



| Teaching Guide      |   |        |  |         |
|---------------------|---|--------|--|---------|
| Identifying Data    |   |        |  | 2021/22 |
| Subject (*)         | Concurrency and Parallelism   | Code   | 614G01018  |         |
| Study programme     | Grao en Enxeñaría Informática   |        |  |         |
| Descriptors         |   |        |  |         |
| Cycle               | Period  | Year   | Type   | Credits |
| Graduate            | 2nd four-month period   | Second | Obligatory   | 6       |
| Language            | SpanishGalicianEnglish  |        |  |         |
| Teaching method     | Hybrid  |        |  |         |
| Prerequisites       |   |        |  |         |
| Department          | Ciencias da Computación e Tecnoloxías da InformaciónComputaciónEnxeñaría de Computadores  |        |  |         |
| Coordinador         | Paris Fernandez, Javier   | E-mail | javier.paris@udc.es  |         |
| Lecturers           | Darriba López, Diego<br>Enes Álvarez, Jonatan<br>Fraguela Rodriguez, Basilio Bernardo<br>González Domínguez, Jorge<br>Otero Freijeiro, David<br>Paris Fernandez, Javier<br>Pérez Vila, Miguel Anxo<br>Quintela Carreira, Juan Jose<br>Ramos García, Lucia<br>Sanchez Penas, Juan Jose<br>Tourinho Dominguez, Juan<br>Veiga Fachal, Jorge  | E-mail | diego.darriba@udc.es<br>jonatan.enes@udc.es<br>basilio.fraguela@udc.es<br>jorge.gonzalezd@udc.es<br>david.otero.freijeiro@udc.es<br>javier.paris@udc.es<br>anxo.pvila@udc.es<br>juan.quintela.carreira@udc.es<br>l.ramos@udc.es<br>juan.jose.sanchez.penas@udc.es<br>juan.tourino@udc.es<br>jorge.veiga@udc.es |         |
| Web                 | campusvirtual.udc.es  |        |  |         |
| General description |   |        |  |         |
| Contingency plan    | <p>1. Modifications to the contents</p> <p>No changes.</p> <p>2. Methodologies</p> <p>There will be no change to the teaching methodologies.</p> <p>3. Mechanisms for personalized attention to students</p> <p>email: daily. Students may contact their teacher through email to ask question about the lectures or the laboratory assignments.</p> <p>teams: daily. Students may ask for a meeting on teams to ask questions about the lectures or the laboratory assignments.</p> <p>4. Modifications in the evaluation</p> <p>No changes to the evaluation.</p> <p>*Evaluation observations:</p> <p>No changes.</p> <p>5. Modifications to the bibliography or webgraphy</p> <p>No changes.</p> |        |  |         |



| Study programme competences / results |  |
|---------------------------------------|--|
| Code                                  | Study programme competences / results  |
| A12                                   | Coñecemento e aplicación dos procedementos algorítmicos básicos das tecnoloxías informáticas para deseñar solucións a problemas, analizando a idoneidade e a complexidade dos algoritmos propostos.  |
| A20                                   | Coñecemento e aplicación dos principios fundamentais e técnicas básicas da programación paralela, concorrente, distribuída e de tempo real.  |
| B3                                    | Capacidade de análise e síntese  |
| C4                                    | Desenvolverse para o exercicio dunha cidadanía aberta, culta, crítica, comprometida, democrática e solidaria, capaz de analizar a realidade, diagnosticar problemas, formular e implantar solucións baseadas no coñecemento e orientadas ao ben común. |
| C6                                    | Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.  |
| C8                                    | 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 |    |          |
| The student should know basic algorithms and how to apply them to solve problems, analyzing the adequacy and complexity of the proposed concurrent and parallel algorithms. | A12                                   | B3 | C4       |
| The student should know how to apply the fundamentals of real time, parallel, concurrent and distributed programming.   | A20                                   |    | C6<br>C8 |

| Contents                                |  |
|---|--|
| Topic                                   | Sub-topic  |
| T1. Concurrent programming fundamentals | 1.1 Concepts<br>1.1.1 Hardware architectures<br>1.1.2 Operating Systems<br>1.1.3 Threads and Processes<br>1.2 Multiprocess programming (fork/join)<br>1.3 Multithread programming<br>1.4 Critical section<br>1.5 Mutual exclusion<br>1.6 Atomic instructions<br>1.7 Condition synchronization<br>1.8 Semaphores<br>1.8.1 Mutex<br>1.8.2 Semaphores<br>1.9 Deadlock. Prevention, avoidance, recovery<br>1.10 Starvation<br>1.11 Communication and synchronization<br>1.12 Scalability |
| T2. Concurrent Algorithms               | 2.1 Producers/consumers.<br>2.2 Readers/writers<br>2.3 Dining philosophers<br>2.4 Shared nothing   |



