270648 - PPTM - Parallel Programming Tools and Models

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 701 - DAC - Department of Computer Architecture
Academic year: 2019
Degree: MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: English

Degree competences to which the subject contributes

Basic:
CB7. Ability to integrate knowledges and handle the complexity of making judgments based on information which, being incomplete or limited, includes considerations on social and ethical responsibilities linked to the application of their knowledge and judgments.
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.

Specific:
CEE4.2. Capability to analyze, evaluate, design and optimize software considering the architecture and to propose new optimization techniques.
CEE4.3. Capability to analyze, evaluate, design and manage system software in supercomputing environments.

Generical:
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.

Teaching methodology

For the part devoted to programming models, theory classes to understand the concepts behind parallel programming models for current supercomputing architectures. This will be followed by a general introduction of the main techniques and basic features of major tools. Laboratory classes will start by introducing advanced features in the most used programming models and the usage of the tools on some simple examples. Then the student will be faced with a few relatively large codes that will have to be analyzed with different tools and optimized using hybrid programming models.

Learning objectives of the subject

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 36h</th>
<th>24.00%</th>
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</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>18h</td>
<td>12.00%</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>96h</td>
<td>64.00%</td>
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## Content

### Basic concepts in parallel programming and performance analysis

**Degree competences to which the content contributes:**

**Description:**
Necessary background to follow an advanced parallel programming course. Issues when programming multicore architectures. General introduction of the main techniques and basic features of current performance analysis tools.

### Advanced shared- and distributed-memory programming: OpenMP and MPI

**Degree competences to which the content contributes:**

**Description:**
Summary of basic features in OpenMP and MPI. Advanced features in OpenMP, MPI and hybrid programming.

### Advanced dataflow programming and novel paradigms for accelerator-based architectures

**Degree competences to which the content contributes:**

**Description:**
Dataflow paradigms (OmpSs). Runtime exploitation of parallelism and architecture hiding. Advanced parallel programming using accelerators: CUDA, OpenCL, OpenACC, ...

### Data acquisition and performance analytics

**Degree competences to which the content contributes:**

**Description:**
Tracing of sequential and parallel applications. Trace processing and performance analytics.

### Models and performance prediction

**Degree competences to which the content contributes:**

**Description:**

### Analysis and optimization of real applications

**Degree competences to which the content contributes:**
Description:
Analysis of two large applications (sequential and/or parallel) and optimization using hybrid programming paradigms (dataflow, shared- and distributed-memory and accelerators).

Qualification system
The evaluation of the course will be based on a set of practical works. At least two major applications will have to be evaluated by each student. At least one of the applications will be in an area to which the student has no previous exposure. A detailed analysis report of the performance "problems" of each application will be required, including a detailed quantification of their importance and suggestions of potential ways to overcome them.

Bibliography