

Seminar in Computer Architecture

Lecture 1a: Intro & Logistics


Dr. Mohammed Alser
Prof. Onur Mutlu

ETH Zürich
Fall 2022
22 September 2022

Brief Self Introduction

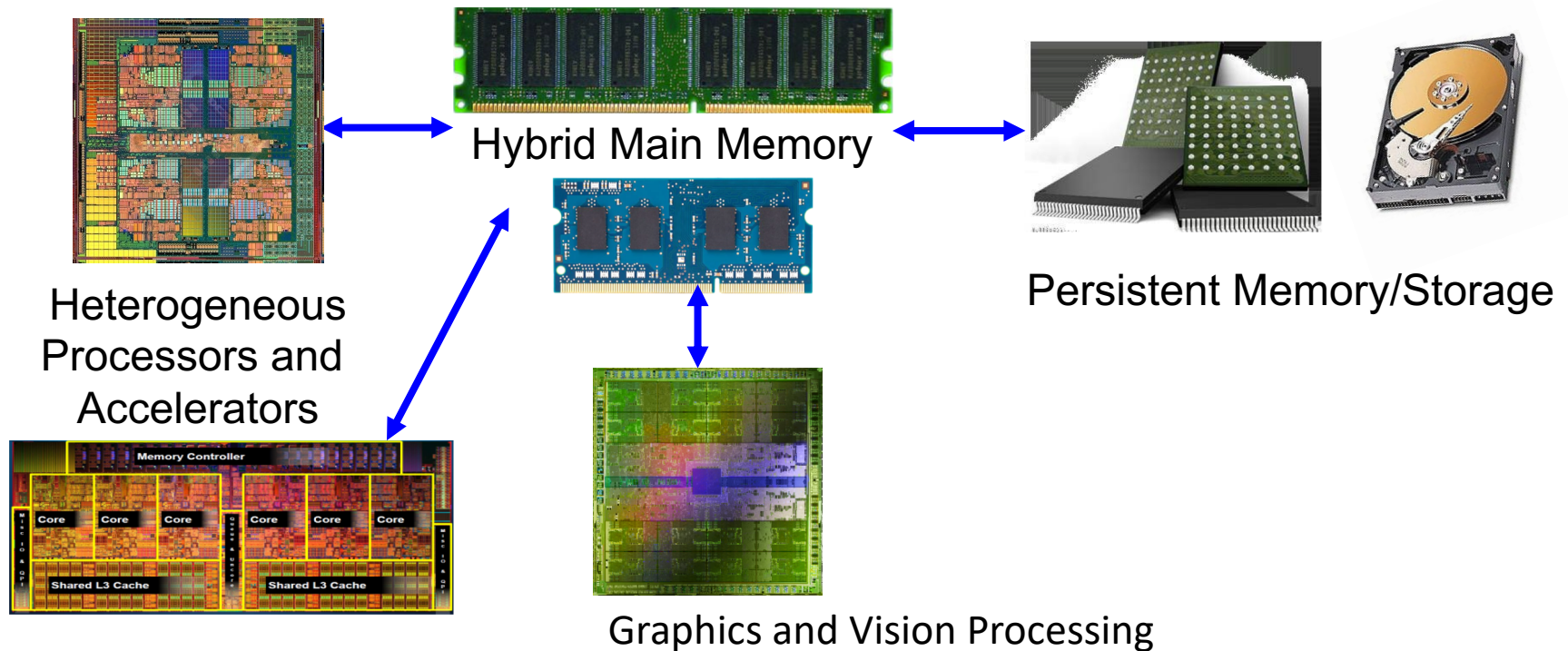


Mohammed Alser

- Lecturer and Senior Researcher, [SAFARI Research Group](#), [ETH Zürich](#), since Sept. 2018.
- PhD from Bilkent University (Turkey) 2018, worked at UCLA, TU Dresden, and PETRONAS.
- [Received the IEEE Turkey Doctoral Dissertation Award](#) and a number of international prestigious awards.
-  <https://twitter.com/mealser>
- My main research is in **bioinformatics, computational genomics, metagenomics**, and computer architecture.
- I am especially excited about **building** new data structures, algorithms, and architectures that **make intelligent genome analysis a reality**.

Current Research Mission

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

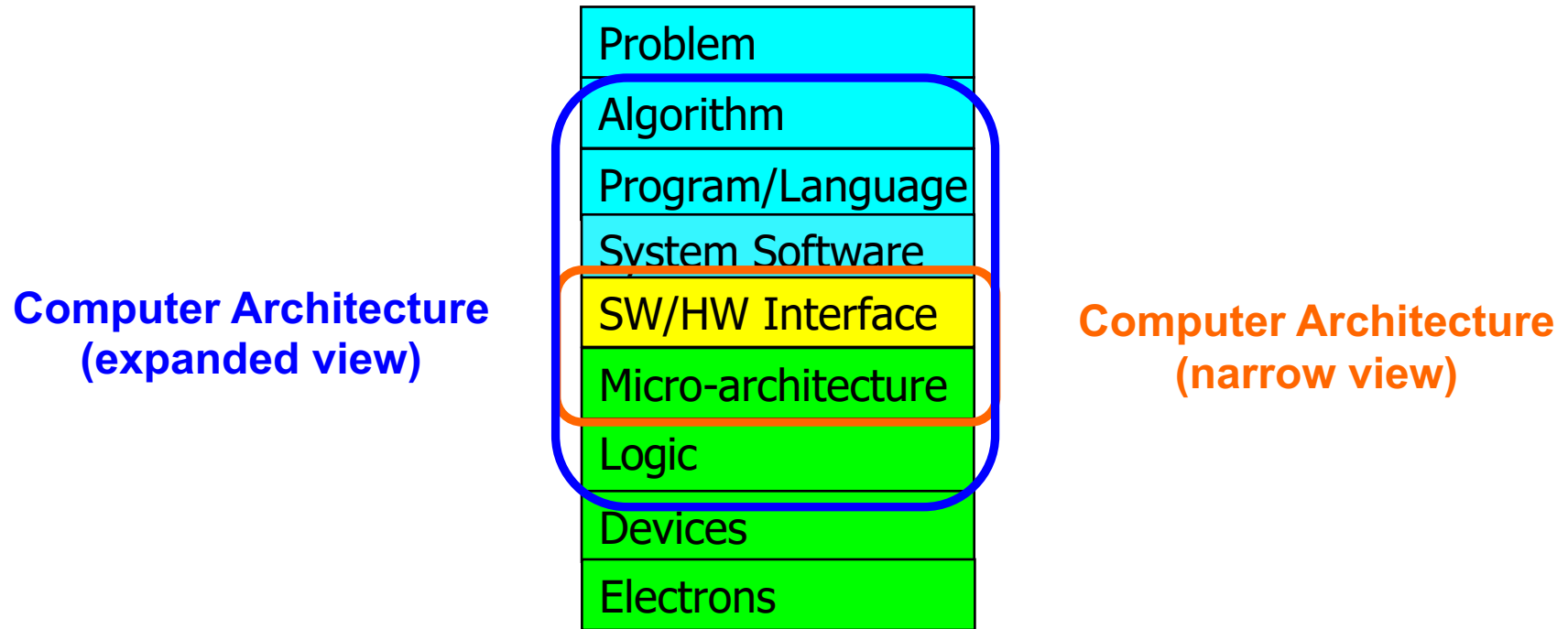


Build fundamentally better architectures

Four Key Current Directions

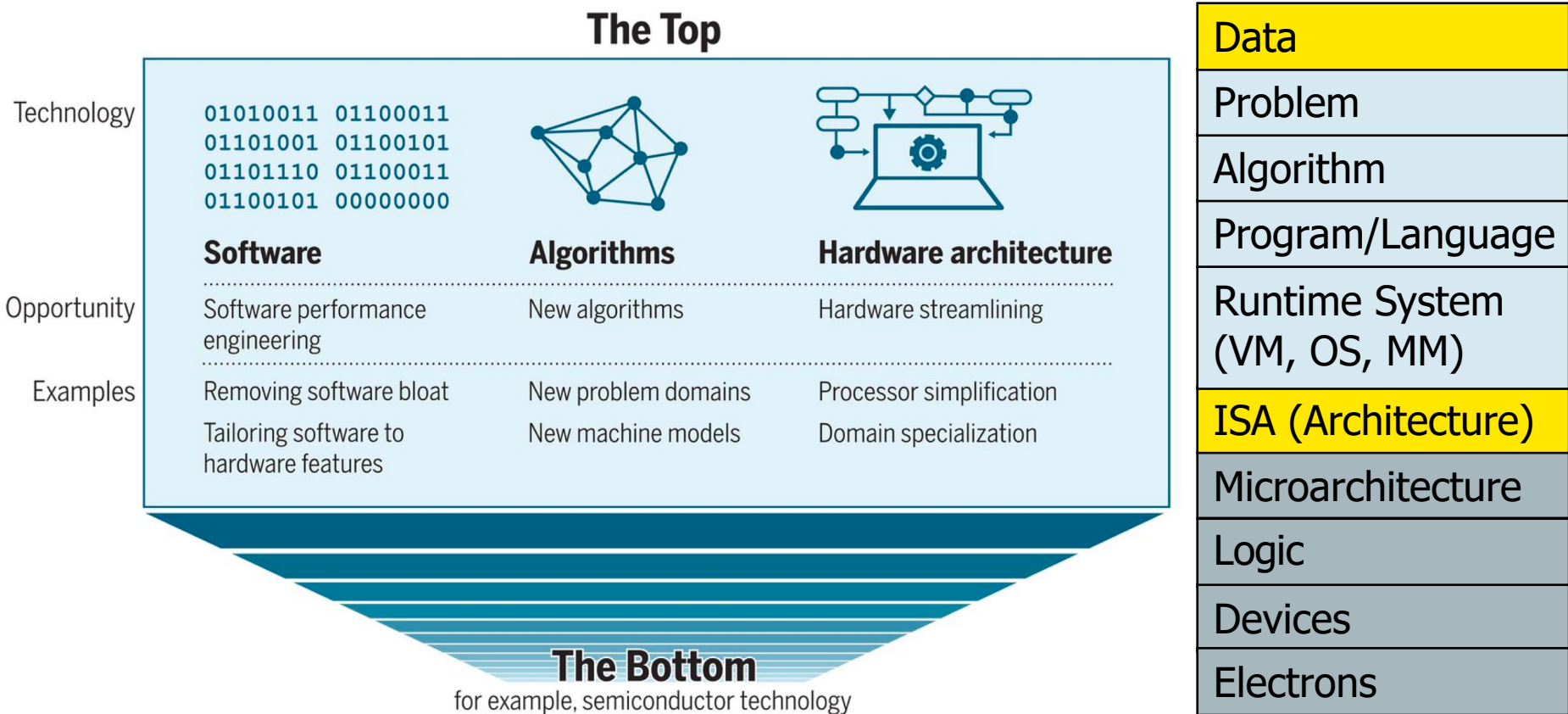
- Fundamentally **Secure/Reliable/Safe** Architectures
- Fundamentally **Energy-Efficient** Architectures
 - **Memory-centric** (Data-centric) Architectures
- Fundamentally **Low-Latency and Predictable** Architectures
- Architectures for **AI/ML, Genomics, Medicine, Health**

The Transformation Hierarchy



Computing System

Leiserson+, "[There's plenty of room at the Top: What will drive computer performance after Moore's law?](#)", Science, 2020



Richard Feynman, "[There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics](#)", a lecture given at Caltech, 1959.

Software & Hardware Optimizations

Multiplying Two 4096-by-4096 Matrices

```
for i in xrange(4096):  
    for j in xrange(4096):  
        for k in xrange(4096):  
            C[i][j] += A[i][k] * B[k][j]
```

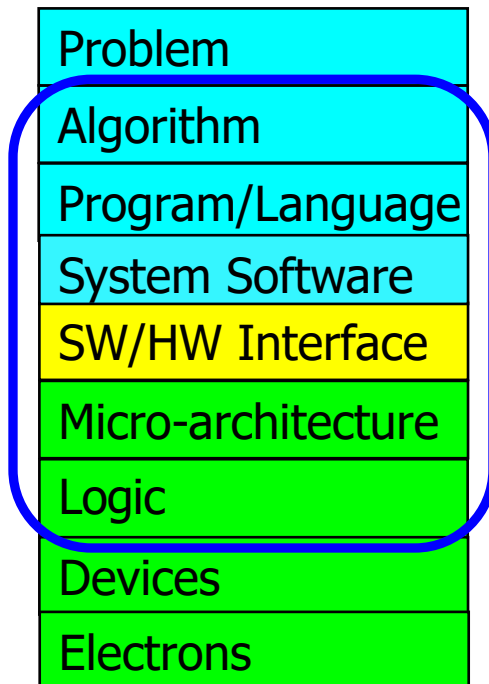
$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix} \times \begin{bmatrix} 7 & 8 \\ 9 & 10 \\ 11 & 12 \end{bmatrix} = \begin{bmatrix} & 58 & \\ & & \end{bmatrix}$$

Implementation	Running time (s)	Absolute speedup
Python	25,552.48	1x
Java	2,372.68	11x
C	542.67	47x
Parallel loops	69.80	366x
Parallel divide and conquer	3.80	6,727x
plus vectorization	1.10	23,224x
plus AVX intrinsics	0.41	62,806x

Leiserson+, "[There's plenty of room at the Top: What will drive computer performance after Moore's law?](#)", Science, 2020

To achieve the highest **energy efficiency** and **performance**:

