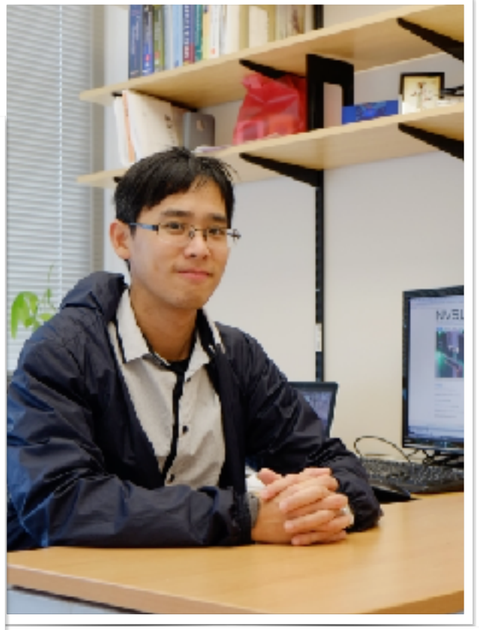
First Day of CS203: Advanced Computer Architecture (2025 Winter)

Prof. Usagi a.k.a.
Hung-Wei Tseng

Instructor — Hung-Wei Tseng

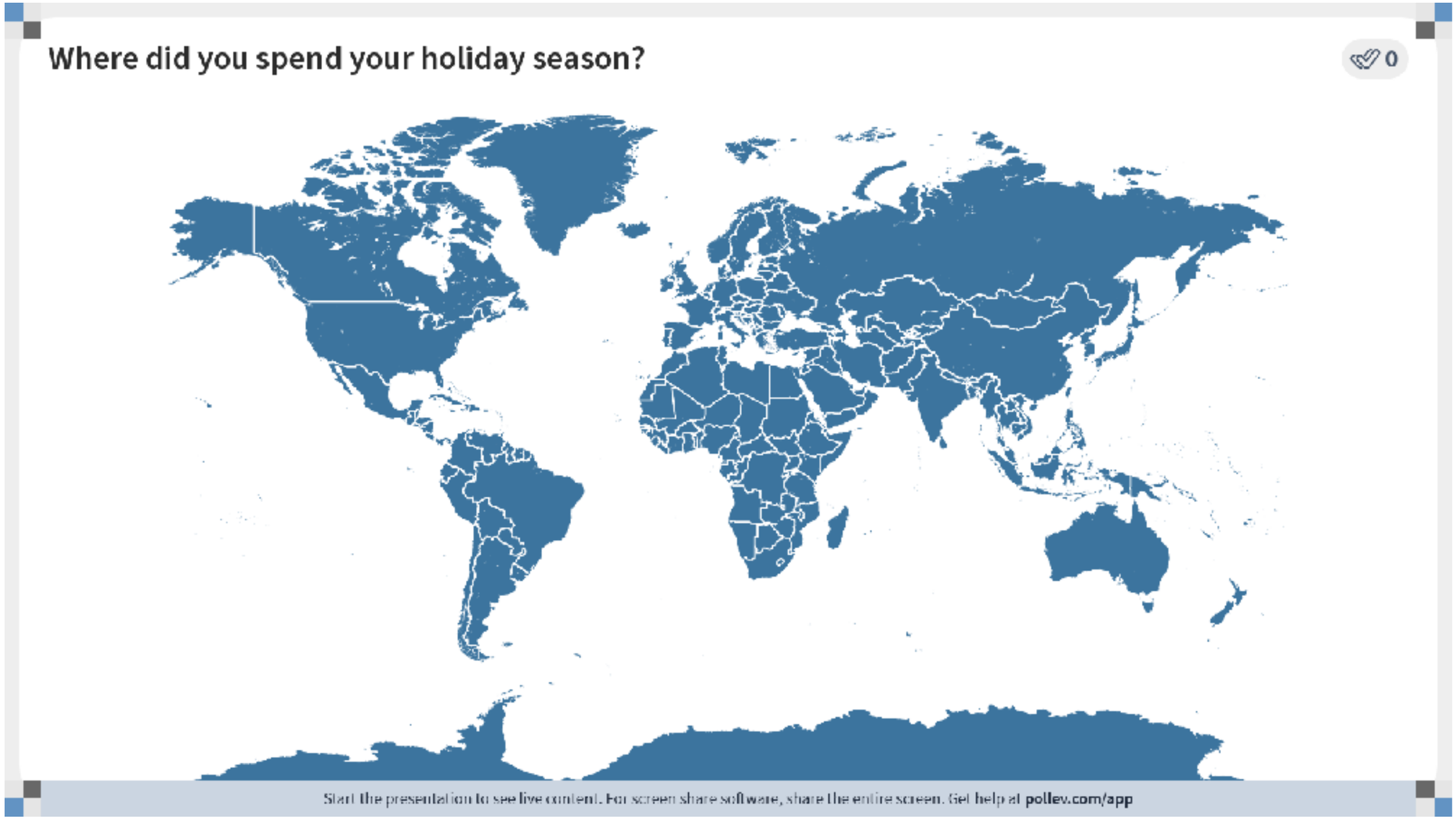
- Associate Professor @ UC Riverside, 05/2019—
- Website: https://intra.engr.ucr.edu/~htseng/
- E-mail: cs203 @ escal.org
- Visiting Researcher @ Google, 01/2023—03/2023
  - Working for TensorFlow Lite
- PhD in **Computer Science**, University of California, San Diego, 2014
- Research Interests
  - General-purpose computing on AI/ML/NN/RayTracing accelerators
  - Or anything else fun — we have an OpenUVR project recently
- Fun fact: Hung-Wei was once considering a career path as a singer but went back to academia due to the unsuccessful trial



Now, make sure you login to Poll Everywhere (through the App or the website) with your UCR email (you're preregistered already)

