Aaron Bernstein

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Research Interests

My research is in theoretical computer science. I am especially interested in graph algorithms. Specific topics include sublinear algorithms (e.g. streaming/parallel), dynamic graph algorithms, online algorithms, distributed algorithms, and approximation algorithms.

Professional Experience

New York University
   Associate Professor, Department of Computer Science, Tandon School of Engineering
   August 1, 2024 – present

Rutgers University, New Brunswick
   Assistant Professor, Department of Computer Science
   Fall 2018 – August 1, 2024.

Technical University of Berlin
   Post-Doctoral researcher in the group Graph Algorithms and Combinatorial Optimization.
   Summer 2016 – June 2018.
   Host: Martin Skutella.

Education

Columbia University
   Ph.D. in Computer Science, Fall 2010 – Summer 2016.
   Advisor: Cliff Stein.
   Ph.D. Thesis: Dynamic Algorithms for Shortest Paths and Matching

Massachusetts Institute of Technology
   B.S. Summa cum Laude in Mathematics, May 2009.

Funding

Remark: I am the sole PI in all grants below.

Sloan Research Fellowship, $70,000. Start date: May 2024. End date: none.

Google Research Scholar Gift, $60,000. Start date: March 2024. End date: none.

NSF CAREER Grant 1942010: Jan 15, 2020 – Jan 1, 2025, $554,988

Simons Award for Graduate Students in Theoretical Computer Science: Summer 2014 – Summer 2016, $48,000

NSF Graduate Research Fellowship: Fall 2010 – Spring 2015

Columbia University Presidential Fellowship: Fall 2010 – Spring 2014

Honors and Awards

Presburger Award for Young Scientists, 2023, given by the European Association of Theoretical Computer Science (EATCS).

Best Paper Award, FOCS 2022, "Negative-Weight Single-Source Shortest Paths in Near-linear Time"

Best Paper Award, DISC 2020, "Improved Bounds for Distributed Load Balancing."

Best Paper Award, SODA 2018, "Online bipartite matching with amortized $O(\log^2 n)$ replacements"

Best Paper Award, ICALP 2015, "Fully Dynamic Matching in Bipartite Graphs."

Best Student Paper Award, STOC 2013, "Maintaining shortest paths under deletions in weighted directed graphs."

Best Student Paper Award, SODA 2012, "Near linear time $(1 + \epsilon)$-approximation for restricted shortest paths in undirected graphs".

Best Student Paper Award, SODA 2010, "A Nearly Optimal Algorithm for Approximating Replacement Paths and k Shortest Simple Paths in General Graphs"

PhD Advising

Vikrant Ashvinkumar, Fall 2021 - present (co-advised with Jie Gao)

Zachary Langley, 2019 - May 2024

Aditi Dudeja, 2018 - May 2023

Teaching

Graduate Algorithms (NYU): Fall 2024

Undergraduate Algorithms (Rutgers): Fall 2018, Spring 2021, Spring 2022, Fall 2022.

Graduate Algorithms (Rutgers): Spring 2019, Fall 2020, Spring 2023, Fall 2023.

Randomized Algorithms (undergraduate elective, Rutgers): Spring 2024

Service

Workshop Organizing: Co-Organizer for New York Theory Day, which took place in December 2024 and April 2025. This event aims brings together students and researchers in New York City and nearby areas.

One of four co-organizers for a one week workshop on dynamic graphs algorithms at Schloss Dagstuhl in Germany. There were 42 participants. Dagstuhl Seminar #22461, Nov 13 – Nov 18, 2022. https://www.dagstuhl.de/en/seminars/seminar-calendar/seminar-details/22461

Program Committees: ICALP 2019, SOSA 2021, SODA 2022, STOC 2023, SODA 2024, SOSA 2024, STOC 2024 workshop committee, SODA 2025

Undergraduate Mentoring: Mentored numerous undergraduates during independent studies at Rutgers and also via the DIMACS REU program at Rutgers University.

