

## Paul R. Eller

### CONTACT

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### ADDRESS

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### RESEARCH FOCUS

My primary research interest is in developing, analyzing, and optimizing scalable numerical algorithms and applications for extreme-scale computer systems

### INTERESTS

Scientific computing, high performance computing, parallel computing, linear solvers, preconditioners, multigrid methods, GPUs, accelerators, performance modeling

### EDUCATION

**University of Illinois at Urbana-Champaign (UIUC)**, Champaign, IL  
Ph.D. Computer Science December 2019  
Advisor: William Gropp

**Virginia Polytechnic Institute & State University (Virginia Tech)**, Blacksburg, VA  
M.S. Computer Science August 2009  
Advisor: Adrian Sandu  
B.S. Computer Science May 2007  
Minor Mathematics

### RESEARCH EXPERIENCE

#### Postdoctoral Research Associate in Scientific Computing

Oak Ridge National Laboratory, National Center for Computational Sciences  
Oak Ridge, TN Jan 2019-present

- Developing more efficient mixed precision solvers using AMGX for GTC and other ORNL applications
- Developing optimized dense linear algebra routines for CoMet that take advantage of newer reduced precision features on GPUs
- Analyzing network performance on Summit and other ORNL HPC systems and developing performance optimizations for ORNL applications at scale

#### Research Assistant with Bill Gropp

University of Illinois at Urbana-Champaign, Champaign, IL Aug 2013-Dec 2019

- Developed scalable Krylov solvers using non-blocking allreduces to improve performance, with a focus on scalable preconditioned conjugate gradient (PCG) methods
- Developed performance models to better understand observed performance at scale and guide performance optimizations such as node-aware and topology-aware communication
- Analyzed PCG solver performance and robustness on the Blue Waters and Piz Daint supercomputers to more clearly understand when scalable methods outperform standard methods
- Analyzed and improved scalable Krylov solver performance within quantum chromodynamics (Quda) and computational fluid dynamics (Nek5000) applications

- Developed software tools to analyze performance variation and network performance at scale

### **Computer Science Intern with Mark Hoemmen**

Sandia National Lab, Albuquerque, NM, Summer 2015 and 2016

- Continued research developing and analyzing scalable Krylov solvers
- Integrated code to use network performance counters and analyze performance variation into my existing tools to better understand the network performance of Krylov solvers
- Developed tools for injecting network noise into parallel algorithms
- Analyzed performance of Kokkos thread-safe, thread-scalable unordered map for shared memory architectures with Carter Edwards

### **Computer Science Intern with Jed Brown and Barry Smith**

Argonne National Lab, Argonne, IL, Summer 2014

- Continued project developing support for threads for PETSc
- Improved and generalized simple threaded programming model
- Developed threading models for PETSc that allow users to have more control over threads
- Improved support for OpenMP, Pthreads, and Intel threaded building blocks

### **Research Computer Scientist**

U.S. Army Corps of Engineers - Engineer Research and Development Center - Information Technology Lab, Vicksburg, MS, Aug. 2009 - Aug. 2013

- Developed PETSc interface for pWASH123d
- Developed a finite difference time domain method for GPUs for an acoustic simulation
- Researched methods to use machine learning to choose the best linear solver to solve linear systems for pWASH123d and ADaptive Hydraulics (ADH)
- Parallelized Gridded Surface Subsurface Hydrologic Analysis (GSSHA) using MPI to run on DoD supercomputers

### **Undergraduate/Graduate Research Assistant with Adrian Sandu**

Virginia Tech, Blacksburg, VA May 2006 - July 2009

- Developed C versions of forward and adjoint integrators for the Kinetic Pre-Processor
- Developed a Perl parser to convert GEOS-Chem input files to KPP input files
- Parallelized KPP chemistry step within GEOS-Chem using OpenMP
- Developed a version of STEM that runs on a graphics processing unit using CUDA

### **HONORS**

- Givens Associate at Argonne National Lab Summer 2014
- Computer Science Excellence Fellowship 2013-2014
- Department of the Army Achievement Medal for Civilian Service 2012
- ERDC Research and Development Achievement Award 2012
- SMART Scholarship recipient for 2008-2009 school year
- Deans List Fall 2005, Spring 2006, Fall 2006, Spring 2007
- Pamplin Leader Award 2004

## ACTIVITIES

- Member of SIAM and ACM
  - President of SIAM Student Chapter at Illinois 2015-2016
  - Officer of SIAM Student Chapter at Illinois 2016-2018
- Teaching Assistant for CS 450 Numerical Analysis Fall 2015
  - Developed and led weekly discussion section
  - Developed homework assignments
- Teaching Assistant for CS 420 Parallel Programming for Scientists and Engineers Fall 2013
  - Developed homework assignments, programming projects, and tests
  - Gave lectures as needed

## COMPUTER SKILLS

**Languages:** C, C++, Python, Fortran, Java

**APIs/Libraries:** MPI, OpenMP, pthreads, PETSc, Charm++, CUDA, Matlab, NumPy, SciPy  
Experience with Kokkos, Hypre, Intel threaded building blocks, Perl, Postgre SQL

## PUBLICATIONS

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Ph.D. Thesis. University of Illinois at Urbana-Champaign, Urbana, IL, 2019.

“Using Performance Models to Understand Scalable Krylov Solver Performance at Scale for Structured Grid Problems.” P.R. Eller, T. Hoefler, W. Gropp. Conference Paper. International Conference on Supercomputing 2019.

