Real Time Embedded Systems

Introduction
Course schedule

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Embedded systems *(Wikipedia)*

- **Embedded systems** use a variety of dedicated operating systems. In some cases, the "operating system" software is directly linked to the application to produce a monolithic special-purpose program. In the simplest embedded systems, there is no distinction between the OS and the application.
- Embedded systems that have certain time requirements are known as Real-time operating systems.

Course organization

- 2h courses
- 2h laboratory
- 4 credits

- Exams :
    - oral project presentation
    - lab's/project reports

- http://moodle.epfl.ch/course/view.php?id=391

Main hardware support

- This course is oriented on the teaching of **embedded systems (based on FPGA as practical laboratories)**.
- **Real time embedded systems** programming is practically demonstrated with the ***DE1-SOC*** system for laboratories and final mini-project

CONTENTS

- **FPGA Cyclone V-SOC**
- Embedded system developed on the FPGA with softcore NIOS II processor and some I/O interface + **2xARM A9** hardcore processor .
- Co-design development of a **Web server**.
- Real time operating system is study and used in the laboratories : **MicroC/OS-II** and/or **Linux**
- **VHDL and C/C++ developments**

Course Scheduling, topics

- Quartus-Prime, NIOSII design → Embedded system on FPGA
- Interruptions
- ISR/DSR, Interrupt Service Routine on some OS
- Monitor, Kernel, Scheduler
- Hardware resources as memory (SDRAM) timings

Course Scheduling, topics

- Thread,
- Mutex, Semaphore, Events Flags
- Priority and inversion priority
- Real OS studies
- Multiprocessor system
- Hardware Accelerator
- ARM A9 hardcore with hardcore Interfaces
- Network and Web server

Course Scheduling (2)

- **Laboratories :**
  - **Reports**
  - **Oral presentation**

Embedded systems

- Somes french « traductions » :
  - ➢ Systèmes embarqués
  - ➢ Systèmes enrobés
  - ➢ Systèmes enfouis

Embedded system, definition

There is no formal definition of an ***embedded system***, but it is generally accepted to be a type of computer designed **to solve** a **specific problem or task**.

This is in contrast to a general-purpose computer such as a PC or workstation.

Embedded systems typically use a **microprocessor** combined with other hardware and software to solve a specific computing problem.

Embedded system, definition

Microprocessors range from simple (by today's standards) **8-bit microcontrollers** to the worlds fastest and most sophisticated **64-bit microprocessors**.

Embedded system **software** ranges from a small executive to a large real-time operating system (RTOS) with a graphical user interface (GUI).

Typically, the embedded system software must **respond to events** in a **deterministic way** and should be guaranteed **not to crash**.

Embedded system, definition

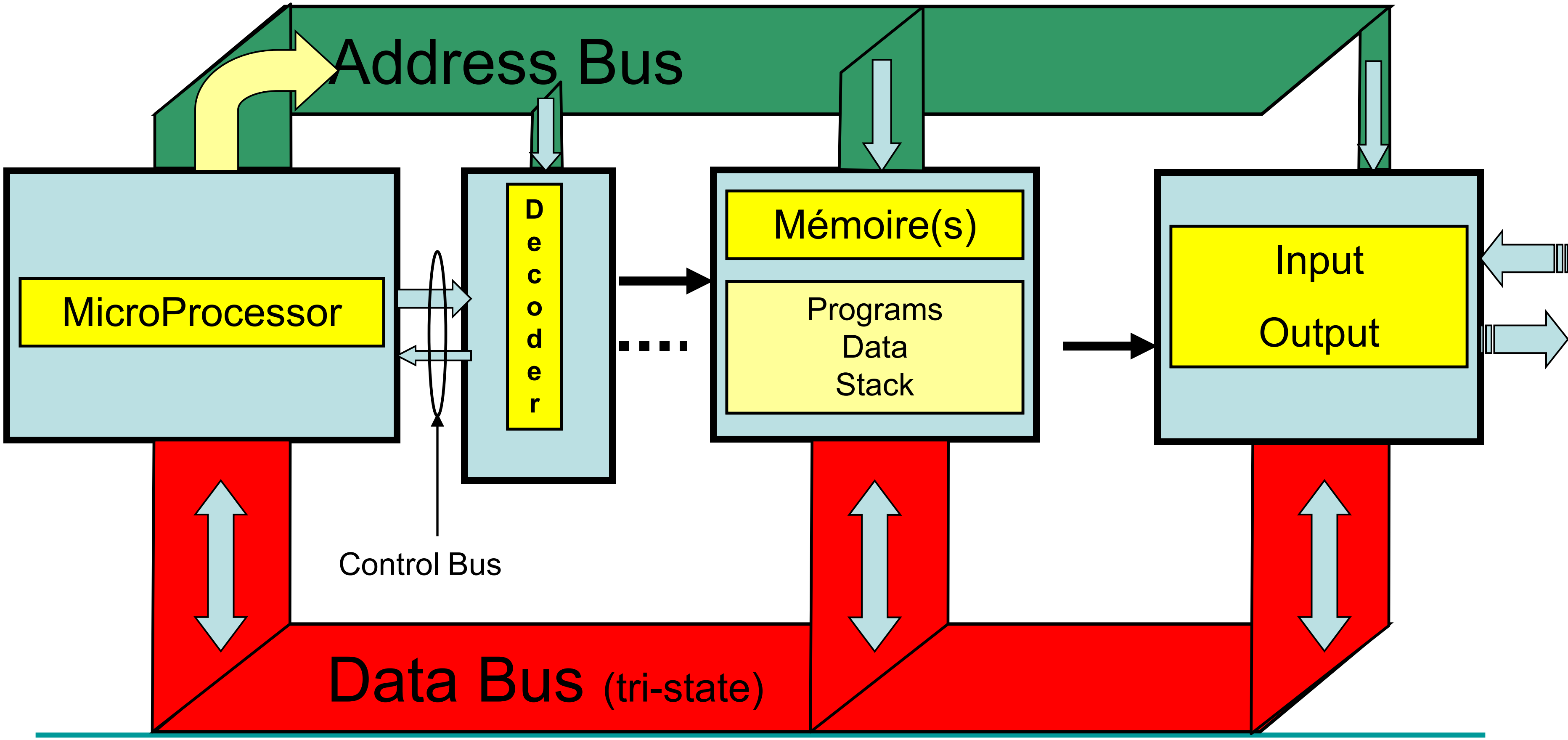
The embedded system landscape is as diverse as the world’s population :

