Embedded systems

LECTURER: TRẦN NGUYÊN NGỌC

EMAIL: NGOCTN@SOICT.HUST.EDU.VN; NGOC.TRANNGUYEN@HUST.EDU.VN

OFFICE: 405-B1 HUST

Content

1. Concepts of embedded systems
2. Characteristics of embedded systems
3. Structure of an embedded system
4. Design an embedded system

1.1. Concept

The combination of

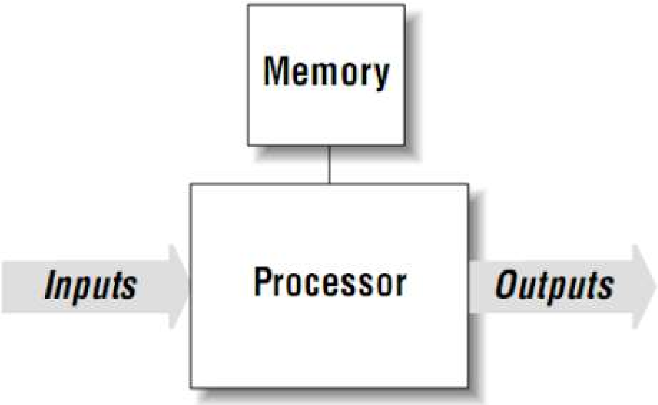
- Hardware
- Software
- Mechanical structure
- Other components

To execute (a) specialized function(s) (*Michael Barr, Programming Programming Embedded System in C and C++)*

An application contains at least a programmable computer (microcontroller, microprocessor,…)that normal users cannot aware a computer-based system. (*Michael J. Pont, Embedded C)*

1.1. Diagram of an embedded system

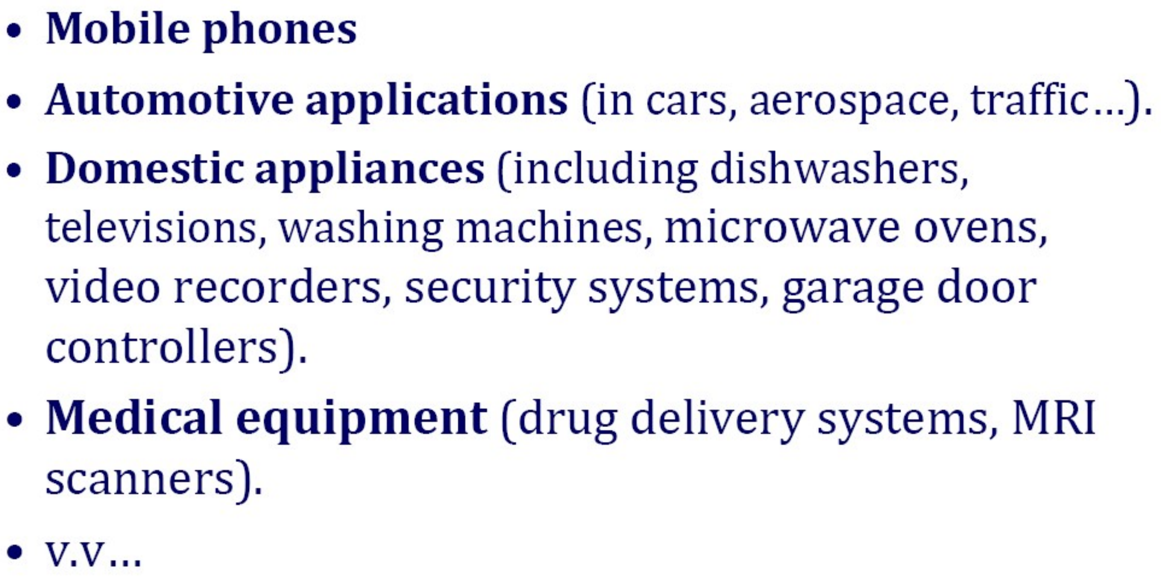
General diagram of an embedded system :



- An embedded system contains a micro-processor and software
- Software are contained in main memory (RAM, ROM) can be stored inside or outside its chip or processor
- All embedded system have some IO methods

