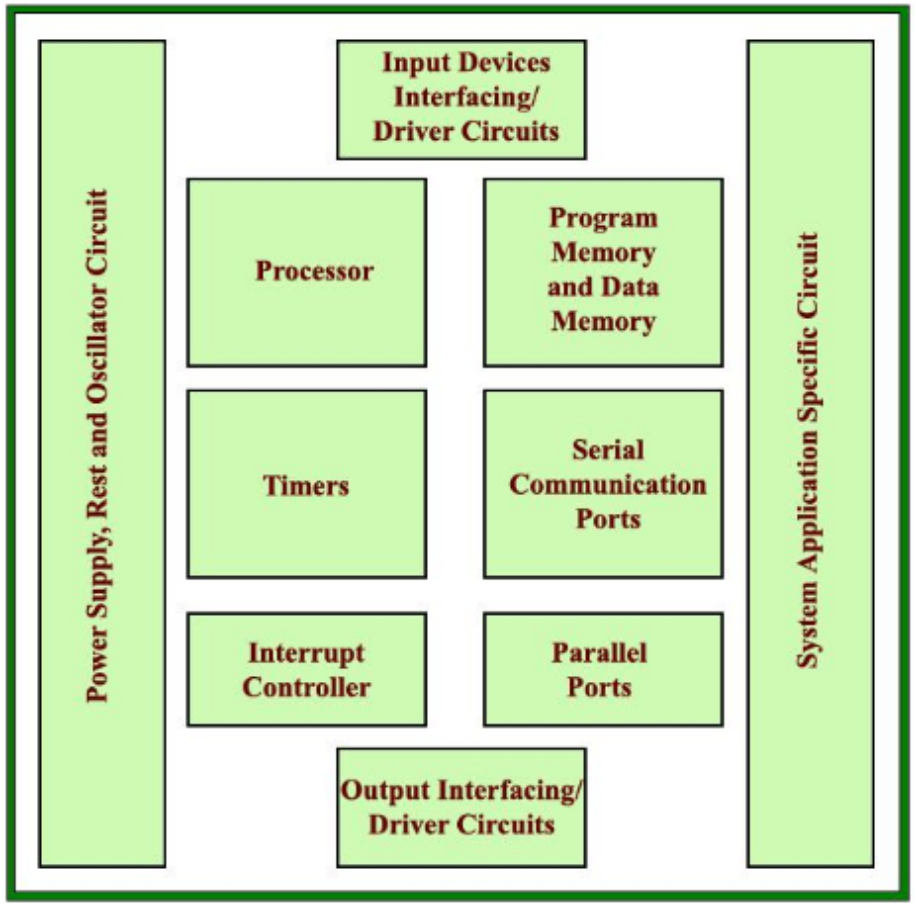
Components of Embedded Systems

- It has Hardware
  - Processor, Timers, Interrupt controller, I/O Devices, Memories, Ports, etc.
- It has main Application Software
  - Which may perform concurrently the series of tasks or multiple tasks.
- It has Real Time Operating System (RTOS)
  - RTOS defines the way the system work. Which supervise the application software. It sets the rules during the execution of the application program. A small scale embedded system may not need an RTOS.

Embedded System Hardware



Embedded System Constraints

- An embedded system is software designed to keep in view three constraints:
  - Available system memory
  - Available processor speed
  - The need to limit the power dissipation
- When running the system continuously in cycles of wait for events, run, stop and wakeup.

What makes embedded systems different?

- Real-time operation
- Size
- Cost
- Time
- Reliability
- Safety
- Energy
- Security

Embedded System Classifications

1. Small Scale Embedded System
2. Medium Scale Embedded System
3. Sophisticated Embedded System

Small Scale Embedded System

- Single 8 bit or 16bit Microcontroller.
- Little hardware and software complexity.
- They May even be battery operated.
- Usually “C” is used for developing these system.
- The need to limit power dissipation when system is running continuously.
- Programming tools: Editor, Assembler and Cross Assembler

Medium Scale Embedded System

- Single or few 16 or 32 bit microcontrollers or Digital Signal Processors (DSP) or Reduced Instructions Set Computers (RISC).
- Both hardware and software complexity.
- Programming tools: RTOS, Source code Engineering Tool, Simulator, Debugger and Integrated Development Environment (IDE).

Sophisticated Embedded System

- Enormous hardware and software complexity, which may need scalable processor or configurable processor and programming logic arrays.
- Constrained by the processing speed available in their hardware units.
- Programming Tools: For these systems may not be readily available at a reasonable cost or may not be available at all. A compiler or retargetable compiler might have to be developed for this.

Processor

- A Processor is the heart of the Embedded System.
- For an embedded system designer knowledge of microprocessor and microcontroller is a must.

Microprocessor

- A microprocessor is a single chip semi conductor device also which is a computer on chip, but not a complete computer.
- Its CPU contains an ALU, a program counter, a stack pointer, some working register, a clock timing circuit and interrupt circuit on a single chip.
- To make complete micro computer, one must add memory usually ROM and RAM, memory decoder, an oscillator and a number of serial and parallel ports.

Microcontroller

- A microcontroller is a functional computer system-on-a-chip. It contains a processor, memory, and programmable input/output peripherals.
- Microcontrollers include an integrated CPU, memory (a small amount of RAM, program memory, or both) and peripherals capable of input and output.

Various Microcontrollers

- INTEL
  - 8031,8032,8051,8052,8751,8752
- PIC
  - 8-bit PIC16, PIC18,
  - 16-bit DSPIC33 / PIC24,
  - PIC16C7x
- Motorola
  - MC68HC11

Microprocessor vs. Microcontroller

MICROPROCESSOR	MICROCONTROLLER
The functional blocks are ALU, registers, timing & control units	It includes functional blocks of microprocessors & in addition has timer, parallel i/o, RAM, EPROM, ADC & DAC
Bit handling instruction is less, One or two type only	Many type of bit handling instruction
Rapid movements of code and data between external memory & MP	Rapid movements of code and data within MC
It is used for designing general purpose digital computer systems	They are used for designing application specific dedicated systems

Embedded Processor

- Special microprocessors & microcontrollers often called, Embedded processors.
- An embedded processor is used when fast processing fast context-switching & atomic ALU operations are needed.
- Examples : ARM 7, INTEL i960, AMD 29050.

Other Hardware

- Power Source
- Clock Oscillator
- Real Time Clock (RTC)
- Reset Circuit, Power-up Reset and watchdog timer Reset
- Memory
- I/O Ports, I/O Buses
- Interrupt Handler
- DAC and ADC
- LCD and LED Display
- Keypad/Keyboard