SAFARI

SAFARI Research Group

Think Big, Aim High

ETH zürich

View in your browser

June 2023

Dear SAFARI friends & colleagues,

We are pleased to share our group highlights from 2022 and the first part of 2023 with you in this next edition of our newsletter. 2022 saw a full return of in-person teaching and conference talks, travel, regular office presence, and collaborations abroad. Our research, education, service, and outreach activities continued at full speed and rigor. Although we were back to teaching in the classroom, we continued to livestream our lectures on our **YouTube channel**, allowing a global audience to follow our classes, while continuing to democratize education and research. We also continued our **SAFARI Live Seminar Series**, hosting talks by researchers worldwide, with many insightful talks from leaders in both industry and academia. Our lectures and seminars will continue to be livestreamed in 2023, and you can continue to find our seminar recordings, and most of our educational and outreach activities on our **YouTube channel**.

In our research, we enjoyed presenting work at many top conferences, many in person, and have continued to produce high-quality research at high quantity, thanks to rigorous and close collaboration within our group and with our industrial & academic partners. Our group also took over new offices in the ETH OAT building in Oerlikon, where we are now settling in and sharing the space with new groups and collaborators. We look forward to continuing our productive and impactful work in the rest of 2023 and beyond (collaboratively with hopefully many of you), expanding to new opportunities and collaborations, and always maintaining a continued dedication to sharing our passion in both research and teaching globally.

We wish you a wonderful second half of 2023 filled with good health, happiness, creativity, optimism, and many great ideas that can change the world positively!

Onur Mutlu & **the SAFARI team**

News & Awards

Feb 2022: Onur Mutlu received an Intel 2021 Outstanding Researcher Award for his work on "*Efficient Compute-in-Memory Architectures".* His contributions to emerging-workload-driven research has led to open-source benchmark suites that help hardware-software co-design and exploration for near-memory architectures. His team's research has also led to innovative near-memory architectures for deep learning and genomics applications. Congratulations! ***Read more***

March 2022: Our work on *"Benchmarking Memory-Centric Computing Systems: Analysis of Real Processing-in-Memory Hardware"*, led by Juan Gómez Luna, was highlighted in the ETH News for Industry article: In-Memory-Computing: faster and more energy efficient. ***Read the article***

May 2022: Onur Mutlu and colleagues, Benjamin Lee, Engin Ipek, and Doug Burger, received the NVMW 2022 Persistent Impact Prize for their 2009 ISCA paper on *"Architecting Phase Change Memory as a Scalable DRAM Alternative"*.

"Architecting Phase Change Memory as a Scalable DRAM Alternative" was awarded the Persistent Impact Prize in recognition of its seminal contribution to understanding how non-volatile memories might replace conventional DRAM. It also played a critical role in introducing Phase Change Memory (PCM) technology to the architecture community, spawning a wide range of follow-on work. ***Read more***

June 2022: We're honoured that Minesh Patel was awarded the DSN-2022 William C. Carter Award for his PhD Dissertation *"Enabling Effective Error Mitigation in Memory Chips That Use On-Die Error-Correcting Codes"*.

Read more

June 2022:

EU Horizon Project BioPIM kick-off

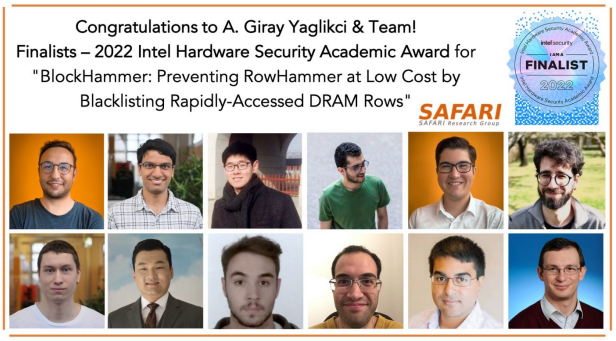
We kicked off our newly funded EU Horizon research project, **BioPIM**, led by Can Alkan at Bilkent University, together with project partners at IBM, Institut Pasteur, UPMEM, CNRS, and TECHNION, and have had a successful first year of the project. Onur Mutlu, Juan Gómez Luna and Mohammed Alser are leading the research activities at ETH.

Read more on our group contributions

BioPIM

The goal of BioPIM is the realization of cheap, ultra-fast, and ultra-low energy mobile genomics that eliminates the current dependence of sequence analysis on large and power-hungry computing clusters/data centers commonly based on FPGAs or GPUs.

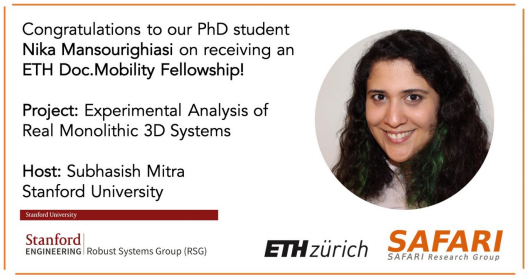
Project BioPIM website

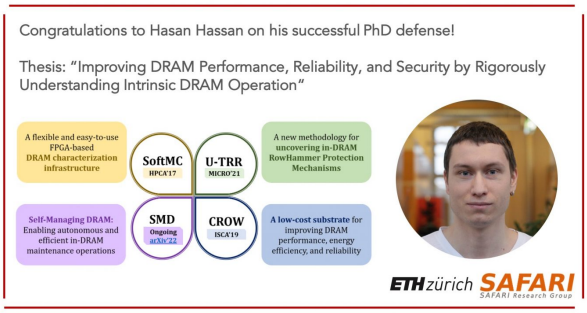


Aug 2022: We were nominated as one of four finalists for the Intel Hardware Security Academic Award for our work on *BlockHammer*, our state-of-the-art throttling-based RowHammer defense. We'd like to congratulate Abdullah Giray Yağlıkçı & team on their honorable mention amidst a very competitive field.

Read more

Sept 2022: Our PhD student, Nika Mansourighiasi, was awarded a 2022 ETH Doc.Mobility Fellowship. Nika will carry out part of her PhD work in 2023-24 at Stanford University under the supervision of Subhasish Mitra. Congratulations! ***Read more***





Sept 2022: We'd like to congratulate our recent PhD graduate, Hasan Hassan, on his successful PhD defense in September for his thesis work *"Improving DRAM Performance, Reliability, and Security by Rigorously Understanding Intrinsic DRAM Operation"*. Hasan was awarded the EDAA Outstanding Dissertation Award at DATE 2023 in April (you can read more below on his recent award). ***Read more on Hasan's PhD work.***

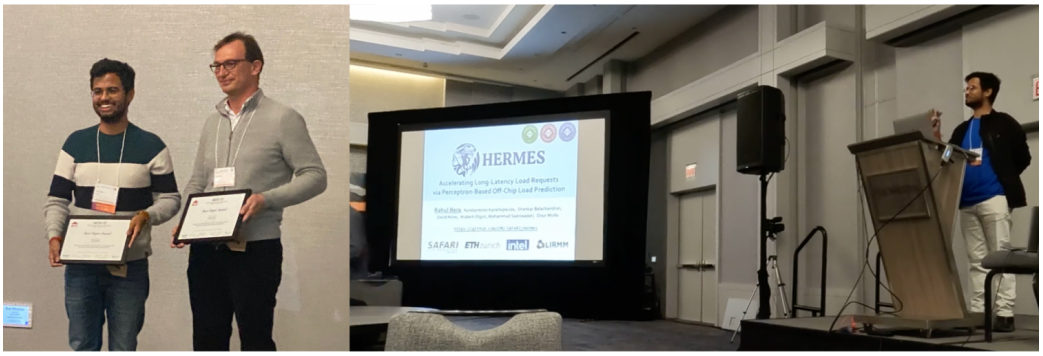
Sept 2022: Congratulations to Christina Giannoula on her PhD defense for her thesis *"Accelerating Irregular Applications via Efficient Synchronization and Data Access Techniques"*.
Christina talked to us about her PhD work and her future plans. ***Read Christina's interview.***

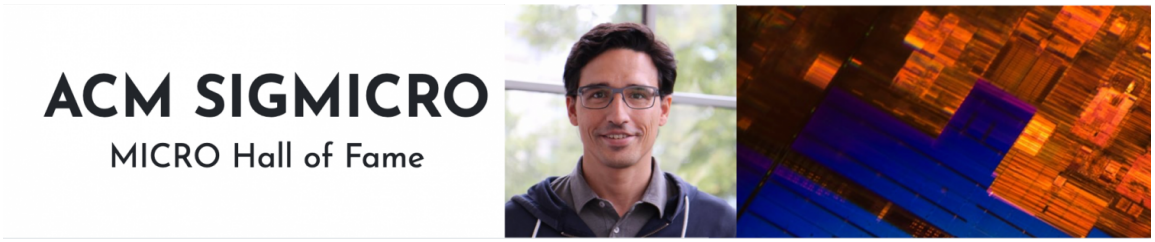
Swiss National Science Foundation

Sept 2022: We gratefully acknowledge the SNSF for our project grant on *Near-Data-Processing Architectures and Algorithms for Metagenomic Analysis*, starting in 2023.

Oct 2022: Our PhD student, Rahul Bera, and co-authors won a Best Paper Award at MICRO 2022 for their work *"Hermes: Accelerating Long-Latency Load Requests via Perceptron-Based Off-Chip Load Prediction"*. Congratulations!

Read more on the Best Paper Award and interview with Rahul.



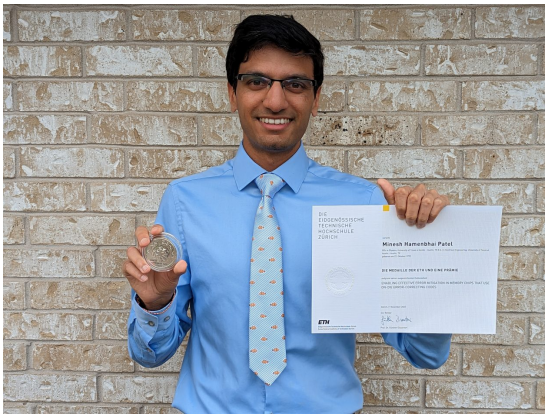


Oct 2022: Congratulations to our senior researcher, Juan Gómez-Luna, on being inducted into the MICRO Hall of Fame, in recognition of eight or more papers published in MICRO!

Oct 2022: Congratulations to Mohammad Sadrosadati and Mohammed Alser on being selected to participate in the prestigious Global Young Scientists Summit, an event that brings together exceptional young researchers and top scientific minds, many of them Nobel Laureates, and recipients of the Fields Medal, Millennium Technology Prize and Turing Award. Mohammed Alser attended in January 2022, and Mohammad Sadrosadati attended in January 2023.

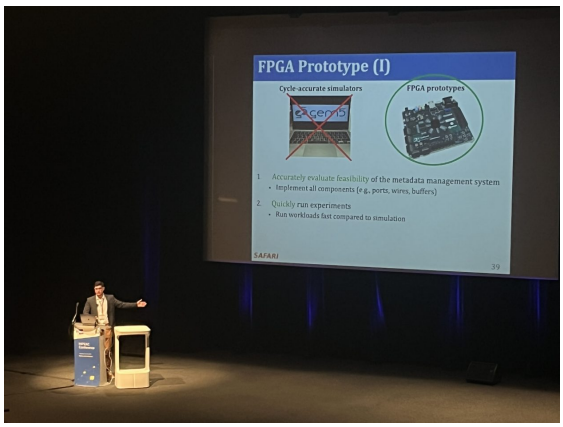
Nov 2022: Onur Mutlu received a Google Security and Privacy Research Award for work on hardware security and side-channels. This award recognizes the work done by Mutlu and his team for making significant contributions to protecting users across the Internet, especially for their decade-long work on the DRAM RowHammer vulnerability.

