Shelby Lockhart, PhD

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Education

Aug 2016 – May 2023	**University of Illinois at Urbana-Champaign**, Urbana-Champaign, IL, USA *Doctor of Philosophy (PhD) in Computer Science* Advisor: Luke N. Olson Thesis Title: Reducing Communication Bottlenecks in Iterative Solvers Research Areas: Scientific Computing and High Performance Computing Cumulative GPA: 3.71/4.00
Aug 2012 – May 2016	**Wake Forest University**, Winston-Salem, NC, USA *Bachelor of Science (BS) in Mathematics* Double majored in Computer Science Cumulative GPA: 3.72 / 4.00, Magna Cum Laude

Research Experience

Scientific Computing Group, Dept. of CS, University of Illinois at Urbana-Champaign
Graduate Research Assistant

Jan 2021 - May 2023	Project: PSAAP Grant - Center for Exascale-enabled Scramjet Design Advisor: Luke N. Olson

- Designed and implemented models for communication on heterogeneous architectures, demonstrating the importance of locality-aware communication strategies in achieving optimal distributed communication performance with MPI.
- Designed an optimal point-to-point communication strategy for the unstructured-mesh boundary exchanges for use within the *MIRGE-Com* framework.
- Research Areas: performance modeling, GPU data movement, CUDA-aware, GPUDirect, MPI, locality-aware parallel communication, sparse matrix operations, unstructured-meshes, large-scale multi-physics simulations, CUDA

Aug 2017 - May 2020	Project: ExxonMobil Research Grant	Advisor: Luke N. Olson

- Performed a performance analysis of enlarged Krylov methods at scale.
- Developed optimal locality-aware communication for use in the sparse matrix-block vector product of enlarged Krylov methods and implemented within the RAPtor solver framework, demonstrating 60x-80x speedup over standard distributed communication practices.
- Research Areas: SPD linear systems of equations, Krylov methods, performance modeling, locality-aware parallel communication, MPI, sparse matrix operations, parallel linear algebra

Scientific Computing Group, Computation, CASC, Lawrence Livermore National Laboratory
Predictive Science Academic Alliance Program III Student Intern

May 2021 - Aug 2021	Project: Low Synchronous AA	Advisors: Carol S. Woodward and David J. Gardner

- Implemented low synchronization orthogonalization methods within the SUNDIALS codebase for use within Anderson Acceleration.
- Analyzed the parallel performance of low synchronization orthogonalization methods outside of and within

the context of Anderson Acceleration, demonstrating up to 8x speedup over standard orthogonalization techniques at large-scales.

- Research Areas: Nonlinear systems of equations, fixed point iterations, Anderson acceleration, orthogonalization, MPI, collective communication, parallel linear algebra, portable HPC software, CUDA

Scientific Computing Group, Computation, CASC, Lawrence Livermore National Laboratory
Computation Scholar Program Graduate Intern

Jun 2020 - Aug 2020 | Project: Low Synchronous AA   Advisors: Carol S. Woodward and David J. Gardner

- Researched low synchronization orthogonalization methods and their potential use within Anderson Acceleration.
- Research Areas: Nonlinear systems of equations, fixed point iterations, Anderson acceleration, orthogonalization, MPI, collective communication, parallel linear algebra, portable HPC software, CUDA

Jun 2018 - Aug 2018 | Project: `NVECTOR_OPENMPDEV`   Advisors: Carol S. Woodward and David J. Gardner

- Implemented an OpenMP 4.5 N_Vector within the SUNDIALS codebase for offloading computation to GPUs.
- Research Areas: OpenMP, GPU-based compute, portable HPC software, node-level parallelism

Computational and Applied Mathematics Group, Oak Ridge National Laboratory
Department of Energy HERE Graduate Intern

Jun 2017 - Aug 2017 | Project: Reduced Order Modeling for Finite Element Methods   Advisor: Clayton Webster

- Research Areas: Finite element methods, reduced order modeling, partial differential equations

Scientific Computing Group, Dept. of CS, University of Illinois at Urbana-Champaign
Independent Study Research

Aug 2016 - May 2017 | Project: Analysis of the Universal Number Format   Advisor: Michael Heath

- Research Areas: Rounding error, truncation error, numerical precision, floating point

Dept. of Mathematics, Wake Forest University
Undergraduate Thesis Research

Aug 2015 - May 2016 | Project: Limited-Memory Trust-Region Methods for Sparse Relaxation
Advisor: Jennifer Erway

- Research Areas: Large-scale constrained optimization, trust-region methods, limited-memory quasi-Newton methods, BroydenFletcher-Goldfarb-Shanno update

