

SIAM Conference on Applied Mathematics Education 2016

MS 13: Experience of REU Site Directors in Applied Mathematics

- Matthias K. Gobbert, Nagaraj Neerchal, Bradford E. Peercy, Kofi Adragani, University of Maryland, Baltimore County, *REU Site: Interdisciplinary Program in HPC*
- Marianne Korten, Kansas State University, *Sumar Math REU, Undergraduate Research During the School Year, Accessibility in Math, and Preparation for Graduate School*
- Jung-Han Kimn, Stephen Gent, South Dakota State Univ., *Simulation and Analysis at South Dakota State University REU Site*
- Enyue Lu, Salisbury University, *Involving Undergraduate Students in Emerging Parallel Computing Research*



REU Site: Interdisciplinary Program in High Performance Computing

Undergraduate Research in an REU Site: From Nothing to Publication in Eight Weeks

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Profiles of UMBC and Department

UMBC = University of Maryland, Baltimore County:

- founded in 1966 as third research university in USM;
- 14,000 students (11,000 undergrad., 3,000 graduate);
- 400 research faculty in 34 departments;
- science and technology focus, particularly biology/medical research, plus Visual Arts, Public Policy, Psychology, Theatre;
- #1 Up and Coming university for six years (2009-2014) by U.S. News & World Report, among "Best Undergraduate Teaching" since 2009
- top-5 in "most innovative" since 2015
- President Freeman A. Hrabowski named by TIME Magazine as one of Americas 10 Best College Presidents in 2009, one of the 100 Most Influential People in the World in 2012.

Department of Mathematics and Statistics:

- 400 undergraduate majors, 55 B.A./B.S. Math/Stat per year;
- M.S./Ph.D. in Applied Mathematics and in Statistics;
- Applied Mathematics oldest graduate program at UMBC (first Ph.D. in 1975)!



Center for Interdisciplinary Research and Consulting (CIRC)

- ❑ Nagaraj K. Neerchal, Statistics, and Matthias K. Gobbert, Mathematics
- ❑ Started in 2003 in form of regular class with client-based projects; some results of these: journal paper and long-term RA position
- ❑ **CIRC makes department's expertise in statistics and in applied mathematics available to the community on campus and beyond in consulting format**
- ❑ Mathematics and statistics graduate students gain hands on interdisciplinary experience vital for industry and academia jobs = industrial mathematics
- ❑ CIRC has full-time RAs since 2005, circ.umbc.edu
- ❑ **Benefits to students:** experience, publications, presentations, RAs
- ❑ **Benefits to department:** visibility, connections, money, uniqueness, synergy between programs, energy level!



High Performance Computing Facility

- ❑ Initiated by MRI proposal in Jan. 2007 that outlined the need for **(i) hardware, (ii) sys. admin, (iii) user support, and (iv) usage policies**
- ❑ **2009:** MRI grant to 23 faculty in 10 departments (2008); 86 nodes; two quad-core Intel processors and 24 GB memory per node; quad-data rate (QDR) InfiniBand; 160 TB central storage
- ❑ **2013:** MRI grant to 30 faculty (2012); extension by 72 nodes with two eight-core Intel CPU and 64 GB memory per node, including 19 hybrid nodes with two NVIDIA K20 GPU and 19 hybrid nodes with two 60-core Intel Phi accelerators; extension of network; extension of storage; gift from NASA (first large-scale computer gift to UMBC!)
- ❑ As of 2016 => 300+ node cluster worth on the order of \$2.0M
- ❑ **Publications 2008 to 2015** over 200, including more than 77 journal papers, 24 conference papers, and 28 theses.
- ❑ **HPCF user support:** since 2008 full-time RAs, hpcf.umbc.edu
- ❑ **Coordinated community building:** Math 447/627 Parallel Computing, colloquium talks in departments across campus, tech. rep. server, meetings with administrators, follow-up grant proposals, etc.



Concept of HPC REU

8 weeks, team-based with 4 undergraduate students, 3 (over-lapping) phases:

- ❑ Phase I – 2 weeks: intensive hands-on instruction on scientific, statistical, and parallel computing, introducing Linux, C, MPI, Matlab, R, and team building by homework
- ❑ Phase II – 5 weeks: research on application project (with computational focus) from outside mathematics/statistics
- ❑ Phase III – 1 week: complete documentation of work as (i) HPCF tech. rep., (ii) poster, (iii) slides, (iv) webpage
- ❑ Accompanying professional development program

Shown from perspective of students in following!