“Scalable Non-blocking Preconditioned Conjugate Gradient Methods.” P.R. Eller and W. Gropp. Conference Paper. International Conference for High Performance Computing, Networking, Storage and Analysis 2016.

“Scalable Three-term Recurrence Preconditioned Conjugate Gradient Methods.” P.R. Eller and M. Hoemmen. Technical Report. CSRI Summer Proceedings 2016.

“A Thread-Scalable Performance Portable Unordered Map for Manycore Architectures.” P.R. Eller and H.C. Edwards. Technical Report. CSRI Summer Proceedings 2015.

“Development of Parallel GSSHA.” P.R. Eller, J.C. Cheng, A.R. Byrd, C.W. Downer, and N. Pradhan. Technical Report. US Army Corps of Engineers Research and Development Center 2013.

“Dynamic Linear Solver Selection for Transient Simulations Using Multi-label Classifiers.” P.R. Eller, J.C. Cheng, and R.S. Maier. Conference Paper. International Conference on Computational Science 2012.

“Dynamic Linear Solver Selection for Transient Simulations Using Machine Learning on Distributed Systems.” P.R. Eller, J.C. Cheng, and R.S. Maier. Conference Paper. International Parallel and Distributed Processing Symposium ParLearning 2012.

“A Scenario Study for Improving Cost-effectiveness in Acoustic Time Reversal Source Relocation in an Urban Environment.” L. Liu, H. Xie, D.G. Albert, P.R. Eller, and J.C. Cheng. Journal Paper. Journal of Computational Acoustics 2012.

“Computing Acoustic Source Locations in Urban Environments.” L. Liu, D. Albert, H. Xie, P. Eller, and J.C. Cheng. Conference Paper. International Conference on Theoretical and Computational Acoustics 2011.

“Performance Improvement of the 2-D Finite Difference Time Domain Acoustic Wave Simulation Using Multiple GPUs.” P.R. Eller, J.C. Cheng, D.G. Albert, and L. Liu. Conference Paper. Army Science Conference 2010.

“Acceleration of 2-D Finite Difference Time Domain Acoustic Wave Simulation Using GPUs.” P.R. Eller, J.C. Cheng, D.G. Albert. Conference Paper. DoD High Performance Computing Modernization Program 2010 Users Group Conference.

“Improving Parallel Performance of Large-scale Watershed Simulations.” P.R. Eller, J.C. Cheng, H.V. Nguyen, R.S. Maier. Conference Paper. International Conference on Computational Science 2010.

“Development and Acceleration of Parallel Chemical Transport Models.” P.R. Eller, K. Singh, A. Sandu. Conference Paper. SpringSim '10 Multiconference High Performance Computing Symposium, 2010.

“Development and Acceleration of Parallel Chemical Transport Models.” P.R. Eller. Masters Thesis. Virginia Tech, Blacksburg, VA, 2009.

“Implementation and Evaluation of an Array of Chemical Solvers in a Global Chemical Transport Model.” P.R. Eller, K. Singh, A. Sandu, K. Bowman, D.K. Henze, M. Lee. Journal Paper. Geoscientific Model Development 2009.

“Towards the Construction of a Standard Adjoint GEOS-Chem Model.” K. Singh, P.R. Eller, A. Sandu, D. Henze, K. Bowman, M. Kopacz, M. Lee. Conference Paper. High Performance Computing and Simulation Symposium 2009.

“Improving GEOS-Chem Model Forecasts through Profile Retrievals from Tropospheric Emission Spectrometer.” K. Singh, P.R. Eller, A. Sandu, K. Bowman, D. Jones, M. Lee. Conference Paper. International Conference on Computational Sciences 2009.

## **PRESENTATIONS AND POSTERS**

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Invited Seminar. Math and Computer Science Division at Argonne National Laboratory. July 2019.

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Invited Seminar. Center for Computing Research at Sandia National Laboratory. June 2019.

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Invited Seminar. Innovative Computing Laboratory at the University of Tennessee. June 2019.

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Invited Seminar. Leadership Computing Facility at Oak Ridge National Laboratory. June 2019.

“Scalable Non-blocking Krylov Solvers for Extreme-scale Computing.” P.R. Eller. Conference Poster and Presentation. Doctoral Showcase. Supercomputing 18.

“Using Non-Blocking Communication to Achieve Scalability for Preconditioned Conjugate Gradient Methods.” W.D. Gropp and P.R. Eller. Conference Presentation. SIAM Conference on Parallel Processing for Scientific Computing 2018.

“Non-blocking Conjugate Gradient Methods for Extreme-scale Computing.” P.R. Eller and W. Gropp. Conference Poster. Supercomputing 15.

“Non-blocking Conjugate Gradient Methods for Extreme-scale Computing.” P.R. Eller and W. Gropp. Conference Presentation. 17th Copper Mountain Conference on Multigrid Methods 2015.

“Using GPU-Based Accelerators to Prepare for Exascale Computing in Defense Applications.” P.R. Eller. Conference Presentation. SIAM CSE 2011.

“Performance Improvement of the 2-D Finite Difference Time Domain Acoustic Wave Simulation Using Multiple GPUs.” P.R. Eller, J.C. Cheng, D.G. Albert, and L. Liu. Conference Presentation. DoD HPCMP GPU-Accelerator Workshop 2010.

“Developing Numerical Integrators for The Kinetic Pre-Processor.” P.R. Eller, N. Hobbs, D. Jacob, T. Jiang. Poster Presentation. Virginia Tech Symposium for Undergraduate Research in Engineering 2006.