Cyber and Information Security Research Group, Oak Ridge National Laboratory
Department of Energy SULI Intern

Jun 2015 - Aug 2015 | Project: STUCCO (Situation and Threat Understanding by Correlating Contextual Observations)
Advisor: Robert Bridges

- Research Areas: NLP, supervised training for machine learning, cyber security

Teaching Experience

Dept. of CS at University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, USA
Graduate Teaching Assistant

Aug 2020 - Dec 2020	Course: Numerical Analysis, CS 450	Professor: Luke N. Olson
Jan 2019 - May 2019	Course: Numerical Methods for PDEs, CS 555	Professor: Paul Fischer
Jan 2017 - May 2017	Course: Numerical Analysis, CS 450	Professor: Paul Fischer
Aug 2016 - Dec 2016	Course: Numerical Methods, CS 357	Professor: Andreas Kloeckner

Dept. of CS at Wake Forest University, Winston-Salem, NC, USA
Teaching Assistant

Aug 2015 - May 2016	Course: Computer Organization (using MIPS assembly)	Professor: Pete Santago
Jan 2015 - May 2015	Course: Introduction to Computer Science (using Python)	Professor: Pete Santago

Awards and Achievements

Apr 2023	**Sydney Fernbach Fellowship**, *Finalist* *Lawrence Livermore National Laboratory*
Mar 2023	**Selected to attend Rising Stars in Computational and Data Sciences** *Oden Institute, Sandia National Laboratory, Lawrence Livermore National Laboratory*
Oct 2022	**ACM/IEEE CS George Michael Memorial HPC Fellowship**, *Honorable Mention* *ACM, IEEE Computer Society, SC Conference*
Aug 2018	**Outstanding Poster Presentation**, *Summer Student Poster Symposium* *Lawrence Livermore National Laboratory*
Aug 2016	**Saburo Muroga Endowed Fellowship** *University of Illinois at Urbana-Champaign*
May 2016	**John W. Sawyer Prize in Computer Science** *Wake Forest University*
Apr 2015	**Upsilon Pi Epsilon: International Honor Society for the Computing and Information Disciplines** *Wake Forest University*
Apr 2014	**Pi Mu Epsilon: International Honor Society for Mathematics** *Wake Forest University*

Publications

2023
1. **Lockhart, S.**, Bienz, A., Gropp, W. & Olson, L. Characterizing the Performance of Node-Aware Strategies for Irregular Point-to-Point Communication on Heterogeneous Architectures. *Parallel Computing* (Apr. 2023).
2. **Lockhart, S.**, Bienz, A., Gropp, W. & Olson, L. Performance Analysis and Optimal Node-Aware Communication for Enlarged Conjugate Gradient Methods. *ACM Trans. Parallel Comput.* **10** (Mar. 2023).

2022   3. **Lockhart, S.**, Gardner, D. J., Woodward, C. S., Thomas, S. & Olson, L. N. *Performance of Low Synchronization Orthogonalization Methods in Anderson Accelerated Fixed Point Solvers* in *Proceedings of the 2022 SIAM Conference on Parallel Processing for Scientific Computing* (2022), 49–59.

2021   4. Bienz, A., Olson, L. N., Gropp, W. D. & **Lockhart, S.** *Modeling Data Movement Performance on Heterogeneous Architectures* in *2021 IEEE High Performance Extreme Computing Conference (HPEC)* (2021), 1–7.

2019   5. Karlin, I., Park, Y., de Supinski, B. R. & et al. (including Shelby Lockhart). *Preparation and Optimization of a Diverse Workload for a Large-Scale Heterogeneous System* in *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis* (Association for Computing Machinery, Denver, Colorado, 2019).

2017   6. Adhikari, L., DeGuchy, O., Erway, J. B., **Lockhart, S.** & Marcia, R. F. *Limited-memory trust-region methods for sparse relaxation* in *Wavelets and Sparsity XVII* (eds Lu, Y. M., Ville, D. V. D. & Papadakis, M.) **10394** (SPIE, 2017), 95–102.

