UNIVERSITÀ DI PISA

HIGH PERFORMANCE COMPUTING

GABRIELE MENCAGLI

Anno accademico	2020/21
CdS	INFORMATICA E NETWORKING
Codice	532AA
CFU	9

Moduli	Settore/i	Tipo	Ore	Docente/i
HIGH PERFORMANCE COMPUTING	INF/01	LEZIONI	72	GABRIELE MENCAGLI

Obiettivi di apprendimento

Conoscenze
Parallel Processing Methodologies
Shared-Memory Parallel Architectures
Distributed-Memory Architectures (basics)
Graphical Processing Units (basics)
Interconnection Networks for Parallel Machines (basics)
Cost Models and Methodologies for Performance Evaluation

Modalità di verifica delle conoscenze
Written and oral exam.

Capacità
Ability to model, analyze and implement parallel processing systems at any level, both processes and their run-time support implementations, and firmware (knowledge about the behavior of HPC-enabling platforms).

Modalità di verifica delle capacità
Written and oral exam.

Prerequisiti (conoscenze iniziali)

The needed background in Computer Architecture includes basic concepts in system level structuring, modularity and parallelism design principles, hardware and firmware machine level, assembler machine level, processes and their run-time support, communication, operating systems functionalities, input-output, memory hierarchies and caching, instruction-level parallelism, optimizing compilers. This required background is contained in the following recommended reading:
M. Vanneschi, Structured Computer Architecture Background: Appendix of the High Performance Computing course textbook, by M. Vanneschi.

Programma (contenuti dell'insegnamento)

The course deals with two interrelated issues in high-performance computing: *i)* fundamental concepts and techniques in parallel computation structuring and design, including parallelization methodologies and paradigms, parallel programming models, their implementation, and related cost models; *ii)* architectures of high-performance computing systems, including shared-memory multiprocessors, distributed-memory multicomputers, GPUs, clusters, and others. Both issues are studied in terms of structural models, static and dynamic support to computation and programming models, performance evaluation, capability for building complex and heterogeneous applications and/or enabling platforms, also through examples of application cases. Technological features and trends are studied, in particular multi-/many-core technology and high-performance networks.

Course outline: the course is structured into two parts:

• <u>*Structuring and Design Methodology for Parallel Applications*</u>: structured parallelism at applications and processes levels, cost models, impact of communications, parallel computations as queueing systems/queueing networks, parallel paradigms (Pipeline, Data-Flow, Farm, Function Partitioning, Data Parallel), parallel systems at the firmware level, instruction level parallelism (Pipeline, Superscalar, Multithreaded CPUs), SIMD architectures and GPUs;

• <u>*Parallel Architectures*</u> : shared-memory multiprocessors (SMP and NUMA architectures), distributed-memory multicomputers (Clusters and

MPP architectures), GPUs, run-time support to interprocess communication, interconnection networks, performance evaluation and multicore architectures.

Bibliografia e materiale didattico

Text book: M. Vanneschi, *High Performance Computing: Parallel Processing Models and Architectures*. Pisa University Press, 2014.

Modalità d'esame

Written and oral exam

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