no two systems are the same.

Embedded systems range from large computers such as an air traffic control system to small computers such as a handheld computer that fits into your pocket.

Jason Andrews

Computer System Architecture



Embedded systems

- Somes examples :
  - Caméra
  - Car : ABS, ignition, climatisation, etc..
  - Mobiles phones
  - PDA (Personal Digital Assistant)
  - DVD players
  - Mouse
  - …

Operating systems

- eCOS
- MicroC/OS-II
- Linux, uLinux
- Windows CE
- PALM OS
- etc…

- Real Time or NOT !?

RTOS, some proprietary RTOS (from Wikipedia)

- Ardence RTX
- BeOS
- ChorusOS
- DMERT
- DNIX
- DSOS
- embOS (Segger)
- HP-1000/RTE
- INtime [9]
- ITRON
- LynxOS
- MERT
- **MicroC/OS-II**
- µnOS
- MQX RTOS [10]
- Multiuser DOS
- Nucleus
- On Time RTOS-32 [11]
- OS-9
- OSE
- OSEK/VDX
- OSEKtime
- PDOS
- Phar Lap ETS
- PikeOS
- Portos [12]
- pSOS
- QNX
- REX
- RFW (RMX for Windows) [13]
- RMX
- RSX-11
- RT-11
- rt-kernel [14]
- RTKernel [15]
- RTOS-UH
- RTXC
- RTXC-32 [16]
- RTXC Quadros [17]
- Salvo RTOS [18]
- SCIOPTA [19]
- SINTRAN III
- Symbian OS
- THEOS
- ThreadX
- UNIX-RTR
- VelOSity
- INTEGRITY
- VRTX
- VxWorks
- Windows CE

RTOS, open source (from Wikipedia)