Phase I – Weeks 1 to 3

Training in scientific, statistical, and parallel computing:

- ❑ Intensive hands-on training
- ❑ Introduction to Linux, C, MPI, Matlab, R
- ❑ Lectures complemented by computer labs with graduate TAs
- ❑ Homework done by assigned research teams

Simultaneously (Thursday afternoon), clients present their projects:





Phase II – Weeks 1 to 7

Research on application problem in team of 4 undergraduates:

- ❑ Each team has faculty mentor and dedicated graduate RA
- ❑ Team members know each others' strengths and preferences by now!
- ❑ Proposal of work to client by end of Week 3
- ❑ Updates to client in person (talk), by conference call, or similar





Phase III – Weeks 3 to 8

Complete range of documentation of results:

- ❑ Deliverable to client can be computation, data analysis, code, visualization, webpage, advice, or others
- ❑ Tech. rep. posted on HPCF webpage, other publication considered
- ❑ Presentations in poster form and for oral presentation at the UMBC Summer Undergraduate Research Fest (SURF)
- ❑ Project webpage at REU Site hpcreu.umbc.edu





Professional Development Program

Obvious parts:

- ❑ Introduction to LaTeX, preparation of poster, talk, webpage
- ❑ GRE preparation course (in collaboration with other UG programs!)
- ❑ Presentations by Dean of the Graduate School on graduate school application; other presentations, e.g., on posters by Assistant College Dean and on career choices by Director of Academic Advising





Professional Development Program

Many not-so-obvious parts:

- ❑ Tech. report HPCF-201X-Y posted on HPCF Publications webpage
- ❑ 'Vertically Integrated' support for each team with graduate RA and faculty; local and/or returning students as peer mentors
- ❑ VIP visits by President, Provost, Dean, VP Research, for instance, and also GPD and editor of *UMBC Review: Journal of Undergraduate Research* as example of undergraduate journal (e.g., SIURO)
- ❑ Interview all visitors about their career; teams give 'elevator speech' to visitors; students write report about visit for Special Events page.
- ❑ Make *explicit* the guidance on research techniques, including tracking sources, documenting, issues of integrity, etc.
- ❑ Share our experiences for graduate school advice, for instance, share our perspective on admissions
- ❑ Field trips, e.g., to NSA, NIH, as well as to D.C. and Baltimore



Sample Project from 2012

Graph 500 Performance on a Distributed-Memory Cluster

- ❑ **Team members:** Jordan B. Angel, Amy M. Flores, Justine S. Heritage, and Nathan C. Wardrip, **Graduate RA:** Andrew M. Raim, **Faculty mentor:** Matthias K. Gobbert, **Clients:** Richard C. Murphy (Sandia National Lab) and David J. Mountain (LPS)
- ❑ **Benchmark quantifies memory speed of computer.**
Submitted for Nov. 2012 ranking
- ❑ **Trip to conference Supercomputing 2012 in Salt Lake City**
for the formal announcement of the ranking as #98:
- ❑ **First reunion of a team**
led to travel funding by NSA as REU Supplement





Sample Project from 2013

Dynamics of Computational Islet Simulations

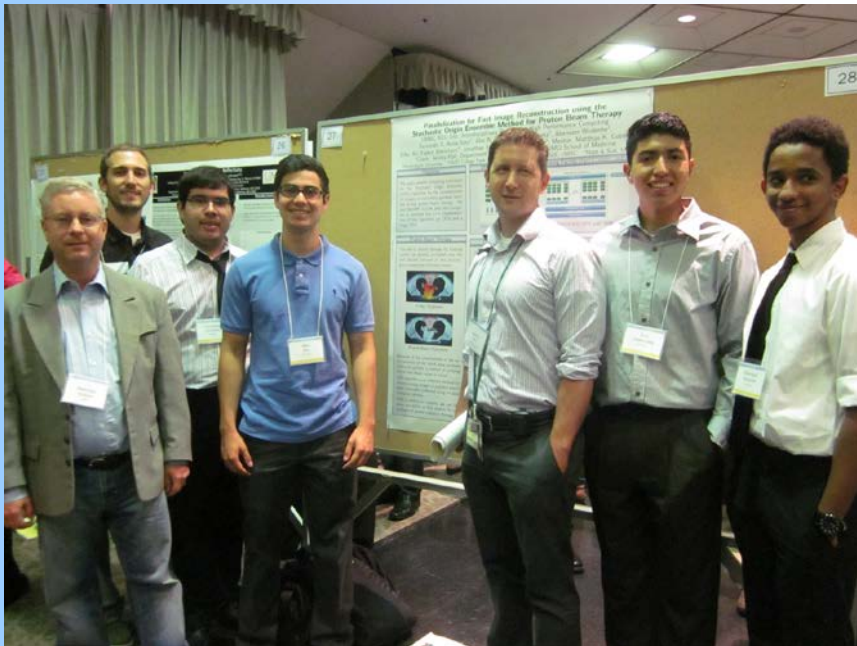
- ❑ **Team members:** Gemma Gearhart, Shuai Jiang, Thomas J. May, Jane Pan (UMBC Meyerhoff Scholar, NSA grant to Meyerhoff Program),
Graduate RA: Samuel Khuvis, **Faculty mentor:** Matthias K. Gobbert,
Clients: Bradford E. Percy (UMBC) and Arthur Sherman (NIH)
- ❑ **Presentations:** 1 of 6 oral presentations at SURF, poster at SURF, Gobbert at BEER (International Symposium on **B**iomathematics and **E**cology **E**ducation and **R**esearch)
- ❑ **Publications:**
 - Jane Pan, Gemma Gearhart, Shuai Jiang, Thomas J. May, *UMBC Review: Journal of Undergraduate Research*, vol. 15, pp. 31-53, 2014.
 - Gemma Gearhart, Shuai Jiang, Thomas J. May, Jane Pan, Samuel Khuvis, Matthias K. Gobbert, Bradford E. Percy, and Arthur Sherman, *Proceedings of BEER 2013*, 2014, **and inaugural issue of *Letters in Biomathematics***, vol. 1, no. 1, 2014.



