

# Seminar in Computer Architecture

## Lecture 1a: Intro & Logistics

Prof. Onur Mutlu

ETH Zürich  
Spring 2022  
24 February 2022

# 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](mailto:omutlu@gmail.com)

## ■ Research and Teaching in:

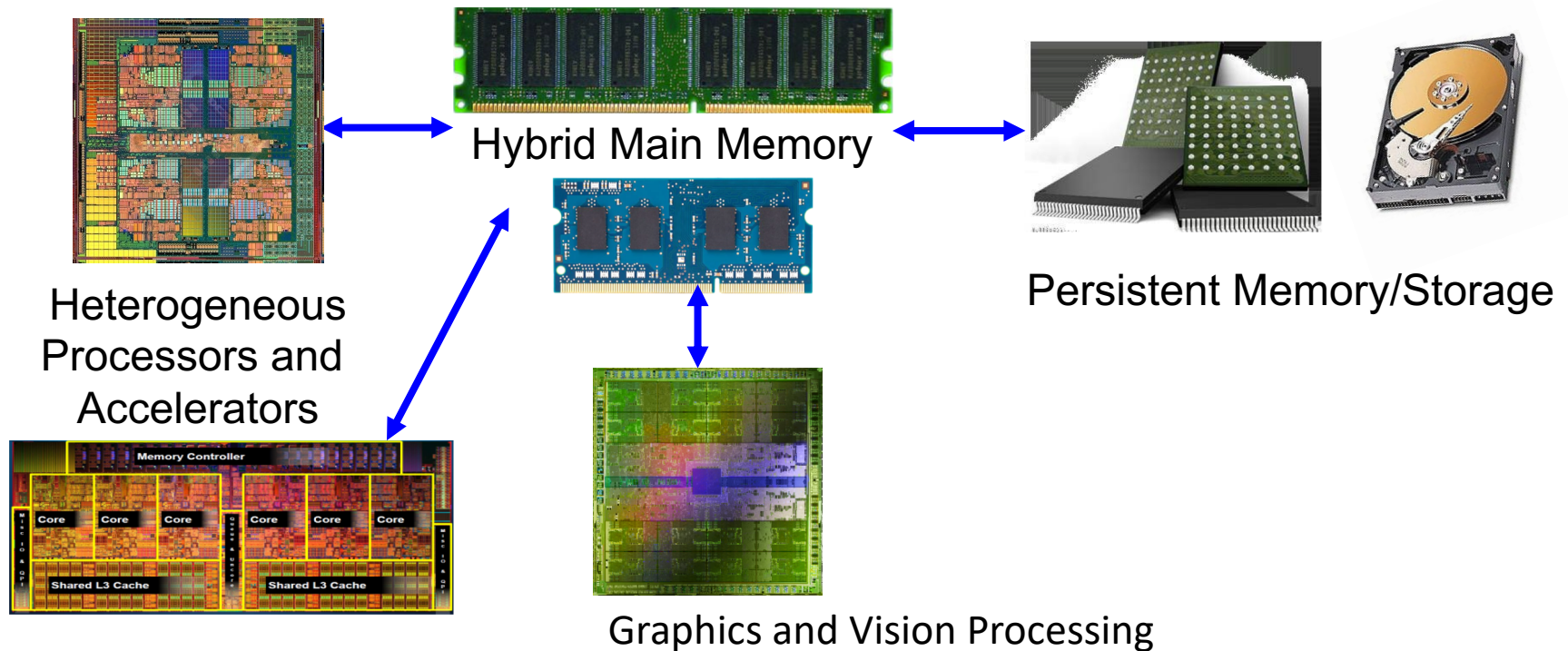
- ❑ **Computer architecture, systems, hardware security, bioinformatics**
- ❑ Memory and storage systems
- ❑ Robust & dependable hardware systems: security, safety, predictability, reliability
- ❑ Hardware/software cooperation
- ❑ New computing paradigms; architectures with emerging technologies/devices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



# Current Research Mission

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



**Build fundamentally better architectures**

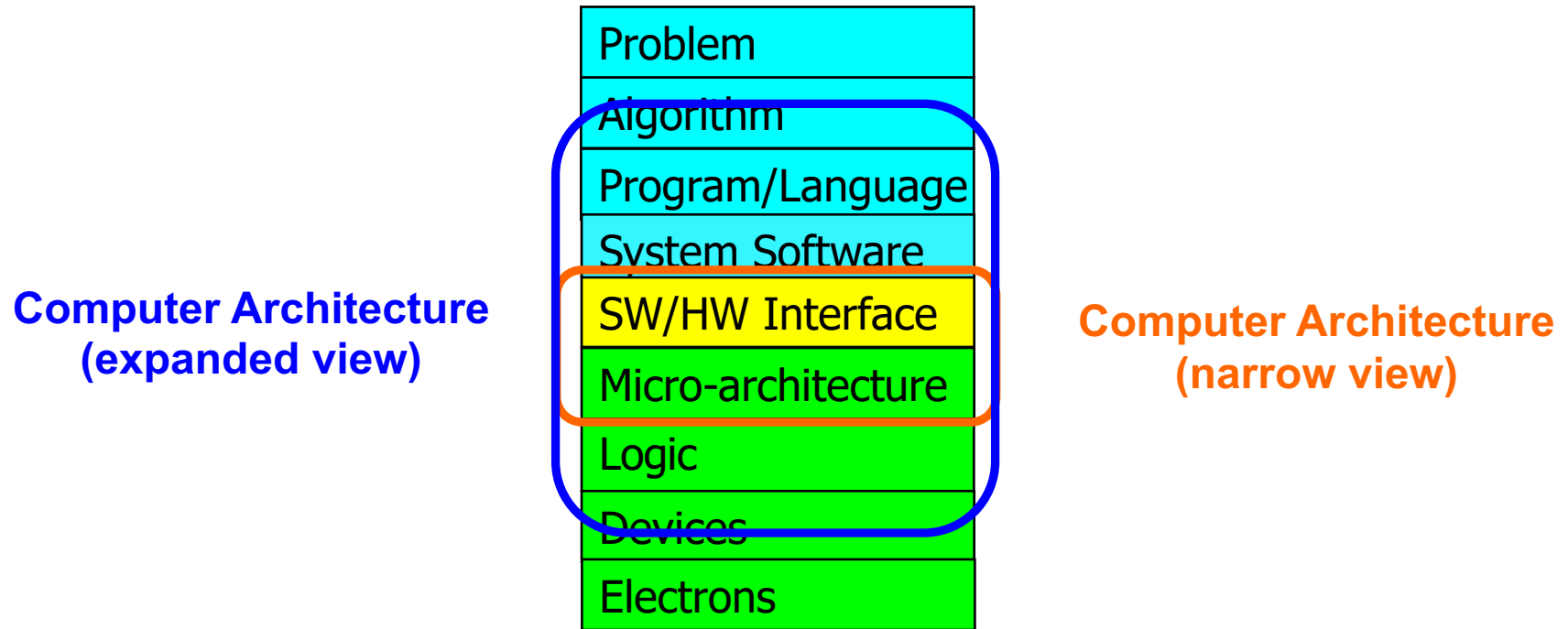
# Four Key Current Directions

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- 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**

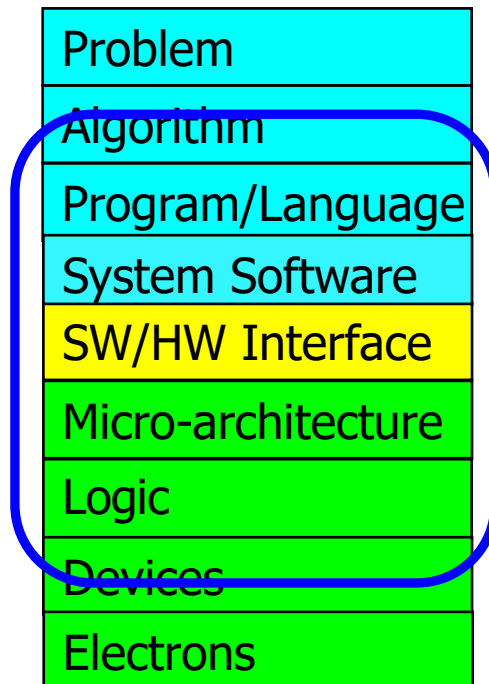
# The Transformation Hierarchy

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

**we must take the expanded view**  
of Computer Architecture

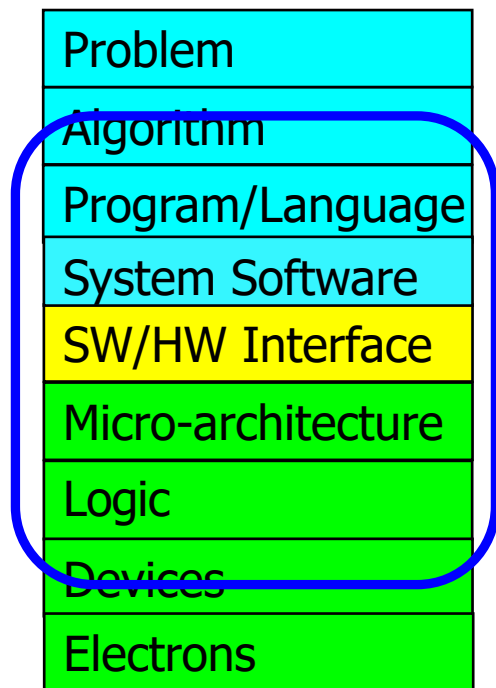


**Co-design across the hierarchy:**  
**Algorithms to devices**

**Specialize as much as possible**  
**within the design goals**

# Current Research Mission & Major Topics

## Build fundamentally better architectures



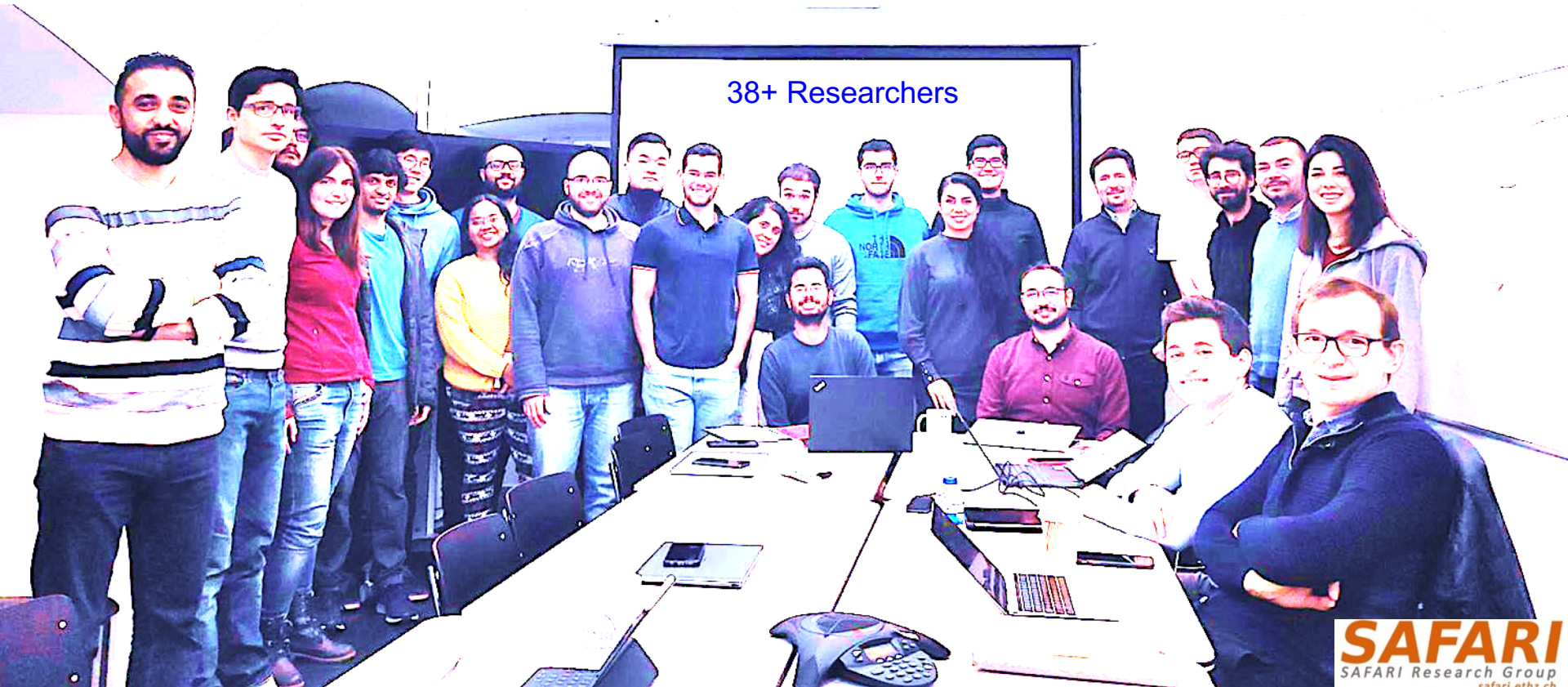
**Broad research  
spanning apps, systems, logic  
with architecture at the center**

- 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*

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



**SAFARI**  
SAFARI Research Group  
[safari.ethz.ch](https://safari.ethz.ch)

## Think BIG, Aim HIGH!

**SAFARI**

<https://safari.ethz.ch>



# SAFARI Newsletter January 2021 Edition

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



**SAFARI**  
SAFARI Research Group

Newsletter  
January 2021

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



Dear SAFARI friends,

Happy New Year! We are excited to share our group highlights with you in this second edition of the SAFARI newsletter (You can find the first edition from April 2020 [here](#)). 2020 has

# 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 PhD and Post-Doc Alumni

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- <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

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- 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

👍 20    🗨 DISLIKE    ➦ SHARE    ≡+ SAVE    ...