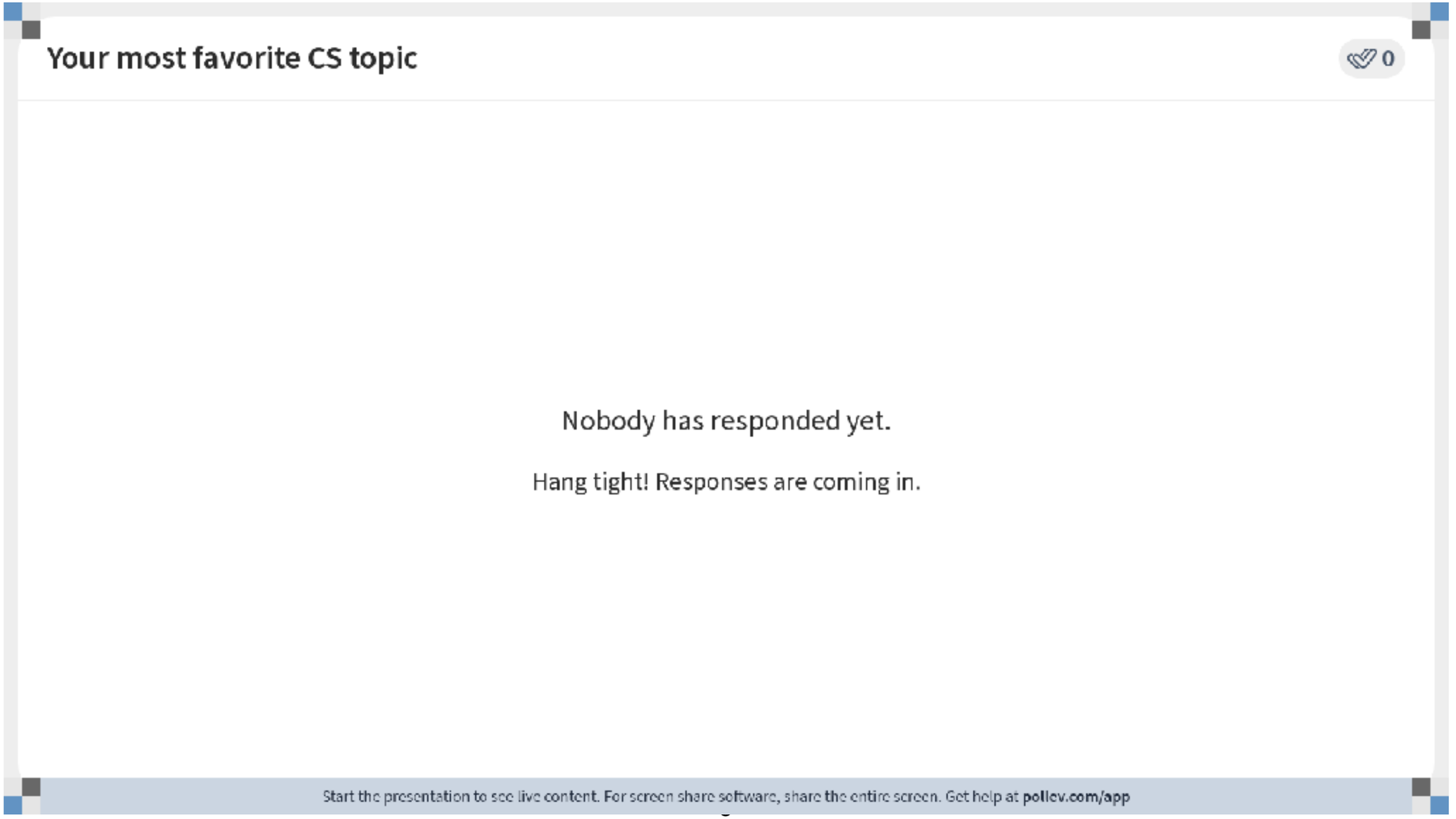
https://www.pollev.com/hungweitseng close in 1:30

Where did you spend your holiday season?



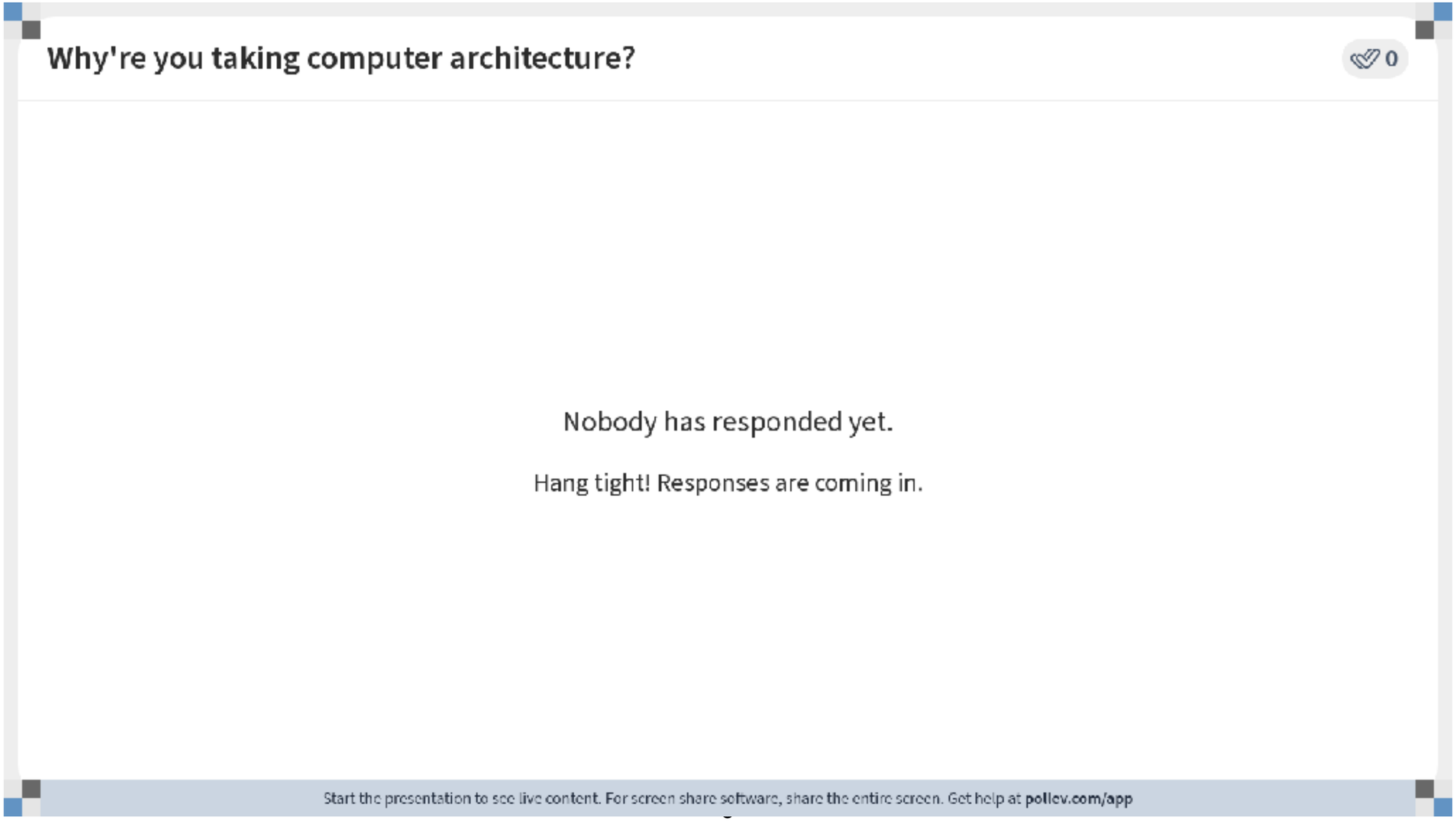
https://www.pollev.com/hungweitseng close in 1:30

