Teaching Guide				
Identifying Data				2023/24
Subject (*)	Parallel Processing		Code	614G02023
Study programme	Grao en Ciencia e Enxeñaría de Datos			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	1st four-month period	Third	Obligatory	6
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Enxeñaría de Computadores			
Coordinador	Enes Álvarez, Jonatan	E-mail	jonatan.enes@udc.es	
Lecturers	Enes Álvarez, Jonatan	E-mail	jonatan.enes@udc.es	
Web				
General description	In this subject, the student will learn the basic role that the use of parallelism plays when it comes to accelerating the execution of programs in general, and of massive data processing in particular. The theory knowledge will start with the most basic concepts of parallelism, including its usefulness and applicability, the basic technical context of parallel programs, and the historical evolution (Chapter 1). Next, the main current hardware technologies that are used for parallel processing will be analyzed, includign their underlying technical details that allow to exploit parallelism out of programs (Chapter 2). After this, more advanced concepts regarding parallelism will be introduced, as well as classifications systems, software design patterns that allow to implement parallel programs, and techniques to measure the performance of such programs (Chapter 3). Finally, all of this acquired knowledge will be applied to study the state-of-the-art Big Data technologies and frameworks which allow for massive data processing (Chapter 4). On the more practical side of the subject, the student will complete several sessions with an incremental approach in order to gain the knowledge and ability to program and deploy solutions for parallel processing. These sessions will start with simple technical approaches and abilities, and will progress towards more complete solutions, which will be increasingly related with data processing. In addition, these practical sessions will be self-contained and heavily focused to solving problems or scenarios with several specific techniques or technologies. This subject has a strong dependency with previous subjects like "Fundamentals of Programming I and Fundamentals of Programming II", mostly due to the technical programming ability, and with "Design and Analysis of Algorithms" for the knowledge to analyze the complexity of algorithms and programs. To a lesser extent, knowledge from the subject "Fundamentals of Computers" is advisable to understand the empirical behavior and the overall efficiency of some programs.			

Study programme competences / results	
Code	Study programme competences / results
A12	CE12 - Capacidade de coñecer e aplicar os principios fundamentais, principais paradigmas e técnicas da programación paralela e distribuída ao desenvolvemento de algoritmos para o procesamento e análise masiva de datos.
B2	CB2 - Que os estudantes saiban aplicar os seus coñecementos ao seu traballo ou vocación dunha forma profesional e posúan as competencias que adoitan demostrarse por medio da elaboración e defensa de argumentos e a resolución de problemas dentro da súa área de estudo
B3	CB3 - Que os estudantes teñan a capacidade de reunir e interpretar datos relevantes (normalmente dentro da súa área de estudo) para emitir xuízos que inclúan unha reflexión sobre temas relevantes de índole social, científica ou ética
B4	CB4 - Que os estudantes poidan transmitir información, ideas, problemas e solucións a un público tanto especializado como non especializado

B7	CG2 - Elaborar adecuadamente e con certa orixinalidade composicións escritas ou argumentos motivados, redactar plans, proxectos de traballo, artigos científicos e formular hipóteses razoables.
B8	CG3 - Ser capaz de manter e estender formulacións teóricas fundadas para permitir a introdución e explotación de tecnoloxías novas e avanzadas no campo.
B9	CG4 - Capacidade para abordar con éxito todas as etapas dun proxecto de datos: exploración previa dos datos, preprocesado, análise, visualización e comunicación de resultados.
B10	CG5 - Ser capaz de traballar en equipo, especialmente de carácter multidisciplinar, e ser hábiles na xestión do tempo, persoas e toma de decisións.
C1	CT1 - Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida.
C4	CT4 - Valorar a importancia que ten a investigación, a innovación e o desenvolvemento tecnolóxico no avance socioeconómico e cultural da sociedade.

Learning outcomes			
Learning outcomes	Study programme competences / results		
Know of and understand the technical requirements and the current technologies that allow for parallelism.	A12	B8 B9	
Know of the different currently available technologies to implement parallelism, their applicability, limits, advantages and disadvantages.	A12	B4 B8 B9	
Be able to use parallelism techniques to adapt existing solutions so that they allow parallel processing.	A12	B2 B4 B7 B8 B9 B10	C1
Be able to analyze the performance if a processing solution, with and without parallelization.	A12	B2 B4 B7 B8 B9 B10	C1
Understand the role that parallelization plays in today's society when it comes to key data processing tasks for society, business and research.	A12	B3 B4 B8 B10	C4

Contents	
Topic	Sub-topic
Chapter 1 - Introduction and previous concepts	* The process and sequential program * Lifecycle of a process * Threads * Paralell program * Usefulness of parallelism

Chapter 2 - Hardware parellelism, hierarchy	* Levels of parallelism * Internal processor parallelism (hidden) * Processor functionalities (low-level parallelism) * Processor accessible resources (high-level parallelism) * Pool of machines (Cluster and Supercomputer) * Distributed computing * Specific devices * State of the art of processors
Chapter 3 - Software parallelism, design and implementation	* Flynn taxonomy * Frameworks and languages for parallelism * Key concepts * Paradigms for parallel processing * Parallel programs analysis * Parallel programs design
Chapter 4 - Parallelism for Big Data	* Data storage * Resource and execution management * Batch processing * Streaming processing

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A12 B3 B8 B9 C4	20	30	50
Laboratory practice	A12 B2 B4 B7 B9 B10 C1	20	60	80
Objective test	A12 B2 B4 B7 B9 C1 C4	3	11	14
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
Guest lecture / keynote speech	* Theory sessions will introduce the basic knowledge later used on practice sessions. * Other concepts will also be explained in detail, either because they are key to understand the technologies and techniques used on the practice sessions, or because they are more advanced and are crucial to understand the paper that parallelism has on nowadays society.