Onur Mutlu Lectures  
22.7K subscribers

ANALYTICS

EDIT VIDEO

# Our Major Courses & Lectures

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- **First Computer Architecture & Digital Design Course**
  - ❑ Digital Design and Computer Architecture
  - ❑ Spring 2021 Livestream Edition:  
[https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi\\_uej3aY39YB5pfW4SJ7LIN](https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi_uej3aY39YB5pfW4SJ7LIN)
- **Advanced Computer Architecture Course**
  - ❑ Computer Architecture
  - ❑ Fall 2021 Livestream Edition:  
[https://www.youtube.com/watch?v=4yfkM\\_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF](https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF)
- **Seminar in Computer Architecture**
  - ❑ [https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)

# DDCA (Spring 2021)



Trace: · schedule

Home

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
- Moodle

<https://safari.ethz.ch/digitaltechnik/spring2021/doku.php?id=schedule>

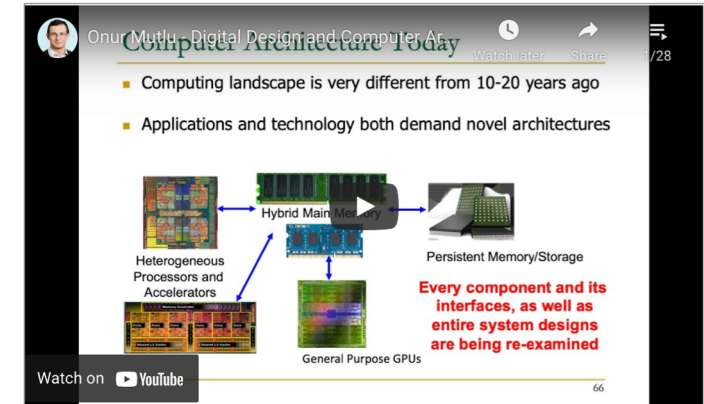
[https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi\\_uej3aY39YB5pfW4SJ7LIN](https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi_uej3aY39YB5pfW4SJ7LIN)

## Bachelor's course

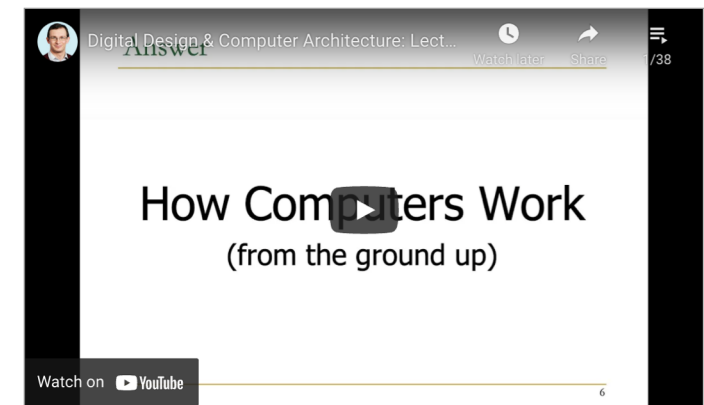
- ❑ 2<sup>nd</sup> semester at ETH Zurich
- ❑ Rigorous introduction into "How Computers Work"
- ❑ Digital Design/Logic
- ❑ Computer Architecture
- ❑ 10 FPGA Lab Assignments

## Lecture Video Playlist on YouTube

LiveStream Lecture Playlist



Recorded Lecture Playlist



## Spring 2021 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Lab	HW
W1	25.02 Thu.	YouTube Live	L1: Introduction and Basics Q238 (PDF) Z388 (PPT)	Required Suggested Mentioned		
	26.02 Fri.	YouTube Live	L2a: Tradeoffs, Metrics, Mindset Q238 (PDF) Z388 (PPT)	Required		
			L2b: Mysteries in Computer Architecture Q238 (PDF) Z388 (PPT)	Required Mentioned		
W2	04.03 Thu.	YouTube Live	L3a: Mysteries in Computer Architecture II Q238 (PDF) Z388 (PPT)	Required Suggested Mentioned		

# Comp Arch (Fall 2021)

- <https://safari.ethz.ch/architecture/fall2021/doku.php?id=schedule>
- **Youtube Livestream:**
  - ❑ [https://www.youtube.com/watch?v=4yfkM\\_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILKTOF](https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILKTOF)
- 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

Computer Architecture - Fall 2021

Recent Changes Media Manager Sitemap

Trace: readings start schedule

Home

Announcements

Materials

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

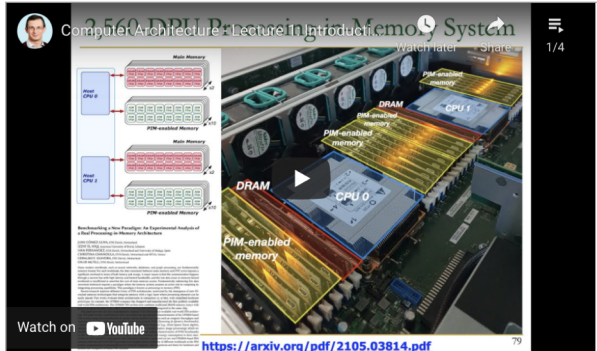
Resources

- 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

2.560-DPU Processing in a Memory System




Watch on YouTube

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

Recorded Lecture Playlist

TESLA Full Self-Driving Computer (2021)



Watch on YouTube

<https://www.youtube.com/watch?v=Ucp0TTmvqOE?i=4236>

Fall 2021 Lectures & Schedule

Week	Date	Livestream	Lecture	Readings	Lab	HW
W1	30.09 Thu.	<a href="#">YouTube</a> <a href="#">Live</a>	<b>L1: Introduction and Basics</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Required Mentioned	Lab 1 Out	HW 0 Out
	01.10 Fri.	<a href="#">YouTube</a> <a href="#">Live</a>	<b>L2: Trends, Tradeoffs and Design Fundamentals</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Required Mentioned		
W2	07.10 Thu.	<a href="#">YouTube</a> <a href="#">Live</a>	<b>L3a: Memory Systems: Challenges and Opportunities</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Described Suggested		HW 1 Out
			<b>L3b: Course Info &amp; Logistics</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>			
			<b>L3c: Memory Performance Attacks</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Described Suggested		
	08.10 Fri.	<a href="#">YouTube</a> <a href="#">Live</a>	<b>L4a: Memory Performance Attacks</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Described Suggested	Lab 2 Out	
			<b>L4b: Data Retention and Memory Refresh</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Described Suggested		
			<b>L4c: RowHammer</b> <a href="#">arXiv (PDF)</a> <a href="#">PPT</a>	Described Suggested		

# Seminar in Comp Arch (Fall 2021)

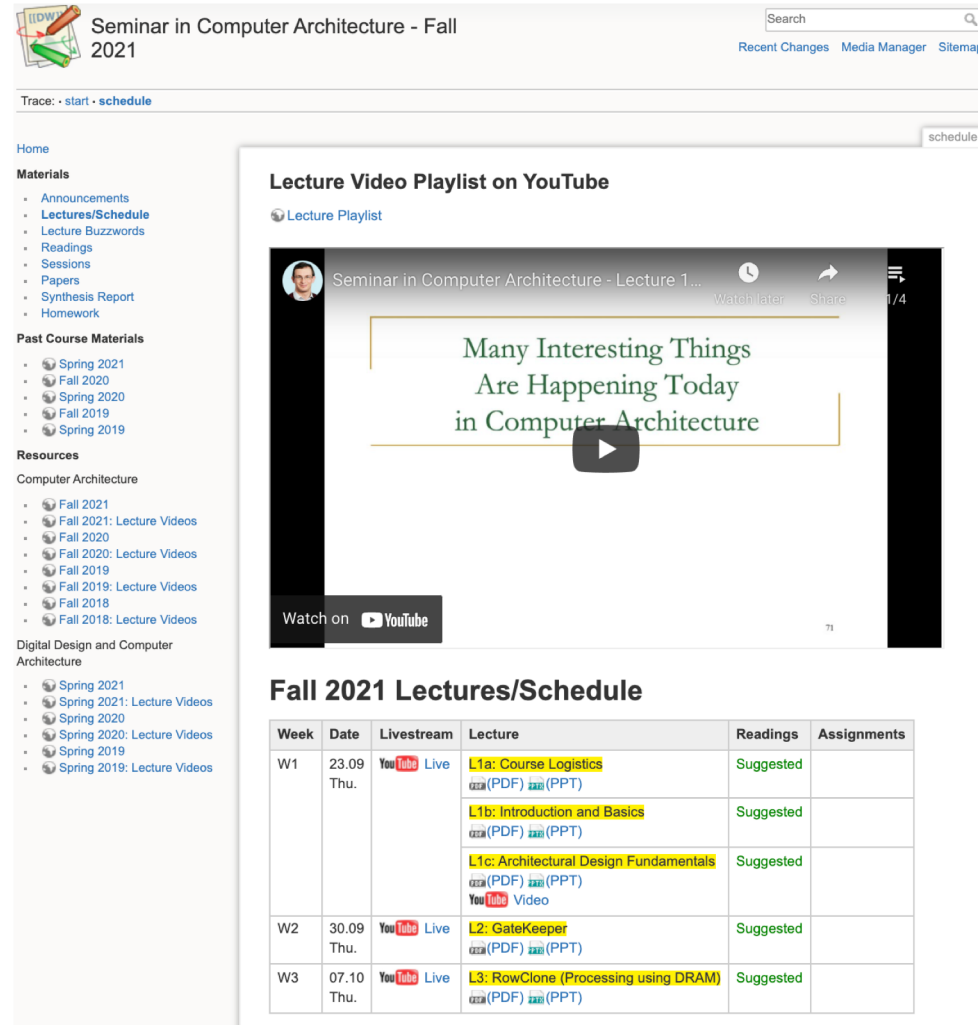
- [https://safari.ethz.ch/architecture\\_seminar/fall2021/doku.php?id=schedule](https://safari.ethz.ch/architecture_seminar/fall2021/doku.php?id=schedule)

- **Youtube Livestream:**

- [https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)

- **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 - Fall 2021

Trace: start - schedule

Home

Materials

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

Past Course Materials

- 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

Lecture Video Playlist on YouTube

Lecture Playlist

Seminar in Computer Architecture - Lecture 1...

