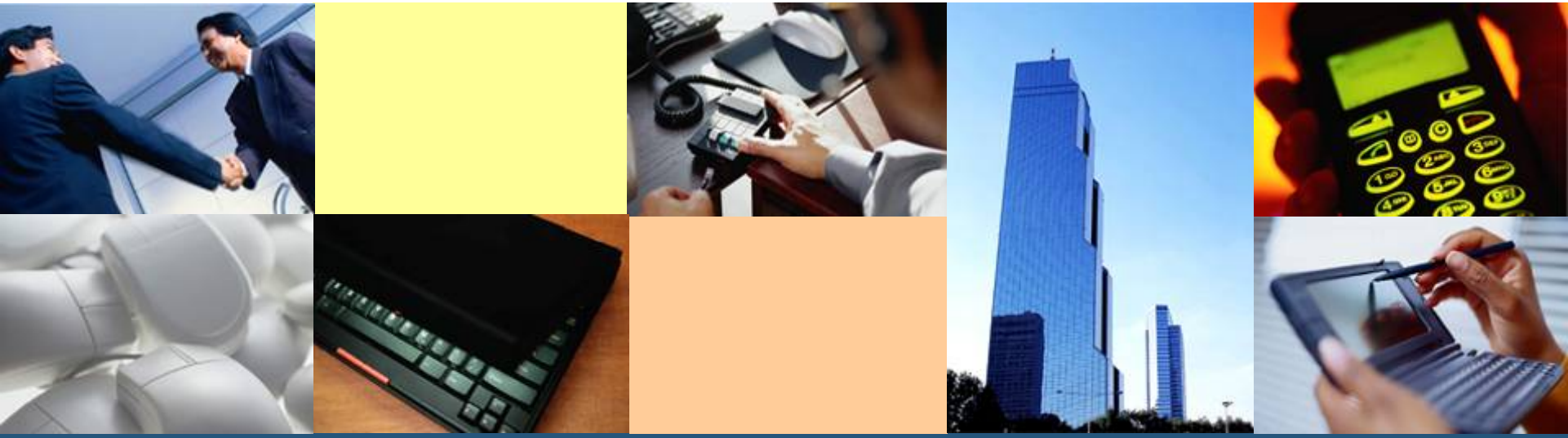
ANDES TECHNOLOGY

國立交通大學 National Chiao Tung University

Embedded System Introduction



Agenda

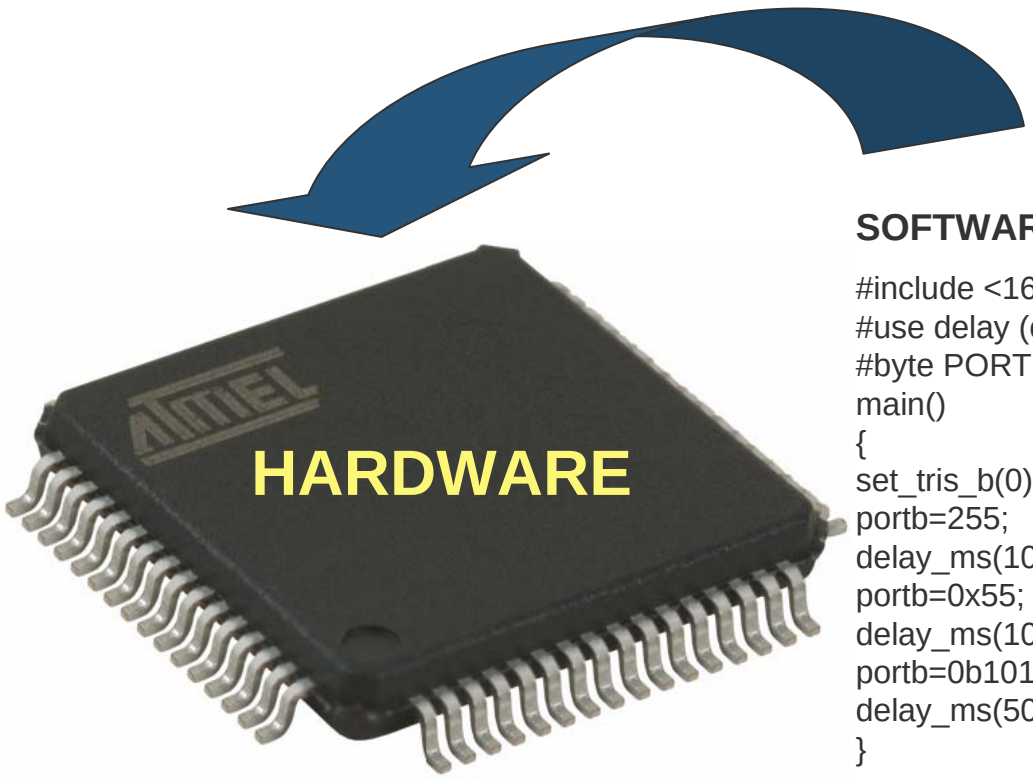
- Embedded System
- Classification of Embedded System
- Processor
- Applications

Embedded System (1/2)

❖ Definition

- An Embedded System is one that has computer hardware with software embedded in it as one of its important components.
- An **embedded system** is a special-purpose **computer** system designed to perform one or a few dedicated functions
- With **real-time computing** constraints
- Include hardware, software and mechanical parts

Embedded System (2/2)



