Joseph (Joe) Izraelevitz

joseph.izraelevitz@colorado.edu
https://www.colorado.edu/ecee/joseph-joe-izraelevitz

Research Interests

I work at the intersection of ***systems software*** and ***distributed computing theory***, and most of my work is tied together by the twin themes of ***emerging memory technologies*** and ***parallel programming***. On the systems side, I have built run-time libraries for ensuring consistent state on machines with new nonvolatile memory technologies, concurrent and persistent data structures, and novel consensus protocols using network-accessible memory. On the theory side, I have proven my systems work correct and developed formal tools for reasoning about programs in nonvolatile memory. In general, I build practical systems with formal guarantees, and publish in both systems (e.g., ASPLOS, MICRO) and theory (e.g., DISC) venues.

Education

2012-2018 Ph.D. in Computer Science - University of Rochester, Rochester, NY
Dissertation title: Concurrency Implications of Nonvolatile Byte-Addressable Memory [38]
Advisor: Prof. Michael L. Scott, Dept. of Computer Science

2004-2009 B.S./M.S. in Computer Science - Washington University in St. Louis
Second major in History
Thesis title: Automated Archaeological Survey of Ancient Irrigation Canals [41]
Advisor: Prof. Robert Pless, Dept. of Computer Science

Work Experience

Aug 2019-Present University of Colorado, Boulder, CO
Assistant Professor, Electrical, Computer, and Energy Engineering

My research addresses the entire system stack as the memory system becomes more heterogeneous, to include non-uniform memory, nonvolatile memory, secure memory, and network-accessible memory.

Aug 2018-Aug 2019 UC San Diego, San Diego, CA
Postdoctoral Scholar, Mentor: Prof. Steven Swanson

Nonvolatile Systems
The Nonvolatile Systems Lab at UCSD is a research group investigating the impact of new nonvolatile memory (NVM) on the design of computer systems, while there I participated in various projects on NVM including file systems [11], data structures, and hardware [10].

Jan 2018-Aug 2018 IMDEA Software Institute, Madrid, Spain
Postdoctoral Researcher, Mentor: Dr. Alexey Gotsman

Primitives for RDMA
In contrast to event based network protocols, RDMA allows us to directly access the memory of a remote machine, bypassing the remote CPU. This project investigated how to leverage RDMA primitives in order to build extremely fast and provably correct consensus algorithms [2].

Aug 2012-Jan 2018 University of Rochester, Computer Science Department, Rochester, NY
Doctoral Student, Advisor: Prof. Michael L. Scott

Infrastructure for Nonvolatile Memory
The replacement of DRAM with nonvolatile memory technologies (NVM) promises to create a new opportunity for fast, durable storage. In this line of work, I built practical and theoretical techniques to allow application programmers to use and reason about NVM and its state on power failure. In particular, I developed a composable correctness condition called *durable linearizability* [29, 19], and further built new libraries and data structures that use NVM [12, 26, 16].

Shared Memory Synchronization
In large shared-memory machines, synchronization and communication between threads is often a major obstacle to scalability; useful and performant tools are needed for the programmer. This work produced new nonblocking concurrent data structures [44, 14, 17], garbage collection techniques [13], and hardware primitives [15].

June 2015-Aug 2016 Hewlett-Packard (HP) Labs, Palo Alto, CA
Research Associate, Systems Group, Mentor: Dr. Terence Kelly

Nonvolatile Memory and Persistent Caches
This work studied the implications that using NVM caches, in addition to NVM main memory, would have on system design, resulting in two papers [16, 18], and three patent applications [33, 34, 35].

June 2014-Sep 2014 Oracle Labs, Burlington, MA
Research Intern, Scalable Synchronization Group, Mentors: Dr. Yossi Lev, Dr. Virendra Marathe

Side-effects of Lock Elision
This project investigated the performance effects of lock elision using both optimistic software synchronization techniques and hardware transactional memory on real-world benchmarks [28].