Many Interesting Things Are Happening Today in Computer Architecture

Watch on YouTube

Fall 2021 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Assignments
W1	23.09 Thu.	YouTube Live	L1a: Course Logistics L1b: Introduction and Basics L1c: Architectural Design Fundamentals	Suggested	
W2	30.09 Thu.	YouTube Live	L2: GateKeeper	Suggested	
W3	07.10 Thu.	YouTube Live	L3: RowClone (Processing using DRAM)	Suggested	

# Hands-On Project Courses

- [https://safari.ethz.ch/projects\\_and\\_seminars/doku.php](https://safari.ethz.ch/projects_and_seminars/doku.php)



SAFARI Project & Seminars Courses  
(Spring 2021)



[Recent Changes](#) [Media Manager](#) [Sitemap](#)

Trace: • [start](#)

[Home](#)

Projects

- [SoftMC](#)
- [Ramulator](#)
- [Accelerating Genomics](#)
- [Mobile Genomics](#)
- [Processing-in-Memory](#)
- [Heterogeneous Systems](#)
- [SSD Simulator](#)

[start](#)

## SAFARI Projects & Seminars Courses (Spring 2021)

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

### Courses we offer:

- Understanding and Improving Modern DRAM Performance, Reliability, and Security with Hands-On Experiments
- Designing and Evaluating Memory Systems and Modern Software Workloads with Ramulator
- Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms
- Genome Sequencing on Mobile Devices
- Exploring the Processing-in-Memory Paradigm for Future Computing Systems
- Hands-on Acceleration on Heterogeneous Computing Systems
- Understanding and Designing Modern NAND Flash-Based Solid-State Drives (SSDs) by Building a Practical SSD Simulator



# PIM Course (Fall 2021)

## 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<sup>a,b</sup>, Saugata Ghose<sup>b,c</sup>, Juan Gómez-Luna<sup>a</sup>, Rachata Ausavarungnirun<sup>d</sup>

SAFARI Research Group

<sup>a</sup>ETH Zürich  
<sup>b</sup>Carnegie Mellon University  
<sup>c</sup>University of Illinois at Urbana-Champaign  
<sup>d</sup>King 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> 108

## Fall 2021 Meetings/Schedule

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

# Genomics (Fall 2021)

## Fall 2021 Edition:

- [https://safari.ethz.ch/projects\\_and\\_seminars/fall2021/doku.php?id=bioinformatics](https://safari.ethz.ch/projects_and_seminars/fall2021/doku.php?id=bioinformatics)

## Youtube Livestream:

- <https://www.youtube.com/watch?v=MnogTeMjY8k&list=PL5Q2soXY2Zi8sngH-TrNZnDhDkPq55J9J>

## Project course

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

Mobile Genomics Course - Meeting 1: Course...

Understanding **genetic variations**

Predicting the **presence** and **relative abundances** of **microbes** in a sample

Rapid surveillance of **disease outbreaks**

Developing **personalized medicine**

## Fall 2021 Meetings/Schedule

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

# Hetero. Systems (Fall'21)

## Fall 2021 Edition:

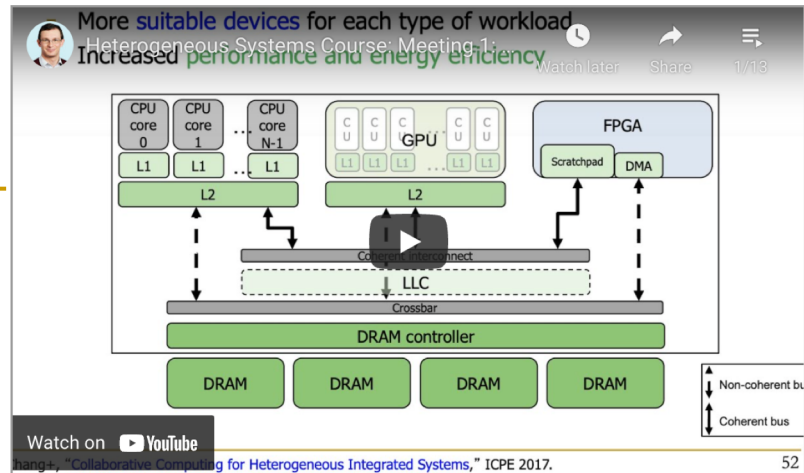
- https://safari.ethz.ch/projects\_and\_seminars/fall2021/doku.php?id=heterogeneous\_systems

## 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)


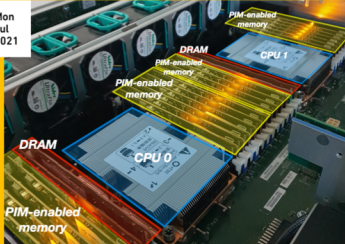
## SAFARI Live Seminars in Computer Architecture

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


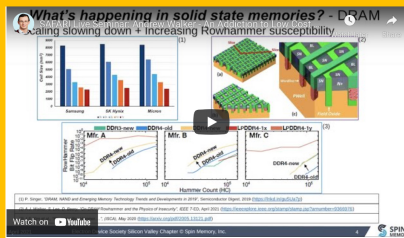
## SAFARI Live Seminars in Computer Architecture

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 throughput<sup>1</sup> 1.2 TFLOPS compute throughput<sup>2</sup>

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

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## 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

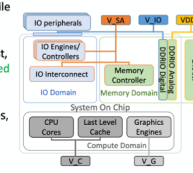
**SAFARI**  
SAFARI Research Group

**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

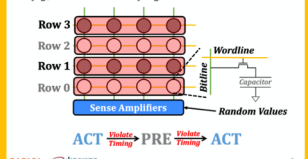
**SAFARI**  
SAFARI Research Group

**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



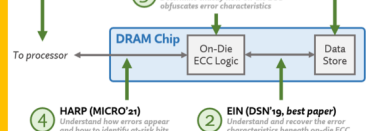
**Position Paper (Ongoing)** Arguing for increased transparency of DRAM reliability characteristics

**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

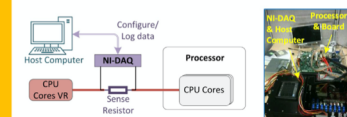
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**4** Mo Okt 2021



**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)



**SAFARI**

<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.

SAFARI

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

Opportunities and challenges of computational data-driven immunology

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

Watch on YouTube

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

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

Watch on YouTube

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

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

Sean Lie  
Co-founder & Chief HW Architect, Cerebras

Watch on YouTube

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 on YouTube

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

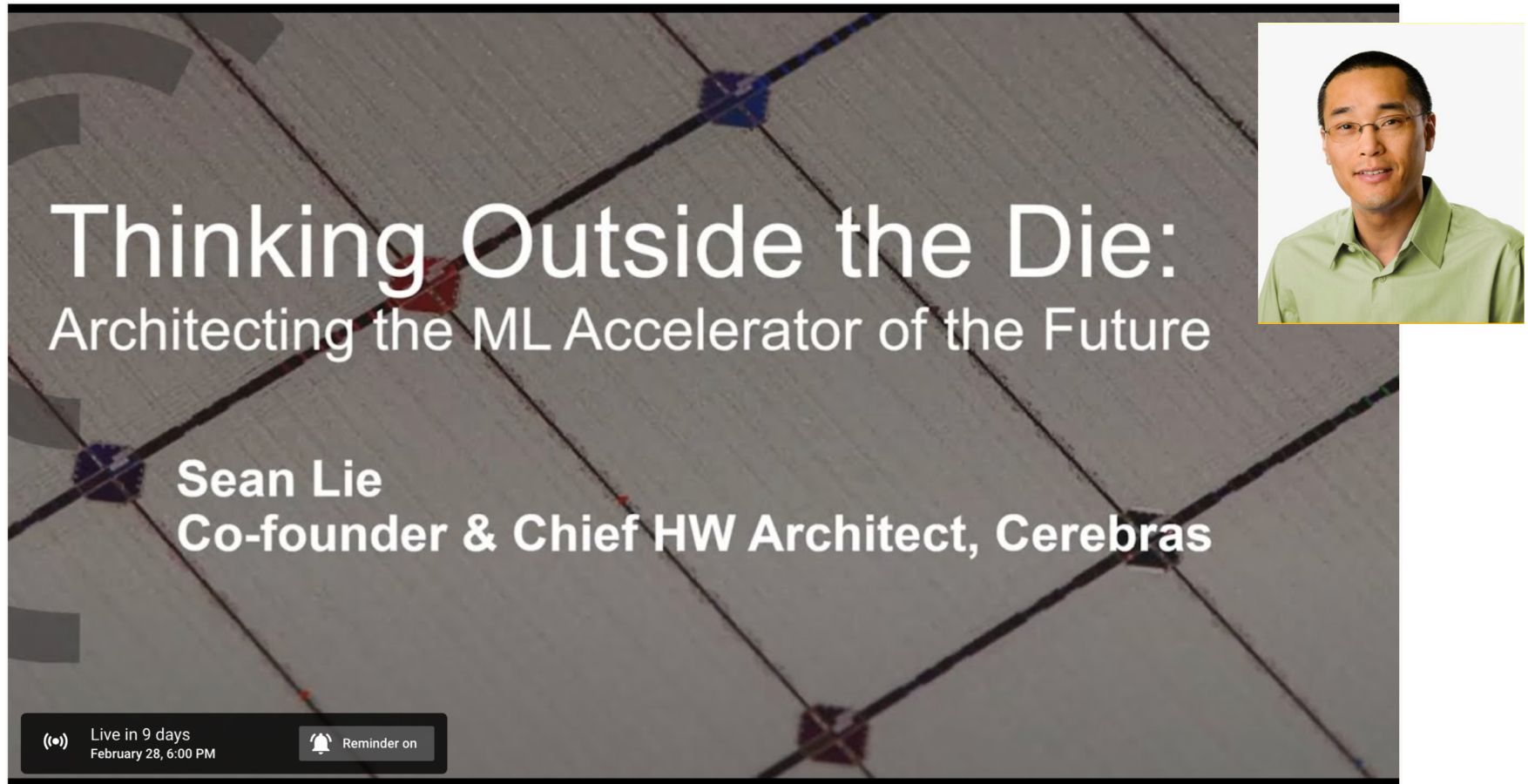
Watch on YouTube

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)

# Upcoming SAFARI Live Seminar (Feb 28)

<https://www.youtube.com/watch?v=x2-qB0J7KHw>



The video player shows a title card with a background image of a circuit board. The title is 'Thinking Outside the Die: Architecting the ML Accelerator of the Future'. The speaker is 'Sean Lie, Co-founder & Chief HW Architect, Cerebras'. A small inset photo of Sean Lie is in the top right. At the bottom left, it says 'Live in 9 days February 28, 6:00 PM' and 'Reminder on'.

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

**Sean Lie**  
Co-founder & Chief HW Architect, Cerebras

Live in 9 days  
February 28, 6:00 PM

Reminder on

SAFARI Live Seminar - Thinking Outside the Die: Architecting the ML Accelerator of the Future

1 waiting • Scheduled for Feb 28, 2022

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**Onur Mutlu Lectures**  
22.6K subscribers

ANALYTICS

EDIT VIDEO

# 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

# Research & Teaching: Some Overview Talks

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

## ■ Future Computing Architectures

- [https://www.youtube.com/watch?v=kgiZISOcGFM&list=PL5Q2soXY2Zi8D\\_5MGV6EnXEJHnV2YFBjI&index=1](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](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](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](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](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](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](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](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)

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- 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)]

# 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 thumbnail of the speaker in the top right, and a bottom bar with engagement metrics (74 likes, 1 comment), share and save buttons, and a description of the panel talk at the Undergraduate Architecture Mentoring Workshop at ISCA 2021.

Applying to Grad School  
& Doing Impactful Research

Onur Mutlu  
[omutlu@gmail.com](mailto: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



# 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](mailto: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

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

43

# Papers, Courses, Talks, Videos, Artifacts

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- All are available at

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

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

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

# Suggested Reading on Mindset & More

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**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.