Sample Project from 2015

Parallelization for Fast Image Reconstruction using the Stochastic Origin Ensemble Method for Proton Beam Therapy

Team members: Fernando X. Avila-Soto, Alec N. Beri, Eric Valenzuela, and Abenezer Wudenhe (UMBC Meyerhoff Scholar, NSA grant to Meyerhoff Program),
Graduate RAs: Ari Rapkin Blenkhorn, Jonathan S. Graf, and Samuel Khuvis
Faculty mentor: Matthias K. Gobbert, **Client:** Jerimy Polf, UMD School of Medicine





Sample Project from 2016

Performance Comparison of Intel Xeon Phi KNL

- ❑ **Team members:** Ishmail A. Jabbie (UMBC Meyerhoff Scholar, NSA grant to Meyerhoff Program), George Owen, and Benjamin Whiteley, **Graduate RA:** Jonathan S. Graf, **Faculty mentor:** Matthias K. Gobbert, **Client:** Samuel Khuvis (ParaTools, Inc.)
- ❑ The Intel Xeon Phi is a 68-core processor with 1 TFLOP/s peak performance. Team benchmarked a reference code on a pre-production second-generation Knights Landing (KNL) with excellent performance.
- ❑ **Poster presentations:**
 - Summer Undergraduate Research Fest (SURF) August 2016
 - SIAM Conference on Computational Science and Engineering 2017 by George Owen (LSU) as part of Minisymposium *Parallel Computing for Models using Partial Differential Equations*
 - *Research Experiences for Undergraduates Symposium* (Arlington, VA = NSF) hosted by the Council on Undergraduate Research