Publications

Files: A copy of each of my publications can be found at my website: `https://wp.nyu.edu/tandonschoolofengineering-aaronbernstein/publications/`

REFEREED CONFERENCE ARTICLES (in reverse chronological order)

C1. *Streaming and Communication Complexity of Load-Balancing via Matching Contractors.* with Sepehr Assadi and Zachary Langley and Lap Chi Lau and Robert Wang. Symposium on Discrete Algorithms (SODA), 2025.

C2. *Faster Approximation Algorithms for Restricted Shortest Paths in Directed Graphs..* with Vikrant Ashvinkumar and Adam Karczmarz. Symposium on Discrete Algorithms (SODA), 2025.

C3. *Matching Composition and Efficient Weight Reduction in Dynamic Matching..* with Jiale Chen and Aditi Dudeja and Zachary Langley and Aaron Sidford and Ta-Wei Tu. Symposium on Discrete Algorithms (SODA), 2025.

C4. *Maximum Flow by Augmenting Paths in $n^{2+o(1)}$ Time..* with Joakim Blikstad and Thatchaphol Saranurak and Ta-Wei Tu. Foundations of Computer Science (FOCS), 2024.

C5. *Parallel and Distributed Exact Single-Source Shortest Paths with Negative Edge Weights..* with Vikrant Ashvinkumar and Nairen Cao and Christoph Grunau and Bernhard Haeupler and Yonggang Jiang and Danupon Nanongkai and Hsin-Hao Su. Europoen Symposium on Algorithms (ESA), 2024.

C6. *Are There Graphs Whose Shortest Path Structure Requires Large Edge Weights?.* with Greg Bowdin and Nicole Wein. In *Innovations in Theoretical Computer Science* (ITCS), 2024.

C7. *All-Norm Load Balancing in Graph Streams via the Multiplicative Weights Update Method..* with Sepehr Assadi and Zach Langely. In *Innovations in Theoretical Computer Science* (ITCS), 2023.

C8. *Closing the Gap Between Directed Hopsets and Shortcut Sets.*
with Nicole Wein. In the *Proceedings of the 34th Symposium on Discrete Algorithms* (SODA), 2023.

C9. *Negative-Weight Single-Source Shortest Paths in Near-Linear Time.*
with Danupon Nanongkai, Christian Wulff-Nilsen. In the *Proceedings of the 63rd Symposium on Foundations of Computer Science* (FOCS), 2022 **(Best Paper Award)**.

C10. *Decremental Matching in General Graphs.*
with Sepehr Assadi, Aditi Dudeja. In the *Proceedings of the 49th International Colloquium on Automata, Languages and Programming* (ICALP), 2022.

C11. *Fully-Dynamic Graph Sparsifiers Against an Adaptive Adversary.*
with Jan van den Brand, Maximilian Probst Gutenberg, Danupon Nanongkai, Thatchaphol Saranurak, Aaron Sidford, He Sun. In the *Proceedings of the 49th International Colloquium on Automata, Languages and Programming* (ICALP), 2022.

C12. *Incremental SCC maintenance in sparse graphs.*
with Aditi Dueja, Seth Pettie. In the *Proceedings of the 29th European Symposium on Algorithms* (ESA), 2021.

C13. *Deterministic Decremental SSSP and Approximate Min-Cost Flow in Almost-Linear Time.*
with Maximillian Probst Gutenberg, Thatchaphol Saranurak. In the *Proceedings of the 62rd Symposium on Foundations of Computer Science* (FOCS), 2021.

C14. *A Framework for Dynamic Matching in Weighted Graphs.*
with Aditi Dudeja, Zach Langely. In the *Proceedings of the 53rd Symposium on Theory of Computing* (STOC), 2021.

C15. *Near-Optimal Decremental SSSP in Dense Weighted Digraphs.*
with Maximilan Probst Gutenberg, Christian Wulff-Nilsen. In the *Proceedings of the 61st Symposium on Foundations of Computer Science* (FOCS), 2020.