we must take the expanded view
of Computer Architecture

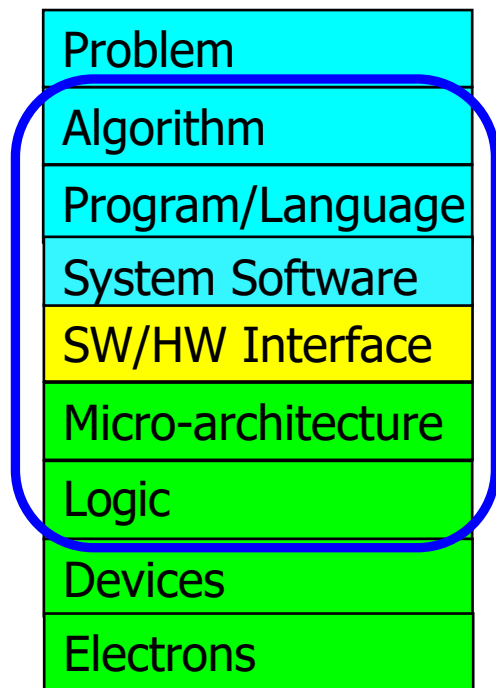


Co-design across the hierarchy:
Algorithms to devices

Specialize as much as possible
within the design goals

Current Research Mission & Major Topics

Build fundamentally better architectures

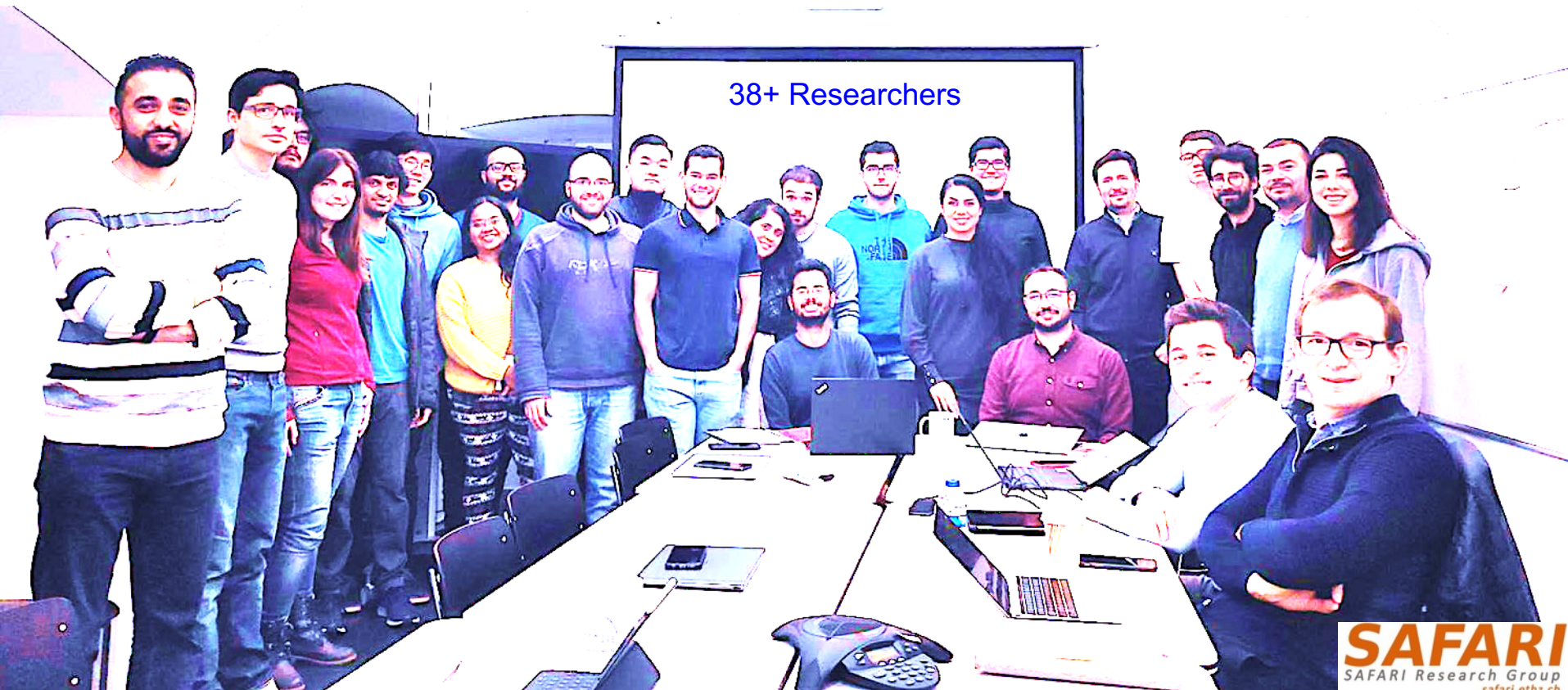


**Broad research
spanning apps, systems, logic
with architecture at the center**

- Data-centric arch. for low energy & high perf.
 - Proc. in Mem/DRAM, NVM, unified mem/storage
- Low-latency & predictable architectures
 - Low-latency, low-energy yet low-cost memory
 - QoS-aware and predictable memory systems
- Fundamentally secure/reliable/safe arch.
 - Tolerating all bit flips; patchable HW; secure mem
- Architectures for ML/AI/Genomics/Graph/Med
 - Algorithm/arch./logic co-design; full heterogeneity
- Data-driven and data-aware architectures
 - ML/AI-driven architectural controllers and design
 - Expressive memory and expressive systems

Onur Mutlu's SAFARI Research Group

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



SAFARI
SAFARI Research Group
safari.ethz.ch

Think BIG, Aim HIGH!

SAFARI

<https://safari.ethz.ch>

Brief Self Introduction



■ Onur Mutlu

- ❑ Full Professor @ ETH Zurich ITET (INFK), since Sept 2015
- ❑ Strecker Professor @ Carnegie Mellon University ECE (CS), 2009-2016, 2016-...
- ❑ Started the Comp Arch Research Group @ Microsoft Research, 2006-2009
- ❑ Worked @ Google, VMware, Microsoft Research, Intel, AMD
- ❑ PhD in Computer Engineering from University of Texas at Austin in 2006
- ❑ BS in Computer Engineering & Psychology from University of Michigan in 2000
- ❑ <https://people.inf.ethz.ch/omutlu/> omutlu@gmail.com

■ Research and Teaching in:

- ❑ **Computer architecture, systems, hardware security, bioinformatics**
- ❑ Memory and storage systems
- ❑ Robust & dependable hardware systems: security, safety, predictability, reliability
- ❑ Hardware/software cooperation
- ❑ New computing paradigms; architectures with emerging technologies/devices
- ❑ Architectures for bioinformatics, genomics, health, medicine, AI/ML
- ❑ ...

SAFARI Newsletter December 2021 Edition

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

SAFARI
SAFARI Research Group

Think Big, Aim High

ETH zürich



View in your browser
December 2021



SAFARI Newsletter January 2021 Edition

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



Newsletter
January 2021

*Think Big, Aim High, and
Have a Wonderful 2021!*



Dear SAFARI friends,

SAFARI Newsletter April 2020 Edition

- <https://safari.ethz.ch/safari-newsletter-april-2020/>



[View in your browser](#)

Think Big, Aim High



Dear SAFARI friends,



2019 and the first three months of 2020 have been very positive eventful times for SAFARI.

SAFARI PhD and Post-Doc Alumni

- <https://safari.ethz.ch/safari-alumni/>
- Minesh Patel (ETH Zurich), MICRO 2020 and DSN 2020 Best Paper Awards; ISCA Hall of Fame 2021
- Damla Senol Cali (Bionano Genomics), SRC TECHCON 2019 Best Student Presentation Award
- Nastaran Hajinazar (ETH Zurich)
- Gagandeep Singh (ETH Zurich), FPL 2020 Best Paper Award Finalist
- Amirali Boroumand (Stanford Univ → Google), SRC TECHCON 2018 Best Student Presentation Award
- Jeremie Kim (ETH Zurich), EDAA Outstanding Dissertation Award 2020; IEEE Micro Top Picks 2019; ISCA/MICRO HoF 2021
- Nandita Vijaykumar (Univ. of Toronto, Assistant Professor), ISCA Hall of Fame 2021
- Kevin Hsieh (Microsoft Research, Senior Researcher)
- Justin Meza (Facebook), HiPEAC 2015 Best Student Presentation Award; ICCD 2012 Best Paper Award
- Mohammed Alser (ETH Zurich), IEEE Turkey Best PhD Thesis Award 2018
- Yixin Luo (Google), HPCA 2015 Best Paper Session
- Kevin Chang (Facebook), SRC TECHCON 2016 Best Student Presentation Award
- Rachata Ausavarungrun (KMUNTB, Assistant Professor), NOCS 2015 and NOCS 2012 Best Paper Award Finalist
- Gennady Pekhimenko (Univ. of Toronto, Assistant Professor), ISCA Hall of Fame 2021; ASPLOS 2015 SRC Winner
- Vivek Seshadri (Microsoft Research)
- Donghyuk Lee (NVIDIA Research, Senior Researcher), HPCA Hall of Fame 2018
- Yoongu Kim (Software Robotics → Google), TCAD'19 Top Pick Award; IEEE Micro Top Picks'10; HPCA'10 Best Paper Session
- Lavanya Subramanian (Intel Labs → Facebook)
- Samira Khan (Univ. of Virginia, Assistant Professor), HPCA 2014 Best Paper Session
- Saugata Ghose (Univ. of Illinois, Assistant Professor), DFRWS-EU 2017 Best Paper Award
- Jawad Haj-Yahya (Huawei Research Zurich, Principal Researcher)

SAFARI Research Group: Introduction and Research

- Onur Mutlu,
"SAFARI Research Group: Introduction & Research"
*Invited Talk at the ETH Future Computing Laboratory
Huawei Day, Virtual, 19 October 2021.*
[[Slides \(pptx\)](#) ([pdf](#))]
[[Talk Video](#) (15 minutes)]

Short Video on SAFARI Research Group



SAFARI Research Group: Introduction & Research -- ETH Future Computing Laboratory Talk - Onur Mutlu

529 views • Premiered Jan 15, 2022

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Onur Mutlu Lectures
22.7K subscribers

ANALYTICS

EDIT VIDEO

Our Major Courses & Lectures

- **First Computer Architecture & Digital Design Course**
 - ❑ Digital Design and Computer Architecture
 - ❑ Spring 2022 Livestream Edition:
<https://www.youtube.com/playlist?list=PL5Q2soXY2Zi97Ya5DEUpMpO2bbAoaG7c6>
- **Advanced Computer Architecture Course**
 - ❑ Computer Architecture
 - ❑ Fall 2021 Livestream Edition:
https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF
- **Seminar in Computer Architecture**
 - ❑ https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_hxizriwKmFHgcoe2Q8-m0

DDCA (Spring 2022)



Digital Design and Computer Architecture -
Spring 2022

Search

Recent Changes Media Manager Sitemap

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Announcements

Materials

- Lectures/Schedule
- Lecture Buzzwords
- Readings
- Optional HWs
- Labs
- Extra Assignments
- Exams
- Technical Docs

Resources

- Computer Architecture (CMU) SS15: Lecture Videos
- Computer Architecture (CMU) SS15: Course Website
- Digitaltechnik SS18: Lecture Videos
- Digitaltechnik SS18: Course Website
- Digitaltechnik SS19: Lecture Videos
- Digitaltechnik SS19: Course Website
- Digitaltechnik SS20: Lecture Videos
- Digitaltechnik SS20: Course Website
- Digitaltechnik SS21: Lecture Videos
- Digitaltechnik SS21: Course Website
- Moodle

<https://safari.ethz.ch/digitaltechnik/spring2022/doku.php?id=schedule>

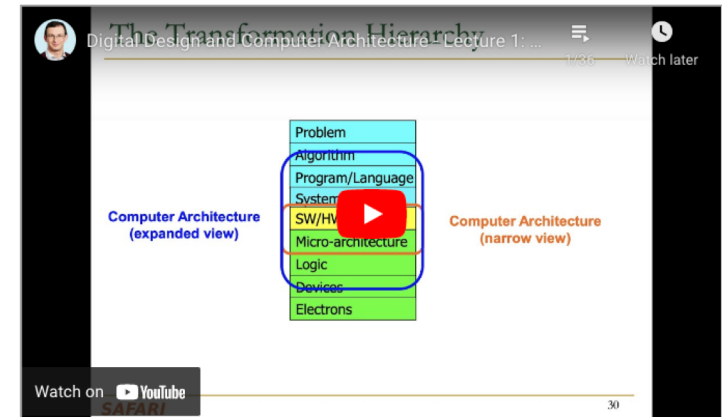
<https://www.youtube.com/playlist?list=PL5Q2soXY2Zi97Ya5DEUpMpO2bbAoaG7c6>

Bachelor's course

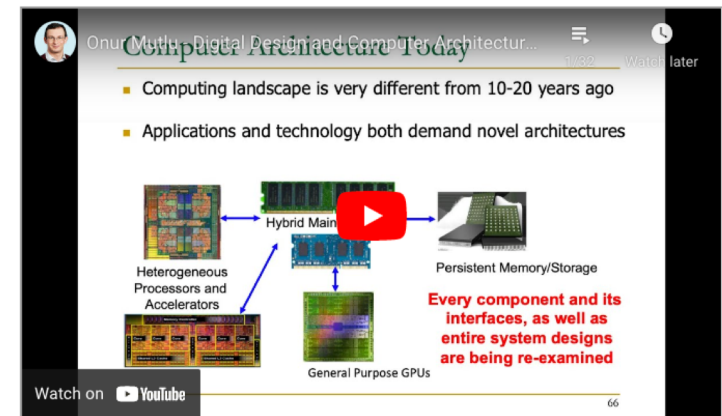
- ❑ 2nd semester at ETH Zurich
- ❑ Rigorous introduction into "How Computers Work"
- ❑ Digital Design/Logic
- ❑ Computer Architecture
- ❑ 10 FPGA Lab Assignments

Lecture Video Playlist on YouTube

Livestream Lecture Playlist



Recorded Lecture Playlist



Spring 2022 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Lab	HW
W1	24.02 Thu.	YouTube Live	L1: Introduction and Basics (PDF) (PPT)	Suggested Mentioned		
	25.02 Fri.	YouTube Live	L2a: Tradeoffs, Metrics, Mindset (PDF) (PPT)	Required Suggested Mentioned		
			L2b: Mysteries in Computer Architecture (PDF) (PPT)	Required Suggested		

Comp Arch (Fall'21)

Fall 2021 Edition:

- <https://safari.ethz.ch/architecture/fall2021/doku.php?id=schedule>

Fall 2020 Edition:

- <https://safari.ethz.ch/architecture/fall2020/doku.php?id=schedule>

Youtube Livestream (2021):

- https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF

Youtube Livestream (2020):


- <https://www.youtube.com/watch?v=c3mPdZA-Fmc&list=PL5Q2soXY2Zi9xidyIgBxUz7xRPS-wisBN>

Master's level course

- Taken by Bachelor's/Masters/PhD students
- Cutting-edge research topics + fundamentals in Computer Architecture
- 5 Simulator-based Lab Assignments
- Potential research exploration
- Many research readings

SAFARI

<https://www.youtube.com/onurmutlulectures>


Computer Architecture - Fall 2021

Recent Changes
Media Manager
Sitemap

Trace: readings · start · schedule

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Announcements

Materials

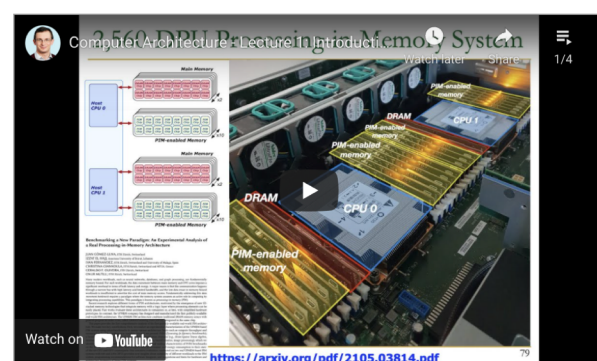
Resources

- Lectures/Schedule
- Lecture Buzzwords
- Readings
- HWs
- Labs
- Exams
- Related Courses
- Tutorials

- Computer Architecture FS20: Course Webpage
- Computer Architecture FS20: Lecture Videos
- Digitaltechnik SS21: Course Webpage
- Digitaltechnik SS21: Lecture Videos
- Moodle
- HotCRP
- Verilog Practice Website (HDLBits)

Lecture Video Playlist on YouTube

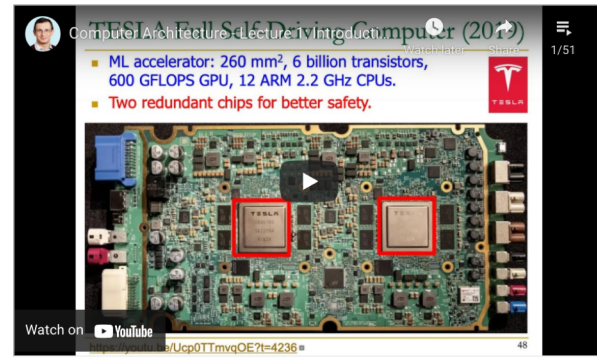
Livestream Lecture Playlist



Watch on YouTube

<https://arxiv.org/pdf/2105.03814.pdf>

Recorded Lecture Playlist



Watch on YouTube

Fall 2021 Lectures & Schedule

Week	Date	Livestream	Lecture	Readings	Lab	HW
W1	30.09 Thu.	Yes Live	L1: Introduction and Basics PDF PPT	Required Mentioned	Lab 1 Out	HW 0 Out
	01.10 Fri.	Yes Live	L2: Trends, Tradeoffs and Design Fundamentals PDF PPT	Required Mentioned		
W2	07.10 Thu.	Yes Live	L3a: Memory Systems: Challenges and Opportunities PDF PPT	Described Suggested		HW 1 Out
			L3b: Course Info & Logistics PDF PPT			
			L3c: Memory Performance Attacks PDF PPT	Described Suggested		
	08.10 Fri.	Yes Live	L4a: Memory Performance Attacks PDF PPT	Described Suggested	Lab 2 Out	
			L4b: Data Retention and Memory Refresh PDF PPT	Described Suggested		
			L4c: RowHammer PDF PPT	Described Suggested		

Seminar in Comp Arch (Spring 2022)


- https://safari.ethz.ch/architecture_seminar/spring2022/doku.php?id=schedule

- **Youtube Livestream:**

- https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_hxizriwKmFHgcoe2Q8-m0

- **Critical analysis course**

- Taken by Bachelor's/Masters/PhD students
 - Cutting-edge research topics + fundamentals in Computer Architecture
 - 20+ research papers, presentations, analyses



Seminar in Computer Architecture - Spring 2022

Trace: • start • sessions • **schedule**

Home

Materials

- Announcements
- Lectures/Schedule**
- Lecture Buzzwords
- Readings
- Sessions
- Papers
- Synthesis Report
- Homework

