058165 - PARALLEL COMPUTING

Fabrizio Ferrandi

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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: Posix threads, 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.

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. 12 – Dec 19.
- 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 ask 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 particular, in case of valid grades, some questions of the written exam could be skipped.

LECTURERS

- Fabrizio Ferrandi
  - Dipartimento di Elettronica, Informazione e Bioingegneria, first floor,
  - phone. 02 2399 3479,
  - e-mail fabrizio.ferrandi@polimi.it,
  - Home page Ferrandi: http://ferrandi.faculty.polimi.it/
  - Send an e-mail to get in touch with me
- Serena Curzel
  - Dipartimento di Elettronica, Informazione e Bioingegneria,
  - e-mail serena.curzel@polimi.it,
  - Send an e-mail to get in touch with her