Course guide
270071 - STR - Real-Time Systems

Last modified: 30/01/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: ANTONIO CAMACHO SANTIAGO

Others: Segon quadrimestre:
ANTONIO CAMACHO SANTIAGO - 10

PRIOR SKILLS

regarding Designing Microcomputer Based Systems:
Understand the structure of microcomputers, their assembly language and their input interface management capabilities

regarding Operating Systems:
Know the basics of process management, memory management and input / output.

REQUIREMENTS

- Prerequisite CI
- Prerequisite SO

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEC1.1. To design a system based on microprocessor/microcontroller.
CEC2.3. To develop and analyse software for systems based on microprocessors and its interfaces with users and other devices.
CEC2.5. To design and implement operating systems.
CEC3.1. To analyse, evaluate and select the most adequate hardware and software platform to support embedded and real-time applications.
CEC3.2. To develop specific processors and embedded systems; to develop and optimize the software of these systems.
CT5.6. To demonstrate knowledge and capacity to apply the fundamental principles and basic techniques of parallel, concurrent, distributed and real-time programming.

Generical:
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

TEACHING METHODOLOGY

The teaching methodology will be of a deductive nature. The approach will always be the same:
- propose a problem
- try to solve it
- add the necessary pieces of theory to be able to solve properly

The teaching laboratory of the department at the FIB will be the place where both practice and theory are developed.

LEARNING OBJECTIVES OF THE SUBJECT

1.To understand the concept of real-time system
2.To determine when to use a real-time system.
3.To plan a cyclical scheduler
4.Real-time system with fixed priorities
5.Real-time system with dynamic priorities
6.Migrate a real-time operating system to a specific microprocessor
7.To understand the time slots into a RTS to implement bandwidth servers
8.Understand how multi-core real-time systems work
9.To observe the advantages of using a RTS using examples

STUDY LOAD

Type	Hours	Percentage
Hours large group	15,0	10.00
Guided activities	6,0	4.00
Hours medium group	7,5	5.00
Hours small group	37,5	25.00
Self study	84,0	56.00

Total learning time: 150 h

CONTENTS

Introduction to real-time systems

Description:
Explanation of different examples in which the analysis and use of real-time techniques becomes essential

Cyclic real time systems

Description:
Examples of real-time systems that do not have computing capability to be able to solve possible concurrency problems. - Real-time networks
- elevators
- batteries
- crossroads or train tracks
- other examples that broaden the student's vision
- optimal planning

Fixed or dynamic priorities real-time systems

Description:
Online scheduling and preemption.
- Optimal Schedulers
- Rate Monotonic
- Deadline Monotonic
- Earliest Deadline First

Implementation of an RTOS in a microprocessor

Description:
Details to consider when migrating or deploying a real-time operating system on a microprocessor

High level systems. Bandwidth servers

Description:
Implementation of bandwidth servers

Multi-core in real-time systems

Description:
Introduction to real-time systems in systems with more than one microcontroller

ACTIVITIES

Need for a real time system

Description:
Analysis and understanding of the tools needed to provide a temporary response to the tasks of a complex system

Specific objectives:
1, 2

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 4h
Theory classes: 2h
Self study: 2h

Need to calculate the worst case execution time of a task

Description:
How to calculate the worst case code execution of a task

Specific objectives:
1, 2

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 8h
Theory classes: 2h
Practical classes: 2h
Self study: 4h

Scheduling

Description:
Need and implementation of algorithms for schedulability analysis

Specific objectives:
3

Full-or-part-time: 22h 30m
Theory classes: 5h
Practical classes: 2h 30m
Self study: 15h

Bandwidth servers

Description:
Operation and characteristics of bandwidth servers

Specific objectives:
4, 5, 7

Full-or-part-time: 10h 30m
Theory classes: 3h 30m
Practical classes: 1h
Self study: 6h

Multi-core

Description:
Selection of the most suitable multi-core architecture for a specific application

Specific objectives:
8

Full-or-part-time: 8h
Theory classes: 4h
Practical classes: 2h
Self study: 2h

Laboratory practices of real-time systems

Description:
Relevant part of the subject aimed at seeing the implementation details of real-time systems. Special interest in applications that require strict response times and communications.

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 32h
Laboratory classes: 22h
Self study: 10h

Short project

Description:
Brief research work, implementation, deepening, challenge ... related to the real-time systemes.
A preiminary research on the project topic will take place to guide the work.
There will be an open critical debate for the selection of the most opportune solutions.
The results obtained will be presented in public, and a co-evaluation method will be developed.

Full-or-part-time: 33h
Theory classes: 4h
Laboratory classes: 8h
Guided activities: 6h
Self study: 15h

Exam1

Specific objectives:
1, 2, 3, 4, 5

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 12h
Guided activities: 2h
Self study: 10h

Exam 2

Specific objectives:
4, 5, 6, 7, 8, 9

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 20h
Self study: 20h

GRADING SYSTEM

The evaluation of the subject will be done by means of exams, problems, laboratory practices and mini-project, being able to pass the subject without having to do a final exam. The evaluation is done as follows:
- Theory 40%
- Problems 10%
- Lab practices 25%
- Mini-project 25%

Theory: there will be two online exams, CT1 and CT2, each counting 20% on the overall grade of the course
Problems: there will be problems along the course with an overall 10% of the grade of the course
Laboratory practices: there will be several deliveries, each counting equally on the overall grade of the course
Mini-project: a brief and free choice work will be developed to delve into some aspect related to real-time systems

The final NF grade will be:
NF=CT1(20%)+CT2(20%)+PRO(10%)+PRA(25%)+MP(25%)

Competence "G9.3 - Critical ability, assessment ability" will be assessed based on the tasks performed in the theory and problem classes, as well as on the tasks performed in the laboratory practices. In any case it has no weight in the final note of the subject.

BIBLIOGRAPHY

Basic:
- Buttazzo, G.C. Hard real-time computing systems: predictable scheduling algorithms and applications. 3rd ed. Springer, 2011. ISBN 9781461406754.
- Burns, A.; Wellings, A.J. Real-time systems and programming languages: Ada, Real-Time Java and C/Real-Time POSIX. 4th ed. Addison-Wesley, 2009. ISBN 9780321417459.