

EE-390(a)

**Lab on hardware-software digital systems codesign**

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Cursus	Sem.	Type
Electrical and Electronical Engineering	BA6	Opt.
HES - EL	E	Obl.

Language of teaching	English
Credits	3
Withdrawal Session	Unauthorized Summer
Semester	Spring
Exam	During the semester

Workload	90h
Weeks	14
<b>Hours</b>	<b>3 weekly</b>
Practical work	3 weekly

**Number of positions**

**Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.**

**Summary**

During the course, we cover the design of multi-core embedded systems running Linux on an FPGA. Students learn how to develop hardware-software co-design solutions for complex tasks using high-level synthesis languages. We cover debugging co-designed embedded systems with integrated logic analyzers.

**Content****Architecture of embedded systems. SW-HW co-design**

Architecture and SW-HW co-design of embedded systems. Memory hierarchies for multi-core systems. Coherence between custom HW modules and processor memory hierarchy.

Integration of custom HW in the Linux operating system. Physical address space and virtual memory; address translation. Device drivers.

**Tools and design flows**

Division of tasks between SW and HW. Design of peripherals for the ARM AXI4 bus. Integration of HW components in a multi-core system. Simulation and debugging at the system level.

Use of high-level synthesis (HLS) as a productivity booster for the design of HW components that implement complex functionality.

**Keywords**

Embedded system, co-design SW-HW, FPGA, AXI4, Linux, device drivers, High-Level Synthesis (HLS).

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

- Systèmes embarqués microprogrammés (EE-310)
- Systèmes numériques (EE-334)

**Important concepts to start the course**

Architecture of embedded devices.

Design of digital systems in VHDL.

Programming in C.

Basic operating system (Linux) concepts.

**Learning Outcomes**

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

- Compose un système embarqué complexe
- Develop des composants matériels personnalisés et les intégrer
- Synthesize une spécification et une architecture à partir d'une idée abstraite
- Explain les fondations et les principes gouvernant le matériel d'un système digital embarqué

### Teaching methods

Work on small projects that build up the final SW-HW platform. During the course, we introduce the required concepts to build step-by-step a platform composed of SW and HW components. Among other projects, we use HLS to build HW accelerators for convolutions that are later integrated into complete CNNs running on Linux, and a basic video gaming platform with sprite acceleration capabilities.

### Expected student activities

Participation in class sessions and delivery of weekly practical assignments.

### Assessment methods

During the semester, continuous evaluation of weekly assignments will represent a 70% of the final grade. During class hours, the students will be asked (individually) to explain their exercises, either to the teachers or to the whole class. Over the last weeks of the course, one or more guided projects will be completed in groups; the evaluation of these group projects will account for 30% of the final grade. The code of all the assignments will be delivered via a git repository.

### Resources

#### Moodle Link

- [https://go.epfl.ch/EE-390\\_a](https://go.epfl.ch/EE-390_a)