

CS-476

**Real-time embedded systems**

Beuchat René

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Mineur STAS Chine	E	Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Project	2 weekly
<b>Number of positions</b>	

**Summary**

A real time system is subject to important temporal constraints. This course is about understanding where processing time is spent and what a designer can do in order to achieve real-time processing systems. Some solutions are Multiprocessors, accelerators, custom instructions, specialized hardware.

**Content**

During this course, response time measurements of interrupts are studied in laboratories, such as for example: the influence of dynamic memories, cache memories, compilation flags. Interrupts response time measurements, task commutations and synchronizations primitives are carried out on an embedded system based on an FPGA.

The course includes the study of embedded systems management models through polling, interrupts and using a real time kernel with its task management and synchronization primitives.

Specialized programmable interfaces are implemented in VHDL to help with these measurements. A real time kernel is studied and used during the labs. An acquisition system is implemented and the gathered data is transmitted by a Web server. To ensure the real time acquisition and reading by the Web server, a multiprocessor system is developed and implemented on an FPGA.

An Accelerator designed in VHDL makes it possible to facilitate the optimization of functions through hardware on an FPGA. Cross development tools are used.

Each topic is treated by a theoretical course and an associated laboratory. The laboratories are realized on an FPGA board including a hardcore multiprocessor. A real time operating system is studied and used with the laboratories.

**Keywords**

Real Time, FPGA, SOC, microprocessor, hardware accelerator, custom instruction, Real Time OS

**Learning Prerequisites****Required courses**

Introduction to computing systems, Logic systems, Computer architecture

**Recommended courses**

Embedded Systems, Real time Programming

**Important concepts to start the course**

Programmable Logic Architecture (FPGA), Computer Architecture, VHDL, C programming, Real Times basic knowledge (semaphor, synchronization)

**Learning Outcomes**

By the end of the course, the student must be able to:

- Design a multiprocessor system on an FPGA
- Analyze the performance of a real time embedded system
- Use design tools for SOC conception on an FPGA
- Implement a complete real-time system based on a multiprocessor design on an FPGA
- Test the realized system
- Defend the choices during the design phases

### Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Communicate effectively, being understood, including across different languages and cultures.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Make an oral presentation.
- Write a scientific or technical report.

### Teaching methods

Ex cathedra, laboratories and a mini-project

### Expected student activities

- 3 groups of laboratories on specific topics, with a report by group for each of them, 3-4 weeks/topic;
- A final mini-project to practically synthesize the content of the course, with the design of a multiprocessor system on an FPGA, including for example a Web-server, a camera controller, a specific algorithm to be implemented in an FPGA hardware accelerator, 3-4 weeks for this mini-project

### Assessment methods

Continuous control with reports and oral presentation  
all labs 50% + final mini-project 50%

### Supervision

Office hours	No
Assistants	Yes
Forum	Yes

### Resources

#### Virtual desktop infrastructure (VDI)

No

#### Bibliography

Teaching notes and suggested reading material.  
Specialized datasheets (ie.ex. FPGA et specific microcontrollers) and standards.

#### Notes/Handbook

Slides and documents on moodle

#### Moodle Link

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

