High Performance Computing

Academic Year: (2023 / 2024)	**Review date: 30-06-2021**

Department assigned to the subject: Computer Science and Engineering Department

Coordinating teacher: GARCIA BLAS, FRANCISCO JAVIER

Type: Electives ECTS Credits : 6.0

Year : 1 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Operating Systems
computer Architecture

OBJECTIVES

CORE COMPETENCES
- Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
- Students are able to apply their acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
- Students should be able to communicate their findings and the ultimate knowledge and reasons behind them to specialist and non-specialist audiences in a clear and unambiguous manner.
- That students possess the learning skills that will enable them to continue studying in a largely self-directed or autonomous manner.

GENERAL SKILLS
- Ability to project, calculate, and design products, processes and installations in all areas of computer engineering.
- Capacity for mathematical modelling, calculation and simulation in technology and engineering centres, particularly in research, development and innovation tasks in all areas related to Computer Engineering and related multidisciplinary fields.
- Ability to apply acquired knowledge and solve problems in new or unfamiliar environments within broader and more multidisciplinary contexts, with the capacity to integrate knowledge.
- Ability to communicate (orally and in writing) conclusions - and the ultimate knowledge and reasons behind them - to specialised and non-specialised audiences in a clear and unambiguous way.
- Capacity for continuous, self-directed and autonomous learning.

SPECIFIC COMPETENCES
- Ability to design and evaluate operating systems and servers, and applications and systems based on distributed computing.
- Ability to understand and apply advanced knowledge of high-performance computing and numerical or computational methods to engineering problems.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Principles of high-performance computing
1.1 Definition of high-performance systems
1.2 Definition of a computation cluster

2. Design and analysis of high performance applications.
2.1 Modeling of parallel applications
2.2 Application parallelization methodology

3. Parallel Programming Paradigms: Message Passage, Shared Memory, Data Parallelism
3.1 Message Passing (MPI)
3.2 Programming in shared memory systems (OpenMP)
3.3 Parallelism in Heterogeneous GPGPU Systems (CUDA)

4. Data parallelism using Big Data techniques
4.1 Map-Reduce Programming Paradigm
4.2 Storage systems for data intensive systems (HDFS and HBASE)

4.3 Hadoop Apache
4.4 Apache Spark

5. Performance analysis, evaluation and optimization of applications.
5.1 Performance metrics
5.2 Amdahl's Law

LEARNING ACTIVITIES AND METHODOLOGY
EDUCATIONAL ACTIVITIES
Theoretical class
Practical classes
Tutorials
Group work
Individual student work
Partial and final exams

TEACHING METHODS
- Teacher's classroom exhibitions with computer and audiovisual support, in which the main concepts of the subject are developed and the bibliography is provided to complement the students' learning.
- Resolution of practical cases, problems, etc... posed by the teacher individually or in groups.
- Preparation of papers and reports individually or in groups.

ASSESSMENT SYSTEM
The mission of evaluation is to know the degree to which the learning objectives have been met. Therefore, all the work of the student, individually or collectively, will be evaluated by means of continuous assessment of his/her activities through exercises and exams, practical work and other academic training activities described above.

Evaluation will be carried out on an ongoing basis. 50% of the grade will be obtained through continuous evaluation and the remaining 50% through a final exam. The process of continuous evaluation consists of:

SE2: Assignments 50%.
- Practices and laboratory reports, which will count for 50 % of the grade.

SE3: Final exam 50 %.
The final exam will cover all the contents of the subject.

The minimum grade to pass the course is 5 on a scale of 0 to 10.

% end-of-term-examination: 50
% of continuous assessment (assigments, laboratory, practicals…): 50

BASIC BIBLIOGRAPHY
- D. Kirk, W. Hwo. Programming Massively Parallel Processors: A Hands-on Approach, Morgan Kaufmann, 2010

- D.E. Culler, J.P. Singh, with A. Gupta. Parallel Computer Architectures: a Hardware/Software Approach, Morgan Kaufmann Pub, 1999
- Holden Karau, Andy Konwinski, Patrick Wendell & Matei Zaharia Learning Spark, O Reilly, 2015

- Martin Odersky, Lex Spoon, Bil Venners Programming in Scala, Artima.