SOFTWARE PROGRAM

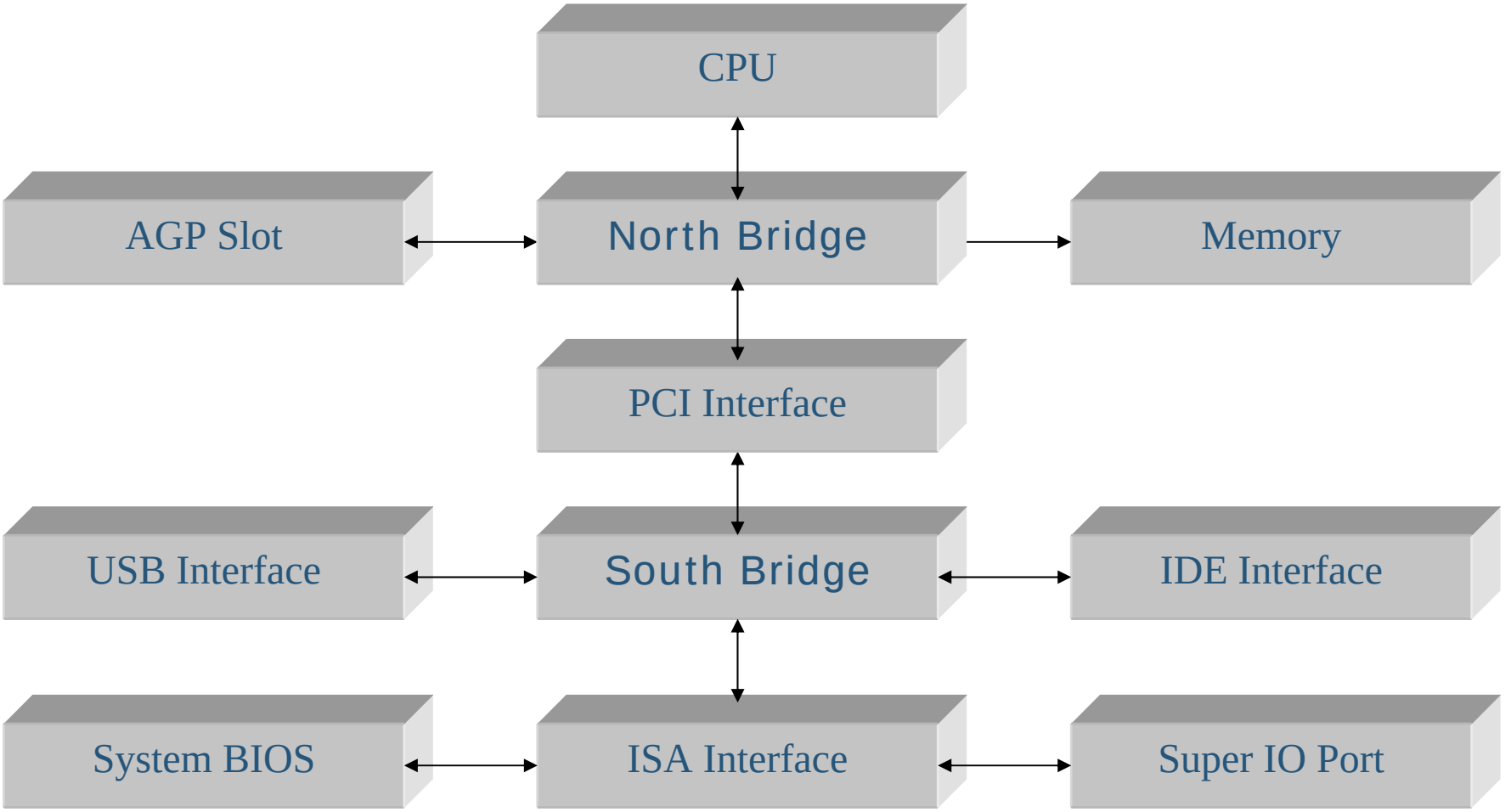
```
#include <16f876a.h>
#use delay (clock=20000000)
#byte PORTB=6
main()
{
set_tris_b(0);
portb=255;        //decimal
delay_ms(1000);
portb=0x55;       //hexadecimal
delay_ms(1000);
portb=0b10101010;  //binary
delay_ms(500);
}
```

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

Computer Hardware

- A Microprocessor
- A Large Memory
  - Primary and Secondary
  - RAM, ROM and caches
- Input Units
  - Keyboard, Mouse, Scanner, etc.
- Output Units
  - Monitor, printer, etc.
- Networking Units
  - Ethernet Card, Drivers, etc.
- I/O Units
  - Modem, Fax cum Modem, etc.