What're your most favorite CS topics?

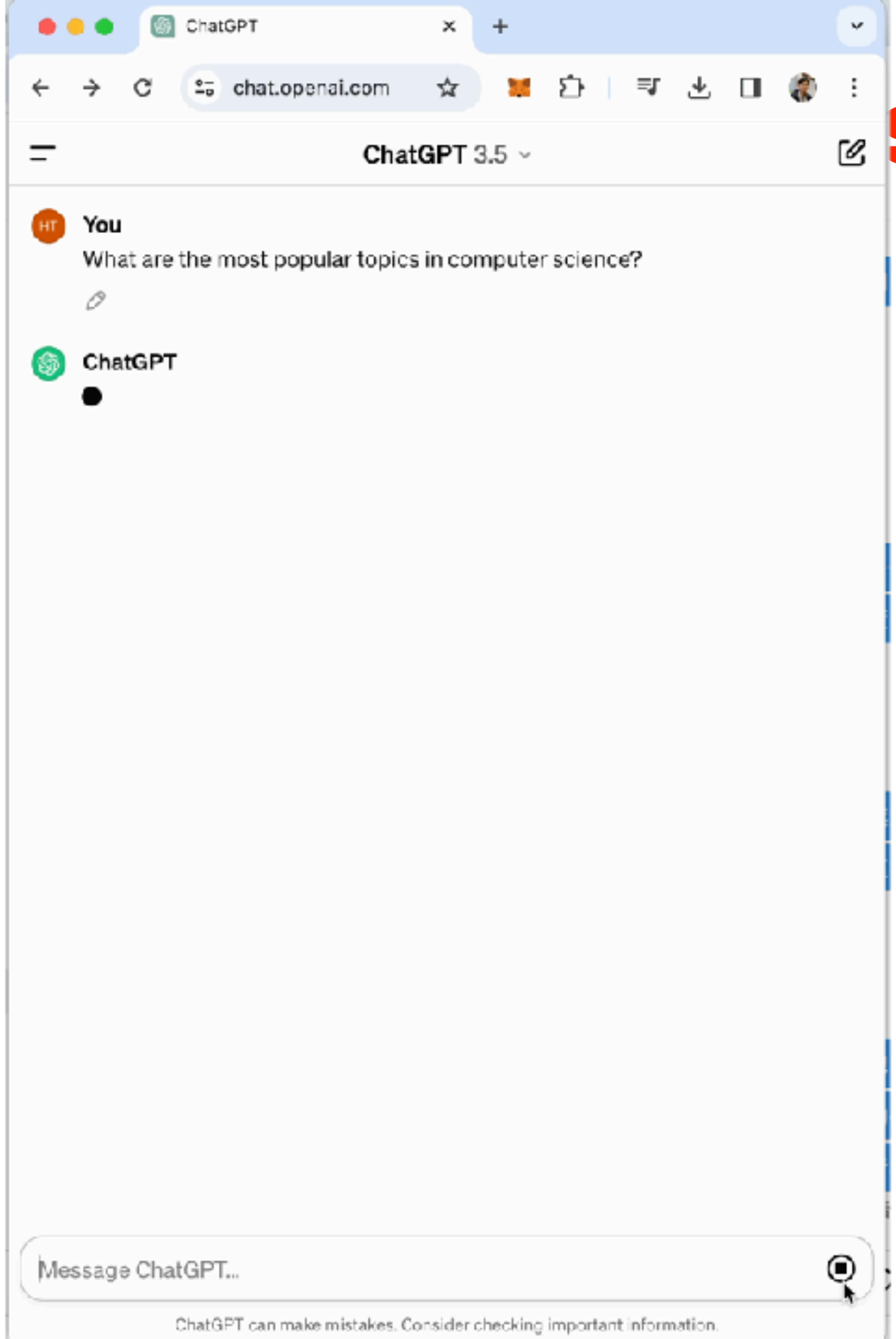


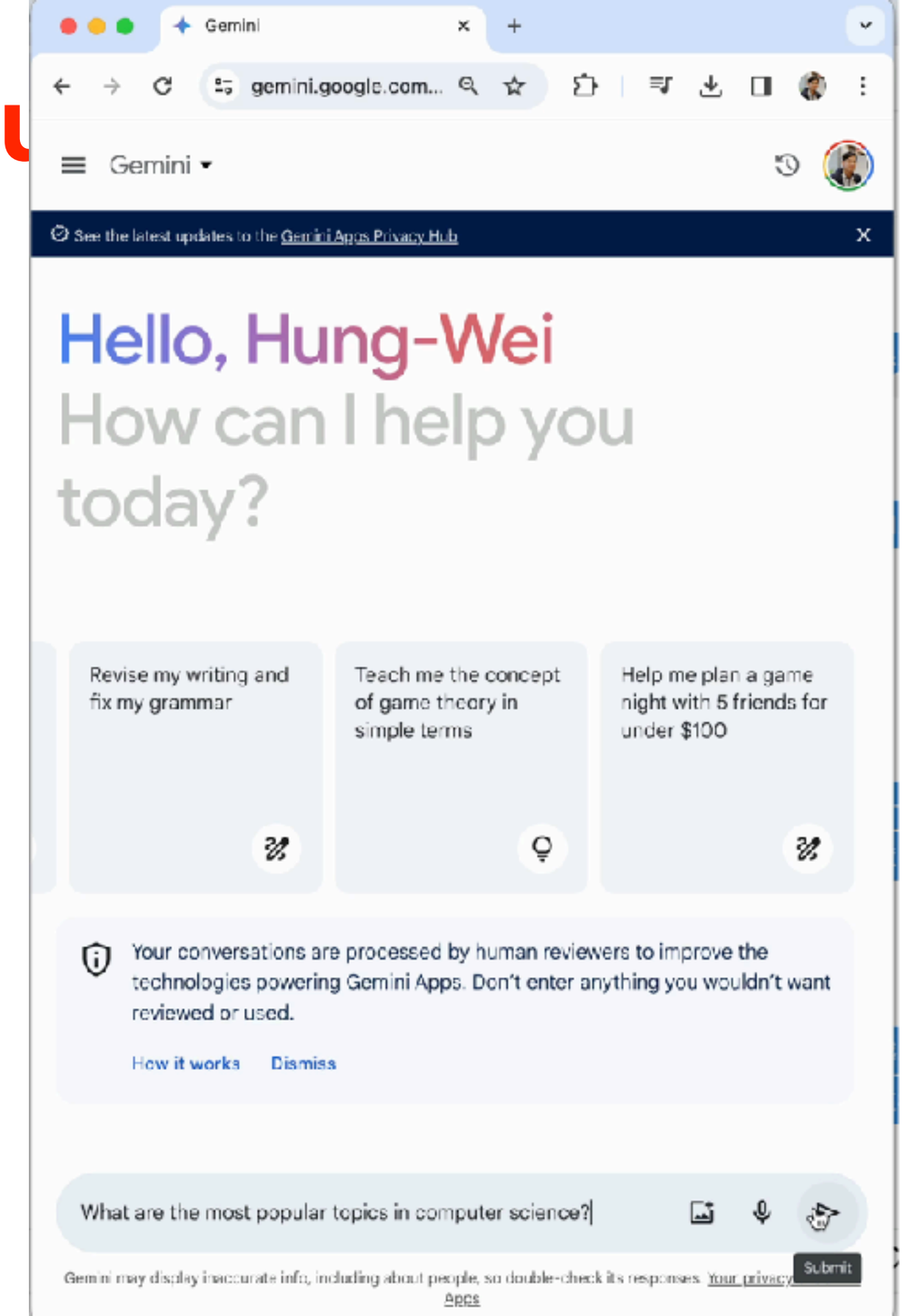
https://www.pollev.com/hungweitseng close in 1:30

Why are you taking CS203?



st popu


ChatGPT
chat.openai.com
ChatGPT 3.5
You
What are the most popular topics in computer science?
ChatGPT
Message ChatGPT...
ChatGPT can make mistakes. Consider checking important information.


Gemini
gemini.google.com...
Gemini
See the latest updates to the Gemini Apps Privacy Hub
Hello, Hung-Wei
How can I help you today?
Revise my writing and fix my grammar
Teach me the concept of game theory in simple terms
Help me plan a game night with 5 friends for under $100
Your conversations are processed by human reviewers to improve the technologies powering Gemini Apps. Don't enter anything you wouldn't want reviewed or used.
How it works
Dismiss
What are the most popular topics in computer science?
Submit
Gemini may display inaccurate info, including about people, so double-check its responses. Your privacy & Gemini Apps

What do you care as a computer scientist?

Algorithms
Data Structures
Software Engineering
Computer Architecture
Programming Languages
User Interfaces

t impor

ChatGPT

chat.openai.com/c...

ChatGPT 3.5

internet, enabling them to send and receive data. Topics include sensor networks, IoT devices, IoT platforms, and edge computing.

6. **Blockchain:** Originally developed for cryptocurrencies like Bitcoin, blockchain technology has broader applications in areas such as supply chain management, voting systems, and secure data sharing.
7. **Computer Vision and Image Processing:** With advancements in deep learning, computer vision has seen significant progress in areas such as object detection, image classification, and facial recognition.
8. **Quantum Computing:** Although still in its early stages, quantum computing has the potential to revolutionize computing by solving certain problems exponentially faster than classical computers. Topics include quantum algorithms, quantum cryptography, and quantum error correction.
9. **Software Engineering:** This encompasses various methodologies, tools, and practices for developing high-quality software systems. Topics include agile development, DevOps, software testing, and software architecture.
10. **Mobile Development:** With the widespread use of smartphones and tablets, mobile development remains an important area. Topics include iOS development, Android development, cross-platform development frameworks, and mobile UX/UI design.

These topics represent just a fraction of the diverse and dynamic field of computer science. New areas of research and innovation continually emerge as technology advances.

What are the most important topics in computer sciences?

ChatGPT can make mistakes. Consider checking important information.

Gemini

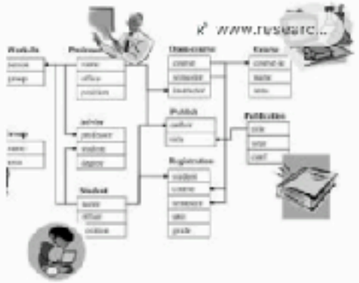
gemini.google.com...

Gemini

See the latest updates to the Gemini Apps Privacy Hub

Computer Networking computer science

- **Databases and Big Data:** Databases are collections of organized data. Big data refers to the large and complex datasets that are being generated by modern businesses and organizations. Database professionals are responsible for designing, building, and maintaining databases, while big data specialists are responsible for analyzing and extracting insights from large datasets.



Databases computer science

These are just a few of the many popular topics in computer science. The field is constantly evolving, so there are always new and exciting things to learn.

Sources

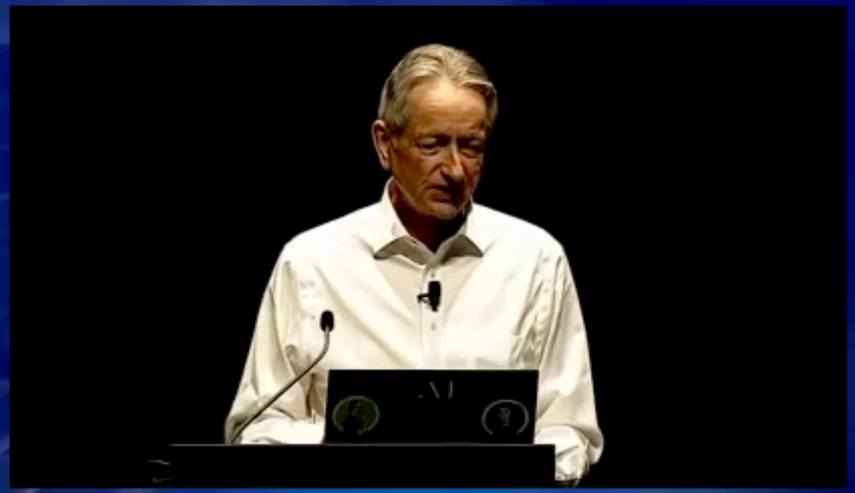
1. www.dailychina.news/showArticle?main_id...

What are the most important topics in computer sciences?

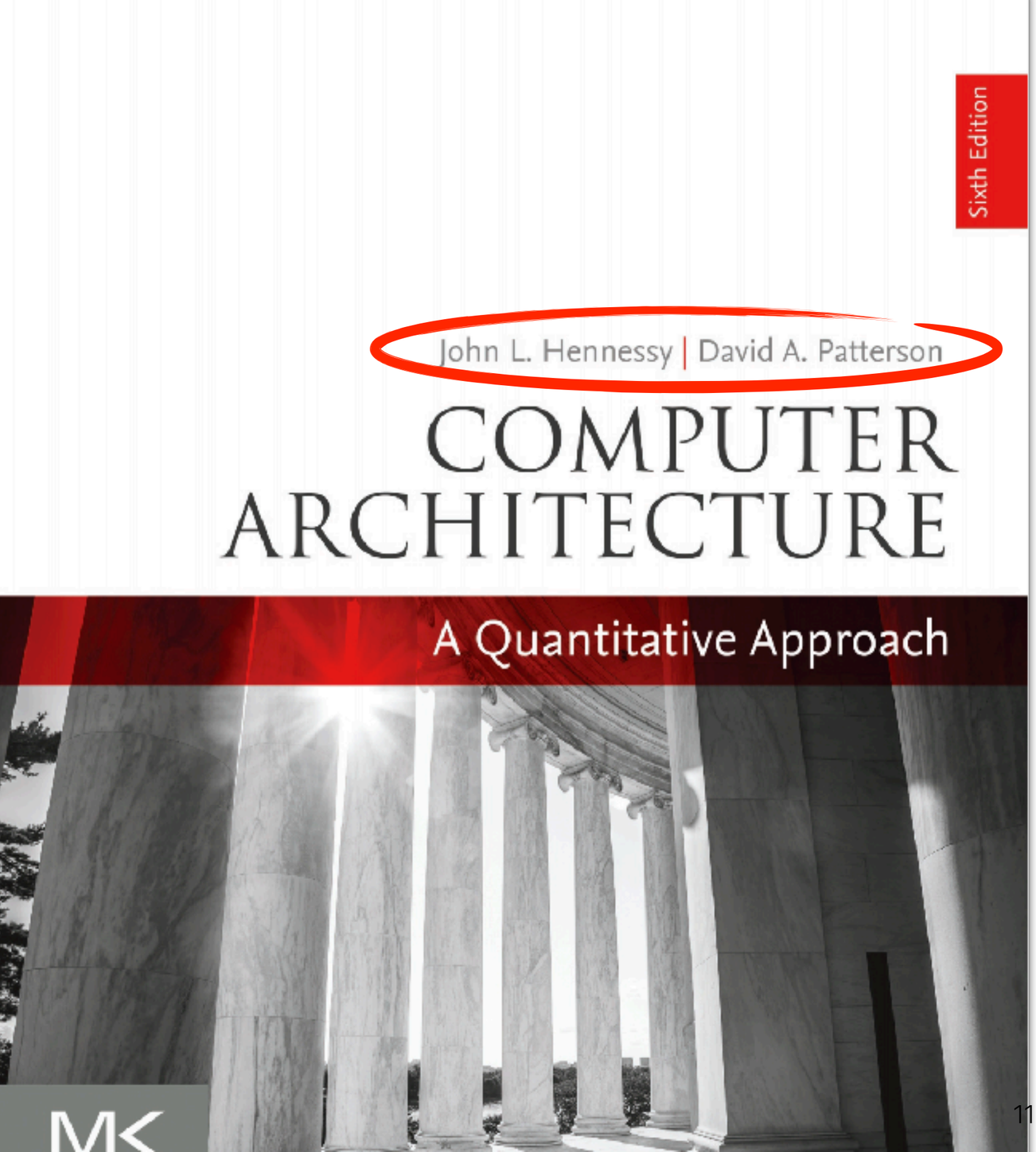
Gemini may display inaccurate info, including about people, so double-check its responses. Your privacy & Gemini Apps

