

Developing IEEE TCPP Parallel and Distributed  
Computing Curriculum  
and  
NSF Advanced Cyberinfrastructure Learning  
and Workforce Development Programs

Sushil K Prasad

Georgia State University  
Program Director, NSF CISE/OAC  
[sprasad@nsf.gov](mailto:sprasad@nsf.gov)

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Dartmouth, May 25th

**What Should every Computer Science and Engineering Student know about Parallel and Distributed Computing (PDC)?**

***IEEE TCPP Curriculum Initiative?***

**TCPP Curriculum Initiative:**

<http://www.cs.gsu.edu/~tcpp/curriculum/>

# Outline – Part 1

- 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?
- Rationale for the resulting preliminary curriculum
- How is it getting evaluated?

# 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, 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 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.

# 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,
- Curriculum Task Forces such as CS2013 ACM/IEEE

# 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.

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”

## 4 Curriculum Areas

Architecture, Programming,  
Algorithms, Cross-cutting

# TCPP Curriculum Example

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

# How is the Curriculum being evaluated?

Early Adopter Program

EduPar/EduHPC 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
- **Last competition: Fall-15 round of competition:** Deadline June 30, 2015
  - NSF funded Cash Award/Stipend up to \$2500/proposal + certificate
  - *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 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
- EduPar-15 @IPDPS, May, India; EduPar-16 @IPDPS, Chicago
- Edu-EuroPar Aug 2015; Edu-EuroPar-2016
- **EduPar-17 @ IPDPS in Orlando**
  - Travel Grants for Early Adopters

# Conclusion – Part 1

- Time is right for PDC curriculum standards
- Core Curriculum Revision is a community effort
  - Curriculum Initiative Website:
  - <http://www.cs.gsu.edu/~tcpp/curriculum/>
- *Need to inculcate “parallel thinking” to all*
- JPDC Special Issue – for Edu\*-2015 workshops
  - Keeping up with Technology: Teaching Parallel, Distributed and High-Performance Computing
- EduHPC-17 @ SC
- Deadline: July, 2017

# Innovations in Cyberinfrastructure Learning and Workforce Development (LWD)

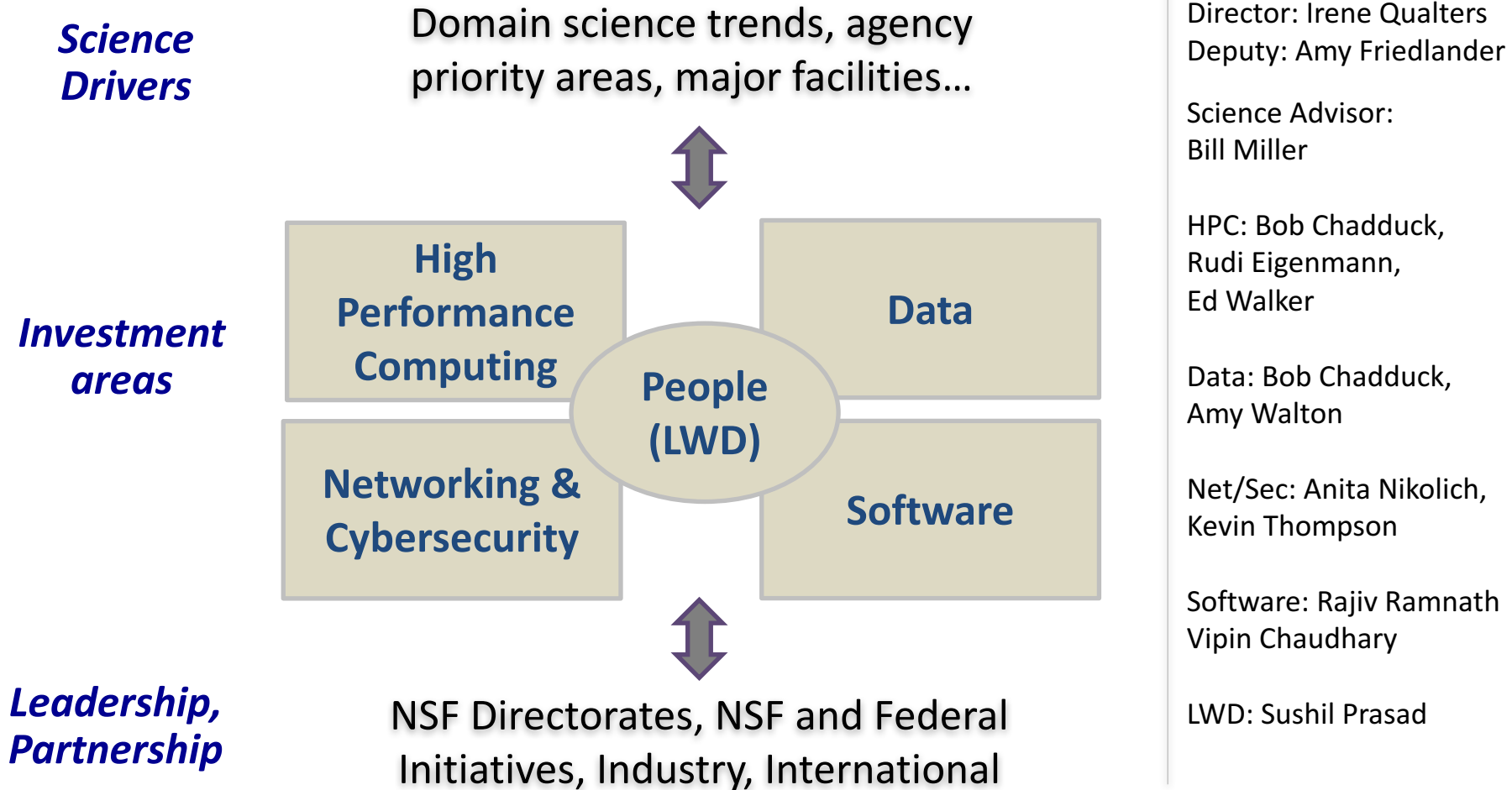
Office of Advanced Cyberinfrastructure Division (OAC)  
Computer and Information Science & Engineering (CISE)  
National Science Foundation