May 2009-Aug 2012 United States Army, Fort Carson, CO
Armor Officer

My three year service in the United States Army included one year-long deployment to Afghanistan as a staff officer. During my service, I filled positions in the battalion communications and planning groups, as well serving as a Tank Platoon Leader. While deployed, I served as the Battalion Afghan National Security Forces Liaison Officer, coordinating American logistical and training support for partnered security forces in Kandahar City.

Publications

Publications are organized by venue. Note that in computing, conference papers are generally rated higher than journal articles, while "workshops" take the role that "conferences" play in most fields. All publications published in 2020 or later were published while a professor at CU.

Conference and Journal Publications

[1] George Hodgkins*, Yi Xu, Steven Swanson, and **Joseph Izraelevitz**. Zhuque: Failure is not an option, it's an exception. *In: 2023 USENIX Annual Technical Conf.* USENIX ATC 23, Boston, MA, USA, 2023. Acceptance rate: 18%. ***CU Student.***

[2] **Joseph Izraelevitz**, Gaukas Wang*, Rhett Hanscom*, Kayli Silvers*, Tamara Silbergleit Lehman, Gregory Chockler, and Alexey Gotsman. Acuerdo: Fast atomic broadcast over RDMA. *In: 51st Intl. Conf. on Parallel Processing*, ICPP '22, Bordeaux, France, 2023. Acceptance rate: 27%. ***CU Student.**

[3] Zhang Liu*, Dirk Grunwald, **Joseph Izraelevitz**, Gaukas Wang*, and Sangtae Ha. Mrtom: Mostly reliable totally ordered multicast, a network primitive to offload distributed systems. *In: 43rd IEEE Intl. Conf. on Distributed Computing Systems*, ICDCS '23, Hong Kong, China, 2023. Acceptance rate: 19%. ***CU Student.**

[4] Casey Nelson, **Joseph Izraelevitz**, R. Iris Bahar, and Tamara Silbergleit Lehman. Eliminating micro-architectural side-channel attacks using near memory processing. *In: 2022 IEEE Intl. Symp. on Secure and Private Execution Environment Design (SEED)*, 2022. Acceptance rate: 71%.

[5] Yi Xu, **Joseph Izraelevitz**, and Steven Swanson. Clobber-nvm: Log less, re-execute more. *In: 26th ACM Intl. Conf. on Architectural Support for Programming Languages and Operating Systems*, ASPLOS 2021, Virtual, USA, 2021. Acceptance rate: 19%.

[6] Juno Kim, Yun Joon Soh, **Joseph Izraelevitz**, Jishen Zhao, and Steven Swanson. Subzero: Zero-copy io for persistent main memory file systems. *In: 11th ACM SIGOPS Asia-Pacific Wkshp. on Systems*, APSys '20, Tsukuba, Japan, 2020. Acceptance rate: 39%. Best Paper Award.

[7] Amirsaman Memaripour, **Joseph Izraelevitz**, and Steven Swanson. Pronto: Easy and fast persistence for volatile data structures. *In: 25th Intl. Conf. on Architectural Support for Programming Languages and Operating Systems*, ASPLOS '20, Lausanne, Switzerland, 2020. Acceptance rate: 18%.

[8] Jian Yang, **Joseph Izraelevitz**, and Steven Swanson. Filemr: Rethinking rdma networking for scalable persistent memory. *In: 17th USENIX Conf. on Networked Systems Design and Implementation*, NSDI '20, Santa Clara, CA, USA, 2020. Acceptance rate: 18%.

[9] Jian Yang, Juno Kim, Morteza Hoseinzadeh, **Joseph Izraelevitz**, and Steven Swanson. An empirical guide to the behavior and use of scalable persistent memory. *In: 18th USENIX Conf. on File and Storage Technologies*, FAST '20, Santa Clara, CA, USA, 2020. Acceptance rate: 17%.

[10] Kunal Korgaonkar, **Joseph Izraelevitz**, Jishen Zhao, and Steven Swanson. Vorpal: Vector clock ordering for large persistent memory systems. *In: 2019 ACM Symp. on Principles of Distributed Computing*, PODC '19, Toronto ON, Canada, 2019. Acceptance rate: 28%.

