



## Teaching Guide

Identifying Data					2023/24
Subject (*)	High Performance Architecture		Code	614973101	
Study programme	Mestrado Universitario en Computación de Altas Prestacións / High Performance Computing (Mod. Virtual)				
Descriptors					
Cycle	Period	Year	Type	Credits	
Official Master's Degree	1st four-month period	First	Obligatory	6	
Language	SpanishEnglish				
Teaching method	Non-attendance				
Prerequisites					
Department	Departamento profesorado másterEnxeñaría de Computadores				
Coordinador	Andrade Canosa, Diego	E-mail	diego.andrade@udc.es		
Lecturers	Andrade Canosa, Diego Tourinho Dominguez, Juan	E-mail	diego.andrade@udc.es juan.tourino@udc.es		
Web	aula.cesga.es				
General description	In this course, the students complete their knowledge about HPC architectures, to this end, we consider modern parallel architectures both from the functional point of view to their design. Thi knowledge will facilitate the student to design correct and efficient parallel algorithms based on the architectural characteristics of the target systems. Courses related with the programming will benefited from this one.				

## Study programme competences

Code	Study programme competences
A1	CE1 - Define, evaluate and select the most appropriate architecture and software to solve a problem
A2	CE2 - Analyze and improve the performance of a given architecture or software
A3	CE3 - Know the high performance computing basic concepts
A4	CE4 - Deepen in the knowledge of different programming tools and programming languages in the field of the high performance computing
A8	CE8 - Be able to apply the acquired knowledge, capabilities and aptitudes to the profesional environment, planning, managing and evaluating project in the high performance computing field
B1	CB6 - Possess and understand the knowledge that give a baseline or opportunity to be original in the development and/or application of ideas, often in a research environment
B2	CB7 - The students have to know how to apply the acquired knowledge and their capacity to solve problems in new or hardly explored environment inside wider contexts (or multidisciplinary) related to its area of development
B3	CB8 - The students have to be able to integrate knowledge and face the complexity to make judgments from information, despite being partial and limited, includes reflexions about the social and ethical responsibilities linked to the application of their judgements and knowledge
B4	CB9 - The students have to be able to communicate their conclusions, their knowledge and the reasons that hold them to specialized and non specialized audience in a clear and unambiguous manner
B5	CB10 - The students have to possess learning skills that allows them to continue to study in a mainly self-driven or autonomous manner
B6	CG1 - Be able to search and select useful information to solve complex problems, using the bibliographic sources of the field
B7	CG2 - Elaborate adqueately and originally written essays or motivated reasonings, write planings, work projects, scientific papers and formulate reasonable hypothesis
B9	CG4 - Be able to plan and do research, development and innovation tasks in high performance computing related environments
B10	CG5 - Be able to work in teams, specially multidisciplinary, and do a proper time and people management and decision taking
C1	CT1 - Use the basic technologies of the information and computing technology field required for the professional development and the long-life learning

## Learning outcomes

Learning outcomes	Study programme competences



The student will know the different types of parallel architectures and their classification.	AJ1 AJ3	BJ1 BJ5	CJ1
The student will study the basics about organization and design of a parallel architecture, both at microarchitecture level and multiprocessor systems level.	AJ2 AJ8	BJ2 BJ4 BJ6	
The student will know the design principles and main components of a multiprocessor system.	AJ2 AJ3 AJ8	BJ1 BJ3 BJ7 BJ9 BJ10	CJ1
The student will learn to analyse parallel architecture performance.	AJ2 AJ4 AJ8	BJ4 BJ7 BJ9	CJ1

Contents	
Topic	Sub-topic
Chapter 1. Parallel computers	<ul style="list-style-type: none"> <li>- Historic introduction</li> <li>- Levels of parallelism: from microarchitecture to supercomputers</li> <li>- Classification</li> </ul>
Chapter 2. Design of multiprocessors, multicores and manycores	<ul style="list-style-type: none"> <li>- Introduction</li> <li>- Architecture of multiprocessors, multicores and manycores</li> <li>- Memory architecture</li> </ul>
Chapter 3. Cache Coherence	<ul style="list-style-type: none"> <li>- Protocols</li> <li>- Snooping (UMA systems)</li> <li>- Protocols based on directories (CC-NUMA systems)</li> </ul>
Tema 4. Sincronización e consistencia de memoria en multiprocesadores	<ul style="list-style-type: none"> <li>- Primitivas de sincronización</li> <li>- Soporte hardware para sincronización</li> <li>- Implementaciones software de sincronización</li> <li>- Modelos de consistencia de memoria</li> <li>- Comparación entre os modelos de consistencia</li> </ul>
Chapter 5. Interconexión networks	<ul style="list-style-type: none"> <li>- Types of networks</li> <li>- Main components</li> <li>- Performance</li> <li>- Design</li> </ul>
Chapter 6. Distributed systems: clusters	<ul style="list-style-type: none"> <li>- Introduction</li> <li>- Cluster architecture</li> <li>- Nodes</li> <li>- Interconnection networks</li> <li>- Software</li> <li>- Tools</li> <li>- Applications</li> <li>- Load balance</li> </ul>
Chapter 7. Introduction to performance analysis.	<ul style="list-style-type: none"> <li>- Motivation</li> <li>- Basic concepts</li> <li>- Characterization of performance issues</li> <li>- Architecture features related to performance</li> </ul>

