NSF/TCPP Curriculum Initiative in Parallel and Distributed Computing – Core Topics for Undergraduates

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Curriculum Initiative Website:
Who are we?

- Chtchelkanova, Almadena - NSF
- Dehne, Frank - University of Carleton, Canada
- Gouda, Mohamed - University of Texas, Austin, NSF
- Gupta, Anshul - IBM T.J. Watson Research Center
- JaJa, Joseph - University of Maryland
- Kant, Krishna - NSF, Intel
- La Salle, Anita - NSF
- LeBlanc, Richard, University of Seattle
- Lumsdaine, Andrew - Indiana University
- Padua, David - University of Illinois at Urbana-Champaign
- Parashar, Manish - Rutgers
- Prasad, Sushil - Georgia State University
- Prasanna, Viktor - University of Southern California
- Robert, Yves - INRIA, France
- Rosenberg, Arnold - Northeastern and Colorado State University
- Sahni, Sartaj - University of Florida
- Shirazi, Behrooz - Washington State University
- Sussman, Alan - University of Maryland
- Weems, Chip - University of Massachussets
- Wu, Jie - Temple University
Why now?

• Computing Landscape has changed
  – Mass marketing of multi-cores
  – General purpose GPUs even in laptops (and handhelds)
• A student with even a Bachelors in Computer Science (CS) or Computer Engineering (CE) must acquire skill sets to develop parallel software
  – No longer instruction in parallel and distributed computing primarily for research or high-end specialized computing
  – Industry is filling the curriculum gap with their preferred hardware/software platforms and “training” curriculums as alternatives with an eye toward mass market.
Stakeholders

- CS/CE Students
- Educators – teaching core courses as well as PDC electives
- Universities and Colleges
- Employers
- Developers
- Vendors
- Authors
- Researchers
- NSF and other funding agencies
- IEEE Technical Committees/Societies, ACM SIGs,
- ACM/IEEE Curriculum Task Force
Current State of Practice

• Students and Educators
  – CS/CE students have no well-defined expectation of what skill set in parallel/distributed computing (PDC) they must graduate with.
  – Educators teaching PDC courses struggle to choose topics, language, software/hardware platform, and balance of theory, algorithm, architecture, programming techniques...
  – Textbooks selection has increasingly become problematic each year, as authors cannot keep up; no single book seems sufficient
  – Industry promotes whatever best suits their latest hardware/software platforms.
  – The big picture is getting extremely difficult to capture.
Curriculum Planning Workshops at DC (Feb-10)

• Goals
  – setup mechanism and processes which would provide periodic curricular guidelines
  – employ the mechanism to develop sample curriculums

• Agenda:
  – Review and Scope
  – Formulate Mechanism and Processes
  – Preliminary Curriculum Planning
    • Core Curriculum
    • Introductory and advanced courses
  – Impact Assessment and Evaluation Plan

Main Outcomes

- Priority: Core curriculum revision at undergraduate level
- Preliminary Core Curriculum Topics
- Sample Intro and Advanced Course Curriculums
Weekly Meetings on Core Curriculum (May-Dec’10; Aug’11-Feb’12)

**Goal:** Propose core curriculum for CS/CS graduates

- **Every individual** CS/CE undergraduate must be at the proposed level of knowledge as a result of their *required* coursework

**Process:** For each topic and subtopic

1. Assign *Bloom’s classification*
   - K = Know the term (basic literacy)
   - C = Comprehend so as to paraphrase/illustrate
   - A = Apply it in some way (requires operational command)

2. Write *learning outcomes*
3. Identify core CS/CE courses impacted
4. Assign number of hours
5. Write suggestions for “how to teach”
### Curriculum Example

<table>
<thead>
<tr>
<th>Algorithms Topics</th>
<th>Bloom#</th>
<th>Course</th>
<th>Learning Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithmic problems</td>
<td></td>
<td></td>
<td>The important thing here is to emphasize the parallel/distributed aspects of the topic</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>broadcast</td>
<td>C/A</td>
<td>Data Struc/Algo</td>
<td>represents method of exchanging information - one-to-all broadcast (by recursive doubling)</td>
</tr>
<tr>
<td>multicast</td>
<td>K/C</td>
<td>Data Struc/Algo</td>
<td>Illustrate macro-communications on rings, 2D-grids and trees</td>
</tr>
<tr>
<td>scatter/gather</td>
<td>C/A</td>
<td>Data Struc/Algo</td>
<td></td>
</tr>
<tr>
<td>gossip</td>
<td>N</td>
<td></td>
<td>Not in core</td>
</tr>
<tr>
<td>Asynchrony</td>
<td>K</td>
<td>CS2</td>
<td>asynchrony as exhibited on a distributed platform, existence of race conditions</td>
</tr>
<tr>
<td>Synchronization</td>
<td>K</td>
<td>CS2, Data Struc/Algo</td>
<td>aware of methods of controlling race condition,</td>
</tr>
<tr>
<td>Sorting</td>
<td>C</td>
<td>CS2, Data Struc/Algo</td>
<td>parallel merge sort,</td>
</tr>
<tr>
<td>Selection</td>
<td>K</td>
<td>CS2, Data Struc/Algo</td>
<td>min/max, know that selection can be accomplished by sorting</td>
</tr>
</tbody>
</table>
Early Adopter Program

• Total 80 institutions worldwide
  – Spring-11: 16 institutions; Fall’11: 18;
  – Spring-12: 21; Fall-12: 25 institutions
  – Most from US (4 year to research institutions);
    • some from South America, A few from Europe, fewer from Asia (India, China).

• Fall-13 round of competition: Deadline June 30, 2013
  – NSF funded Cash Award/Stipend up to $2500/proposal
  – Which course(s), topics, evaluation plan?

• Instructors for core CS/CS courses such as CS1/2, Systems, Data Structures and Algorithms – department-wide multi-course multi-semester adoption preferred
  – Elective courses; graduate courses
EduPar Workshop Series

- EduPar-11 at Alaska, IPDPS-2011
  - Receive feedback from the Adopters
  - Stimulate discussion of curricular and other educational issues.
- EduPar-12 at Shanghai, IPDPS-2012
  - A regular satellite
- EduPar-13 will be at Boston in May 2013
Current Activities

– Curriculum Revision and Formal Curriculum Release
  • Revision through Fall 2011 and Spring/Summer 2012
  • Formal release upcoming this Fall

– Educational Resource Website

– Interface to the Broader Community
  • ACM/IEEE taskforce for CS Curriculum revision CS-2013.
Center for Parallel and Distributed Computing Curriculum Development and Educational Resources (CDER)

• Develop **PDC core curricula** flexible enough for a broad range of programs and institutions; collaborate with all stakeholders
• Develop, collect, and synthesize **pedagogical and instructional materials** for teaching PDC curriculum topics
• Facilitate access to state-of-the-art **hardware and software resources** for PDC instruction and training by instructors and students
• Organize Early Adopter Competitions and EduPar workshops, and related events
Conclusion

• Time is right for PDC curriculum standards
• Core Curriculum Revision is a community effort
  – Curriculum Initiative Website:
    – Linked through TCPP site: tcpp.computer.org

• Feedback: Email sprasad@gsu.edu
• Need to inculcate “parallel thinking” to all
Acknowledgements

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- NVIDIA: Early Adopters