Read more on the award and interview on our RowHammer research.



Nov 2022: Minesh Patel was awarded the ETH doctoral medal for his PhD dissertation (defended October 2021): *"Enabling Effective Error Mitigation in Modern Memory Chips that Use On-Die Error-Correcting Codes".* Congratulations Minesh! ***Read more on Minesh's award, his PhD work, and past interviews.***

Jan 2023: Nandita Vijaykumar, Ataberk Olgun and co-authors won a Best Paper Award at HiPEAC 2023 for their ACM TACO paper *"MetaSys: A Practical Open-source Metadata Management System to Implement and Evaluate Cross-layer Optimizations".* Congratulations to the authors! ***Read more***



Feb 2023: Lukas Breitwieser and co-authors Ahmad Hesam, Fons Rademakers, Juan Gómez Luna, Onur Mutlu received the Best Artifact Award at PPoPP 2023 for BioDynaMo, a flexible and high-performance agent based simulation engine. Congratulations! ***Read more***

April 2023:
We were awarded a Google Open Source Peer Bonus for contributions to our educational YouTube channel Onur Mutlu Lectures. Congratulations team!
Read more

Google Open Source Peer Bonus

April 2023: Onur Mutlu and team received the Huawei OlympusMons Award in recognition of their work on “Data-Centric & Data-Driven Storage System Design for High Performance, Efficiency and Reliability”. ***Read more***

April 2023: Hasan Hassan received the EDAA Outstanding Dissertation Award 2023 for his thesis work that addresses “New directions in safety, reliability, security-aware hardware design, validation and testing”. The award was given at the DATE 2023 conference on April 18 2023.
Read more

SAFARI Workshops and Tutorials 2023

Feb & March 2023:
We held tutorials on Real-world Processing-in-Memory Systems at HPCA 2023 & ASPLOS 2023 with invited speakers from academia and industry, organized by Juan Gomez Luna, Onur Mutlu, and Ataberk Olgun. The tutorials were well attended and we're looking forward to giving more tutorials in the future. You can find the programs and talk recordings here:
HPCA 2023 Tutorial Website | YouTube recordings
ASPLOS 2023 Tutorial Website | YouTube recordings
Read more

Tutorial overview: Our Real-world PIM tutorial focuses on the latest advances in PIM technology, workload characterization for PIM, and programming and optimizing PIM kernels. In the tutorial, we (1) provide an introduction to PIM and taxonomy of PIM systems, (2) give an overview and a rigorous analysis of existing real-world PIM hardware, and (3) conduct hands-on labs looking in-depth at important workloads (including machine learning, sparse linear algebra, bioinformatics) using real PIM systems, and (4), we shed light on how to improve future PIM systems for such workloads.

June 2023:
We'll be giving another Real-World PIM tutorial at ISCA 2023 in June.
ISCA 2023 Tutorial: Real-world Processing-in-Memory Systems for Modern Workloads, Sunday, June 18 (held during ISCA 2023, June 17 – 21, 2023 in Orlando, Florida).

You can join the tutorial in person or online:
ISCA 2023 Tutorial Website | Livestream Link | ISCA 2023 Registration

---

April 2023:

We organized the first BIO-Arch: Workshop on Hardware Acceleration of Bioinformatics Workloads held with RECOMB 2023 in Istanbul. The workshop brought together researchers in bioinformatics, computational biology, and computer architecture communities to discuss the latest work on accelerating bioinformatics analysis (e.g., genome analysis) with efficient system designs that include hardware acceleration and software systems tailored for new hardware technologies. The workshop was followed by a Panel on Hardware Acceleration of Bioinformatics Workloads.

BIO-Arch website | BIO-Arch program | BIO-Arch talk recordings on YouTube

This workshop was a contribution to our BioPIM project and brought together our BioPIM collaborators.

Read more SAFARI news

We thank our industry partners and funding agencies for their support in 2022 and 2023

Our group was generously supported with new and continuing donations and projects in 2022 and 2023 from Google, Huawei, Intel, Xilinx, Microsoft, SRC, SNSF and EU Horizon Europe (and the Swiss State Secretariat for Education, Research and Innovation, SERI, for proving our Horizon Europe funding). 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 form 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.

Alibaba | ASML | Facebook | Futurewei | Huawei | Google | HiSilicon | Intel | IMEC | Microsoft | SRC | VMware | Xilinx

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

2022-2023 Conference and Journal Papers

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." to appear in *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD),* 2023. [arXiv version] [DRAM-Bender Source Code] [DRAM Bender Tutorial Video (43 minutes)]

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", *Proceedings of the 31st Annual Conference on Intelligent Systems for Molecular Biology and the 22nd European Conference on*

Computational Biology (ISMB/ECCB), Lyon, France, July 2023. [RawHash Source Code] [Poster presented at RECOMB 2023 (PDF)]

Onur Mutlu and Can Firtina, "Accelerating Genome Analysis via Algorithm-Architecture Co-Design", Invited Paper in P*roceedings of the 60th Design Automation Conference (DAC)*, Orlando, FL, USA, July 2023. [arXiv version]

Onur Mutlu, "Memory-Centric Computing", Invited Paper in P*roceedings of the 60th Design Automation Conference (DAC)*, Orlando, FL, USA, July 2023.

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)*, Orlando, FL, USA, June 2023. [preprint] [Lightning Talk Slides (pptx) (pdf)] [Lightning Talk Video (3 minutes)] [RowPress Source Code and Datasets] Officially artifact evaluated as available, reusable and reproducible.

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] [Lightning Talk Slides (pptx) (pdf)] [Lightning Talk Video]

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 53nd Annual IEEE/IFIP International Conference on Dependable Systems and Networks Disrupt Track (DSN Disrupt)*, Porto, Portugal, June 2023. [arXiv version]

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] [SPARTA Source Code]

Lois Orosa, Skanda Koppula, Yaman Umuroglu, Konstantinos Kanellopoulos, Juan Gomez-Luna, Michaela Blott, Kees Vissers, Onur Mutlu, "Efficient Convolutional Dataflows on Low-Power Neural Network Accelerators," in *IEEE Transactions on Computers*, 5 May 2023. [arXiv version] [IEEE Xplore (early access)]

Hashem Haghbayan, Antonio Miele, Onur Mutlu, Juha Plosila, "Run-time Resource Management in CMPs Handling Multiple Aging Mechanisms", in *IEEE Transactions on Computers*, 3 May 2023. [IEEE Xplore (early access)]

Juan Gómez Luna, Yuxin Guo, Sylvan Brocard, Julien Legriel, Remy Cimadomo, Geraldo F. Oliveira, Gagandeep Singh, and Onur Mutlu, "Evaluating Machine Learning Workloads on Memory-Centric Computing Systems", *Proceedings of the 2023 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS)*, Raleigh, North Carolina, USA, April 2023. [Extended arXiv version] [Slides (pptx) (pdf)] [PIM-ML Source Code] [Talk Video (15 minutes)]
Best paper session.

Maurus Item, Juan Gómez Luna, Yuxin Guo, Geraldo F. Oliveira, Mohammad Sadrosadati, and Onur Mutlu, "TransPimLib: Efficient Transcendental Functions for Processing-in-Memory Systems", *Proceedings of the 2023 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS)*, Raleigh, North Carolina, USA, April 2023. [arXiv version] [Slides (pptx) (pdf)] [TransPimLib Source Code] [Talk Video (17 minutes)]

M. Banu Cavlak, Gagandeep Singh, Mohammed Alser, Can Firtina, Joel Lindegger, Mohammad Sadrosadati, Nika Mansouri Ghiasi, Can Alkan, and Onur Mutlu, "TargetCall: Eliminating the Wasted Computation in Basecalling via Pre-Basecalling Filtering", *Proceedings of the 21st Asia Pacific Bioinformatics Conference (APBC)*, Changsha, China, April 2023. [TargetCall Source Code] [arXiv version] [Talk Video at BIO-Arch 2023 Workshop] [Poster presented at RECOMB 2023 (PDF)]

Jeremie S. Kim, Can Firtina, M. Banu Cavlak, Damla Senol Cali, Nastaran Hajinazar, Mohammed Alser, Can Alkan, and Onur Mutlu, "AirLift: A Fast and Comprehensive Technique for Remapping Alignments between Reference Genomes", *Proceedings of the 21st Asia Pacific Bioinformatics Conference (APBC)*, Changsha, China, April 2023. [AirLift Source Code] [arXiv version] [Talk Video at BIO-Arch 2023 Workshop, presented by Can Firtina] [Poster presented at RECOMB 2023 (PDF)]

Nour Almadhoun Alserr, Gulce Kale, Onur Mutlu, Oznur Tastan, and Erman Ayday, "Tuning Privacy-Utility Tradeoff in Genomic Studies Using Selective SNP Hiding", *Proceedings of the 21st Asia Pacific Bioinformatics Conference (APBC),* Changsha, China, April 2023. [Source Code] [arXiv version]

Joël Lindegger, Damla Senol Cali, Mohammed Alser, Juan Gómez-Luna, Nika Mansouri Ghiasi, and Onur Mutlu, "Scrooge: A Fast and Memory-Frugal Genomic Sequence Aligner for CPUs, GPUs, and ASICs", *Bioinformatics*, [published online on] 24 March 2023. [Online link

at Bioinformatics Journal] [arXiv version] [Scrooge Source Code] [Poster presented at RECOMB 2023 (PDF)] [Talk Recording BIO-Arch Workshop]

Safaa Diab, Amir Nassereldine, Mohammed Alser, Juan Gómez Luna, Onur Mutlu, and Izzat El Hajj, "A Framework for High-throughput Sequence Alignment using Real Processing-in-Memory Systems", *Bioinformatics*, [published online on] 27 March 2023. [Online link at Bioinformatics Journal] [arXiv version] [AiM Source Code]

Alain Denzler, Rahul Bera, Nastaran Hajinazar, Gagandeep Singh, Geraldo F. Oliveira, Juan Gómez-Luna, and Onur Mutlu, "Casper: Accelerating Stencil Computation using Near-cache Processing", *IEEE Access*, 3 March 2023. [arXiv version] [IEEE Access version]

Ataberk Olgun, Juan Gomez Luna, Konstantinos Kanellopoulos, Behzad Salami, Hasan Hassan, Oguz Ergin, and Onur Mutlu, "PiDRAM: A Holistic End-to-end FPGA-based Framework for Processing-in-DRAM", *ACM Transactions on Architecture and Code Optimization (TACO)*, March 2023. [arXiv version] [IEEE version]
Presented at the 18th HiPEAC Conference, Toulouse, France, January 2023.
[Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Lecture Video (40 minutes)] [PiDRAM Source Code]

Lukas Breitwieser, Ahmad Hesam, Fons Rademakers, Juan Gómez Luna, and Onur Mutlu, "High-Performance and Scalable Agent-Based Simulation with BioDynaMo", *Proceedings of the 28th ACM SIGPLAN Annual Symposium on Principles and Practice of Parallel Programming (PPoPP)*, Montreal, QC, Canada, February 2023. [arXiv version]
[BioDynamo Source Code (Officially Artifact Evaluated with All Badges)]
Officially artifact evaluated as available, reusable and reproducible.
Best artifact award at PPoPP 2023.

Onur Mutlu, Ataberk Olgun, and A. Giray Yaglikci, "Fundamentally Understanding and Solving RowHammer", Invited Special Session Paper at *the 28th Asia and South Pacific Design Automation Conference (ASP-DAC)*, Tokyo, Japan, January 2023. [arXiv version] [Slides (pptx) (pdf)] [Talk Video (26 minutes)]

Can Firtina, Jisung Park, Mohammed Alser, Jeremie S Kim, Damla Senol Cali, Taha Shahroodi, Nika Mansouri Ghiasi, Gagandeep Singh, Konstantinos Kanellopoulos, Can Alkan, Onur Mutlu, "BLEND: a fast, memory-efficient and accurate mechanism to find fuzzy seed matches in genome analysis", *NAR Genomics and Bioinformatics*, March 2023. [arXiv version] [Journal Article] [BLEND Source Code] [Slides (pdf) (pptx)] [Talk Video RECOMB 2023]

Nika Mansouri Ghiasi, Nandita Vijaykumar, Geraldo F. Oliveira, Lois Orosa, Ivan Fernandez, Mohammad Sadrosadati, Konstantinos Kanellopoulos, Nastaran Hajinazar, Juan Gomez-Luna, and Onur Mutlu, "ALP: Alleviating CPU-Memory Data Movement Overheads in Memory-Centric Systems", *IEEE Transactions on Emerging Topics in Computing (TETC),* December 2022. [arXiv version] [IEEE version]

Gagandeep Singh, Dionysios Diamantopoulos, Juan Gómez-Luna, Sander Stuijk, Henk Corporaal, Onur Mutlu, "LEAPER: Fast and Accurate FPGA-based System Performance Prediction via Transfer Learning," *2022 IEEE 40th International Conference on Computer Design (ICCD)*, December 2022. [arXiv version] [IEEE version]

Geraldo F. Oliveira, Juan Gómez-Luna, Saugata Ghose, Amirali Boroumand, Onur Mutlu, "Accelerating Neural Network Inference With Processing-in-DRAM: From the Edge to the Cloud," in *IEEE Micro*, Nov - Dec 2022. [arXiv version] [IEEE version]

Maciej Besta, Cesare Miglioli, Paolo Sylos Labini, Jakub Tetek, Patrick Iff, Raghavendra Kanakagiri, Saleh Ashkboos, Kacper Janda, Michał Podstawski, Grzegorz Kwasniewski, Niels Gleinig, Flavio Vella, Onur Mutlu, Torsten Hoefler, "ProbGraph: High-Performance and High-Accuracy Graph Mining with Probabilistic Set Representations", *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC),* November 2022. [arXiv version] [IEEE version]
SC'22 Best Paper Award

Jeremie S Kim, Can Firtina, Meryem Banu Cavlak, Damla Senol Cali, Can Alkan, Onur Mutlu, FastRemap: a tool for quickly remapping reads between genome assemblies, *Bioinformatics*, October 2022. [arXiv version] [Journal Article in Bioinformatics] [FastRemap Source Code]

Rahul Bera, Konstantinos Kanellopoulos, Shankar Balachandran, David Novo, Ataberk Olgun, Mohammad Sadrosadati, and Onur Mutlu, "Hermes: Accelerating Long-Latency Load Requests via Perceptron-Based Off-Chip Load Prediction", *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Talk Video (12 minutes)] [Lecture Video (25 minutes)] [arXiv version] [Source Code (Officially Artifact Evaluated with All Badges)]
Officially artifact evaluated as available, reusable and reproducible.
Best paper award at MICRO 2022.

João Dinis Ferreira, Gabriel Falcao, Juan Gómez-Luna, Mohammed Alser, Lois Orosa, Mohammad Sadrosadati, Jeremie S. Kim, Geraldo F. Oliveira, Taha Shahroodi, Anant Nori,

and Onur Mutlu, "pLUTo: Enabling Massively Parallel Computation in DRAM via Lookup Tables", *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Lecture Video (26 minutes)] [arXiv version] [Source Code (Officially Artifact Evaluated with All Badges)]
Officially artifact evaluated as available, reusable and reproducible.

Jisung Park, Roknoddin Azizi, Geraldo F. Oliveira, Mohammad Sadrosadati, Rakesh Nadig, David Novo, Juan Gómez-Luna, Myungsuk Kim, and Onur Mutlu, "Flash-Cosmos: In-Flash Bulk Bitwise Operations Using Inherent Computation Capability of NAND Flash Memory" *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Lecture Video (44 minutes)] [arXiv version]

Haiyu Mao, Mohammed Alser, Mohammad Sadrosadati, Can Firtina, Akanksha Baranwal, Damla Senol Cali, Aditya Manglik, Nour Almadhoun Alserr, and Onur Mutlu, "GenPIP: In-Memory Acceleration of Genome Analysis via Tight Integration of Basecalling and Read Mapping", *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Lecture Video (25 minutes)] [arXiv version] [Poster presented at RECOMB 2023 (PDF)] [Talk Recording BIO-Arch Workshop]

Sina Darabi, Mohammad Sadrosadati, Joël Lindegger, Negar Akbarzadeh, Mohammad Hosseini, Jisung Park, Juan Gómez-Luna, Onur Mutlu, and Hamid Sarbazi-Azad, "Morpheus: Extending the Last Level Cache Capacity in GPU Systems Using Idle GPU Core Resources", *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [Longer Lecture Slides (pptx) (pdf)] [Talk Video (12 minutes)] [Lecture Video (32 minutes)] [arXiv version]

Jawad Haj Yahya, Haris Volos, Davide B. Bartolini, Georgia Antoniou, Jeremie S. Kim, Zhe Wang, Kleovoulos Kalaitzidis, Tom Rollet, Zhirui Chen, Ye Geng, Onur Mutlu, and Yiannakis Sazeides, "AgileWatts: An Energy-Efficient CPU Core Idle-State Architecture for Latency-Sensitive Server Applications", *Proceedings of the 55th International Symposium on Microarchitecture (MICRO)*, Chicago, IL, USA, October 2022. [Slides (pptx) (pdf)] [arXiv version]

A. Giray Yağlikçi, Ataberk Olgun, Minesh Patel, Haocong Luo, Hasan Hassan, Lois Orosa, Oğuz Ergin, Onur Mutlu, "HiRA: Hidden Row Activation for Reducing Refresh Latency of Off-the-Shelf DRAM Chips," *2022 55th IEEE/ACM International Symposium on Microarchitecture (MICRO)*, October 2022. [arXiv version] [IEEE version] [MICRO'22 Talk Slides (pdf) (pptx)]

[Talk video (part of lecture P&S DRAM Bender)] [Slides (pdf) (pptx)]

Mostafa Hadizadeh, Elham Cheshmikhani, Maysam Rahmanpour, Onur Mutlu, Hossein Asadi, "CoPA: Cold Page Awakening to Overcome Retention Failures in STT-MRAM Based I/O Buffers," in *IEEE Transactions on Parallel and Distributed Systems*, October 2022. [arXiv version] [IEEE version]

Mohammed Alser, Joel Lindegger, Can Firtina, Nour Almadhoun Alserr, Haiyu Mao, Gagandeep Singh, Juan Gomez-Luna, and Onur Mutlu, "From molecules to genomic variations: Accelerating genome analysis via intelligent algorithms and architectures", Invited Article in *Computational and Structural Biotechnology Journal (CSBJ)*, August 2022. [arXiv version with all Supplementary Materials] [Source Code]

Taha Shahroodi, Mahdi Zahedi, Can Firtina, Mohammed Alser, Stephan Wong, Onur Mutlu, and Said Hamdioui, "Demeter: A Fast and Energy-Efficient Food Profiler Using Hyperdimensional Computing in Memory,", *IEEE Access*, August 2022. [arXiv version] [IEEE version]

Geraldo F. Oliveira, Juan Gómez-Luna, Saugata Ghose, Onur Mutlu, "Methodologies, Workloads, and Tools for Processing-in-Memory: Enabling the Adoption of Data-Centric Architectures", *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording]

Ataberk Olgun, Juan Gómez Luna, Konstantinos Kanellopoulos, Behzad Salami, Hasan Hassan, Oğuz Ergin, Onur Mutlu, "PiDRAM: An FPGA-based Framework for End-to-end Evaluation of Processing-in-DRAM Techniques," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording]

Geraldo F. Oliveira, Amirali Boroumand, Saugata Ghose, Juan Gómez-Luna, Onur Mutlu, "Heterogeneous Data-Centric Architectures for Modern Data-Intensive Applications: Case Studies in Machine Learning and Databases," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording]

Ivan Fernandez, Ricardo Quislant, Christina Giannoula, Mohammed Alser, Juan Gómez-Luna, Eladio Gutiérrez, Oscar Plata, Onur Mutlu, "Exploiting Near-Data Processing to Accelerate Time Series Analysis," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording]

Nika Mansouri Ghiasi, Jisung Park, Harun Mustafa, Jeremie Kim, Ataberk Olgun, Arvid Gollwitzer, Damla Senol Cali, Can Firtina, Haiyu Mao, Nour Almadhoun Alserr, Rachata Ausavarungnirun, Nandita Vijaykumar, Mohammed Alser, Onur Mutlu, "GenStore: In-Storage Filtering of Genomic Data for High-Performance and Energy-Efficient Genome Analysis," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording] [GenStore Source Code] [Poster presented at RECOMB 2023 (PDF)] [Talk Recording BIO-Arch Workshop]

Christina Giannoula, Ivan Fernandez, Juan Gómez-Luna, Nectarios Koziris, Georgios Goumas, Onur Mutlu, "SparseP: Efficient Sparse Matrix Vector Multiplication on Real Processing-In-Memory Architectures," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording] [SparseP Source Code]

Juan Gómez-Luna, Yuxin Guo, Sylvan Brocard, Julien Legriel, Remy Cimadomo, Geraldo F. Oliveira, Gagandeep Singh, Onur Mutlu, "Machine Learning Training on a Real Processing-in-Memory System," *2022 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*, July 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [ISVLSI'22 Talk Recording]

Zaifeng Pan, Feng Zhang, Yanliang Zhou, Jidong Zhai, Xipeng Shen, Onur Mutlu, Xiaoyong Du, "Exploring Data Analytics Without Decompression on Embedded GPU Systems," in *IEEE Transactions on Parallel and Distributed Systems*, July 2022. [IEEE version]

Gagandeep Singh, Dionysios Diamantopoulos, Juan Gómez-Luna, Christoph Hagleitner, Sander Stuijk, Henk Corporaal, and Onur Mutlu. "Accelerating Weather Prediction Using Near-Memory Reconfigurable Fabric", *ACM Trans. Reconfigurable Technol. Syst. (TRETS),* June 2022. [arXiv version] [IEEE version]

A. Giray Yağlıkçı, Haocong Luo, Geraldo F. de Oliviera, Ataberk Olgun, Minesh Patel, Jisung Park, Hasan Hassan, Jeremie S. Kim, Lois Orosa, and Onur Mutlu, "Understanding RowHammer Under Reduced Wordline Voltage: An Experimental Study Using Real DRAM Devices", *Proceedings of the 52nd Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN),* Baltimore, MD, USA, June 2022. [arXiv version] [IEEE version] [Talk Video (34 minutes, including Q&A)] [Lightning Talk Video (2 minutes)] [Slides (pptx) (pdf)] [Lightning Talk Slides (pptx) (pdf)]

Gagandeep Singh, Rakesh Nadig, Jisung Park, Rahul Bera, Nastaran Hajinazar, David Novo, Juan Gomez-Luna, Sander Stuijk, Henk Corporaal, and Onur Mutlu, "Sibyl: Adaptive and Extensible Data Placement in Hybrid Storage Systems Using Online Reinforcement

Learning", *Proceedings of the 49th International Symposium on Computer Architecture (ISCA),* New York, June 2022. [arXiv version] [ACM version] [Talk Video (16 minutes)] [Slides (pptx) (pdf)] [Sibyl Source Code]

Damla Senol Cali, Konstantinos Kanellopoulos, Joel Lindegger, Zulal Bingol, Gurpreet S. Kalsi, Ziyi Zuo, Can Firtina, Meryem Banu Cavlak, Jeremie Kim, Nika MansouriGhiasi, Gagandeep Singh, Juan Gomez-Luna, Nour Almadhoun Alserr, Mohammed Alser, Sreenivas Subramoney, Can Alkan, Saugata Ghose, and Onur Mutlu, "SeGraM: A Universal Hardware Accelerator for Genomic Sequence-to-Graph and Sequence-to-Sequence Mapping", *Proceedings of the 49th International Symposium on Computer Architecture (ISCA)*, New York, June 2022 [arXiv version] [ACM version] [Talk Video (22 minutes)] [Slides (pptx) (pdf)] [SeGraM Source Code and Datasets] [Poster presented at RECOMB 2023 (PDF)] [Talk Recording BIO-Arch Workshop]

Christina Giannoula, Ivan Fernandez, Juan Gomez-Luna, Nectarios Koziris, Georgios Goumas, and Onur Mutlu, "SparseP: Towards Efficient Sparse Matrix Vector Multiplication on Real Processing-In-Memory Architectures", *Proceedings of the ACM International Conference on Measurement and Modeling of Computer Systems (SIGMETRICS)*, Mumbai, India, June 2022. [arXiv Version] [ACM version] [Full Talk Video] [Lecture Talk Video] [Slides (pptx) (pdf)] [SparseP Source Code]

Mohammed Alser, Jeremie S. Kim, Nour Almadhoun Alserr, Stefan W. Tell, and Onur Mutlu, "COVIDHunter: COVID-19 pandemic wave prediction and mitigation via seasonality aware modeling", *Frontiers in Public Health*, June 2022. [Journal Article] [COVIDHunter Source Code] [Switzerland Case Study] [Switzerland Case Study] [Talk Video (7 minutes)] [ISMB/ECCB 2021 Poster (pptx) (pdf)] [ISMB/ECCB 2021 Short Talk Slides (pptx) (pdf)]

Nandita Vijaykumar, Ataberk Olgun, Konstantinos Kanellopoulos, F. Nisa Bostanci, Hasan Hassan, Mehrshad Lotfi, Phillip B. Gibbons, and Onur Mutlu, "MetaSys: A Practical Open-source Metadata Management System to Implement and Evaluate Cross-layer Optimizations", *ACM Transactions on Architecture and Code Optimization (TACO)*, June 2022. [arXiv version]
Presented at the 18th HiPEAC Conference, Toulouse, France, January 2023.
[Slides (pptx) (pdf)] [Preliminary Talk Video (14 minutes)] [SAFARI Live Seminar Video (1 hour 26 minutes)] [MetaSys Source Code]
Best paper award at HiPEAC 2023

Juan Gomez-Luna, Izzat El Hajj, Ivan Fernandez, Christina Giannoula, Geraldo F. Oliveira, and Onur Mutlu, "Benchmarking a New Paradigm: Experimental Analysis and Characterization of a Real Processing-in-Memory System", *IEEE Access*, 10 May 2022.

[arXiv version] [IEEE version] [PrIM Benchmarks Source Code] [Slides (pptx) (pdf)] [Long Talk Slides (pptx) (pdf)] [Short Talk Slides (pptx) (pdf)] [SAFARI Live Seminar Slides (pptx) (pdf)] [SAFARI Live Seminar Video (2 hrs 57 mins)] [Lightning Talk Video (3 minutes)] [Short Talk Video (21 minutes)] [1-hour Talk Video (58 minutes)]
[ETH New for Industry Article]

Joel Lindegger, Damla Senol Cali, Mohammed Alser, Juan Gomez-Luna, and Onur Mutlu, "Algorithmic Improvement and GPU Acceleration of the GenASM Algorithm", *Proceedings of the 21st IEEE International Workshop on High Performance Computational Biology (HICOMB)*, Virtual, May 2022. [arXiv version] [IEEE version] [Lecture Video (39 mins)] [Slides (pptx) (pdf)]

Safaa Diab, Amir Nassereldine, Mohammed Alser, Juan Gomez-Luna, Onur Mutlu, and Izzat El Hajj, "High-throughput Pairwise Alignment with the Wavefront Algorithm using Processing-in-Memory", *Proceedings of the 21st IEEE International Workshop on High Performance Computational Biology (HICOMB)*, Virtual, May 2022.
[arXiv version] [IEEE version] [Slides (pptx) (pdf)]

Amirali Boroumand, Saugata Ghose, Geraldo F. Oliveira, and Onur Mutlu, "Polynesia: Enabling High-Performance and Energy-Efficient Hybrid Transactional/Analytical Databases with Hardware/Software Co-Design", *Proceedings of the 38th International Conference on Data Engineering (ICDE),* Virtual, May 2022. [arXiv version] [IEEE version] [Talk Video (25 mins)] [Short Talk Video (6 mins)] [Slides (pptx) (pdf)] [Short Talk Slides (pptx) (pdf)]

Jorge Gonzalez, Mauricio G. Palma, Maarten Hattink, Ruth Rubio-Noriega, Lois Orosa, Onur Mutlu, Keren Bergman, Rodolfo Azevedo, "Optically connected memory for disaggregated data centers", *Journal of Parallel and Distributed Computing*, May 2022. [Journal Article]

Fernando Meyer, Adrian Fritz, Zhi-Luo Deng, David Koslicki, Till Robin Lesker, Alexey Gurevich, Gary Robertson, Mohammed Alser, et al. "Critical Assessment of Metagenome Interpretation: the second round of challenges". *Nature Methods*, April 2022. [Journal Article]

F. Nisa Bostanci, Ataberk Olgun, Lois Orosa, A. Giray Yaglikci, Jeremie S. Kim, Hasan Hassan, Oguz Ergin, and Onur Mutlu, "DR-STRaNGe: End-to-End System Design for DRAM-based True Random Number Generators", *Proceedings of the 28th International Symposium on High-Performance Computer Architecture (HPCA)*, Virtual, April 2022.
[arXiv version] [IEEE version] [Talk Video (24 minutes)] [Slides (pptx) (pdf)] [Short Talk Slides (pptx) (pdf)] [MSc Thesis Talk Video]

Jawad Haj Yahya, Jeremie S. Kim, A. Giray Yaglikci, Jisung Park, Efraim Rotem, Yanos

Sazeides, and Onur Mutlu, "DarkGates: A Hybrid Power-Gating Architecture to Mitigate the Performance Impact of Dark-Silicon in High Performance Processors", *Proceedings of the 28th International Symposium on High-Performance Computer Architecture (HPCA)*, Virtual, April 2022. [arXiv version] [IEEE version] [Slides (pptx) (pdf)] [Short Talk Slides (pptx) (pdf)]

Mhd Ghaith Olabi, Juan Gomez Luna, Onur Mutlu, Wen-mei Hwu, and Izzat El Hajj, "A Compiler Framework for Optimizing Dynamic Parallelism on GPUs", *Proceedings of the International Symposium on Code Generation and Optimization (CGO)*, Virtual, April 2022. *Officially artifact evaluated as available, reusable and reproducible.*
[arXiv version] [IEEE version] [Slides (pptx) (pdf)] [Short Talk Slides (pptx) (pdf)] [Source Code (Officially Artifact Evaluated with All Badges)]

Hai “Helen” Li, Alaa R. Alameldeen, Onur Mutlu, "Guest Editors’ Introduction: Near-Memory and In-Memory Processing," in *IEEE Design & Test*, April 2022. [IEEE version]

Nika Mansouri Ghiasi, Jisung Park, Harun Mustafa, Jeremie Kim, Ataberk Olgun, Arvid Gollwitzer, Damla Senol Cali, Can Firtina, Haiyu Mao, Nour Almadhoun Alserr, Rachata Ausavarungnirun, Nandita Vijaykumar, Mohammed Alser, and Onur Mutlu, "GenStore: A High-Performance and Energy-Efficient In-Storage Computing System for Genome Sequence Analysis", *Proceedings of the 27th International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS)*, Virtual, February-March 2022. [arXiv version] [ACM version] [Lightning Talk Video (90 seconds)] [Talk Video (17 minutes)] [Talk Slides (pptx) (pdf)] [Lightning Talk Slides (pptx) (pdf)]
HiPEAC Paper Award

Rachata Ausavarungnirun, Onur Mutlu, "The design of an energy-efficient deflection-based on-chip network - Chapter 8", Editor(s): Ali R. Hurson, Hamid Sarbazi-Azad, *Advances in Computers*, Elsevier, Volume 124, February 2022. [Book Chapter]

Jisung Park, Jeonggyun Kim, Yeseong Kim, Sungjin Lee, and Onur Mutlu, "DeepSketch: A New Machine Learning-Based Reference Search Technique for Post-Deduplication Delta Compression", *Proceedings of the 20th USENIX Conference on File and Storage Technologies (FAST)*, Santa Clara, CA, USA, February 2022.
[arXiv version] [Talk Video (15 minutes)] [Slides (pptx) (pdf)]

Feng Zhang, Jidong Zhai, Xipeng Shen, Onur Mutlu, Xiaoyong Du, "POCLib: A High-Performance Framework for Enabling Near Orthogonal Processing on Compression," in *IEEE Transactions on Parallel and Distributed Systems*, vol. 33, no. 2, pp. 459-475, February 2022. [IEEE version]

Lukas Breitwieser, Ahmad Hesam, Jean de Montigny, Vasileios Vavourakis, Alexandros Iosif, Jack Jennings, Marcus Kaiser, Marco Manca, Alberto Di Meglio, Zaid Al-Ars, Fons Rademakers, Onur Mutlu, Roman Bauer, "BioDynaMo: a modular platform for high-performance agent-based simulation", *Bioinformatics*, January 2022. [arXiv version] [bioRxiv version] [Journal Article in Bioinformatics] [BioDynaMo Supplementary Materials & Data, Zenodo] [BioDynaMo Source Code version 1.04, GitHub] [BioDynaMo website]

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.

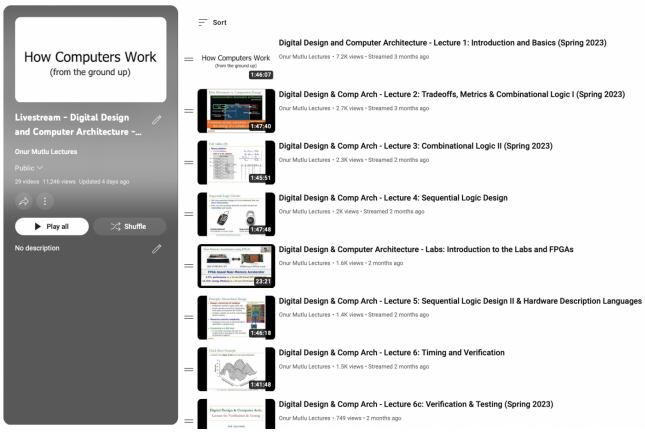
Courses 2022 & 2023

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

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

Digital Design and Computer Architecture

Course Website Spring 2022
Lecture Videos (YouTube) Spring 2022
Course Website Spring 2023
Lecture Videos (YouTube) Spring 2023



Digital Design and Computer Architecture is a 2nd semester Bachelor's course that gives a rigorous introduction into "How Computers Work", with 10 FPGA Lab Assignments.

Seminar in Computer Architecture

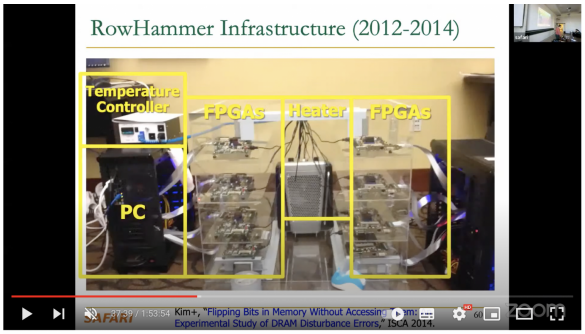
Course Website Spring 2022
Lecture Videos (YouTube) Spring 2022
Course Website Fall 2022
Lecture Videos (YouTube) Fall 2022
Course Website Spring 2023
Lecture Videos (YouTube) Spring 2023

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)

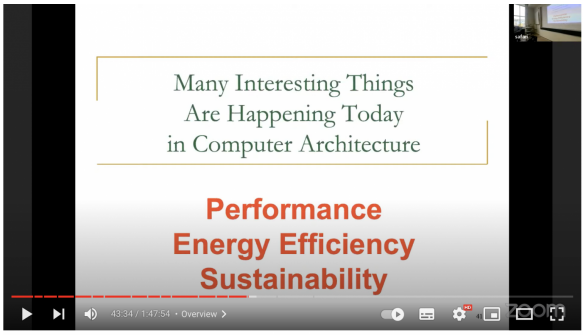
This lecture on RowHammer is currently the most up-to-date talk or lecture on RowHammer given by Onur Mutlu.



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

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

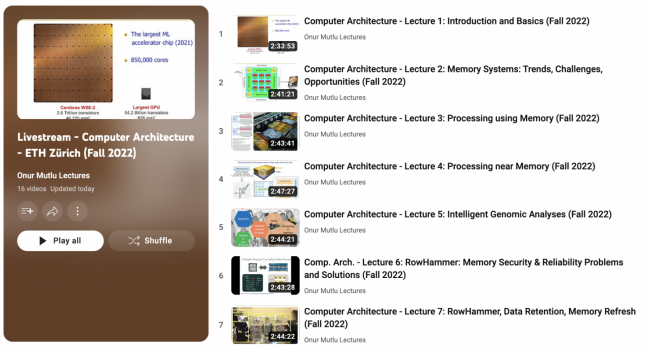
This lecture gives an overview of the group and research topics and what we expect from applicants. We encourage you to watch it if you'd like to **work with us**!



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

Computer Architecture

Course Website Fall 2022
Lecture Videos (YouTube Playlist)



Computer Architecture is a critical analysis course taken by Bachelor's/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 2022 & 2023

The Projects and Seminars (P&S) courses are hands-on learning courses 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 2022: P&S Course Listings and Websites
Fall 2022: P&S Course Listings and Websites
Spring 2023: P&S Course Listings and Websites

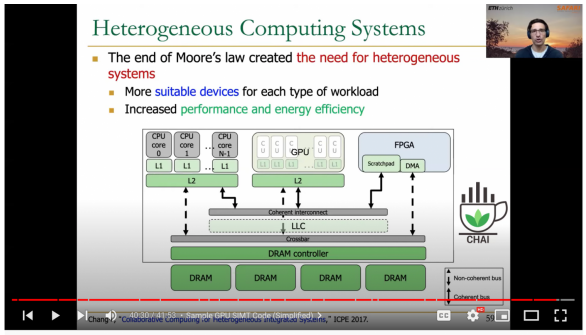
Programming Heterogeneous Computing Systems with GPUs and other Accelerators

Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

Lecturer: Juan Gómez Luna



HetSys Course: Lecture 1: Hands-on Acceleration on Heterogeneous Computing Systems (Spring 2022)

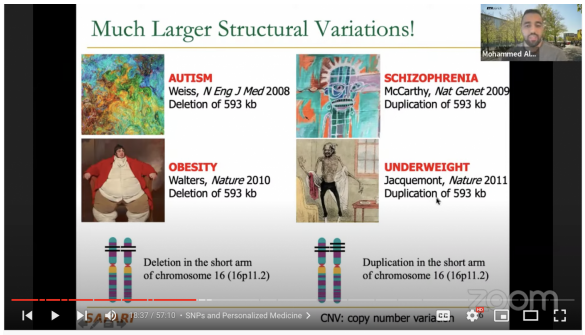
Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms

Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

Lecturer: Mohammed Alser



Accelerating Genomics Course - Meeting 2: Introduction to Sequencing (Spring 2022)

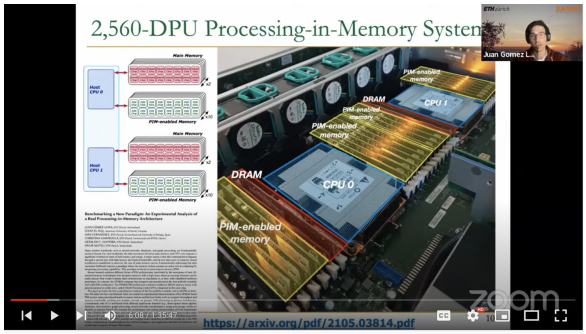
Data-Centric Architectures: Fundamentally Improving Performance and Energy

Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

Lecturer: Juan Gómez Luna



Processing-in-Memory Course: Lecture 1: Exploring the PIM Paradigm for Future Systems - Spring 2022

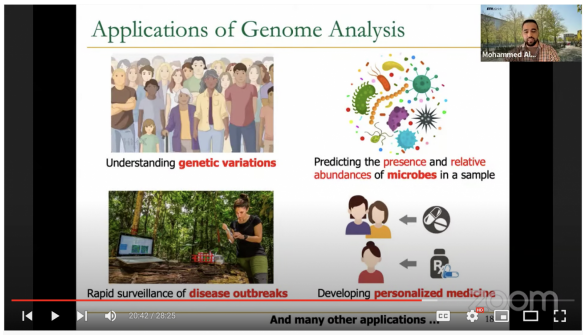
Genome Sequencing on Mobile Devices

Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

Lecturer: Mohammed Alser



Mobile Genomics Course - Meeting 1: Course Introduction & Project Proposals (Spring 2022)

FPGA-based Exploration of DRAM and RowHammer

Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

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

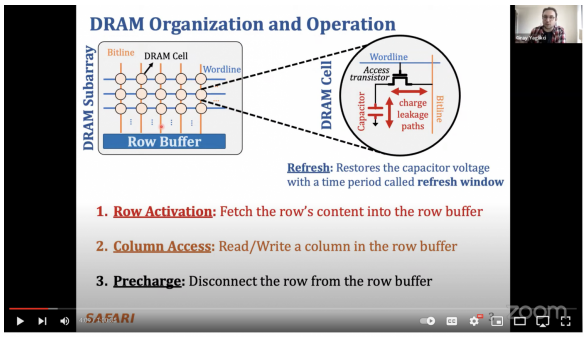
Course Website Spring 2022

Course Website Fall 2022

Course Website Spring 2023

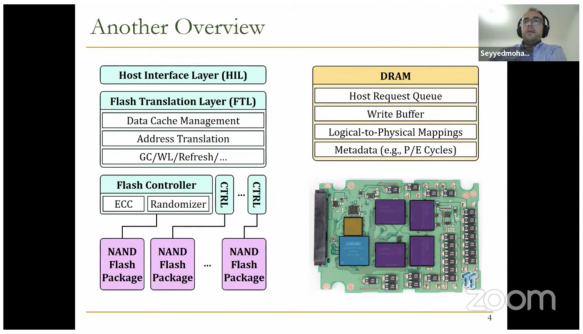
Lecturer: Jisung Park (Spring 2022)

Lecturer: Hasan Hassan (Spring 2022)
Lead Supervisor: Giray Yaglikci



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

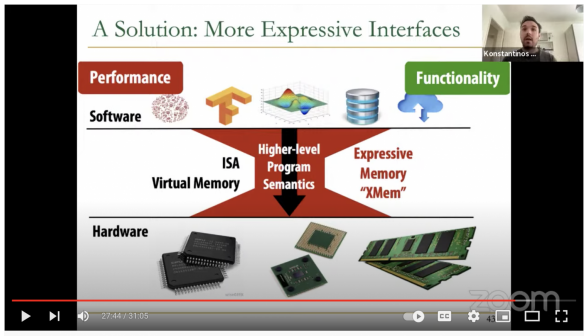
Lecturer: Mohammad Sadrosadati



Livestream - P&S Modern SSDs (Fall 2022)
Modern Solid-State Drives (SSDs) - Lecture 1: Basics of NAND Flash-Based SSDs (Fall 2022)

Intelligent Architectures using Hardware/Software Cooperative Techniques

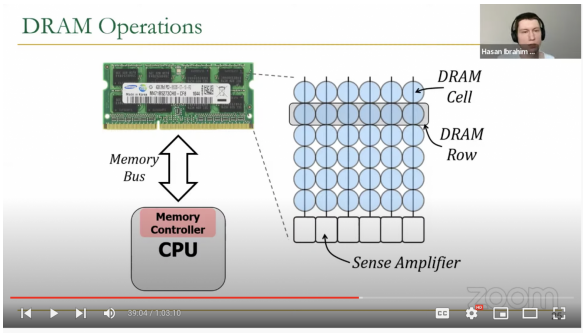
Course Website Spring 2022
Course Website Fall 2022
Course Website Spring 2023
Lead Supervisor: Konstantinos Kanellopoulos



Hardware/Software Co-design Course - Lecture 1: 16.03.22 (Spring 2022)

Exploration of Emerging Memory Systems

Course Website Spring 2022
Course Website Fall 2022
Course Website Spring 2023
Lecturer: Hasan Hassan (Spring 2022)
Lead Supervisor: Haocong Luo



Ramulator Course: Meeting 1: Logistics & Intro to Simulating Memory Systems Using Ramulator (S2022)

Selected Additional Teaching:

PUMPS+AI 2022
Summer School
September 3-6th, 2022
Barcelona

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Juan Gómez Luna was an invited lecture once again at the PUMPS+AI summer school at Barcelona Supercomputing Center in Sept 2022.
He gave the following lectures:

Lecture 2: Input regularization: covering two techniques that can be used to regularize input data for further computation. [Slides (pptx) (pdf)].
These two techniques are also covered in our P&S HetSys course in: Lecture 13: Parallel patterns: Merge | Lecture 14: Dynamic parallelism
Lecture 4: GPU implementation of neural networks: an introduction to CNN, lowering convolutional layers to matrix multiplication, and advanced tiling (in shared memory and registers) for matrix multiplication [Slides (pptx) (pdf)]
This lecture is also covered in our P&S HetSys: Lecture 9: Advanced tiling for matrix multiplication
Lecture 6: Advanced features: Tensor cores, warp programming, unified memory: covering advanced programming features such as tensor cores for ML/AI acceleration, warp programming for efficient inter-thread communication and synchronization, and unified memory for efficient and more programmable collaboration between CPU and GPU [Slides (pptx) (pdf)]
This material is covered in several P&S HetSys lectures: Lecture 7: Parallel patterns: Histogram | Lecture 8: Parallel patterns: Convolution | Lecture 15: Collaborative computing

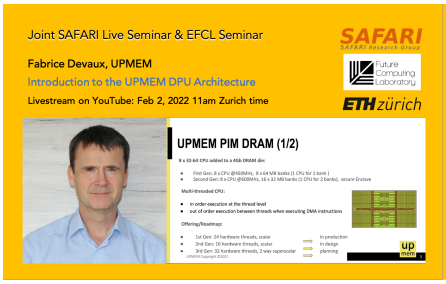
Juan will be teaching at PUMPS+AI summer school again in June 2023, and we'll post our course materials as soon as they're available. You can find the program and overview on the **PUMPS+AI 2023 website.**

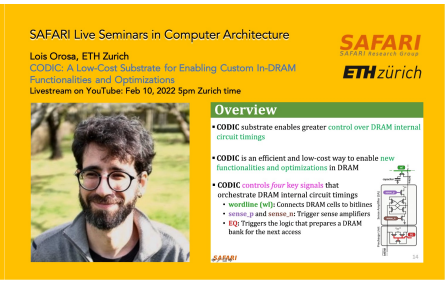
PUMPS+AI 2023
ACM Summer School
June 26-30th, 2023
Barcelona

Complete SAFARI Course Listing

SAFARI Live Seminar Series

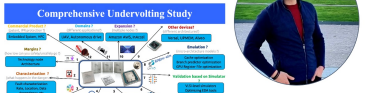
We started hosting our **SAFARI Live Seminar** series in 2021 and have continued to livestream our seminars in 2022 & 2023, while also having more seminars in person once again in 2023. Click on the thumbnails below for talk details and link to the talk recording.





SAFARI Live Seminars in Computer Architecture

Understanding the Reliability and Power-Efficiency Trade-offs of Modern FPGAs through Undervolting



SPEAKER
BEHZAD SALAMI
SAFARI Research Group

SAFARI Research Group ETH zürich

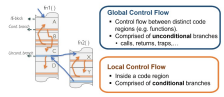
MAY 31, 2022 6:30PM CEST

SAFARI Live Seminars in Computer Architecture

Performance is All About Instruction Supply

NTNU

Understanding Control Flow Behavior



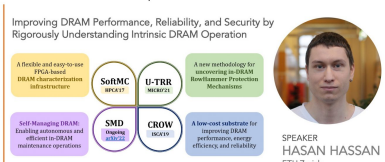
SPEAKER
RAKESH KUMAR
Norwegian University of Science and Technology (NTNU)

SAFARI Research Group ETH zürich

JUNE 9, 2022 3:00PM CEST

SAFARI Live Seminars in Computer Architecture

Improving DRAM Performance, Reliability, and Security by Rigorously Understanding Intrinsic DRAM Operation



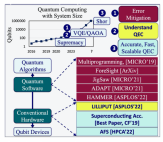
SPEAKER
HASAN HASSAN
ETH Zurich

SAFARI Research Group ETH zürich

SEPT 15, 2022 3:00PM CEST

SAFARI Live Seminars in Computer Architecture

Software and Architecture for Reliable Quantum Computing



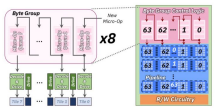
SPEAKER
POULAMI DAS
Georgia Institute of Technology

ETH zürich SAFARI Georgia Tech

SEPT 27, 2022 1:00PM CEST

EFCL & SAFARI Live Seminar ETH zürich

Enabling Practical Processing Using Emerging Memories



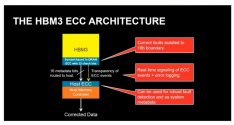
SPEAKER
Saugata GHOSE
ARCANA Research Group
University of Illinois Urbana-Champaign

Cisco Research Center SAFARI ARCANA ILLINOIS

OCT 19, 2022 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

HBM3 RAS: The Journey to Enhancing Die-Stacked DRAM Resilience at Scale



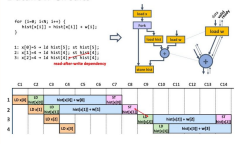
SPEAKER
Sudhanva Gurumurthi
AMD Fellow

SAFARI ETH zürich AMD

OCT 25, 2022 4:00PM CEST

SAFARI Live Seminars in Computer Architecture

From C/C++ Code to High-Performance Dataflow Circuits



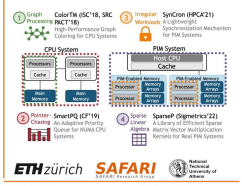
SPEAKER
LANA JOSIPOVIĆ
Digital Systems and Design Automation Group, ETH Zurich

ETH zürich SAFARI

NOV 7, 2022 4:00PM CET

SAFARI Live Seminars in Computer Architecture

Accelerating Irregular Applications via Efficient Synchronization and Data Access Techniques



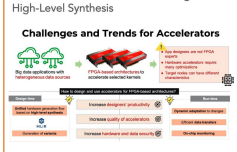
SPEAKER
Christina Giannoula
Computing Systems Lab, NTUA

ETH zürich SAFARI

NOV 9, 2022 4:00PM CET

SAFARI Live Seminars in Computer Architecture

Modern Trends in Accelerator Design with High-Level Synthesis



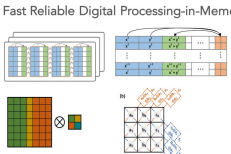
SPEAKER
CHRISTIAN PILATO
Politecnico di Milano

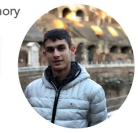
ETH zürich SAFARI POLITECNICO MILANO 1863

NOV 28, 2022 3:00PM CET

SAFARI Live Seminars in Computer Architecture

Fast Reliable Digital Processing-in-Memory





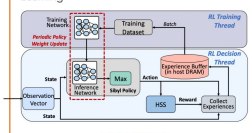
SPEAKER
Orian Leitersdorf
Technion - Israel Institute of Technology

ETH zürich TECHNION Israel Institute of Technology SAFARI

NOV 29, 2022 11:00AM CET

SAFARI Live Seminars in Computer Architecture

Sibyl: Adaptive and Extensible Data Placement in Hybrid Storage Systems Using Online Reinforcement Learning



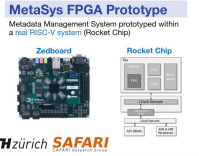
SPEAKER
Gagandeep Singh
SAFARI Research Group, ETH Zurich

ETH zürich SAFARI

DEC 7, 2022 4:15PM CET

SAFARI Live Seminars in Computer Architecture

MetaSys: Cross-Layer Optimization with a Practical Open-source Metadata Management System



SPEAKER
ATABERK OLGUN
SAFARI Research Group, ETH Zurich

ETH zürich SAFARI

DEC 12, 2022 4:00PM CET

SAFARI Live Seminars in Computer Architecture

Groq, Deterministic Low Latency Supercomputing at Scale

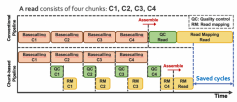
SPEAKER
OSKAR MENCER
Maxeler Technologies, a Groq Company

ETH zürich SAFARI MAXELER

DEC 13, 2022 1:00PM CET

SAFARI Live Seminars in Computer Architecture

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



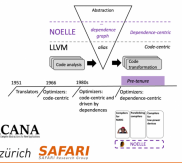
SPEAKER
HAIYU MAO
SAFARI Research Group, ETH Zurich

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

ARCANA ETH zürich SAFARI

April 4, 2023 2:00PM CEST

SAFARI Live Seminars in Computer Architecture

Software-Hardware Co-design of Edge AI Systems

SPEAKER
YIRAN CHEN
Duke University

IEEE Switzerland Section CAS
SAFARI Duke CENTER for COMPUTATIONAL EVOLUTIONARY INTELLIGENCE

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 Future Computing Laboratory
The University of Texas at Austin Chandra Department of Electrical and Computer Engineering Cockrell School of Engineering

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 SAFARI
The Grainger College of Engineering Electrical & Computer Engineering

May 17, 2023 5:00PM CEST

SAFARI Live Seminars in Computer Architecture

Detecting Copy Number Variants in Exome Sequencing Data via Deep Learning

SPEAKER
Ercument Cicek
Bilkent University
(EPFL visiting professor)

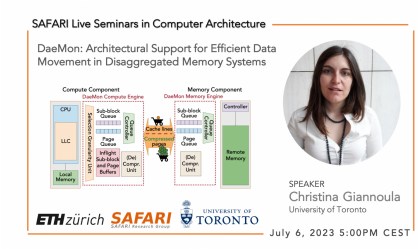
SAFARI ETH zürich CICEKLAB

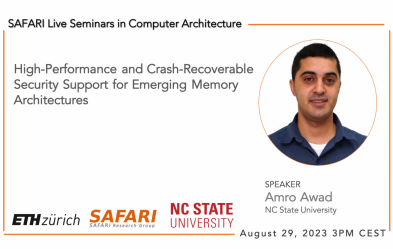
June 2, 2023 11:00AM CEST

SAFARI Live Seminars Schedule 2021-2023

SAFARI Live Seminar Series YouTube Playlist 2021-2023

Upcoming SAFARI Live Seminars in summer 2023:

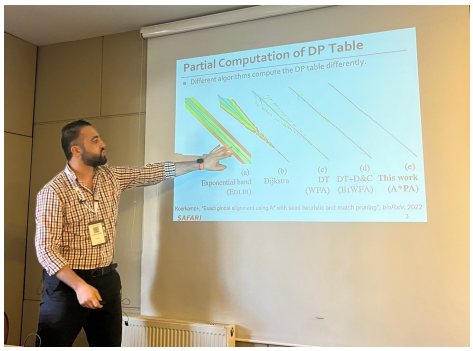




SAFARI Talk Highlights

Below we provide a few talk highlights from 2022 and 2023. 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.

