

SAFARI

SAFARI Research Group

Think Big, Aim High



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July 2024



Dear SAFARI friends & colleagues,

We are pleased to share our group highlights since the [last edition of our newsletter](#) published in June 2023. In this issue, we'd like to take the opportunity to celebrate 15 years of the SAFARI Research Group, from its humble start at [Carnegie Mellon University](#) in 2009 to our current active and large group at ETH Zurich. We are proud to have a very enthusiastic, diverse and talented set of group members, and are also proud of our 25+ very successful [PhD and postdoc alumni](#) who have gone on to influential industry and academic careers, with many accomplishments to celebrate both during and since their time with

SAFARI.

Over the last 15 years, SAFARI has been built on the goal of contributing groundbreaking research and solving important problems in computer architecture that will have a large and lasting impact, and drive positive change for society. Our group culture and motivation has been shaped by many inspirational and diverse research cultures and ideas over the years, which we try to encourage and nurture through a strong collaborative style and a diverse and talented set of people, starting at CMU and which has continued to ETH.

Since our last newsletter, we have continued to teach [our courses at ETH](#), we've presented our work at many conferences including [HPCA](#), [ASPLOS](#), [PACT](#), [MICRO](#), [ISCA'23](#), [ISCA'24](#), [DSN](#), [ISMB](#), [RECOMB](#), [SRC TECHCON](#), [Flash Memory Summit](#), [HiPEAC](#), [ISPASS](#) and a few more, given lectures and participated in several summer schools, continued to offer our Memory-Centric Computing tutorials, and have gratefully received donations and funding for our work. Onur Mutlu has been on sabbatical and has been giving many talks (see our talks section below for some of his talk recordings and slides). We were also honored to receive several awards for our work, including the Jean-Claude Laprie Award in Dependable Computing 2024 for our seminal paper on RowHammer, "[Flipping bits in memory without accessing them: An experimental study of DRAM disturbance errors](#)", published at ISCA 2014 ten years ago.

We look forward to continuing our productive and impactful work in 2024, expanding our collaborations, and always maintaining a continued dedication to sharing our passion in both research and teaching globally. We hope you enjoy this edition of our newsletter, and we wish you a wonderful second half of 2024!

Onur Mutlu & the SAFARI team



Image: Original SAFARI banner from the SAFARI CMU website.

News & Awards



June 2023: Distinguished Artifact Award ISCA 2023

We're excited to have won a Distinguished Artifact Award at ISCA 2023 for our work "RowPress: Amplifying Read Disturbance in Modern DRAM Chips", led by Haocong Luo. Congratulations to Haocong and co-authors Ataberk Olgun, Abdullah Giray Yağlıkçı, Yahya Can Tuğrul, Steve Rhyner, M. Banu Cavlak, Joël Lindegger, Mohammad Sadrosadati, and Onur Mutlu on this well-deserved award.

[Read more](#)

ISCA@50 25-Year Retrospective: 1996-2020

June 2023: [ISCA@50 Retrospective](#), 5 of our papers chosen

In celebration of the 50th anniversary of the [ACM/IEEE International Symposium on Computer Architecture \(ISCA\)](#) in 2023, a special retrospective of selected papers was created to mark the ISCA-50 birthday. The collection highlights the most significant and memorable papers from 1996 through 2020 (ISCA-23 through ISCA-47), and tells an exciting and meaningful story of how research at ISCA progressed over those twenty-five years. We were very honored to have 5 of our papers recognized in this celebratory retrospective. Congratulations to Onur Mutlu and team, and all co-authors on this recognition.

[Read more](#)



Sept 2023: Best Doctoral Thesis Award

We would like to congratulate [Christina Giannoula](#) on receiving the Best Doctoral Thesis Award from her home university [National Technical University of Athens \(NTUA\)](#) for her PhD thesis on "Accelerating Irregular Applications via Efficient Synchronization and Data Access Techniques". [Read more](#) (Photo: [msvf](#))

Oct 2023: ACM Student Research Competition (SRC)

We received a few awards at the SRC at PACT & MICRO. At PACT, Lukas Zink won 1st place in the undergrad category and we took home the top 3 in the grad category: Giray Yaglikci (1st), Geraldo F. Oliveira (2nd), Xavier Servot (3rd). At MICRO, Konstantinos Kanellopoulos received 3rd place in the grad category.



Congratulations to our students!

[Read more SAFARI at PACT](#) | [Read more SAFARI at MICRO](#)



Nov 2023: Distinguished Artifact Award MICRO 2023

We were awarded a Distinguished Artifact Award at MICRO 2023 for our work “Victima: Drastically Increasing Address Translation Reach by Leveraging Underutilized Cache Resources”, led by Konstantinos Kanellopoulos. Congratulations to Konstantinos and Victima co-authors Hong Chul Nam, F. Nisa Bostanci, Rahul Bera, Mohammad Sadrosadati, Rakesh Kumar, Davide Basilio Bartolini and Onur Mutlu on this well-deserved award.

[Read more](#)

Nov 2023: MICRO Hall of Fame

Congratulations to Mohammad Sadrosadati on being inducted into the [MICRO Hall of Fame](#) (in recognition of eight or more papers published in MICRO).

[Read more](#)



We also had several (now) alumni recently inducted: Juan Gómez-Luna (2022), Jeremie S. Kim (2021), with Onur Mutlu currently the overall leader, behind his PhD supervisor, Yale Patt.



February 2024: IEEE Micro Top Picks

Our recent ISCA 2023 paper, "[RowPress: Amplifying Read Disturbance in Modern DRAM Chips](#)", was chosen as an IEEE Micro 2024 Top Pick. Congratulations to Haocong Luo and co-authors on this achievement.

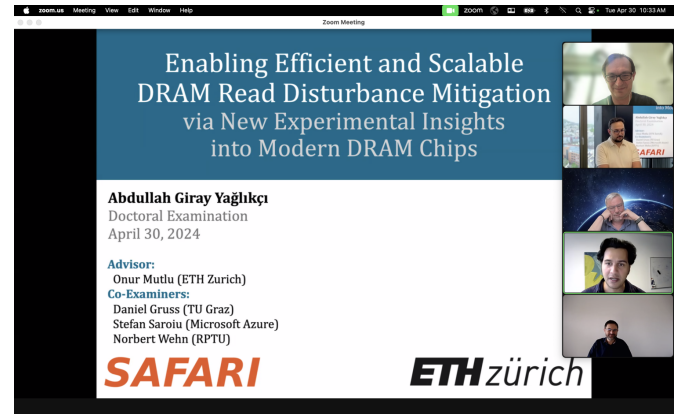
MICRO Top Picks paper [\[arXiv version\]](#) [\[IEEE Xplore\]](#)

April 2024: PhD defense

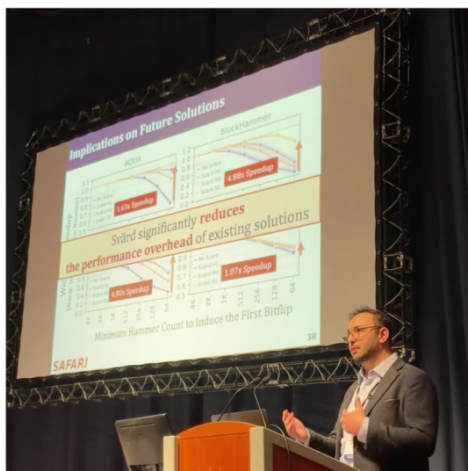
We'd like to congratulate [Abdullah Giray Yağlıkçı](#) on his successful PhD defense!

Giray defended his thesis "Enabling Efficient and Scalable DRAM Read Disturbance Mitigation via New Experimental Insights into Modern DRAM Chips" on April 30, 2024 (online).

[Read more](#)



Giray answered a few questions about his PhD work, RowHammer, and his future plans in a recent interview. Scroll down to our [Meet our Members](#) section to read his interview, and [read the full interview here](#).



June 2024: Jean-Claude Laprie Award

We are extremely honored to have received the Jean-Claude Laprie Award in Dependable Computing 2024 for our ISCA'14 paper: "[Flipping bits in memory without accessing them: An experimental study of DRAM disturbance errors](#)". This is the first paper to introduce, demonstrate, analyze, and propose solutions to DRAM row disturbance errors, now known

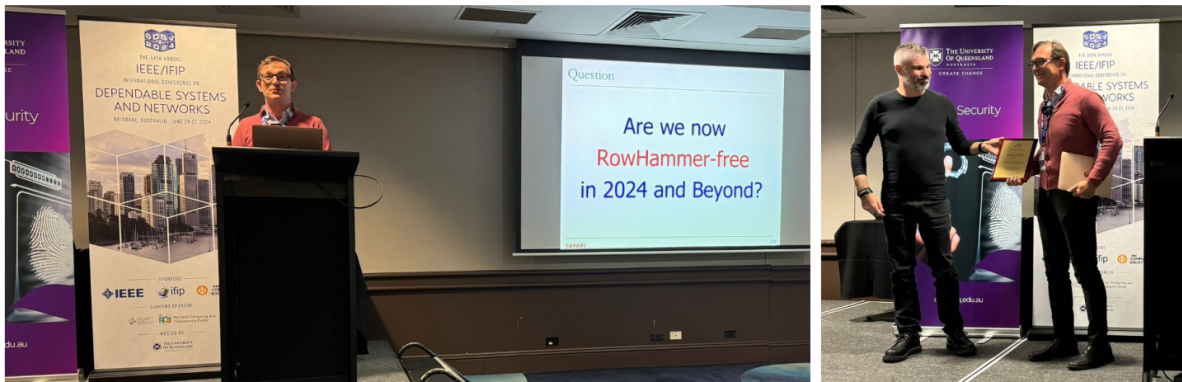
as RowHammer, and the proposed solution, PARA (Probabilistic Adjacent Row Activation). Onur Mutlu received the award at [DSN 2024](#) on behalf of the author team.

“Our paper was published at ISCA 2014 ten years ago. It has had extensive influence on both industry (including memory, CPU, systems and testing companies) and academia across multiple communities, including computer architecture, hardware and systems security, dependable systems, reliability physics. Much progress has been made in the past 10 years, yet the technology scaling problems that lead to RowHammer and read disturbance bitflips remain to be solved (well) and memory robustness is an increasingly important issue. I am personally honored to receive such a long-term impact award that is named after a true pioneer in dependable computing systems.”, Onur Mutlu.