[11] Jian Yang, **Joseph Izraelevitz**, and Steven Swanson. Orion: A distributed file system for non-volatile main memories and RDMA-capable networks. *In: 17th USENIX Conf. on File and Storage Technologies*, FAST '19, Boston, MA, 2019. Acceptance rate: 18%.

[12] Qingrui Liu, **Joseph Izraelevitz**, Se Kwon Lee, Michael L. Scott, Sam H. Noh, and Changhee Jung. Ido: Compiler-directed failure atomicity for nonvolatile memory. *In: 51st IEEE/ACM Intl. Symp. on Microarchitecture*, MICRO '18, Fukuoka, Japan, 2018. Acceptance rate: 21%.

[13] Haosen Wen, **Joseph Izraelevitz**, Wentao Cai, H. Alan Beadle, and Michael L. Scott. Interval based memory reclamation. *In: 23rd ACM SIGPLAN Symp. on Principles and Practice of Parallel Programming*, PPoPP '18, Vienna, Austria, 2018. Acceptance rate: 20%.

[14] **Joseph Izraelevitz** and Michael L. Scott. Generality and speed in nonblocking dual containers. *In: ACM Trans. on Parallel Computing*, 3(4):22:1–22:37, 2017.

[15] **Joseph Izraelevitz**, Lingxiang Xiang, and Michael L. Scott. Performance improvement via always-abort HTM. *In: 26th Intl. Conf. on Parallel Architectures and Compilation Techniques*, PACT '17, Portland, OR, USA, 2017. Acceptance rate: 23%.

[16] Faisal Nawab, **Joseph Izraelevitz**, Terence Kelly, Charles B. Morrey, Dhruva Chakrabarti, and Michael L. Scott. Dalí: A periodically persistent hash map. *In: 31st Intl. Symp. on Distributed Computing*, DISC '17, Vienna, Austria, 2017. Acceptance rate: 24%.

[17] Matthew Graichen, **Joseph Izraelevitz**, and Michael L. Scott. An unbounded nonblocking double-ended queue. *In: 45th Intl. Conf. on Parallel Processing*, ICPP '16, Philadelphia, PA, USA, 2016. Acceptance rate: 21%.

[18] **Joseph Izraelevitz**, Terence Kelly, and Aasheesh Kolli. Failure-atomic persistent memory updates via JUSTDO logging. *In: 21st Intl. Conf. on Architectural Support for Programming Languages and Operating Systems*, ASPLOS '16, Atlanta, GA, USA, 2016. Acceptance rate: 23%.

[19] **Joseph Izraelevitz**, Hammurabi Mendes, and Michael L. Scott. Linearizability of persistent memory objects under a full-system-crash failure model. *In: 30th Intl. Conf. on Distributed Computing*, DISC '16, Paris, France, 2016. Acceptance rate: 24%.

Short Peer-reviewed Publications (Workshop papers, posters, etc.)

[20] Samuel Thomas, Kidus Workneh*, Ange-Thierry Ishimwe*, Zack McKevitt*, Phaedra Curlin*, R. Iris Bahar, **Joseph Izraelevitz**, and Tamara Lehman. Baobab merkle tree for efficient secure memory. *In: IEEE Computer Architecture Letters*, 2024. To appear. ***CU Student.**

[21] George Hodgkins*, Yi Xu, Steven Swanson, and **Joseph Izraelevitz**. Zhuque: Failure is not an option, it's an exception. *In: 14th Annual Non-Volatile Memories Wkshp.* NVMW '23, San Diego, CA, USA, 2023. ***CU Student.**

[22] Fernando Villanea, Max Eaton*, Penglei Huang*, and **Joseph Izraelevitz**. Poster presentation: Implement a better random seed generator for genomic simulation. *In: 2023 Conf. of the Society of Molecular Biology and Evolution*, SMBE '23, Ferrara, Italy, 2023. ***CU Student.**

[23] Amirsaman Memaripour, Yi Xu, **Joseph Izraelevitz**, and Steven Swanson. Poster presentation: Nvhooks: Compiler support for non-volatile memory programming. *In: 11th Annual Non-Volatile Memories Wkshp.* NVMW '20, San Diego, CA, USA, 2020.

