IEEE-TCPP Parallel and Distributed Computing Curriculum Initiative

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CDER Center

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TCPP Curriculum Initiative:
https://tcpp.cs.gsu.edu/curriculum/
Main Outcomes

- Priority: Core curriculum revision at undergraduate level

- Preliminary Core Curriculum Topics

- Sample Intro and Advanced Course Curriculums
CDER Timeline

2010
NSF Planning Workshop

2011
TCPP Curriculum v1

2012
NSF CI-ADDO
$1.2 M

2013
ACM/IEEE CS2013 Curricula

2015
JPDC Special Issue

2017
CDER Book Vol. 2

2018
JPDC Special Issue

2019
EuroEduPar @ HiPC, India

2020
CyberTraining Implementation (2020-23) $1M

EduPar @ IPDPS
Early Adopter Competitions (Intel/Nvidia for International) – 143 Early Adopters

EduHPC @ SC

EuroEduPar @ EuroPar

CDER Book Vol. 1

EduHiPC @ HiPC, India

CyberTraining Workshops

Prasad/EduHPC-21
## TCPP Curriculum Example

### 3 Curriculum Areas + Cross-Cutting
Architecture, Programming, Algorithms

<table>
<thead>
<tr>
<th>Algorithms Topics</th>
<th>Bloom#</th>
<th>Course</th>
<th>Learning outcome and teaching notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algorithmic problems</td>
<td></td>
<td></td>
<td>Algorithmic problems section contains parallel algorithms for certain problems. The important thing here is to emphasize the parallel/distributed aspects of the topic.</td>
</tr>
<tr>
<td><em>Communication and Synchronization</em></td>
<td></td>
<td></td>
<td>Understand (at the pseudo-code level) how certain patterns of communication can be implemented in a parallel/distributed model. Also appreciate the cost of communication in PDC.</td>
</tr>
<tr>
<td>Reduction and Broadcast for communication</td>
<td>C</td>
<td>Data Struc/Algo</td>
<td>Understand, for example, how recursive doubling can be used to for all-to-one reduction, and its dual, one-to-all reduction, in log(p) steps. The same applies to all-to-all broadcast and all-to-all reduction. Recognize that all-to-all broadcast/reduction are synchronizing operations in a distributed (event-driven) environment.</td>
</tr>
<tr>
<td>synchronization and synchronization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel Prefix (Scan)</td>
<td>C</td>
<td>Data Struc/Algo</td>
<td>Understand the structure of at least one simple parallel prefix algorithm. One could consider recursive or iterative approaches (such as those of Ladner-Fischer, Kogge-Stone, Brent-Kung)</td>
</tr>
<tr>
<td>Multicast</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permutation</td>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Early Adopter and Training Programs

• Over 140 institutions worldwide
  – Spring-11: 16 institutions; Fall’11: 18;
  – Spring-12: 21; Fall-12: 25 institutions, Fall-13: 25 institutions, Fall-14: 25, Fall-15: 13
  – Most from US (4 year to research institutions, one high school)
  – Some from South America, a few from Europe, fewer from Asia (India, China, Indonesia, Singapore), Middle East

• NSF CyberTraining PDC Workshops - Summer 2018-21
  – UMass/Maryland; Tennessee Tech
  – NSF/Intel funded stipend up to $5K/proposal
  – Instructor training + adoption plans
Edu* 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 workshop of IPDPS
  - EduPar-15 @IPDPS, May, India; EduPar-16, Chicago, EduPar-17 in Orlando; EduPar-18 in Vancouver, EduPar-19 @ IPDPS, Brazil, **EduPar’20**, EduPar21 – online, EduPar22 in France – May22
- **EduHPC Workshop** at SC-13 + BOF at SIGCSE-14
  - EduHPC-14 @ SC-14, Nov – New Orleans; EduHPC-15 in Austin, EduHPC-16, EduHPC-17, EduHPC-18 in Dallas, EduHPC-19 @ SC in Denver
  - **EduHPC-20 @ SC - online**, EduHPC-21 @ SC – hybrid
- **Euro-EduPar** Aug 2015; Euro-EduPar-2016, EEP-2017, EEP-18,
- **EduHiPC 2018 @ HiPC in Bangalore** – for India and the region
  - EduHiPC’19 @ HiPC in Hyderabad Dec’19
  - EduHiPC’21 @ HiPC in Bangalore
NSF/TCPP Curriculum Initiative – Additional Resources