Past Course Materials

- Fall 2021
- Spring 2021
- Fall 2020
- Spring 2020
- Fall 2019
- Spring 2019

Resources

Computer Architecture

- Fall 2021
- Fall 2021: Lecture Videos
- Fall 2020
- Fall 2020: Lecture Videos
- Fall 2019
- Fall 2019: Lecture Videos
- Fall 2018
- Fall 2018: Lecture Videos

Digital Design and Computer Architecture

- Spring 2021
- Spring 2021: Lecture Videos
- Spring 2020
- Spring 2020: Lecture Videos
- Spring 2019
- Spring 2019: Lecture Videos

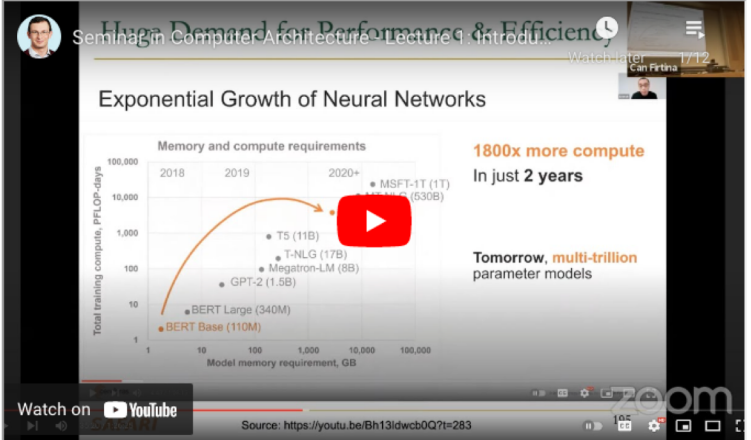
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Recent Changes Media Manager Sitemap

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Lecture Video Playlist on YouTube

Lecture Playlist



Watch on YouTube


Source: <https://youtu.be/Bh13ldwcb0Q?t=283>

Spring 2022 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Assignments
W1	24.02 Thu.	YouTube Live	L1a: Course Logistics Q22A (PDF) Q22B (PPT)	Suggested	
			L1b: Introduction and Basics Q22A (PDF) Q22B (PPT)	Suggested	
			L1c: Architectural Design Fundamentals Q22A (PDF) Q22B (PPT)	Suggested	
W2	03.03 Thu.	YouTube Live	L2: Memory-Centric Computing Q22A (PDF) Q22B (PPT)	Suggested	
W3	10.03 Thu.	YouTube Live	L3: Memory-Centric Computing II Q22A (PDF) Q22B (PPT)	Suggested	
W4	17.03 Thu.	YouTube Live	L4: Memory-Centric Computing III Q22A (PDF) Q22B (PPT)	Suggested	
W5	24.03 Thu.	YouTube Live	L5: Accelerating Genome Analysis Q22A (PDF) Q22B (PPT)	Suggested	

Hands-On Project Courses

- https://safari.ethz.ch/projects_and_seminars/doku.php



The screenshot shows the homepage of the SAFARI Project & Seminars Courses (Fall 2022) wiki. The header includes a search bar and navigation links for Recent Changes, Media Manager, and Sitemap. The main content area features a large title and a welcome message. A sidebar on the left lists various courses under the heading 'Courses'. The main content area also lists the courses offered, each with a course ID.

SAFARI Project & Seminars Courses (Fall 2022)

Search

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Courses

- [SoftMC](#)
- [Ramulator](#)
- [Accelerating Genomics](#)
- [Mobile Genomics](#)
- [Processing-in-Memory](#)
- [Heterogeneous Systems](#)
- [Modern SSDs](#)
- [Hardware/Software Co-design](#)

SAFARI Projects & Seminars Courses (Fall 2022)

Welcome to the wiki for Project and Seminar courses SAFARI offers.

Courses we offer:

- [FPGA-based Exploration of DRAM and RowHammer: 227-0085-35L](#)
- [Exploration of Emerging Memory Systems: 227-0085-34L](#)
- [Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms: 227-0085-33L](#)
- [Genome Sequencing on Mobile Devices: 227-0085-36L](#)
- [Data-Centric Architectures: Fundamentally Improving Performance and Energy: 227-0085-37L](#)
- [Programming Heterogeneous Computing Systems with GPUs and other Accelerators: 227-0085-51L](#)
- [Understanding and Designing Modern NAND Flash-Based SSDs \(Solid-State Drives\): 227-0085-44L](#)
- [Intelligent Architectures using Hardware/Software Cooperative Techniques: 227-0085-56L](#)

Genomics (Spring 2022)

■ Fall 2021 Edition:

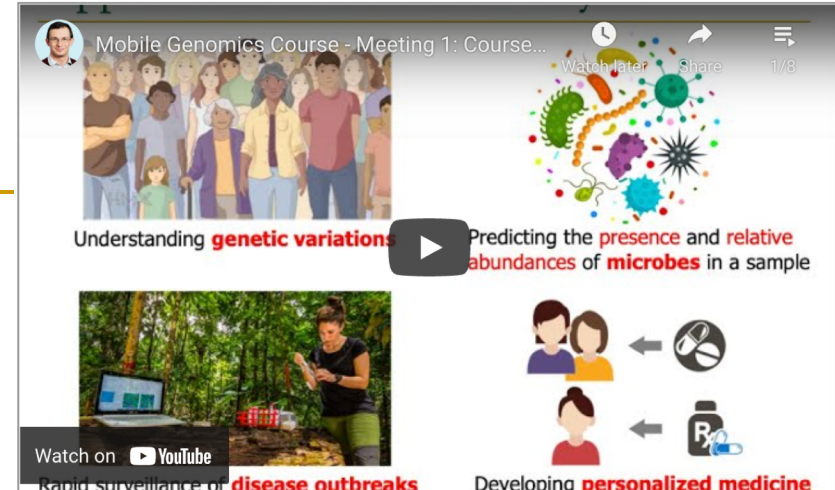
- https://safari.ethz.ch/projects_and_seminars/spring2022/doku.php?id=bioinformatics

■ Youtube Livestream:

- https://www.youtube.com/playlist?list=PL5Q2soXY2Zi8NrPDgOR1yRU_Cxxjw-u18

■ Project course

- Taken by Bachelor's/Master's students
- Genomics lectures
- Hands-on research exploration
- Many research readings



Fall 2021 Meetings/Schedule

Week	Date	Livestream	Meeting	Learning Materials	Assignments
W1	5.10 Tue.	YouTube Live	M1: P&S Accelerating Genomics Course Introduction & Project Proposals PDF (PDF) PPT (PPT) YouTube Video	Required Materials Recommended Materials	
W2	20.10 Wed.	YouTube Live	M2: Introduction to Sequencing PDF (PDF) PPT (PPT)		
W3	27.10 Wed.	YouTube Live	M3: Read Mapping PDF (PDF) PPT (PPT)		
W4	3.11 Wed.	YouTube Live	M4: GateKeeper PDF (PDF) PPT (PPT)		
W5	10.11 Wed.	YouTube Live	M5: MAGNET & Shouji PDF (PDF) PPT (PPT)		
W6	17.11 Wed.		M6.1: SneakySnake PDF (PDF) PPT (PPT) YouTube Video		
			M6.2: GRIM-Filter PDF (PDF) PPT (PPT) YouTube Video		
W7	24.11 Wed.		M7: GenASM PDF (PDF) PPT (PPT) YouTube Video		
W8	01.12 Wed.	YouTube Live	M8: Genome Assembly PDF (PDF) PPT (PPT)		
W9	13.12 Mon.	YouTube Live	M9: GRIM-Filter PDF (PDF) PPT (PPT)		
W10	15.12 Wed.	YouTube Live	M10: Genomic Data Sharing Under Differential Privacy PDF (PDF) PPT (PPT)		

PIM Course (Fall'21)

Fall 2021 Edition:

- https://safari.ethz.ch/projects_and_seminars/fall2021/doku.php?id=processing_in_memory

Youtube Livestream:

- https://www.youtube.com/watch?v=9e4Chnwdovo&list=PL5Q2soXY2Zi-841fUYYUK9EsXKhQKRPyX

Project course

- Taken by Bachelor's/Master's students
- Processing-in-Memory lectures
- Hands-on research exploration
- Many research readings

PIM Review and Open Problems
Processing in Memory Course: Meeting 1: Ex...

Watch later Share 1/10

A Modern Primer on Processing in Memory

Onur Mutlu^{a,b}, Saugata Ghose^{b,c}, Juan Gómez-Luna^a, Rachata Ausavarungnirun^d

SAFARI Research Group

^aETH Zürich
^bCarnegie Mellon University
^cUniversity of Illinois at Urbana-Champaign
^dKing Mongkut's University of Technology North Bangkok

Onur Mutlu, Saugata Ghose, Juan Gomez-Luna, and Rachata Ausavarungnirun, "A Modern Primer on Processing in Memory" Invited Book Chapter in *Emerging Computing: From Devices to Systems - Looking Beyond Moore and Von Neumann*, Springer, to be published in 2021.

Watch on YouTube

<https://arxiv.org/pdf/1903.03988.pdf>

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Fall 2021 Meetings/Schedule

Week	Date	Livestream	Meeting	Learning Materials	Assignments
W1	05.10 Tue.	You Tube Live	M1: P&S PIM Course Presentation PDF (PDF) PPT (PPT)	Required Materials Recommended Materials	HW 0 Out
W2	12.10 Tue.	You Tube Live	M2: Real-World PIM Architectures PDF (PDF) PPT (PPT)		
W3	19.10 Tue.	You Tube Live	M3: Real-World PIM Architectures II PDF (PDF) PPT (PPT)		
W4	26.10 Tue.	You Tube Live	M4: Real-World PIM Architectures III PDF (PDF) PPT (PPT)		
W5	02.11 Tue.	You Tube Live	M5: Real-World PIM Architectures IV PDF (PDF) PPT (PPT)		
W6	09.11 Tue.	You Tube Live	M6: End-to-End Framework for Processing-using-Memory PDF (PDF) PPT (PPT)		
W7	16.11 Tue.	You Tube Live	M7: How to Evaluate Data Movement Bottlenecks PDF (PDF) PPT (PPT)		
W8	23.11 Tue.	You Tube Live	M8: Programming PIM Architectures PDF (PDF) PPT (PPT)		
W9	30.11 Tue.	You Tube Live	M9: Benchmarking and Workload Suitability on PIM PDF (PDF) PPT (PPT)		
W10	07.12 Tue.	You Tube Live	M10: Bit-Serial SIMD Processing using DRAM PDF (PDF) PPT (PPT)		

PIM Course (Current)

Spring 2022 Edition:

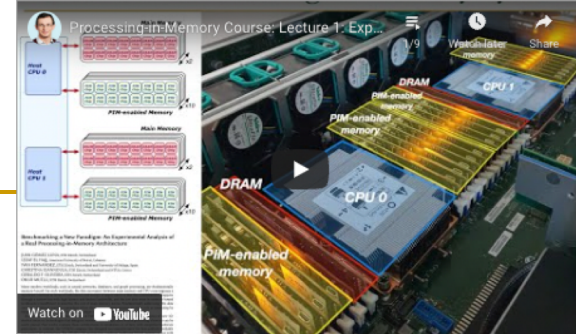
- https://safari.ethz.ch/projects_and_seminars/spring2022/doku.php?id=processing_in_memory

Youtube Livestream:

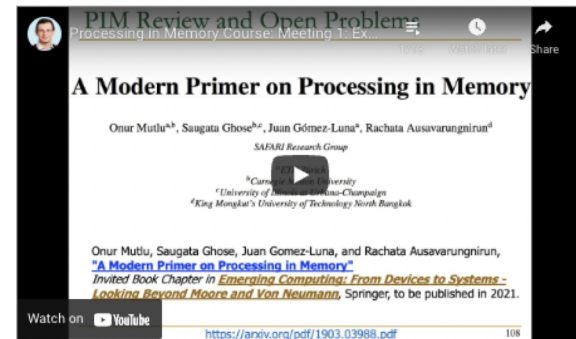
- https://www.youtube.com/watch?v=9e4Chnwdovo&list=PL5Q2soXY2Zi-841fUYYUK9EsXKhQKRPyX

Project course

- Taken by Bachelor's/Master's students
- Processing-in-Memory lectures
- Hands-on research exploration
- Many research readings



Recorded Lecture Playlist



Spring 2022 Meetings/Schedule

Week	Date	Livestream	Meeting	Learning Materials	Assignments
W1	10.03 Thu.	Live	M1: P&S PIM Course Presentation (PDF) (PPT)	Required Materials Recommended Materials	HW 0 Out
W2	15.03 Tue.		Hands-on Project Proposal		
	17.03 Thu.	Premiere	M2: Real-world PIM: UPMEM PIM (PDF) (PPT)		
W3	24.03 Thu.	Live	M3: Real-world PIM: Microbenchmarking of UPMEM PIM (PDF) (PPT)		
W4	31.03 Thu.	Live	M4: Real-world PIM: Samsung HBM-PIM (PDF) (PPT)		
W5	07.04 Thu.	Live	M5: How to Evaluate Data Movement Bottlenecks (PDF) (PPT)		
W6	14.04 Thu.	Live	M6: Real-world PIM: SK Hynix AEM (PDF) (PPT)		
W7	21.04 Thu.	Premiere	M7: Programming PIM Architectures (PDF) (PPT)		
W8	28.04 Thu.	Premiere	M8: Benchmarking and Workload Suitability on PIM (PDF) (PPT)		
W9	05.05 Thu.	Premiere	M9: Real-world PIM: Samsung AxDIMM (PDF) (PPT)		
W10	12.05 Thu.		M10: Real-world PIM: Alibaba HB PNM (PDF) (PPT)		

Hetero. Systems (Fall'21)

Fall 2021 Edition:

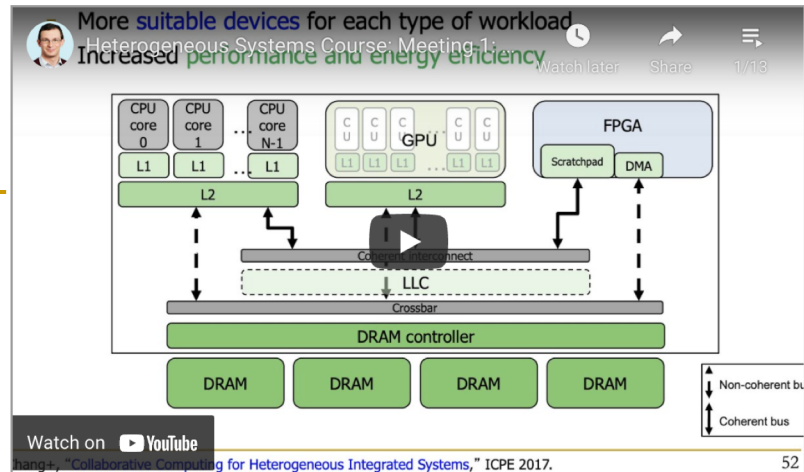
- https://safari.ethz.ch/projects and seminars/fall2021/doku.php?id=heterogeneous_systems

Youtube Livestream:

- https://www.youtube.com/watch?v=QYbjwzsfMM&list=PL5Q2soXY2Zi_OwkTgEyA6tk3UsoPBH737

Project course

- Taken by Bachelor's/Master's students
- GPU and Parallelism lectures
- Hands-on research exploration
- Many research readings



Fall 2021 Meetings/Schedule

Week	Date	Livestream	Meeting	Learning Materials	Assignments
W1	07.10 Thu.	YouTube Live	M1: P&S Course Presentation (PDF) (PPT)	Required Materials Recommended Materials	HW 0 Out
W2	14.10 Thu.	YouTube Live	M2: SIMD Processing and GPUs (PDF) (PPT)		
W3	21.10 Thu.	YouTube Live	M3: GPU Software Hierarchy (PDF) (PPT)		
W4	28.10 Thu.	YouTube Live	M4: GPU Memory Hierarchy (PDF) (PPT)		
W5	04.11 Thu.	YouTube Live	M5: GPU Performance Considerations (PDF) (PPT)		
W6	11.11 Thu.	YouTube Live	M6: Parallel Patterns: Reduction (PDF) (PPT)		
W7	18.11 Thu.	YouTube Live	M7: Parallel Patterns: Histogram (PDF) (PPT)		
W8	25.11 Thu.	YouTube Live	M8: Parallel Patterns: Convolution (PDF) (PPT)		
W9	02.12 Thu.	YouTube Live	M9: Parallel Patterns: Prefix Sum (Scan) (PDF) (PPT)		
W10	09.12 Thu.	YouTube Live	M10: Parallel Patterns: Sparse Matrices (PDF) (PPT)		
W11	16.12 Thu.	YouTube Live	M11: Parallel Patterns: Graph Search (PDF) (PPT)		
W12	22.12 Thu.	YouTube Live	M12: Dynamic Parallelism (PDF) (PPT)		
W13	06.01 Thu.	YouTube Live	M13: Collaborative Computing (PDF) (PPT)		

SAFARI Live Seminars (I)


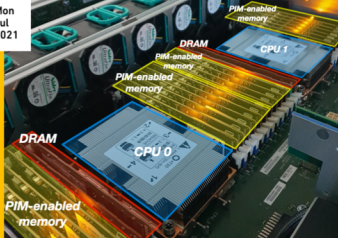
SAFARI Live Seminars in Computer Architecture

Dr. Juan Gómez Luna, ETH Zurich

Understanding a Modern Processing-in-Memory Architecture: Benchmarking and Experimental Characterization

SAFARI
SAFARI Research Group

12 Mon Jul 2021

SAFARI Live Seminars in Computer Architecture

Dr. Andrew Walker, Schiltron Corporation & Nexgen Power Systems

An Addition to Low Cost Per Memory Bit – How to Recognize It and What to Do About It

SAFARI
SAFARI Research Group

19 Mo Jul 2021





SAFARI Live Seminars in Computer Architecture

Geraldo F. Oliveira, ETH Zurich

DAMOV: A New Methodology and Benchmark Suite for Evaluating Data Movement Bottlenecks

SAFARI
SAFARI Research Group

22 Do Jul 2021



Near-Data Processing (2/2)

UPMEM (2019) Samsung HBM-PIM (2021)

Near-DRAM-banks processing for general-purpose computing

0.9 TOPS compute throughput¹ 1.2 TFLOPS compute throughput²

The goal of Near-Data Processing (NDP) is to mitigate data movement

SAFARI (1) Drexler, "The Near-Data Processing Research Landscape", DSD 2021. (2) Drexler, "The Near-Data Processing Research Landscape", DSD 2021. (3) Drexler, "The Near-Data Processing Research Landscape", DSD 2021.