Presentations

Apr 2023	**Sydney Fernbach Fellowship Finalist Technical Seminar**, LLNL, Livermore, CA, USA *Communication Reduction Strategies for Scalable Iterative Solvers*
Apr 2023	**Rising Stars in Computational and Data Sciences**, Austin, TX, USA *Reducing Communication Costs in Scalable Iterative Solvers*
Feb 2023	**SIAM Conference on Computational Science and Engineering (CSE23)**, Amsterdam, Netherlands *Anderson Acceleration on Emerging Architectures*
Oct 2022	**Center for Exascale-enabled Scramjet Design PSAAP Annual Review**, Urbana, IL, USA *Data Movement Modeling*
Apr 2022	**17th Copper Mountain Conference on Iterative Methods**, Virtual *Reducing Communication Costs in ECG with Optimal Node-Aware Communication*
Apr 2022	**Center for Exascale-enabled Scramjet Design PSAAP TST Meeting**, Urbana, IL, USA *Data Movement Modeling*
Feb 2022	**SIAM Conference on Parallel Processing for Scientific Computing Conference Proceedings**, Virtual *Performance of Low Synchronization Orthogonalization Methods in Anderson Accelerated Fixed Point Solvers*
May 2021	**ASC PI Meeting 2021**, Virtual *Modeling Data Movement on Heterogeneous Architectures*
Feb 2020	**SIAM Conference on Parallel Processing for Scientific Computing Poster Session**, Seattle, WA, USA *Multi-Step Communication in Enlarged Krylov Subspace Solvers*
Apr 2019	**9th JLESC Workshop**, Knoxville, TN, USA *Designing Scalable Solvers for Enlarged Krylov Subspace Methods*
Aug 2018	**LLNL Summer Student Poster Symposium**, Livermore, CA, USA *Increasing the Portability of SUNDIALS with OpenMP 4.5*

Significant Codebase Contributions

RAPtor: parallel algebraic multigrid solver	Implementation of block vector operations, *enlarged* Krylov methods, and *Split* optimal node-aware communication.
SUNDIALS	Implementation of an OpenMP 4.5 N_Vector for increased portability of the SUNDIALS software stack, as well as, low synchronization orthgonalization routines for use within Anderson acceleration in the KINSOL package.
BenchPress	High-volume ping-pong MPI benchmarking tests.

Other Work Experience

Dept. of Mathematics at Wake Forest University, Winston-Salem, NC, USA

Aug 2014 - May 2016 | *Math Center Tutor*   Supervisor: Jules Connolly

- Tutored in 9 undergraduate mathematics courses

Best Choice Center, Winston-Salem, NC, USA

Aug 2012 - Dec 2014 | *Middle School Tutor*   Supervisor: Mildred Houser

- Tutored in an after-school program for low-income families

Technical Skills

Programming Languages	C, C++, Python, MATLAB
Code Management	Make, CMake, bash, vim, git, GoogleTest, pytest, Travis CI, Spack
Debugging and Profiling	GDB, Valgrind, NVIDIA Visual Profiler, HPCToolkit, TAU
Parallel and Distributed Computing	• MPI, CUDA, OpenMP (including OpenMP with device-offloading), mpi4py • Familiarity with PyOpenCL and PyCuda • Extensive experience developing portable software on various large-scale HPC platforms • Extensive experience benchmarking and modeling MPI communication performance on large-scale HPC platforms
Scientific Libraries	SUNDIALS, *hypre*, MFEM, PETSc, XBraid, LAPACK, cuSPARSE, NumPy, SciPy
Operating Systems	macOS, Unix, Linux, Microsoft Windows
Machine Learning	• Working knowledge of PyTorch • Knowledge of distributed deep learning and related parallelization techniques
Documentation	LaTeX, TikZ, Beamer, Keynote, Microsoft Office

Other Relevant Skills

Communication	• Collaborate well with teams of diverse backgrounds and technical expertise • Ability to communicate objectives and importance of technical work to both technical and non-technical audiences

Project Management	• Ability to manage research projects and coordinate within a remote-working environment • Effective at designing and adhering to project timelines and deliverables
Research and Analysis	• Problem solving, the ability to break down complex problems into manageable tasks • Critical thinking skills, such as the ability to analyze the impact of hardware configurations on software performance and develop software optimization strategies

Service

2023	**ExaMPI23: Workshop on Extreme Scale MPI Committee Member**, SC23
2022 - 2023	**Community Outreach**, Participated in discussion panels at elementary schools in the Urbana-Champaign, IL community
2019 - 2020	**SIAM Student Chapter President**, University of Illinois at Urbana-Champaign, IL, USA
2017 - 2018	**SIAM Student Chapter Officer**, University of Illinois at Urbana-Champaign, IL, USA

Memberships

Society for Industrial and Applied Mathematics (SIAM)   Women in High Performance Computing (WHPC)
Association for Computing Machinery (ACM)   Association for Women in Mathematics (AWM)
Institute of Electrical and Electronics Engineers (IEEE)

Professional References

Luke N. Olson
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Lawrence Livermore National Laboratory
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