The return of backpropagation

- Between 2005 and 2009 researchers (in Canada!) made several technical advances that enabled backpropagation to work better in feed-forward nets.
  - Unsupervised pre-training; random dropout of units; rectified linear units.
  - The technical details of these advances are very important to the researchers but they are not the main message.
  - The main message is that backpropagation now works amazingly well if you have two things:
    - a lot of labeled data
    - a lot of convenient compute power (*e.g.* GPUs)



acm FCRC



Computer Architecture

Enables

Deep Learning

Computer Architects — Hidden Figures

What is “Computer Architecture”?

puter a

ChatGPT

chat.openai.com/c/640...

ChatGPT 3.5

threats, knowledge of security principles and cryptographic techniques is crucial for protecting data and systems from unauthorized access and attacks.

9. **Artificial Intelligence and Machine Learning**: AI and ML are transforming various industries and applications. Understanding concepts like neural networks, deep learning, reinforcement learning, and natural language processing is becoming increasingly important.
10. **Human-Computer Interaction (HCI)**: HCI focuses on designing interactive systems that are user-friendly and efficient. Understanding user behavior, usability principles, and interaction design is essential for developing effective user interfaces.

These topics serve as foundational knowledge for computer scientists and are applicable across various domains and specialties within the field. Additionally, interdisciplinary areas such as bioinformatics, computational biology, and computational neuroscience are gaining importance, highlighting the interdisciplinary nature of computer science.

You

What is computer architecture?

ChatGPT

Message ChatGPT...

ChatGPT can make mistakes. Consider checking important information.

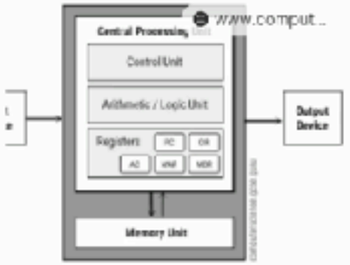
Gemini

gemini.google.com...

Gemini

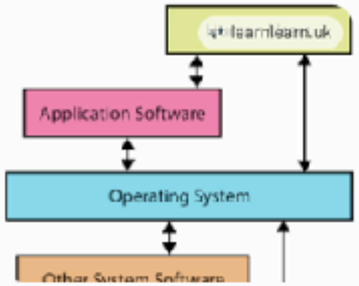
See the latest updates to the Gemini Apps Privacy Hub

well as the software that controls them. An understanding of computer architecture is essential for writing efficient programs and designing new computing systems.



Computer Architecture computer science

- **Operating Systems:** An operating system (OS) is the software that manages the hardware and software resources of a computer. It provides a platform for running other programs and applications. Operating systems are essential for the smooth operation of computers.



Operating Systems computer science

These are just a few of the most important topics in computer science. These foundational concepts are essential for understanding how computers work and for creating new technologies.

What is computer architecture?

Submit

Gemini may display inaccurate info, including about people, so double-check its responses. Your privacy & Gemini Apps

What's computer architecture?

architecture noun

ar·chi·tec·ture | \ ˈär-kə-ˌtek-chər \

Definition of architecture

1 : the art or science of building

specifically : the art or practice of designing and building structures and especially habitable ones

2 a : formation or construction resulting from or as if from a conscious act

// the *architecture* of the garden

b : a unifying or coherent form or structure

// a novel that lacks *architecture*

3 : architectural product or work

// buildings that comprise the *architecture* of the square

4 : a method or style of building

// Gothic *architecture*

5 : the manner in which the components of a computer or computer system are organized and integrated

// different program *architectures*

The manner in which the components of a computer or computer system are organized and integrated

How much do we understand “Computer Architectures” for now

Processors and memories are essential for most modern general-purpose computers

Moore’s Law is still alive

On the same machine, programs with fewer lines of code will have shorter execution time

On the same machine, an algorithm with lower computational complexities will have shorter execution time when solving the same problem with the same input

On the same machine, algorithm implementations with the same computational complexities will similar execution time when solving the same problem with the same input

Leveraging more “bit-wise” operations in C code will make the program significantly faster

Algorithm complexity is less important if we have rich parallel processing capabilities

The smaller size of a transistor, the smaller power consumption of it

GPUs are not limited by Moore's Law

The performance growth of recent GPU architectures can match the demand of efficient AI/ML training

Isn't "algorithm" and "computational complexity" good enough?

Demo

```
if(option)
    std::sort(data, data + arraySize);

for (unsigned c = 0; c < arraySize*1000; ++c) {
    int t = std::rand();

    (data[c%arraySize] >= t)
            sum ++;
    }
}
```

$O(nlog_2n)$

$O(n)$

if option is set to 1: $O(nlog_2n)$

otherwise, O(n): $O(n)$

On the same machine, programs with fewer lines of code will have shorter execution time

On the same machine, an algorithm with lower computational complexities will have shorter execution time when solving the same problem with the same input

Demo (2)

A

```
for(i = 0; i < ARRAY_SIZE; i++)
{
  for(j = 0; j < ARRAY_SIZE; j++)
  {
    c[i][j] = a[i][j]+b[i][j];
  }
}
```

B

```
for(j = 0; j < ARRAY_SIZE; j++)
{
  for(i = 0; i < ARRAY_SIZE; i++)
  {
    c[i][j] = a[i][j]+b[i][j];
  }
}
```

$O(n^2)$ **Complexity** $O(n^2)$

Performance?

