

Course guide 340384 - PACO-I5001 - Parallelism and Concurrence

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Unit in charge: Teaching unit:	Vilanova i la Geltrú School of Engineering 701 - DAC - Department of Computer Architecture.		
Degree:	BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2018). (Compulsory subject).		
Academic year: 2024	ECTS Credits: 6.0 Languages: Catalan, Spanish		
LECTURER			
Coordinating lecturer:	Eva Marín Tordera		
Others:	Eva Marín Tordera Farreras Esclusa, Montserrat		

PRIOR SKILLS

It is advisable to have studied Computer Architecture and Operating Systems.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEFB5. Knowledge of informatic systems, its structure, function and interconnection, as well as fundamentals of its programming.
CEFC2. Ability to plan, conceive, develop, manage informatic projects, services and systems in all areas, leading their

implementation and continuous improvement assassing their economic and social repercussions.

3. CEFC8. Ability to analyze, to design, to construct and to maintain applications in a well built, secure and efficient way choosing the most adequated paradigms and languages.

4. CEFC9. Ability to know, understand and assess computer structure and architecture, as well as basic components forming them.

5. CEFC14. Knowledge and application of fundamentals principals and basic techniques of parallel, concurrent, distributed and real time programming.

TEACHING METHODOLOGY

Theory classes are conducted using the resources available in the classroom (whiteboards, multimedia equipment) and are based on oral exposure by teachers of content on the subject under study (expository method). In some cases, there will be lectures based on the participation and involvement of students through short-term activities in the classroom, such as direct questioning, student presentations on specific topics or resolution of problems related to the theoretical exposed. Also the teacher will solve classroom exercises and propose collection exercises for students to prepare them independently. These exercises will be solved in class by the students individually or in groups of two people.

Small group classes are:

- Laboratory classes: be performed on school computer classrooms. The student must take practice prepared (read and understand the statement of the practice from a script that was previously found in digital campus), and sometimes if indicated shall make a preliminary report. The practices will be individual.



LEARNING OBJECTIVES OF THE SUBJECT

The main objectives of this course are:

- · Paradigms concurrency, parallel and distributed systems: (client-server, load sharing, tasks, etc.)..
- · Platforms parallel (shared memory architectures, distributed memory).
- \cdot Tools to aid the development of parallel programs
- · Programming and evaluation of parallel programs (programming models for different parallel platforms).
- · Memory Coherence and consistency. Communication sincronizació, race conditions, mutex, critical section, monitors, deadlock.

STUDY LOAD

Туре	Hours	Percentage
Hours large group	30,0	20.00
Self study	90,0	60.00
Hours small group	30,0	20.00

Total learning time: 150 h

CONTENTS

1. Introduction to parallelism

Description:

Need of parallelism. Parallelism versus concurrence. Problems using concurrence: deadlock, lifelock, starvation, fairness, data races

Related activities:

Activity 1. Unit 1 problems Activity 2. Lab 0: Experimental setup, tools and programming model

Full-or-part-time: 11h Theory classes: 1h

Practical classes: 2h Self study : 8h

2. Analysis of parallel applications

Description:

Can a computation be divided into different parts? It is divided based on the tasks to do or based on the input/output data. Will there be dependence of data between the tasks? How will they be solved? A good decomposition determines the parallel degree achievable.

Related activities:

Activity 1. Problems: Analysis of parrallel applications Activity 2: Lab 1: Experimental setup, tools and programming model Activity2: Lab 2: Brief tutorial on OpenMP programming model

Full-or-part-time: 18h

Theory classes: 2h Practical classes: 2h Laboratory classes: 4h Self study : 10h



3. Basics of parallel programing: Tasks decomposition

Description:

Identification of concurrence patterns. Tasks decomposition, granularity and analysis of dependences. Identification of parallelism patterns: task parallelism versus divide and conquer. Mechanisms to implement the task decomposition: thread creation and destruction, thread synchronization patterns, exclusion when accessing share data.

Related activities:

Activity 1. Task parallelism problems

Activity 2. Lab 3: Embarrassingly parallelism with OpenMP: Mandelbrot set

Activity 2: Lab 4: Divide and Conquer parallelism with OpenMP: Sorting

Activity 4. Knowledge test

Related competencies :

I_CEFC14. CEFC14. Knowledge and application of fundamentals principals and basic techniques of parallel, concurrent, distributed and real time programming.

I_CEFC9. CEFC9. Ability to know, understand and assess computer structure and architecture, as well as basic components forming them.

I_CEFB5. CEFB5. Knowledge of informatic systems, its structure, function and interconnection, as well as fundamentals of its programming.

I_CEFC2. CEFC2. Ability to plan, conceive, develop, manage informatic projects, services and systems in all areas, leading their implementation and continuous improvement assassing their economic and social repercussions.

I_CEFC8. CEFC8. Ability to analyze, to design, to construct and to maintain applications in a well built, secure and efficient way choosing the most adequated paradigms and languages.

Full-or-part-time: 23h Theory classes: 4h Laboratory classes: 4h Guided activities: 2h Self study : 13h

4. Introduction to (shared-memory) Parallel Architectures

Description:

Parallelism inside a processor (IDLP, DLP, TLP), multiprocessors with share memory, multiprocessors with distributed memory.

Related activities: Activity 1. Unit 4 problems

Full-or-part-time: 21h Theory classes: 2h Practical classes: 6h

Self study : 13h

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5. Basics of parallel programing: Data decomposition

Description:

Data decomposition (geometric versus recursive structure), data flow organization (regular versus irregular). Mechanisms to implement the data decomposition: creation and destruction process, process synchronization (barrier) and communications patterns (point-to-point communication, synchronous and asynchronous communication)

Related activities:

Activity 1. Data decomposition problems Activity 2. Lab 5: Geometric decomposition: solving the heat equation

Full-or-part-time: 17h Theory classes: 3h Practical classes: 4h Laboratory classes: 2h Self study : 8h

GRADING SYSTEM

1st partial knowledge test *0,2+ problems *0.1 + 0.3 * Laboratory + complementary *0.1 Working + 2nd partial knowledge test *0.3> = 5

The second partial exam can be a 2nd partial exam with a weight of 30% or a final exam with a weight of 50% in order to recover the first partial (the student chooses what to do). In this second case the formula is:

Problems * 0.1 + Laboratory * 0.3 + complementary work * 0.1 + Final knowledge test * 0.5 > = 5

The complementary work is optional, if it is done it counts for 10% of the grade, if it is not done the 1st partial exam will have a weight of 25% and the second partial 35%, or if the final is done it would have a weight of 60%.

The 1st and 2nd partial knoeledge tests are reevaluable (or final test)

EXAMINATION RULES.

Activities 1, 2 and 4 are in person.

Activity 3 is non-attendance, although there may be a short presentation in class. In the activities that take place in group the mark will be the same for all group members

BIBLIOGRAPHY

Basic:

- Mattson, Timothy G.; Sanders, Beverly A.; Massingill, Berna. Patterns for parallel programming [on line]. Boston [etc.]: Addison-Wesley, 2005 [Consultation: 14/02/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=7116 386. ISBN 0321228111.

RESOURCES

Computer material:

- Software a Boada. Connection and software in boada.ac.upc.edu

Other resources:

It is recommended to use a laptop with a terminal