058165 - PARALLEL COMPUTING

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COURSE OBJECTIVES

This course aims to understand the fundamental principles of designing modern parallel computing systems and teach parallel programming techniques.

An innovative teaching activity (1 CFU), Blended Learning & Flipped Classroom, is planned for some of the topics covered by the course.

COURSE LEARNING OUTCOME: LIFELONG LEARNING SKILLS

Students will understand how a complex parallel algorithm has to be analyzed, designed, and assessed.

They will play with real problems, understanding where pitfalls may come when you move from a theoretical formulation down to an actual implementation considering existing tools and architectures.

MAIN LECTURES TOPICS

Motivations for parallel chips, processor basics: why parallelism?

Multicore processors, SIMD processors, Memory models.

GPU architectures

Heterogenous parallel processing & Accelerators

Parallel programming abstractions: PRAM model.

Parallel programming basics: multithreading, data parallelism, shared memory space, memory consistency, synchronization.

Tools and languages for parallel programming: OpenMP, Message Passing Interface, and CUDA.

Parallel programming performance analysis and optimization.

Data and computation parallel patterns: map, reduce, scan, gather, scatter, etc.

Domain-specific programming languages: Halide. Heterogenous computing.

PREVIOUS KNOWLEDGE

Basic of computing architectures

Basic data structures

Computational Complexity theory

C/C++ knowledge could help

PC TEACHING MATERIAL

- John L. Hennessy and David A. Patterson, Computer Architecture, Sixth Edition: A Quantitative Approach, Editore: Morgan Kaufmann, 2017

- Michael McCool, James Reinders, Arch Robison, Structured Parallel Programming: Patterns for Efficient Computation, Editor: Morgan Kaufmann, 2012, ISBN: 0124159931 http://parallelbook.com/

- Peter Pacheco, An Introduction to Parallel Programming, Editore: Publisher: Morgan Kaufmann; 1 edition, 2011, ISBN: 978-0123742605

- Jason Sanders, CUDA by Example: An Introduction to General-Purpose GPU Programming. 1st Edition. , Editore: Addison-Wesley, 2010

- David Kirk and Wen-mei Hwu, Programming Massively Parallel Processors, Second Edition: A Hands-on Approach. 2nd Edition , Editor: Morgan Kauffmann, 2012

- Parallel programming online material link

- Additional material is available on the WeBeep platform of Politecnico di Milano https://webeep.polimi.it/login/index.php Note: access restricted to course participants

EXAM HOW

- Evaluation is based on a written exam

- Exam content

  - The solution of some problems based on the practical application of the course concepts and techniques

  - Open answers to some questions on the course concepts and techniques

- After each written test, the teacher can complement the assessment procedure with an oral examination

CONTINUOUS ASSESSMENT

- Continuous assessment will be implemented through two intermediate tests: one as a mid-term test and one at the end of the semester: Nov. 6 – Dec 18.

- All students are admitted to the second test, regardless of the outcome of the first one

- The achieved results will be valid till the end of the academic year or till a student asks to repeat the given part

- Each intermediate test contributed to the final grade with 16 points

- The exam is considered passed if, in both parts, the students get a grade not less than 7, and the sum of the two grades is greater or equal to 18

- 30 cum laude is assigned if students get a sum of grades greater than 30

- If either the first or the second test has a grade less than 7 or the total is less than 18, the student has to take the written test on one of the following dates according to the schedule provided by the School's Academic Calendar

- The student may use one of the valid partial results on the next exam dates. In this case, a customized written exam version will be provided to the student for the parts not yet valid

INNOVATIVE-LEARNING CLASSROOM ACTIVITIES

- Participation in innovative-learning classroom activities will be assessed and will contribute to the final evaluation grade. In case of valid grades, some questions of the written exam could be skipped.

LECTURERS

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