Demo (2)

A

```
for(i = 0; i < ARRAY_SIZE; i++)
{
  for(j = 0; j < ARRAY_SIZE; j++)
  {
    c[i][j] = a[i][j]+b[i][j];
  }
}
```

B

```
for(j = 0; j < ARRAY_SIZE; j++)
{
  for(i = 0; i < ARRAY_SIZE; i++)
  {
    c[i][j] = a[i][j]+b[i][j];
  }
}
```

$O(n^2)$ **Complexity** $O(n^2)$

A Lot Better! **Performance?** **Worse**

On the same machine, algorithm implementations with the same computational complexities will similar execution time when solving the same problem with the same input

Demo (3) — Bitwise operations?

A

```
void regswap(int* a, int* b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}
```

B

```
void xorswap(int* a, int* b) {
    *a ^= *b;
    *b ^= *a;
    *a ^= *b;
}
```

Leveraging more “bit-wise” operations in C code will make the program significantly faster

Demo (4) — quick sort v.s. bitonic sort on GPU

Quick Sort

$O(nlog_2n)$

Bitonic Sort

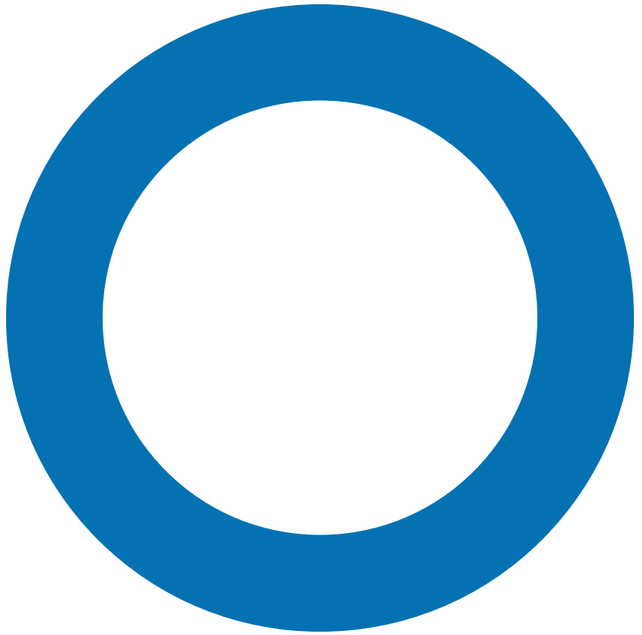
$O(nlog_2^2n)$

```
void BitonicSort() {

    int i,j,k;

    for (k=2; k<=N; k=2*k) {
        for (j=k>>1; j>0; j=j>>1) {
            for (i=0; i<N; i++) {
                int ij=i^j;
                if ((ij)>i) {
                    if ((i&k)==0 && a[i] > a[ij])
                        exchange(i,ij);
                    if ((i&k)!=0 && a[i] < a[ij])
                        exchange(i,ij);
                }
            }
        }
    }
}
```

Algorithm complexity is less important if we have rich parallel processing capabilities



? ? ? ?