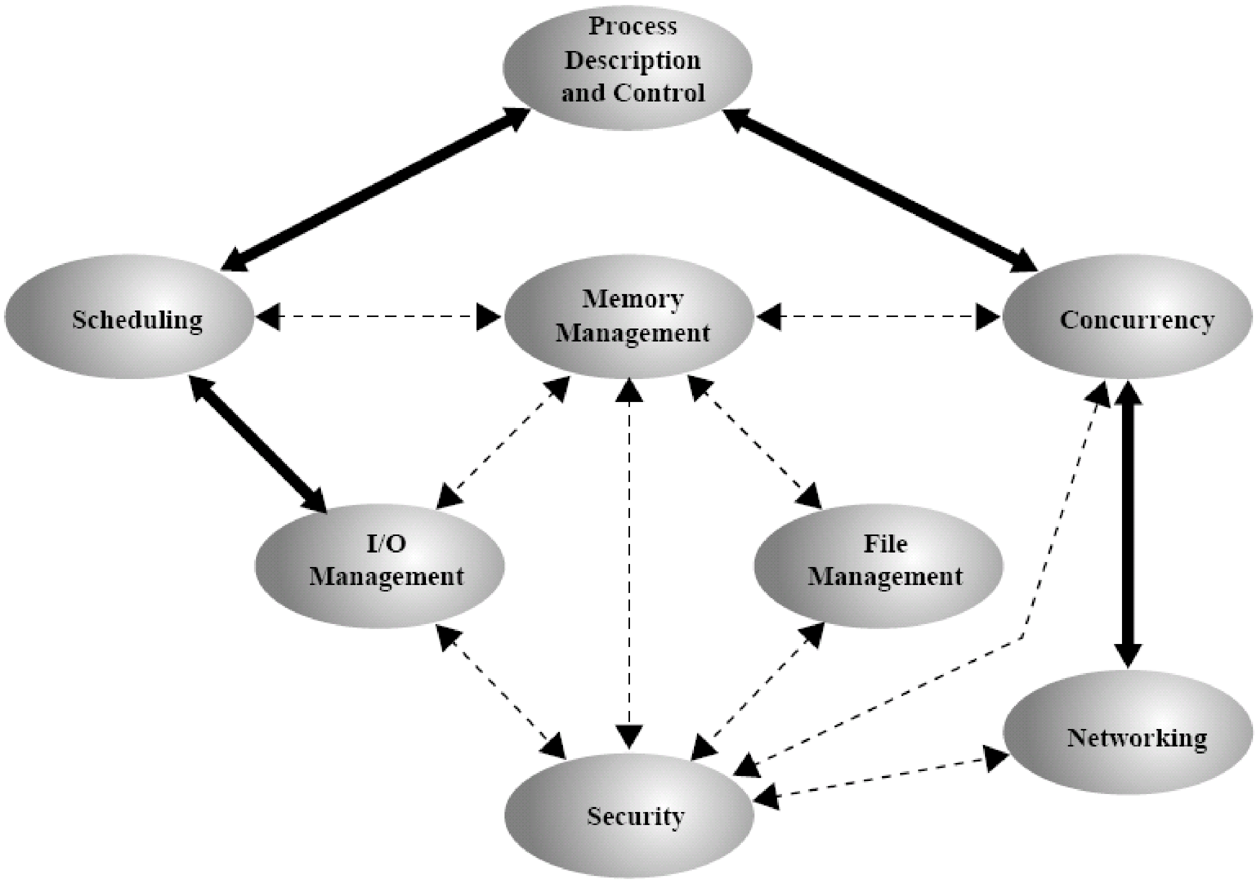
- **eCos**
- µKOS [1]
- EROS
- CapROS
- Coyotos
- Fiasco (L4 clone) [2]
- FreeRTOS
- C Executive- ROMable kernel for embedded systems [3]
- scmRTOS - Single-Chip Microcontroller RTOS [4]
- Linux as of kernel version 2.6.18
- MenuetOS
- Nut/OS [5]
- Phoenix-RTOS
- Prex
- RTAI
- RTEMS
- RTLinux
- Solaris [6]
- SHaRK
- TRON Project T-Kernel is now available for free from T-Engine Forum.
- TUD:OS
- Xenomai [7]
- Marte OS [8]
- …

Operating systems

- Hard Real time:
  - ➢Life will depend on the response time in the execution of a task