Onur Mutlu, “RowHammer, RowPress & Beyond: Can We Be Free of Bitflips (Soon)?”, Jean-Claude Laprie Award Talk at DSN 2024, Brisbane, Australia, 26 June 2024.

[\[Slides \(pdf\) \(pptx\)\]](#) [\[Talk Video\]](#)

[Read more](#)



July 2024: Best Paper Award at ISCA 2024

Congratulations to Rahul Bera, Adithya Ranganathan and co-authors on receiving the Best Paper Award at [ISCA 2024](#) for our joint work with Intel on “[Constable: Improving Performance and Power Efficiency by Safely Eliminating Load Instruction Execution](#)”.

[Read more](#)





Onur Mutlu and the SAFARI Research Group have been collaborating with Intel for more than 24 years. This collaboration has resulted in many innovative ideas, impactful publications, and technology transfer to real industrial products used by hundreds of millions of people, along with two major best paper awards at [MICRO 2022](#) and (this award) [ISCA 2024](#), two major Test of Time Awards for our works on [Runahead Execution](#) and [RowHammer](#) (the [Jean-Claude Laprie Award in Dependable Computing 2024](#)), and [ISCA-50 Retrospective Selection](#) for our [ISCA 2013](#), [ISCA 2014](#) papers (5 of our papers were chosen).

Upcoming PhD defense:

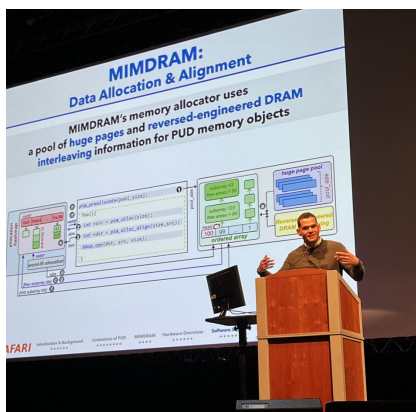
[Can Firtina](#) will soon defend his PhD thesis.

His PhD work covers topics related to genome analysis and its acceleration via new algorithms and architectures with a special focus on real-time analysis of raw nanopore signals. Can will be on the job market this fall, looking for faculty positions and research positions in industry. [Feel free to reach out to him.](#)



Upcoming PhD defense:

Geraldo F. Oliveira is preparing to defend his PhD thesis soon. Geraldo's PhD work focuses on taking advantage of new memory technologies to accelerate distinct classes of applications and provide system support for novel memory-centric systems. Geraldo will also be on the job market soon!



SAFARI Workshops, Tutorials, Meetings & Conference Participation



Real-World PIM tutorials:

We held tutorials on Real-world Processing-in-Memory Systems in 2023 at [HPCA 2023](#), [ASPLOS 2023](#), [ISCA 2023](#) and [MICRO 2023](#) with invited speakers from academia and industry, organized by Juan Gomez Luna, Onur Mutlu, and Ataberk Olgun.

You can watch all the talks online:

[HPCA 2023 Tutorial Website](#) | [YouTube recordings](#)

[ASPLOS 2023 Tutorial Website](#) | [YouTube recordings](#)

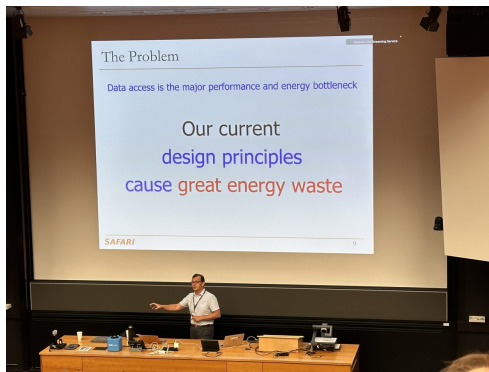
[ISCA 2023 Tutorial Website](#) | [YouTube recordings](#)

[MICRO 2023 Tutorial Website](#) | [YouTube recordings](#) >> [Read more](#)

BIO-Arch: Workshop on Hardware Acceleration of Bioinformatics Workloads, organized with RECOMB 2023 in Istanbul. You can watch the talks online:

[BIO-Arch website](#) | [BIO-Arch program](#) | [BIO-Arch talk recordings on YouTube](#)

EFCL Summer School: We participated in the [EFCL Summer School on Open Source IC Design and Computer Architectures](#), June 3-7 2024 at ETH Zurich. We led Track 4 on "Computer Architecture and Memory Systems", and three mixer groups, where students in different tracks "mixed", focusing on different topics. It was also a great privilege to have Yale Patt with us for a keynote on "[Random thoughts after 60 years in the trenches](#)". Onur Mutlu also returned from his sabbatical for a keynote on "[Memory-Centric Computing](#)" and gave several lectures in Track 4. You can find links to our lecture and keynote recordings [on our Track 4 website](#). All the keynote recordings are available [here](#).



Keynote Lectures, EFCL Summer School, June 2024:

Onur Mutlu, "[Memory-Centric Computing](#)"

[\[Talk Video\]](#) [\[Slides \(pdf\)\]](#) [\(pptx\)\]](#)

Yale Patt, "[Random thoughts after 60 years in the trenches](#)"

[\[Talk Video\]](#)

BioPIM Consortium Meeting:

We met in Grenoble for our second face-to-face [BioPIM](#) meeting on May 30-31 2024, hosted by our project partner, [UPMEM](#). We've had a productive year -- BioPIM partners published 14 journal papers and 4 conference papers. Within two years, BioPIM has contributed to 41 publications. We're looking forward to the next face-to-face meeting in Zurich.



Memory-Centric Tutorials:

Following on from our successful Real-World PIM Tutorials, we held tutorials on Memory-Centric Computing in June: [Memory-Centric Computing Systems, HEART 2024](#), June 21 2024, Porto, Portugal. [Memory-Centric Computing Systems, ISCA 2024](#), June 29 2024, Buenos Aires, Argentina.

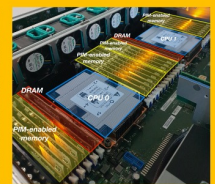
ISCA 2024 Memory-Centric Computing Systems Tutorial

Saturday, June 29, Buenos Aires, Argentina

Organizers: Geraldo F. Oliveira, Dr. Mohammad Sadrosadati, Ataberk Olgun, Professor Onur Mutlu

Program: <https://events.safari.ethz.ch/isca24-memorycentric-tutorial/>

Overview of PIM | PIM taxonomy
PIM in memory & storage
Real-world PNM systems
PUM for bulk bitwise operations
Programming techniques & tools
Infrastructure for PIM Research
Research challenges & opportunities



You can find all the materials for our Memory-Centric Tutorials online:

[HEART 2024 Tutorial Website](#) | [YouTube recordings](#)

[ISCA 2024 Tutorial Website](#) | [YouTube recordings](#)

Read more SAFARI news

We thank our industry partners and funding agencies for their support in 2023 and 2024

Our group was generously supported with new and continuing donations and projects in 2023 and 2024 from Google, Huawei, Intel, Xilinx, Microsoft, SRC, SNSF and EU Horizon Europe. We thank all of our industry partners for their continued support of our research, and partners who have generously supported us with new donations this year, as well as funding support from SNSF and Horizon Europe (and SERI). We also want to thank the [ETH Foundation](#), [ETH Transfer](#) and the [ETH EU GrantsAccess](#) teams for facilitating and supporting our industry relations, projects, and gift funding.

We always welcome new project collaborations, donations and gifts to support our research. Please contact [Onur Mutlu](#) for more information on donating and being a SAFARI Research Group supporter.



Publications

Conference and Journal Papers (June 2023 - present)

Steve Rhyner, Haocong Luo, Juan Gómez-Luna, Mohammad Sadrosadati, Jiawei Jiang, Ataberk Olgun, Harshita Gupta, Ce Zhang, and Onur Mutlu, "[Demystifying Distributed Optimization Algorithms on a Real-World Processing-In-Memory Architecture](#)", to appear in *Proceedings of the 33rd International Conference on Parallel Architectures and Compilation*

Techniques (PACT), October 2024. [\[Preliminary arXiv version\]](#)

Ataberk Olgun, Yahya Can Tugrul, Nisa Bostanci, Ismail Emir Yuksel, Haocong Luo, Steve Rhyner, Abdullah Giray Yaglikci, Geraldo F. Oliveira, and Onur Mutlu, "[ABACuS: All-Bank Activation Counters for Scalable and Low Overhead RowHammer Mitigation](#)", *Proceedings of the 33rd USENIX Security Symposium (USENIX Security)*, August 2024. [\[arXiv version\]](#)
[\[ABACuS Source Code \(Officially Artifact Evaluated with All Badges\)\]](#)
Officially artifact evaluated as available, functional, and reproduced

Ataberk Olgun, F. Nisa Bostanci, Geraldo F. Oliveira, Yahya Can Tugrul, Rahul Bera, A. Giray Yaglikci, Hasan Hassan, Oguz Ergin, and Onur Mutlu, "[Sectored DRAM: A Practical Energy-Efficient and High-Performance Fine-Grained DRAM Architecture](#)", *ACM Transactions on Architecture and Code Optimization (TACO)*, [online] June 2024. [\[arXiv version\]](#) [\[ACM Digital Library version\]](#)

Haocong Luo, Ataberk Olgun, A. Giray Yağlıkçı, Yahya Can Tuğrul, Steve Rhyner, Meryem Banu Cavlak, Joël Lindegger, Mohammad Sadrosadati, Onur Mutlu, "[RowPress Vulnerability in Modern DRAM Chips](#)," in *IEEE Micro Special Issue: Micro's Top Picks from 2023 Computer Architecture Conferences (MICRO TOP PICKS)*, to appear, July/August 2024. [\[arXiv version\]](#) [\[IEEE Xplore\]](#)

