



COURSE DESCRIPTION REAL-TIME SYSTEMS

SSD: SISTEMI DI ELABORAZIONE DELLE INFORMAZIONI (ING-INF/05)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55) ACADEMIC YEAR 2022/2023

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE MODULE: NOT APPLICABLE CHANNEL: FG A-Z YEAR OF THE DEGREE PROGRAMME: I PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II CFU: 9

REQUIRED PRELIMINARY COURSES

None.

PREREQUISITES

Basic programming skills.

LEARNING GOALS

The course provides essential knowledge and skills about operating systems and programming for real-time systems used in industrial domains, particularly the automotive sector. It provides the skills needed to design, tune and develop real-time systems, with practical sessions on several environments, such as real-time Linux and FreeRTOS.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student needs to show to know the problems of real-time computing, to illustrate the theoretical foundations of algorithms for the scheduling of real-time periodic and aperiodic tasks, for the management of shared resources with temporal constraints, including their feasibility tests, to recognize the main time-sensitive networking solutions, to understand the principles of programming and networks applied to real-time systems and reconduct them to the automotive industrial context.

Applying knowledge and understanding

The students need to show abstraction abilities related to design problems of real-time systems and to opportunely reconduct them to theoretical models used for the feasibility check. He/she has to be able to solve dimensioning problems of real-time system using the acquired methodologies and algorithms, to be able to implement simple real-time software systems using the primitives for the management of periodic and aperiodic tasks and for real-time inter-process communication.

COURSE CONTENT/SYLLABUS

Introduction. Real-time systems: application fields, dimensioning, deadline, hard and soft real-time systems, the role of Real-Time Operating Systems (RTOS).

Background. Operating systems: basic notions and functions. Scheduling, memory management, file system, input/output. Examples of programming multithreaded applications in Linux.

Computer architectures and predictability. Microcontrollers and embedded systems. Nondeterminism sources in hardware and software.

Real-time scheduling. Scheduling of aperiodic and periodic tasks. Cyclic executive. Rate Monotonic. Deadline Monotonic. Earliest Deadline First. Feasibility Analysis.

Resource Management. Mutual Exclusion and Semaphores. Priority Inversion. Priority Inheritance and Priority Ceiling.

Real-time networking. The ISO/OSI Stack. Real-time traffic models and sources of nondeterminism in networks. CSMA/CD and Token Ring protocols. Controller Area Network (CAN). **Real-Time Operating Systems.** Primitives for programming concurrent applications in real-time environments. Input/Output. Examples of RTOS. Focus on real-time Linux and FreeRTOS. **The Automotive context.** Standards: OSEK, AUTOSAR, MISRA C, ISO 26262. Practical examples and applications.

READINGS/BIBLIOGRAPHY

Slides, lecture notes, technical papers.

Textbooks:

- G. Buttazzo: "Hard-Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications", Third Edition, Springer.

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures (65% of the course), laboratory activities and exercises (35% of the course).

EXAMINATION/EVALUATION CRITERIA

a) Exam type	
$\mathbf{\nabla}$	Written
$\mathbf{\nabla}$	Oral
	Project discussion
	Other
In case of a written exam, questions refer to	
	Multiple choice answers
	Open answers
$\mathbf{\nabla}$	Numerical exercises

b) Evaluation pattern

The written exam consists in the resolution of numerical exercises. During the course, programming exercises will be performed as well to be discussed during the oral exam. The written exam performance is binding to have access to the oral exam. The final vote is established as average between written and oral exams.