Course guide
270071 - STR - Real-Time Systems

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: 2021 ECTS Credits: 6.0 Languages: Catalan

LECTURER

Coordinating lecturer: ANTONIO CAMACHO SANTIAGO
Others: Segon quadrimestre:
JUAN ARANDA LÓPEZ - 10
ANTONIO CAMACHO SANTIAGO - 10
JUAN CLIMENT VILARÓ - 10
ENRIC XAVIER MARTIN RULL - 10
MANUEL VINAGRE RUIZ - 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.

General:
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. Clearly identify the need for online planning
4. To identify the need to use a RTS
5. To plan a cyclical scheduler
6. To understand the function of the stack in a microprocessor
7. Disassemble a process from the stack of a microprocessor
8. Migrate a real-time operating system to a specific microprocessor
9. To understand the time slots into a RTS to implement bandwidth servers
10. To observe the advantages of using a RTS using examples

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes</td>
<td>15,0</td>
<td>10.00</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.00</td>
</tr>
<tr>
<td>Laboratory classes</td>
<td>37,5</td>
<td>25.00</td>
</tr>
<tr>
<td>Self study</td>
<td>84,0</td>
<td>56.00</td>
</tr>
<tr>
<td>Practical classes</td>
<td>7,5</td>
<td>5.00</td>
</tr>
</tbody>
</table>

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

**Real-time systems "Passive" or without computing capability**

**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
### Active real-time systems, or with computing capability

**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

#### I can’t I solve this problem?

**Description:**
This activity will highlight the advantages and disadvantages of scheduling concurrent tasks without prior planning. Specifically a problem will be selected and solved (as far as possible), throughout the solution we will see how RTS techniques appear naturally.

**Specific objectives:**
1, 4

**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:** 6h 30m
- Theory classes: 1h 30m
- Practical classes: 1h
- Laboratory classes: 3h
- Self study: 1h
Cyclic scheduler and the difficulties of planning by hand.

Description:
The easiest way to schedule a set of tasks is to use cyclic planning, but is this the best solution from a design point of view?. In this activity we will highlight the difficulties we may encounter in generating a cyclical executive. In this same activity we will highlight some needs for the use of a RTOS.

Specific objectives:
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: 14h
Theory classes: 2h 30m
Practical classes: 1h 30m
Laboratory classes: 6h
Self study: 4h

Introduction to arduino, the platform for the rest of the course

Description:
Activity aimed at introducing the student to the secrets of arduino. This will be the platform we will use for the rest of the course.

Specific objectives:
6

Full-or-part-time: 11h
Theory classes: 1h
Laboratory classes: 3h
Guided activities: 2h
Self study: 5h

Remove a task from the runtime stack and relocate it. Introduction to RTOS

Description:
In this activity we will suspend the execution of a process and completely remove it from the execution stack. We will then reinsert it into the stack and restart execution at the point where we left it. In this way we open the door to understand the operation of the RTOS suspend/resume task state

Specific objectives:
6, 7

Full-or-part-time: 18h
Theory classes: 2h
Practical classes: 1h
Laboratory classes: 5h
Self study: 10h
### FreeRTOS, a RTOS for multiple architectures. Migration of an RTOS on the Arduino Mega.

**Description:**
In this activity we will open, analyze, and understand a RTOS.

**Specific objectives:**
8

**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:** 52h
- Theory classes: 3h
- Practical classes: 2h
- Laboratory classes: 8h
- Self study: 39h

### Examples of application: control of a DC motor

**Description:**
In this activity we will take a classic example of control, controlling a DC motor and see how using an RTOS significantly simplifies implementation and maintenance.

**Specific objectives:**
10

**Full-or-part-time:** 6h 30m
- Laboratory classes: 4h
- Guided activities: 0h 30m
- Self study: 2h

### Band servers

**Description:**
In this activity we will see the ways in which it is possible to implement a bandwidth server on a built-in device such as arduino.

**Specific objectives:**
9

**Full-or-part-time:** 3h
- Theory classes: 3h
Knowledge test

**Description:**
Knowledge test

**Specific objectives:**
4, 5, 6, 7, 8, 9, 10

**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 analyze and interpret its results. Analysis, synthesis and evaluation capacity.

**Full-or-part-time:** 5h 30m
Guided activities: 0h 30m
Self study: 5h

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Knowledge test

**Description:**
Knowledge test

**Full-or-part-time:** 5h 30m
Guided activities: 0h 30m
Self study: 5h

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Knowledge test

**Description:**
Knowledge test

**Full-or-part-time:** 5h 30m
Guided activities: 0h 30m
Self study: 5h

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Knowledge test

**Description:**
Knowledge test

**Full-or-part-time:** 5h 30m
Guided activities: 0h 30m
Self study: 5h

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**Mini-project**

**Description:**
Brief research work, implementation, deepening, ... related to the RTS

**Full-or-part-time:** 17h
Laboratory classes: 6h
Guided activities: 5h
Self study: 6h
GRADING SYSTEM

The evaluation of the subject will be done by means of exams, 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 50%
- Lab practices 25%
- Mini-project 25%

Theory: there will be two online exams, CT1 and CT2, each counting 25% (on the overall grade of the subject)
Laboratory practices: there will be several deliveries, each counting equally on the overall grade of the subject
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:

\[ NF = CT1 (25\%) + CT2 (25\%) + PR (25\%) + MP (25\%) \]

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: