

# Nathan Beckmann

Computer Science Department  
School of Computer Science  
Carnegie Mellon University

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## RESEARCH INTERESTS

I am interested in improving the energy-efficiency of computer systems. Specifically, my research addresses the data bottleneck: computers spend most of their energy accessing data, not processing it. My research designs new, data-centric systems that dramatically reduce the cost of accessing data. This research spans many topics, including computer systems, computer architecture, programming models, operating systems, storage, and performance modeling & analysis.

## EDUCATION

**Massachusetts Institute of Technology** ..... Sep 2015  
*Ph.D.*, Electrical Engineering and Computer Science.  
*Thesis:* Design and Analysis of Spatially-Partitioned Shared Caches.  
*Supervisor:* Daniel Sanchez.

**Massachusetts Institute of Technology** ..... Sep 2010  
*S.M.*, Electrical Engineering and Computer Science.  
*Thesis:* Distributed Naming in a Factored Operating System.  
*Supervisor:* Anant Agarwal.

**University of California, Los Angeles** ..... Mar 2008  
*B.S.* Computer Science. *Summa cum Laude.*  
*B.S.* Mathematics of Computation. *Summa cum Laude.*

## AWARDS

Best Paper nominee at ISCA ..... 2022  
Best Paper at SOSP ..... 2021  
Google Research Scholar Award ..... 2021  
Best Paper at APoCS ..... 2020  
NSF CAREER Award ..... 2019  
Google Faculty Research Award ..... 2019  
Google Faculty Research Award ..... 2017  
George M. Sprowls Doctoral Thesis Prize ..... 2015  
*Best doctoral thesis in computer science at MIT.*

Best Paper nominee at HPCA ..... 2015  
William A. Martin Memorial Thesis Award ..... 2010  
*Best master's thesis in computer science at MIT.*

UCLA Bachelor of the Year in Computer Science ..... 2008  
UCLA Rose Hills Foundation Science and Engineering Scholarship (2×) ..... 2007 & 2008

## PROFESSIONAL EXPERIENCE

**Carnegie Mellon University** ..... Jan 2017 - Present  
ASSISTANT PROFESSOR in the Computer Science Department of the School of Computer Science.

**Massachusetts Institute of Technology** ..... Sep 2015 - Jan 2017  
POSTDOC with Prof. Daniel Sanchez; worked on well-behaved, high-performance memory systems for parallel processors.

**Massachusetts Institute of Technology** ..... Sep 2012 - Sep 2015  
RESEARCH ASSISTANT to Prof. Daniel Sanchez; worked on scheduling data across caches in parallel processors.

**Massachusetts Institute of Technology** ..... Sep 2008 - Sep 2012  
RESEARCH ASSISTANT to Profs. Anant Agarwal, Frans Kaashoek, and Nickolai Zeldovich; worked on distributed operating systems (fos project).

**NVidia** ..... Summer 2007  
SOFTWARE INTERN in the embedded division; worked on OpenGL ES 2.0 and optimizing customer applications.

**Symantec Research Labs** ..... Summers 2005 & 2006  
RESEARCH INTERN at Symantec Research Labs; prototyped an early design of an extrusion detection system.

**University of California, Los Angeles** ..... Sep 2003 - Mar 2008  
UNDERGRADUATE RESEARCHER with Profs. Glenn Reinman and Miodrag Potkonjak; worked on cache organization for physics simulation and statistical analysis of sensor networks.

## REFEREED JOURNAL PUBLICATIONS

- Kangaroo: Theory and Practice of Caching Billions of Tiny Objects on Flash** ... ACM Transactions on Storage 2022  
Sara McAllister, Benjamin Berg, Julian Tutuncu-Macias, Juncheng Yang, Sathya Gunasekar, Jimmy Lu, Daniel S. Berger,  
*Nathan Beckmann*, Gregory R. Ganger
- Practical Bounds on Offline Caching with Variable Object Sizes** ..... (*Journal of SIGMETRICS*) POMACS 2018  
Daniel Berger, *Nathan Beckmann*, Mor Harchol-Balter  
Acceptance Rate: 16%
- Cache Calculus: Modeling Caches through Differential Equations** ..... CAL 2016  
*Nathan Beckmann*, Daniel Sanchez