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| T3. Parallel programming principles                | 3.1 Concepts<br>3.1.1 Levels of parallelism<br>3.1.2 Data dependencies<br>3.2 Message passing model<br>3.2.1 Basic concepts<br>3.2.2 Point to point communication<br>3.2.3 Collective operations<br>3.3 Analysis of parallel algorithms<br>3.3.1 Performance measure of parallel algorithms<br>3.4 Methodology for parallel programming<br>3.4.1 Task decomposition<br>3.4.2 Task assignment<br>3.4.3 Optimization techniques<br>3.5 Schemes for parallel algorithms<br>3.5.1 Single Process Multiple Data<br>3.5.2 Master/slave paradigm |
| T4. Design of parallel algorithms and applications | 4.1 Message passing libraries<br>4.2 Case of study<br>4.3 Performance evaluation<br>4.4 Inclusion of optimization techniques  |

| Planning                        |                        |                                      |                               |             |
|---------------------------------|------------------------|--------------------------------------|-------------------------------|-------------|
| Methodologies / tests           | Competencies / Results | Teaching hours (in-person & virtual) | Student?s personal work hours | Total hours |
| Guest lecture / keynote speech  | A12 A20 C4 C6 C8       | 30                                   | 45                            | 75          |
| Mixed objective/subjective test | A12 A20 B3 C4 C6       | 3                                    | 0                             | 3           |
| Laboratory practice             | A12 A20 B3 C8          | 16                                   | 24                            | 40          |
| Problem solving                 | B3 C6                  | 10                                   | 19                            | 29          |
| Practical test:                 | A12 A20 B3             | 2                                    | 0                             | 2           |
| Personalized attention          |                        | 1                                    | 0                             | 1           |

(\*)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  | Lecture with audiovisual reinforcement materials, and questions directed at the students to reinforce the transmission of concepts and improve the learning process. |
| Mixed objective/subjective test | Written exam with questions about the content of the lectures and the practical problems solved in the laboratory practice.  |
| Laboratory practice             | Practical activities aimed at enhancing the comprehension of the material by the students, such as programming exercises.  |
| Problem solving                 | Solving of concrete problems that appeared during the laboratory practice, possibly exploring multiple solutions.  |
| Practical test:                 | Tests about the contents of the laboratory practices. Part of the ongoing evaluation.  |

| Personalized attention |             |
|------------------------|-------------|
| Methodologies          | Description |
|                        |             |



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| Laboratory practice<br>Problem solving | <p>During the laboratory practice, seminars and problem solving sessions students will be able to ask questions about the contents. The teacher, after considering these questions, will reinforce specific topics, solve problems that involve the concepts that are unclear, or any other activity that may help to improve the understanding of the content.</p> <p>All tutoring sessions will be held online.</p> |
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| Assessment                      |                        |  |               |
|---------------------------------|------------------------|--|---------------|
| Methodologies                   | Competencies / Results | Description  | Qualification |
| Practical test:                 | A12 A20 B3             | Ongoing assesment exams on the contents of the lectures and the laboratory practices.  | 20            |
| Laboratory practice             | A12 A20 B3 C8          | Practical exercises divided on two blocks: concurrency and parallelism. Each block is worth 50% of the laboratory practice grade. Exercises can be solved in groups of two, but will be graded individually.                           | 30            |
| Mixed objective/subjective test | A12 A20 B3 C4 C6       | Exam on the contents explained during the lectures and practiced in the laboratory. There will be two parts: concurrency (topics T1 and T2) and parallelism (topics T3 and T4). Each part is worth 50% of the grade of the mixed test. | 50            |

| Assessment comments  |
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| <p>The final grade will be the weighted addition of the mixed test, the laboratory practice grades, and the practical test grades. In order to pass it is necessary to get at least 50% of the maximum grade.</p> <p>For the July evaluation only the mixed test will be graded again (70% of the total grade).</p> <p>The grade obtained during the term in the laboratory practice (30% of the final grade) and the practicas tests (20% of the final grade) will be used for both the June and July evaluations. The grade for the laboratory practices will not be reassessed during the second opportunity. The evaluation of the laboratory practices must be done in the group assigned to each student.</p> <p>No special consideration will be given to students with part time enrollment.</p> |

| Sources of information |  |
|------------------------|--|
| <b>Basic</b>           | <ul style="list-style-type: none"> <li>- Doug Lea (2000). Concurrent programming in Java design, principles and patterns . Reading, Massachusetts: Addison Wesley</li> <li>- Joe Armstrong (2007). Programming Erlang: Software for a Concurrent World. United States: Pragmatic Programmers</li> <li>- Francisco Almeida [et al.] (2008). Introducción a la Programación Paralela. Madrid: Paraninfo Cengage Learning</li> <li>- Peter S. Pacheco (1997). Parallel Programming with MPI. San Francisco, California : Morgan Kauffman</li> </ul> |
| <b>Complementary</b>   | - Wilkinson, B. y Allen, M.. (1999). Parallel Programming. Techniques and Applications Using Networked Workstations and Parallel Computers. . Upper Saddle River, New Jersey : Prentice Hall,  |

| Recommendations  |
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| <b>Subjects that it is recommended to have taken before</b>  |
| Programming II/614G01006<br>Algorithms/614G01011<br>Computer Structure/614G01012<br>Programming Paradigms/614G01014<br>Software Design/614G01015 |
| <b>Subjects that are recommended to be taken simultaneously</b>  |
| Operating Systems/614G01016<br>Networks/614G01017<br>Software Process/614G01019  |



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| Subjects that continue the syllabus        |
| Internet and Distributed Systems/614G01023 |
| Other comments                             |
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(\*)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.