1.3. Applications of embedded systems

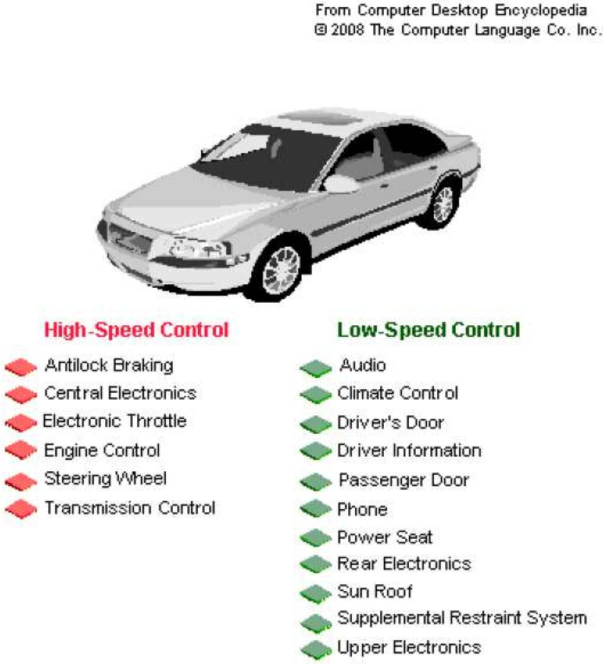
- Many real applications for embedded systems

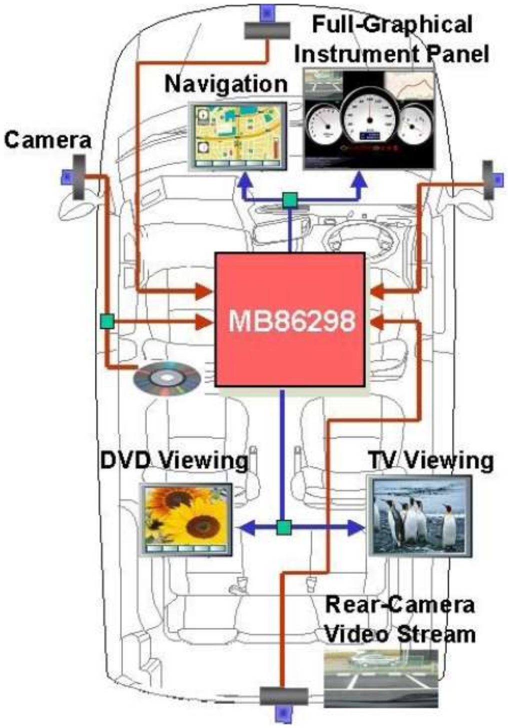


- **Mobile phones**
- **Automotive applications** (in cars, aerospace, traffic...).
- **Domestic appliances** (including dishwashers, televisions, washing machines, microwave ovens, video recorders, security systems, garage door controllers).
- **Medical equipment** (drug delivery systems, MRI scanners).
- v.v...

1.4. Examples

- In Cars:





1.4. Examples (continue)

Automatic seller machines
- Chipset: 16-bit Hitachi H8/300H processor
- Mechanical components: motor,

Toothbrush
- 8-bit processor

Digital cameras
- DIGIC II Image Processor

1.4. Examples (continue)

PC Mouse with 8-bit micro-controller:

- Capture movements and keys
- Encode, and connect to PC/Laptop

Computer hard-drive

- 32-bit micro-controller (ARM)
- Integrate digital signal processing

1.4. Examples (continue)

Sony Aibo ERS-7 Robotic Dog:

- 64-bit bicro-controller MIPS R7000
- OS Aperios Sony’s Real Time OS

Point of Sales System

- Processor Intel x86
- OS: Windows XP Embedded

1.5. Examples in Vetnam

- **BKAV SMARTHOME**
  - Zigbee
  - 3D controlling system
  - Save energy
  - Automatic scenario scripts
- **VINFAST/ VINSMARTHOME**
  - Vinsmarthome: similar functions as BKAV
  - Vinfast: Vivi assistant
- **Robot Tosy**
  - High performance chips
  - AI
  - Precision mechanics