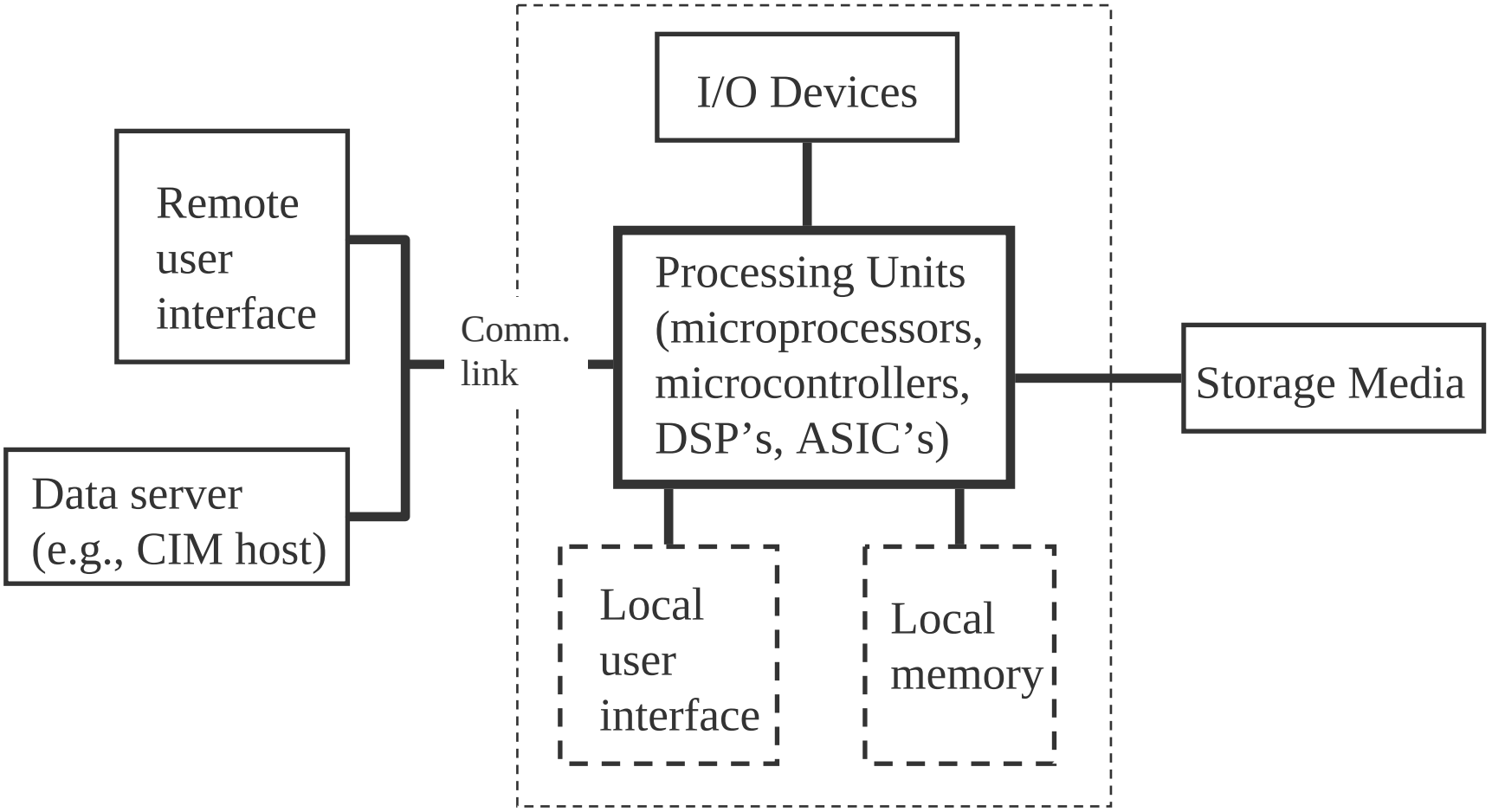
Computer System Hardware Architecture



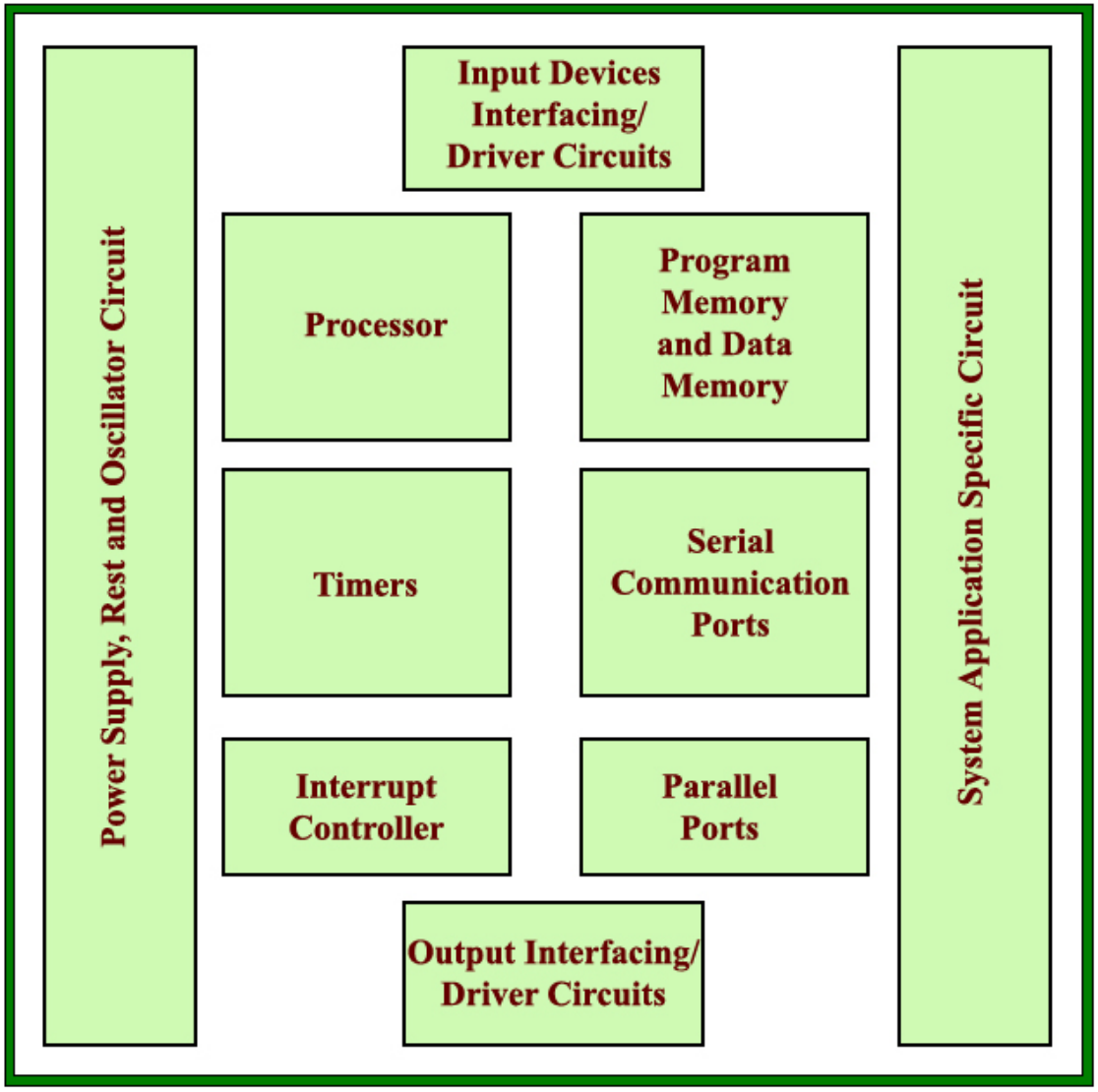
Components of Embedded System (1/2)

- 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.**

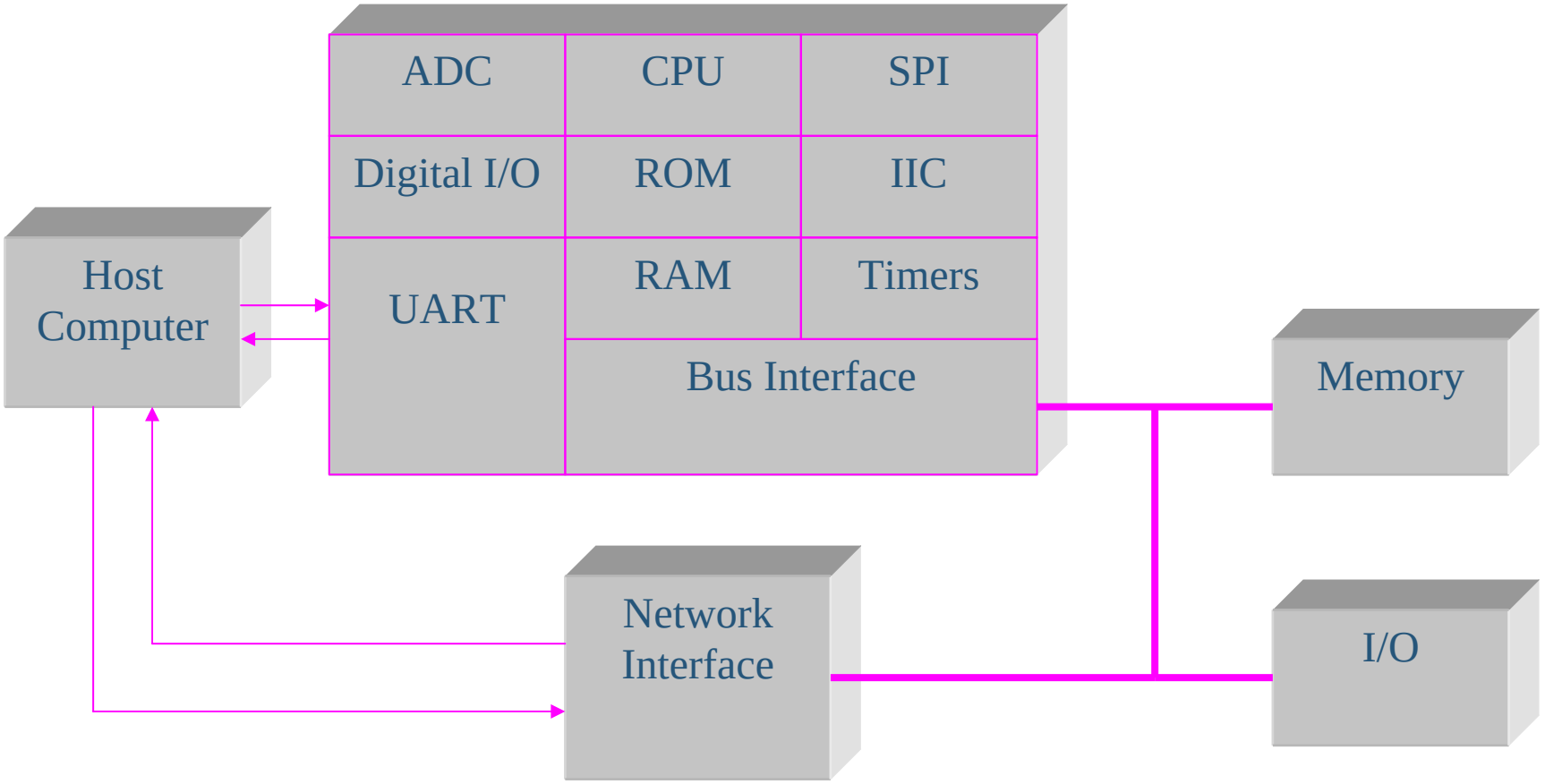
Components of Embedded system (2/2)



