Universitat Autònoma de Barcelona

2017/2018

Architecture of Parallel Computers

Code: 43342
ECTS Credits: 6

Degree	Type	Year	Semester
4314660 Computer Engineering	OB	1	2

Contact

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Use of languages

Principal working language: english (eng)

Teachers

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Daniel Franco Puntes

Prerequisites

Basic knowledge of Computer Architecture and Structure

Objectives and Contextualisation

- Know and understand the organization and operation of the different architectures of parallel computers, both internally to the compute node and at the system level
- Implement the suitable strategy and methodology for the evaluation of performance (response time, throughput, reliability, power consumption ...) in an advanced computer, including proper selection of indexes, metrics and measurement and simulation tools
- Analyze and interpret the results of the evaluation to identify and quantify the performance bottlenecks (computation, memory, communications, input / output)
- Understand, select, implement and analyze actions to improve performance

Skills

- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Communicate orally and in writing in English.
- Continue the learning process, to a large extent autonomously
- Define and communicate results, guaranteeing high levels of performance and quality.
- Design and evaluate operating systems and servers and applications and systems based on distributed computing.
- Direct work on computer systems, complying with current rules and guidelines and safeguarding the quality of the service.
- Display a spirit of enterprise and innovation and a wide-ranging vision in the search for new areas to explore in a specific field of the computer engineering profession.
- Integrate and apply the knowledge acquired and solve problems in new or little-known situations within broader (or multidisciplinary) contexts.

- Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
- Launch, lead and manage manufacturing processes for computer hardware, safeguarding persons and goods and overseeing product quality and certification
- Model, design, and define architectures, implement, manage, operate and maintain computer applications, networks, systems, services and content.
- Propose, calculate and design products, processes and installations in all areas of computer engineering.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Understand and apply advanced knowledge of high-performance computing and numerical or computational methods to engineering problems.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Learning outcomes

1. Analyse and evaluate the performance of advanced computer-system architectures, including parallel platforms, using the appropriate indices, metrics and tools.
2. Choose and use the most suitable indices, metrics and tools to evaluate and analyse the performance of a high-performance computing system.
3. Choose the most suitable high-performance architecture for an application on the basis of its computational characteristics: parallelism and locality of data access.
4. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
5. Communicate orally and in writing in English.
6. Continue the learning process, to a large extent autonomously
7. Define and communicate results, guaranteeing high levels of performance and quality.
8. Direct work on computer systems, complying with current rules and guidelines and safeguarding the quality of the service.
9. Display a spirit of enterprise and innovation and a wide-ranging vision in the search for new areas to explore in a specific field of the computer engineering profession.
10. Integrate and apply the knowledge acquired and solve problems in new or little-known situations within broader (or multidisciplinary) contexts.
11. Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
12. Interpret information on the performance of an advanced computer system and take measures to improve the system.
13. Launch, lead and manage manufacturing processes for computer hardware, safeguarding persons and goods and overseeing product quality and certification
14. Propose, calculate and design products, processes and installations in all areas of computer engineering.
15. Set up a distributed computing system to reach the desired performance levels on running a particular application.
16. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
17. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Content

- Parallel computers: design principles and types of parallelism used to improve performance. Classification.
- Hierarchy of the computer system: parallelism both internal to the compute node and in the system. Multi-core processors and multi-thread execution. Accelerators. Distributed computing systems and large-scale computers.
- Memory system hierarchy. Shared memory and distributed memory computers.
- Interconnection networks: types, configuration and topology. Routing information. Simulation and modeling of interconnection networks.

- Parallel Input / Output for High Performance Computers.
- Performance Evaluation. Metrics. Evaluation indices. Measuring Tools. Computer simulation tools. Analysis and interpretation of results. Identifying problems and bottlenecks in performance.
- Fault Tolerance in High-Performance Computers.

Methodology

- Lectures
- Laboratory Practices
- Oral presentation of work
- Based learning problems / projects
- Cooperative learning
- Personal Study
- Reading articles of interest

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Laboratory Practice	15	0.6	1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 15, 16
Lectures	26	1.04	1, 2, 3, 4, 6, 11, 12, 15, 16, 17
Type: Supervised			
Developing Jobs	15	0.6	9, 10, 11, 13
Type: Autonomous			
Assignment development	45	1.8	1, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15
Study and Lab. work preparation	30	1.2	1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 15, 16
Study and test preparation	15	0.6	6, 11, 16, 17

Evaluation

Dates of continuous assessment and delivery of papers will be published in the Virtual Campus (VC) and may be subject to programming changes for reasons of adaptation to possible incidents. Always be sure to read the VC of these changes as it is understood that it is the usual platform for information exchange between teacher and students.

Student assessment will be based on different items collected for the different activities of the subject:

Test synthesis (S, 1.5 + 1.5 points) Oral discussion and delivery of document answers

Laboratory Practice (L, 1.5 + 1.5 points) Deliver documents results, answers and conclusions.

Free Assignment (T; 3 points): From recommended readings and using performance measures, the goal is to analyze and explain the reasons for the design of a high-performance computing system. Requires oral defense and summary document. The assesment will be based on the difficulty of the proposed challenges, achieving goals, exposure and oral defense, and the written document.

Assistance (A, 1 point)

FINAL grade = L + S + T + A

Not Evaluable assessment shall be consideredin cases where the student has not been evaluated by activities involving more than 20% of the total grade, or in exceptional cases.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Assignment Presentation and Oral Defense	30%	2	0.08	4, 5, 6, 7, 8, 9, 10, 11, 13, 14
Attendance to classes and additional activities	10%	0	0	5
Interconnection Networks Lab. Assignment	15%	0	0	1, 2, 3, 5, 11, 12, 15, 16
Performance Measurement Lab. Assignment	15%	0	0	1, 2, 3, 5, 11, 12, 15, 16
Synthesis Assignment #1	15%	1	0.04	1, 4, 5, 6, 11, 12, 17
Synthesis Assignment #2	15%	1	0.04	1, 4, 5, 6, 11, 12, 15, 16, 17

Bibliography

Structured Parallel Programming: Patterns for efficient computation
M. McCool, J. Reinders, A. Robison (Elsevier) 2012

Computer Architecture: A Quantitative Approach. 5th Edition
John Hennessy, David Patterson, Morgan Kaufmann (Elsevier) 2012

Programming Massively Parallel Processors: A Hands-on Approach
D. Kirk, & W.-M. Hwu, Morgan Kaufmann (Elsevier), 2010

Parallel Programming for Multicore and Cluster Systems
T. Rauber, G. Rünger, Springer (Elsevier), 2010

Fault Tolerant Systems
I Koren, C, Mani Krishna, Morgan Kaufmann (Elsevier), 2007

Parallel I/O for High Performance Computing
John M. May, Morgan Kaufmann Publishers, 2001