## REFEREED CONFERENCE & WORKSHOP PUBLICATIONS

- RipTide: A programmable, energy-minimal dataflow compiler and architecture** ..... MICRO 2022  
Graham Gobieski, Souradip Ghosh, Marijn Heule, Todd Mowry, Tony Nowatzki, *Nathan Beckmann*, Brandon Lucia  
Acceptance Rate: 22%
- Brief Announcement: Spatial Locality and Granularity Change in Caching** ..... SPAA 2022  
*Nathan Beckmann*, Phillip B. Gibbons, Charles McGuffey  
Acceptance Rate: 37%
- täkö: A Polymorphic Cache Hierarchy for General-Purpose Optimization of Data Movement** ..... ISCA 2022 (*Best Paper nominee*)  
Acceptance Rate: 17%
- Brian Schwedock, Piratach Yoovidhya, Jennifer Seibert, *Nathan Beckmann*
- Kangaroo: Caching Billions of Tiny Objects on Flash** ..... SOSP 2021 (*Best Paper*)  
Sara McAllister, Benjamin Berg, Julian Tutuncu-Macias, Juncheng Yang, Sathya Gunasekar, Jimmy Lu, Daniel Berger,  
*Nathan Beckmann*, Gregory R. Ganger  
Acceptance Rate: 16%
- Brief Announcement: Block-Granularity-Aware Caching** ..... SPAA 2021  
*Nathan Beckmann*, Phillip Gibbons, Charles McGuffey  
Acceptance Rate: 50%
- SNAFU: An Ultra-Low-Power, Energy-Minimal CGRA-Generation Framework and Architecture** ..... ISCA 2021  
Graham Gobieski, Oguz Atli, Ken Mai, Brandon Lucia, *Nathan Beckmann*  
Acceptance Rate: 19%
- The Role of Edge Offload in Hardware-Accelerated Mobile Devices** ..... HotMobile 2021  
Mahadev Satyanarayanan, *Nathan Beckmann*, Grace A. Lewis, Brandon Lucia  
Acceptance Rate: 36%
- The CacheLib Caching Engine: Design and Experiences at Scale** ..... OSDI 2020  
Benjamin Berg, Daniel S. Berger, Sara McAllister, Isaac Grosf, Sathya Gunasekar, Jimmy Lu, Michael Uhlar, Jim Carrig,  
*Nathan Beckmann*, Mor Harchol-Balter, Gregory R. Ganger  
Acceptance Rate: 18%
- Jumanji: The Case for Dynamic NUCA in the Datacenter** ..... MICRO 2020  
Brian Schwedock, *Nathan Beckmann*  
Acceptance Rate: 19%
- Tvarak: Software-Managed Hardware Offload for DAX NVM Storage Redundancy** ..... ISCA 2020  
Rajat Kateja, *Nathan Beckmann*, Greg Ganger  
Acceptance Rate: 18%
- Livia: Data-Centric Computing Throughout the Memory Hierarchy** ..... ASPLOS 2020  
Elliot Lockerman, Axel Feldmann, Mohammad Bakhshalipour, Alex Stanescu, Shashwat Gupta, Daniel Sanchez, *Nathan Beckmann*  
Acceptance Rate: 18%
- Writeback-Aware Caching** ..... APOCS 2020 (*Best Paper*)  
*Nathan Beckmann*, Phillip Gibbons, Bernhard Haeupler, Charles McGuffey  
Acceptance Rate: 60%
- MANIC: An Energy-Efficient Architecture for Ultra-Low-Power Embedded Systems** ..... MICRO 2019  
Graham Gobieski, Amolak Nagi, Nathan Serafin, Mehmet Meric Isgenc, *Nathan Beckmann*, Brandon Lucia  
Acceptance Rate: 23%
- PHI: Architectural Support for Synchronization- and Bandwidth-Efficient Commutative Scatter Updates** ..... MICRO 2019  
Acceptance Rate: 23%
- Anurag Mukkara, *Nathan Beckmann*, Daniel Sanchez
- Brief Announcement: Writeback-Aware Caching** ..... SPAA 2019  
*Nathan Beckmann*, Phillip Gibbons, Bernhard Haeupler, Charles McGuffey  
Acceptance Rate: 40%
- Intelligence Beyond the Edge: Inference on Intermittent Embedded Systems** ..... ASPLOS 2019  
Graham Gobieski, Brandon Lucia, *Nathan Beckmann*  
Acceptance Rate: 21%
- Improving the Locality of Graph Processing through Hardware-Accelerated Traversal Scheduling** ... MICRO 2018  
Anurag Mukkara, *Nathan Beckmann*, Maleen Abeydeera, Xiaosong Ma, Daniel Sanchez  
Acceptance Rate: 21%
- Intermittent Deep Neural Network Inference** ..... SysML 2018  
Graham Gobieski, *Nathan Beckmann*, Brandon Lucia  
Acceptance Rate: 57%
- LHD: Improving Cache Hit Rate by Maximizing Hit Density** ..... NSDI 2018  
*Nathan Beckmann*, Haoxian Chen, Asaf Cidon  
Acceptance Rate: 15%
- Cache-Guided Scheduling: Exploiting Caches to Maximize Locality in Graph Processing** ..... AGP at ISCA 2017  
Anurag Mukkara, *Nathan Beckmann*, Daniel Sanchez
- Nexus: A New Approach to Replication in Distributed Shared Caches** ..... PACT 2017  
Po-An Tsai, *Nathan Beckmann*, Daniel Sanchez  
Acceptance Rate: 23%