Embedded System Hardware (1/2)



Embedded System Hardware (2/2)

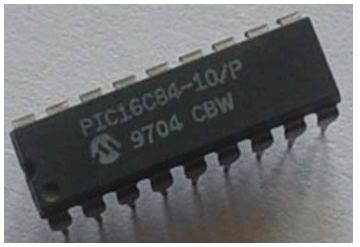


Embedded System Constraints

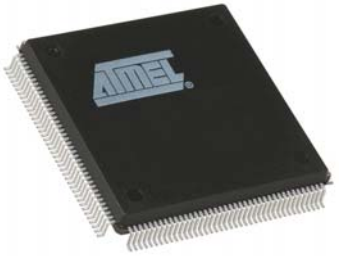
- An embedded system is software designed to keep in view three constraints
  - Available system memory
  - Available processor speed
  - The need to limit the power dissipation
- When running the system continuously in cycles of wait for events, run, stop and wakeup.

Classification of Embedded System

- Small Scale Embedded System

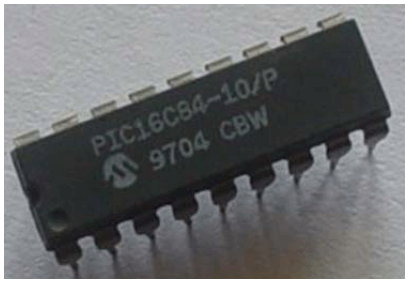


- Medium Scale Embedded System



- Sophisticated Embedded System

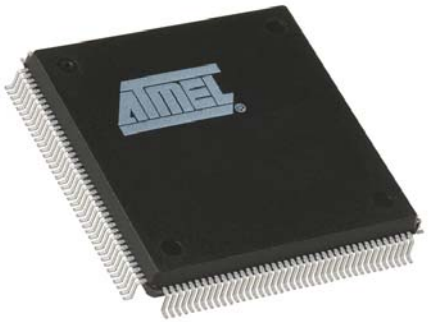
Small Scale Embedded System



- 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

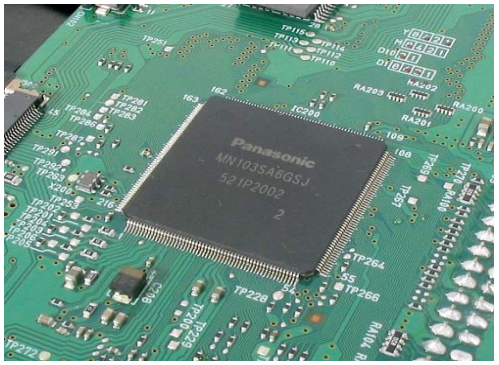
Medium Scale Embedded System

- 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 br developed for this.

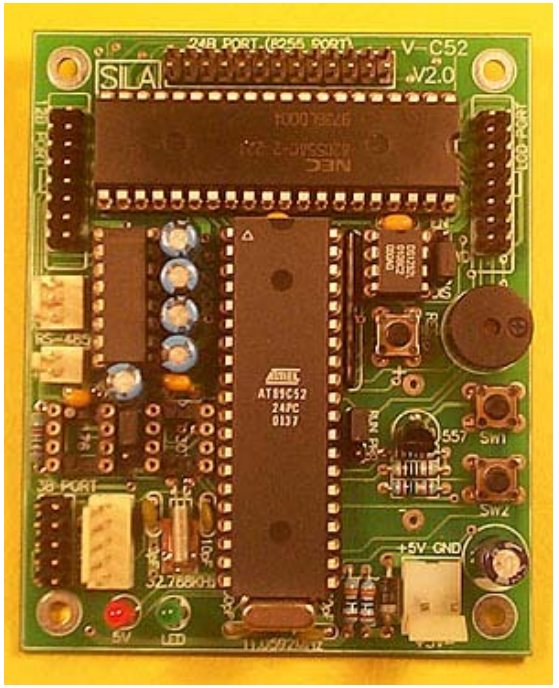


Processor

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

Two Essential Units:
- Control Unit (CU),
- Execution Unit (EU)

Operations:
- Fetch
- Execution



Various Processor

- General Purpose processor (GPP)
  - Microprocessor
  - Microcontroller
  - Embedded Processor
  - Digital signal Processor
- Application Specific System Processor (ASSP)
- Multi Processor System using GPPs