Laboratory practice	* Each practice lessons will be briefly explained by the teacher on a lesson class, and the students are expected to start it right away. * Practice sessions will be self-contained and will deal with several specific problems or scenarios where parallelism plays an important role and where previously explained techniques or technologies are used. * Each practice will focus on a single scenario or problem and will be composed of previous description and explanation, a proposed code to be analyzed and used, and a series of questions to work on. The student will have to work on the practice, starting on its first practice session and then continuing on its out-of-classroom time. The questions can range from performing an extension of the code, to performing an empirical study of its performance using several parallelism configurations, describing its behavior or functioning, or other types of questions overall focused at assessing the degree to which the student comprehended the problem and the solution. _____
Objective test	* At the end of the term, and exam will be carried out to evaluate all the subject's knowledge, primarily the concepts from the theory sessions, but also to a lesser extent the ones from the practice sessions.

Personalized attention	
Methodologies	**Description**
Guest lecture / keynote speech Laboratory practice	* Personalized attention will focus on supporting the students with the overall subject. * On the one hand, personalized attention will be available for those that have some issue understanding any concept exposed on the theory sessions, so that no student has any difficulty in keeping up with the classes and with those topics that will be the subject of evaluation. * On the other hand, personalized attention will also be available for any student that requires some help with specific issues that arise from the practice lessons, whether they are due to technical problems or more deep understanding issues of the key concepts dealt with. Although this help will be available for any practice lesson throughout the term, it is advisable to deal with any doubt or problem either during the practice lesson or shortly afterwards. _____ Those students with an approved dispensation for non-attendance at classes can also benefit by using this personalized attention to ask for the practice briefing as it was given during the ordinary practice classes.

Assessment			
Methodologies	**Competencies / Results**	**Description**	**Qualification**
Laboratory practice	A12 B2 B4 B7 B9 B10 C1	* All the practice lessons will be assessed and graded. Such assessments can be individual using a questionare, or in a group through a submission. Groups will be formed previously and once created, can not be changed throughout the course. * The dates and timelines for practice assessments and submissions will be previously informed to the students. _____ ____	50

Objective test	A12 B2 B4 B7 B9 C1 C4	* Written exam carried out individually at the end of the term. * It will mainly evaluate and assess concepts from the theory lessons. * To a lesser point, some questions will also be present to re-asses key concepts from the practice lessons.	50

Assessment comments
In order to pass the subject:a minimum of 40% is required on the objective test, or final exam (2 points out of 5).a minimum of 40% is required on the practice lessons (2 points out of 5).Practice sessions will be NON REPEATABLE for the second chance.Part-time students can attend any practice class group, once it has been previously notified.Part-time students or students with approved dispensation for non-attendance at classes can submit their practice lessons taking into account the longest group-specific deadline available. In case a practice lesson is assessed using a quiz, a different date will be previously negotiated if needed.In order to comply with the current legislation in regards to gender equality, 2 measures will be taken:Parity groups are to be formed, as much as possibleAll the quizzes and the final objective test will be corrected using a blind method in order to assure the student's anonimity.

Sources of information	
Basic	- ---------- (Tema 1). ---------- . - Jesús Carretero Pérez (2021). Sistemas operativos: una visión aplicada . Madrid : McGraw-Hill - Francisco Almeida (2008). Introducción a la programación paralela. Madrid : Paraninfo Cengage Learning - ---------- (Tema 2). ---------- . - Sarah L. Harris (2021). Digital design and computer architecture. Amsterdam : Elsevier, Morgan Kaufmann - Julio Ortega Lopera (2005). Arquitectura de computadores. Madrid : Thomson - David A. Patterson (2014). Computer organization and design: the hardware/software interface. Waltham, MA : Morgan Kaufmann - ---------- (Tema 3). ---------- . - Giancarlo Zaccone (2015). Python parallel programming cookbook. Packt Publishing - Jan Palach (2014). Parallel programming with Python. Packt Publishing - ---------- (Tema 4). ---------- . - Tomasz Drabas (2017). Learning PySpark. Packt Publishing
Complementary	- William Stallings (2005). Sistemas operativos: aspectos internos y principios de diseño. Madrid : Pearson - Bertil Schmidt (2017). Parallel programming: concepts and practice. Cambridge, MA : Morgan Kaufmann - Peter S. Pacheco (2021). An introduction to parallel programming. Burlington, MA : Morgan Kaufmann - Jorge Luis Ortega-Arjona (2010). Patterns for parallel software design. Sussex, UK: Wiley series in software design patterns - John L. Hennesy (2019). Computer architecture: a quantitative approach. Cambridge, Massachusetts : Morgan Kaufmann - Vijay Srinivas Agneeswaram (2014). Big Data analytics beyond Hadoop: real-time applications with Storm, Spark, and more Hadoop alternatives. Upper Saddle River, NJ : Pearson Education

Recommendations
Subjects that it is recommended to have taken before
Design and Analysis of Algorithms/614G02011 Fundamentals of Computers/614G02005 Fundamentals of Programming II/614G02009 Fundamentals of Programming I/614G02004
Subjects that are recommended to be taken simultaneously
Algorithms/614G03008
Subjects that continue the syllabus
Advanced Parallel Processing /614G02034

Other comments
It is recommended to have some knowledge and ability to program with Python, as all it will be the language used for all of the practice lessons.It is recommended to have some degree of expertise with a Linux operating system, mainly process and filesystem management.