Sushil K Prasad,  
Questions: [sprasad@nsf.gov](mailto:sprasad@nsf.gov)



# Office of Advanced Cyberinfrastructure (OAC)

*Mission: Support **advanced cyberinfrastructure** to accelerate discovery and **innovation across all disciplines***



# Communities of Concern



# Learning and Workforce Development

## Student Research

## Training

- REU SITES

- NRT

Lol: Dec'17

Full: Feb'18

## Faculty Research

- CRII

- CAREER

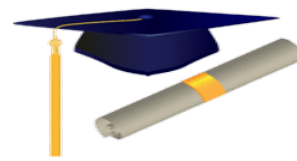
CAREER Proposal Writing Workshop:

March'17

## Training/Workforce Development

- CyberTraining

Deadline: Oct, 2017



# OAC Research Programs:

**Focus:** *Use-inspired/applied, multidisciplinary* in Advanced CI + computation/data-enabled science and engineering

- Faculty Research – *CI Contributors*
  - **CAREER** - NSF 15-555: Most prestigious award supporting junior faculty as a teacher-scholar; min \$400K/5yrs; July'17
    - Number of submissions doubled in FY16 and tripled in FY'17
    - 30 active awardees
    - Now open to **non-tenure track** faculty
  - **CRII** - NSF 15-569: Faculty or *research scientists* in their **first 3 years**; \$175K/ 2yrs; Aug'17
- Student Research Training - *CI Contributors/Users*
  - **REU site** - NSF 13-542: Research participation by undergraduate students; \$360K/3yrs; Aug'17

# Challenges in Education and Training



# CyberTraining - *Training-based Workforce Development for Advanced Cyberinfrastructure* - NSF 17-507

- *Informal, scalable* training models and pilot activities
  - In advanced CI, computational and data-enabled science/engineering topics
- Participation: MPS, ENG, GEO, EHR/DGE, CISE/CCF; *OAC - lead;*
- \$300K-\$500K/award; 1-3 years in duration
- **Tracks:** *1: CI Professionals*
  - *2: Domain science and engineering - CI Contributors/Users*
  - *3: Computational & Data Science Literacy - undergraduate level - CI Users*
- **Excellent** community response in the inaugural round!
  - Next Deadline: **Oct, 2017**

# Other LWD Opportunities within OAC

- Graduate Preparedness DCL (NSF 16-067)
- EAGERs, Workshops, RCNs
  - Seed Exploration of Informal/Formal Training and Education, Broadening Participation
  - Students, Post-Docs, Faculty, CI Professionals
- CC\* - CI Engineer -> Cyber Team
- Student Travel Grants
- *Discuss with me and other OAC Program Officers*
- To subscribe to *OAC Mailing List*:  
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[ACI-ANNOUNCE-subscribe-request@listserv.nsf.gov](mailto:ACI-ANNOUNCE-subscribe-request@listserv.nsf.gov)