Can Firtina, Maximilian Mordig, Joël Lindegger, Harun Mustafa, Sayan Goswami, Stefano Mercogliano, Yan Zhu, Andre Kahles and Onur Mutlu, "[Rawsamble: Overlapping and Assembling Raw Nanopore Signals using a Hash-based Seeding Mechanism](#)", *32nd Annual Conference on Intelligent Systems for Molecular Biology (ISMB)*, July 2024. [\[Slides \(pdf\) \(pptx\)\]](#)

Rahul Bera, Adithya Ranganathan, Joydeep Rakshit, Sujit Mahto, Anant V. Nori, Jayesh Gaur, Ataberk Olgun, Konstantinos Kanellopoulos, Mohammad Sadrosadati, Sreenivas Subramoney, and Onur Mutlu, "[Constable: Improving Performance and Power Efficiency by Safely Eliminating Load Instruction Execution](#)", *Proceedings of the 51st Annual International Symposium on Computer Architecture (ISCA)*, July 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[arXiv version\]](#)
[\[Load Inspector Source Code\]](#) *Best paper award at ISCA 2024*

Nika Mansouri Ghiasi, Mohammad Sadrosadati, Harun Mustafa, Arvid Gollwitzer, Can Firtina, Julien Eudine, Haiyu Mao, Joel Lindegger, Meryem Banu Cavlak, Mohammed Alser, Jisung Park, and Onur Mutlu, "[MegIS: High-Performance and Low-Cost Metagenomic Analysis with In-Storage Processing](#)", *Proceedings of the 51st Annual International Symposium on Computer Architecture (ISCA)*, July 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[arXiv version\]](#)

Julian Pavon, Ivan Vargas Valdivieso, Carlos Rojas, Cesar Hernandez, Mehmet Aslan, Roger Figueras, Yichao Yuan, Joel Lindegger, Mohammed Alser, Francesc Moll, Santiago Marco-Sola, Oguz Ergin, Nishil Talati, Onur Mutlu, Osman Unsal, Mateo Valero, and Adrian Cristal, "[QUETZAL: Vector Acceleration Framework For Modern Genome Sequence Analysis](#)", *Proceedings of the 51st Annual International Symposium on Computer Architecture (ISCA)*, July 2024. [[Slides \(pptx\)](#)] [[pdf](#)]

Oğuzhan Canpolat, A. Giray Yağlıkçı, Geraldo F. Oliveira, Ataberk Olgun, Oğuz Ergin, and Onur Mutlu, "[Understanding the Security Benefits and Overheads of Emerging Industry Solutions to DRAM Read Disturbance](#)", *4th Workshop on DRAM Security (DRAMsec), held with 51st Annual International Symposium on Computer Architecture (ISCA)*, July 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)] [[Source Code](#)]

Ismail Emir Yuksel, Yahya Can Tugrul, F. Nisa Bostanci, Geraldo F. Oliveira, A. Giray Yaglikci, Ataberk Olgun, Melina Soysal, Haocong Luo, Juan Gomez-Luna, Mohammad Sadrosadati, and Onur Mutlu, "[Simultaneous Many-Row Activation in Off-the-Shelf DRAM Chips: Experimental Characterization and Analysis](#)", *Proceedings of the 54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN)*, June 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)] [[SiMRA-DRAM Source Code \(Officially Artifact Evaluated with All Badges\)](#)]
Officially artifact evaluated as both code and dataset available, reviewed and reproducible

Ataberk Olgun, Majd Osseiran, Abdullah Giray Yaglikci, Yahya Can Tugrul, Haocong Luo, Steve Rhyner, Behzad Salami, Juan Gomez Luna, and Onur Mutlu, "[Read Disturbance in High Bandwidth Memory: A Detailed Experimental Study on HBM2 DRAM Chips](#)", *Proceedings of the 54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN)*, June 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)] [[HBM Read Disturbance Source Code \(Officially Artifact Evaluated with All Badges\)](#)]
Officially artifact evaluated as both code and dataset available, reviewed and reproducible

Haocong Luo, Ismail Emir Yüksel, Ataberk Olgun, A. Giray Yağlıkçı, Mohammad Sadrosadati, and Onur Mutlu, "[An Experimental Characterization of Combined RowHammer and RowPress Read Disturbance in Modern DRAM Chips](#)", *Proceedings of the 54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks Disrupt Track (DSN Disrupt)*, June 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)]

Lois Orosa, Ulrich Ruhrmair, A Giray Yaglikci, Haocong Luo, Ataberk Olgun, Patrick Jattke, Minesh Patel, Jeremie S. Kim, Kaveh Razavi, and Onur Mutlu, "[SpyHammer: Understanding and Exploiting RowHammer Under Fine-Grained Temperature Variations](#)", *IEEE Access*, June 2024. [[arXiv version](#)]

Kailash Gogineni, Sai Santosh Dayapule, Juan Gomez-Luna, Karthikeya Gogineni, Peng Wei, Tian Lan, Mohammad Sadrosadati, Onur Mutlu, Guru Venkataramani, "[SwiftRL: Towards Efficient Reinforcement Learning on Real Processing-In-Memory Systems](#)", *Proceedings of the 2024 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS)*, May 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)]

Zülal Bingöl, Mohammed Alser, Onur Mutlu, Ozcan Ozturk, Can Alkan, "[GateKeeper-GPU: Fast and Accurate Pre-Alignment Filtering in Short Read Mapping](#)", *IEEE Transactions on Computers (TC)*, May 2024. [[arXiv version](#)] [[IEEE version](#)]

Sungjun Cho, Beomjun Kim, Hyunuk Cho, Gyeongseob Seo, Onur Mutlu, Myungsuk Kim, Jisung Park, "[AERO: Adaptive Erase Operation for Improving Lifetime and Performance of Modern NAND Flash-Based SSDs](#)", *Proceedings of the 29th International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS)*, April 2024. [[arXiv version](#)]

Mohammed Alser, Brendan Lawlor, Richard J. Abdill, Sharon Waymost, Ram Ayyala, Neha Rajkumar, Nathan LaPierre, Jaqueline Brito, Andre M. Ribeiro-dos-Santos, Nour Almadhoun, Varuni Sarwal, Can Firtina, Tomasz Osinski, Eleazar Eskin, Qiyang Hu, Derek Strong, Byoung-Do (B. D) Kim, Malak S. Abedalthagafi, Onur Mutlu and Serghei Mangul, "[Packaging and containerization of computational methods](#)", *Nature Protocols*, April 2024. [[Journal article](#)]

Abdullah Giray Yağlıkçı, Geraldo Francisco de Oliveira, Yahya Can Tugrul, Ismail Yuksel, Ataberk Olgun, Haocong Luo, and Onur Mutlu, "[Spatial Variation-Aware Read Disturbance Defenses: Experimental Analysis of Real DRAM Chips and Implications on Future Solutions](#)," *Proceedings of the 30th International Symposium on High-Performance Computer Architecture (HPCA)*, April 2024. [[IEEE Xplore](#)] [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)]

F. Nisa Bostanci, Ismail Emir Yuksel, Ataberk Olgun, Konstantinos Kanellopoulos, Yahya Can Tugrul, A. Giray Yaglikci, Mohammad Sadrosadati, and Onur Mutlu, "[CoMeT: Count-Min-Sketch-based Row Tracking to Mitigate RowHammer at Low Cost](#)", *Proceedings of the 30th International Symposium on High-Performance Computer Architecture (HPCA)*, April 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[arXiv version](#)] [[CoMeT Source Code \(Officially Artifact Evaluated with All Badges\)](#)]
Officially artifact evaluated as available, reviewed and reproducible

Ismail Emir Yüksel, Yahya Can Tugrul, Ataberk Olgun, F. Nisa Bostancı, A. Giray Yaglıkçı, Geraldo F. Oliveira, Haocong Luo, Juan Gomez-Luna, Mohammad Sadrosadati, Onur Mutlu,

"Functionally-Complete Boolean Logic in Real DRAM Chips: Experimental Characterization and Analysis", *Proceedings of the 30th International Symposium on High-Performance Computer Architecture (HPCA)*, April 2024. [\[IEEE Xplore\]](#) [\[Slides \(pptx\) \(pdf\)\]](#) [\[arXiv version\]](#) [\[FCDRAM Source Code\]](#)

Geraldo F. Oliveira, Ataberk Olgun, Abdullah Giray Yaglikci, F. Nisa Bostanci, Juan Gomez-Luna, Saugata Ghose, and Onur Mutlu, "MIMDRAM: An End-to-End Processing-Using-DRAM System for High-Throughput, Energy-Efficient and Programmer-Transparent Multiple-Instruction Multiple-Data Processing", *Proceedings of the 30th International Symposium on High-Performance Computer Architecture (HPCA)*, April 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[arXiv version\]](#) [\[MIMDRAM Source Code\]](#)

Jie Zhang, Hongjing Huang, Jie Sun, Juan Gómez Luna, Onur Mutlu and Zeke Wang, "SparseACC: A Generalized Linear Model Accelerator for Sparse Datasets", *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD)*, March 2024. [\[IEEE Xplore\]](#)

Ivan Fernandez, Christina Giannoula, Aditya Manglik, Ricardo Quisiant, Nika Mansouri Ghiasi, Juan Gómez Luna, Eladio Gutierrez, Oscar Plata and Onur Mutlu, "MATSA: An MRAM-Based Energy-Efficient Accelerator for Time Series Analysis", *IEEE Access*, March 2024. [\[IEEE Xplore\]](#) [\[arXiv version\]](#)

Deepanjali Mishra, Konstantinos Kanellopoulos, Ashish Panwar, Akshitha Sriraman, Vivek Seshadri, Onur Mutlu and Todd C. Mowry, "Address Scaling: Architectural Support for Fine-Grained Thread-Safe Metadata Management", *IEEE Computer Architecture Letters*, March 2024. [\[IEEE Xplore\]](#)

Can Firtina, Kamlesh Pillai, Gurpreet S. Kalsi, Bharathwaj Suresh, Damla Senol Cali, Jeremie S. Kim, Taha Shahroodi, Meryem Banu Cavlak, Joël Lindegger, Mohammed Alser, Juan Gómez Luna, Sreenivas Subramoney and Onur Mutlu, "ApHMM: Accelerating Profile Hidden Markov Models for Fast and Energy-efficient Genome Analysis", *ACM Transactions on Architecture and Code Optimization (TACO)*, February 2024. [\[IEEE Xplore\]](#) [\[arXiv version\]](#) [\[ApHMM-GPU Source Code\]](#) [\[Talk Recording HiPEAC\]](#)