C16. *Deterministic Decremental Reachability, SCC, and Shortest Paths via Directed Expanders and Congestion Balancing.*
with Maximilan Probst Gutenberg, Thatchapol Saranurak. In the *Proceedings of the 61st Symposium on Foundations of Computer Science* (FOCS), 2020.

C17. *Online Matching with Recourse: Random Edge Arrivals.*
with Aditi Dudeja. In the *Proceedings of the 40th conference n Foundations of Software Technology and Theoretical Computer Science* (FSTTCS), 2020.

C18. *Improved Bounds for Distributed Load Balancing.*
with Sepehr Assadi, Zachary Langely. In the Proceedings of *34th International Symposium on Distributed Computing* (DISC), 2020 **(Best Paper Award)**.

C19. *Improved Bounds for Matching in Random-Order Streams.*
In the Proceedings of *47th International Colloquium on Automata, Languages, and Programming* (ICALP), 2020.

C20. *Decremental strongly-connected components and single-source reachability in near-linear time.*
with Maximilian Probst Gutenberg, Christian Wulff-Nilsen. In the *Proceedings of the 51st Symposium on Theory of Computing* (STOC), 2019 **(invited to special journal issue for STOC 2019)**.

C21. *Distributed exact weighted all-pairs shortest paths in near-linear time.*
with Danupon Nanongkai. In the *Proceedings of the 51st Symposium on Theory of Computing* (STOC), 2019 **(invited to special journal issue for STOC 2019)**.

C22. *Towards a Unified Theory of Sparsification for Matching Problems.*
with Sepehr Assadi. In the *Proceedings of Symposium on Simplicity of Algorithms* (SOSA), 2019.

C23. *A Deamortization Approach for Dynamic Spanner and Dynamic Maximal Matching.*
with Sebastian Forster, Monika Henzinger. In the Proceedings of *30th Symposium on Discrete Algorithms* (SODA), 2019.

C24. *Coresets Meet EDCS: Algorithms for Matching and Vertex Cover on Massive Graphs.*
with Sepehr Assadi, MohammadHossein Bateni, Vahab Mirrokni, Cliff Stein. In the Proceedings of *30th Symposium on Discrete Algorithms* (SODA), 2019.

C25. *Distance-preserving graph contractions.*
with Aaron Bernstein, Karl Däubel, Yann Disser, Max Klimm, Torsten Mütze, Frieder Smolny. In Proceedings of *Innovations in Theoretical Computer Science* (ITCS), 2018.

C26. *Online bipartite matching with amortized $O(\log^2 n)$ replacements.*
with Jacob Holm and Eva Rotenberg. In the proceedings of *29th Symposium on Discrete Algorithms* (SODA), 2018 **(best paper award)**.

C27. *Incremental Topological Sort and Cycle Detection in $\tilde{O}(m\sqrt{n})$ Expected Total Time.*
with Shiri Chechik. In the proceedings of the *29th Symposium on Discrete Algorithms* (SODA), 2018.

C28. *Deterministic Partially Dynamic Single Source Shortest Paths in Weighted Graphs.*
In the proceedings of *44th International Colloqium on Automata, Languages, and Programming* (ICALP), 2017.

C29. *General Bounds for Incremental Maximization.*
with Yann Disser and Martin Gross. In the proceedings of *44th International Colloqium on Automata, Languages, and Programming* (ICALP), 2017.

C30. *Simultaneously Load Balancing for Every p-norm, With Reassignments.*
with Tsvi Kopelowitz, Ely Porat, Seth Pettie, and Clifford Stein. In the proceedings of *Innovations in Theoretical Computer Science* (ITCS) 2017.

C31. *Deterministic Partially Dynamic Single Source Shortest Paths for Sparse Graphs.*
with Shiri Chechik. In the proceedings of *28th Symposium on Discrete Algorithms* (SODA), 2017.