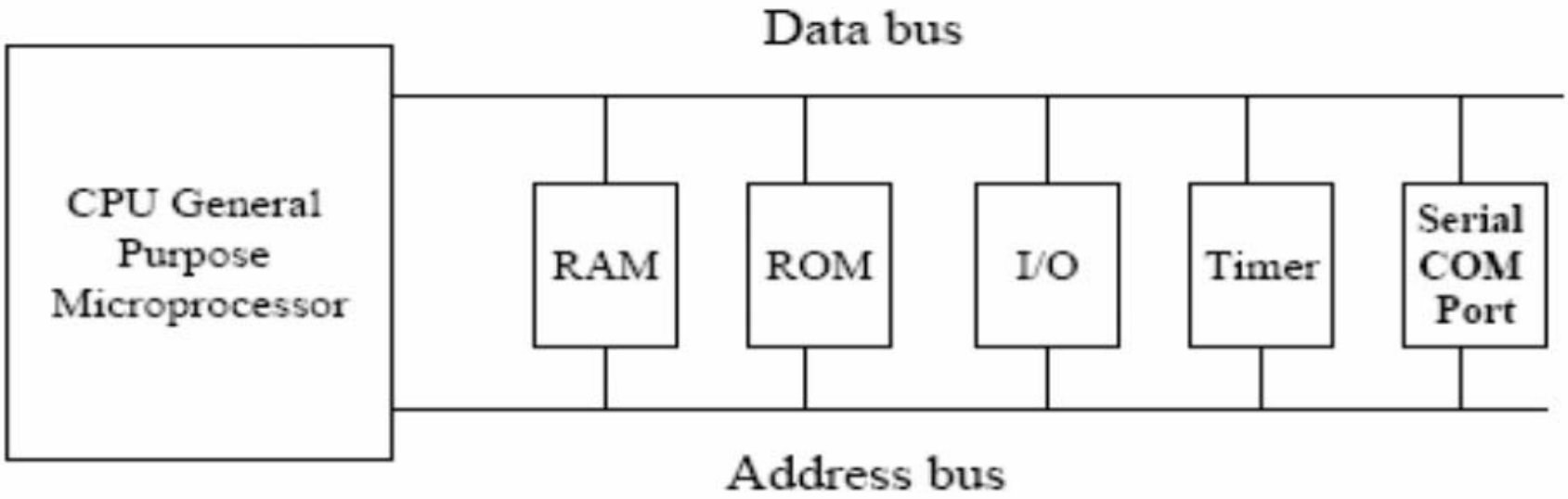
Microprocessor (1/2)

- Microprocessor is often abbreviated MPU for Microprocessor Unit or just MP
- 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.
- Various Microprocessor
  - Intel: 8086, 8088, 80186, 80188 80286, 80386
  - Motorola: 6800, 6809, 68000, G3, G4, G5

Microprocessor (2/2)

General Purpose Microprocessors

Microprocessors lead to versatile products



These general microprocessors contain no RAM, ROM, or I/O ports on the chip itself

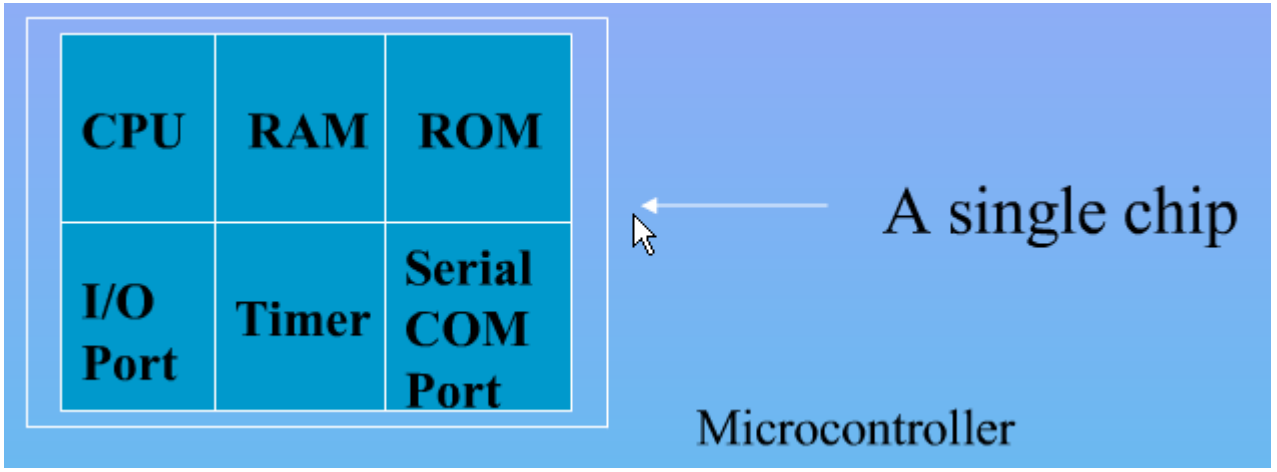
Ex. Intel's x86 family (8088, 8086, 80386, 80386, 80486, Pentium)

Microcontroller (1/2)

- AKA: MCU, uC, μC
- 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 Microcontroller
  - INTEL: 8032,8051,8052
  - PIC
    - 8-bit PIC16, PIC18
    - 16-bit DSPIC33 / PIC24

Microcontroller (2/2)

- A smaller computer
- On-chip RAM, ROM, I/O ports...
- Example ： Motorola’s 6811, Intel’s 8051



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 computers system	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 : AndeScore N9/10/12, ARM 7/9/11, INTEL i960, AMD 29050.

DSP

- DSP as a GPP is a single chip VLSI unit.
- It includes the computational capabilities of microprocessor and multiply & accumulate units (MAC).
- DSP has large number of applications such as image processing, audio, video & telecommunication processing systems.
- It is used when signal processing functions are to be processed fast.
- Examples : PAC, TMS320Cxx, SHARC, Motorola 5600xx

Application Specific System Processor (ASSP)

- ASSP is dedicated to specific tasks and provides a faster solution.
- An ASSP is used as an additional processing unit for running the application in place of using embedded software.
- Examples : IIM7100, W3100A

Multi-Processor System Using GPPs

- Multiple processors are used when a single processor does not meet the needs of different task.
- The operations of all the processors are synchronized to obtain an optimum performance.

How to design a good Embedded Processor?