Mohammed Alser, "Sparsified Genomics: Rethinking Large-Scale Genomic Analyses", presented at BIO-Arch Workshop, RECOMB 2023. [Slides (pdf) (pptx)] [Talk Video] [Related Paper]



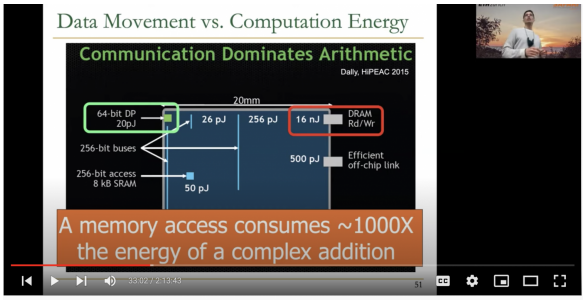
Can Firtina, "BLEND: a fast, memory-efficient and accurate mechanism to find fuzzy seed matches in genome analysis", presented at RECOMB 2023, in *NAR Genomics and Bioinformatics*, March 2023. [arXiv version] [Journal Article] [BLEND Source Code] [Slides (pdf) (pptx)] [Talk Video]

Onur Mutlu, **"The Story of RowHammer"** Invited Talk at the Workshop on Robust and Safe Software 2.0 (RSS2), held with the 27th International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS), Virtual, 28 February 2022. [Slides (pptx) (pdf)] [Talk Video]

The Story of RowHammer - Invited Talk in Robust & Safe Software Workshop (ASPLOS 2022) - Onur Mutlu

---

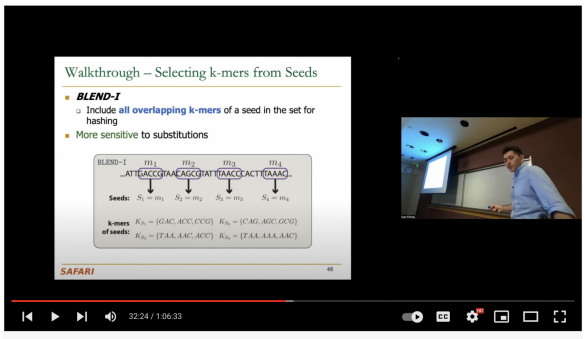
Juan Gómez Luna, **"Enabling the Processing-in-Memory Paradigm for Future Computing Systems (Introducción al Procesamiento en Memoria)"** (in Spanish) Invited Lecture, Universidad de Córdoba, Date: March 16, 2022. [Slides (pptx) (pdf)] [Talk Video]



PIM for Future Computing Systems (in Spanish) - Juan Gómez Luna - Lecture @ Univ. of Córdoba

---

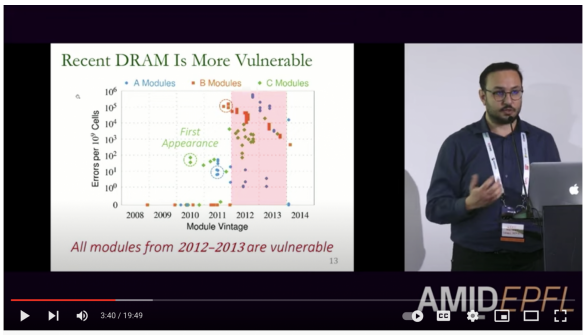
Can Firtina, **"Enabling Accurate, Fast, and Memory-Efficient Genome Analysis via Efficient and Intelligent Algorithms"**, Invited Talk, PASSION Lab Seminar, Department of Electrical Engineering and Computer Sciences, UC Berkeley, May 27 2022. [Slides (pptx) (pdf)] [Talk Video]



Enabling Accurate, Fast, and Memory-Efficient Genome Analysis - Can Firtina (Talk at UC Berkeley)

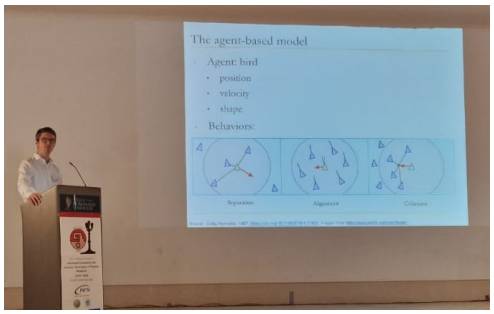
Can Firtina, **“Enabling Accurate, Fast, and Memory-Efficient Genome Analysis via Efficient and Intelligent Algorithms”,** Invited Seminar Talk, BIN590 Graduate Seminar in Bioinformatics, Graduate School of Informatics, Middle East Technical University, Virtual, January 10 2022. [Slides (pptx) (pdf)] [Talk Video]

A. Giray Yaglikci, **"Fundamentally Understanding and Solving RowHammer”**, Microsoft Swiss Joint Research Center – AI, Confidential Computing, Health, Cloud and Systems in The Applied Machine Learning Days (AMLD) 2022, Mar 29, 2022. [Slides (pptx) (pdf)] [Talk Video]



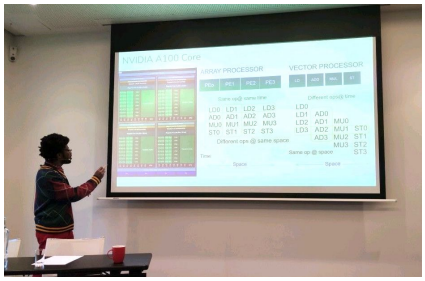
Fundamentally Understanding and Solving RowHammer by A. Giray Yaglikci

---



Lukas Breitwieser, **"Towards extreme-scale agent-based simulation with BioDynaMo"**, Plenary Talk, 21st International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT'22), Bari, Italy, October 2022. [Slides (pptx) (pdf)]

Filipe Mulonde, **"Foundations of GPU programming"**, Invited Talk, Meeting C++ 2022, Berlin, November 2022. [Slides (pptx) (pdf)] [Talk Video]



Mohammed Alser, **"Rethinking Genomic Analyses: Preparing Computer Science Students for Pandemics"**, Invited Talk, International Workshop of the Arab-German Young Academy of Sciences and Humanities (AGYA), Interdisciplinary Implementations in Education Systems, Tunis, Tunisia, 21–22 Nov 2022. [Slides (pptx) (pdf)]

Mohammed Alser, **"Intelligent Genome Analysis via Intelligent Algorithms and Architectures"**, Invited Talk, International Genome Graph Symposium 2022**,** (IGGSy'22) Monte Verita, Ascona, July 3-7, 2022. [Slides (pptx) (pdf)]

Mohammed Alser, **"Technology Dictates Algorithms: Developments in Read Mapping"** 30th Annual International Conference on Intelligent Systems for Molecular Biology (ISMB'22) Madison, Wisconsin, July 10-14, 2022 (in-person and virtual) [Slides (pptx) (pdf)]

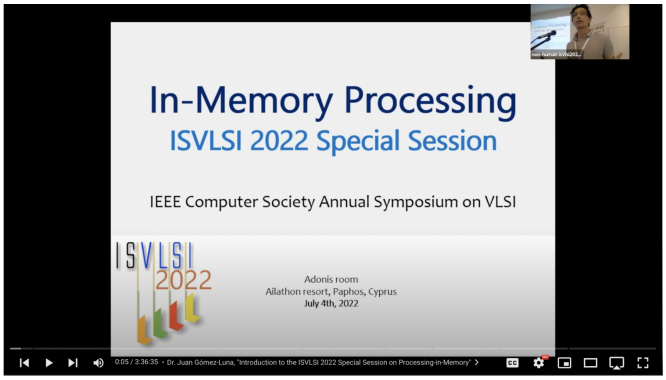
Mohammed Alser, **"Analyzing Genomes via Intelligent Algorithms & Architectures"**, Invited Talk, EFCL (ETH Future Computing Laboratory) & CSNOW (Network of Women in Computer Science) Workshop, ETH Zurich, May 2022. [Slides (pptx) (pdf)]

Mohammed Alser, **"Analyzing Genomes via Efficient HW/SW Co-Design"**, Invited Talk, System-on-Chip Lab speaker series, Khalifa University, UAE, Feb 2022. [Slides (pptx) (pdf)] [Talk Video]

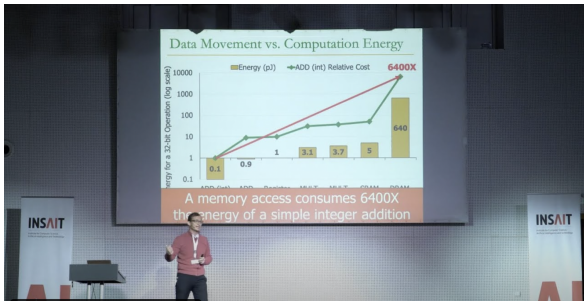
Juan Gómez-Luna, Izzat El Hajj, Ivan Fernandez, Christina Giannoula, Geraldo F. Oliveira, Onur Mutlu, **"Benchmarking Memory-Centric Computing Systems: Analysis of Real Processing-in-Memory Hardware, SRC TECHCON 2022"**, Austin, TX, Sept 18-20, 2022. [Slides (pptx) (pdf)]

Juan Gomez Luna, **"Introduction: In-Memory Processing ISVLSI 2022 Special Session"**, Session Chair Talk, IEEE Computer Society Annual Symposium on VLSI, Pafos, Cyprus, July 2022. [Slides (pptx) (pdf)]

ISVLSI 2022 Special Sessions:
Special Session 3: In Memory Processing I
Special Session 4: In Memory Processing II
Chair: Juan Gómez Luna
[Conference Proceedings]
[SAFARI ISVLSI'22 Talk Slides]
[ISVLSI'22 Session Recording (all talks)]
All SAFARI Conference Papers are also listed above in the Publications section.



ISVLSI 2022 Special Session on Processing-in-Memory

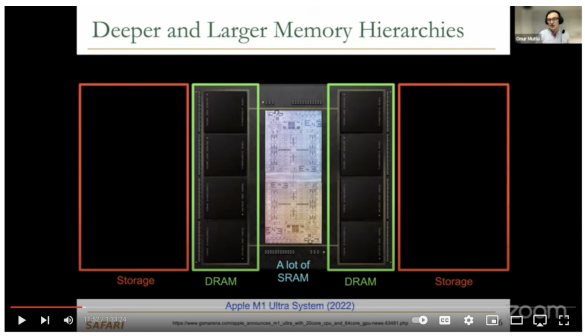


Onur Mutlu, **"Intelligent Architectures for Intelligent Machines"**, Invited Talk at INSAIT Conference on Emerging Trends in AI and Computing Research, Sofia, Bulgaria, 1 October 2022. [Slides (pptx) (pdf)] [Talk Video (33 minutes, including Q&A)]

Onur Mutlu, **"Security Aspects of DRAM: The Story of RowHammer"**, Invited Tutorial at 14th IEEE Electron Devices Society International Memory Workshop (IMW), Dresden, Germany, 15 May 2022. [Slides (pptx)(pdf)] [Tutorial Video (57 minutes)]

The Story of RowHammer -- Invited Tutorial at IMW 2022 (Intl. Memory Workshop) - Onur Mutlu

---



Memory-Centric Computing - IEEE CICC Educational Session Talk

Onur Mutlu, **"Memory-Centric Computing"** - Invited Talk, IEEE CICC Educational Session Talk, 21 April 2023 [Slides (pdf) (pptx)] [Talk Video]

Onur Mutlu, **"Accelerating Genome Analysis"**, Invited Talk at the Barcelona Supercomputing Center (BSC), Barcelona, Spain, 6 September 2022. [Slides (pptx) (pdf)] [Talk Video (1 hour 35 minutes, including Q&A)] [Related Invited Paper (at IEEE Micro, 2020)] [Related Invited Paper (at Computational and Structural Biology Journal, 2022)]

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)]

Onur Mutlu, **"The Story of RowHammer"**, Keynote Talk at the 6th NTUA Computing Systems Research Day, Athens, Greece, 10 January 2023. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at the LiG Seminar, Virtual, 29 November 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory System Design for AI/ML Accelerators & ML/AI Techniques for Memory System Design"**, Invited Talk at the Intel-SRC Research Program Review Conference, Virtual, 10 November 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Accelerating Genome Analysis"**, Invited Talk at the Montenegro Academy of Sciences Conference, Montenegro, 2 November 2022. [Slides (pptx) (pdf)] [Related Invited Paper (at IEEE Micro, 2020)] [Related Invited Paper (at Computational and Structural Biology Journal, 2022)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at the SONOVA Workshop, Zurich, Switzerland, 24 October 2022. [Slides (pptx) (pdf)]