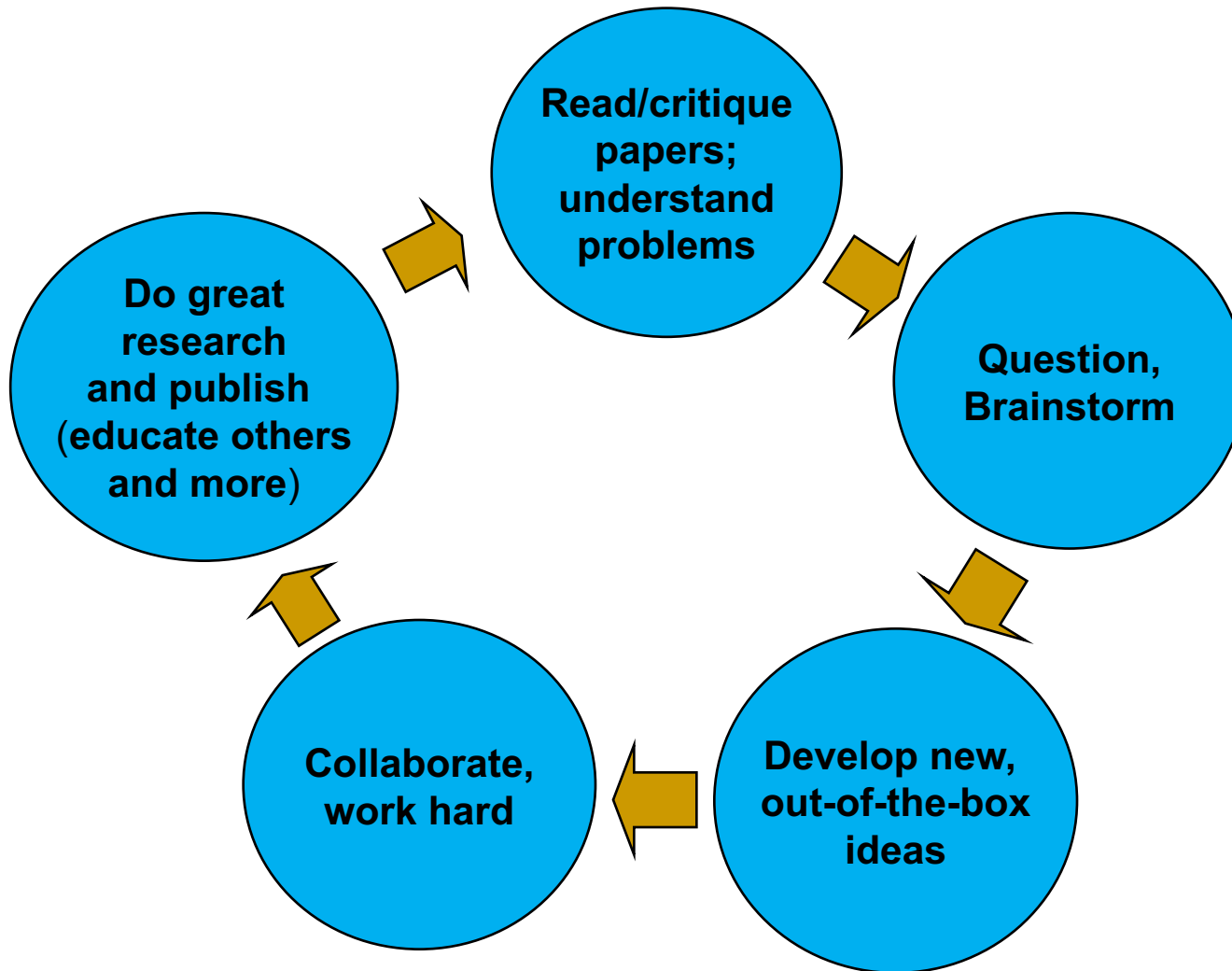
# Recap: Some Goals of This Course

---

- 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

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# 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](mailto: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 Sadr,
- Dr. Jisung Park,
- Dr. Gagandeep Singh,
- Hasan Hassan,
- Abdullah Giray Yaglikci,
- Can Firtina,
- Geraldo Francisco De Oliveira Junior,
- Rahul Bera,
- Konstantinos Kanellopoulos,
- Nika Mansouri Ghiasi,
- Rakesh Nadig
- Ataberk Olgun
- Joel Lindegger
- Haocong Luo,
- João Dinis Ferreira,
- Roberto Starc

- 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

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- [https://safari.ethz.ch/architecture\\_seminar/spring2022](https://safari.ethz.ch/architecture_seminar/spring2022)
- 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=16853>
- Check frequently for:
  - Announcements and due dates
  - Quizzes
  - Paper discussion
  - Assignment submissions



# Homework 0

---

- Due March 3
  - [https://safari.ethz.ch/architecture\\_seminar/spring2022](https://safari.ethz.ch/architecture_seminar/spring2022)
- 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.



# 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)



# 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

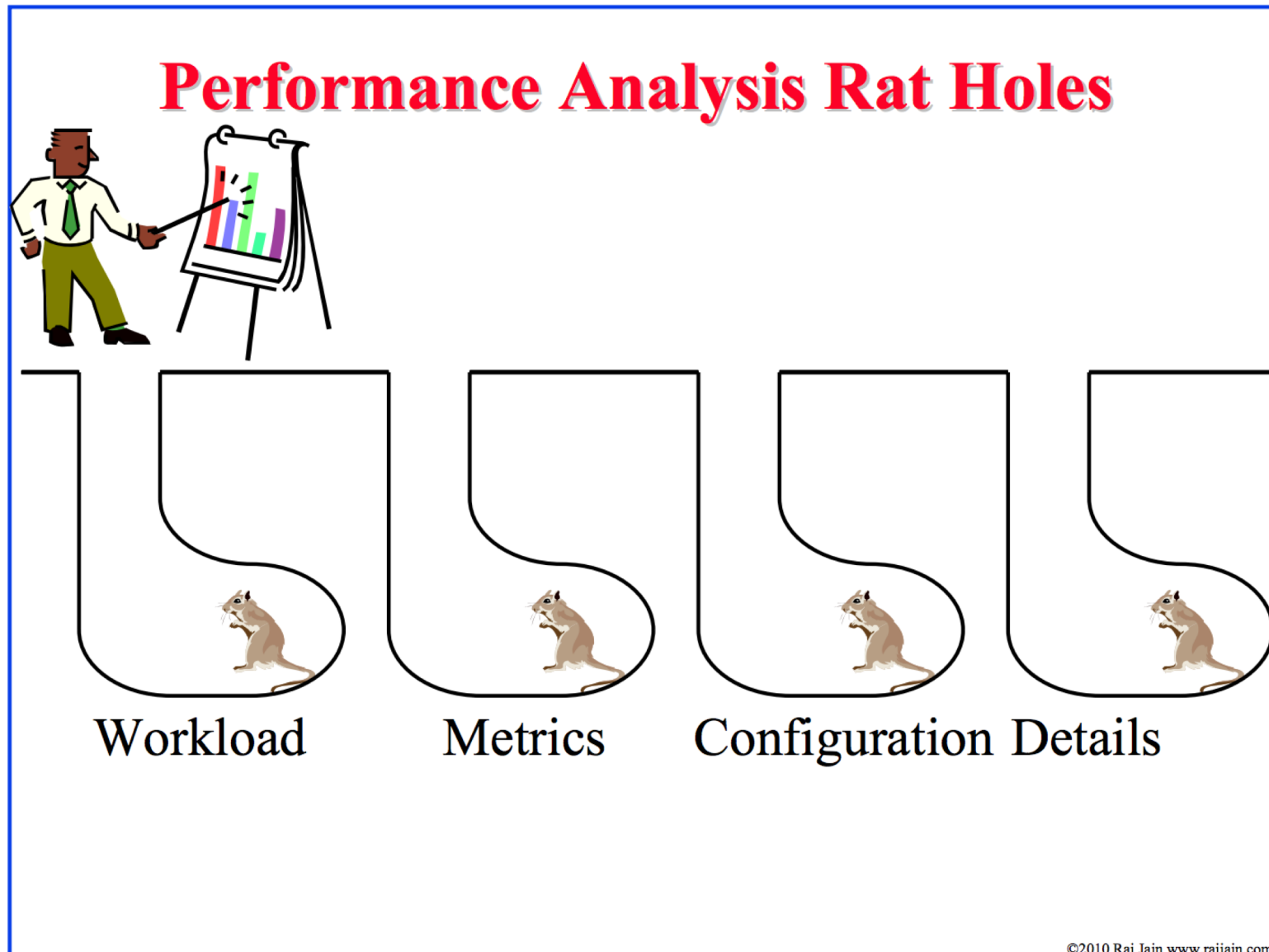
**~10 min Critique  
plus  
~15 min Discussion**