Planning				
Methodologies / tests	Competencies	Ordinary class hours	Student's personal work hours	Total hours



Workbook	A1 A3 B1 B5	22	0	22
Problem solving	A2 A4 B2 B6 B10 C1	24	24	48
Supervised projects	A8 B3 B4 B7 B9	0	72	72
Mixed objective/subjective test	B4 B7	2	0	2
Personalized attention		6	0	6

(\*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
Methodologies	Description
Workbook	The student reads electronic documents used by the lecturer in his lectures together with some bibliographic reference about specific topics of this subject.
Problem solving	Practices and exercises are done to support contents explained on workbook. Solution to these practices is evaluated through tutoring hours.
Supervised projects	Students will develop individually or joined to other students specific projects/works. Solution to these projects is evaluated through tutoring hours.
Mixed objective/subjective test	Some questions about practice and supervised projects can be done by lecturer.

Personalized attention	
Methodologies	Description
Problem solving	Laboratory practice:
Supervised projects	Lecturer and student analyse the practices done by the student.  Supervised projects: Students receive lecturer guidance about their assigned supervised projects, and the accomplishment of the scheduled goals are verified periodically.

Assessment			
Methodologies	Competencies	Description	Qualification
Problem solving	A2 A4 B2 B6 B10 C1	Valórase o correcto funcionamento, a estruturación do código, e a comprensión dos conceptos traballados. Tamén valórase a participación activa do estudante durante as sesións de prácticas.	39
Supervised projects	A8 B3 B4 B7 B9	No caso de desenvolvemento de código, valoranse os mesmos aspectos que nas prácticas. No caso de traballos escritos, valorase a capacidade de comprensión e síntesis sobre o tema proposto, e a calidade da presentación.	59
Mixed objective/subjective test	B4 B7	Tanto no caso das prácticas como dos traballos tutelados o profesor pode facer preguntas concretas aos estudantes que poden complementar a avaliación.	2

Assessment comments
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The evaluation of this subject is based on academic tasks (60%) and labs together with the tracking of an active participation in class (40%).

Evaluation in the first opportunity (January): It will follow the continuous evaluation described before. There will not be a written exam.

Evaluation in the second opportunity (July): It will be necessary to handle the academic works and labs not handled or failed in the first opportunity. There will no be exam.

NO-SHOW policy: A student will be considered no-show when it has not submitted any task or practice during the course.

During the evaluation, the teacher can ask students to identify themselves using an ID document or passport, or performing the additional checks that they require. The online students can be asked a digital certificate or an affidavit of the autorship of the handled tasks or labs.

Part-time students: These students will have scheduling flexibility for the handling of the academic works and they can make use of teacher's office hours.

### Sources of information

<b>Basic</b>	Dado que se tratan de reflectir non soamente os fundamentos da arquitectura de supercomputadores senón tamén os avances máis recentes, moita da información bibliográfica consultarase en artigos publicados en revista e dispoñibles online e noutras fontes de consulta dispoñibles online. A bibliografía básica necesaria para seguir cada parte da materia a irá indicando o profesor durante as clases. Bibliografía básica. Os libros polos que se segue máis directamente partes da materia son:1. Arquitectura de Computadores, Xullo Ortega, Mancia Anguita e Alberto Prieto. Thompson. 2005.2. High Performance Cluster Computing, Rajkumar Buyya, ed., Prentice Hall PTR, 1999. ISBN 0-13-013784-7, 0-13-013785-5.
<b>Complementary</b>	Bibliografía complementaria. Os seguintes son libros que permiten consultar máis en profundidade algúns contidos:1. Parallel Computer Architecture, David E. Culler, Jaswinder Pal Singh e Anoop Gupta. Morgan Kaufmann Publishers. 1999.2. In Search of Clusters, 2ª ed., Gregory Pfister, Prentice Hall, 1998, ISBN: 0138997090.3. Organización e Arquitectura de Computadores (7ª edición), W. Stallings. Prentice Hall. 2007.4. Computer Architecture: a Quantitative Approach (6ª edición), John L. Hennessy e David A. Patterson. Morgan Kaufmann Publishers. 2017.

### Recommendations

#### Subjects that it is recommended to have taken before

#### Subjects that are recommended to be taken simultaneously

Parallel Programming/614473102

#### Subjects that continue the syllabus

Heterogeneous Programming/614473103

HPC on the Cloud/614473106

Advanced Parallel Programming/614473107



Other comments

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.