[24] Jian Yang, Juno Kim, Morteza Hoseinzadeh, **Joseph Izraelevitz**, and Steven Swanson. An empirical guide to the behavior and use of scalable persistent memory. *In: 11th Annual Non-Volatile Memories Wkshp.* NVMW '20, San Diego, CA, USA, 2020.

[25] Faisal Nawab, **Joseph Izraelevitz**, Terence Kelly, Charles B. Morrey, Dhruva Chakrabarti, and Michael L. Scott. Dalí: A periodically persistent hash map. *In: 9th Annual Non-Volatile Memories Wkshp.* NVMW '18, San Diego, CA, USA, 2018.

[26] **Joseph Izraelevitz**, Virendra Marathe, and Michael L. Scott. Poster presentation: Composing durable data structures. *In: 8th Annual Non-Volatile Memories Wkshp.* NVMW '17, San Diego, CA, USA, 2017.

[27] **Joseph Izraelevitz**, Lingxiang Xiang, and Michael L. Scott. Performance improvement via always-abort HTM. *In: 12th ACM SIGPLAN Wkshp. on Transactional Computing*, TRANSACT '17, Austin, TX, USA, 2017.

[28] **Joseph Izraelevitz**, Alex Kogan, and Yossi Lev. Implicit acceleration of critical sections via unsuccessful speculation. *In: 11th ACM SIGPLAN Wkshp. on Transactional Computing*, TRANSACT '16, Barcelona, Spain, 2016.

[29] **Joseph Izraelevitz**, Hammurabi Mendes, and Michael L Scott. Brief announcement: Preserving happens-before in persistent memory. *In: 28th ACM Symp. on Parallelism in Algorithms and Architectures*, SPAA'16, Asilomar Beach, CA, USA, 2016.

[30] **Joseph Izraelevitz** and Michael L. Scott. Brief announcement: A generic construction for nonblocking dual containers. *In: 2014 ACM Symp. on Principles of Distributed Computing*, PODC '14, Paris, France, 2014.

[31] **Joseph Izraelevitz** and Michael L. Scott. Brief announcement: Fast dual ring queues. *In: 26th ACM Symp. on Parallelism in Algorithms and Architectures*, SPAA '14, Prague, Czech Republic, 2014.

Patents and Patent Applications

[32] Virendra Marathe and **Joseph Izraelevitz**. Systems and methods for constructing composable persistent data structures, Patent US10007581B2, US, 2018. Oracle International Corporation.

[33] Terence Kelly, Charles B. Morrey, Dhruva Chakrabarti, Aasheesh Kolli, Qiong Cai, Andrew C. Walton, and **Joseph Izraelevitz**. Register store, Patent application filed, US, 2016. Hewlett Packard Enterprise.

[34] Faisal Nawab, **Joseph Izraelevitz**, Terence Kelly, Charles B. Morrey, and Dhruva Chakrabarti. Memory system to access uncorrupted data, Patent application filed, US, 2016. Hewlett Packard Enterprise.

[35] **Joseph Izraelevitz**, Terence Kelly, Aasheesh Kolli, and Charles B. Morrey. Resuming execution in response to failure, Patent application filed (WO2017074451), US, 2015. Hewlett Packard Enterprise.

Unrefereed Publications (TRs, theses, etc.)

[36] **Joseph Izraelevitz**, Jian Yang, Lu Zhang, Amirsaman Memaripour, Yun Joon Soh, Subramanya R. Dulloor, Jishen Zhao, Juno Kim, Xiao Liu, Zixuan Wang, Yi Xu, and Steven Swanson. Basic performance measurements of the intel optane dc persistent memory module. *In: arXiv preprint arXiv:1903.05714*, 2019.

[37] Jian Yang, Juno Kim, Morteza Hoseinzadeh, **Joseph Izraelevitz**, and Steven Swanson. An empirical guide to the behavior and use of scalable persistent memory. *In: arXiv preprint arXiv:1908.03583*, 2019.