# 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

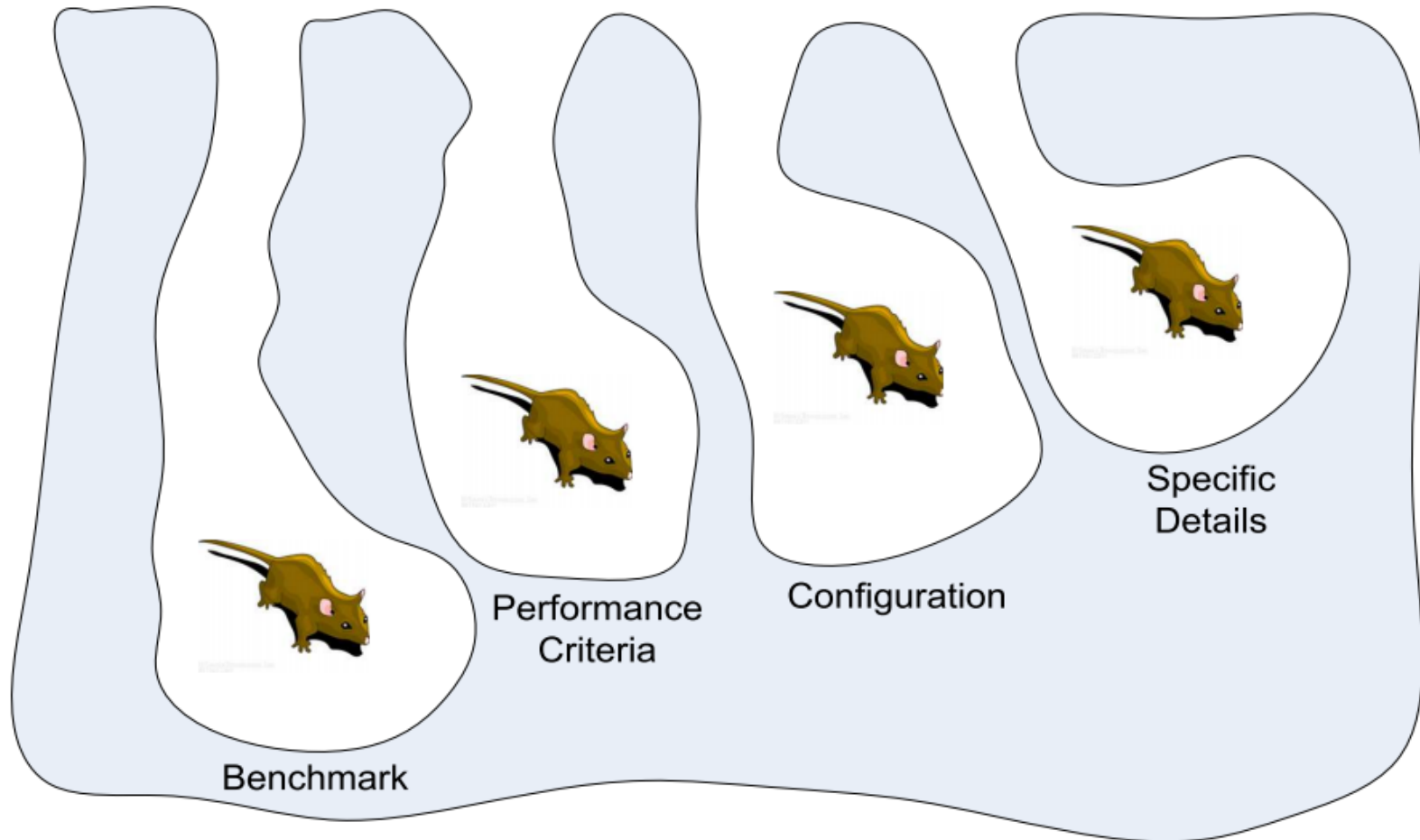
# Try to Avoid Rat Hole Discussions



# Try to Avoid Rat Hole Discussions

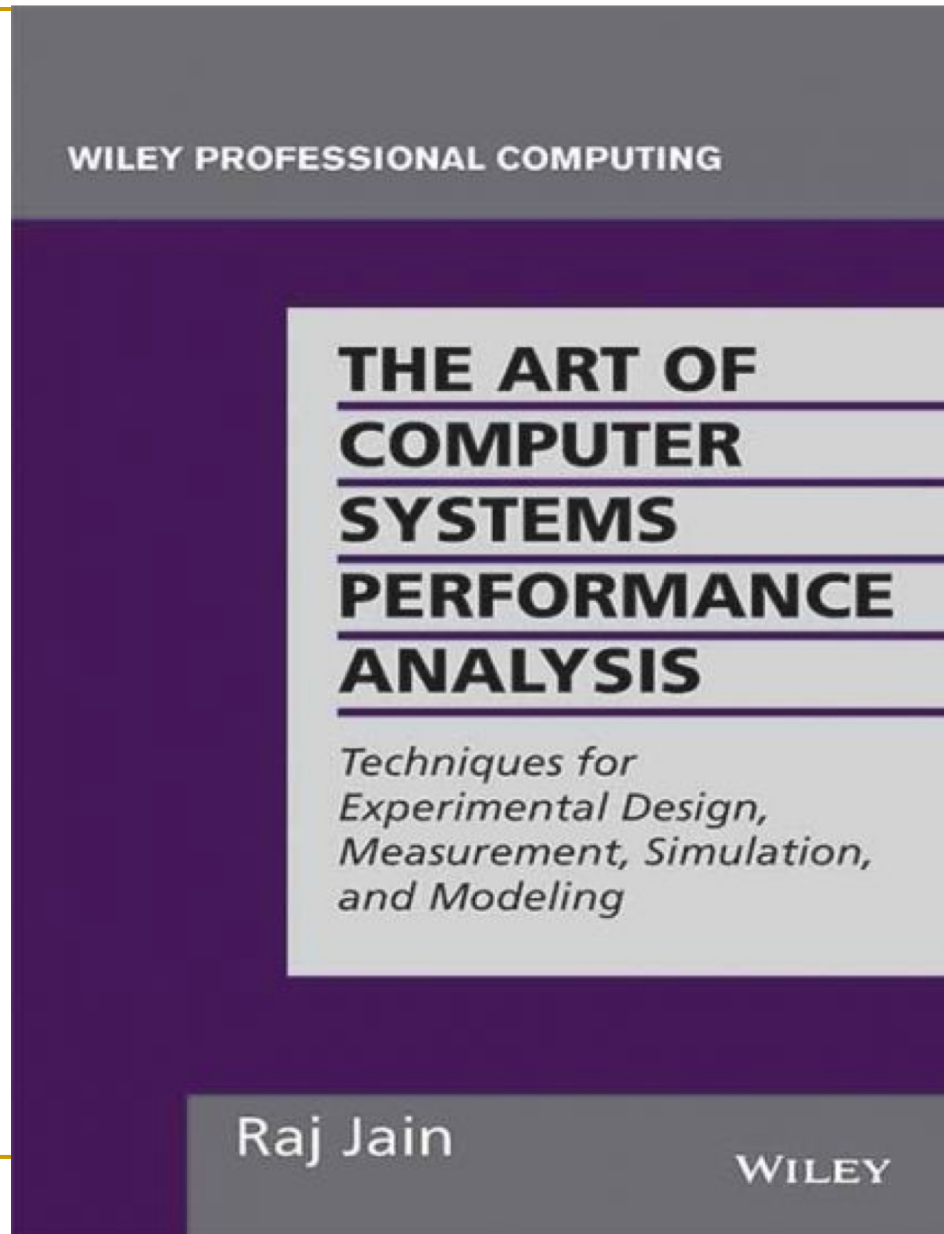
---

## Performance Analysis Rat Holes



# Aside: A Recommended Book

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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.

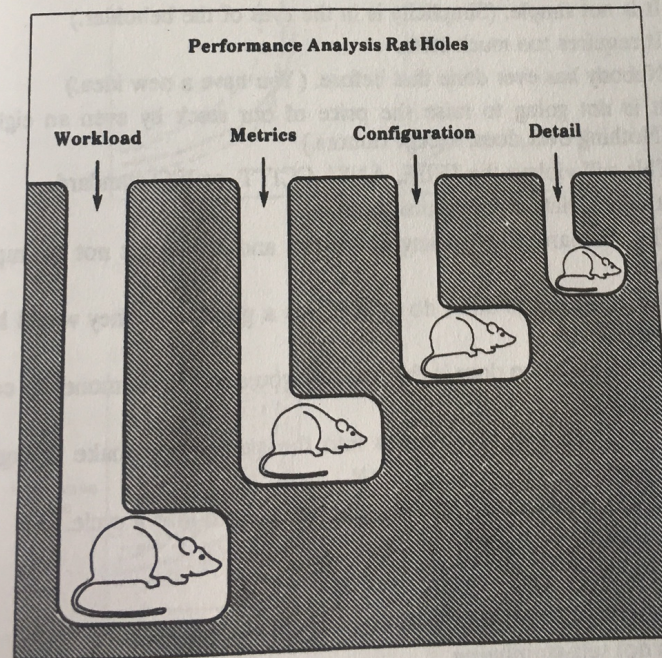


FIGURE 10.26 Four issues in performance presentations that commonly lead to endless discussion.

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**



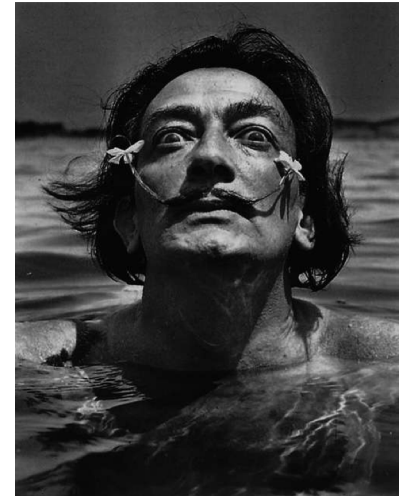
# Who Painted This Painting?

---



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

**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. The main content is a presentation slide titled "DRAM & RowHammer". On the left side of the slide, there is a vertical toolbar with icons for a target, settings, a bar chart, a hammer, a dumbbell, and a play button. The slide content includes:

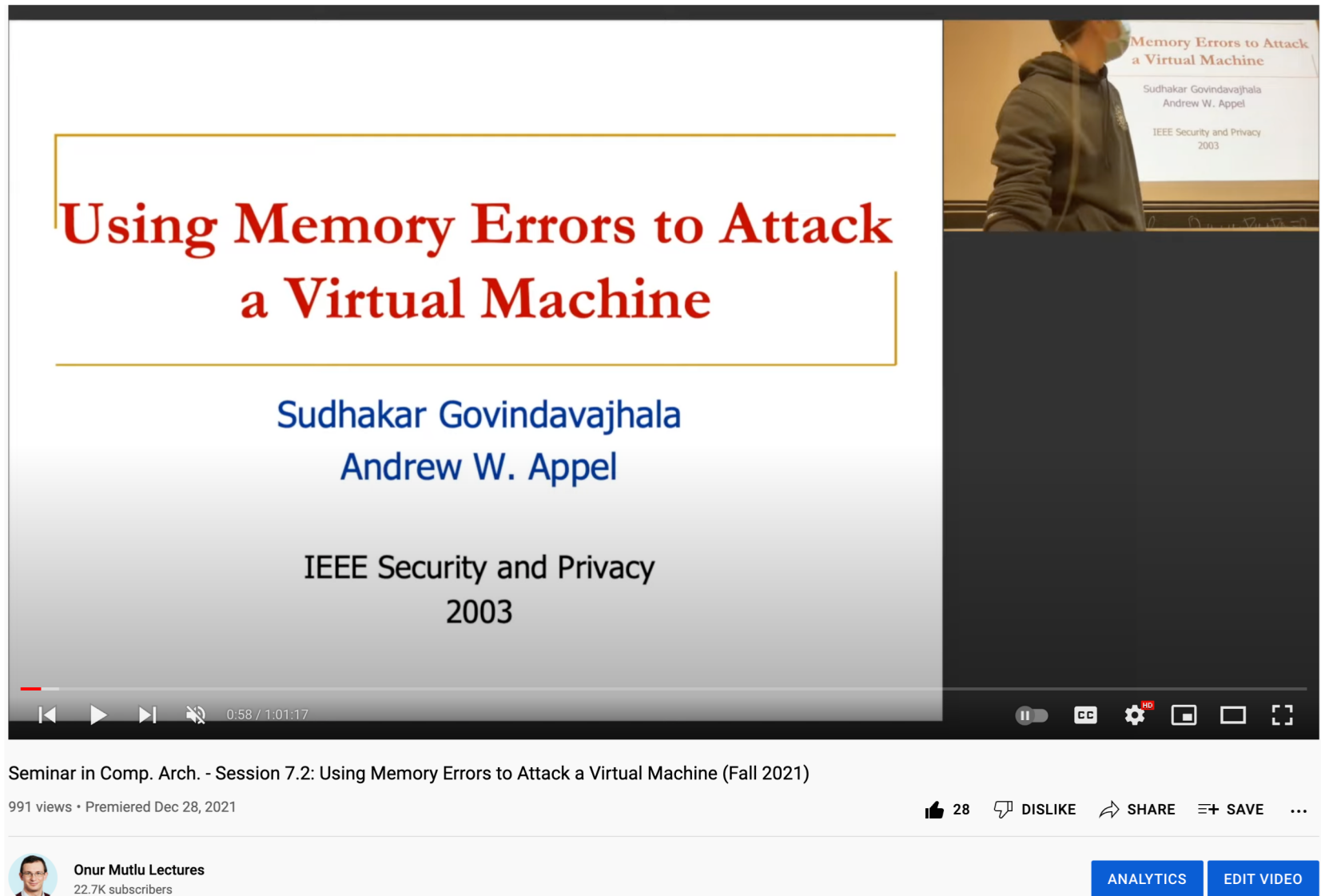
- A diagram of a "DRAM Bank" showing a grid of cells with "Row Decoder", "Row Buffer", "Bitline", and "Wordline" labels.
- A text box stating: "Cause: memory density scaling" with arrows pointing to "↓ DRAM cell size" and "↓ cell-to-cell spacing".
- A red text box stating: "RowHammer: rapidly activating (opening) and precharging (closing) DRAM row can cause bit-flips in nearby rows".
- A visual metaphor showing a hammer hitting a grid of blue circles, with a red circle highlighted and labeled  $V_{high}$ .

The video player controls at the bottom show a progress bar at 4:29 / 34:11, a play button, a volume icon, and various settings and window controls.

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 includes a progress bar at 0:58 / 1:01:17, a video thumbnail of a person, and a description area.

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

**DRAM Commands**

The diagram illustrates the timing of DRAM commands. It shows a 4x4 grid of memory cells. The first row is highlighted with a dashed blue box. Below the grid, a timing diagram shows the sequence of commands and actions:

- Command:** ACTIVATE, PRECHARGE, Next ACT
- Data:** (No data transfer during these commands)
- DRAM Action:** Open row, Activate sense amplifier, Close row, Drive bitlines to  $V_{dd}/2$

**Row access strobe:  $t_{RAS}$**   
Minimum delay between ACTIVATE and the next PRECHARGE command

**Row precharge:  $t_{RP}$**   
Minimum delay between PRECHARGE and the next ACTIVATE command

5:11 / 1:02:20

Seminar in Computer Architecture - Session 2.2: ComputeDRAM (Spring 2021)



Lorenzo Rai

# Other Example Presentations & Discussions

[List of example papers presented]:

[https://safari.ethz.ch/architecture\\_seminar/fall2021/doku.php?id=schedule](https://safari.ethz.ch/architecture_seminar/fall2021/doku.php?id=schedule)

[List of YouTube videos]:

[https://www.youtube.com/playlist?list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)

## Fall 2021 Lectures/Schedule

Week	Date	Livestream	Lecture
W1	23.09 Thu.	YouTube Live	<b>L1a: Course Logistics</b> PDF (PDF) PPT (PPT)
			<b>L1b: Introduction and Basics</b> PDF (PDF) PPT (PPT)
			<b>L1c: Architectural Design Fundamentals</b> PDF (PDF) PPT (PPT) YouTube Video
W2	30.09 Thu.	YouTube Live	<b>L2: GateKeeper</b> PDF (PDF) PPT (PPT)
W3	07.10 Thu.	YouTube Live	<b>L3: RowClone (Processing using DRAM)</b> PDF (PDF) PPT (PPT)
W4	14.10 Thu.	YouTube Live	<b>L4: Memory Channel Partitioning</b> PDF (PDF) PPT (PPT)



