Preparing Computer Science Students for An Increasingly Parallel World
Teaching Parallel Computing Early and Often

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The widespread deployment of multicore-based computer systems over the last decade has brought about drastic changes in the software and hardware landscape. However, most undergraduate computer science (CS) curricula have not embraced the pervasiveness of parallel computing. In their first years, CS undergraduates are typically exclusively trained to think and program sequentially. However, too firm a root in sequential thinking can be a non-trivial barrier for parallel thinking and computing. Thus, there is an urgent need to teach multicore and parallel computing concepts earlier and often in CS programs.

This project addresses the rapidly widening gap between highly parallel computer architectures and the sequential programming approach taught in traditional CS courses. It proposes to systematically integrate parallel computing into current undergraduate curricula. Specifically, its goals are to develop course modules and projects for introducing parallel computing concepts in several early computer science courses, to design an upper-level multicore programming course that serves as a capstone for parallel computing concepts, and to promote this model by making all relevant material freely available.

The Early and Often Approach

<table>
<thead>
<tr>
<th>Level of Abstraction</th>
<th>Level</th>
<th>A. Elementary Notions</th>
<th>B. Parallelization Techniques and Parallel Algorithms</th>
<th>C. Parallel Architectures</th>
<th>D. Task Orchestration</th>
<th>E. Performance</th>
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<tbody>
<tr>
<td></td>
<td>high</td>
<td>Concurrency and Parallelism, Decomposition, Power and Performance</td>
<td>SMP, Clusters, NUMA, UMA, Cache Sharing, Cache Coherence</td>
<td>Communication, Synchronization, Scheduling for Power and Performance, Data Dependence</td>
<td>Speedup, Efficiency, Scalability, Cache Locality, Load Balancing, Complexity Analysis</td>
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Breaks away from traditional mode of teaching parallel programming as an upper-level elective

- Introduce parallelism early in the curriculum in required courses
- Repeat key concepts in different courses throughout the curriculum
- Tie concepts together in an upper-level capstone course

Module Principles

1. modules should be classified and introduced based on level of abstraction
2. modules should provide parallel context to existing content
3. modules should be self-contained for easy adoption across different institutions

Modules available on website starting Summer 2013

Example Module

Name: Task Orchestration - scheduling and mapping
Topics: Scheduling algorithms for multi-processor systems, affinity-based scheduling, energy-aware scheduling
Length: 2 lectures (@ 1 hour and 20 minutes each)
Projects: Derive an optimal affinity-based schedule for a loop-based application (e.g., an n-body simulation). OpenMP implementation and supporting framework provided with module
Course: Operating Systems
Context: OS Scheduling
Assessment: programming project, one exam question

Website

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