Gagandeep Singh, Mohammed Alser, Kristof Denolf, Can Firtina, Alireza Khodamoradi, Meryem Banu Cavlak, Henk Corporaal and Onur Mutlu, "RUBICON: a framework for designing efficient deep learning-based genomic basecallers", *Genome Biology*, February 2024. [\[Journal Article\]](#) [\[arXiv version\]](#) [\[RUBICON Source Code\]](#)

Konstantinos Kanellopoulos, Hong Chul Nam, F. Nisa Bostanci, Rahul Bera, Mohammad

Sadrosadati, Rakesh Kumar, Davide Basilio Bartolini, and Onur Mutlu, "[Victima: Drastically Increasing Address Translation Reach by Leveraging Underutilized Cache Resources](#)", *Proceedings of the 56th International Symposium on Microarchitecture (MICRO)*, November 2023. [[Slides \(pptx\) \(pdf\)](#)] [[arXiv version](#)] [[Victima Source Code \(Officially Artifact Evaluated with All Badges\)](#)]

Officially artifact evaluated as available, functional, reusable and reproducible
Distinguished artifact award at MICRO 2023

Konstantinos Kanellopoulos, Rahul Bera, Kosta Stojilkovic, Nisa Bostanci, Can Firtina, Rachata Ausavarungnirun, Rakesh Kumar, Nastaran Hajinazar, Mohammad Sadrosadati, Nandita Vijaykumar, and Onur Mutlu, "[Utopia: Fast and Efficient Address Translation via Hybrid Restrictive & Flexible Virtual-to-Physical Address Mappings](#)", *Proceedings of the 56th International Symposium on Microarchitecture (MICRO)*, November 2023. [[Slides \(pptx\) \(pdf\)](#)] [[arXiv version](#)] [[Utopia Source Code](#)]

Taha Shahroodi, Gagandeep Singh, Mahdi Zahedi, Haiyu Mao, Joel Lindegger, Can Firtina, Stephan Wong, Onur Mutlu, and Said Hamdioui, "[Swordfish: A Framework for Evaluating Deep Neural Network-based Basecalling using Computation-In-Memory with Non-Ideal Memristors](#)", *Proceedings of the 56th International Symposium on Microarchitecture (MICRO)*, November 2023. [[Slides \(pptx\) \(pdf\)](#)] [[arXiv version](#)]

Haocong Luo, Yahya Can Tuğrul, F. Nisa Bostancı, Ataberk Olgun, Abdullah Giray Yaglikci and Onur Mutlu, "[Ramulator 2.0: A Modern, Modular, and Extensible DRAM Simulator](#)", *IEEE Computer Architecture Letters*, November 2023. [[IEEE Xplore](#)] [[arXiv](#)] [[Ramulator2 Source Code](#)]

Jinfan Chen, Juan Gómez-Luna, Izzat El Hajj, YuXin Guo, and Onur Mutlu, "[SimplePIM: A Software Framework for Productive and Efficient Processing in Memory](#)", *Proceedings of the 32nd International Conference on Parallel Architectures and Compilation Techniques (PACT)*, October 2023. [[Slides \(pptx\) \(pdf\)](#)] [[SimplePIM Source Code](#)]

Harshita Gupta, Mayank Kabra, Juan Gómez-Luna, Konstantinos Kanellopoulos, and Onur Mutlu, "[Evaluating Homomorphic Operations on a Real-World Processing-In-Memory System](#)", *Proceedings of the 2023 IEEE International Symposium on Workload Characterization Poster Session (IISWC)*, Ghent, Belgium, October 2023. [[arXiv version](#)] [[Lightning Talk Slides \(pptx\) \(pdf\)](#)] [[Poster \(pptx\) \(pdf\)](#)]

Geraldo F. Oliveira, Saugata Ghose, Juan Gómez Luna, Amirali Boroumand, Alexis Savery, Sonny Rao, Salman Qazi, Gwendal Grignou, Rahul Thakur, Eric Shiu and Onur Mutlu, "[Extending Memory Capacity in Modern Consumer Systems With Emerging Non-Volatile](#)

Memory: Experimental Analysis and Characterization Using the Intel Optane SSD", *IEEE Access*, November 2023. [\[IEEE Xplore\]](#)

Joël Lindegger, Can Firtina, Nika Mansouri Ghiasi, Mohammad Sadrosadati, Mohammed Alser, and Onur Mutlu, "RawAlign: Accurate, Fast, and Scalable Raw Nanopore Signal Mapping via Combining Seeding and Alignment", *arXiv*, October 2023. [\[arXiv version\]](#) [\[RawAlign Source Code\]](#)

Can Firtina, Melina Soysal, Joël Lindegger, and Onur Mutlu, "RawHash2: Mapping Raw Nanopore Signals Using Hash-Based Seeding and Adaptive Quantization", Preprint on *arXiv*, September 2023. [\[arXiv version\]](#) [\[RawHash2 Source Code\]](#)

Can Firtina, Nika Mansouri Ghiasi, Joel Lindegger, Gagandeep Singh, Meryem Banu Cavlak, Haiyu Mao, and Onur Mutlu, "RawHash: Enabling Fast and Accurate Real-Time Analysis of Raw Nanopore Signals for Large Genomes", *Bioinformatics*, June 2023; *Proceedings of the 31st Annual Conference on Intelligent Systems for Molecular Biology and the 22nd European Conference on Computational Biology (ISMB/ECCB)*, July 2023. [\[Journal Article\]](#) [\[arXiv version\]](#) [\[RawHash Source Code\]](#) [\[Poster presented at RECOMB 2023 \(PDF\)\]](#) [\[Slides \(pptx\) \(pdf\)\]](#) [\[Talk Video\]](#)

Onur Mutlu and Can Firtina, "Accelerating Genome Analysis via Algorithm-Architecture Co-Design", Invited Paper in *Proceedings of the 60th Design Automation Conference (DAC)*, Orlando, FL, USA, July 2023. [\[arXiv version\]](#) [\[Slides \(pptx\) \(pdf\)\]](#) [\[DAC 2023 Talk Video \(37 minutes\)\]](#)

Onur Mutlu, "Memory-Centric Computing", Invited Paper in *Proceedings of the 60th Design Automation Conference (DAC)*, Orlando, FL, USA, July 2023. [\[Slides \(pptx\) \(pdf\)\]](#)

Haocong Luo, Ataberk Olgun, Giray Yaglikci, Yahya Can Tugrul, Steve Rhyner, M. Banu Cavlak, Joel Lindegger, Mohammad Sadrosadati, and Onur Mutlu, "RowPress: Amplifying Read Disturbance in Modern DRAM Chips", *Proceedings of the 50th International Symposium on Computer Architecture (ISCA)*, June 2023. [\[Extended arxiv version\]](#) [\[Slides \(pptx\) \(pdf\)\]](#) [\[Lightning Talk Slides \(pptx\) \(pdf\)\]](#) [\[Lightning Talk Video \(3 minutes\)\]](#) [\[Talk Video \(14 minutes, including Q&A\)\]](#) [\[RowPress Source Code and Datasets \(Officially Artifact Evaluated with All Badges\)\]](#)

Officially artifact evaluated as available, reusable and reproducible

Distinguished artifact award at ISCA 2023

One of the 12 computer architecture papers of 2023 selected as Top Picks by IEEE Micro

Rakesh Nadig, Mohammad Sadrosadati, Haiyu Mao, Nika Mansouri Ghiasi, Arash Tavakkol,

Jisung Park, Hamid Sarbazi-Azad, Juan Gómez Luna, and Onur Mutlu, "[Venice: Improving Solid-State Drive Parallelism at Low Cost via Conflict-Free Accesses](#)", *Proceedings of the 50th International Symposium on Computer Architecture (ISCA)*, Orlando, FL, USA, June 2023. [[arXiv version](#)] [[Slides \(pptx\)](#)] [[pdf](#)] [[Lightning Talk Slides \(pptx\)](#)] [[pdf](#)] [[Lightning Talk Video \(3 minutes\)](#)] [[Talk Video \(14 minutes, including Q&A\)](#)]

Ataberk Olgun, Majd Osserian, A. Giray Yağlıkçı, Yahya Can Tugrul, Haocong Luo, Steve Rhyner, Behzad Salami, Juan Gomez-Luna, and Onur Mutlu, "[An Experimental Analysis of RowHammer in HBM2 DRAM Chips](#)", *Proceedings of the 53rd Annual IEEE/IFIP International Conference on Dependable Systems and Networks Disrupt Track (DSN Disrupt)*, June 2023.