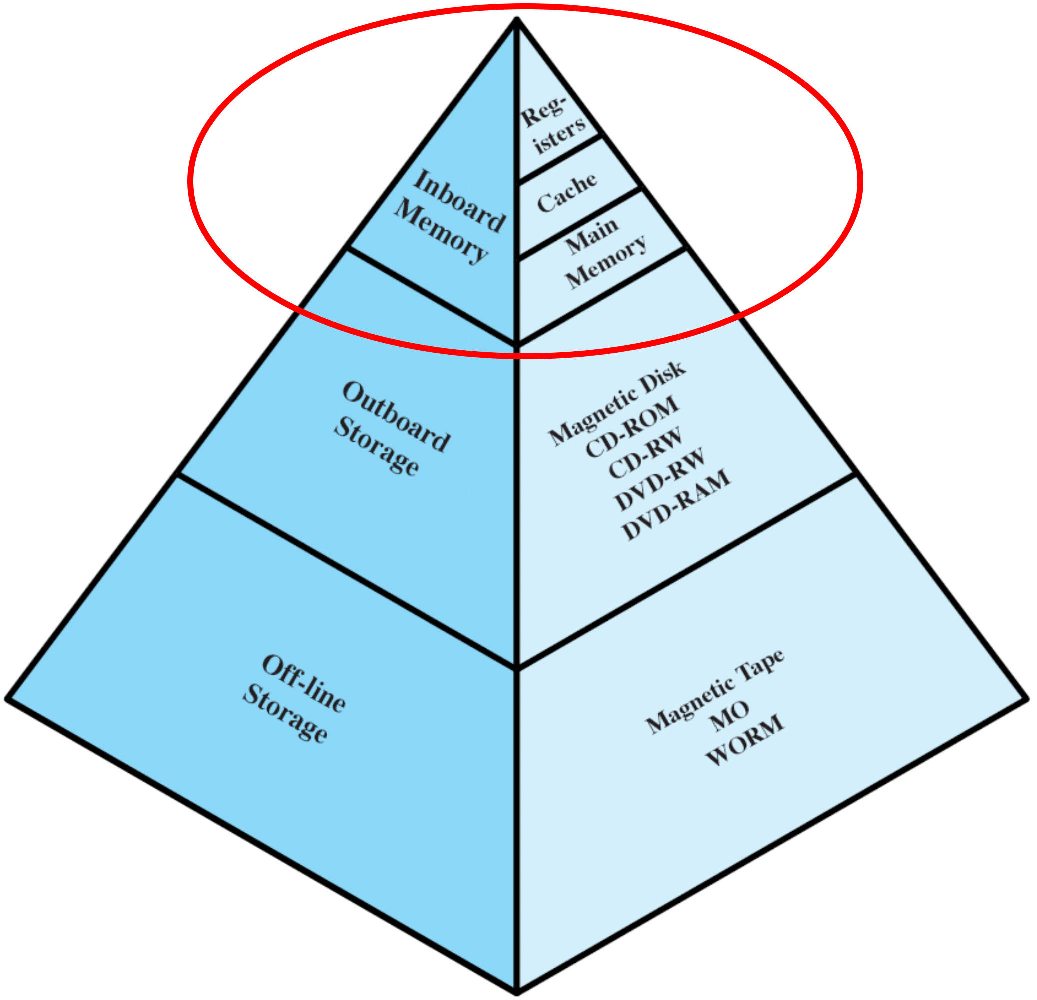
- Soft Real time:
  - ➢Life will NOT depend on the response time in the execution of a task

OS General View of topics

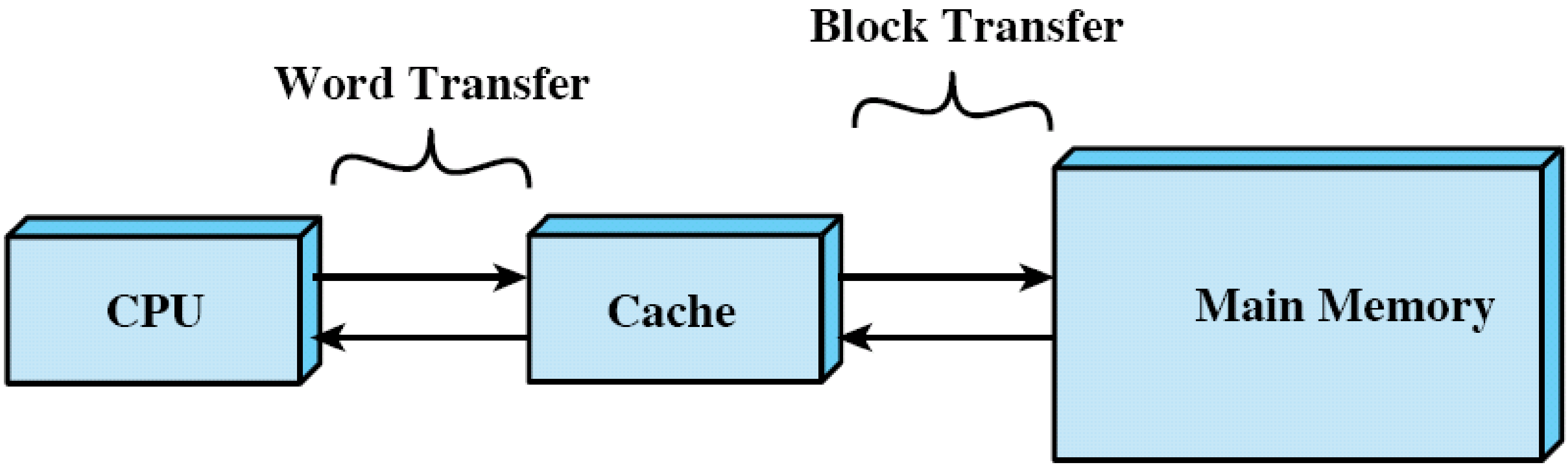


Operating Systems, Internals and Design Principles, [William Stallings]

Memory hierarchy



Memory hierarchy



Références

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