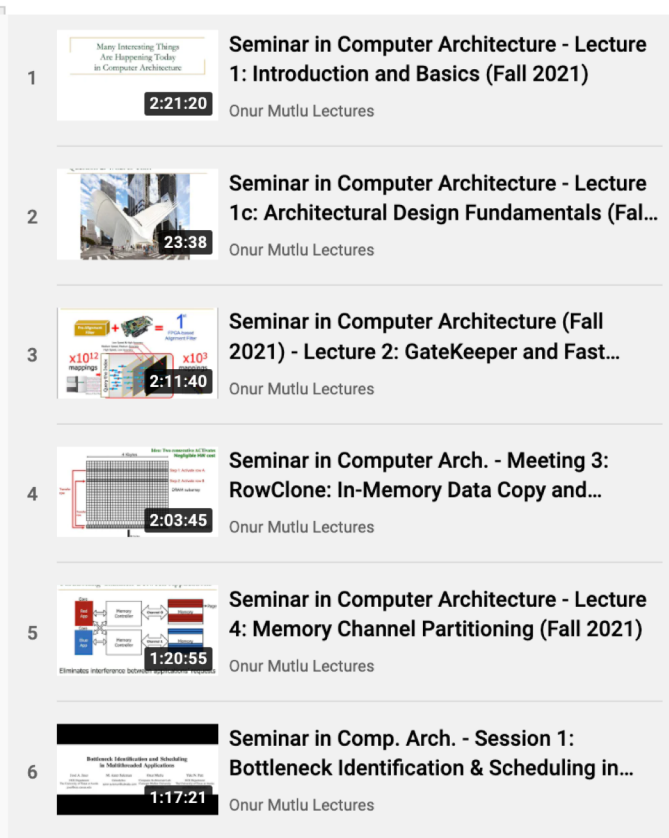
**Livestream - Seminar in Computer Architecture - ETH Zürich (Fall 2021)**

13 videos • 448 views • Last updated on Jan 16, 2022

Onur Mutlu's livestream lecture videos from the Seminar in Computer Architecture course taught at ETH Zürich in Fall 2021. Course website including all slides and assignments:  
[https://safari.ethz.ch/architecture\\_s...](https://safari.ethz.ch/architecture_s...)

Onur Mutlu Lectures

SUBSCRIBED



- Seminar in Computer Architecture - Lecture 1: Introduction and Basics (Fall 2021)**  
2:21:20  
Onur Mutlu Lectures
- Seminar in Computer Architecture - Lecture 1c: Architectural Design Fundamentals (Fall 2021)**  
23:38  
Onur Mutlu Lectures
- Seminar in Computer Architecture (Fall 2021) - Lecture 2: GateKeeper and Fast...**  
2:11:40  
Onur Mutlu Lectures
- Seminar in Computer Arch. - Meeting 3: RowClone: In-Memory Data Copy and...**  
2:03:45  
Onur Mutlu Lectures
- Seminar in Computer Architecture - Lecture 4: Memory Channel Partitioning (Fall 2021)**  
1:20:55  
Onur Mutlu Lectures
- Seminar in Comp. Arch. - Session 1: Bottleneck Identification & Scheduling in...**  
1:17:21  
Onur Mutlu Lectures



# Past Example Reviews

[List of example reviews]:

[https://safari.ethz.ch/architecture\\_seminar/fall2021/doku.php?id=schedule](https://safari.ethz.ch/architecture_seminar/fall2021/doku.php?id=schedule)

[List of YouTube videos]:

[https://www.youtube.com/playlist?list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/playlist?list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)



## 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

# How to Participate

# How to Make the Best Out of This?

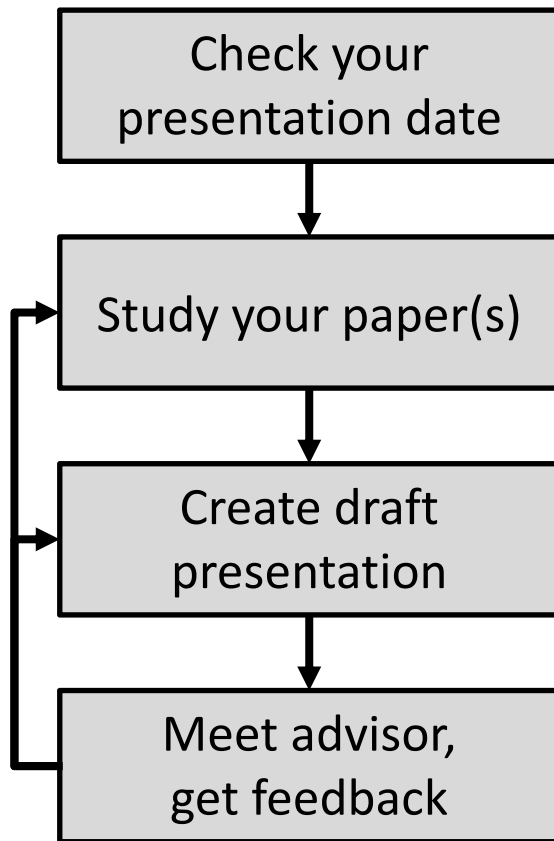
---

- 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

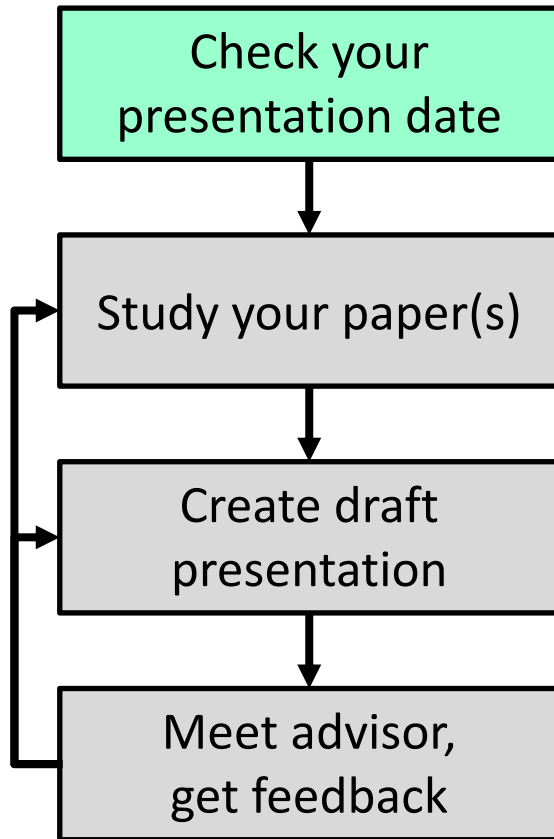
# Preparing a Talk

---



# Preparing a Talk: Start Early

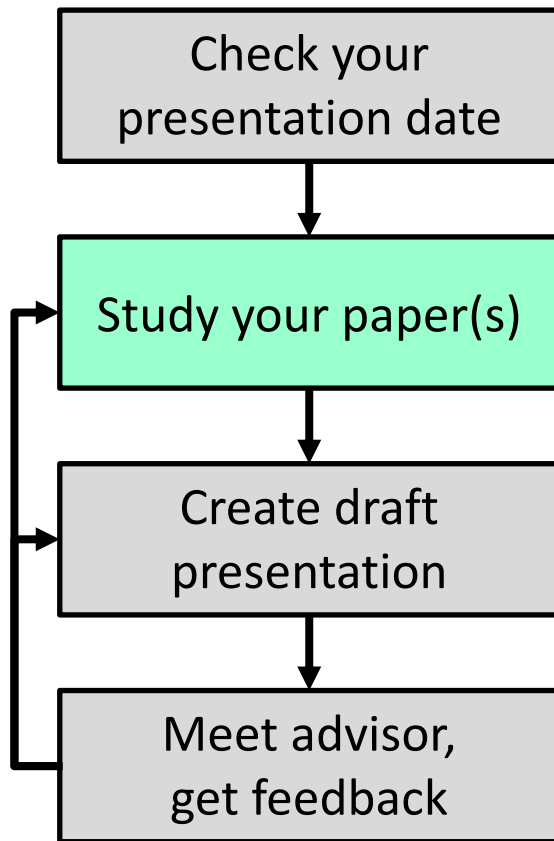
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- Preparing a good presentation takes time
- Start early!

# Preparing a Talk: Study Paper

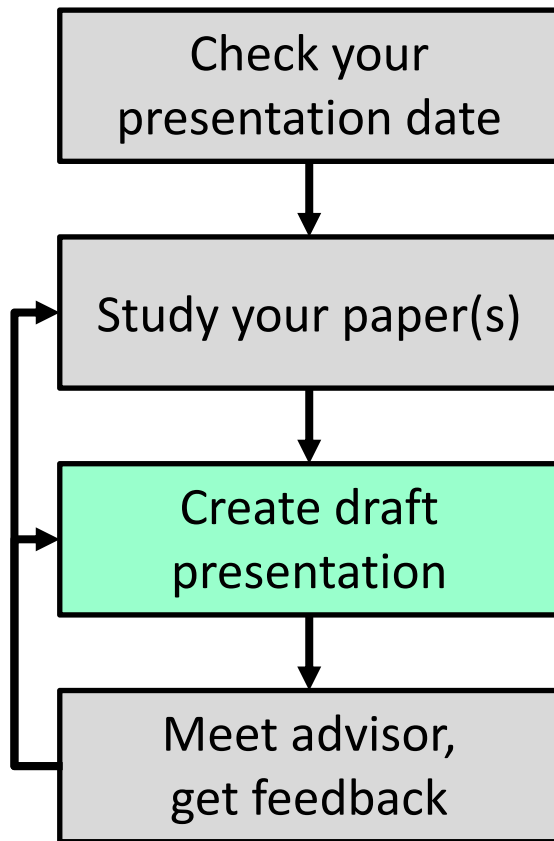
---



- 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

---

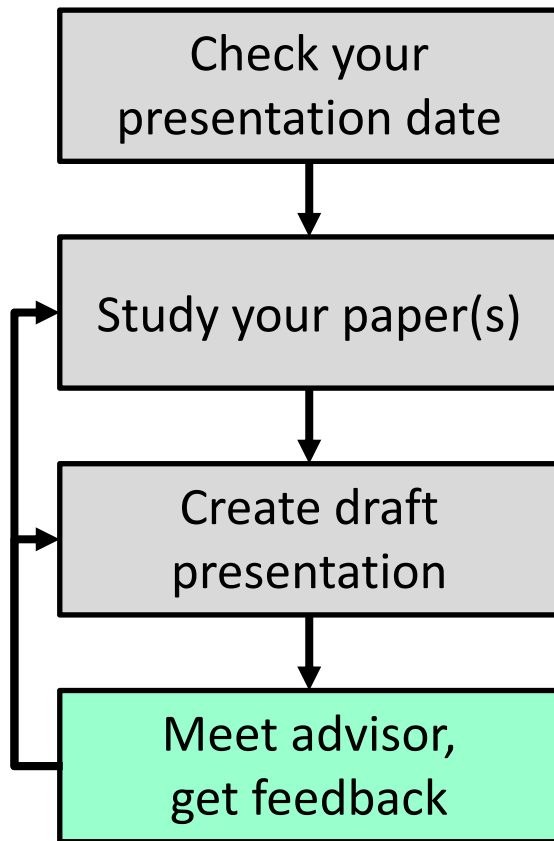


- Explain the motivation for the work
- Clearly present the technical solution and results
  - Include a demo if appropriate
- Outline limitations or improvements
- Focus on the key concepts
  - Do not present all of the details



# 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 next week*
  - *Your presentations start on 10 March*
  - 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

---

- Due March 3
  - [https://safari.ethz.ch/architecture\\_seminar/spring2022](https://safari.ethz.ch/architecture_seminar/spring2022)
- 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.