[[arXiv version](#)] [[IEEE Xplore](#)] [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video \(24 minutes, including Q&A\)](#)]

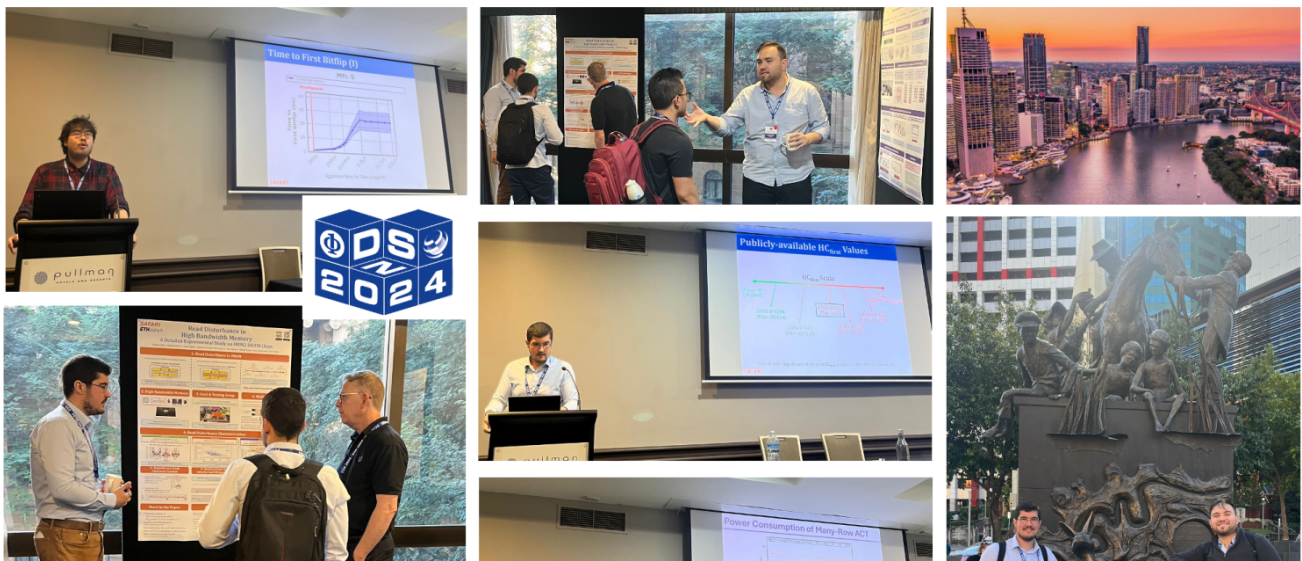
Gagandeep Singh, Alireza Khodamoradi, Kristof Denolf, Jack Lo, Juan Gómez-Luna, Joseph Melber, Andra Bisca, Henk Corporaal, and Onur Mutlu, "[SPARTA: Spatial Acceleration for Efficient and Scalable Horizontal Diffusion Weather Stencil Computation](#)", *Proceedings of the 37th International Conference on Supercomputing (ICS)*, Orlando, FL, USA, June 2023.

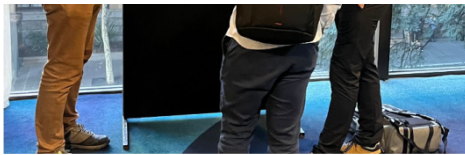
[[arXiv version](#)] [[Slides \(pptx\)](#)] [[pdf](#)] [[SPARTA Source Code](#)]

Ataberk Olgun, Hassan Hasan, A. Giray Yağlıkçı, Yahya Can Tuğrul, Lois Orosa, Haocong Luo, Minesh Patel, Oğuz Ergin, and Onur Mutlu. "[DRAM Bender: An Extensible and Versatile FPGA-based Infrastructure to Easily Test State-of-the-art DRAM Chips](#)." *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD)*, June 2023.

[[Extended arXiv version](#)] [[DRAM-Bender Source Code](#)] [[DRAM Bender Tutorial Video \(43 minutes\)](#)]

To our publications





Videos: Talks & Courses

We are committed to democratizing education through our regular posting of course lectures and talk videos online. We livestream lectures and talks on YouTube and make all media and material freely available on both our course website and YouTube channels. **Our YouTube channels** have tens of thousands of subscribers, and our online materials are used by students, universities, and industry leaders over the globe. We are particularly dedicated to sharing our resources with those without access to state-of-the-art computer architecture classes.

Courses 2023 & Spring 2024

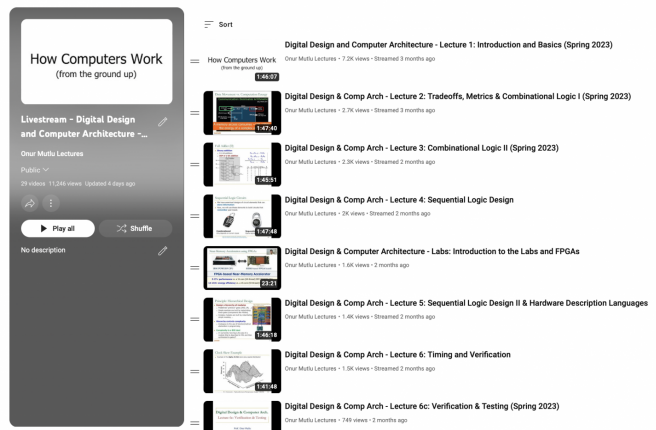
<https://safari.ethz.ch/courses/>



DDCA Spring 2023 edition, Lecture 1 "Introduction & Basics". Photo credit: Can Firtina

Digital Design and Computer Architecture

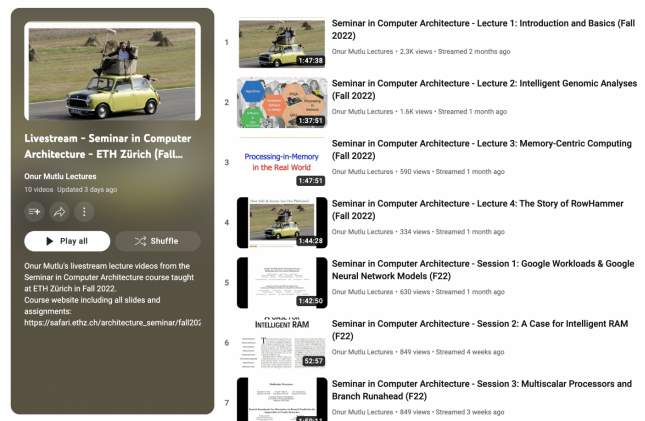
Spring 2023 Course Website
Spring 2023 Lecture Videos (YouTube)
Spring 2024 (Course Website),
Spring 2024 Lecture Videos (YouTube)



Digital Design and Computer Architecture is a 2nd semester bachelor course that gives a rigorous introduction into “How Computers Work” and hands-on FPGA lab assignments.

Seminar in Computer Architecture

Spring 2023 Course Website
Spring 2023 Lecture Videos (YouTube)
Fall 2023 Course Website
Fall 2023 Lecture Videos (YouTube)
Spring 2024 Course Website

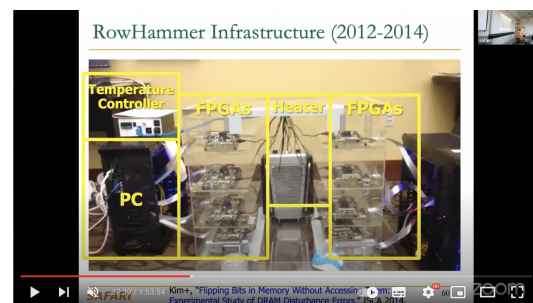


The Seminar in Computer Architecture covers fundamental and cutting-edge research papers in computer architecture. Students learn how to rigorously analyze, present and discuss research papers.

Lecture Highlights:

Seminar in Computer Architecture,
Lecture 4: RowHammer (Spring 2023)

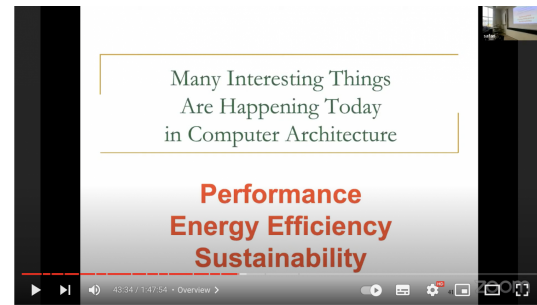
This lecture on RowHammer is currently the most up-to-date talk or lecture on RowHammer given by Onur Mutlu.



Seminar in Computer Architecture - Lecture 4: RowHammer (Spring 2023)

Seminar in Computer Architecture, Lecture 5a: SAFARI Research Group Introduction & Research (Spring 2023)

This lecture gives an overview of the group and research topics and what we expect from applicants. We encourage you to watch it if you'd like to **work with us!**

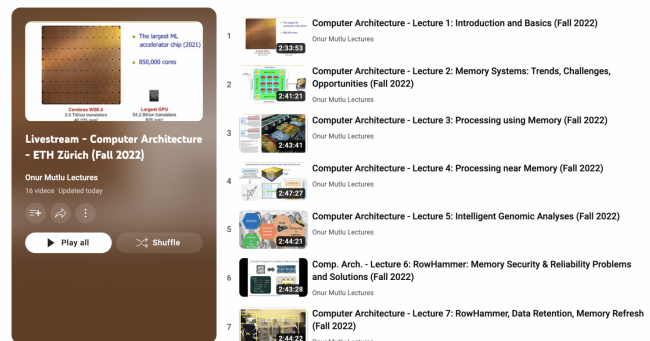


Seminar in Computer Architecture - Lecture 5: SAFARI Introduction & Research Topics (Spring 2023)

Computer Architecture

Course Website Fall 2023

Lecture Videos (YouTube Playlist)



Computer Architecture is a critical analysis course taken by Bachelor/Masters/PhD students. We look in-depth at cutting-edge research topics + fundamentals in Computer Architecture, including 20+ research papers, presentations and analyses.

SAFARI Projects & Seminars 2023 & 2024

The Projects and Seminars (P&S) courses provide hands-on learning and are designed to teach practical knowledge and skills. These courses encourage independent experimentation and design, critical thinking, and allow for explorative learning through project work.

