Developing IEEE-TCPP Parallel/Distributed Curriculum and NSF CyberTraining Program

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TCPP Curriculum Initiative:
http://www.cs.gsu.edu/~tcpp/curriculum/
Outline

• IEEE-TCPP Curriculum
  – Why this curriculum initiative and what are the opportunities for the audience?
  – Key Activities and Milestones
    • ACM/IEEE 2013 CS Curriculum Taskforce
      – provided direct link to us for rigorous coverage
  – How was the curriculum formulated?
  – How is it getting evaluated?
  – Current Activities

• NSF CyberTraining Program
  – Computational and Data-driven Science for All
  – Goals; Communities of Concern
  – Award Framework
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 – George Mason University
- La Salle, Anita - NSF
- LeBlanc, Richard, Seattle University
- 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
- Sahni, Sartaj - University of Florida
- Shirazi, Behrooz - Washington State University
- Sussman, Alan - University of Maryland
- Weems, Chip, University of Massachusetts
- 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.
How was the curriculum formulated?

Why would they come?

*Field of Dreams (1989)*: "If you build it, he will come"
Curriculum Planning Workshops at DC (Feb-10) and at Atlanta (April-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 Tele-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)

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

## 4 Curriculum Areas
- Architecture, Programming, Algorithms, Cross-cutting

<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 Structures/Algorithms</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>
How is the Curriculum being evaluated?

Early Adopter Program
EduPar/EduHPC/Euro-EduPar Workshop series
Early Adopter Program

• Over 100 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

• Next competition: Deadline Feb 12, 2019
  – NSF/Intel funded Cash Award/Stipend up to $1500-5000/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
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-13** in Boston + **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
- **EduPar-15** @IPDPS, May, India; **EduPar-16**, Chicago, **EduPar-17** in Orlando; **EduPar-18** in Vancouver
- **EduHiPC 2018 @ HiPC in Banglore** – for India and the region
  - Monday, Dec 2018
- **EduPar-19** @ IPDPS in Rio in May’19
  - Deadline Jan 18, 2019
CDER Book Project

• Lack of suitable textbooks to integrate PDC topics into the core courses
  – CS1, CS2, Systems, and Data Structures and Algorithms

• **Part I - For instructors:** Basic Concepts and References on what and how to teach

• **Part 2: For students:** Supplemental teaching material for core courses

• 9 chapters
  – over 27K chapter downloads – free downloads

• **2nd Volume – Published Nov’19**

  – **Vol 3** – Early Adopter course and topic exemplars and accompanying resources
<table>
<thead>
<tr>
<th>New Aspects</th>
<th>Areas</th>
<th>Architecture</th>
<th>Algorithms</th>
<th>Programming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Lead/ Aspect Lead</td>
<td>Chip Weems</td>
<td>Arnold Rosenberg</td>
<td>Alan Sussman</td>
<td></td>
</tr>
<tr>
<td>Exemplars</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>Distributed</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>Big Data</td>
<td>Trilce Estrada</td>
<td>Craig Stunkel</td>
<td>Cynthia Phillips, Debzani Deb</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>Krishna Kant, Craig Stunkel</td>
<td>Craig Stunkel, Karen Karavanic</td>
<td>Denis Trystram</td>
<td>John Dougherty</td>
</tr>
<tr>
<td>Crosscutting</td>
<td>Sheikh Ghafoor Arny Rosenberg Anshul Gupta</td>
<td>Craig Stunkel, Eric Freudenthal</td>
<td>Robert Robey, Martina Barnas</td>
<td>Sheikh Gafoor, Eric Freudenthal</td>
</tr>
</tbody>
</table>
Sponsorship Acknowledgements

- NSF
  - NSF/TCPP Curriculum Initiative
  - Early adopter competitions (stipend, travel)
  - EduPar/EduHPC workshop series
  - CRI-ADDO CDER (2012-15)

- Intel
  - international early adopter institutions (stipend, travel)

- nVIDIA
  - GPU cards to all the 50+ early adopters from Spring'11, Fall'11 and Spring'12 rounds.