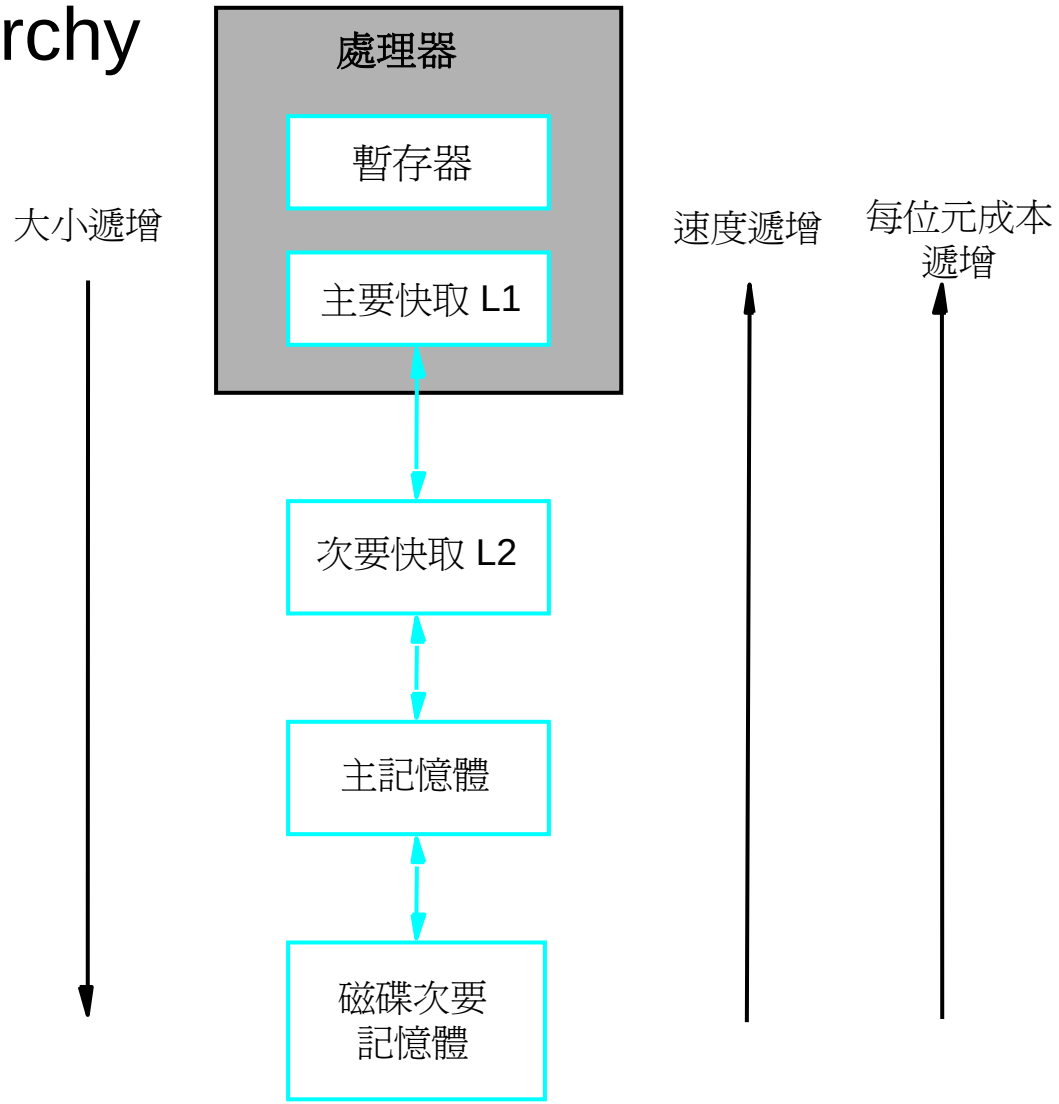
- Understand the functional requirements of the applications.
- Design techniques
  - Software
    - C/C++
    - Assembly
  - Hardware
    - Verilog/VHDL
    - PCB
- Select those features you want.
- Evaluate the design rely on modern integration development tool.

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

Memory

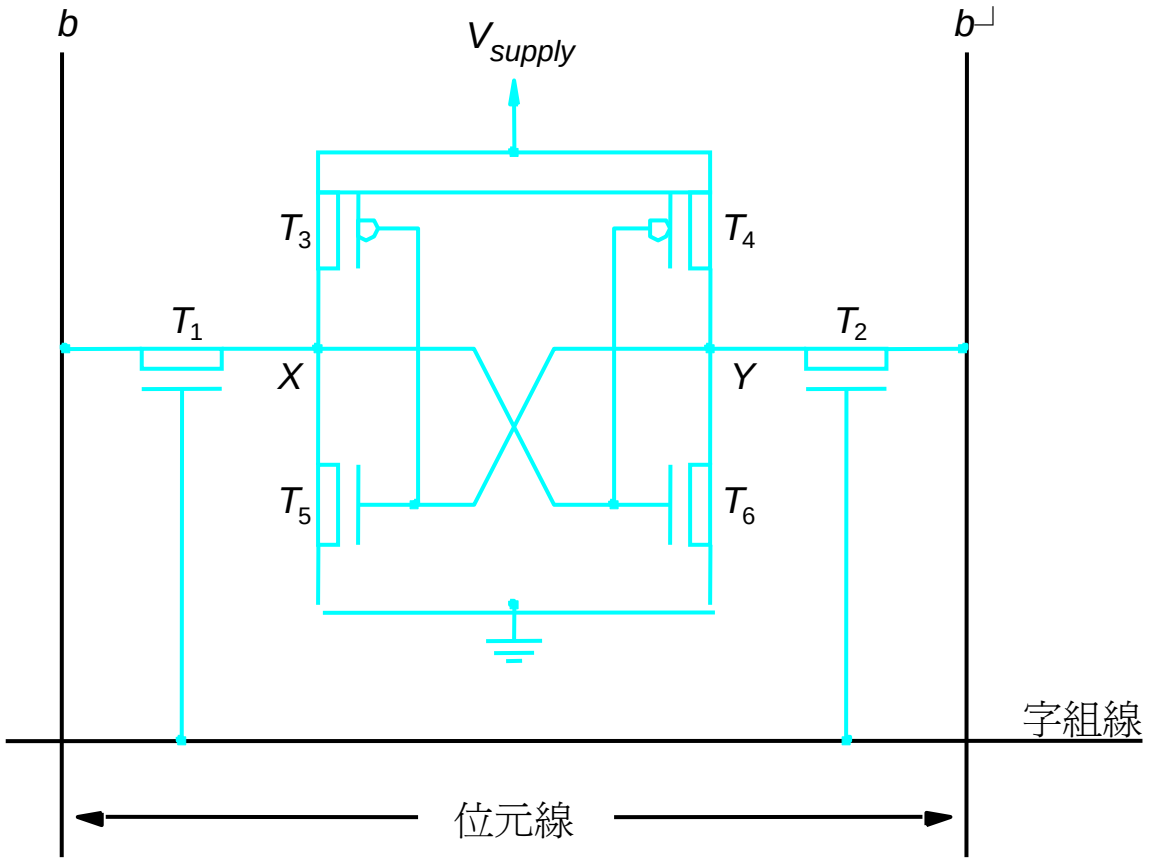
Memory hierarchy



SRAM (For construct Cache memory)

- Static Random Access Memory
- Read/write very fast
- Needs 6 transistors thus high cost and needs more area
- Low power consumption
- Implementation technology
  - CMOS
- Construct cache memory
- Access time - 10 nanoseconds

