DEGREE CURRICULUM

HIGH-PERFORMANCE COMPUTING

Coordination: Francesc Giné

Academic year 2014-15

2014-15

Subject's general information

Subject name	High-performance Computing
Code	103059
Semester	2nd Semester
Typology	Mandatory
ECTS credits	6
Theoretical credits	3
Practical credits	3
Coordination	Francesc Giné
Office and hour of attention	Thursday from15h30' up to 17h in the office 3.09 of EPS
Department	Computer and Industrial Engineering
Modality	Presencial
Important information on data processing	Consult this link for more information.
Language	English 100%
Degree	Master's Degree in Informatics Engineering
Office and hour of attention	Thursday from15h30' up to 17h in the office 3.09 of EPS
E-mail addresses	sisco@diei.udl.cat; jlerida@diei.udl.cat

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JOSEP LLUIS LERIDA MONSÓ

Subject's extra information

To follow this course, the student should have solid knowledge of structured programming in C language and Architecture and Computer Technology. Specifically, it is important that the student has achieved in deep the concepts of memory hierarchy and pipelining.

Learning objectives

Objectives associated with transversal skills:

- Read English with a high degree of understanding.
- Listen and understand the lessons taught in English.
- Express themselves correctly in English, using the technical vocabulary fluently.
- Explain ideas and concepts in an understandable way.
- Use appropriate vocabulary in every circumstance and to use the appropriate technical vocabulary when it is necessary.
- In oral presentations: See the audience, use the appropriate tone and volume, show empathy with the audience.
- Write clearly and accurately
- Identify the audience to which the information is addressed.
- Explain ideas and concepts in an understandable way, adapting its vocabulary to the audience.
- Listen, understand and answer appropriately to questions by a non-expert audience in the field.

Objectives associated with specific skills for the master degree:

- Know and use benchmarking tools.
- Analyze the performance of a computer from an analytical aspect.
- Know the main paradigms of parallel programming.
- Implement and debug parallel applications using the programming paradigm shared memory OpenMP
- Implement and debug parallel applications using the programming paradigm distributed memory MPI
- Know and use the tools of cloud computing
- Know and understand the operation of the main types of parallel computers
- Solve simple numerical algorithms by programming paradigm distributed memory MPI
- Solve simple numerical algorithms by programming paradigm shared memory OpenMP
- Define virtual machines using cloud tools.

Competences

University of Lleida strategic competences

- Appropriate skills in oral and written language.
- Command of a foreign language.
- Capacity to convey information, ideas, problems and solutions to both a specialized and no specialized public.
- Capacity to draft, design and implement projects and/or give novel solutions, using engineering-related tools.
- Capacity to conceive, design and implement projects and/or contribute to new solutions, using engineering tools.

Degree-specific competences

- Capacity to understand and apply advanced knowledge in high-performance computing and numerical or computational methods to problems of engineering.
- Capacity to apply mathematical, statistical and artificial intelligence methods, design and develop applications, services, intelligent systems and systems based on knowledge.

Subject contents

1. Introduction: High Performance Computing (2h f+6h NF)
2. Performance analysis and benchmarking (6h F+18h NF)
    - Metrics
    - Performance,
    - Bechmarks
    - Amdhal Law.
3. Introduction to the parallel processing (6h F+12h NF)
    - Introduction
    - Concepts
    - Parallel programming models
    - Design of parallel applications
    - Limits of the parallel processing
4. Shared-memory Parallel Programming with OpenMP (9h F+18h NF)
    - Main Characteristics
    - Parallel Regions
    - Data Scoping
    - OpenMP worksharing for loops
    - Reductions
    - Loop Scheduling
    - Synchronization
5. Distributed-memory Parallel Programming with MPI (12h P+34h NP)
    - Main Characteristics
    - Messages and Point-to-point communications
    - Collective communication
    - Grouping Data for communication
    - Communicators and Topologies
6. Cloud Computing (6h F+18h NF)
    - Cloud Essentials
    - Anatomy of the cloud
    - Oportunities
    - Amazon cloud
7. Parallel computers (3h F+9h NF)
    - Types of parallel computers
    - Vectorial processors
    - Array processors
    - Examples of Supercomputers

Methodology

Every week, each student will receive:

- Three hours of class attendance. These classes will be conducted both in the classroom, explaining the theoretical content of the course, accompanied by illustrative examples and problem solving, as the lab, explaining the contents in a more practical way. As a support material of the class, we will follow the slides for the course.
- Support materials to follow the subject in a non-attendance way.

The evaluation is continuous throughout the semester and consists of five different parts:

- A written test.
- Three practices: benchmarking, openMP and MPI.
- A report about a supercomputing infraestructure.

Development plan

- **Week 1**: Introduction: High Performance Computing
- **Weeks 2-3**: Performance analysis and benchmarking
- **Weeks 4**: Introduction to the parallel processing
- **Weeks 5-7**: Shared-memory Parallel Programming with OpenMP
- **Weeks 8-12**: Distributed-memory Parallel Programming with MPI
- **Week 9**: Partial Exam
- **Weeks 13-14**: Cloud Computing
- **Week 15**: Parallel Computers

Evaluation

There is a continous evaluation and consists of the following five tests compared with the corresponding percentage of the final mark of the course:

- First practice benchmarking: 10%
- First partial exam: 20%
- Second practice OpenMP: 20%
- Third practice MPI: 30%
- Work supercomputer - Cloud Computing: 15%
- Oral Presentation: 5%

Therefore, the final mark for the course will be:

Final grade = 10%Benchmarking+20%OpenMP+30%MPI+20%Partial Exam+15% Supercomputer Work+5% Oral Presentation
The practices of the previous year can be recognized retaining the same result obtained in the previous year.

Students who fail the continuous assessment with a score lower than 5 shall be entitled to recover the partial exam that will count 25% of the final mark.

Bibliography

I. Foster

Designing and Building Parallel Programs

Addison-Wesley, 1994

P.S. Pacheco,

Parallel Programming with MPI,

Morgan Kaufmann Publishers , 1997

-R. Chandra, L. Dagum, D. Kohr,

Parallel Programming in OpenMP,

Morgan Kaufmann Publishers , 2001