SAFARI Live Seminars in Computer Architecture

Gennady Pekhimenko, University of Toronto

Efficient DNN Training at Scale: from Algorithms to Hardware

SAFARI
SAFARI Research Group

5 Do Aug 2021



DNN Training vs. Inference

Step 1 - Forward Pass (makes a prediction)
Step 2 - Backward Pass (calculates error gradients)

Generated in the forward pass Used in the backward pass

DNN training requires stashing feature maps for the backward pass (not required in inference)

SAFARI Live Seminars in Computer Architecture

Jawad Haj-Yahya, Huawei Research Center Zurich

Power Management Mechanisms in Modern Microprocessors and Their Security Implications

SAFARI
SAFARI Research Group

16 Mo Aug 2021



Overview of a Modern SoC Architecture

- 3 domains in modern thermally-constrained mobile SoC: Compute, Memory, IO
- Several voltage sources exist, and some of them are shared between domains
- IO controllers and engines, IO interconnect, memory controller, and DDRIO typically each has an independent clock




SAFARI Live Seminars in Computer Architecture

Ataberk Olgun, TOBB & ETH Zurich

QUAC-TRNG: High-Throughput True Random Number Generation Using Quadruple Row Activation in Commodity DRAM Chips

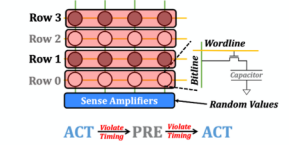
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15 Mi Sep 2021



Using QUAC to Generate Random Values

Use QUAC to activate DRAM rows that are initialized with conflicting data (e.g., two '1's and two '0's) to generate random values




SAFARI Live Seminars in Computer Architecture

Minesh Patel, ETH Zurich

Enabling Effective Error Mitigation in Memory Chips That Use On-Die ECCs

SAFARI
SAFARI Research Group

21 Tues Sep 2021



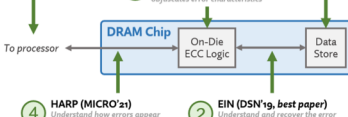
Position Paper (Ongoing) Arguing for increased transparency of DRAM reliability characteristics

REAPER (ISCA'17) Understand the basic properties of DRAM data-retention errors

BEER (MICRO'20, best paper) Determine exactly how on-die ECC adjusts error characteristics

HARP (MICRO'21) Understand how errors appear and how to identify at-risk bits

EIN (DSN'19, best paper) Understand and recover the error characteristics beneath on-die ECC




SAFARI Live Seminars in Computer Architecture

Christina Giannoula, National Technical University of Athens

Efficient Synchronization Support for Near-Data-Processing Architectures

SAFARI
SAFARI Research Group

27 Mo Sep 2021



NDP Synchronization Solution Space

Shared Memory Message-passing

Hardware Cache Coherence Remote Atomics Specialized Hardware Support

Software-based Schemes Specialized Hardware Support

NDP Systems: SynCron (HPCA'21)


SAFARI Live Seminars in Computer Architecture

Jawad Haj-Yahya, Huawei Research Center Zurich

Security Implications of Power Management Mechanisms in Modern Processors, Current Studies and Future Trends

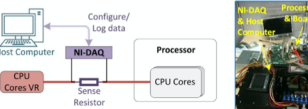
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4 Mo Okt 2021



Experimental Methodology

- We experimentally study three modern Intel processors - Haswell, Coffee Lake, and Cannon Lake
- We measure voltage and current using a Data Acquisition card (NI-DAQ)



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<https://safari.ethz.ch/safari-seminar-series/>

SAFARI Live Seminars (II)

SAFARI Live Seminars in Computer Architecture

Nastaran Hajinazar, ETH Zurich
Data-Centric and Data-Aware Frameworks for Fundamentally Efficient Data Handling in Modern Computing Systems

27 Wed Oct 2021

Overview of Our Approach

Data and the efficient computation of data should be the ultimate priority of the system

- Data-Centric Architectures**
 - Enable computation with minimal data movement
 - Compute where data resides
- Data-Aware Architectures**
 - Understand what they can do with and to each piece of data
 - Make use of different properties of data to improve performance, efficiency, etc.

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SAFARI Live Seminar: Nastaran Hajinazar 27 Oct 2021
Posted on October 1, 2021 by ewent

SAFARI Live Seminars in Computer Architecture

Sergei Mangul, Mangul Lab, USC

Opportunities and challenges of computational data-driven immunology

11 Thu Nov 2021

Sergei Mangul, Ph.D
Assistant Professor,
University of Southern California

https://mangul-lab.usc.edu/athub/id/

ETH zürich

SAFARI Live Seminar: Sergei Mangul 11 Nov 2021
Posted on November 5, 2021 by ewent

Overview

SAFARI Seminar-CODIC: A Low-Cost Substrate for Enabling Customizable DRAM Internal Circuit Timings

- CODIC** substrate enables greater control over DRAM internal circuit timings
- CODIC** is an efficient and low-cost way to enable new functionalities and optimizations in DRAM
- CODIC** controls four key signals that orchestrate DRAM internal circuit timings
 - wordline (wl)**: Connects DRAM cells to bitlines
 - sense_p** and **sense_n**: Trigger sense amplifiers
 - EQ**: Triggers the logic that prepares a DRAM bank for the next access

Watch on YouTube

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SAFARI Live Seminar: Lois Orosa, 10 Feb 2022
Posted on January 16, 2022 by ewent

Join us for our next SAFARI Live Seminar with Lois Orosa.
Thursday, February 10 at 5:00 pm Zurich time (CET)

SAFARI Live Seminars in Computer Architecture

Damla Senol Cali, Bionano Genomics
Accelerating Genome Sequence Analysis via Efficient Hardware/Algorithm Co-Design

7 Sun Nov 2021

Our Goal & Approach

- Our Goal:** Accelerating genome sequence analysis by efficient hardware/algorithm co-design
- Our Approach:**
 - Analyze the multiple steps and the associated tools in the genome sequence analysis pipeline,
 - Expose the tradeoffs between accuracy, performance, memory usage and scalability, and
 - Co-design fast and efficient algorithms along with scalable and energy-efficient customized hardware accelerators for the key bottleneck steps of the pipeline

Damla Senol Cali

SAFARI Live Seminar: Damla Senol Cali 07 Nov 2021
Posted on October 18, 2021 by ewent

SAFARI Live Seminar - Pythia: A Customizable HW Prefetching Framework Using Online Reinforcement Learning

Rahul Bera, ETH Zurich
Pythia: A Customizable Hardware Prefetching Framework Using Online Reinforcement Learning

Brief Overview of Pythia

Pythia formulates prefetching as a reinforcement learning problem

State (S_t) → Agent → Action (A_t) → Environment → Reward (R_{t+1})

Environment → Prefetcher → Processor & Memory Subsystem → Reward

Features of memory request to address A (e.g., PC) → Prefetcher → Prefetch from address A+offset (B)

Watch on YouTube

SAFARI Live Seminar: Rahul Bera 20 Dec 2021

SAFARI Live Seminars in Computer Architecture

Sean Lie, Cerebras

Thinking Outside the Die: Architecting the ML Accelerator of the Future

Livestream on YouTube: Feb 28, 2022 18:00 Zurich time

Sean Lie
Co-founder & Chief HW Architect, Cerebras

Posted on January 19, 2022 by ewent

Join us for our SAFARI Live Seminar with Sean Lie, Cerebras Systems
Monday, February 28 2022 at 6:00 pm Zurich time (CET)

SAFARI Live Seminars in Computer Architecture

Gennady Pekhimenko, University of Toronto
Machine Learning Tools in Action

8 Mo Nov 2021

RL-Scope: Cross-Stack Profiling for Deep Reinforcement Learning Workloads

Watch later

SAFARI Live Seminar: Gennady Pekhimenko 08 Nov 2021
Posted on November 1, 2021 by ewent

SAFARI Live Seminar - Introduction to the UPMEM DPU Architecture

UPMEM PIM DRAM (1/2)

8 x 32-bit CPU added to a 4Gb DRAM die:

- First Gen: 8 x CPU @450MHz, 8 x 64 MB banks (1 CPU for 1 bank)
- Second Gen: 8 x CPU @600MHz, 16 x 32 MB banks (1 CPU for 2 banks), secure Enclave

Multi-threaded CPU:

- In order execution at the thread level
- out of order execution between threads when executing DMA instructions

Offering/Roadmap:

- 1st Gen: 24 hardware threads, scalar → in production
- 2nd Gen: 16 hardware threads, scalar → in design
- 3rd Gen: 16 hardware threads, 2 way superscalar → planning

Watch on YouTube


up mem

SAFARI Live Seminar: Fabrice Devaux, 2 Feb 2022

Posted on January 15, 2022 by ewent

Join us for our joint SAFARI Live Seminar & EFCL Seminar with Fabrice Devaux, UPMEM
Wednesday, February 2 2022 at 11:00 am Zurich time (CET)

Open Source Artifacts: SAFARI GitHub



SAFARI Research Group at ETH Zurich and Carnegie Mellon University


Site for source code and tools distribution from SAFARI Research Group at ETH Zurich and Carnegie Mellon University.


📍 ETH Zurich and Carnegie Mellon ... 🔗 <https://safari.ethz.ch/> ✉ omutlu@gmail.com


[🏠 Overview](#) [💻 Repositories 55](#) [📦 Packages](#) [👤 People 40](#) [👥 Teams 1](#) [📁 Projects](#) [⚙ Settings](#)

Pinned

Customize your pins

 **ramulator** Public ⋮
A Fast and Extensible DRAM Simulator, with built-in support for modeling many different DRAM technologies including DDRx, LPDDRx, GDDRx, WIOx, HBMx, and various academic proposals. Described in the...
● C++ ☆ 250 🍴 130

 **prim-benchmarks** Public ⋮
PRIM (Processing-In-Memory benchmarks) is the first benchmark suite for a real-world processing-in-memory (PIM) architecture. PRIM is developed to evaluate, analyze, and characterize the first publ...
● C ☆ 18 🍴 8

 **DAMOV** Public ⋮
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 processin...
● C++ ☆ 12 🍴 1

📁 Repositories

Type ▾ Language ▾ Sort ▾ New

Pythia
A Customizable Hardware Prefetching Framework Using Online Reinforcement Learning.
● C++ ☆ 0 🍴 1 🔄 0 📄 0 Updated yesterday

BurstLink
☆ 0 🍴 0 🔄 0 📄 0 Updated 21 days ago

SAFARI

<https://github.com/CMU-SAFARI/>

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Papers, Courses, Talks, Videos, Artifacts

- All are available at

<https://people.inf.ethz.ch/omutlu/projects.htm>

<https://www.youtube.com/onurmutlulectures>

<https://github.com/CMU-SAFARI/>

Some Basic Principles We Follow

Principle: Teaching and Research

...

Teaching drives Research

Research drives Teaching

...

Principle: Insight and Ideas

Focus on Insight

Encourage New Ideas

Principle: Learning and Scholarship

Focus on
learning and scholarship

Principle: Environment of Freedom

Create an environment
that values

free & critical exploration,
openness, collaboration,
hard work, creativity

Principle: Learning and Scholarship

The quality of your work
defines your impact

Principle: Good Mindset, Goals & Focus

You can make a
good impact
on the world

Suggestion: Principle: Passion

Follow Your Passion
(Do not get derailed
by naysayers)

Principle: Build Infrastructure

Build Infrastructure to
Enable Your Passion

Principle: Work Hard

Work Hard to
Enable Your Passion

Suggestion: Principle: Resilience & Focus

Be Resilient & Focused
Make It Happen

Principle: Good Mindset, Goals & Focus

You can make a
good impact
on the world

Suggested Reading on Mindset & More

Richard Hamming

“You and Your Research”

Transcription of the
Bell Communications Research Colloquium Seminar
7 March 1986

<https://safari.ethz.ch/architecture/fall2021/lib/exe/fetch.php?media=youandyourresearch.pdf>

Required Reading on Mindset & More

If you really want to be a first-class scientist you need to know yourself, your weaknesses, your strengths, and your bad faults, like my egotism. How can you convert a fault to an asset? How can you convert a situation where you haven't got enough manpower to move into a direction when that's exactly what you need to do? I say again that I have seen, as I studied the history, the successful scientist changed the viewpoint and what was a defect became an asset.

In summary, I claim that some of the reasons why so many people who have greatness within their grasp don't succeed are: they don't work on important problems, they don't become emotionally involved, they don't try and change what is difficult to some other situation which is easily done but is still important, and they keep giving themselves alibis why they don't. They keep saying that it is a matter of luck. I've told you how easy it is; furthermore I've told you how to reform. Therefore, go forth and become great scientists!



