

# Helen Xu

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## Research Vision and Interests

**My research vision is to make design, analysis, and usage of parallel and cache-friendly algorithms and data structures as easy as serial computing in a flat memory.** My research creates theoretically- and practically-efficient parallel algorithms by using a *locality-first strategy* of first understanding and exploiting locality before introducing parallelism. One example of the locality-first strategy is my work in parallel cache-friendly data structures for **sparse graph and sparse tensor applications** (HPEC '18, IPDPS '18, ALENEX '21, SIGMOD '21).

## Current Position

Mar 2022 – Present **Grace Hopper Postdoctoral Scholar in Computing Sciences**, Lawrence Berkeley National Laboratory.  
Host: Dr. Aydın Buluç

## Education

Feb 2022 **Ph.D. in Computer Science**, Massachusetts Institute of Technology.  
Thesis: The Locality-First Strategy for Developing Efficient Multicore Algorithms  
Advisor: Prof. Charles E. Leiserson

May 2018 **S.M. in Computer Science**, Massachusetts Institute of Technology.  
Thesis: Fill Estimation for Blocked Sparse Matrices and Tensors  
Advisor: Prof. Charles E. Leiserson

May 2016 **B.S. with Honors in Computer Science**, Stony Brook University.  
Thesis: Write-optimized Skip Lists  
Advisor: Prof. Michael A. Bender  
Awards: Ranked first in the 2016 graduating class of over 100 students and received the Undergraduate Teaching Assistant Award (top 1% of TAs in the CS department)

## Publications

Published 13 peer-reviewed conference papers (9 full papers and 4 short papers) in venues including SIGMOD, PODS, SPAA, and IPDPS.

### Conference Publications

ESA '22 *When Are Cache-Oblivious Algorithms Cache Adaptive? A Case Study of Matrix Multiplication and Sorting.* Arghya Bhattacharya, Abiyaz Chowdhury, **Helen Xu**, Rathish Das, Rezaul A. Chowdhury, Rob Johnson, Rishab Nithyanand, Michael A. Bender. In European Symposium on Algorithms, 2022.

- ACDA '21 *Multidimensional Included and Excluded Sums*. **Helen Xu**, Sean Fraser, and Charles E. Leiserson. In SIAM Conference on Applied and Computational Discrete Algorithms, 2021.
- SIGMOD '21 *Terrace: A Hierarchical Graph Container for Skewed Dynamic Graphs*. Prashant Pandey, Brian Wheatman, **Helen Xu**, and Aydın Buluç. In ACM SIGMOD International Conference on Management of Data, 2021.
- ALLENEX '21 *A Parallel Packed Memory Array to Store Dynamic Graphs*. Brian Wheatman and **Helen Xu**. In SIAM Symposium on Algorithm Engineering and Experiments, 2021.
- APOCS '21 *Beyond Worst-case Analysis of Multicore Caching Strategies*. (in alphabetical order) Shahin Kamali and **Helen Xu**. In SIAM Symposium on Algorithmic Principles of Computer Systems, 2021.
- SPAA '20 *Closing the Gap Between Cache-Oblivious and Cache-Adaptive Analysis*. (in alphabetical order) Michael A. Bender, Rezaul A. Chowdhury, Rathish Das, Rob Johnson, William Kuszmaul, Andrea Lincoln, Quanquan C. Liu, Jayson Lynch, and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2020.
- SPAA '18 *Cache-Adaptive Exploration: Experimental Results and Scan-Hiding for Adaptivity*. (in alphabetical order) Andrea Lincoln, Quanquan C. Liu, Jayson Lynch, and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2018.
- IPDPS '18 *A Fill Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats*. Peter Ahrens, **Helen Xu**, and Nicholas Schiefer. In IEEE International Parallel and Distributed Processing Symposium, 2018.
- PODS '17 *Write-Optimized Skip Lists*. (in alphabetical order) Michael A. Bender, Martin Farach-Colton, Rob Johnson, Simon Mairas, Tyler Mayer, Cynthia Phillips, and **Helen Xu**. In ACM Symposium on Principles of Database Systems, 2017.