2. Characteristic of an embedded system

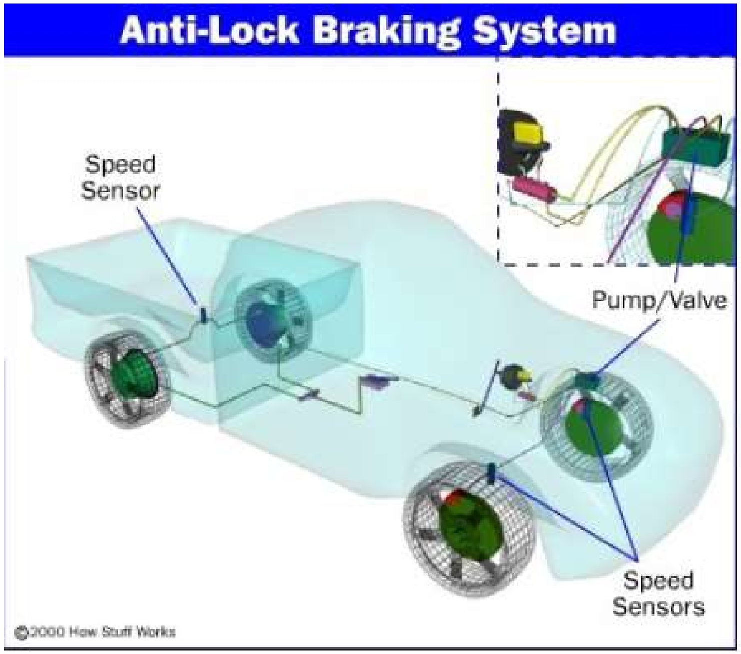
- Specialized purpose(s)
  - Normally, an embedded system is designed to execute a repeatable program
  - Execute multiple functions at the same time

2. Characteristic of an embedded system

- Highly constraint by multiple factors
  - Cost
  - Simple
  - Few components
  - Speed
  - Energy consumption
- Limited resources
  - Performance of micro-processor
  - Memory capacity

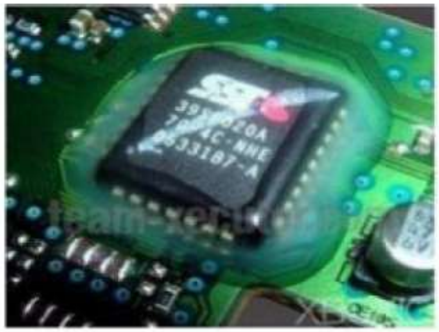
2. Characteristic of an embedded system

- Interactive and real-time
  - Usually interact with external events (reactive)
  - Process to match the requirement of real-time needs
- Satisfy the requirements of
  - Reliability Error tolerance
- Example:
  - Car: ABS, airbag
  - Medical equipments