The Role of This Course

Computer Architecture

- is the **science** and **art** of designing **computing platforms** (hardware, interface, system SW, and programming model)
- to achieve a set of **design goals**
 - E.g., highest performance on earth on workloads X, Y, Z
 - E.g., longest battery life at a form factor that fits in your pocket with cost < \$\$\$ CHF
 - E.g., best average performance across all known workloads at the best performance/cost ratio
 - ...
- Designing a supercomputer is different from designing a smartphone → But, many fundamental principles are similar

Seminar in Computer Architecture

- We will cover **fundamental** and **cutting-edge** research papers in computer architecture
- Multiple components that are aimed at improving students'
 - **technical skills** in computer architecture
 - **critical thinking and analysis**
 - **technical presentation** of concepts and papers
 - in both spoken and written forms
 - **familiarity with key research directions**

Key Goal

(Learn how to)
rigorously
analyze, present, discuss
papers and ideas
in computer architecture

Steps to Achieve the Key Goal

■ Steps for the Presenter

- Read
- Absorb, read more (other related works)
- Critically analyze; think; synthesize
- Prepare a clear and rigorous talk
- Present
- Answer questions
- Analyze and synthesize (in meeting, after, and at course end)

■ Steps for the Participants

- Discuss
- Ask questions
- Analyze and synthesize (in meeting, after, and at course end)

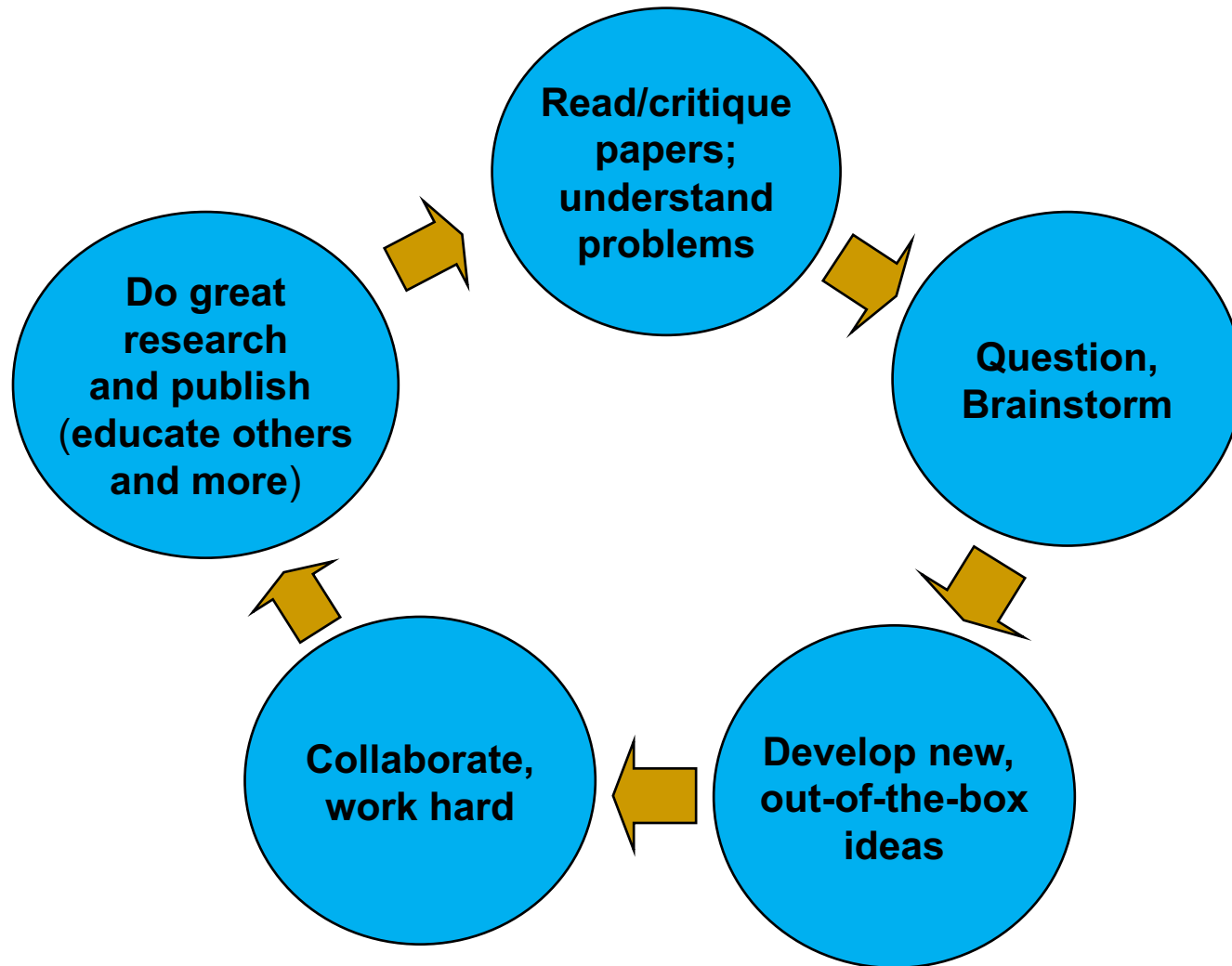
Topics of Papers and Discussion

- hardware security;
- architectural acceleration mechanisms for key applications like machine learning, graph processing, and bioinformatics;
- memory systems;
- interconnects;
- processing inside memory;
- various fundamental and emerging ideas/paradigms in computer architecture;
- hardware/software co-design and cooperation;
- fault tolerance;
- energy efficiency;
- heterogeneous and parallel systems;
- new execution models, etc.

Recap: Some Goals of This Course

- Teach/enable/empower you to:
 - Think critically
 - Think broadly
 - Learn how to understand, analyze, and present papers and ideas
 - Get familiar with key first steps in research
 - Get familiar with key research directions

The Virtuous Cycle of Scientific Progress



Course Info and Logistics

Course Info: Who Are We?



■ Onur Mutlu

- ❑ Full Professor @ ETH Zurich ITET (INFK), since Sept 2015
- ❑ Strecker Professor @ Carnegie Mellon University ECE (CS), 2009-2016, 2016-...
- ❑ Started the Comp Arch Research Group @ Microsoft Research, 2006-2009
- ❑ Worked @ Google, VMware, Microsoft Research, Intel, AMD
- ❑ PhD in Computer Engineering from University of Texas at Austin in 2006
- ❑ BS in Computer Engineering & Psychology from University of Michigan in 2000
- ❑ <https://people.inf.ethz.ch/omutlu/> omutlu@gmail.com

■ Research and Teaching in:

- ❑ **Computer architecture, systems, hardware security, bioinformatics**
- ❑ Memory and storage systems
- ❑ Robust & dependable hardware systems: security, safety, predictability, reliability
- ❑ Hardware/software cooperation
- ❑ New computing paradigms; architectures with emerging technologies/devices
- ❑ Architectures for bioinformatics, genomics, health, medicine, AI/ML
- ❑ ...

Lecturers



Mohammed Alser

Senior Researcher and
Lecturer

Bioinformatics | Computational
Genomics | Hardware/Software
Cooperation |
Specialized/Heterogeneous
Computing Systems | Processing-
in-Memory



@mealser



Juan Gómez Luna

Senior Researcher and
Lecturer

Processing-In-Memory |
Heterogeneous computing |
Memory Systems | Bioinformatics |
Medical imaging

Course Info: Who Are We?

■ Teaching Assistants

- Dr. Mohammad Sadrosadati,
- Rahul Bera,
- João Dinis Ferreira,
- Geraldo Francisco De Oliveira Junior,
- Can Firtina,
- Konstantinos Kanellopoulos,
- Nika Mansouri Ghiasi,
- Abdullah Giray Yaglikci,
- Rakesh Nadig,
- Joël Lindegger,
- Ataberk Olgun,
- Nisa Bostanci,
- Yahya Can Tugrul,
- Haocong Luo,
- Banu Cavlak,
- Aditya Manglik

- Get to know them and their research as they will be your mentors
<https://safari.ethz.ch/group-members/>

Course Requirements and Expectations

- Attendance required for all meetings
- Each student presents one paper
 - Prepare for presentation with engagement from the mentor
 - Full presentation + questions + discussion
- Non-presenters participate during the meeting
 - Ask questions, contribute thoughts/ideas
 - Better if you read/skim the paper beforehand
- Non-presenters take an online short quiz after each session
 - 5 MCQs for each presentation (1 Full day to submit)
- Everyone comments on papers in the online review system
 - After presentation
- Write synthesis report at the end of semester
 - (sample synthesis report online)

Course Website

- https://safari.ethz.ch/architecture_seminar/fall2022
- All course materials to be posted
- Plus other useful information for the course
- Check frequently for announcements and due dates



Moodle

- <https://moodle-app2.let.ethz.ch/course/view.php?id=18460>
- Check frequently for:
 - Announcements and due dates
 - Quizzes
 - Paper discussion
 - Assignment submissions



Homework 0: Student Information

- Due September 26
- https://safari.ethz.ch/architecture_seminar/doku.php?id=homework
- Information about yourself
- All future grading is predicated on homework 0
- If it is not submitted on time, we cannot schedule you for a presentation.



Homework 1: Analyzing a PhD defense

- Due October 6
- https://safari.ethz.ch/architecture_seminar/doku.php?id=homework
- Write a short summary of the PhD defense
- It is mandatory to attend the defense presentation



Paper Review Preferences

- Due TBD
- Check the website and Moodle for instructions
- If it is not submitted on time, we cannot schedule you for a presentation.

How to Deliver a Good Talk

Anatomy of a Good Paper Review (Talk)

- 0: Title, Authors, Venue
- 1: Summary
 - What is the problem the paper is trying to solve?
 - What are the key ideas of the paper? Key insights?
 - What are the key mechanisms? What is the implementation?
 - What are the key results? Key conclusions?
- 2: Strengths (most important ones)
 - Does the paper solve the problem well? Is it well written? ...
- 3: Weaknesses (most important ones)
 - This is where you should **think critically**. Every paper/idea has a weakness. This does not mean the paper is necessarily bad. It means there is room for improvement and future research can accomplish this.
- 4: Thoughts/Ideas: Can you do better? Present your ideas.
- 5: Takeaways: What you learned/enjoyed/disliked? Why?
- 6: Discussion starters and questions.
- Review should be short and concise (20 minutes or < one page)

An Example of Executive Summary

Executive Summary

Motivation:

- Repeatedly **toggle a DRAM row's wordline voltage** causes bit flips in nearby rows
- This vulnerability, **RowHammer**, **worsens in denser DRAM chips**
- Understanding RowHammer enables designing **effective and efficient solutions**

Problem: No study demonstrates how **wordline voltage (VPP)** affects RowHammer

Goal: Experimentally understand how **VPP** affects **RowHammer** and **DRAM operation**

Experimental study: **272 DRAM chips** from **three major DRAM manufacturers**

VPP's effect on RowHammer: *Six observations* show that with reduced VPP,

- **Bit error rate** caused by a RowHammer attack reduces by **15.2% (66.9% max)**
- A row needs to be activated **7.4% more times (85.8% max)** to induce the first bit flip

VPP's effect on DRAM operation: *Nine observations* show that with reduced VPP,

- **208 out of 272** tested DRAM chips **reliably operate** using nominal timing parameters
- Erroneous DRAM chips can reliably operate with
 - **A longer row activation latency**, i.e., 24ns/15ns for 48/16 chips,
 - **Single-error-correcting codes** or **2x the refresh rate** *only for* 16.4% of rows

Conclusion: Reducing wordline voltage can **reduce RowHammer vulnerability** *without* significantly affecting **reliable DRAM operation**

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Another Example of Executive Summary

Executive Summary

Problem: DRAM on-die ECC **complicates** third-party reliability studies

- **Proprietary** design **obfuscates** raw bit errors in an **unpredictable** way
- **Interferes** with (1) design, (2) test & validation, and (3) characterization

Goal: understand **exactly how** on-die ECC obfuscates errors

Contributions:

1. **BEER:** new testing methodology that determines a DRAM chip's **unique on-die ECC function** (i.e., its parity-check matrix)
 - Exploits **ECC-function-specific** uncorrectable error patterns
 - Requires no hardware support, inside knowledge, or metadata access
2. **BEEP:** new error profiling methodology that infers the **raw bit error locations** of error-prone cells from the **observable uncorrectable errors**

BEER Evaluations:

- Apply BEER to 80 real LPDDR4 chips from 3 major DRAM manufacturers
- Show correctness in simulation for 115,300 codes (4-247b ECC words)

We hope BEER and BEEP enable valuable studies in the future

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Suggested Paper Discussion Format

- Problem & Goal
- Key Ideas/solution
- Novelty
- Mechanisms & Implementation
- Major Results
- Takeaways/Conclusions

**~20-25 minute
Summary**

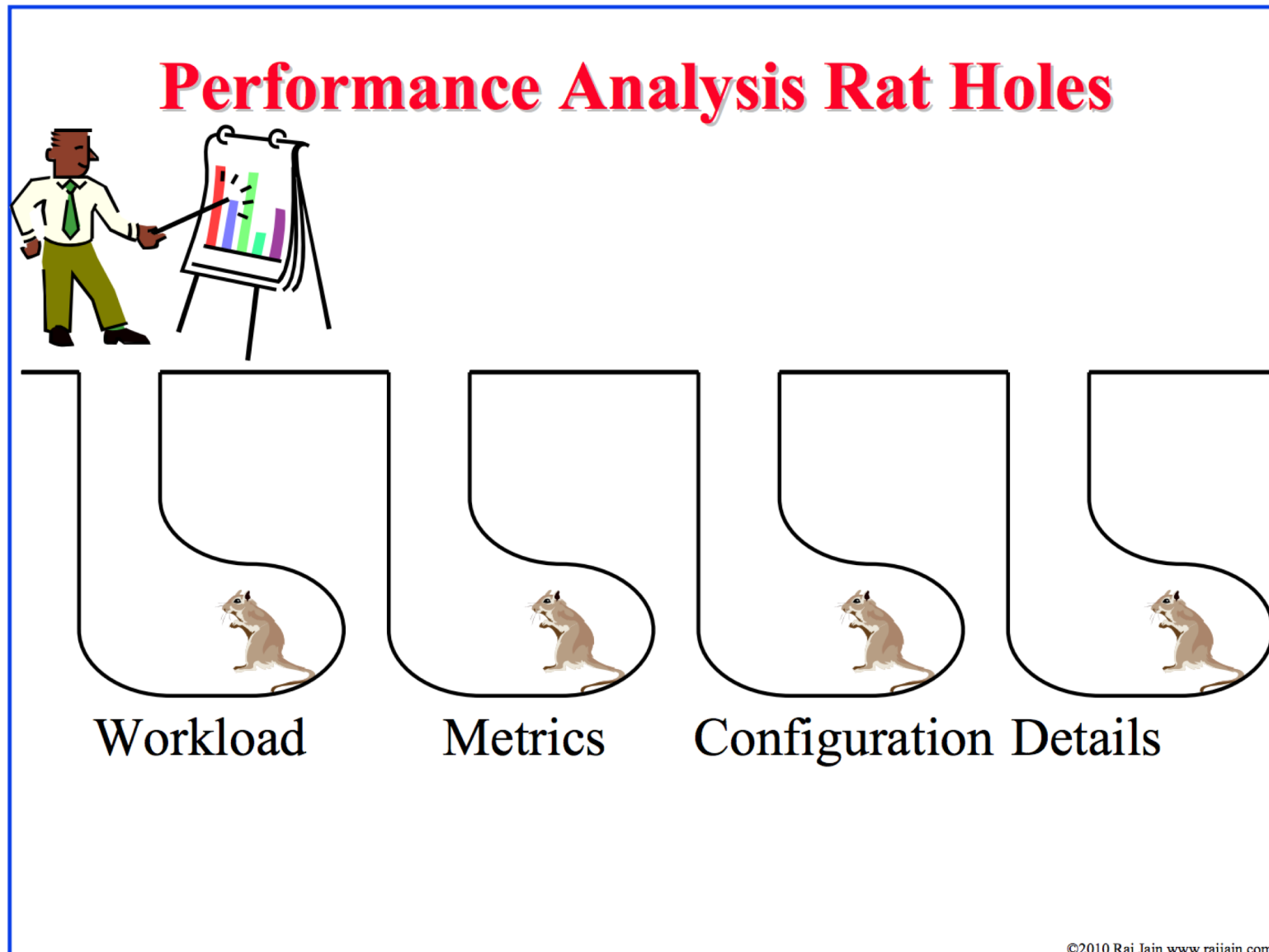
- Strengths
- Weaknesses
- Alternatives
- New ideas/problems
- Brainstorming and Discussion