#### Peer-Reviewed Short Publications

- HPEC '20 *Work-Efficient Parallel Algorithms for Accurate Floating-Point Prefix Sums*. Sean Fraser, **Helen Xu**, and Charles E. Leiserson. In IEEE High Performance Extreme Computing Conference, 2020.
- SPAA '20 *Brief Announcement: Multicore Paging Algorithms Cannot Be Competitive*. (in alphabetical order) Shahin Kamali and **Helen Xu**. In ACM Symposium on Parallelism in Algorithms and Architectures, 2020.
- ICONS '19 *Dynamic Programming with Spiking Neural Computing*. (in alphabetical order) James Aimone, Ojas Parekh, Cynthia Phillips, Ali Pinar, William Severa, and **Helen Xu**. In International Conference on Neuromorphic Systems, 2019.
- HPEC '18 *Packed Compressed Sparse Row: A Dynamic Graph Representation*. Brian Wheatman and **Helen Xu**. In IEEE High Performance Extreme Computing Conference, 2018.

#### Awards

##### Postdoctoral

- 2022 **Grace Hopper Fellowship in Computing Sciences** for two years of postdoctoral study at Berkeley Lab.

2022 **Argonne Training Program for Extreme-Scale Computing (ATPESC)**, a fully-funded two-week course on high-performance computing.

#### Graduate

2021 **Finalist for Best Student Presentation** at ACDA 2021.

2020 **Rising Stars Workshop** held virtually at UC Berkeley.

2020 **Chateaubriand Fellowship** for Spring 2020 at ENS Lyon.

2016 **National Physical Science Consortium (NPSC) Graduate Fellowship**, awarded for six years of graduate study.

#### Undergraduate

2016 **Undergraduate Teaching Assistant Award**, awarded to around 1% of TAs in the department of Computer Science.

2015 **NSF Research Experience for Undergraduates Supplement**, awarded for one year of undergraduate research.

2013-2016 **Christian Mata Scholarship for Excellence in Computer Science**, awarded to the top ranked computer science student in every year at Stony Brook University.

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### Research Positions Held

Sep 2016 - **Supertech Group** *Massachusetts Institute of Technology*, Cambridge, MA.

Feb 2022 Designed, analyzed, and implemented parallel and cache-friendly algorithms for shared-memory multicores.

Mentor: Prof. Charles E. Leiserson.

Summer 2020 **Architecture Research Group** *NVIDIA Research*, Westford, MA.

Created and evaluated compressed data structures for sparse tensor computations.

Mentor: Dr. Michael Pellauer.

Spring 2020 **Resource Optimization: Models, Algorithms, and Scheduling Group** *ENS Lyon*, Lyon, France.

Studied algorithms for multi-resource job scheduling with theoretical guarantees.

Mentors: Professors Loris Marchal, Frederic Vivien, and Anne Benoit.

Summer 2019 **Systems and Networking Group** *Microsoft Research*, Cambridge, UK.

Developed and implemented algorithms for novel parallel machine learning accelerators.

Mentor: Dr. Nuno Lopes.

Summer 2016 **Discrete Mathematics and Optimization Group** *Sandia National Laboratories*, Albuquerque, NM.

Simplified and refined randomized I/O-efficient data structures.

Mentor: Dr. Cindy Phillips

Summer 2015 **Systems and Security Research Group** *Sandia National Laboratories*, Livermore, CA.

Designed and implemented a network event tracking database using an existing write-optimized fractal tree index.

Mentor: Dr. Tom Kroeger

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### Teaching

#### Qualifications

2021 **Kaufman Teaching Certificate Program (KTCP)** *Teaching and Learning Lab*, Massachusetts Institute of Technology, Cambridge, MA.

Course page: <https://tll.mit.edu/programming/grad-student-programming/kaufman-teaching-certificate-program/>

- Completed a semester-long course consisting of developing teaching skills via weekly workshops.
- Prepared and delivered a teaching demo on algorithms to a general audience and provided peer feedback.

### Experience

2017 - 2018 **Teaching Assistant** *Department of Electrical Engineering and Computer Science*, Massachusetts Institute of Technology, Cambridge, MA.

Performance Engineering of Software Systems (6.172, Fall 2017 and Fall 2018) OpenCourseware: <https://ocw.mit.edu/courses/6-172-performance-engineering-of-software-systems-fall-2018/>

- Led weekly recitations (TA-led tutorial sessions) and office hours.
- Developed the course cloud infrastructure, including the course development environment and tools suite.
- Coordinated with instructors to write and grade homeworks and exams.
- Helped students with assignments on the course discussion forum.

2014 - 2015 **Teaching Assistant** *Department of Computer Science*, Stony Brook University, Stony Brook, NY.

Foundations of Computer Science (CSE 150, Fall 2014; CSE 215, Spring 2015)

- Led weekly recitations and office hours.
- Coordinated with instructors to write and grade homeworks and exams.