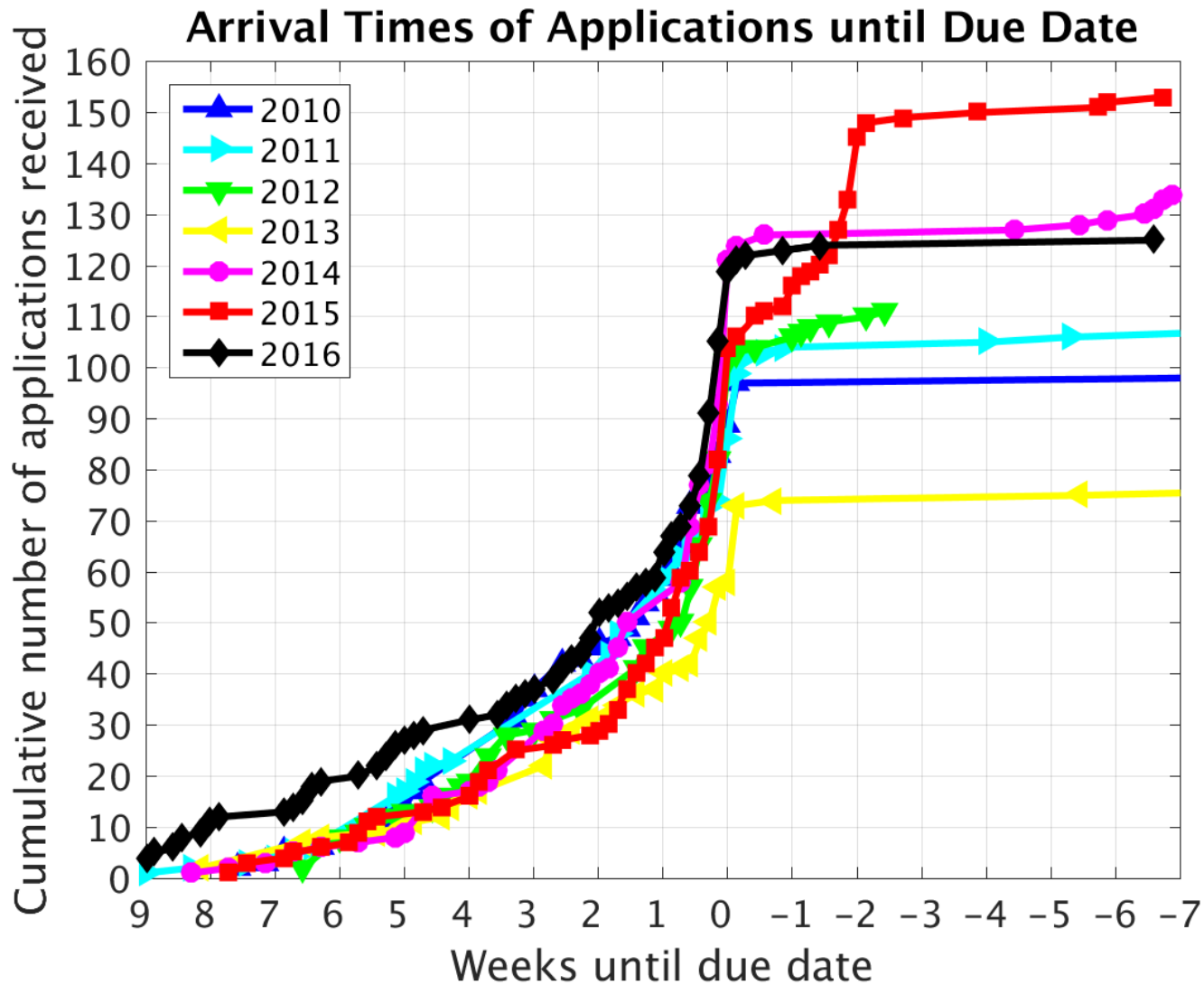
Basic Timeline of Work

Timeline of year-round REU Site work:

- ❑ August: *proposal due to NSF*
- ❑ November: publish webpage with application details, *if not rejected*
- ❑ Late December and later: receive (inquiries and) applications
- ❑ February: *informal e-mail from NSF promising award --- hopefully!*
- ❑ March 1: “nationally agreed-upon” due date, widely used
- ❑ March 8: earliest date to require decision on offers
- ❑ April: put staff in place, finish admissions, *formal NSF award*
- ❑ May: housing, dining, and other contracts and on-campus arrangements (room reservations, building access, ID cards, access to rec center / pool, equipment, order books, and much more)
- ❑ June: last-minute preparations
- ❑ June to August: run program, collect photos, reports, etc. for webpage
- ❑ August: recover, get ready for semester --- but finish REU Site, too!
- ❑ November: start over, prepare annual report (due by April only)



Application Arrivals 2010-2014





Most Vital Demographics 2010-2016

	2010	2011	2012	2013	2014	2015	2016	Totals
Applicants	98	107	111	77	136	153	125	807
Participants	9	13	12	16	22	33	28	133
Females	4	4	6	8	6	10	13	51
African Americans	3	4	0	4	9	8	6	34
Hispanics	2	1	3	1	2	4	5	18
Disability	-	-	-	0	1	2	2	5
Veterans	0	1	1	0	1	0	0	3
Non-PhD-granting	2	4	8	8	4	12	14	52
Teams	2	4	3	4	5	8	7	33
Grad Assistants	4	3	6	4	7	7	4	18
Faculty	2	3	2	3	4	4	4	4



Lessons Learned

- ❑ **Track from the start:** demographic information in online application, complete contact info, use special e-mail address to receive all application material, read material as it comes in
- ❑ **Recruitment:** NSF and AMS webpages 60%, other mostly personal mails
- ❑ **Document and present:** schedule and more details on webpage, take photos (people and events!), collect reports of all events including training
- ❑ **Team work** as goal in itself, then manage pro-actively and explicitly
- ❑ **Use modern technology and methods:** examples Blackboard, iPad
- ❑ **Stay in touch** for longitudinal tracking and for documenting 'future' outcomes such as presentations at home institutions and conferences
- ❑ **Publications 2010 to 2016 to date** 51 publications, consisting of 34 tech. rep., 11 journal papers, 3 conference papers, and 3 senior theses.

For all details on our program: hpcreu.umbc.edu

Acknowledgments: NSF, NSA, DOD, UMBC, HPCF, CIRC