**~10 min Critique
plus
~15 min Discussion**

More Advice on Paper Review/Talk

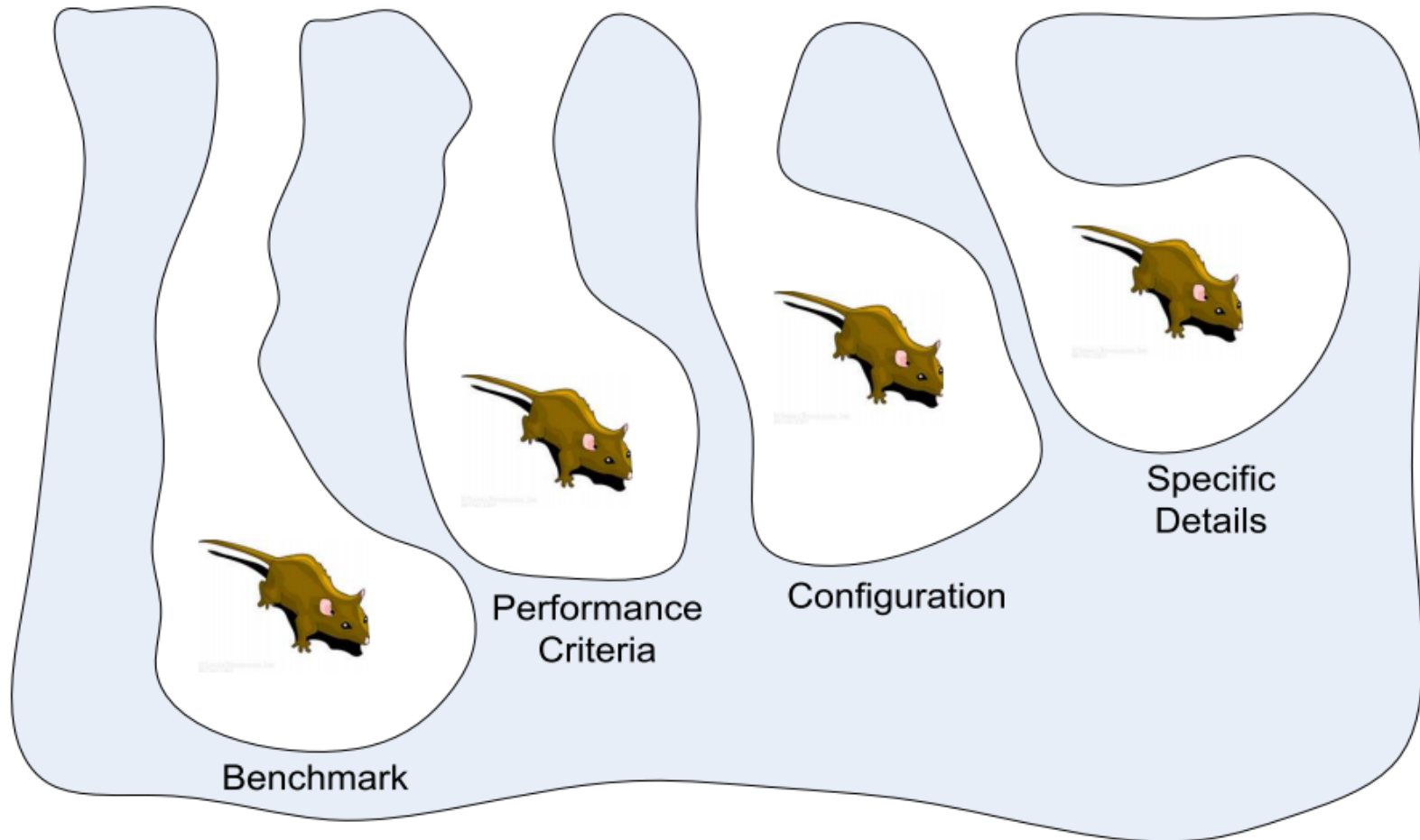
- When doing the paper reviews and analyses, be very critical
- Always think about better ways of solving the problem or related problems
 - Question the problem as well
 - Read background papers (both past and future)
- This is how things progress in science and engineering (or anywhere), and how you can make big leaps
 - By critical analysis
- A few sample text reviews provided online

Try to Avoid Rat Hole Discussions

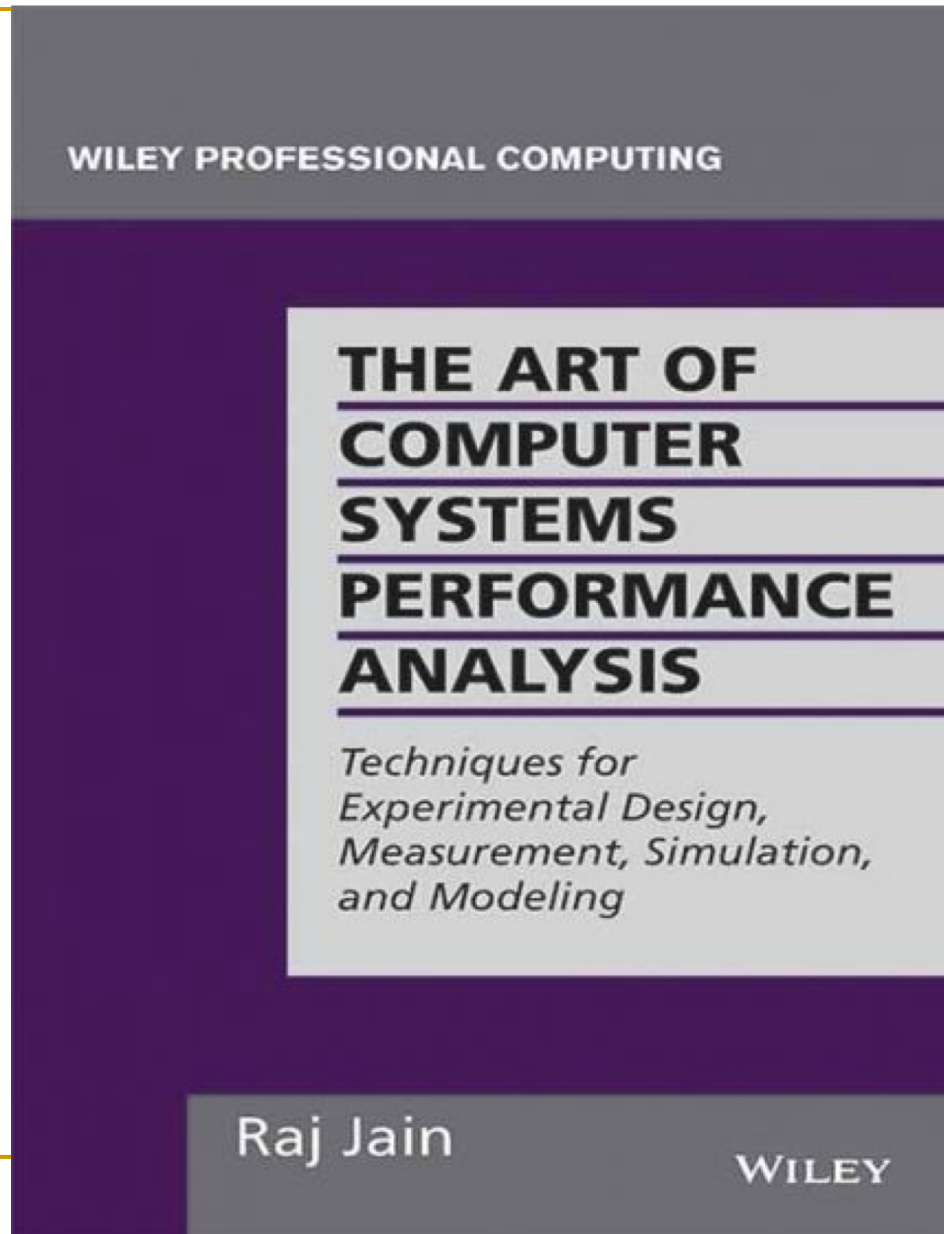


Try to Avoid Rat Hole Discussions

Performance Analysis Rat Holes



Aside: A Recommended Book



Raj Jain, "[The Art of Computer Systems Performance Analysis](#)," Wiley, 1991.

10.8 DECISION MAKER'S GAMES

Even if the performance analysis is correctly done and presented, it may not be enough to persuade your audience—the decision makers—to follow your recommendations. The list shown in Box 10.2 is a compilation of reasons for rejection heard at various performance analysis presentations. You can use the list by presenting it immediately and pointing out that the reason for rejection is not new and that the analysis deserves more consideration. Also, the list is helpful in getting the competing proposals rejected!

There is no clear end of an analysis. Any analysis can be rejected simply on the grounds that the problem needs more analysis. This is the first reason listed in Box 10.2. The second most common reason for rejection of an analysis and for endless debate is the workload. Since workloads are always based on the past measurements, their applicability to the current or future environment can always be questioned. Actually workload is one of the four areas of discussion that lead a performance presentation into an endless debate. These “rat holes” and their relative sizes in terms of time consumed are shown in Figure 10.26. Presenting this cartoon at the beginning of a presentation helps to avoid these areas.

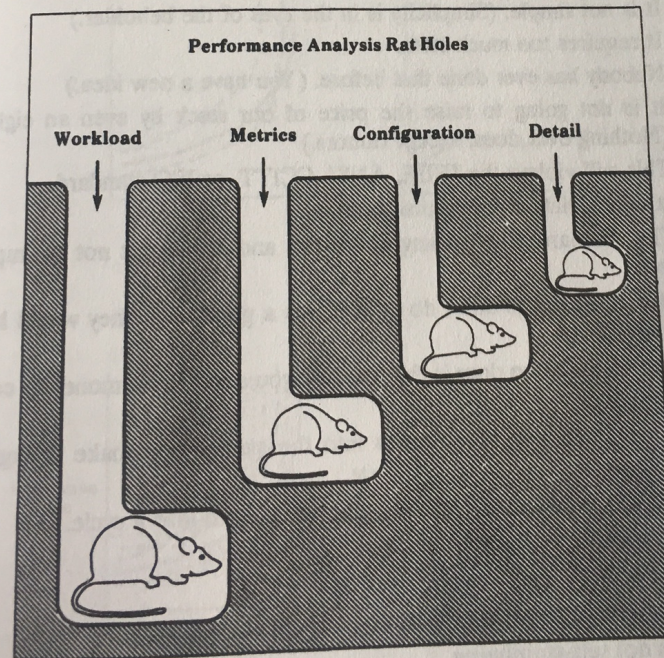


FIGURE 10.26 Four issues in performance presentations that commonly lead to endless discussion.

Raj Jain, "The Art of Computer Systems Performance Analysis," Wiley, 1991.

Box 10.2 Reasons for Not Accepting the Results of an Analysis

1. This needs more analysis.
2. You need a better understanding of the workload.
3. It improves performance only for long I/O's, packets, jobs, and files, and most of the I/O's, packets, jobs, and files are short.
4. It improves performance only for short I/O's, packets, jobs, and files, but who cares for the performance of short I/O's, packets, jobs, and files; its the long ones that impact the system.
5. It needs too much memory/CPU/bandwidth and memory/CPU/bandwidth isn't free.
6. It only saves us memory/CPU/bandwidth and memory/CPU/bandwidth is cheap.
7. There is no point in making the networks (similarly, CPUs/disks/...) faster; our CPUs/disks (any component other than the one being discussed) aren't fast enough to use them.
8. It improves the performance by a factor of x , but it doesn't really matter at the user level because everything else is so slow.
9. It is going to increase the complexity and cost.
10. Let us keep it simple stupid (and your idea is not stupid).
11. It is not simple. (Simplicity is in the eyes of the beholder.)
12. It requires too much state.
13. Nobody has ever done that before. (You have a new idea.)
14. It is not going to raise the price of our stock by even an eighth. (Nothing ever does, except rumors.)
15. This will violate the IEEE, ANSI, CCITT, or ISO standard.
16. It may violate some future standard.
17. The standard says nothing about this and so it must not be important.
18. Our competitors don't do it. If it was a good idea, they would have done it.
19. Our competition does it this way and you don't make money by copying others.
20. It will introduce randomness into the system and make debugging difficult.
21. It is too deterministic; it may lead the system into a cycle.
22. It's not interoperable.
23. This impacts hardware.
24. That's beyond today's technology.
25. It is not self-stabilizing.
26. Why change—it's working OK.

Raj Jain, "The Art of Computer Systems Performance Analysis," Wiley, 1991.

More Advice on Talks

- Kayvon Fatahalian, “Tips for Giving Clear Talks”
 - <http://graphics.stanford.edu/~kayvonf/misc/cleartalktips.pdf>
 - Many useful and simple principles here

“Every sentence matters”

“The audience prefers not to think” (about things you can just tell them)

**“Surprises are bad”: say why before what
(indicate why you are saying something before you say it)**

Explain every figure, graph, or equation

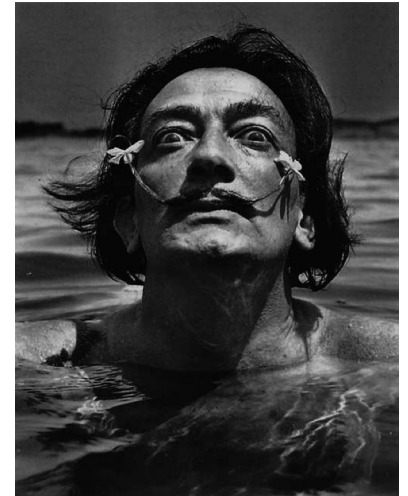
When improving the talk, the audience is always right

Who Painted This Painting?



Salvador Dali @ 1924

What About This?



Salvador Dali @ 1937

Takeaway

Learn the basic principles

before you can

consciously choose to break them

Seminar Talk Examples

Past Seminar Presentation and Discussion

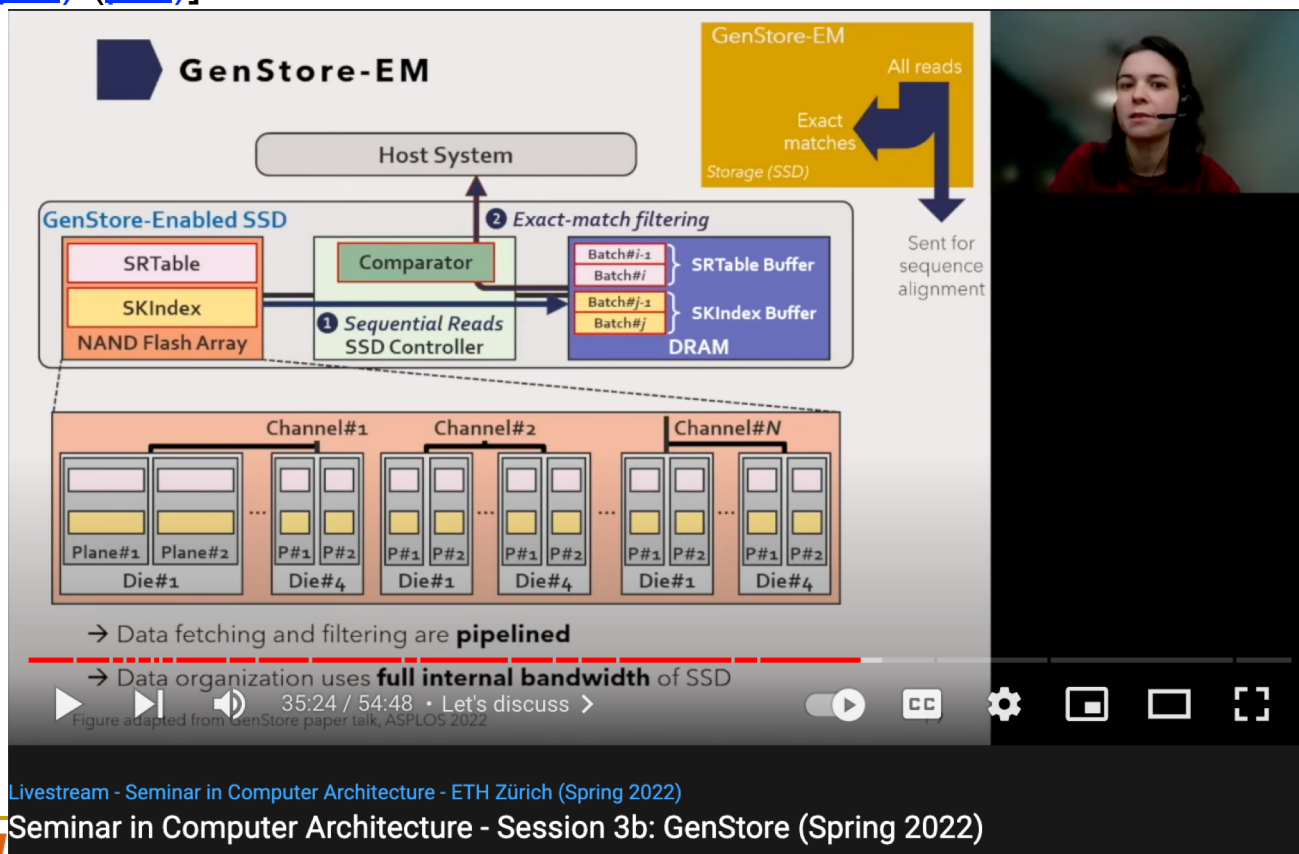
Jennifer Schmitz

[GenStore: a high-performance in-storage processing system for genome sequence analysis, ASPLOS 2022](#)

Session 3.2: Seminar in Computer Architecture – Spring 2022,

[\[Talk Video\]](#) (54 minutes including discussion)

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



Livestream - Seminar in Computer Architecture - ETH Zürich (Spring 2022)

Seminar in Computer Architecture - Session 3b: GenStore (Spring 2022)

Past Seminar Presentation and Discussion

Yanick Schimpf

[SISA: Set-Centric Instruction Set Architecture for Graph Mining on Processing-in-Memory Systems, MICRO 2021](#)

Session 1.2: Seminar in Computer Architecture – Spring 2022,

[\[Talk Video\]](#) (60 minutes including discussion)

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

Expressiveness

Complex Problems Simple Problems

Abstraction or programming model	A?	Pattern M.	Learning	"Low-c."	Remarks															
	m	e	s	i	v	s	l	p	e	l	a	v	t	c	b	f	c	c	p	r
Vertex-centric (ver-c)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Edge-centric (edge-c)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Array maps	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
GraphBLAS [90]	Ⓛ	Ⓛ	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Neural message passing, graph networks [13, 62]	Ⓛ	Ⓛ	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pattern matching	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Joins [36]	Ⓡ	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Set-Centric / SISA	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ	Ⓢ

Level of support provided

Compared programming models

SISA is only model that provides support for all complex problems

Ataberk Olgun...