# 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.

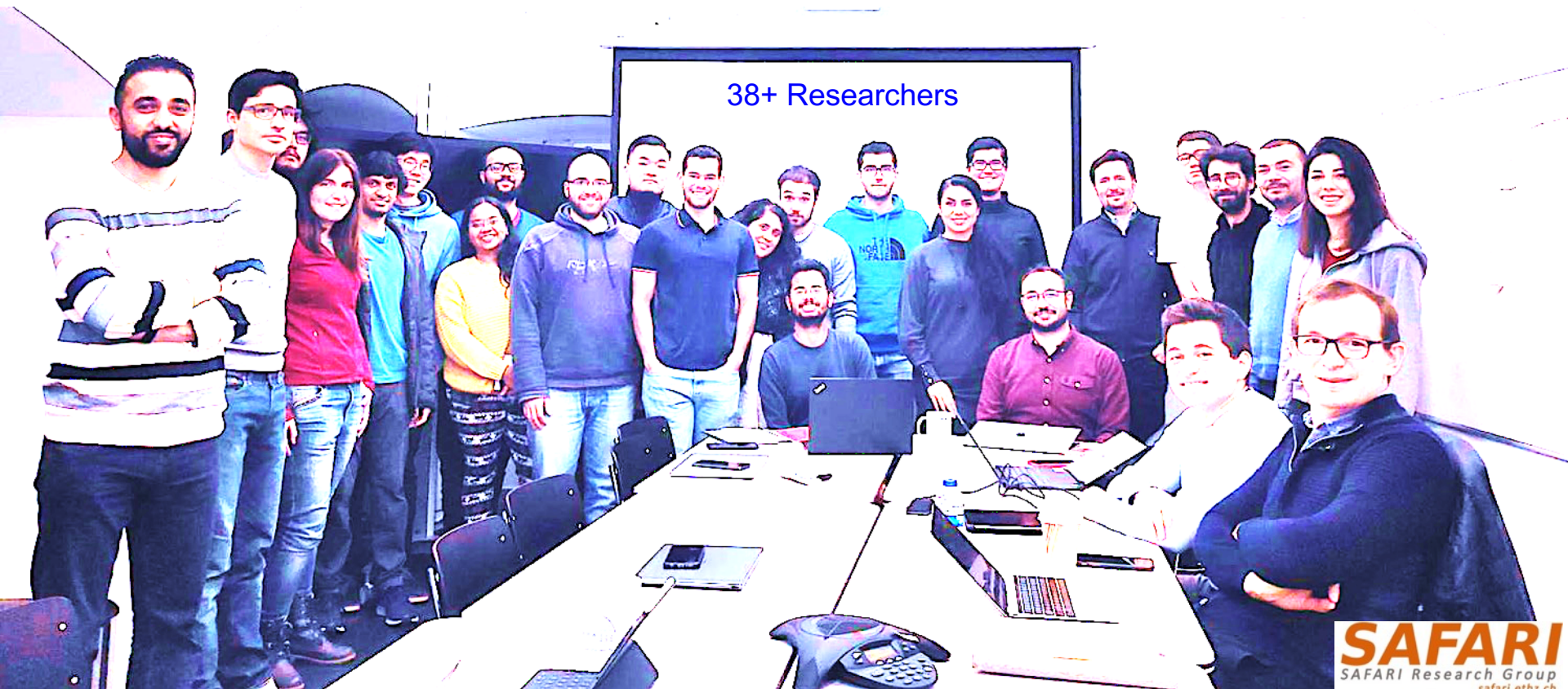


# Synergistic Activities

# Onur Mutlu's SAFARI Research Group

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

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



**SAFARI**  
SAFARI Research Group  
[safari.ethz.ch](https://safari.ethz.ch)

## Think BIG, Aim HIGH!

**SAFARI**

<https://safari.ethz.ch>

# SAFARI Newsletter January 2021 Edition

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



**SAFARI**  
SAFARI Research Group

Newsletter  
January 2021

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



Dear SAFARI friends,

Happy New Year! We are excited to share our group highlights with you in this second edition of the SAFARI newsletter (You can find the first edition from April 2020 [here](#)). 2020 has

# 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 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)

# 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

# Our Major Courses & Lectures

---

- **First Computer Architecture & Digital Design Course**
  - ❑ Digital Design and Computer Architecture
  - ❑ Spring 2021 Livestream Edition:  
[https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi\\_uej3aY39YB5pfW4SJ7LIN](https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi_uej3aY39YB5pfW4SJ7LIN)
- **Advanced Computer Architecture Course**
  - ❑ Computer Architecture
  - ❑ Fall 2021 Livestream Edition:  
[https://www.youtube.com/watch?v=4yfkM\\_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF](https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILkTOF)
- **Seminar in Computer Architecture**
  - ❑ [https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)

# DDCA (Spring 2021)



Trace: · schedule

Home

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
- Moodle

<https://safari.ethz.ch/digitaltechnik/spring2021/doku.php?id=schedule>

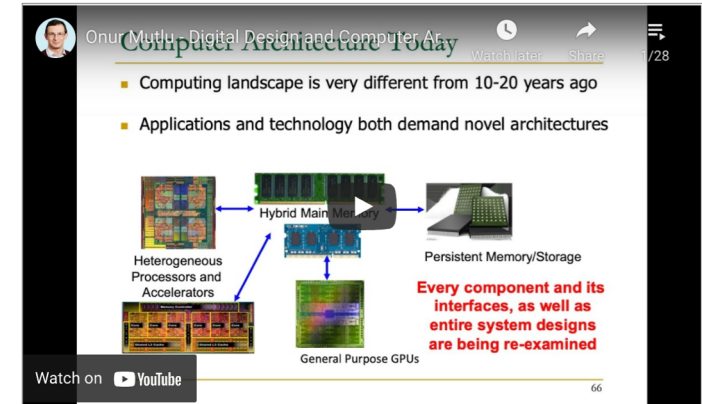
[https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi\\_uej3aY39YB5pfW4SJ7LIN](https://www.youtube.com/watch?v=LbC0EZY8yw4&list=PL5Q2soXY2Zi_uej3aY39YB5pfW4SJ7LIN)

## Bachelor's course

- ❑ 2<sup>nd</sup> 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 2021 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Lab	HW
W1	25.02 Thu.	YouTube Live	L1: Introduction and Basics Q238 (PDF) Z388 (PPT)	Required Suggested Mentioned		
	26.02 Fri.	YouTube Live	L2a: Tradeoffs, Metrics, Mindset Q238 (PDF) Z388 (PPT)	Required		
			L2b: Mysteries in Computer Architecture Q238 (PDF) Z388 (PPT)	Required Mentioned		
W2	04.03 Thu.	YouTube Live	L3a: Mysteries in Computer Architecture II Q238 (PDF) Z388 (PPT)	Required Suggested Mentioned		



# Comp Arch (Fall 2021)


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

■ **Youtube Livestream:**

❑ [https://www.youtube.com/watch?v=4yfkM\\_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILKTOF](https://www.youtube.com/watch?v=4yfkM_5EFgo&list=PL5Q2soXY2Zi-Mnk1PxjEIG32HAGILKTOF)

■ **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


Computer Architecture - Fall 2021

Recent Changes
Media Manager
Sitemap

Trace:
readings
start
schedule

Home

Announcements

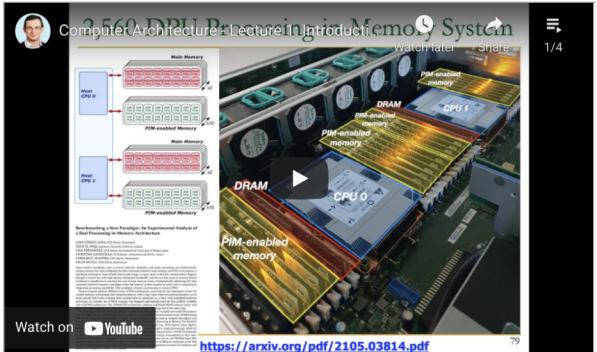
Materials

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

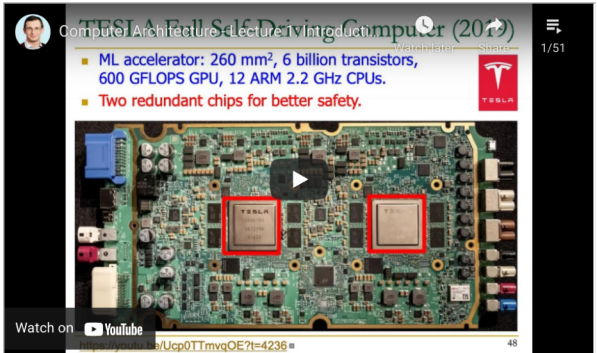


2.560-DPU Processing in a Memory System

Watch on YouTube

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

Recorded Lecture Playlist



TESLA Full Self-Driving Computer (2021)

- ML accelerator: 260 mm<sup>2</sup>, 6 billion transistors, 600 GFLOPS GPU, 12 ARM 2.2 GHz CPUs.
- Two redundant chips for better safety.

Watch on YouTube

Fall 2021 Lectures & Schedule

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

# Seminar in Comp Arch (Fall 2021)

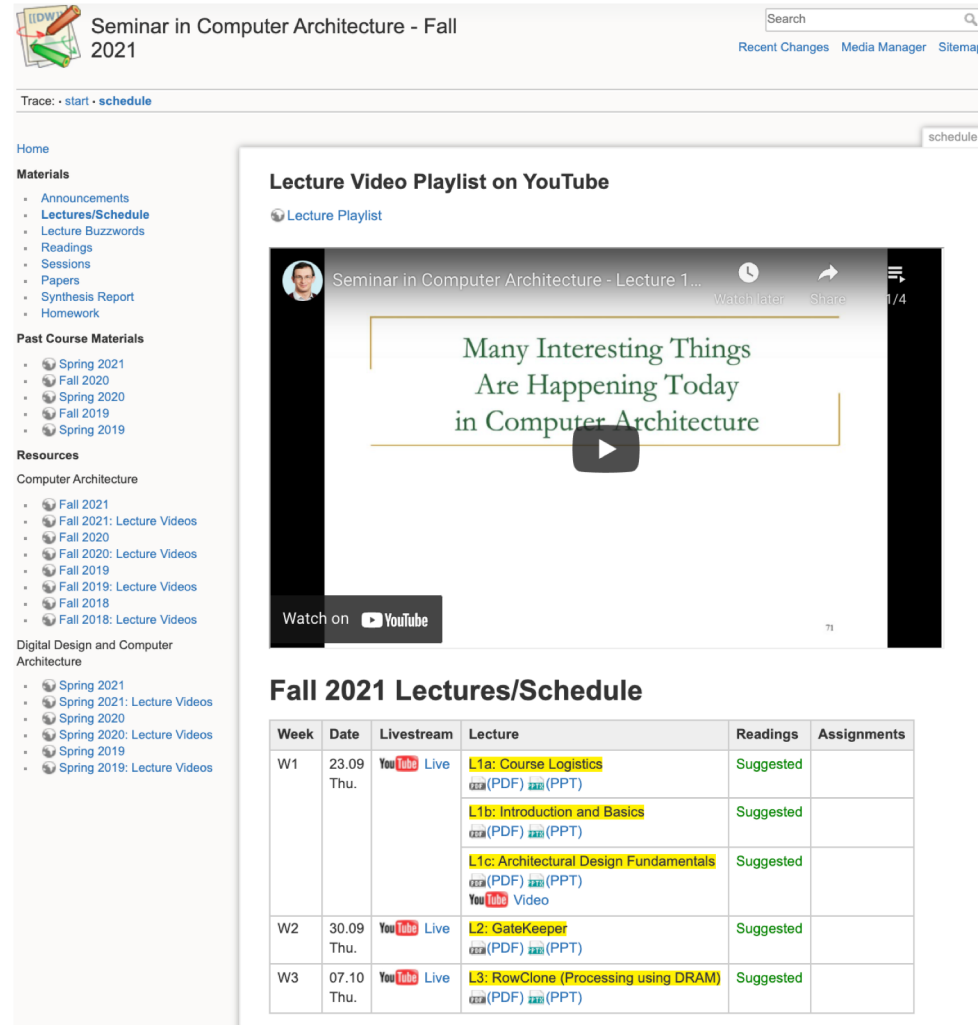
- [https://safari.ethz.ch/architecture\\_seminar/fall2021/doku.php?id=schedule](https://safari.ethz.ch/architecture_seminar/fall2021/doku.php?id=schedule)

- **Youtube Livestream:**

- [https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi\\_7UBNmC9B8Yr5JSwTG9yH4](https://www.youtube.com/watch?v=4TcP297mdsI&list=PL5Q2soXY2Zi_7UBNmC9B8Yr5JSwTG9yH4)

- **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 - Fall 2021

Trace: start - schedule

Home

Materials

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

Past Course Materials

- 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

Lecture Video Playlist on YouTube

Lecture Playlist

Seminar in Computer Architecture - Lecture 1...