**Jenga: Software-Defined Cache Hierarchies** ..... ISCA 2017  
 Po-An Tsai, *Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 17%

**Maximizing Cache Performance Under Uncertainty** ..... HPCA 2017  
*Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 22%

**Whirlpool: Improving Cache Management with Application-Level Data Classification** ..... ASPLOS 2016  
 Anurag Mukkara, *Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 22%

**Modeling Cache Performance Beyond LRU** ..... HPCA 2016  
*Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 22%

Technical report: MIT CSAIL, April 2015.

**Rubik: Fast Analytical Power Management for Latency-Critical Systems** ..... MICRO 2015  
 Harshad Kasture, Davide Bartolini, *Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 22%

**Talus: A Simple Way to Remove Cliffs in Cache Performance** ..... HPCA 2015 (Best Paper nominee)  
*Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 22%

**CDCS: Scaling Non-Uniform Cache Architectures with Computation and Data Co-Scheduling** ..... HPCA 2015  
*Nathan Beckmann*, Po-An Tsai, Daniel Sanchez ..... Acceptance Rate: 22%

**Jigsaw: Scalable Software-Defined Caches** ..... PACT 2013  
*Nathan Beckmann*, Daniel Sanchez ..... Acceptance Rate: 17%

**The Case for Elastic Operating System Services in fos** ..... DAC 2012  
 Lamia Youseff, *Nathan Beckmann*, Harshad Kasture, Charles Gruenwald III, David Wentzlaff, Anant Agarwal ..... Acceptance Rate: 23%

**An Operating System for Multicore and Clouds: Mechanisms and Implementation** ..... SOCC 2010  
 David Wentzlaff, Charles Gruenwald III, *Nathan Beckmann*, Kevin Modzelewski, Adam Belay, Lamia Youseff, Jason Miller, Anant Agarwal ..... Acceptance Rate: 19%

Technical report: MIT CSAIL, Feb 2010.

**ATAC: Improving Performance and Programmability with On-Chip Optical Networks** ..... ISCAS 2010  
 James Psota, Jason Miller, George Kurian, Henry Hoffmann, *Nathan Beckmann*, Jonathan Eastep, Anant Agarwal ..... Acceptance Rate: 45%

**A Unified Operating System for Clouds and Manycore: fos** ..... CAOS at HiPEAC 2010  
 David Wentzlaff, Charles Gruenwald III, *Nathan Beckmann*, Kevin Modzelewski, Adam Belay, Lamia Youseff, Jason Miller, Anant Agarwal

Technical report: MIT CSAIL, November 2009.

**Graphite: A Distributed Parallel Simulator for Multicores** ..... HPCA 2010  
 Jason Miller, Harshad Kasture, George Kurian, Charles Gruenwald III, *Nathan Beckmann*, Christopher Celio, Jonathan Eastep, Anant Agarwal ..... Acceptance Rate: 18%

Technical report: MIT CSAIL, November 2009.