1:24:48 / 2:02:44

Livestream - Seminar in Computer Architecture - ETH Zürich (Spring 2022)

Seminar in Computer Architecture - Session 1: A Logic-in-Memory Computer & SISA (Spring 2022)

Past Seminar Presentation

Sofie Daniels

[BlockHammer: Preventing RowHammer at Low Cost by Blacklisting Rapidly-Accessed DRAM Rows, HPCA 2021,](#)

Session 1.2: Seminar in Computer Architecture - Spring 2021,

[\[Talk Video\]](#) (34 minutes excluding discussion)

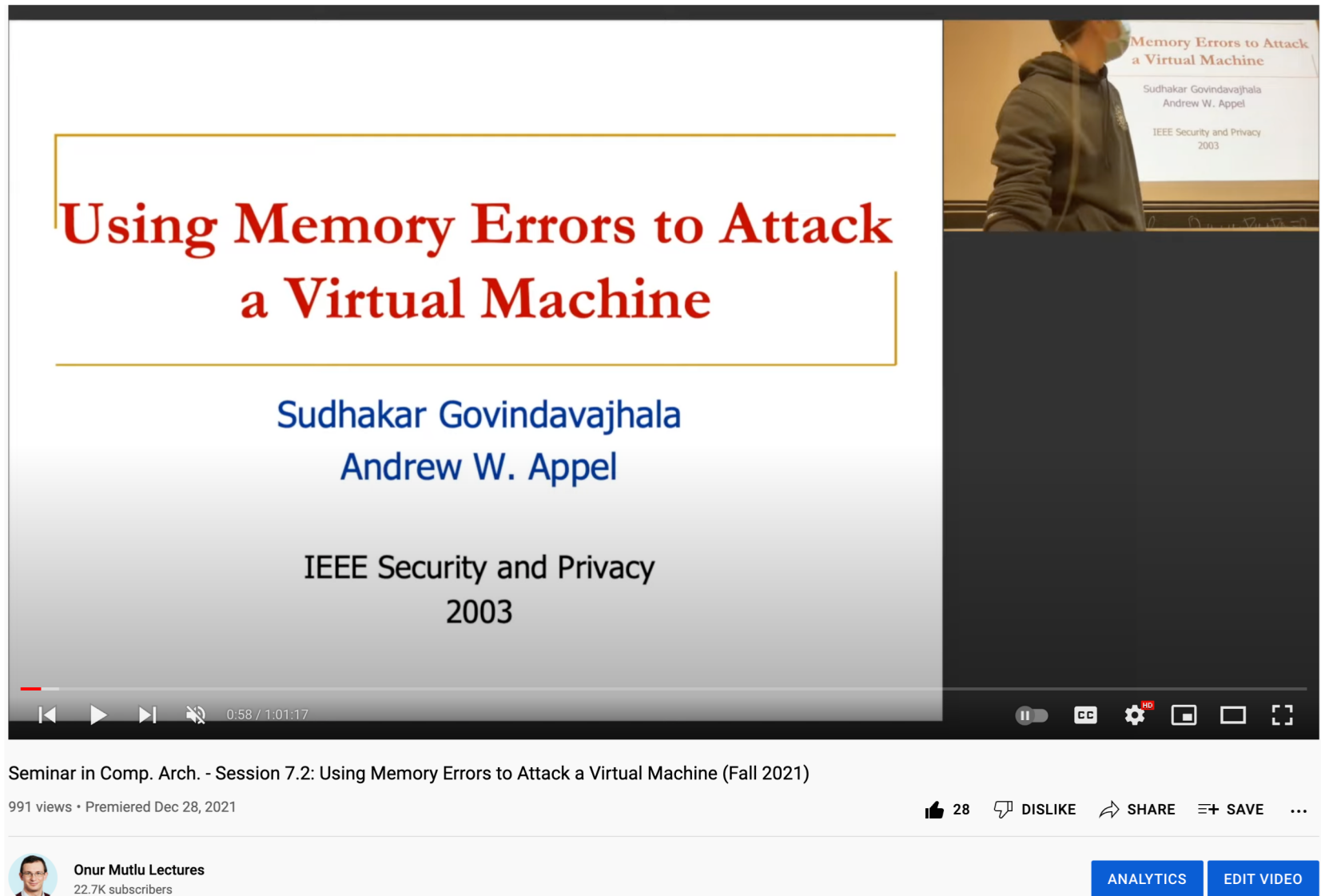
[Slides ([pptx](#)) ([pdf](#))]

The screenshot shows a video player interface with a presentation slide titled "DRAM & RowHammer". The slide content includes:

- A target icon in the top left corner.
- A diagram of a "DRAM Bank" showing a grid of cells with "Row Decoder", "Bitline", "Wordline", "DRAM Row", and "Row Buffer" labels.
- A text box stating: "Cause: memory density scaling" with sub-points "↓ DRAM cell size" and "↓ cell-to-cell spacing".
- A red text box defining "RowHammer": "rapidly activating (opening) and precharging (closing) DRAM row can cause bit-flips in nearby rows".
- A visual of a hammer striking a grid of DRAM cells, with a lightning bolt labeled V_{high} indicating the voltage applied to the row.
- A video player control bar at the bottom showing a progress bar at 4:29 / 34:11 and various control icons.

Seminar in Computer Architecture - Session 1.2: BlockHammer (ETH Zürich, Spring 2021)

Past Seminar Presentation and Discussion



The image shows a YouTube video player with a presentation slide. The slide has a white background with a yellow border. The title "Using Memory Errors to Attack a Virtual Machine" is in large red font. Below it, the authors "Sudhakar Govindavajhala" and "Andrew W. Appel" are listed in blue. At the bottom, "IEEE Security and Privacy 2003" is written in black. The video player interface includes a progress bar at 0:58 / 1:01:17, a play button, and a volume icon. The video title "Seminar in Comp. Arch. - Session 7.2: Using Memory Errors to Attack a Virtual Machine (Fall 2021)" is displayed below the player, along with "991 views • Premiered Dec 28, 2021". The channel name "Onur Mutlu Lectures" with "22.7K subscribers" is shown on the left. On the right, there are buttons for "ANALYTICS" and "EDIT VIDEO".

Using Memory Errors to Attack a Virtual Machine

Sudhakar Govindavajhala
Andrew W. Appel

IEEE Security and Privacy
2003

Seminar in Comp. Arch. - Session 7.2: Using Memory Errors to Attack a Virtual Machine (Fall 2021)

991 views • Premiered Dec 28, 2021

Onur Mutlu Lectures
22.7K subscribers

ANALYTICS EDIT VIDEO

Past Seminar Presentation and Discussion

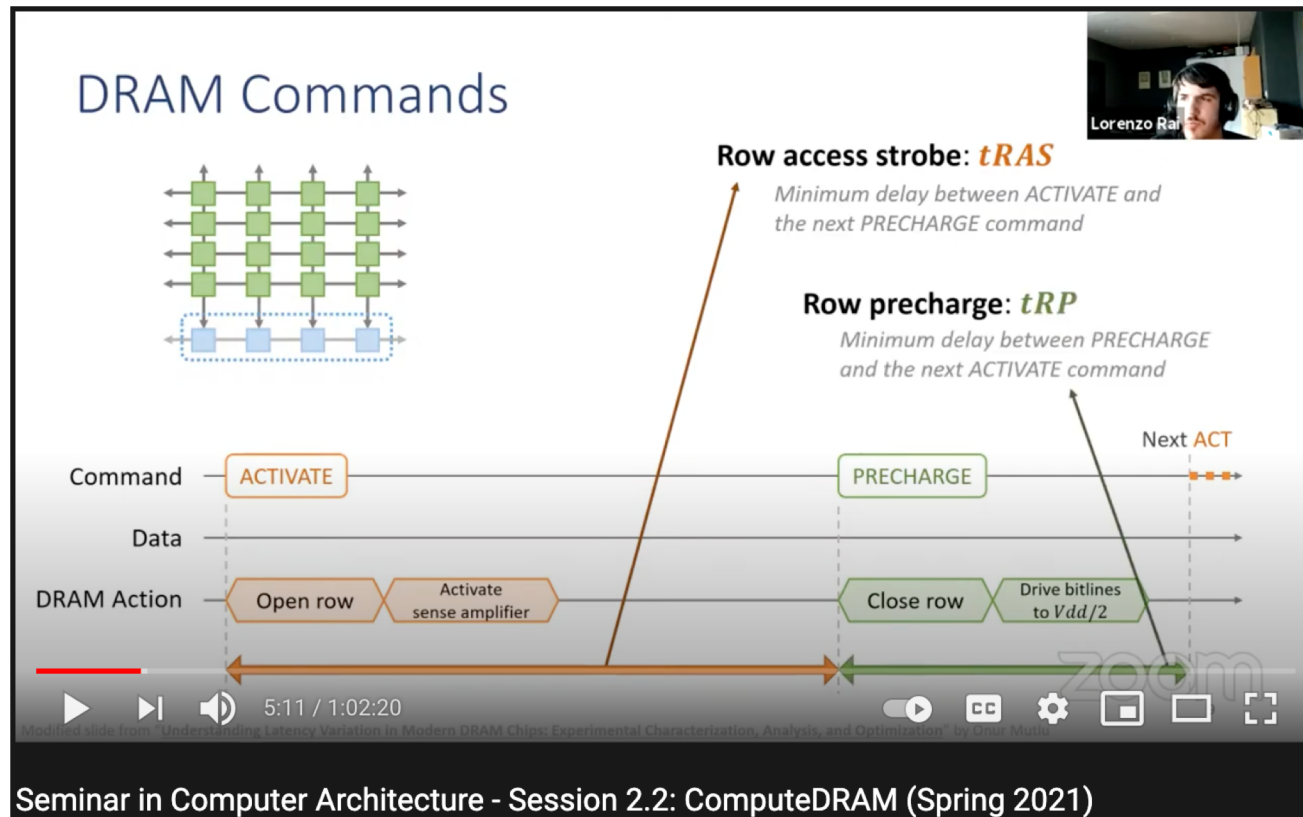
Lorenzo Rai

[ComputeDRAM: In-Memory Compute Using Off-the-Shelf DRAMs, MICRO 2019](#)

Session 1.2: Seminar in Computer Architecture - Spring 2021,

[\[Talk Video\]](#) (62 minutes including discussion)

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



Past Example Reviews

[List of example reviews]:

https://safari.ethz.ch/architecture_seminar/spring2022/doku.php?id=schedule

[List of YouTube videos]:

https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_hxizriwKmFHgcoe2Q8-m0



Seminar in Computer Architecture - Spring 2022

Rec

Trace: • [buzzwords](#) • [readings](#) • [sessions](#) • [papers](#) • [synthesis_report](#) • [homework](#) • [announcements](#) • [sidebar](#) • [schedule](#) • [start](#)

Home

Materials

- [Announcements](#)
- [Lectures/Schedule](#)
- [Lecture Buzzwords](#)
- [Readings](#)
- [Sessions](#)
- [Papers](#)
- [Synthesis Report](#)
- [Homework](#)

Past Course Materials

- [Fall 2021](#)
- [Spring 2021](#)
- [Fall 2020](#)
- [Spring 2020](#)
- [Fall 2019](#)
- [Spring 2019](#)

Seminar in Computer Architecture – Spring 2022 (227-2211-00L)

Welcome to the wiki for Seminar in Computer Architecture for Spring 2022

Edit

Announcements

[Latest announcements](#)

Edit

Lectures

Thursday, 16:15-18:00. This is the second time during the pandemic to have a h
hope it is still a safe and fruitful option.

Online Teaching

Other Example Presentations & Discussions

























[List of example reviews]:

https://safari.ethz.ch/architecture_seminar/spring2022/doku.php?id=schedule

[List of YouTube videos]:

https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_hxizriwKmFHgcoe2Q8-m0

Spring 2022 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Assignments
W1	24.02 Thu.	 	L1a: Course Logistics  (PDF)  (PPT)	Suggested	
			L1b: Introduction and Basics  (PDF)  (PPT)	Suggested	
			L1c: Architectural Design Fundamentals  (PDF)  (PPT)		
W2	03.03 Thu.	 	L2: Memory-Centric Computing  (PDF)  (PPT)		
W3	10.03 Thu.	 	L3: Memory-Centric Computing II  (PDF)  (PPT)		
W4	17.03 Thu.	 	L4: Memory-Centric Computing III  (PDF)  (PPT)		
W5	24.03 Thu.	 	L5: Accelerating Genome Analysis  (PDF)  (PPT)		



Livestream - Seminar in Computer Architecture - ETH Zürich (Spring 2022)

13 videos • 518 views • Last updated on Sep 5, 2022



Onur Mutlu's livestream lecture videos from the Seminar in Computer Architecture course taught at ETH Zürich in Spring 2022.

Course website including all slides and assignments:

https://safari.ethz.ch/architecture_s...




Onur
Mutlu
Lectures

SUBSCRIBED




1



Seminar in Computer Architecture - Lecture 1: Introduction and Basics (Spring 2022)

Onur Mutlu Lectures


2



Seminar in Computer Architecture - Lecture 2: Memory-Centric Computing (Spring 2022)

Onur Mutlu Lectures


3



Seminar in Computer Architecture - Lecture 3: Memory-Centric Computing II (Spring 2022)

Onur Mutlu Lectures


4



Seminar in Computer Architecture - Lecture 4: Memory-Centric Computing III (Spring 2022)

Onur Mutlu Lectures


5



Seminar in Computer Arch. - Lecture 5: Accelerating Genome Analysis (Spring 2022)

Onur Mutlu Lectures

6



Seminar in Computer Arch. - Lecture 6: Rethinking Virtual Memory (Spring 2022)

Onur Mutlu Lectures

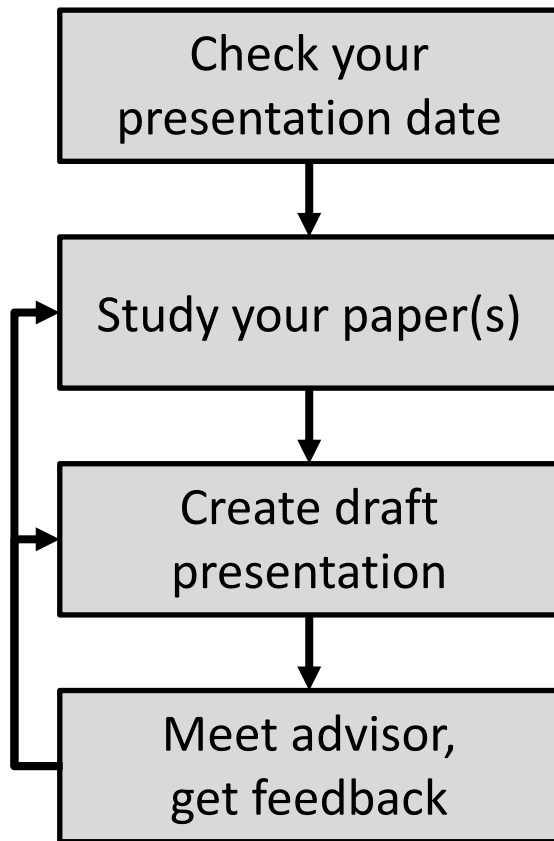
How to Participate

How to Make the Best Out of This?