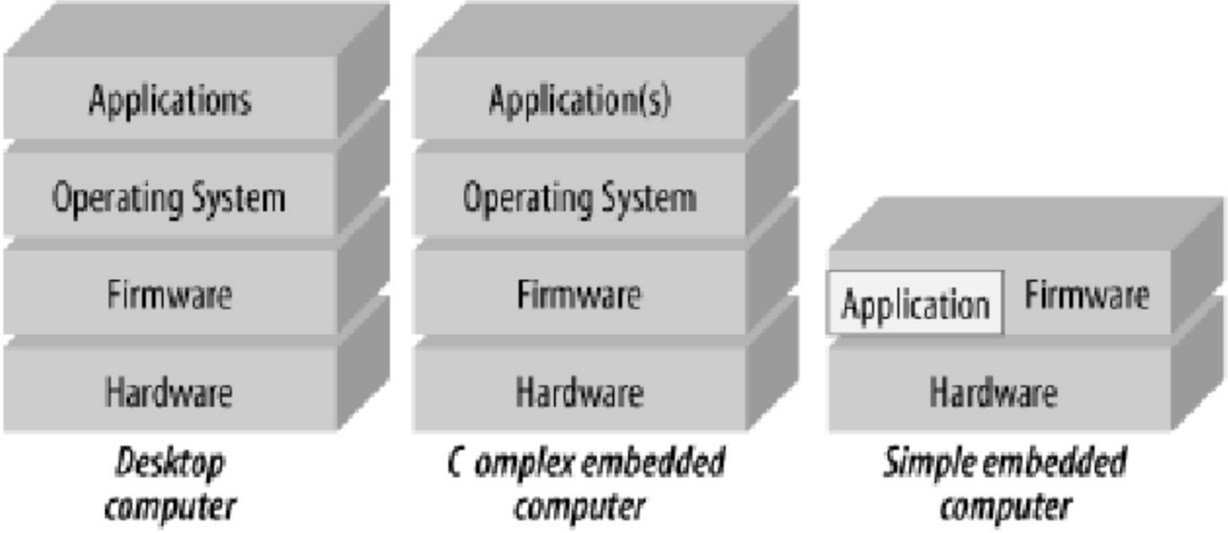


2. Characteristic of an embedded system

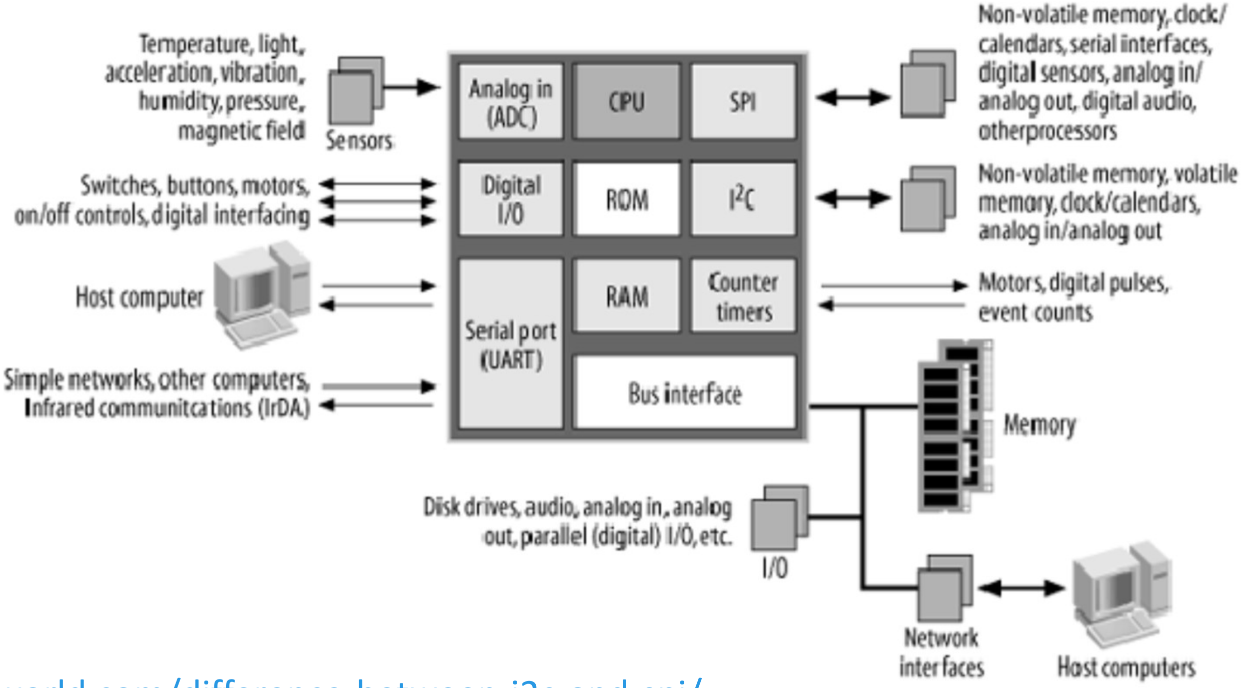
- Hardware and software combination
  - Software usually are installed on embedded memory (firmware)
  - Stored in EEPROM or FLASH