**Hardware-based Public-key Cryptography with Public Physically Unclonable Functions** .. Information Hiding 2009  
*Nathan Beckmann*, Miodrag Potkonjak

**ADDITIONAL TECHNICAL REPORTS**

**Spatial Locality and Granularity Change in Caching** ..... arXiv 2022  
*Nathan Beckmann*, Phillip B. Gibbons, Charles McGuffey

**PIKA: A Network Service for Multikernel Operating Systems** ..... MIT CSAIL, Jan 2014  
*Nathan Beckmann*, Charles Gruenwald III, Charles Johnson, Harshad Kasture, Fillipo Sironi, Anant Agarwal, Frans Kaashoek, Nikolai Zeldovich

**Efficient Cache Coherence on Manycore Optical Networks** ..... MIT CSAIL, Feb 2010  
 George Kurian, *Nathan Beckmann*, Jason Miller, James Psota, Anant Agarwal

**Core Count vs Cache Size for Manycore Architectures in the Cloud** ..... MIT CSAIL, Feb 2010  
 David Wentzlaff, *Nathan Beckmann*, Jason Miller, Anant Agarwal

**ATAC: A Manycore Processor with On-Chip Optical Network** ..... MIT CSAIL, May 2009  
 Jason Miller, James Psota, George Kurian, *Nathan Beckmann*, Jonathan Eastep, Jifeng Liu, Mark Beals, Jurgen Michel, Lionel Kimerling, Anant Agarwal

**OTHER WRITING**

**The Case for a Programmable Memory Hierarchy** ..... SIGARCH blog, 5 Apr 2021

**TALKS**

**Re-Thinking the Hardware-Software Interface for Data-Centric Systems** ..... Georgia Tech, 20 May 2022

**Re-Thinking the Hardware-Software Interface for Data-Centric Systems** ..... MIT, 16 May 2022

**Re-Thinking the Hardware-Software Interface for Data-Centric Systems** ..... Stanford, 10 May 2022

**Re-Thinking the Hardware-Software Interface for Data-Centric Systems** ..... Cornell, 4 May 2022

Re-Thinking the Hardware-Software Interface for Data-Centric Systems ..... U. Washington, 27 Apr 2022  
 LHD: Improving Cache Hit Rate by Maximizing Hit Density ..... PMHO @ PPOPP, 2 Apr 2022  
 Making Data Access Faster and Cheaper via Ubiquitous Flash Caching ..... PDL Summer Seminar, 10 Jun 2021  
 Making Data Access Faster and Cheaper via Ubiquitous Flash Caching ..... Google, 6 Apr 2021  
 Overview of Caching Research at the Parallel Data Lab ..... Cache@Scale, 4 Mar 2021  
 Practical Bounds on Offline Caching with Variable Object Sizes ..... PMHO @ PPOPP, 28 Feb 2021  
 Tvarak: Software-Managed Hardware Offload for DAX NVM Storage Redundancy ..... ISCA, 2 Jun 2020  
 The Case for a Richer Memory Interface ..... Memory Systems Panel @ ISCA, 2 Jun 2020  
 Pushing the Limits of Online and Offline Caching ..... U. Rochester, 2 Dec 2019  
 Teaching An Old Cache New Tricks: Learning Better Caching Policies Online ML for Systems @ ISCA, 23 Jun 2019  
 Intelligence Beyond the Edge: Inference on Intermittent Embedded Systems ..... Stanford, 1 May 2019  
 Teaching An Old Cache New Tricks: Learning Better Caching Policies Online ..... Google, 19 Sep 2018  
 LHD: Improving Cache Hit Rate by Maximizing Hit Density ..... PDL Retreat, Bedford Springs, 24 Oct 2017  
 Maximizing Cache Performance Under Uncertainty ..... HPCA, Austin, 6 Feb 2017  
 Whirlpool: Improving Dynamic Cache Management with Static Data Classification . ASPLOS, Atlanta, 4 Apr 2016  
 Hardware and Software Techniques to Scale the Memory Wall ..... Berkeley, 28 Mar 2016  
 Hardware and Software Techniques to Scale the Memory Wall ..... NYU, 23 Mar 2016  
 Hardware and Software Techniques to Scale the Memory Wall ..... CMU, 17 Mar 2016  
 Modeling Cache Performance Beyond LRU ..... HPCA, Barcelona, 14 Mar 2016  
 Hardware and Software Techniques to Scale the Memory Wall ..... Toronto, 8 Mar 2016  
 Hardware and Software Techniques to Scale the Memory Wall ..... Stanford, 2 Mar 2016  
 Talus: A Simple Way to Remove Cliffs in Cache Performance ..... HPCA, San Francisco, 9 Feb 2015  
 Jigsaw: Scalable Software-Defined Caches ..... PACT, Edinburgh, 11 Sep 2013

