An experience of early initiation to parallelism in the Computing Engineering Degree at the University of Murcia, Spain

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### Parallelism at the Univ. of Murcia

**Present situation**

<table>
<thead>
<tr>
<th>Course</th>
<th>First semester</th>
<th>Second semester</th>
<th>Third semester</th>
<th>Fourth semester</th>
<th>Fifth semester</th>
<th>Sixth semester</th>
</tr>
</thead>
</table>

- Parallelism in System courses from the third semester.
- Basic concepts of concurrency and distributed computing in a programming course in the fourth semester.
- Algorithmic aspects are not studied in any compulsory course.
- Intensification in parallelism in some specializations, but parallelism is not included in all the specializations.

⇒ Computer Science students at the University of Murcia can obtain their degree without having developed and optimized any parallel code.

#### Early Adopters project

<table>
<thead>
<tr>
<th>Course</th>
<th>First semester</th>
<th>Second semester</th>
<th>Third semester</th>
<th>Fourth semester</th>
<th>Fifth semester</th>
<th>Sixth semester</th>
</tr>
</thead>
</table>

- Four compulsory courses in the second year of the degree. Two courses already included parallelism; two courses include topics of parallelism for the first time.
- Systems and Programming courses, with topics in the four parallelism aspects of the IEEE TCPP curriculum.
- Three departments and a Computing Centre: coordinated treatment of the topics.

### Topics of the IEEE TCPP curriculum dealt with in the project

<table>
<thead>
<tr>
<th>Topic or course</th>
<th>Previous</th>
<th>First semester</th>
<th>Second semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture classes</td>
<td>0.5 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Supercalar</td>
<td>0.5 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SMID/Vector</td>
<td>0.5 K</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pipelines</td>
<td>6 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Osx execution</td>
<td>4 X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Multicore</td>
<td>1 K</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NUMA (shared memory)</td>
<td>0.5 K</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cache organization</td>
<td>2 K</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Atomicity</td>
<td>2 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Impact memory hier. on soft.</td>
<td>3.5 A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cycles per instr.</td>
<td>0.5 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Benchmarks</td>
<td>0.5 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Spec marks</td>
<td>0.5 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Peak performance</td>
<td>0.5 K</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MIPs/FLOPS</td>
<td>1 C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sustained performance</td>
<td>0.5</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- **Shared memory**
  - 12 A
- **Distributed memory**
  - 12 C
- **Client-server**
  - 0.5 C
- **Task/thread spawning**
  - 2.5 A
- **SPMD**
  - 2 C
- **Shared memory notations**
  - 10 A
- **Language extensions**
  - 1 K
- **Libraries**
  - 10 A
- **SPMD notations**
  - 3 A
- **MPI**
  - 3 C
- **Semantic tasks and threads**
  - 5.5 C
- **Synchronization**
  - 2 A
- **Critical regions**
  - 2.5 A
- **Producer-consumer**
  - 1.5 A
- **Monitors**
  - 4 A
- **Deadlocks**
  - 0.5 K
- **Memory models**
  - 0.5 K
- **Scheduling and comp.**
  - 2 C
- **Decomposition strategies**
  - 1 K
- **Loop fusion**
  - 0.5 A
- **Scheduling and mapping**
  - 3 C
- **Performance monitoring**
  - 2 A
- **Performance metrics**
  - 1.5 C
- **Speed-up**
  - 2 C
- **Amdahl’s law**
  - 1 C

- **Asymptotics cost.**
  - 0.5 C
- **Time**
  - 0.5 C
- **Space**
  - 0.5 C
- **Speed-up**
  - 0.5 C
- **Notions from scheduling**
  - 1 K
- **Divide and Conquer**
  - 0.5 A
- **Broadcast**
  - 0.5 K
- **Asynchrony**
  - 1 K
- **Synchronization**
  - 1 A
- **Sorting**
  - 0.5 A
- **Graph-search**
  - 0.5 K
- **Specialized computations**
  - 1 K

- **Why and what is PDC.**
  - 1 C
- **Concurrency**
  - 1 C
- **Non-determinism**
  - 1 A
- **Power**
  - 0.5 K
- **Locality**
  - 1.5 C
- **Security in Dist. systems**
  - 1 K

In red are the new topics and those treated in more depth.

#### Approximate number of hours devoted in each course to each part of the curriculum (previously treated/included in the project):

<table>
<thead>
<tr>
<th>Course</th>
<th>Architecture</th>
<th>Programming</th>
<th>Algorithms</th>
<th>Cross Cutting</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>POS</td>
<td>0 / 1</td>
<td>0 / 5</td>
<td>-</td>
<td>0 / 0.5</td>
<td>0 / 6.5</td>
</tr>
<tr>
<td>ACA</td>
<td>21 / 1</td>
<td>13 / 0</td>
<td>-</td>
<td>2 / 0.5</td>
<td>36 / 1.5</td>
</tr>
<tr>
<td>CDF</td>
<td>1 / 0.5</td>
<td>42 / 13</td>
<td>2.5 / 0</td>
<td>3 / 0</td>
<td>48.5 / 13.5</td>
</tr>
<tr>
<td>ADS</td>
<td>0 / 1.5</td>
<td>0 / 13.5</td>
<td>0 / 5.5</td>
<td>-</td>
<td>0 / 20.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>22 / 4</td>
<td>55 / 31.5</td>
<td>2.5 / 5.5</td>
<td>5 / 1</td>
<td>84.5 / 42</td>
</tr>
</tbody>
</table>

#### Funding

This work is supported by Intel through the IEEE TCPP Early Adopters program, and partially supported by the Consellería de Educación de la Región de Murcia (Fundación Séneca, 08/63/PI/08).

More information: [http://www.um.es/earlyadopters](http://www.um.es/earlyadopters)