3. General structure of embedded systems



3.1. Diagram of an embedded system


Temperature, light, acceleration, vibration, humidity, pressure, magnetic field
Sensors
Switches, buttons, motors, on/off controls, digital interfacing
Host computer
Simple networks, other computers, Infrared communitcations (IrDA)
Analog in (ADC)
CPU
SPI
Digital I/0
ROM
I2C
Serial port (UART)
RAM
Counter timers
Bus interface
Non-volatile memory, clock/ calendars, serial interfaces, digital sensors, analog in/ analog out, digital audio, otherprocessors
Non-volatile memory, volatile memory, clock/calendars, analog in/analog out
Motors, digital pulses, event counts
Memory
Disk drives, audio, analog in, analog out, parallel (digital) I/O, etc.
I/0
Network interfaces
Host computers

https://aticleworld.com/difference-between-i2c-and-spi/

3.2. Micro-processor

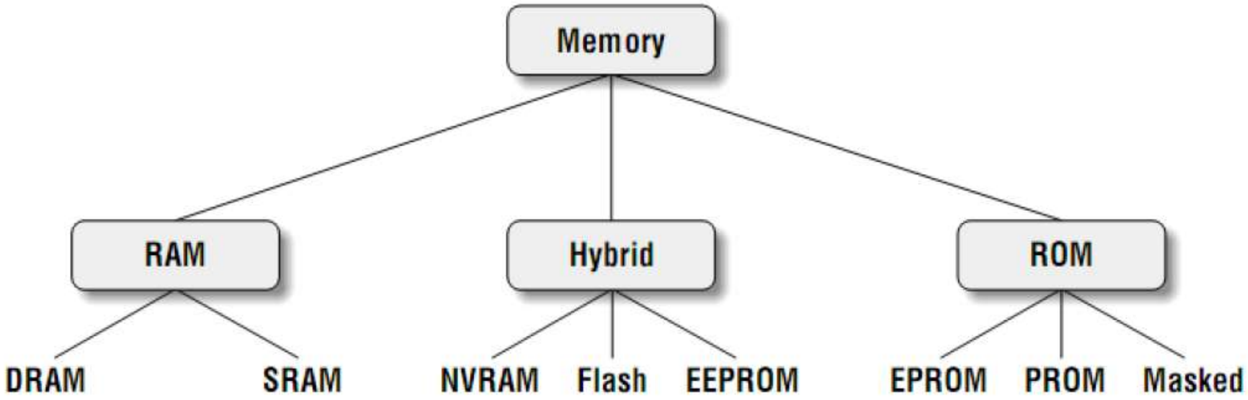
- Processor:
  - An independent processor cannot do any tasks
  - It needs to communicate with memory (containing programs, data), and IO devices (interacting with external world)
- Micro-processor
  - Micro-processor is designed on an integrated circuit/ chip
  - Popular brands: Intel, FreeScale IBM, MIPS, ARM, SUN PARC

3.3. Microcontroller

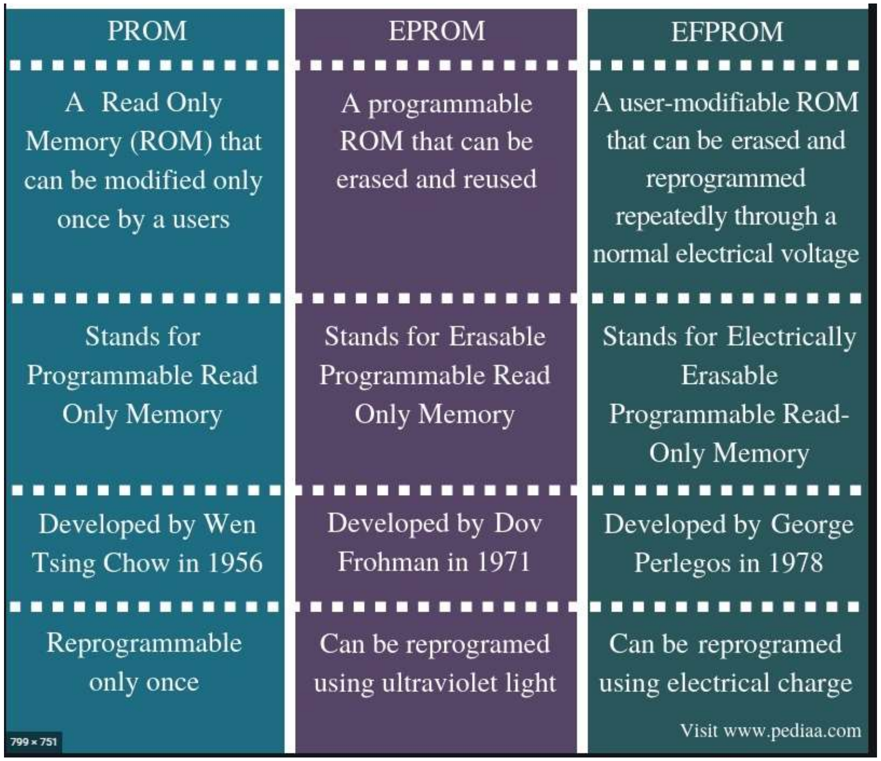
- Microcontroller
  - Contain microprocessor, memory, IO ports on a single chip, IC
  - Usually used in embedded systems
  - Wide scope: AVRs, PICs, ARMs,…
  - Architecture: 8-bit, 16-bit, 32-bit, 64-bit
  - Memory comes with chip/IC or an extensible components
- SoC (System-on-chip)