Spring 2023: [P&S Course Listings and Websites](#)

Fall 2023: [P&S Course Listings and Websites](#)

Spring 2024: [P&S Course Listings and Websites](#)

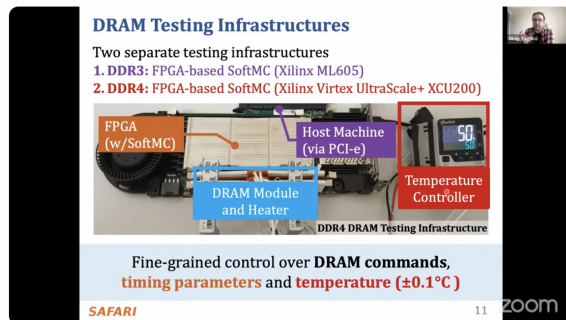
FPGA-based Exploration of DRAM and RowHammer

[Spring 2023 Course Website](#)

[Fall 2023 Course Website](#)

[Spring 2024 Course Website](#)

Lecturers: Giray Yaglikci and Ataberk Olgun



P&S DRAM Bender: A Deeper Look into RowHammer's Sensitivities by Giray Yaglikci

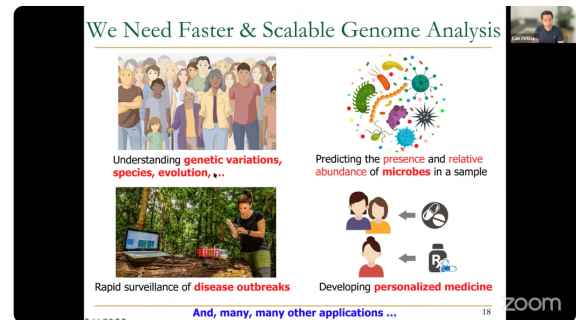
Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms

[Spring 2023 Course Website](#)

[Fall 2023 Course Website](#)

[Spring 2024 Course Website](#)

Lecturer: Can Firtina



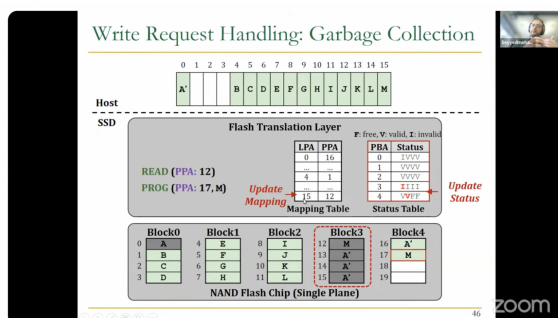
P&S Genomics - Lecture 1: P&S Course Introduction & Scope (Fall 2023)

Understanding and Designing Modern NAND Flash-Based Solid-State Drives (SSDs)

[Spring 2023 Course Website](#)

[Spring 2024 Course Website](#)

Lecturer: Mohammad Sadrosadati



Modern Solid-State Drives (SSDs) - Lecture 3: Advanced NAND Flash Commands & Mapping (Spring 2023)

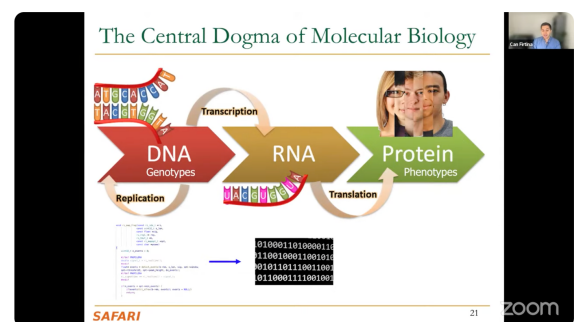
Genome Sequencing on Mobile Devices

[Spring 2023 Course Website](#)

[Fall 2023 Course Website](#)

[Spring 2024 Course Website](#)

Lecturer: Can Firtina



P&S Genomics - Lecture 2: Introduction to Genome Analysis (Fall 2023)

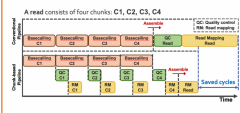
Complete SAFARI Course Listing

SAFARI Live Seminar Series

We started hosting our **SAFARI Live Seminar** series in 2021 and have continued to livestream all our seminars in 2023 & 2024, while also having many seminars in person. We are happy to invite speakers for a live seminar, so please get in touch if you're interested in giving a talk! Click on the thumbnails below for talk details and link to the talk recording.

SAFARI Live Seminars in Computer Architecture

GenPIP: In-Memory Acceleration of Genome Analysis via Tight Integration of Basecalling and Read Mapping



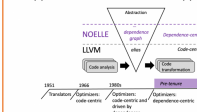
SPEAKER
HAIYU MAO
SAFARI Research Group, ETH Zurich

ETH zürich SAFARI

March 29, 2023 1:00PM CEST

SAFARI Live Seminars in Computer Architecture

Evolving abstractions within and around compilers to support modern hardware and application trends



SPEAKER
SIMONE Campanoni
ARCANA research lab
Northwestern University

ETH zürich SAFARI

April 4, 2023 2:00PM CEST

SAFARI Live Seminars in Computer Architecture

Software-Hardware Co-design of Edge AI Systems

IEEE Switzerland Section CAS
SAFARI! Duke



SPEAKER
YIRAN CHEN
Duke University

April 18, 2023 4:00PM CEST

SAFARI-EFCL Seminar

Hardware for ML and ML for Hardware



SPEAKER
LIZY JOHN
University of Texas at Austin

ETH zürich SAFARI! University of Texas at Austin

May 12, 2023 11:00AM CEST

SAFARI Live Seminars in Computer Architecture

The ISA of Modern Storage Systems: Interface, Specialization, and Approach



SPEAKER
JIAN Huang
University of Illinois,
Urbana-Champaign

ETH zürich UNIVERSITY OF ILLINOIS

May 17, 2023 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

Detecting Copy Number Variants on Exome Sequencing Data via Deep Learning



SPEAKER
Erçument Cicek
Bilkent University
(EPFL visiting professor)

SAFARI! ETH zürich CICEKLAB

June 2, 2023 11:00AM CEST

SAFARI Live Seminars in Computer Architecture

Secure and Scalable Rowhammer Defenses



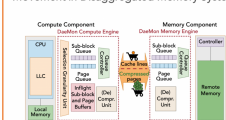
SPEAKER
Anish Saxena
Georgia Tech

SAFARI! ETH zürich Georgia Institute of Technology

June 26, 2023 10:30AM CEST

SAFARI Live Seminars in Computer Architecture

DaeMon: Architectural Support for Efficient Data Movement in Disaggregated Memory Systems



SPEAKER
Christina Giannoula
University of Toronto

ETH zürich SAFARI UNIVERSITY OF TORONTO

July 6, 2023 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

Cross-Layer SSD Optimizations by Exploiting 3D Flash Memory Characteristics



SPEAKER
Jihong Kim
Seoul National University

ETH zürich SAFARI

July 12, 2023 10AM CEST

SAFARI-EFCL Seminar

A Potpourri of Ideas and Results in DRAM, FPGA Infrastructures, and RISC-V Processors



SPEAKER
Oguz Ergin
TOBB ETÜ

ETH zürich TOBB ETÜ

August 21, 2023 3PM CEST

SAFARI Live Seminars in Computer Architecture

High-Performance and Crash-Recoverable Security Support for Emerging Memory Architectures



SPEAKER
Amro Awad
NC State University

ETH zürich SAFARI NC STATE UNIVERSITY

August 29, 2023 3PM CEST

SAFARI Live Seminars in Computer Architecture

An Introduction to Multimodal Understanding: Building Models to See, Hear, and Read the World



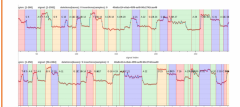
SPEAKER
Skanda Koppula
Google DeepMind

ETH zürich SAFARI Google DeepMind

Sept 14, 2023 2PM CEST

SAFARI Live Seminars in Computer Architecture

An Ecosystem for Scalable & Computationally Efficient Nanopore Data Processing



SPEAKER
Hasindu Gamaarachchi
UNSW Sydney

ETH zürich SAFARI UNSW

Sept 27, 2023 9AM CEST

SAFARI Live Seminars in Computer Architecture

Reshaping DRAM Scaling by Enabling System-Memory Cooperation



SPEAKER
Minesh Patel
SAFARI Research Group
(former PhD student)

ETH zürich SAFARI

Oct 4, 2023 2PM CEST

SAFARI Live Seminars in Computer Architecture

How does one bit-flip corrupt an entire deep neural network, and what to do about it



SPEAKER
Yanjing Li
University of Chicago

ETH zürich SAFARI UNIVERSITY OF CHICAGO

Oct 17, 2023 6PM CEST

SAFARI Live Seminars in Computer Architecture

A Deeper Look into RowHammer's Characteristics in Real Modern DRAM Chips



SPEAKER
Abdullah Giray Yağlıkçı
SAFARI Research Group, ETH Zurich

ETH zürich SAFARI

JAN 17, 2024 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

Software/Hardware Co-design and Dataflow acceleration for Short Read Alignment



SPEAKER
Konstantina Koliogeorgi
MicroLab, NTUA

ETH zürich SAFARI

JAN 29, 2024 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

Efficiently and Scalably Mitigating RowHammer in Modern and Future DRAM-Based Memory Systems



SPEAKER
Abdullah Giray Yağlıkçı
SAFARI Research Group, ETH Zurich

ETH zürich SAFARI

FEB 2, 2024 5:00PM CEST

Automatic Detection of
Microarchitectural LeaksSPEAKER
Boris Köpf
Microsoft Azure Research

APRIL 10, 2024 10:00AM CEST

Landscape of Genomics for Systems
ResearchSPEAKER
REETU DAS
University of Michigan

May 21, 2024 3:00PM CEST

Exploiting RowPress and RowHammer
and How To Defend Against ItSPEAKER
Jonas Juffinger
IAIK, TU Graz

JULY 16, 2024 2:00PM CEST

SAFARI Live Seminars Schedule 2021-2024

SAFARI Live Seminar Series YouTube Playlist 2021-2024

Meet our Members

Interview with [Abdullah Giray Yağlıkçı](#)

Giray recently [defended his PhD](#). He sat down with us to answer a few questions about his PhD work, RowHammer, and his future plans in a recent interview.

[Read the full interview here](#)



Q: In your PhD work, you made some significant contributions to better understanding the RowHammer vulnerability. Can you tell us a bit about your contributions and their overall significance to understanding (and maybe even coming closer to solving) RowHammer?

Giray: Certainly! We conducted several experiments on many real DRAM chips to understand their vulnerability to read disturbance under different conditions. We found this line of research interesting and extremely important because read disturbance becomes more and more severe going forward and we need to understand why and how it happens really well so that we can solve it efficiently and scalably. These experiments and analyses were published in two papers: one in MICRO'21[1] and one in DSN'22[2]. Let me quickly mention what I really like about our findings on two examples.

First, we discovered that RowHammer has a really peculiar relationship with temperature: as temperature increases, a DRAM cell first becomes more vulnerable to read disturbance until some temperature level and then becomes less vulnerable as we keep increasing temperature. This observation seems quite odd at first look because what most people assume is a monotonically worsening vulnerability to read disturbance with increasing temperature. So, we dug into the literature on circuit-level error mechanisms that explain why and how read disturbance might happen. We saw a particular circuit-level error mechanism

called trap-assisted charge leakage, exhibiting a temperature sensitivity similar to that of read disturbance. This finding shows us that this particular error mechanism actually dominates other error mechanisms in many DRAM cells across manufacturers. Now, with this finding, we understand DRAM read disturbance more thoroughly than before.

