

Description du module, disponible en: FR

## Advanced Embedded Software

### Informations générales

Nombre de crédits ECTS

3

Code du module

TSM\_AdvEmbSof

Valable pour l'année académique

2021-2022 DRAFT

Dernière modification

2021-03-18

Coordinateur/coordinatrice du module

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Explication des définitions de langue par lieu :

- Les cours se dérouleront dans la langue définie ci-dessous par lieu/exécution.
- Les documents sont disponibles dans les langues définies ci-dessous. Pour le multilinguisme, voir la répartition en pourcentage (100% = documents complets)
- L'examen est disponible à 100% dans chaque langue sélectionnée pour chaque lieu/exécution.

	Berne	Lausanne	Lugano	Zurich
Leçons		X F 100%		
Documentation		X F 0%	X E 100%	
Examen		X F 100%		

Catégorie de module

TSM approfondissement technico-scientifique

Leçons

2 leçons et 1 leçon de pratique par semaine

### Compétences préalables

Connaissances préalables, compétences initiales

- Knowledge of the C programming language and of an object-oriented language.
- Good knowledge of computer and microprocessor architecture.
- Basic understanding of operating system concepts (scheduling, process/thread).
- Basic concurrent programming

## Brève description du contenu et des objectifs

An embedded system is a specialized computer system with embedded hardware. There exists a wide variety of embedded systems, but in general such systems are processing systems capable of sensing physical inputs from their environment and of communicating the results. Usually embedded systems are designed to perform repeating tasks, either periodically or spontaneously, for low cost, low power, and optimal performance.

In this module, we investigate how microcontroller-based embedded systems can be developed, by emphasizing on the following advantages:

- Provide flexibility with a software-based approach, with the right partition of the system into hardware and software components.
- Provide extensibility of the system.
- Provide easier error detection and debugging capabilities.
- Provide portability with the use of an embedded operating system and allow the programmer to abstract the hardware details of each platform.

## Objectifs, contenus, méthodes

### Objectifs d'apprentissage, compétences à acquérir

The students will learn the most important features of a modern RTOS by implementing their own scenario on an IoT development platform that offers a wide range of sensing, processing and communication capabilities. Starting from a basic super loop/bare metal implementation, the students will rapidly reach the limitations of this implementation. These limitations will be studied and improved solutions using scheduling, threading and synchronization will be put in place by the students for the development of a robust, portable and easily maintainable software. In addition, the students will also:

- Implement methods for analyzing the CPU and memory usage of the system.
- Develop methods for automated testing including unit tests and integration tests, toward CI/CD of embedded systems.

At the end of the module, the students will be able to:

- Develop a multi-tasking application on a microcontroller-based embedded system, using a RTOS
- Use the debugging capabilities and build the test environment for an embedded application.
- Understand the memory organization and usage of their application.
- Develop a framework for updating embedded applications, including a bootloader application.

### Contenu des modules avec pondération du contenu des cours

Introduction to Embedded Systems and Software

- Applications for Embedded Systems
- Attributes of Embedded Systems
- Options for Building Embedded Systems
- Microcontroller-based Embedded Systems
- Internet Of Things (IoT) and Embedded Systems
- Embedded Systems and Operating Systems (OS)
- Introduction to Mbed OS

Scheduling for Embedded Systems

- Programming models of Embedded Systems
- Overview of Scheduling Algorithms
- Static cyclic scheduling
- Event-driven scheduling and Interrupts
- Dynamic RTC Scheduling
- Dynamic Preemptive Scheduling
- Comparison of Scheduling Algorithms

Tasks and Concurrency

- Design of Embedded Software into Multiple Tasks
- Multitasking and Embedded OS (Mbed OS)
- Tasks and Real-Time OS
- Mbed OS Task Scheduling
- Mbed OS Threads
- Concurrency Mechanisms (Events, Mutex, Semaphore, Queue, Mail)
- Priority Inversion and Resource Access Protocols

Memory of Embedded Systems

- Principles of Memory Management
- Cortex-M Program Image Structure
- Mbed OS Memory Model
- Code, Data and Memory
- Memory Protection Unit of Cortex-M Processors

Bootloader

- Deploying Updates to Embedded Systems
- Bootloader Principles
- Bootloader Requirements and Application
- Memory Model for Bootloaders

Testing

- Levels of Testing
- Unit Testing on Mbed OS
- Integrations Testing on Mbed OS
- CI/CD for Embedded Systems

### Méthodes d'enseignement et d'apprentissage

This module uses lecture notes and practical exercises which are given in the form of codelabs. The students have to develop their own software based on a specification, with the help of lecture notes and codelabs material.

### Bibliographie

References are given in the lecture notes and in the codelabs.

## Evaluation

### Conditions d'admission

Le module n'utilise pas de conditions d'admission.

### Principe pour les examens

**En règle générale, tous les examens de fin de module réguliers et les examens de rattrapage sont organisés sous la forme écrite**

### Examen de fin de module régulier et examen écrit de répétition

#### Type de l'examen

écrit

#### Durée de l'examen

120 minutes

#### Aides autorisées

*Les aides suivantes sont autorisées:*

#### Aides électroniques autorisées

The exam is separated in two parts.

Part 1 : no numerical help

Part 2 : computer allowed

#### Autres aides autorisées

Two two-sided A4-pages with personal notes

### Cas spécial: examen de répétition oral

#### Type de l'examen

oral

#### Durée de l'examen

30 minutes

#### Aides autorisées

*Les aides suivantes sont autorisées:*

#### Aides électroniques autorisées

None

#### Autres aides

Two two-sided A4-pages with personal notes