• **CDER Book series:**
  - Vol 1: Topics in Parallel and Distributed Computing
    - Introducing Concurrency in Undergraduate Courses, *Morgan Kaufman*
  - Vol 2: Topics in Parallel and Distributed Computing
    - Enhancing the Undergraduate Curriculum: Performance, Concurrency, and Programming on Modern Platforms, *Springer*
  - Free Pre-Print Version on CDER site (44K downloads)
  - Plan for 3<sup>rd</sup> Volume – Experience of Adopters
    - Exemplars + Resources on courses and topics

• **CDER Heterogenous Cluster**
  - Multi-core, GPU, Shared/Distributed Memory, *Hadoop/Spark*
  - Ask for class accounts

• **JPDC Special Issue** - Keeping up with Technology: Teaching Parallel, Distributed and High-Performance Computing (2017, 2019, 2021)
CDER Courseware Website

Upload and Search Course Material

• **Type:**
  - Slides, Syllabus, Tutorial, Video
  - Animation, Article, Award, Blog, Book, Competition
  - Course Template, Course Module, Data
  - Hardware Access, Software/Tools
  - Proposal, Report

• **Courses:**
  - CS1, CS2, Systems, Data Structures and Algorithms, ...

• **NSF/TCPP Topic/Subtopic Classification:**
  - **ALGORITHMS**
    - Parallel and Distributed Models and Complexity
    - Algorithmic Paradigms
      - Divide & conquer (parallel aspects)
    - Algorithmic problems
  - **ARCHITECTURE**
  - **PROGRAMMING**
  - **CROSS-CUTTING**

- **open** - Work in Progress
## Curriculum Version II Activities

<table>
<thead>
<tr>
<th></th>
<th>Areas</th>
<th>Architecture</th>
<th>Algorithms</th>
<th>Programming</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Aspects</strong></td>
<td><strong>Area Lead/Aspect Lead</strong></td>
<td>Chip Weems</td>
<td>Anshul Gupta</td>
<td>Alan Sussman</td>
</tr>
<tr>
<td><strong>Exemplars</strong></td>
<td>Sushil Prasad</td>
<td>Karen Karavanic, Eric Freudenthal</td>
<td>Erik Saule, Duane Merril, David Bunde</td>
<td>David Brown, Eric Freudenthal</td>
</tr>
<tr>
<td><strong>Distributed</strong></td>
<td>Vaidyanathan Ramachandran</td>
<td>Vaidyanathan Ramachandran, Manish Parashar</td>
<td>Vaidyanathan Ramachandran, Costas Busch, Denis Trystram</td>
<td>Alan Sussman, Chi Shen</td>
</tr>
<tr>
<td><strong>Big Data</strong></td>
<td>Trilce Estrada</td>
<td>Craig Stunkel</td>
<td>Cynthia Phillips, Debzani Deb</td>
<td></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>Krishna Kant, Craig Stunkel</td>
<td>Craig Stunkel, Karen Karavanic</td>
<td>Denis Trystram</td>
<td>John Dougherty</td>
</tr>
<tr>
<td><strong>Pervasive</strong></td>
<td>Sheikh Ghafoor</td>
<td>Craig Stunkel, Eric Freudenthal</td>
<td>Robert Robey, Martina Barnas</td>
<td>Sheikh Gafoor, Eric Freudenthal</td>
</tr>
</tbody>
</table>
• **Timeline:**

  • **Version-2-beta released @ EduHPC’20**
    • Public Feedback: sushil.prasad@utsa.edu
  
  • **Companion Activities:**
    • Exemplars
    • CE-oriented TCPP Curriculum
    • Competencies-based - knowledge, skills and attitudes

• **NSF Institute Planning Grant => 5 planning workshops**
  1. SC’19
  2. SIGCSE’20 - online
  3. July 27, 2020 – online
  4. Mar 26-27, 2021 - online
  5. NSF Report Workshop – Oct’21