[38] **Joseph Izraelevitz**. Concurrency implications of nonvolatile byte-addressable memory, Department of Computer Science, University of Rochester, 2018. Ph.D. Thesis.

[39] **Joseph Izraelevitz** and Michael L. Scott. A generic construction for nonblocking dual containers. Technical report TR 992, Department of Computer Science, University of Rochester, 2014.

[40] **Joseph Izraelevitz** and Michael L. Scott. Fast dual ring queues. Technical report TR 990, Department of Computer Science, University of Rochester, 2014.

[41] **Joseph Izraelevitz**. Automated archaeological survey of ancient irrigation canals, Department of Computer Science, Washington University in St. Louis, 2009. Master's Thesis.

[42] **Joseph Izraelevitz**. Poster presentation: Analyzing software dependencies on supercomputers with REV. *In: Los Alamos National Laboratory Student Symp.* Los Alamos, NM, USA, 2007.

Manuscripts in Progress

[43] Samuel Thomas, Kidus Workneh*, Jac McCarty, **Joseph Izraelevitz**, Iris Bahar, and Tamara Lehman. A midsummer night's tree: Efficient and high performance secure scm, 2023. In review. ***CU Student.***

[44] **Joseph Izraelevitz**, Wentao Cai, Haosen Wen, Terence Kelly, Hideaki Kimura, and Michael L. Scott. Polytree: A synchronization framework for building ordered maps, 2018. In progress.

Teaching

- *Instructor, Compiler Construction. (SP2022, SP2023, SP2024)* This project-based class explores the compiler pipeline through the intensive development of a Python to x86 compiler.
- *Instructor, Concurrent Programming. (FL2019, FL2020, FL2022, FL2023)* This class explores the essentials of concurrent programming, covering shared memory synchronization.
- *Instructor, Modern Computer Systems. (SP2023, SP2024)* This class introduces students to the state-of-the-art research in computer systems through a semester long project.
- *Instructor, C Programming. (SP2020, SP2021)* This introductory programming class covers the essentials of the C and C++ languages for engineering majors.

Honors and awards

- Faculty Speaker at Departmental Commencement, chosen by students, 2023.
- Holland Departmental Award Winner for Outstanding Teaching, 2023.
- Commendation (Runner-up) Outstanding Dissertation Award Competition for Engineering, U. of Rochester, 2018.
- Hopeman Fellowship (School of Engineering scholarship), 2013-2014.
- Sproull Fellow (full-tuition award to U. of Rochester), 2012-2013.
- Induction into Tau Beta Pi – Engineering Honor Society, 2009.
- Induction into Phi Alpha Theta – History Honor Society, 2009.
- George C. Marshall Cadet Award (top military graduate at Washington U. in St. Louis), 2009.
- Alexander S. Langsdorf Fellow (full-tuition award to Washington U. in St. Louis), 2004-2009.
- J. Robert Oppenheimer Memorial Scholar, 2004.
- National Merit Finalist, 2003.

Grants

- PI for *Ultra-fast Self Checkpointing Recovery Architecture* ($244,000) funded by Sandia National Laboratories (DOE), 2023.
- PI for *CAREER: Programming Heterogeneous Memory Hierarchies* ($524,470) funded by NSF, 2023.
- co-PI for *Optimizing Computer Simulation for Use in Archaic Genomics* ($50,000 with $4,500 for Co-PI Izraelevitz) funded by CU Boulder's Research and Innovation Office, 2023.
- PI for *Resilient Memory Systems for Recovery in Hybrid Systems* ($54,339) funded by Sandia National Laboratories (DOE), 2023.
- External collaborator on *SACRED-MA: Safe And seCure REmote Direct Memory Access*, funded by EPSRC, 2023.
- PI for *Optimized Reflective Memory over RDMA for Real-time System Testing* ($67,820) funded by Genuen, 2023.
- PI for *Low-latency Communication over RDMA for Real-time System Testing* ($168,268) funded by Genuen, 2022.
- Co-PI for *Enabling High IPC in Future Multi-NUMA Systems* ($415,000, with $95,000 for Co-PI Izraelevitz) funded by the NSF/Intel Partnership on Foundational Microarchitecture Research (FoMR) Program, 2020.
- Awarded travel grants to PACT'17, SPAA'16.