3.4. Memory

- RAM
- ROM, EPROM, EEROM (EEPROM)
- Flash (newest ROM technology, dominant), sử dụng rộng rãi trong vi điều khiển, hệ nhúng



3.4. Memory (Cont.)

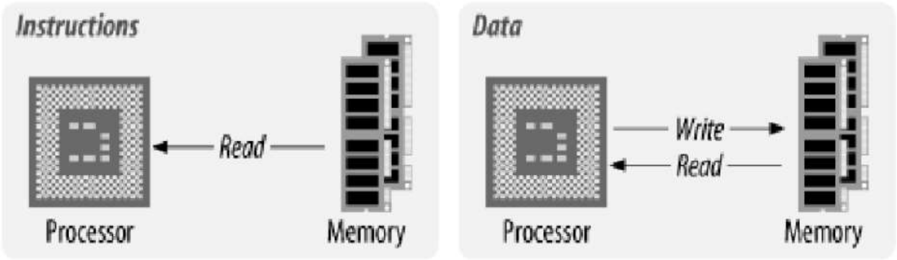


PROM	EPROM	EFPROM
A Read Only Memory (ROM) that can be modified only once by a users	A programmable ROM that can be erased and reused	A user-modifiable ROM that can be erased and reprogrammed repeatedly through a normal electrical voltage
Stands for Programmable Read Only Memory	Stands for Erasable Programmable Read Only Memory	Stands for Electrically Erasable Programmable Read-Only Memory
Developed by Wen Tsing Chow in 1956	Developed by Dov Frohman in 1971	Developed by George Perlegos in 1978
Reprogrammable only once	Can be reprogramed using ultraviolet light	Can be reprogramed using electrical charge

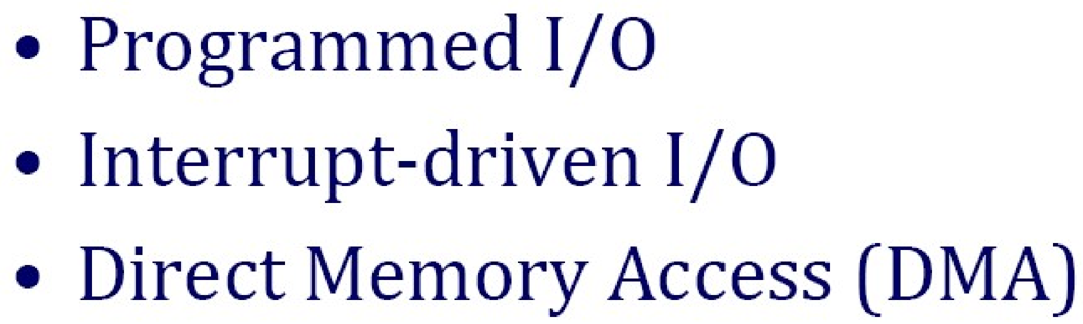
Visit www.pediaa.com

3.5. Von Neumann architecture

- Đặc trưng máy tính kiến trúc Von Neumann:
  - Lệnh và dữ liệu chia sẻ trong cùng 1 bộ nhớ
  - Đối với bộ nhớ, không có sự khác biệt dữ lệnh và dữ liệu (ma do CPU quyết định đối xử khi nhận về)
  - Bộ nhớ được tổ chức thành một mảng tuyến tính các ngăn nhớ.

