INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Advanced computing			Field of study	Computer Engineering										
Master in	Informatics			School	School of Technology and Management										
Academic Year	2023/2024	Year of study	2	Level	2-2	ECTS credits	6.0								
Type	Semestral	Semester	1	Code	5060-710-2101-00-23										
Workload (hours)	162	Contact hours	T -	TP 60	PL -	TC -	S -	E -	OT -	O -					

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): José Carlos Rufino Amaro, Rui Alexandre Coelho Alves

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. understand the importance of high performance computing technologies
2. know how to develop high performance applications based on the main related programming models
3. know how to take advantage of cluster and cloud environments to run high performance applications

Prerequisites

Before the course unit the learner is expected to be able to:
1. know how to code programs in the C language with a medium level of complexity
2. master fundamental concepts of Computer Architecture, Operating Systems and Distributed Systems
3. be proficient in using the command line environment and development tools in Linux

Course contents

Introduction to High-Performance Computing, Shared-Memory Programming, Distributed Memory Programming, Heterogeneous Programming, High-Performance Computing Environments.

Course contents (extended version)

1. Introduction to High-Performance Computing
   - Conceitos e Terminologia
   - Classes of Parallel Systems
   - Parallel Computer Memory Architectures
   - Topics on Designing Parallel Programs
   - Parallel Programming Models
2. Shared-Memory Programming
   - Introduction to the Pthreads standard
   - Pthreads API overview
   - Thread management
   - Synchronization mechanisms
   - Application design patterns
   - Debugging and profiling
3. Distributed Memory Programming
   - Introduction to the MPI standard
   - MPI API overview
   - Task environment management
   - Point-to-Point communication
   - Collective communication
   - Derived data-types
   - Groups and communicators management
   - Debugging and profiling
4. Heterogeneous Programming
   - Introduction to the OpenCL standard
   - OpenCL API overview
   - OpenCL applications workflow
   - Kernels design and programming
   - OpenCL memory hierarchy
   - Synchronization features
   - Debugging and profiling
5. High-Performance Computing Environments
   - On-premises HPC clusters (ROCKS, OpenHPC)
   - Cloud-based HPC clusters (AWS)

Recommended reading

1. "An Introduction to Parallel Programming (2nd Edition)"; Peter Pacheco; Morgan Kaufmann, 2021
2. "Parallel Programming: Concepts and Practice"; B. Schmidt, J. Gonzalez-Dominguez, C. Hundt, M. Schlarb; Morgan Kaufmann, 2017
3. "Programming with POSIX Threads"; David Butenhof; Addison Wesley, 1997
4. "Using MPI"; W. Gropp, W. Lusk, A. Skjellum; The MIT Press, 2014
5. "Heterogeneous Computing with OpenCL 2. 0"; D. R. Kaeli, P. Mistry, D. Schaa, D. P. Zhang; Morgan Kaufmann, 2015

Teaching and learning methods

Classes in which the presentation of concepts alternates with the resolution of related exercises, complemented by practical works carried out extra-classes. All documentation (slides, exercises and practical works) is provided through an e-learning platform.

Assessment methods

- Option 1 - (Regular, Student Worker) (Final, Supplementary, Special)
   - Final Written Exam - 20%
   - Practical Work - 80%

Language of instruction

English

Electronic validation

José Carlos Rufino Amaro, Rui Alexandre Coelho Alves	Tiago Miguel Ferreira Guimaraes Pedrosa	José Eduardo Moreira Fernandes	Nuno Adriano Baptista Ribeiro
16-10-2023	25-10-2023	30-10-2023	06-11-2023