External Service

- *Working Group Member.* CRA LEVEL UP Workshop on Inclusive Undergraduate Computing Education, 2024.
- *Reviewer.* ACM Trans. on Parallel Computing (TOPC), 2024.
- *Reviewer.* IEEE Trans. on Distributed Systems (TPDS), 2024.
- *External PC.* Intl Symp. on Computer Architecture, 2024.
- *External PC.* Symp. Principles & Practice of Parallel Programming (PPoPP), 2024.
- *External PC.* Conf. Architectural Support for Programming Languages & Operating Systems (ASPLOS), 2024.
- *Panelist.* NSF Review Panel, 2023.
- *PC Member.* Conf. Architectural Support for Programming Languages & Operating Systems (ASPLOS), 2023.
- *PC Member.* Conf. Architectural Support for Programming Languages & Operating Systems (ASPLOS), 2022.
- *PC Member.* Symp. on Operating Systems Design and Implementation (OSDI), 2021.
- *Reviewer.* ACM Trans. on Storage (TOS), 2021.

- *External PC*. Conf. Architectural Support for Programming Languages & Operating Systems (ASPLOS), 2021.
- *Reviewer*. ACM Trans. on Storage (TOS), 2020.
- *Organizing Committee*. Persistence in Real Life (PiRL), 2020.
- *PC Member*. Intl. Symp. on Distributed Computing (DISC), 2020.
- *Reviewer*. Very Large Data Base (VLDB) Journal, 2020.
- *PC Member*. ACM Symp. on Parallelism in Algorithms and Architectures (SPAA), 2020.
- *PC Member*. Nonvolatile Memories Workshop (NVMW), 2020.
- *Reviewer*. IEEE Computer Architecture Letters (CAL), 2020.
- *PC Member*. IEEE/ACM Intl. Symp. on Cluster, Cloud and Grid Computing (CCGrid), 2020.
- *Organizing Committee*. Persistence in Real Life (PiRL), 2019.
- *External PC*. ACM Symp. on Principles of Distributed Computing (PODC), 2019.
- *Reviewer*. IEEE Trans. on Parallel and Distributed Systems (TPDS), 2019.
- *Reviewer*. ACM Trans. on Architecture and Code Optimization (TACO), 2019.
- *PC Member*. Nonvolatile Memories Workshop (NVMW), 2019.
- *Publicity Chair*. Nonvolatile Memories Workshop (NVMW), 2019.
- *PC Member*. IEEE/ACM Intl. Symp. on Cluster, Cloud and Grid Computing (CCGrid), 2019.
- *External PC*. Intl. Symp. on Memory Management (ISMM), 2017.
- *Artifact Evaluation PC*. Symp. on Principles & Practice of Parallel Programming (PPoPP), 2017.
- *External PC*. Intl. Conf. on Parallel Architectures and Compilation Techniques (PACT), 2016.
- *External PC*. Intl. Conf. on Distributed Computing (DISC), 2014.

Internal Service

- *Committee Co-Chair*. Dept. Graduate Student Committee, 2023-present.
- *Lead Author*. Dept. Policy on Ph.D. Admission, Evaluation, Dismissal, 2021.
- *Committee Member*. Dept. Graduate Student Committee, 2019-present.

Talks

- Invited talk at Intel Foundations of Microarchitecture Research: Providing Failure Atomicity on Storage Class Memory, 2022.
- Invited talk at Intl. Wkshp. on High Performance Transaction Systems (HPTS): An Empirical Guide to the Behavior of Scalable Persistent Memory, 2019.
- Invited talk at Microsoft Research: Distributed Algorithms over RDMA. Cambridge, UK. July, 2018
- Invited talk at VMWare Research: Linearizability of Persistent Memory Objects Under a Full-System-Crash Failure Model. Palo Alto, CA, August 2016.
- Presented papers at ASPLOS [18], DISC×2 [19],[16], PACT [15], SPAA×2 [29],[31], TRANSACT×2 [27],[28].