C32. *Deterministic Decremental Single Source Shortest Paths: Beyond the $O(mn)$ Barrier.*
with Shiri Chechik. In the proceedings of *48th Symposium on Theory of Computing* (STOC), 2016.

C33. *Faster Fully Dynamic Matchings with Small Approximation Ratio.*
with Cliff Stein. In the proceedings of *27th Symposium on Discrete Algorithms* (SODA), 2016.

C34. *Fully Dynamic Matching in Bipartite Graphs.*
with Cliff Stein. In the proceedings of *42nd International Colloqium on Automata, Languages, and Programming* (ICALP), 2015 **(best paper award)**.

C35.   *Maintaining Shortest Paths Under Deletions in Weighted Directed Graphs.*
       In the proceedings of *45th Symposium on Theory of Computing* (STOC), 2013 (**best student paper award**).

C36.   *Near Linear Time (1+ε)-Approximation for Restricted Shortest Paths in Undirected Graphs.*
       In the proceedings of *23rd ACM-SIAM Symposium on Discrete Algorithms* (SODA), 2012 (**best student paper award**).

C37.   *Improved Dynamic Algorithms for Maintaining Approximate Shortest Paths Under Deletions.*
       with Liam Roditty. In the proceedings of *22nd ACM-SIAM Symposium on Discrete Algorithms* (SODA), 2011.

C38.   *A Nearly Optimal Algorithm for Approximating Replacement Paths and k Shortest Simple Paths in General Graphs.*
       In the proceedings of *21st ACM-SIAM Symposium on Discrete Algorithms* (SODA), 2010 (**best student paper award**).

C39.   *Fully Dynamic $(2 + \epsilon)$-Approximate All-Pairs Shortest Paths with Fast Query and Close to Linear Update Time.*
       In the proceedings of *The 50th Annual Symposium on Foundations of Computer Science* (FOCS), 2009.

C40.   *A Nearly Optimal Oracle for Avoiding Failed Vertices and Edges.*
       with David Karger. In the proceedings of *41st Symposium on Theory of Computing* (STOC), 2009.

C41.   *Improved Distance Sensitivity Oracles via Random Sampling.*
       with David Karger. In the proceedings of *19th ACM-SIAM Symposium on Discrete Algorithms* (SODA), 2008.

Refereed Journal Articles in Reverse Chronological Order

S1.   *Distributed Exact Weighted All-Pairs Shortest Paths in Randomized Near-Linear Time.*
       with Danupon Nanongkai. *SIAM Journal of Computing, Issue 52: special issue for STOC 2019.* Published in 2023..

S2.   *Decremental Strongly Connected Components and Single-Source Reachability in Near-Linear Time.*
       with Maximilian Probst Gutenberg, Christian Wulff-Nilsen. *SIAM Journal of Computing, Issue 52: special issue for STOC 2019.* Published in 2023..

S3.   *General bounds for incremental maximization.*
       with Yann Disser, Martin Groß, Sandra Himburg. *Mathematical Programming*, 2022.

S4.   *A Deamortization Approach for Dynamic Spanner and Dynamic Maximal Matching.*
       with Sebastian Forster, Monika Henzinger. *ACM Transaction on Algorithms*, 2021.

S5.   *Online Bipartite Matching with Amortized $O(\log^2(n))$ Replacements.*
       with Jakob Holm, Eva Rotenberg. *Journal of the ACM*, 2019.

S6.   *Distance-Preserving Graph Contractions.*
       with Karl Däubel, Yann Disser, Max Klimm, Torsten Mütze, Frieder Smolny. *Siam Journal of Discrete Math*, 2019.

S7.   *Maintaining Shortest Paths Under Deletions in Weighted Directed Graphs.*
        In the special issue of *Siam Journal of Computing* for STOC 2013.

S8.   *Decremental Approximate-APSP in Directed Graphs.*
        In *Encyclopedia of Algorithms*, 2016.

S9.   *Dynamic Approximate APSP.*
        In *Encyclopedia of Algorithms*, 2016.