Onur Mutlu, "Intelligent Architectures for Intelligent Machines", Distinguished Lecture at Ontario Tech Engineering Research Distinguished Speaker Series, Virtual, 19 October 2021. [Slides (pptx) (pdf)] [Talk Video (58 minutes, including Q&A)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Tutorial at the DFG SPP Summer School on Scalable Data Management for Future Hardware, Seeheim, Germany, 12 October 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Tutorial at the 31st International Conference on Parallel Architectures and Compilation Techniques (PACT), Chicago, IL, USA, 8 October 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at Northwestern University, Evanston, IL, US, 7 October 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at the University of Chicago, Chicago, IL, US, 6 October 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at Microsoft Azure Hardware Learning Session, Virtual, 27 September 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at the Huawei Strategy & Technology Workshop, Virtual, 27 September 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Distinguished Lecture at the Simon Fraser University, Burnaby, BC, Canada, 22 September 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at the University of British Columbia, Vancouver, BC, Canada, 20 September 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at MATEO 2022 - Multicore Architectures and Their Effective Operation (MATEO), Barcelona, Spain, 2 September 2022. [Slides (pptx) (pdf)] [Talk Video (30 minutes, including Q&A)]

Onur Mutlu, **"Memory System Design for AI/ML Accelerators & ML/AI Techniques for Memory System Design"**, Invited Talk at the SRC Annual Review, San Diego, CA, USA, 30 August 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"The Story of RowHammer"**, Invited Talk at Google, San Diego, CA, USA, 29

August 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at the Stanford Mini Symposium, Palo Alto, CA, USA, 15 July 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Plenary Keynote Talk at 20th IEEE Computer Society Annual Symposium on VLSI (ISVLSI), Paphos, Cyprus, 4 July 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Tutorial at the 22nd International Conference on Embedded Computer Systems: Architectures, Modeling, and Simulation (SAMOS), Samos, Greece, 3 July 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Transforming Server Architectures"**, Keynote Talk at the Swiss Data Center Summit (DC SUMMIT), Zurich, Switzerland, 30 June 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Keynote Talk at HiPChips Chiplet Workshop, held with the International Symposium on Computer Architecture (ISCA), New York, NY, 19 June 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Accelerating Genome Analysis"**, Keynote Talk at 4th Workshop on Accelerator Architecture in Computational Biology and Bioinformatics (AACBB), held with the International Symposium on Computer Architecture (ISCA), New York, NY, USA, 18 June 2022. [Slides (pptx)(pdf)] [Related Invited Paper (at IEEE Micro, 2020)] [Related Invited Paper (at Computational and Structural Biology Journal, 2022)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at EPFL CIS Edge AI Summer School, Lausanne, Switzerland, 15 June 2022. [Slides (pptx) (pdf)] [Lecture Video (1 hour 37 minutes, including Q&A)]

Onur Mutlu, **"Memory-Centric Computing"**, Invited Talk at Micron, Virtual, 3 June 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Security Aspects of DRAM: The Story of RowHammer"**, Invited Talk at IBM Research, Yorktown Heights, NY, USA, 16 May 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Security Aspects of DRAM: The Story of RowHammer"**, Invited Lecture at the New York University Hardware Security Class, Virtual, 29 April 2022. [Slides (pptx) (pdf)] [Talk Video (1 hour 35 minutes, including Q&A)]

Onur Mutlu, **"Accelerating Genome Analysis"**, Keynote Talk at the Systems for Post-Moore Architectures Workshop (SPMA), held with the EuroSys Conference (EUROSYS), Virtual, 5 April 2022. [Slides (pptx) (pdf)] [Related Invited Paper (at IEEE Micro, 2020)]

Onur Mutlu, **"Intelligent Architectures for Intelligent Computing Systems"**, Invited Talk at the Faculty Development Program of Meerut Institute of Engineering & Technology on Advanced Computing Techniques, Virtual, 6 March 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Keynote Talk at the Thoughtworks Engineering for Research Symposium (E4R), Virtual, 19 February 2022. [Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Keynote Talk at the Intel Interconnect & Connectivity Summit (IICS), Virtual, 9 February 2022.
[Slides (pptx) (pdf)]

Onur Mutlu, **"Memory-Centric Computing"**, Opening Keynote Talk at the National Technical University of Athens Research Challenges in Computer Science Symposium (NTUA-RCCS), Virtual, 18 January 2022.
[Slides (pptx) (pdf)]

Visit **Onur's talks page** for past talks and further reading

---

Selected Open Source Releases

We released many research artifacts and tools in 2022 & 2023. All are available on GitHub:

CMU-SAFARI /

BLEND is a mechanism that can efficiently find fuzzy seed matches between sequences to significantly improve the performance and accuracy while reducing the memory space usage of two important applications: 1) finding overlapping reads and 2) read mapping. Firtina et al. "BLEND: a fast, memory-efficient and accurate mechanism to find fuzzy seed matches in genome analysis", *NAR Genomics and Bioinformatics.*

AIM (Alignment-in-Memory) is a Framework for High-throughput Sequence Alignment using Real Processing-in-Memory Systems, described in our Bioinformatics paper, https://doi.org/10.1093/bioinformatics/btad155

TargetCall is the first pre-basecalling filter that is applicable to a wide range of use cases to eliminate wasted computation in basecalling. Described in our preprint: https://arxiv.org/abs/2212.04953

SPARTA is a novel spatial accelerator for horizontal diffusion weather stencil computation, as described in ICS 2023 paper by Singh et al. https://arxiv.org/pdf/2303.03509.pdf.

BioDynamo is a flexible and high-performance agent based simulation engine. This repository contains artifacts and materials to support the reproducibility of the paper: Breitwieser et al., "High-

BlockHammer is a low-cost, effective, and easy-to-adopt RowHammer mitigation mechanism that overcomes the two key challenges by selectively throttling memory accesses that could otherwise cause RowHammer bit-flips.
Yaglikci et al. 2021, "BlockHammer: Preventing RowHammer at Low Cost by Blacklisting Rapidly-Accessed DRAM Rows", HPCA'21.

PIM-ML is a benchmark for training machine learning algorithms on the UPMEM architecture, which is the first publicly-available real-world processing-in-memory (PIM) architecture. Described in the ISPASS 2023 paper by Gomez-Luna et al. https://arxiv.org/pdf/2207.07886.pdf.

TransPimLib is a library for transcendental (and other hard-to-calculate) functions in general-purpose PIM systems, TransPimLib provides CORDIC-based and LUT-based methods for trigonometric functions, hyperbolic functions, exponentiation, logarithm, square root, etc. Described in ISPASS'23 paper by Item et al. https://arxiv.org/pdf/2304.01951.pdf.

DAMOV is a benchmark suite and a methodical framework targeting the study of data movement bottlenecks in modern applications. It is intended to study new architectures, such as near-data processing. Described by Oliveira et al. https://arxiv.org/pdf/2105.03725.pdf.

of the paper: Breitwieser et al., "High-Performance and Scalable Agent-Based Simulation with BioDynaMo," PPoPP '23: https://arxiv.org/pdf/2301.06984.pdf

---

Genome-on-Diet is a software tool that exemplifies sparsified genomics, which greatly reduces the amount of data used for certain genome analytics tasks to improve both performance and energy efficiency, while preserving analysis accuracy. Alser et al. https://arxiv.org/abs/2211.08157.

SeGraM is a universal genomic mapping accelerator that supports both sequence-to-graph mapping and sequence-to sequence mapping, for both short and long reads. Senol Cali et al., "SeGraM: A Universal Hardware Accelerator for Genomic Sequence-to-Graph and Sequence-to-Sequence Mapping", ISCA'22.

Sibyl is a hybrid storage system (HSS) uses multiple different storage devices to provide high and scalable storage capacity at high performance. Data placement across different devices is critical to maximize the benefits of such a hybrid system. Singh et al., "Sibyl: Adaptive and Extensible Data Placement in Hybrid Storage Systems using Online Reinforcement Learning", ISCA'22

Scrooge is a high-performance pairwise sequence aligner based on the GenASM

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. Four prototypes are available on different FPGA boards. Olgun et al. https://arxiv.org/pdf/2211.05838.pdf

---

Hermes is a speculative mechanism to accelerate long-latency off-chip load requests by removing on-chip cache access latency from their critical path. Bera et al., "Hermes: Accelerating Long-Latency Load Requests via Perceptron-Based Off-Chip Load Prediction", MICRO'22

---

pLUTo is a DRAM-based Processing-using-Memory architecture that leverages the high density of DRAM to enable the massively parallel storing and querying of lookup tables (LUTs). Ferreira et al., "pLUTo: Enabling Massively Parallel Computation in DRAM via Lookup Tables", MICRO'22.

ApHMM-GPU is the first GPU implementation of the Baum-Welch algorithm for profile Hidden Markov Models (pHMMs). It includes many of the software optimizations as proposed in the ApHMM paper, which is described by Firtina et al. at

sequence aligner based on the GenASM algorithm. Scrooge includes three novel algorithmic improvements on top of GenASM, and high-performance CPU and GPU implementations. Lindegger et al. https://doi.org/10.48550/arXiv.2208.09985

Molecules2Variations is the first work to provide a comprehensive survey of a prominent set of algorithmic improvement and hardware acceleration efforts for the entire genome analysis pipeline used for the three most prominent sequencing data, short reads (Illumina), ultra-long reads (ONT), and accurate long reads (HiFi). Alser et al., https://arxiv.org/abs/2205.07957

SparseP is the first open-source Sparse Matrix Vector Multiplication (SpMV) software package for real-world Processing-In-Memory (PIM) architectures. SparseP is developed to evaluate and characterize the first publicly-available real-world PIM architecture, the UPMEM PIM architecture. Giannoula et al. "SparseP: Towards Efficient Sparse Matrix Vector Multiplication on Real Processing-In-Memory Architectures", SIGMETRICS'22.

PiDRAM is the first flexible end-to-end

https://arxiv.org/abs/2207.09765.

GenStore is the first in-storage processing system designed for genome sequence analysis that greatly reduces both data movement and computational overheads of genome sequence analysis by exploiting low-cost and accurate in-storage filters. Mansouri Ghiasi et al., "GenStore: A High-Performance and Energy-Efficient In-Storage Computing System for Genome Sequence Analysis", ASPLOS'22.

Metasys is the first open-source FPGA-based infrastructure with a prototype in a RISC-V core, to enable the rapid implementation and evaluation of a wide range of cross-layer software/hardware cooperative techniques techniques in real hardware. Vijaykumar, Olgun, et al., "MetaSys: A Practical Open-source Metadata Management System to Implement and Evaluate Cross-layer Optimizations", *ACM TACO.*

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). Firtina et al. https://www.biorxiv.org/content/10.1101/2023.01.22.525080v1

FastRemap Source Code is a tool for Quickly Remapping Reads between

framework that enables system integration studies and evaluation of real Processing-using-Memory techniques. Prototype on a RISC-V rocket chip system implemented on an FPGA. Olgun, et al. "PiDRAM: A Holistic End-to-end FPGA-based Framework for Processing-in-DRAM". *ACM TACO.*

Genome Assemblies. Kim, et al. https://arxiv.org/pdf/2201.06255.pdf

---

SelfManagingDRAM (SMD): source code for evaluating the performance and DRAM energy benefits of Self-Managing DRAM (SMD), proposed in https://arxiv.org/abs/2207.13358

(top) MICRO'22 in Chicago, Oct 2022; SAFARI group bbq, summer 2022
(bottom) Farewell to Jisung Park, August 2022; MICRO'22 architectural boat ride.

Think Big, Aim High
Study & Work with Us!

SAFARI
SAFARI Research Group

Think Big, Aim High

View in your browser

Subscribe to Our Newsletter

Past SAFARI Newsletters:

April 2020

January 2021

December 2021