- IEEE TCPP, IBM
  - Keynotes in the past
Innovations in NSF Advanced Cyberinfrastructure Research Workforce Development and Education Programs

Office of Advanced Cyberinfrastructure (OAC)
Computer and Information Science & Engineering (CISE)
National Science Foundation

Sushil K Prasad,
Questions: sprasad@nsf.gov
Dec 2018
NSF Office of Advanced Cyberinfrastructure

Program Staff

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Software

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Learning & Workforce Development

Beth Plale
Science Advisor

Ed Walker*

Stefan Robila*

TBD*

Kevin Thompson

Alejandro Suarez
Cooperative Agreements

Julie Stalhut
AAAS S&T Policy Fellow

* IPA Appointment

Join NSF/OAC: Multiple Program Officer openings
My Journey as a NSF Program Director

• What does ACI/OAC do – OAC’s Mission?
  – Advanced CI – cyberinfrastructure funding in HW, SW, Data, Networking, Security
  – Forward looking research and education, but…

• Status of research and education programs in OAC
  – Dwindling when arrived in 2015 – participation in CAREER, CRII, REU site; NRT
  – Multidisciplinary, use-inspired focus

• My IEEE TCPP experience
  – Massive Outreach
  – Connecting with diverse, multidisciplinary research communities

=> OAC CAREER: Twice as many proposals in 2016; Thrice in 2017
OAC Research and Education Scope

• OAC mission: 2. Forwarding looking research and education
  – Multidisciplinary, use-inspired focus
• Continual Internal discussions within OAC and NSF
• Studied current and past programs
• Workshops; NSCI, NAS study
• Converged on a key gap in training/education => CyberTraining Program
  – Computational and data-driven science for all
  – 2 competitions in 2017 and 2018
    • extraordinary response and growth
Communities of Concern

**CI Contributors**

*Cyber Scientists*

to develop new capabilities

**CI Professionals**

*Professional Staff*
to deploy & support new capabilities

**CI Users**

*Area Scientists*
to exploit new capabilities

Prasad/EduHiPC-18
Overarching and Solicitation Goals

- **Overarching Goal:** prepare, nurture and grow scientific *research* workforce
- **Goal 1:** ensure *broad adoption* of CI tools, methods, and resources, *OR*
- **Goal 2:** integrate skills into educational *curriculum/instructional material fabric* in
  - advanced cyberinfrastructure (CI) +
  - computational and data science and engineering (CDS&E)
  - spanning undergraduate and graduate courses.
- **Innovative, scalable training, education, and curricular** programs addressing
  - targeting one or both of the solicitation goals
  - Emerging needs and Unresolved bottlenecks
  - Undergrads, grad students, instructors, faculty, research CI professionals
FY 19: Award Framework

• Excellent community response
  • 40% additional submissions in 2\textsuperscript{nd} round!
  • About 25 awards made in FY 16 and FY17

• Three project classes:
  • \textit{Pilot}: Exploratory activities
    • $300K, 2 yrs
  • \textit{Implementation}: Broadly accessible to community
    • \textit{Small}: $500K, 4 yrs
    • \textit{Medium}: foster a community,
      • $1M, 4 yrs
  • \textit{Large-scale Project Conceptualization}:
    • Planning grants for potential future institute-like CyberTraining projects
      • $500k, 2 yrs

• No separate tracks, still 3 communities of concerns
  • CI Professionals, CI Contributors, and CI Users

• Next Deadline:
  • Feb 6, 2019
  • Webinar on Nov 26
Conclusion and Opportunities

• Need to inculcate “parallel thinking” to all
• Core Curriculum Revision is a community effort
  – Curriculum Initiative Website:
  – http://www.cs.gsu.edu/~tcpp/curriculum/
• Early Adopter competition
  – Deadline Feb 12, 2019
• EduPar-19 @ IPDPS in Rio in May’19
  – Paper/Peachy Assignment/Poster Deadline Jan 18, 2019
• CDER Book Vol 3
  – Course and topic exemplars and accompanying resources
• For US-based: NSF CyberTraining Solicitation
  – Next Deadline: Feb 6, 2019
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