Computação em Larga Escala

Introduction to CLE

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Introduction

Teachers

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Objectives

- Introduce students to the principles of **High-Performance Computing (HPC)**.
- Familiarize them with key paradigms for **algorithm design**, **communication**, and **synchronization** in parallel programming.

Learning Outcomes

By the end of this course students will:

- Understand the main challenges of programming at different levels of parallelism (**coarse**, **medium**, and **fine**).
- Develop practical skills for designing and implementing basic parallel applications on **multiprocessing architectures**.
- Gain hands-on experience with **C/C++ parallel programming tools**, including the **std::thread library**, **MPI**, and **CUDA**.

Prerequisites

- A basic understanding of **computer architecture**.
- Familiarity with **operating systems** and **multiprogrammed environments**.
- Proficiency in **C/C++ programming** and a foundational knowledge of **concurrent programming principles**.

Syllabus

High-Performance Computing

- Overview of parallel machine architecture
- Techniques for task decomposition in parallel computing
- Understanding Amdahl's law and performance limits
- Tools and frameworks for parallel application development

Medium-Grain Parallelism

- Revisiting core concepts of computer architecture
- Principles and challenges of concurrency
- Mechanisms for synchronization in parallel systems
- Practical use of **std::thread** for thread-based programming

Syllabus

Coarse-Grain Parallelism

- Fundamentals of the message-passing paradigm
- Synchronization strategies across distributed systems
- Introduction to MPI and its programming model

Fine-Grain Parallelism

- Using GPUs for heterogeneous parallel computing
- Key structural and functional elements of GPU architecture
- Introduction to CUDA C/C++ for GPU programming
- Exploring CUDA's fine-grained parallel programming approach

Lectures & Lab Classes

Lectures

- Lectures cover key topics from the syllabus.
- Students are encouraged to actively participate in discussions, fostering critical reasoning and problem-solving skills.

Lab Classes

- Labs emphasize the principle **“learning by doing”** and focus on discussing implementation strategies for solving specific problems.

Lectures & Lab Classes

Work Assignments

- Assignment 1
  - Develop a concurrent solution for the given problems.
- Assignment 2:
  - Implement a parallel solution using message passing with MPI.
- Assignment 3:
  - Design a parallel solution using shared variables with CUDA.

Group Work

- Students collaborate in groups of two. Each group must:
  - Present their approach to problem-solving.
  - Defend their implementation during a dedicated query session.

Grading

$$\text{course grade} = \frac{5 \times \text{theorical mark} + 5 \times \text{lab mark}}{10}$$

- Rounding is always done half up to the nearest whole number, except when the lab mark exceeds the theoretical mark by more than three points; in this case, rounding is performed half down.
- **Theoretical grading:**
  - Based on a written examination (época normal ou época de recurso).
- **Lab grading:**
  - Comprised of Work Assignments 1 through 3, with each carrying equal weight.

Grading

- **Pass:** Both theoretical and lab marks must be **8.5 or higher**, and the overall course grade must be **10 or higher**.
- **Fail:** Any of the following:
  - Theoretical mark is below the minimum required.
  - Lab mark is below the minimum required.
  - Final grade is below 10.
- **Fail by Absence (regular student)**
  - More than **two** lab classes are missed – $14 \times 20\% = 2.8$
    - Regulamento de Estudos da Universidade de Aveiro (REUA) - Regulamento 833/2021, publicado em Diário da República, 2ª Série de 3 de setembro de 2021, Artigo 18.º, n.º6.

Final Remarks

- **Important Dates**
  - deadline for work assignment 1 $\longrightarrow$ 19 de Março de 2025
  - deadline for work assignment 2 $\longrightarrow$ 16 de Abril de 2025
  - deadline for work assignment 3 $\longrightarrow$ 5 de Junho de 2025
- All documentation about the course is available on the eLearning platform (Moodle).
- For further questions, refer to the course operational document or contact me directly.