The second example is about the effect of memory access patterns. Until our study, it was widely accepted that you must open and close DRAM rows as fast as possible to achieve the worst possible access pattern to induce read disturbance bitflips. We found out that you can actually exacerbate read disturbance if you spend some extra time keeping a row open once it is opened. Later on, Haocong Luo, also from our group, more rigorously investigated this finding and discovered yet another read disturbance phenomenon called RowPress, which is different than RowHammer. Again, with these findings, today we understand DRAM read disturbance better.

These are just two examples of the impact of our experiments on building a detailed understanding of DRAM read disturbance. We also rigorously analyzed the variation of read disturbance vulnerability across different cells within a module and different voltage levels. I am really proud of our contributions in this direction because they help the whole community understand the read disturbance vulnerability in a more detailed way and thus develop much stronger systems.

Q: What would you like to do going forward, do you have an interest in working in industry or will you look for a position in academia? Will you continue to focus on DRAM and hardware security, or where do you see your future interests?

Giray: I greatly enjoy conducting research, so I keep working on new research projects at the moment, but this is a question that also keeps my mind busy nowadays. Today there are outstanding security issues in modern computing systems including but not limited to RowHammer. Today, we can solve these issues at the cost of significant performance loss and increased energy consumption. Going forward, we need to tackle these security issues together with improving system performance and energy efficiency. To achieve this, we need systems with better isolation across processes in both microarchitecture and memory and tackle major performance bottlenecks like excessive data movement and time-consuming maintenance operations. My plan is to broaden my research scope accordingly. I see myself in academia eventually, but I want to improve my understanding and research perspective with some experience in industry research. So, I actively look for research positions in academia and industry.

[*Read Giray's full interview here*](#)

SAFARI Talk Highlights

Below we provide a few talk highlights from 2023 and 2024. We were excited to once again attend many conferences, and present and discuss our work in person. For links to all talk recordings for our conference paper contributions, see our Publications above.



Onur Mutlu, **"Memory-Centric Computing"**, Lightning Talk at the Design Automation Conference (DAC) 2023, July 2023.

[\[Slides \(pptx\) \(pdf\)\]](#) [\[Talk Video\]](#)



Onur Mutlu, **"Memory-Centric Computing"**, Stanford University SystemX Seminar, 4 April 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[Talk Video\]](#)

Onur Mutlu, **"Memory-Centric Computing"**, Arizona State University ACME Center, 28 March 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[Talk Video\]](#)

Onur Mutlu, **"RowHammer, RowPress & Beyond: Can We Be Free of Bitflips (Soon)?"**, University of California Berkeley, 28 February 2024. [\[Slides \(pptx\) \(pdf\)\]](#) [\[Talk Video\]](#)

Onur Mutlu, **"RowHammer, RowPress & Beyond: Can We Be Free of Bitflips (Soon)?"**, North Carolina State University (NCSU), 16 February 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Duke University & ATHENA AI Institute Distinguished Lecture, 15 February 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Future Computing Platforms: Challenges and Opportunities"**, Stanford University SystemX Seminar, 8 February 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, UT-Austin ECE Colloquium, 31 January 2024. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Machine Learning Driven Memory and Storage Systems"**, IBM Research, 19 December 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"RowHammer, RowPress & Beyond: Can We Be Free of Bitflips (Soon)?"**, New Jersey Institute of Technology (NJIT), 18 December 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, School of AI Algiers AI Summit, 14 December 2023 [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Security of PIM Systems"**, Dagstuhl MAD (Microarchitectural Attacks & Defenses), 30 November 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"RowHammer, RowPress & Beyond: Can We Be Free of Bitflips (Soon)?"**, Dagstuhl MAD (Microarchitectural Attacks & Defenses), 30 November 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"RowHammer, RowPress & Beyond : Can We Be Free of Bitflips (Soon)?"**, Google Zurich Hardware Security Summit, 15 November 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"RowHammer, RowPress and Beyond: Can We Be Free of Bitflips (Soon)?"**, Stanford University Computer Systems Seminar, 26 October 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, SLIP Keynote @ ICCAD, 2 November 2023 [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Rivos, 25 October 2023 [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, SK Hynix Meeting, 10 October 2023 [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Securing the Memory System: The Story of RowHammer"**, Monte Verita SW Abstractions for HW Security Workshop, 2 October 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"RowHammer, RowPress & Beyond : Can We Be Free of Bitflips (Soon)?"**, Meta, 28 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Hermes & Sibyl: ML-Driven Memory & Storage Management"**, VMware, 27 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, DOT-PIM Workshop @ ESWEEK, 21 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Pythia & Hermes: ML-Driven Prefetching"**, VMware, 20 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, "Storage-Centric Computing for Modern Data-Intensive Workloads", NCIS Keynote, 16 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Intelligent Architectures for Intelligent Machines"**, VMware, 13 September 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Hunan University, 17 August 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Accelerating Genome Analysis via Algorithm-Architecture Co-Design"**, DAC 2023 Special Session Talk, 11 July 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, IMACAW Keynote Talk @ DAC, 9 July 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing: Accelerating Data-Intensive Workloads"**, SAMOS Special Session on Memory-Centric Computing, 5 July 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Securing the Memory System: The Story of RowHammer"**, New York University, 23 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video \(1 hour 25 minutes, including Q&A\)](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Real-World PIM Tutorial Opening Talk @ ISCA-50, 18 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Securing the Memory System: The Story of RowHammer"**, University of Montenegro Lecture, 9 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Accelerating Genome Analysis: A Primer on an Ongoing Journey"**, CANU (Montenegro Academy of Sciences) Lecture @ UDG, 8 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Accelerating Genome Analysis: A Primer on an Ongoing Journey"**, University of Montenegro Faculty of Medicine, 8 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Huawei Global Software Technology Summit Keynote, 1 June 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Storage-Centric Computing for Modern Data-Intensive Workloads"**, Huawei Next Generation Data Storage Architecture Innovation Forum Keynote, 15 May 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Memory-Centric Computing"**, eda WorkShop Keynote (Hanover, DE), 8 May 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, IEEE Custom Integrated Circuits Conference (CICC) Educational Session, 23 April 2023. [[Slides \(pptx\)](#)] [[pdf](#)] [[Talk Video](#)]

Onur Mutlu, **"Accelerating Genome Analysis: A Primer on an Ongoing Journey"**, BIO-Arch Workshop @ RECOMB, 14 April 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Reinventing Computing & Storage"**, OlympusMons Award Keynote Speech, 7 April 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, WSOS (Winter School on Operating Systems) Opening Talk, 3 April 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Keynote Talk at the 5th Workshop on Accelerated Machine Learning (AccML), held with the HiPEAC Conference, Toulouse, France, 18 January 2023. [[Slides \(pptx\)](#)] [[pdf](#)]

Onur Mutlu, **"Memory-Centric Computing"**, Keynote Talk at the Memory-Centric Computing

for Data-Intensive Workloads (MCC), held with the HiPEAC Conference, Toulouse, France, 18 January 2023. [\[Slides \(pptx\) \(pdf\)\]](#)

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at UCLA, Los Angeles, CA, USA, 13 January 2023. [\[Slides \(pptx\) \(pdf\)\]](#)

Selected talks from SAFARI group members:

Can Firtina, **"Real-time Analysis of Genomic Sequences from Nanopore Electrical Signals by Fast and Accurate Hash-based Search"**, Invited Talk, *Tufts University - Department of Computer Science, hosted by Prof. Lenore J. Cowen*, Medford, MA, USA. May 3 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#) [\[Talk Video\]](#)



Mohammad Sadrosadati, **"Storage-Centric Computing"**, Snow Mountain Summit 2023 European Innovation Stars, 13 June 2023. [\[Slides \(pdf\)\]](#)

Mohammad Sadrosadati, **"Storage-Centric Computing for Modern Data-Intensive Workloads"**, Huawei STW 2023, 27 September 2023. [\[Slides \(pdf\)\]](#)

Haiyu Mao, **"Data-Centric Architecture and Algorithm Co-design for Modern Data-Intensive Applications"**, UK Talks: University of Glasgow, 7 Nov 2023, University of Edinburgh, 8 Nov 2023, University of Cambridge, 10 Nov 2023, King's College London, 14 Nov 2023. [\[Slides \(pdf\) \(pptx\)\]](#)

Haiyu Mao, **"Processing-in-Memory for Genome Analysis"**, Huawei PIM Workshop, Zurich, 28 June 2023. [\[Slides \(pdf\) \(pptx\)\]](#)

Can Firtina, **"Enabling Fast, Accurate, and Efficient Real-Time Genomic Sequence Analysis via New Algorithms and Architectures"**, Invited Talk, *Huawei Research Center Zurich*, Zurich, Switzerland. May 17 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **"Real-time Sequence Analysis from Raw Nanopore Electrical Signals with Accurate Hash-based Search Mechanisms"**, Invited Talk, *The Broad Institute of MIT and Harvard, hosted by Victoria Popic, Ph.D.*, Cambridge, MA, USA. May 10 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“Real-time Analysis of Genomic Sequences from Nanopore Electrical Signals by Fast and Accurate Hash-based Search”**, Invited Talk, *The Jackson Laboratory (JAX)*, hosted by *Joshy George, Ph.D.*, Farmington, CT, USA. May 6 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“Introduction to Real-Time Raw Nanopore Signal Analysis: RawHash and RawHash2”**, Invited Lecture, *BIO310 - Introduction to Bioinformatics*, *Sabanci University*, Virtual. March 18 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“RawHash and RawHash2: Enabling Fast and Accurate Real-time Analysis of Raw Nanopore Signals for Large Genomes using a Hash-based Seeding Mechanism”**, Invited Talk, *Leibniz Institute for Immunotherapy (LIT)*, hosted by *Prof. Birte Kehr*, Regensburg, Germany. January 17 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“ApHMM: Accelerating Profile Hidden Markov Models for Fast and Energy-Efficient Genome Analysis”**, Conference Talk, *High Performance, Edge And Cloud computing (HiPEAC) 2024*, Munich, Germany. January 17 2024. [\[Video\]](#) [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“Enabling Fast, Accurate and Efficient Real-Time Genome Analysis via New Algorithms and Architectures”**, Invited Talk, *Technical University of Munich (TUM) - School of Computation, Information and Technology (CIT)*, hosted by *Prof. Ulf Schlichtmann*, Munich, Germany. January 16 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“Enabling Fast, Accurate and Efficient Real-Time Genome Analysis via New Algorithms and Architectures”**, Invited Talk, *Huawei Munich Research Center*, Munich, Germany. January 15 2024. [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

