

P&S DRAM Bender

FPGA-based Exploration of DRAM and RowHammer

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P&S DRAM Bender: Content

You will learn

- how **modern DDR4 DRAM** operates in detail
- how to characterize a DRAM chip's behavior using an **FPGA-based infrastructure (DRAM Bender)**
- how to use DRAM Bender to **develop your own DRAM experiments** and gain hand-on experience in studying DRAM characteristics

P&S DRAM Bender: Key Takeaways

- This P&S is aimed at improving your
 - **Knowledge** in Computer Architecture and Memory Systems
 - **Technical skills** in running DRAM experiments using real devices
 - **Critical thinking and analysis**
 - Familiarity with key **research directions**
 - **Technical presentation** of your project
 - **Communication skills** (by interacting with a group of researchers)

P&S DRAM Bender: Key Goal

(Learn how to)
Study real DRAM* chips
using an FPGA-based infrastructure
to gain new insights into DRAM behavior

*Dynamic Random Access Memory (DRAM) is the prevalent main memory technology.

Prerequisites of the Course

- **Digital Design and Computer Architecture** (or equivalent course)
 - Especially a well understanding of the following topics:
 - Combinational / Sequential Logic & Hardware Description Languages
 - Von Neumann Model & Instruction Set Architectures
 - Assembly Programming
 - Microarchitecture and Memory Hierarchy
- Familiarity with
 - **FPGA programming** (Verilog HDL, Xilinx Vivado/ISE)
 - A **programming** language (C++/Python)
- Interest in
 - **Low-level hacking** and memory reliability/security/energy efficiency/performance
 - Interest in discovering **why things do or do not work** and **solving problems**

Course Info: Who Are We? (I)

■ Onur Mutlu

- ❑ Full Professor @ ETH Zurich ITET (INFK), since September 2015
- ❑ Strecker Professor @ Carnegie Mellon University ECE/CS, 2009-2016, 2016-...
- ❑ PhD from UT-Austin, worked at Google, VMware, Microsoft Research, Intel, AMD
- ❑ <https://people.inf.ethz.ch/omutlu/>
- ❑ omutlu@gmail.com (Best way to reach me)
- ❑ <https://people.inf.ethz.ch/omutlu/projects.htm>

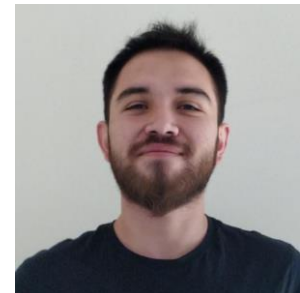


■ Research and Teaching in:

- ❑ Computer architecture, computer systems, hardware security, bioinformatics
- ❑ Memory and storage systems
- ❑ Hardware security, safety, predictability
- ❑ Fault tolerance
- ❑ Hardware/software cooperation
- ❑ Architectures for bioinformatics, health, medicine
- ❑ ...

Course Info: Who Are We? (II)

- Lead Supervisor:
 - Abdullah Giray Yaglikci
- Supervisors:
 - Ataberk Olgun
 - Haocong Luo
 - Yahya Tugrul
 - Banu Cavlak
 - Ismail Yuksel
- Get to know us and our research
 - <https://safari.ethz.ch/group-members>



Onur Mutlu's SAFARI Research Group

Computer architecture, HW/SW, systems, bioinformatics, security, memory

<https://safari.ethz.ch/safari-newsletter-december-2021/>

38+ Researchers



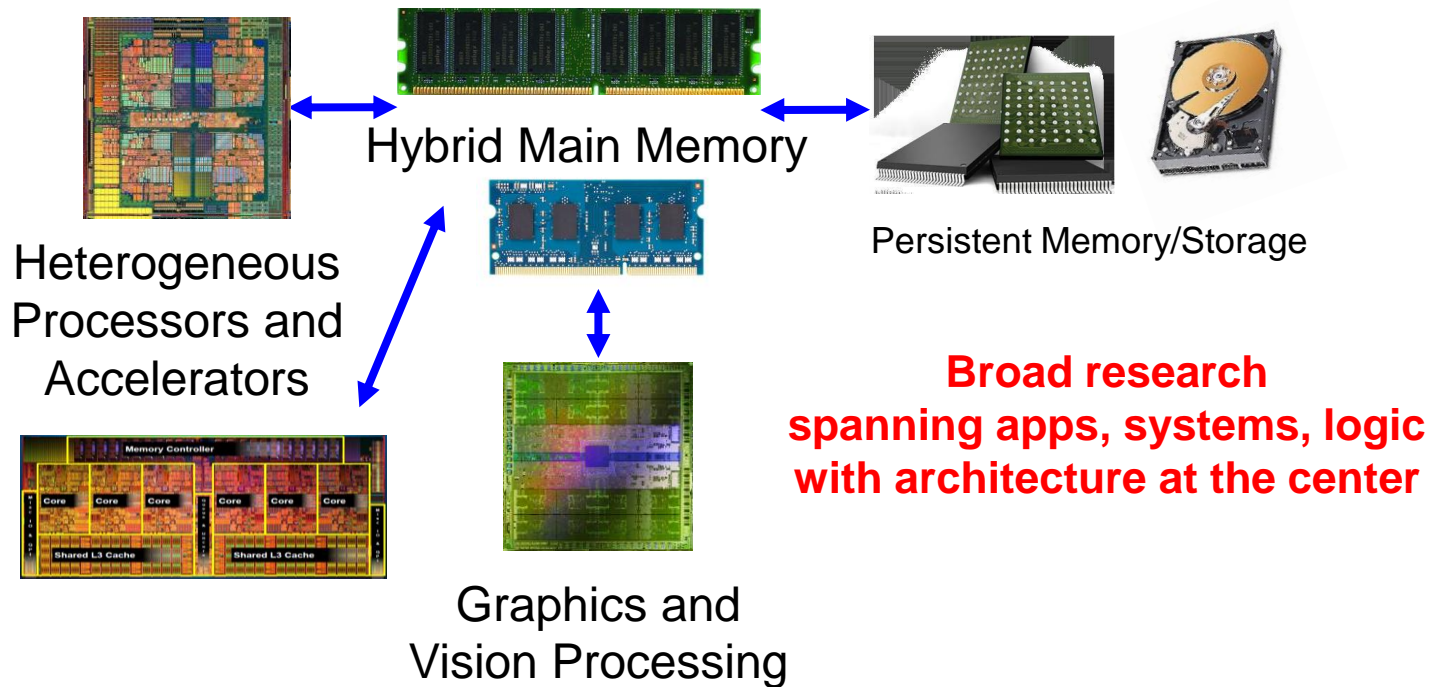
Think BIG, Aim HIGH!