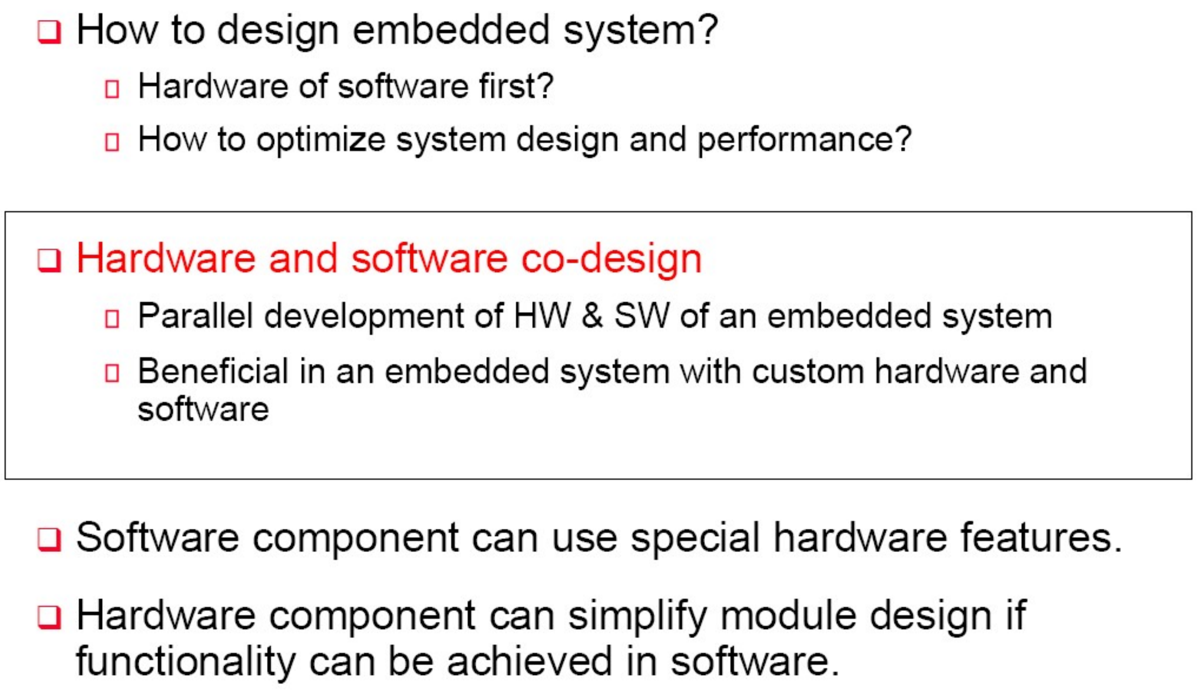


3.6. Input/Ouput methods



- Programmed I/O
- Interrupt-driven I/O
- Direct Memory Access (DMA)