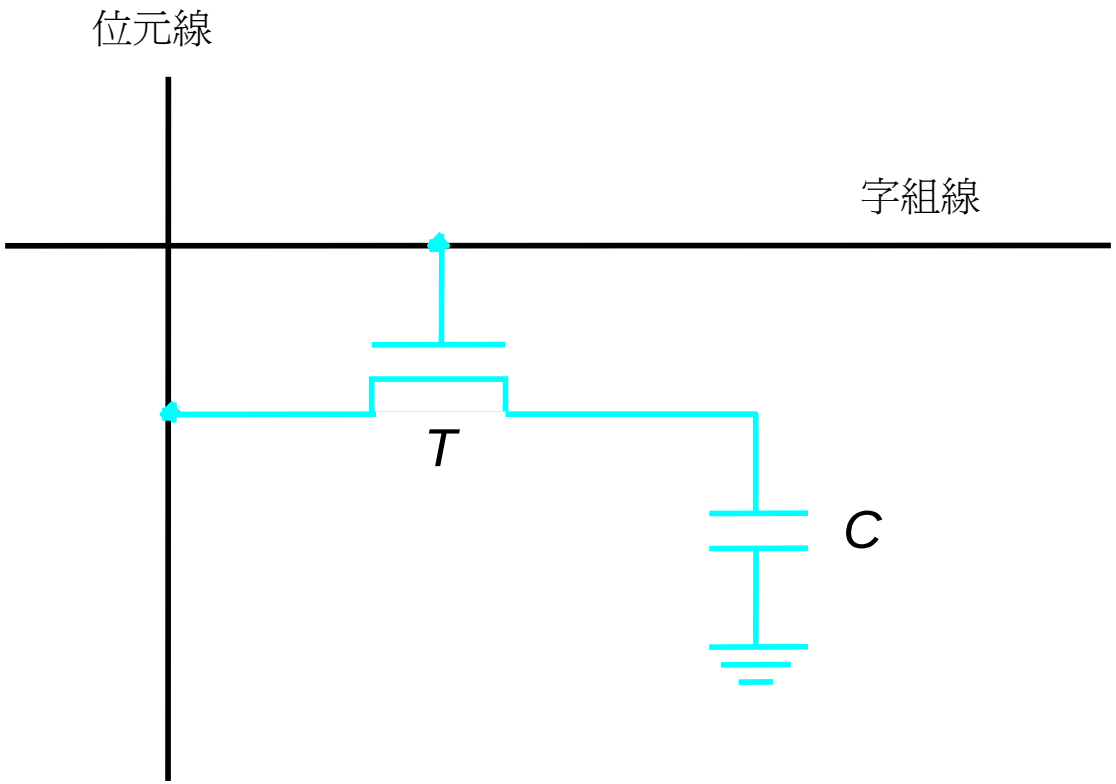
SRAM



DRAM (For construct Main memory)

- Dynamic Random Access Memory
- Needs 1 transistor and 1 capacitor
- Lower cost and compact
- Each bit must be refreshed periodically
- Implementation technology
  - CMOS
- Access time - 50 to 150 nanoseconds

DRAM



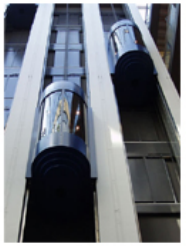
Embedded Processor Applications

- Household appliances:
  - Microwave ovens, Television, DVD Players & Recorders
- Audio players
- Integrated systems in aircrafts and missiles
- Cellular telephones
- Electric and Electronic Motor controllers
- Engine controllers in automobiles
- Calculators
- Medical equipments
- Videogames
- Digital musical instruments, etc.