Many Interesting Things Are Happening Today in Computer Architecture

Watch on YouTube

Fall 2021 Lectures/Schedule

Week	Date	Livestream	Lecture	Readings	Assignments
W1	23.09 Thu.	YouTube Live	L1a: Course Logistics L1b: Introduction and Basics L1c: Architectural Design Fundamentals	Suggested	
W2	30.09 Thu.	YouTube Live	L2: GateKeeper	Suggested	
W3	07.10 Thu.	YouTube Live	L3: RowClone (Processing using DRAM)	Suggested	

# Hands-On Project Courses

- [https://safari.ethz.ch/projects\\_and\\_seminars/doku.php](https://safari.ethz.ch/projects_and_seminars/doku.php)



SAFARI Project & Seminars Courses  
(Spring 2021)



[Recent Changes](#) [Media Manager](#) [Sitemap](#)

Trace: • [start](#)

[Home](#)

Projects

- [SoftMC](#)
- [Ramulator](#)
- [Accelerating Genomics](#)
- [Mobile Genomics](#)
- [Processing-in-Memory](#)
- [Heterogeneous Systems](#)
- [SSD Simulator](#)

[start](#)

## SAFARI Projects & Seminars Courses (Spring 2021)

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

### Courses we offer:

- Understanding and Improving Modern DRAM Performance, Reliability, and Security with Hands-On Experiments
- Designing and Evaluating Memory Systems and Modern Software Workloads with Ramulator
- Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms
- Genome Sequencing on Mobile Devices
- Exploring the Processing-in-Memory Paradigm for Future Computing Systems
- Hands-on Acceleration on Heterogeneous Computing Systems
- Understanding and Designing Modern NAND Flash-Based Solid-State Drives (SSDs) by Building a Practical SSD Simulator

# PIM Course (Fall 2021)

## 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<sup>a,b</sup>, Saugata Ghose<sup>b,c</sup>, Juan Gómez-Luna<sup>a</sup>, Rachata Ausavarungnirun<sup>d</sup>

SAFARI Research Group

<sup>a</sup>ETH Zürich  
<sup>b</sup>Carnegie Mellon University  
<sup>c</sup>University of Illinois at Urbana-Champaign  
<sup>d</sup>King 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> 108

## Fall 2021 Meetings/Schedule

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

# Genomics (Fall 2021)

## Fall 2021 Edition:

- [https://safari.ethz.ch/projects\\_and\\_seminars/fall2021/doku.php?id=bioinformatics](https://safari.ethz.ch/projects_and_seminars/fall2021/doku.php?id=bioinformatics)

## Youtube Livestream:

- <https://www.youtube.com/watch?v=MnogTeMjY8k&list=PL5Q2soXY2Zi8sngH-TrNZnDhDkPq55J9J>

## Project course

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

Mobile Genomics Course - Meeting 1: Course...

Understanding **genetic variations**

Predicting the **presence and relative abundances of microbes** in a sample

Watch on **YouTube**

Rapid surveillance of **disease outbreaks**

Developing **personalized medicine**

## Fall 2021 Meetings/Schedule

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

# Hetero. Systems (Fall'21)

## Fall 2021 Edition:

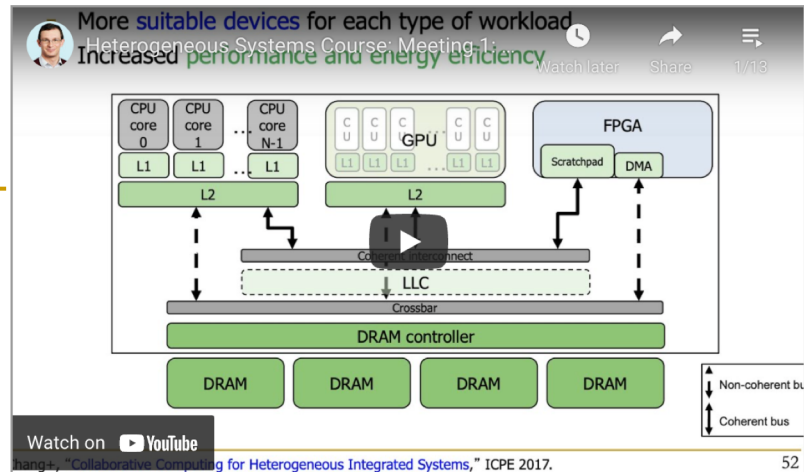
- https://safari.ethz.ch/projects\_and\_seminars/fall2021/doku.php?id=heterogeneous\_systems

## 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)		



# 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 thumbnail of the speaker in the top right, and a bottom bar with engagement metrics (74 likes, 1 comment), share and save buttons, and a description of the panel talk at the Undergraduate Architecture Mentoring Workshop at ISCA 2021.

Applying to Grad School  
& Doing Impactful Research

Onur Mutlu  
[omutlu@gmail.com](mailto: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



# SAFARI Live Seminars (I)


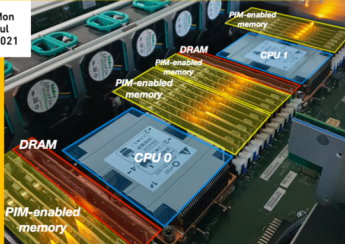
## SAFARI Live Seminars in Computer Architecture

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


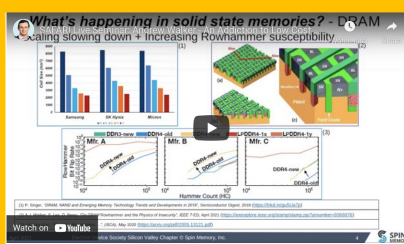
## SAFARI Live Seminars in Computer Architecture

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

**Samsung FIMDRAM (2021)**

Near-DRAM-banks processing for general-purpose computing

0.9 TOPS compute throughput<sup>1</sup>

1.2 TFLOPS compute throughput<sup>2</sup>

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

**SAFARI**


## 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

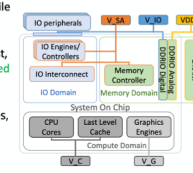
**SAFARI**  
SAFARI Research Group

**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

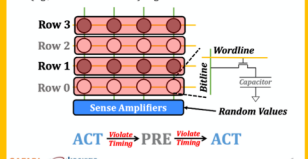
**SAFARI**  
SAFARI Research Group

**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



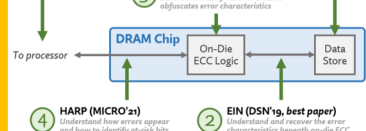
**Position Paper (Ongoing)** Arguing for increased transparency of DRAM reliability characteristics

**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

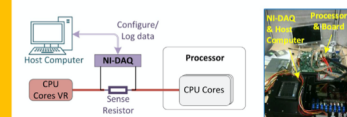
**SAFARI**  
SAFARI Research Group

**4** Mo Okt 2021



**Experimental Methodology**

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



**SAFARI**

<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.

SAFARI

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

Opportunities and challenges of computational data-driven immunology

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

Watch on YouTube

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

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

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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

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

Sean Lie  
Co-founder & Chief HW Architect, Cerebras

Watch on YouTube

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

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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

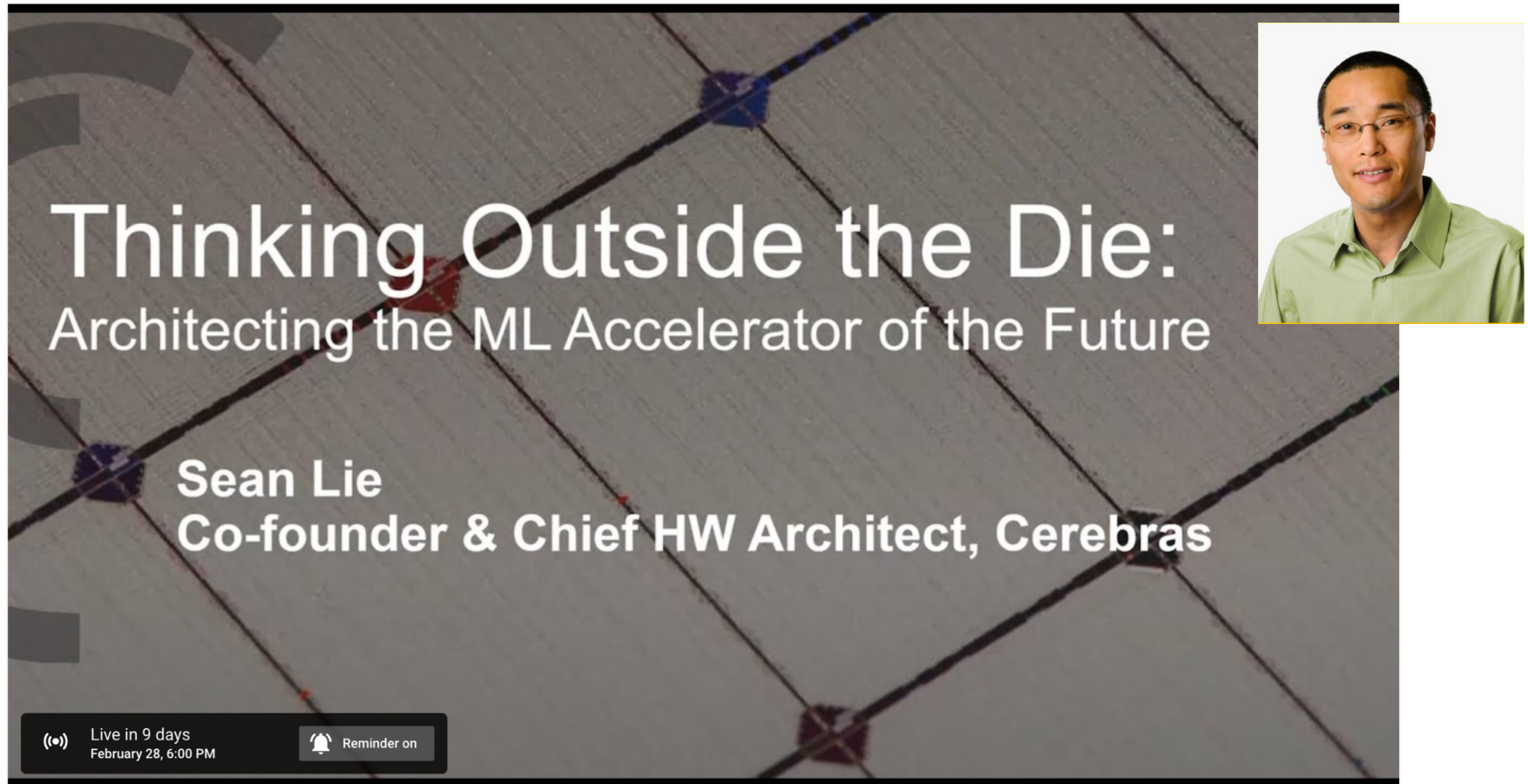
SAFARI Live Seminar: Fabrice Devaux, 2 Feb 2022  
Posted on January 15, 2022 by ewent

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)



# Upcoming SAFARI Live Seminar (Feb 28)

<https://www.youtube.com/watch?v=x2-qB0J7KHw>



SAFARI Live Seminar - Thinking Outside the Die: Architecting the ML Accelerator of the Future

1 waiting • Scheduled for Feb 28, 2022

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Onur Mutlu Lectures  
22.6K subscribers

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# Recommended Lecture for This Week

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- Onur Mutlu,  
[\*\*"Intelligent Architectures for Intelligent Systems"\*\*](#)  
*Invited Talk at [Supercomputing Frontiers Europe \(SCFE\)](#),*  
Virtual, 21 July 2021.  
[[Slides \(pptx\)](#) ([pdf](#))]  
[[Talk Video](#) (52 minutes, including Q&A)]

# Recommended Lecture for This Week



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## Intelligent Architectures for Intelligent Systems

**Onur Mutlu**

Professor of Computer Science Information Technology  
and Electrical Engineering department ETH Zurich



Onur Mutlu - Supercomputing Frontiers Europe'21 - Intelligent Architectures for Intelligent Systems

4,403 views • Premiered Aug 9, 2021

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# Seminar in Computer Architecture

## Lecture 1a: Intro & Logistics

Prof. Onur Mutlu

ETH Zürich  
Spring 2022  
24 February 2022