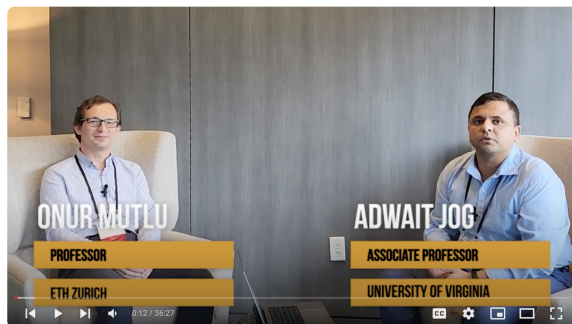
Can Firtina, **“RawHash: enabling fast and accurate real-time analysis of raw nanopore signals for large genomes”**, Conference Talk, *31st Annual Conference on Intelligent Systems for Molecular Biology (ISMB) and the 22nd European Conference on Computational Biology (ECCB)*, Lyon, France. July 25 2023. [\[Video\]](#) [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

Can Firtina, **“RawHash: enabling fast and accurate real-time analysis of raw nanopore signals for large genomes”**, Workshop Talk, *The 5th Workshop on Accelerator Architecture in Computational Biology and Bioinformatics (AACBB)*, Orlando, Florida, USA. June 18 2023. [\[Video\]](#) [\[Slides \(PDF\)\]](#) [\[Slides \(PPT\)\]](#)

The following talks were part of a talk tour in the UK given by [A. Giray Yaglikci](#) and Geraldo F. Oliveira at University of Glasgow, Huawei UK, University College London, Microsoft Research and ARM, March 7-14 2024:

Abdullah Giray Yaglikci, **"Enabling Efficient and Scalable Read Disturbance Mitigation via New Experimental Insights into Modern Memory Chips"**, Computer Laboratory Systems Seminar, University of Cambridge, 14 March 2024 [[Slides \(pptx\)](#)] ([pdf](#)) You can find all of Giray's talk slides on [[GitHub Talk Slides](#)] and his [website](#).

Geraldo F. Oliveira, **"Methodologies, Workloads, and Tools for Processing-in-Memory: Enabling the Adoption of Data-Centric Architectures"**, Computer Laboratory Systems Seminar, University of Cambridge, 14 March 2024. [[Slides \(pptx\)](#)] ([pdf](#))



TCuARCH (Technical Community on Microprogramming and Microarchitecture) meets Prof. Onur Mutlu, Interview with Adwait Jog, 6 September 2023.

[[Interview Video TCuARCH](#)]

[[Interview Video](#)]

PACT 2023 talks



You can watch our talks from the SRC at PACT here:

https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_NVFEcYfkJ7gJcEtcDoFN3

Read more about the competition here:

<https://safari.ethz.ch/student-research-competition-at-pact-2023/>

Lukas Zink, Juan Gómez Luna, Christina Giannoula, Onur Mutlu, **"Towards Throughput-oriented Sparse Matrix Vector Multiplication on a Processing-in-Memory System"**

[[Poster \(PDF\)](#)] [[Talk slides \(PDF\)](#)] [[Talk video \(10 mins\)](#)]

Abdullah Giray Yağlıkci, Onur Mutlu, **"Understanding and Leveraging the Spatial Variation in Read Disturbance Vulnerability of Real DRAM Chips"**

[\[Poster \(PDF\)\]](#) [\[Talk slides \(PDF\)\]](#) [\[Talk video \(10 mins\)\]](#) [\[Preprint \(PDF\)\]](#)

Geraldo F. Oliveira, Onur Mutlu, **“DaPPA: A Data-Parallel Framework for Processing-in-Memory Architectures”**

[\[Poster \(PDF\)\]](#) [\[Talk slides \(PDF\)\]](#) [\[Talk video \(10 mins\)\]](#) [\[Preprint \(PDF\)\]](#)

Xavier Servot, Juan Gómez Luna, Onur Mutlu, **“WNN-PiM: Accelerating Weightless Neural Network Inference and Training on a Real Processing-in-Memory System”**

[\[Poster \(PDF\)\]](#) [\[Talk slides \(PDF\)\]](#) [\[Talk video \(10 mins\)\]](#)

Visit [Onur's talks page](#) for past talks and further reading

Selected Open Source Releases



We released many research artifacts and tools in 2023 & 2024. All are available on GitHub:



CMU-SAFARI /

ABACuS is a new RowHammer mitigation mechanism that prevents RowHammer bitflips at low area, performance, and energy overheads for modern and future DRAM chips that are very vulnerable to RowHammer. Described in our *USENIX Security 2024* paper: <https://arxiv.org/pdf/2310.09977.pdf>



DALL-E's picture of ABACuS

ApHMM-GPU is the first GPU implementation of the Baum-Welch algorithm for profile Hidden Markov Models (pHMMs) as described in our 2024 *TACO* paper: <https://arxiv.org/abs/2207.09765>.

CoMeT is a new low-cost RowHammer mitigation that uses Count-Min Sketch-based aggressor row tracking, as described in our *HPCA 2024* paper: <https://arxiv.org/pdf/2402.18769.pdf>

FCDRAM source code & scripts for experimental characterization and demonstration of performing NOT and up to 16-input AND, NAND, OR, and NOR operations in real DDR4 DRAM chips. Described in our *HPCA 2024* paper: <https://arxiv.org/abs/2402.18736>



RawHash is the first mechanism that can accurately and efficiently map raw nanopore signals to large reference genomes (e.g., a human reference genome) in real-time without using powerful computational resources (e.g., GPUs). Described in our 2023 *Bioinformatics* paper: <https://doi.org/10.1093/bioinformatics/btad272>



A Binary Instrumentation Tool
to Analyze Load Instructions in Off-the-Shelf x86-64 Binaries

License: MIT | release: no releases or repo not found | CS.AR: 2209.00188

The Load Inspector is a binary instrumentation tool that can analyze load instructions in any off-the-shelf x86(-64) binary to dump various statistics, as described in our *ISCA 2024* paper: <https://arxiv.org/abs/2406.18786>

Utopia is a new hybrid address mapping scheme that accelerates address translation while supporting all conventional VM features as described in our *MICRO 2023* paper: <https://arxiv.org/abs/2211.12205>

MIMDRAM is a hardware/software co-designed processing-using-DRAM (PUD) system that enables a multiple-instruction multiple-data (MIMD) execution model in each DRAM subarray (and SIMD execution within each DRAM row segment), described in our *HPCA 2024* paper: <https://arxiv.org/pdf/2402.19080.pdf>

RUBICON is a novel framework to automatically develop deep-learning-based genomic basecallers for any given architecture, as described in our 2024 *Genome Biology* paper: <https://genomebiology.biomedcentral.com/articles/10.1186/s13059-024-03181-2>

Victima is a new software-transparent technique that greatly extends the address translation reach of modern processors by leveraging the underutilized resources of the cache hierarchy, as described in the *MICRO 2023* paper: <https://arxiv.org/pdf/2310.04158/>

Virtuoso is a comprehensive and modular simulation framework that models various VM designs to establish a common ground for virtual memory research, as described in our preprint: <https://arxiv.org/abs/2403.04635>

MetaTrinity is a novel metagenomic analysis tool employing efficient

SimplePIM is the first high-level programming framework for real-world processing-in-memory (PIM) architectures. Described in the *PACT 2023* paper: <https://arxiv.org/pdf/2310.01893.pdf>

RowPress is a widespread read disturbance phenomenon in DRAM that is different from RowHammer. We provide source code & scripts for experimental characterization and real-system demonstration of RowPress, as described in our *ISCA 2023*: https://people.inf.ethz.ch/omutlu/pub/RowPress_isca23.pdf

DRAM-Bender is the first open source DRAM testing infrastructure that can be used to easily and comprehensively test state-of-the-art DDR4 modules of different form factors. Five prototypes are available on different FPGA boards. Described in our *TCAD 2023* paper: <https://arxiv.org/pdf/2211.05838.pdf>

Ramulator 2.0 is a modern, modular, extensible, and fast cycle-accurate DRAM simulator. It provides support for agile implementation and evaluation of new memory system designs (e.g., new DRAM standards, emerging RowHammer mitigation techniques). Described in our 2023 *IEEE Computer Architecture Letters* paper: https://people.inf.ethz.ch/omutlu/pub/Ramulator2_arxiv23.pdf

SPARTA is a novel spatial accelerator for

analysis tool employing efficient containment search techniques and heuristics for read mapping to achieve significant speedup while maintaining high accuracy. As described in our preprint: <https://arxiv.org/abs/2311.02029>

SiMRA-DRAM allows for experimental characterization and demonstration of 1) simultaneous many-row activation, 2) up to nine-input majority operations and 3) copying one row's content to up 31 rows in real DDR4 DRAM chips. Described in our *DSN 2024* paper: <https://arxiv.org/abs/2405.06081>

HBM-Read-Disturbance provides detailed read disturbance (RowHammer and RowPress) characterization of six real HBM2 DRAM chips yielding 23 new observations and 8 new takeaways, as described in the *DSN 2024* paper: <https://arxiv.org/pdf/2310.14665.pdf>



horizontal diffusion weather stencil computation, as described in *ICS 2023* paper: <https://arxiv.org/pdf/2303.03509.pdf>

SequenceLab is a benchmark suite for evaluating computational methods for comparing genomic sequences, such as pre-alignment filters and pairwise sequence alignment algorithms, described in our preprint: <https://arxiv.org/abs/2310.16908>

RawAlign is a real-time raw nanopore read mapper based on the Seed-Filter-Align paradigm as described in our preprint: <https://arxiv.org/abs/2310.05037>



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