<https://safari.ethz.ch>

Current Research Focus Areas

Research Focus: Computer architecture, HW/SW, bioinformatics

- *Memory and storage (DRAM, flash, emerging), interconnects*
- *Heterogeneous & parallel systems, GPUs, systems for data analytics*
- *System/architecture interaction, new execution models, new interfaces*
- *Energy efficiency, fault tolerance, hardware security, performance*
- *Genome sequence analysis & assembly algorithms and architectures*
- *Biologically inspired systems & system design for bio/medicine*



Course Requirements and Expectations

- **Attendance required for all (future) meetings**
 - Meeting 2 (next week)
 - 1-1 meetings with supervisor(s)
 - Group meetings: Project updates
- **Study the learning materials**
- **Each student will carry out a hands-on project**
 - Build, implement, code, and design with close engagement from the supervisors
- **Participation**
 - Ask questions, contribute thoughts/ideas
 - Read relevant papers

We will help in all projects!

If your work is really good, you may get it published!

Course Website

- https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc
- Useful information about the course
- Check your email frequently for announcements

Meeting 1


■ Required Materials

- ❑ DRAMBender Tutorial Video: <https://www.youtube.com/watch?v=FkIVesfdZCI>
- ❑ SoftMC lecture: <https://www.youtube.com/watch?v=tnSPEP3t-Ys>
- ❑ Paper describing SoftMC: https://people.inf.ethz.ch/omutlu/pub/softMC_hpca17.pdf
- ❑ Paper describing DRAMBender: <https://arxiv.org/abs/2211.05838>
- ❑ Example RowHammer study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/Revisiting-RowHammer_isca20.pdf

■ Recommended Materials

- ❑ Example security attack study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/rowhammer-TRRespass_ieee_security_privacy20.pdf
- ❑ Example neural network acceleration study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/EDEN-efficient-DNN-inference-with-approximate-memory_micro19.pdf
- ❑ Example random number generation study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/drangle-dram-latency-based-true-random-number-generator_hpca19.pdf
- ❑ Example physical unclonable function study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/dram-latency-puf_hpca18.pdf
- ❑ The original RowHammer study using SoftMC: https://people.inf.ethz.ch/omutlu/pub/dram-row-hammer_isca14.pdf

Tentative Weekly Schedule

- Week 0 – DRAMBender Tutorial [**arXiv cs.AR 2211.05838**]  YouTube
- Week 1 – Logistics & Intro to DRAM and SoftMC [**HPCA'17**]
- Week 2 – Available Projects | **[HW0 deadline on Monday \(13 March 2023\)](#)**
- Week 3 – Deeper Look Into RowHammer [**MICRO'21**] | **1-1 meetings start**
- Week 4 – Hidden Row Activation [**MICRO'22**]
- Week 5 – Uncovering in-DRAM TRR [**MICRO'21**]
- Week 6 – QUAC-TRNG [**ISCA'21**] | **Group meetings start**
- Week 7 – RowHammer Under Reduced Wordline Voltage [**DSN'22**]
- Week 8 – PiDRAM [**arXiv'21**]
- Week 9+ **Group meetings & 1-1 meetings**

Every week: 1-1 meeting with supervisor(s)

Every four weeks: Group meeting for project updates

Meeting 2 (TBD)

- We will **announce the projects** and will give you some description about them
- You will have a week to submit your project preferences
- The supervisors would like to help you with selecting a project that matches your interests, skills, and background
- It is important that you **study the learning materials** before our next meeting!

Performance Assessment

We expect you to:

- **Learn** how DRAM operates and **perform** DRAM characterization using FPGAs
- **Achieve the goals** of your project
- **Deliver** your **code and results** with sufficient documentation
- Prepare a **final presentation** and present your work to SAFARI

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Course Info: How About You?

- Let us know your background, interests
- Why did you join this P&S?
- Please submit HW0
 - Moodle link in the homework handout