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## Students Advised

### PhD

2018-present **Brian Wheatman**, Johns Hopkins University (hosted at Berkeley Lab in Summer 2022).

Compressed Dynamic Data Structures for Efficient Graph Processing.

2020-present **Arghya Bhattacharya**, Stony Brook University.

An Experimental Evaluation of Cache-Adaptive Algorithms.

### M.Eng theses

expected Feb **Amanda Li**, MIT.

2023 Efficient Dynamic Graph Processing via Data Structure Design.

June 2020 **Sean Fraser**, MIT.

Optimizing Parallel Prefix Sums for Scientific Computing.

June 2019 **Brian Wheatman**, MIT (co-advised with Tim Kaler).

Image Alignment and Dynamic Graph Analytics : Two Case Studies of How Managing Data Movement Can Make (Parallel) Code Run Fast.

June 2019 **Stephanie Ren**, MIT (co-advised with Tao B. Schardl).

Vector-Aware Space Cuts in Stencil Computations.

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## Technical Talks and Presentations

### Invited Seminars

## **Optimizing Dynamic Graph Processing on Multicores with the Locality-First Strategy**

- Lawrence Berkeley National Laboratory, 2022.

## **The Locality-First Strategy for Developing Efficient Multicore Algorithms**

- MIT, 2021.

## **Data Structure Design for Skewed Dynamic Graphs**

- MIT Fast Code Seminar, 2021.
- Williams CS Colloquium, 2021.

## **Updatable Data Compression Formats for Hierarchical Fiber Abstraction**

- NVIDIA Research, 2020.

## **A Fill-Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats**

- Tel Aviv University, 2019.

## **Conference Talks**

### **Multidimensional Included and Excluded Sums**

- *Finalist for Best Student Presentation* at ACDA, 2021.

### **Beyond Worst-case Analysis of Multicore Caching Strategies**

- APOCS, 2021.

### **Work-Efficient Parallel Algorithms for Accurate Floating-Point Prefix Sums**

- HPEC, 2020.

### **Multicore Paging Algorithms Cannot Be Competitive**

- SPAA, 2020.

### **Dynamic Time Warping in Strongly Subquadratic Time: Algorithms for the Low-Distance Regime and Approximate Evaluation**

- ICALP, 2019 (filling in for Bill Kuszmaul).

### **Cache-Adaptive Exploration: Experimental Results and Scan-Hiding for Adaptivity**

- SPAA, 2018.

### **Write-Optimized Skip Lists**

- PODS, 2017 (Joint talk with Tyler Mayer).
- Guest lecture in MIT's advanced performance engineering course (MIT 6.S898), 2017.

## **Posters**

### **A Parallel Packed Memory Array for Dynamic Graphs**

- Rising Stars Poster Session, 2020.

### **A Fill-Estimation Algorithm for Sparse Matrices and Tensors in Blocked Formats**

- CSAIL Alliances Poster Session, 2018.

## **Performance Engineering Discussions**

### **Software Performance Engineering at the End of Moore's Law**

- Jane Street Symposium, 2020.

## Leiserchess Codewalk

- Guest lecture in Performance Engineering of Software Systems (MIT 6.172), 2018.

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## Professional Service

**Program Committee**, ALENEX (2022, 2023), SPAA (2022).

**External Reviewer**, JPDC (2022), ICPP (2021), ACDA (2021), WADS (2021), SPAA (2021, 2020), EuroPar (2020), SOSA (2020), SODA (2019, 2018), ESA (2019, 2022).

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## Outreach Activities

2018 - 2022 **Communication Lab Advisor** with the MIT Electrical Engineering and Computer Science Communications Lab.

Communication Lab Page: <http://mitcommlab.mit.edu/eecs/>

- Reviewed over 50 papers, talks, statements, and CVs via peer coaching.
- Created and implemented a partnership with Professor Saman Amarasinghe's research group to jointly prepare conference presentations via weekly meetings.
- Prepared and led workshops for the NSF Graduate Research Fellowship application (2020, 2021) and the PhD research qualifying exam presentation (2019, 2021).
- Wrote articles about core technical communications topics, such as thesis proposals and paper abstracts.

2017 **Co-president** of MIT Graduate Women in Course 6 (GW6).

Webpage: <http://gw6.scripts.mit.edu/>

- Organized events several times per month for graduate women in the department, including professional development and social activities.

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## References

### Prof. Charles E. Leiserson

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### Prof. Michael A. Bender

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### Dr. Aydın Buluç

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