#### PATENTS

Vector dataflow architecture for embedded systems ..... US Patent App 17500017, Apr 2022  
 Brandon Lucia, *Nathan Beckmann*, Graham Gobieskie  
 Authentication of financial transactions via wireless link ..... US Patent 9177311, Nov 2015  
 Miodrag Potkonjak, *Nathan Beckmann*  
 Autonomous, non-interactive, context-based services for cellular phone ..... US Patent 8744429, June 2014  
 Miodrag Potkonjak, *Nathan Beckmann*  
 Differential uncloneable variability-based cryptography ..... US Patent 9020150, Jun 2013  
*Nathan Beckmann*, Miodrag Potkonjak  
 Method and apparatus for efficient token matching using complex rules ..... US Patent 8160989, April 2012  
 Scott Schneider, *Nathan Beckmann* (at Symantec Research Labs)  
 Semantic compression ..... US Patent pending (filed Apr 2010)  
*Nathan Beckmann*, Miodrag Potkonjak

#### TEACHING

15-418 Parallel Computer Architecture and Programming ..... INSTRUCTOR, CMU, Spring 2022  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Fall 2021  
 15-920 Diversity, Equity, and Inclusion in Computer Science and Society ..... INSTRUCTOR, CMU, Fall 2021  
 15-418 Parallel Computer Architecture and Programming ..... INSTRUCTOR, CMU, Spring 2021  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Fall 2020  
 15-418 Parallel Computer Architecture and Programming ..... INSTRUCTOR, CMU, Spring 2020  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Fall 2019  
 15-418 Parallel Computer Architecture and Programming ..... INSTRUCTOR, CMU, Spring 2019  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Fall 2018  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Spring 2018  
 15-740 Computer Architecture ..... INSTRUCTOR, CMU, Spring 2017  
 6.823 Computer System Architecture ..... TEACHING ASSISTANT, MIT, Spring 2014

#### SERVICE

Panel member for NSF in 2018 and 2019.  
 Program Committee member for ASPLOS 2023, HPCA 2023, SIGMETRICS/Performance 2022, FAST 2022, HPCA 2022, MICRO 2021, ISCA 2021, MICRO 2020, ISCA 2020, MICRO 2019, ISCA 2019, and MICRO 2017.  
 External Program Committee member for ISPASS 2020, HPCA 2019, ASPLOS 2019, and ISCA 2017.  
 Reviewer for ACM Trans. on Architecture and Compiler Optimization (TACO), IEEE/ACM Trans. on Networks (TON), NSDI 2019, Eurosys 2017, HPCA 2016, MICRO 2015, HPCA 2015, MICRO 2014, PACT 2014, and MICRO 2013.  
 Organizer of ZSim tutorial at MICRO 2015 and Graphite tutorial at ISCA 2011.

Major open-source contributor to both ZSim and Graphite.

**PHD STUDENTS**

Souradip Ghosh (Ph.D.) .....	Fall 2021 - present
Nikhil Agarwal (Ph.D.) .....	Fall 2021 - present
Nathan Serafin (Ph.D.) .....	Fall 2020 - present
Sara McAllister (Ph.D.) .....	Fall 2019 - present
Mohammad Bakhshalipour (Ph.D.) .....	Fall 2019 - Spring 2020
Graham Gobieski (Ph.D.) .....	Fall 2017 - Summer 2022
Brian Schwedock (Ph.D.) .....	Fall 2017 - present
Elliot Lockerman (Ph.D.) .....	Summer 2017 - Spring 2022
Haoxian Chen (Ph.D.) .....	Fall 2016 - Summer 2017

**PERSONAL**

*Background:* Born 1986 in Boulder, CO. Raised in Los Angeles, CA. *Citizenship:* United States of America.