TELEVISION

REMOT CONTROL

REFRIGERATORS



ELEVATORS

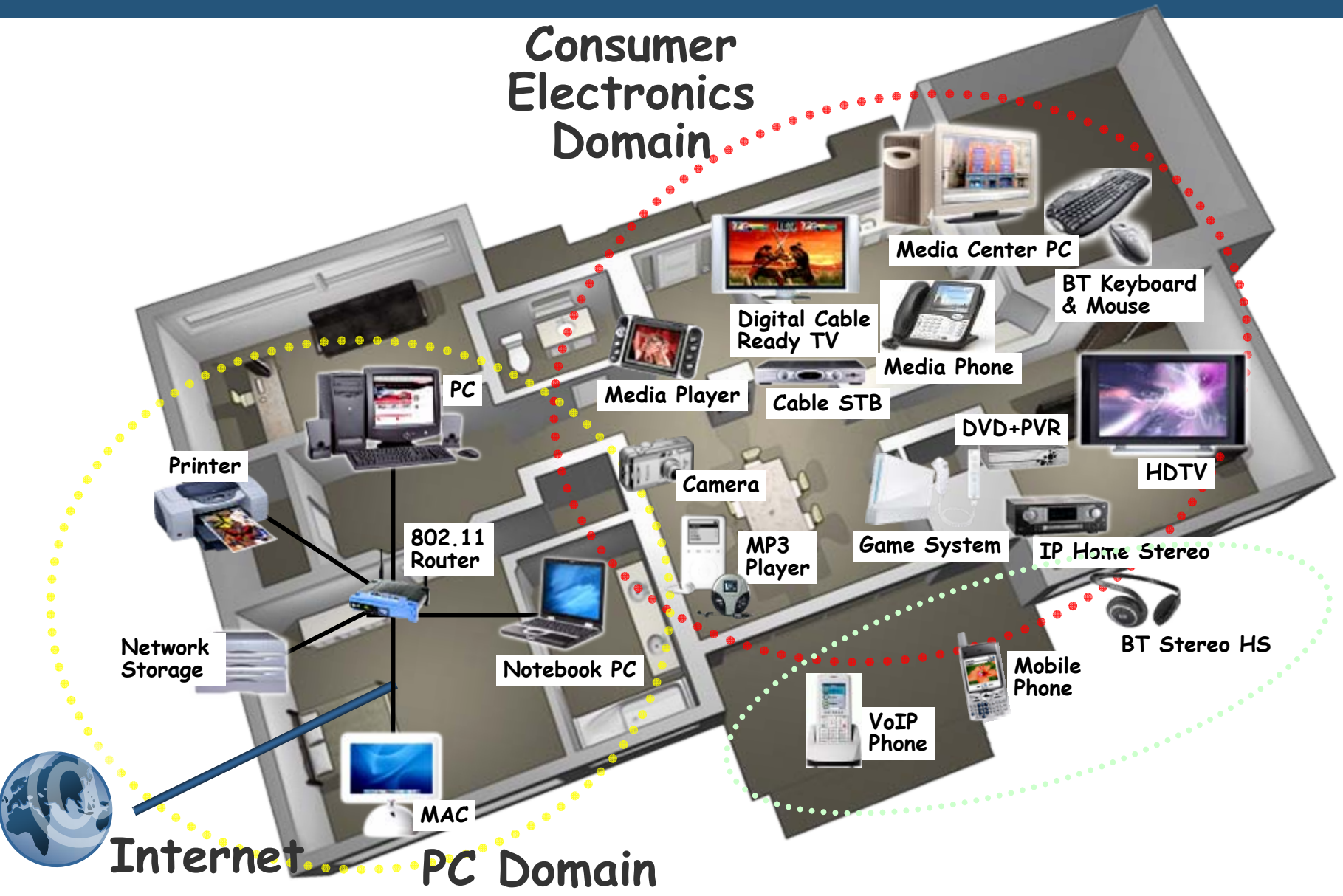
VIDEO GAMES

SET-TOP BOX

PLANES

CARS

Embedded Systems Connect Your Life

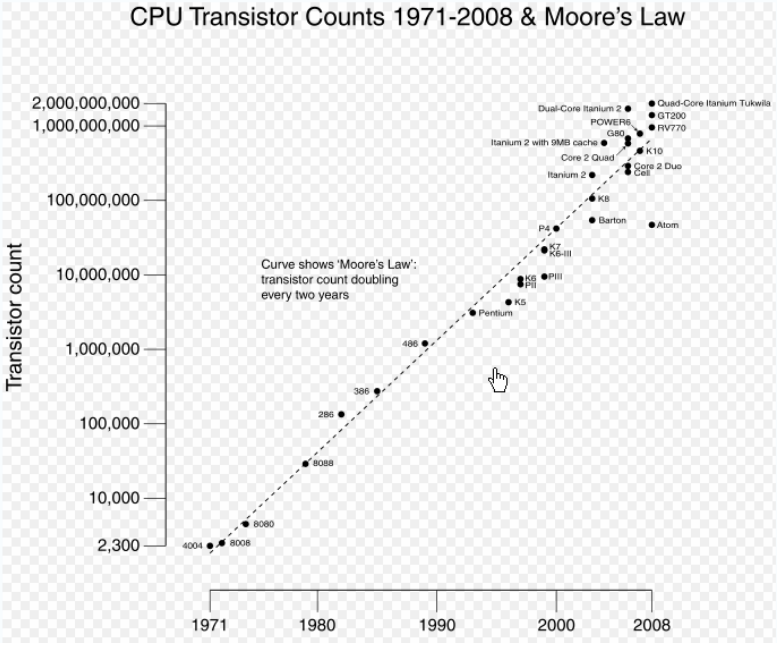


Characteristics of Embedded Systems

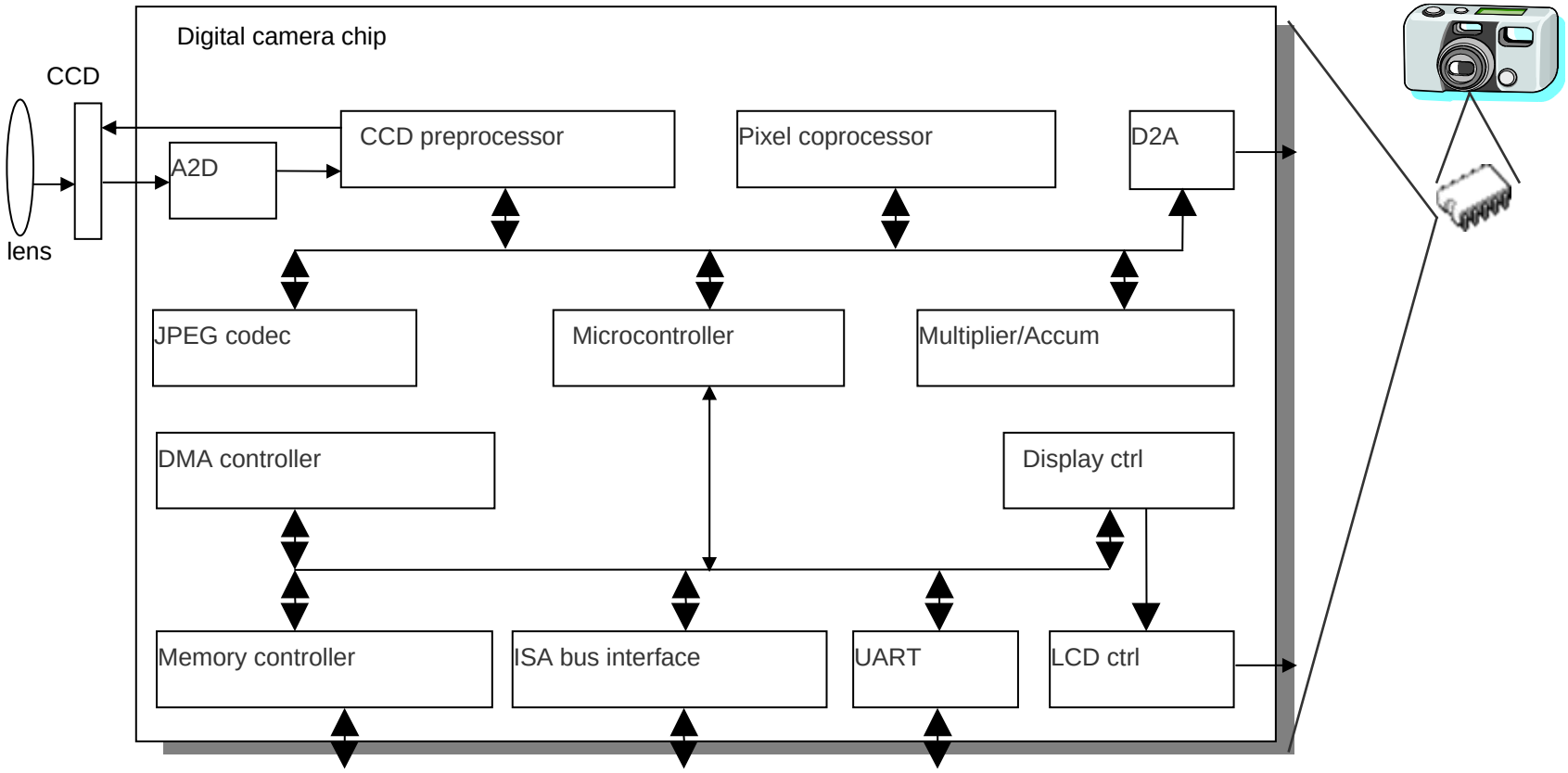
- Sophisticated functionality
- Real-time operation
- Low cost
- Low power
- Designed to tight deadlines by small teams

Three key embedded system technologies

- Three key technologies for embedded systems
  - Processor technology (computer architecture)
  - Design technology (coding style)
  - IC technology (Moore’law)



An embedded system example -- a digital camera



- Single-functioned -- always a digital camera
- Tightly-constrained -- Low cost, low power, small, fast
- Reactive and real-time -- only to a small extent

Website references

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Thank You