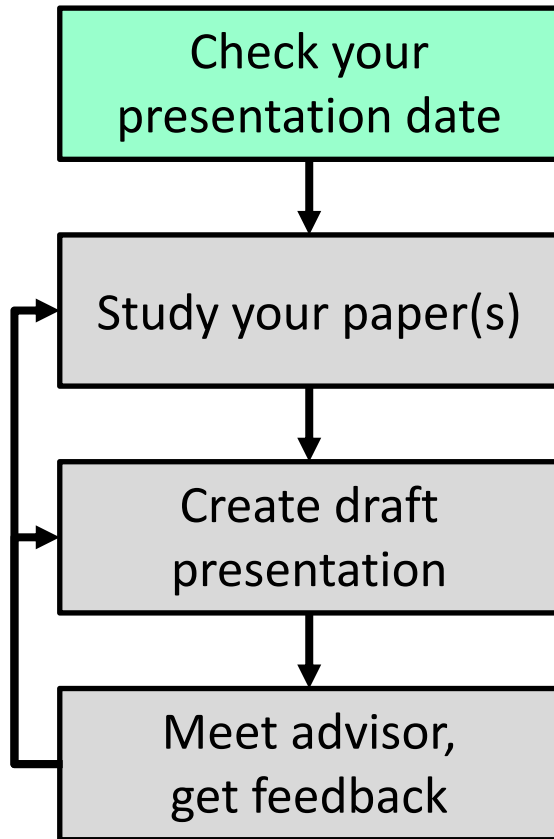
- Come prepared → Read and critically evaluate the paper
- Think new ideas
- Bring discussion points and questions; read other papers
- Be critical
- Brainstorm – be open to new ideas
- Pay attention and discuss+contribute
- Participate online before and after each meeting

Guided Talk Preparation

Preparing a Talk

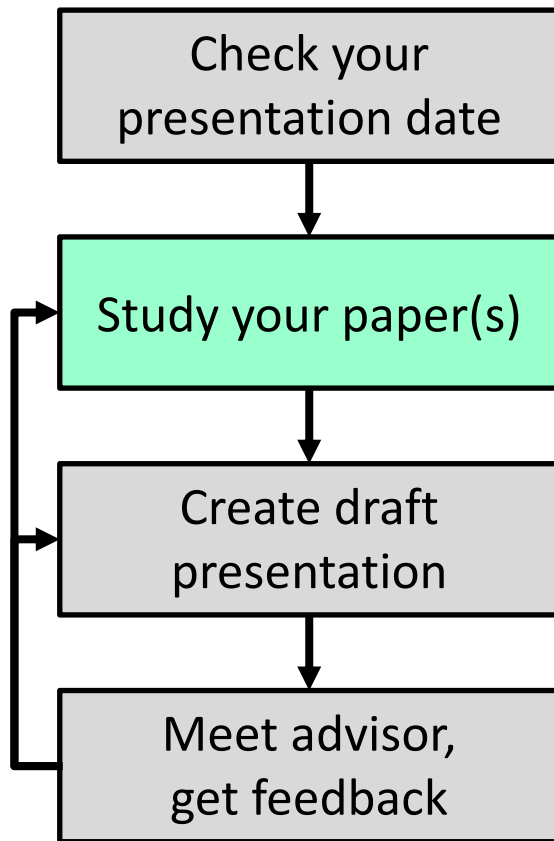


Preparing a Talk: Start Early



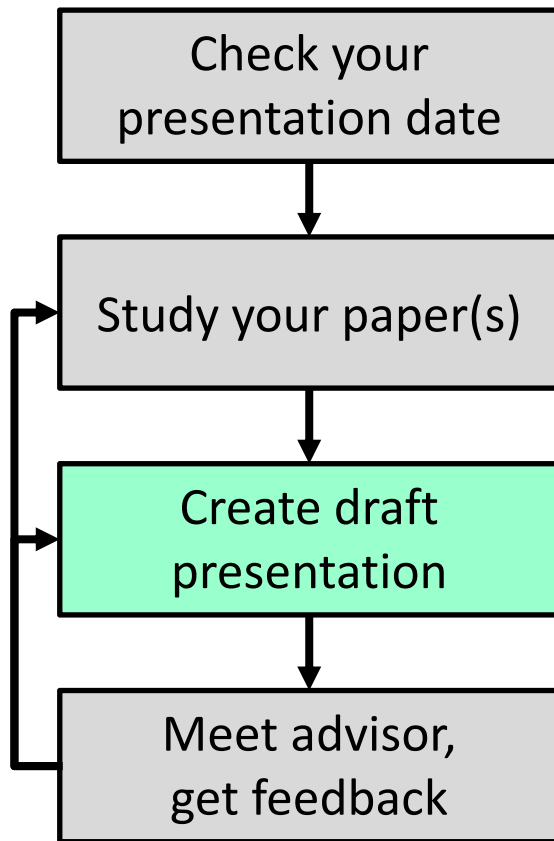
- Preparing a good presentation takes time
- Start early!

Preparing a Talk: Study Paper



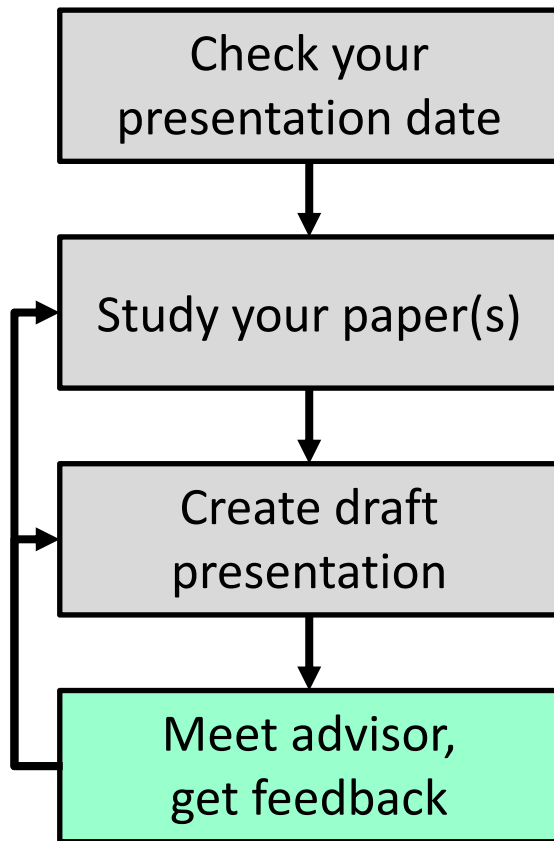
- 3 'C's of reading
 - ❑ *Carefully*: look up terms, possibly read cited papers
 - ❑ *Critically*: find limitations, flaws
 - ❑ *Creatively*: think of improvements
- Try examples by hand
- Try tools if available
- Consult with TA if questions

Preparing a Talk: Create Draft



- Explain the motivation for the work
- Clearly present the technical solution and results
 - Include a demo if appropriate
- Outline limitations or improvements
- Focus on the key concepts
 - Do not present all of the details

Preparing a Talk: Get Feedback



- Prepare for the meeting
 - Schedule early
 - Send slides in advance
 - Write down questions
- Make sure you address feedback
 - Take notes
- Meetings are mandatory!
 - At least one week before the talk
 - Two meetings

Grading and Feedback

Grading Rubric

- Quality of your presentation (60%)
 - ❑ How well did you understand the material?
 - ❑ How well did you present it?
 - ❑ How well did you answer the questions?
 - ❑ Be prepared to explain technical terms
 - ❑ **We will take into account** the difficulty of the paper and the time you had to prepare.
- Quality of the final synthesis paper (30%)
 - ❑ How well did you understand some of the papers presented during the seminar?
- Attendance & Quizzes (10%)
- Participation (during class and online) (BONUS 10%)
 - ❑ Did you ask good questions?
 - ❑ Did you participate and contribute to the discussion?

Feedback

- We will try to (briefly) discuss strengths/weaknesses of your talk in class
 - Let us know upfront if you would prefer **not** to
- You can arrange a meeting with your TA to get feedback

Expected Schedule

Schedule

- We will meet once a week, with two presentations per session
 - *Next meeting is next week*
 - *Your presentations start on 13 October*
 - 22 presentations in total
 - Each presentation: 50 minutes including questions & discussion
- Paper assignment
 - Will be done online
 - Study the list of papers
 - **Check your email** and be responsive

Homework 0: Student Information

- Due September 26
- https://safari.ethz.ch/architecture_seminar/doku.php?id=homework
- Information about yourself
- All future grading is predicated on homework 0
- If it is not submitted on time, we cannot schedule you for a presentation.



Homework 1: Analyzing a PhD defense

- Due October 6
- https://safari.ethz.ch/architecture_seminar/doku.php?id=homework
- Write a short summary of the PhD defense
- It is mandatory to attend the defense presentation



Paper Review Preferences

- Due TBD
- Check the website and Moodle for instructions
- If it is not submitted on time, we cannot schedule you for a presentation.

Why Taking The Course?

Response #1 from Spring 2022

- Computer architecture is, well, for the most part, pretty fun. I wanted to get a bit of a feeling for what the **current state of the field** is.
Also, I wanted to take part in a course where the **students actively participate**. It's interesting to hear **how different people think about the same issue**, you can learn a lot by listening.
- You can also learn a lot by catching yourself saying something nonsensical or by not understanding something really obvious. I had a couple of opportunities to experience both in this course :')

Response #2 from Spring 2022

- My two favorite subjects so far were 'Digital Design and Computer Architecture' and 'Systems Programming and Computer Architecture', but in our 4th semester there is no related subject.
- Taking this seminar this semester allowed me to **learn more about computer architecture** next to my other courses and help me decide if I want to choose related advanced courses in the third year and **put my study focus on computer architecture. I do ;-)**

Response #3 from Spring 2022

- I took a quick look into the first assignment of the course and my two motivations were my interest in Computer Architecture and the desire to learn more about current research in the field.
- Secondly I wanted to seize an opportunity to start doing some research if there is one. The seminar and I achieved both of these goals, so to conclude I consider the course a great success.

How to Approach This Course?

How to Approach This Course

“Formative Experience”

How to Approach This Course

“Reading and analyzing papers will help us a lot into the future”

How to Approach This Course

“High investment,
high return”

How to Approach This Course

“Guidance from
3 top researchers
in the field”

How to Approach This Course

“I would definitely
recommend
this course”

How to Approach This Course

“I really love
Computer Architecture”

How to Approach This Course

Learning experience

Long-term tradeoff
analysis

Critical thinking &
decision making

Synergistic Activities

A Talk on Impactful Growth



The video player shows a presentation slide with the title "Applying to Grad School & Doing Impactful Research" in a green serif font, enclosed in a thin gold border. Below the title, the speaker's name "Onur Mutlu" is listed, followed by his email "omutlu@gmail.com" and his website "https://people.inf.ethz.ch/omutlu". The date "13 June 2020" and the event "Undergraduate Architecture Mentoring Workshop @ ISCA 2021" are also displayed. At the bottom of the slide, the logos for "SAFARI", "ETH zürich", and "Carnegie Mellon" are shown. The video player interface includes a progress bar at 0:27 / 50:31, a small video feed of the speaker in the top right corner, and a bottom bar with engagement metrics (74 likes, 1 comment), share and save buttons, and a three-dot menu. The channel name "Onur Mutlu Lectures" with 17.2K subscribers is visible, along with a description of the panel talk at the ISCA 2021 workshop.

Applying to Grad School
& Doing Impactful Research

Onur Mutlu
omutlu@gmail.com
<https://people.inf.ethz.ch/omutlu>
13 June 2020
Undergraduate Architecture Mentoring Workshop @ ISCA 2021

SAFARI ETH zürich Carnegie Mellon

Arch. Mentoring Workshop @ISCA'21 - Applying to Grad School & Doing Impactful Research - Onur Mutlu
1,563 views • Premiered Jun 16, 2021

Onur Mutlu Lectures
17.2K subscribers

Panel talk at Undergraduate Architecture Mentoring Workshop at ISCA 2021
(<https://sites.google.com/wisc.edu/uar...>)

An Interview on Computing Futures



Interview with Onur Mutlu @ ISCA 2019 on computing research & education (after Maurice Wilkes Award)

6,749 views • Oct 19, 2019

👍 195 🗨️ 0 ➦ SHARE ➦ SAVE ...



Onur Mutlu Lectures
19.1K subscribers

ANALYTICS

EDIT VIDEO

<https://www.youtube.com/watch?v=8ffSEKZhmvo>

Short Video on SAFARI Research Group



SAFARI Research Group: Introduction & Research -- ETH Future Computing Laboratory Talk - Onur Mutlu

529 views • Premiered Jan 15, 2022

👍 20 🗨 DISLIKE ➦ SHARE ≡+ SAVE ...



Onur Mutlu Lectures
22.7K subscribers

ANALYTICS

EDIT VIDEO

<https://www.youtube.com/watch?v=mSr1QQmYuX0>

Research & Teaching: Some Overview Talks

<https://www.youtube.com/onurmutlulectures>

■ Future Computing Architectures

- https://www.youtube.com/watch?v=kgiZISOcGFM&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=1

■ Enabling In-Memory Computation

- https://www.youtube.com/watch?v=njX_14584Jw&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=16

■ Accelerating Genome Analysis

- https://www.youtube.com/watch?v=r7sn41IH-4A&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=41

■ Rethinking Memory System Design

- https://www.youtube.com/watch?v=F7xZLNMIY1E&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=3

■ Intelligent Architectures for Intelligent Machines

- https://www.youtube.com/watch?v=c6_LgzuNdkw&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=25

■ The Story of RowHammer

- https://www.youtube.com/watch?v=sgd7PHQQ1AI&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBjI&index=39

An Interview on Research and Education

- **Computing Research and Education (@ ISCA 2019)**
 - https://www.youtube.com/watch?v=8ffSEKZhmvo&list=PL5Q2soXY2Zi_4oP9LdL3cc8G6NIjD2Ydz

- **Maurice Wilkes Award Speech (10 minutes)**
 - https://www.youtube.com/watch?v=tcQ3zZ3JpuA&list=PL5Q2soXY2Zi8D_5MGV6EnXEJHnV2YFBJI&index=15

More Thoughts and Suggestions

- Onur Mutlu,
["Some Reflections \(on DRAM\)"](#)
*Award Speech for [ACM SIGARCH Maurice Wilkes Award](#), at the **ISCA** Awards Ceremony, Phoenix, AZ, USA, 25 June 2019.*
[\[Slides \(pptx\) \(pdf\)\]](#)
[\[Video of Award Acceptance Speech \(Youtube; 10 minutes\) \(Youku; 13 minutes\)\]](#)
[\[Video of Interview after Award Acceptance \(Youtube; 1 hour 6 minutes\) \(Youku; 1 hour 6 minutes\)\]](#)
[\[News Article on "ACM SIGARCH Maurice Wilkes Award goes to Prof. Onur Mutlu"\]](#)

 - Onur Mutlu,
["How to Build an Impactful Research Group"](#)
*[57th Design Automation Conference Early Career Workshop \(**DAC**\)](#), Virtual, 19 July 2020.*
[\[Slides \(pptx\) \(pdf\)\]](#)
-

More Thoughts and Suggestions (II)

- Onur Mutlu,
"Computer Architecture: Why Is It So Important and Exciting Today?"
Invited Lecture at *Izmir Institute of Technology (IYTE)*, Virtual, 16 October 2020.
[[Slides \(pptx\)](#)] [[pdf](#)]
[[Talk Video](#) (2 hours 12 minutes)]

- Onur Mutlu,
"Applying to Graduate School & Doing Impactful Research"
Invited Panel Talk at *the 3rd Undergraduate Mentoring Workshop, held with the 48th International Symposium on Computer Architecture (ISCA)*, Virtual, 18 June 2021.
[[Slides \(pptx\)](#)] [[pdf](#)]
[[Talk Video](#) (50 minutes)]

Seminar in Computer Architecture

Lecture 1a: Intro & Logistics

Dr. Mohammed Alser
Prof. Onur Mutlu

ETH Zürich
Fall 2022
22 September 2022