4. Design an embedded system

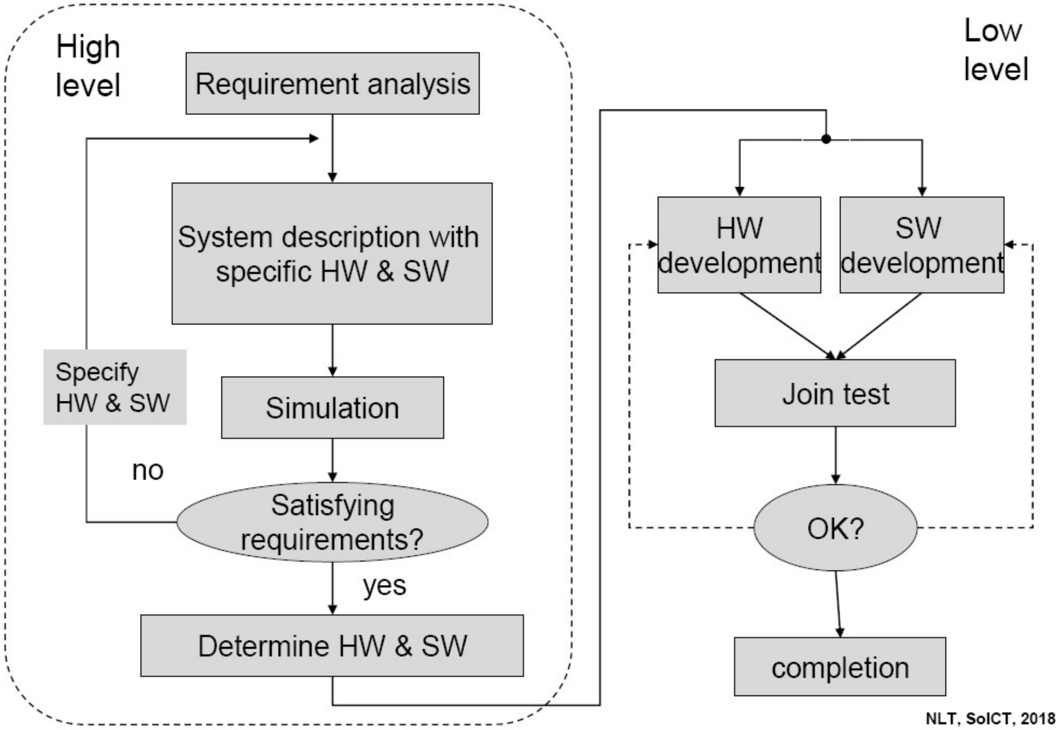


- How to design embedded system?
  - Hardware of software first?
  - How to optimize system design and performance?

- Hardware and software co-design
  - Parallel development of HW & SW of an embedded system
  - Beneficial in an embedded system with custom hardware and software

- Software component can use special hardware features.
- Hardware component can simplify module design if functionality can be achieved in software.

4. Design an embedded system

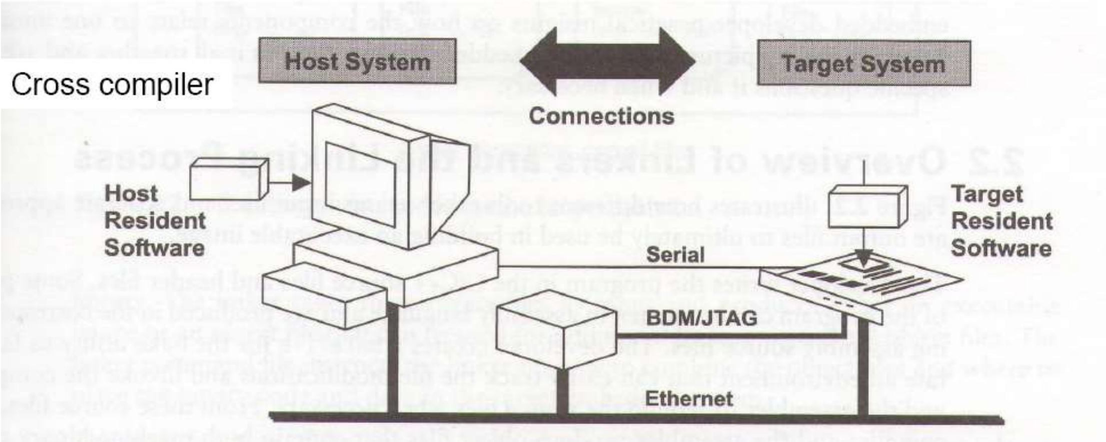


4. Design an embedded system

- ❑ Target system: limited hardware resource → cannot be used as development environment
- ❑ How to develop software to run on target system?
  - → Use a different platform as development environment
- ❑ Platform: hardware, OS, and development tools

4. Design an embedded system

- Cross-platform development
  - Platform: HW + OS + SW development tools
  - Software development where developing platform and running platform are separating



Cross compiler

Figure 2.1 Typical cross-platform development environment.