Thinking about the washlet

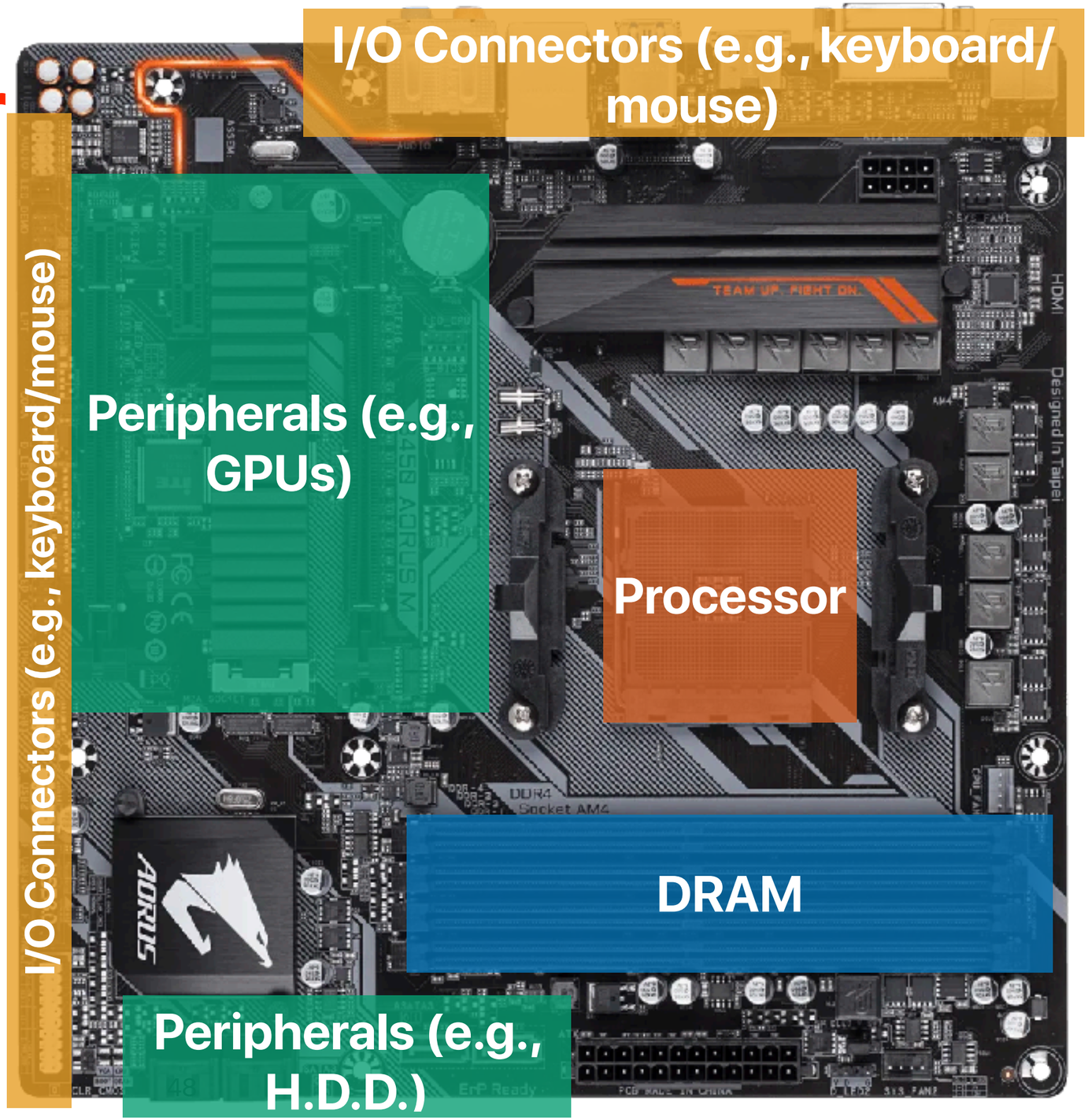
Or a Tesla

Take-aways: Why CS203?

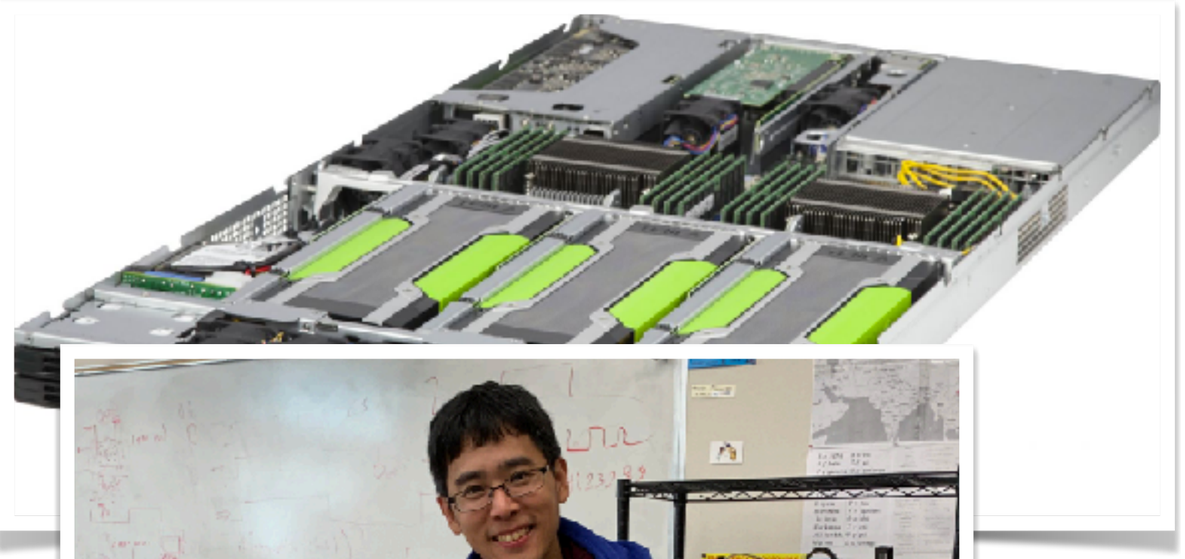
- Algorithm complexity does not work well on “real” computers

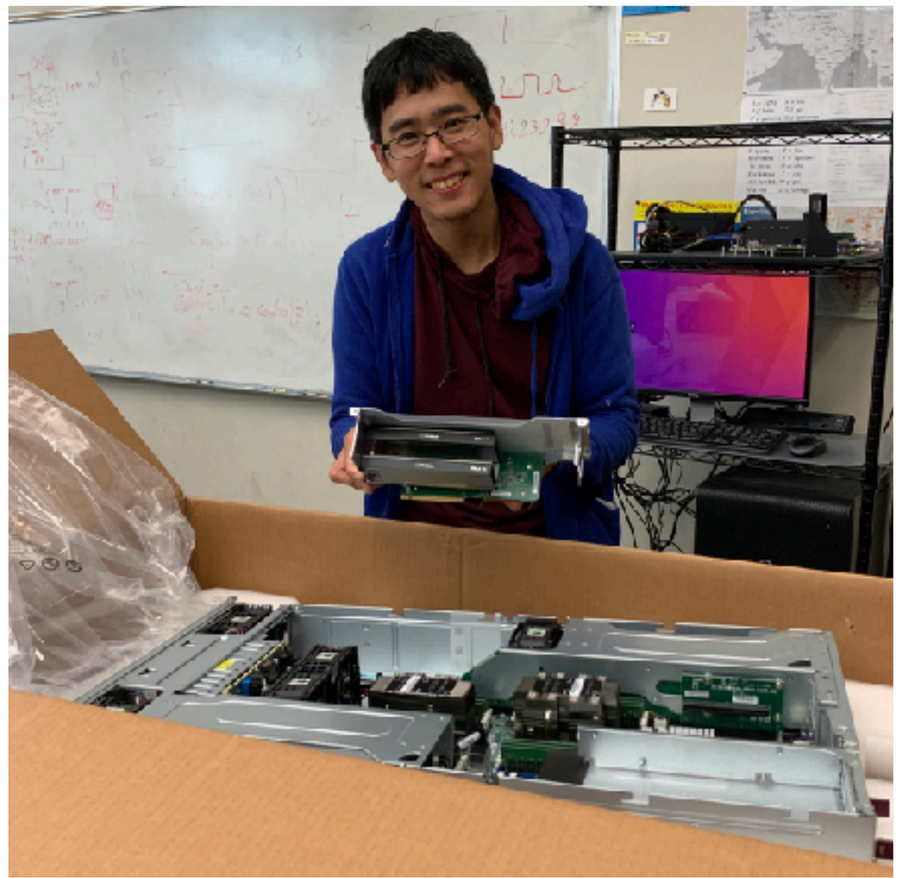
Big Picture of Computer Architecture: the Von Neumann Architecture

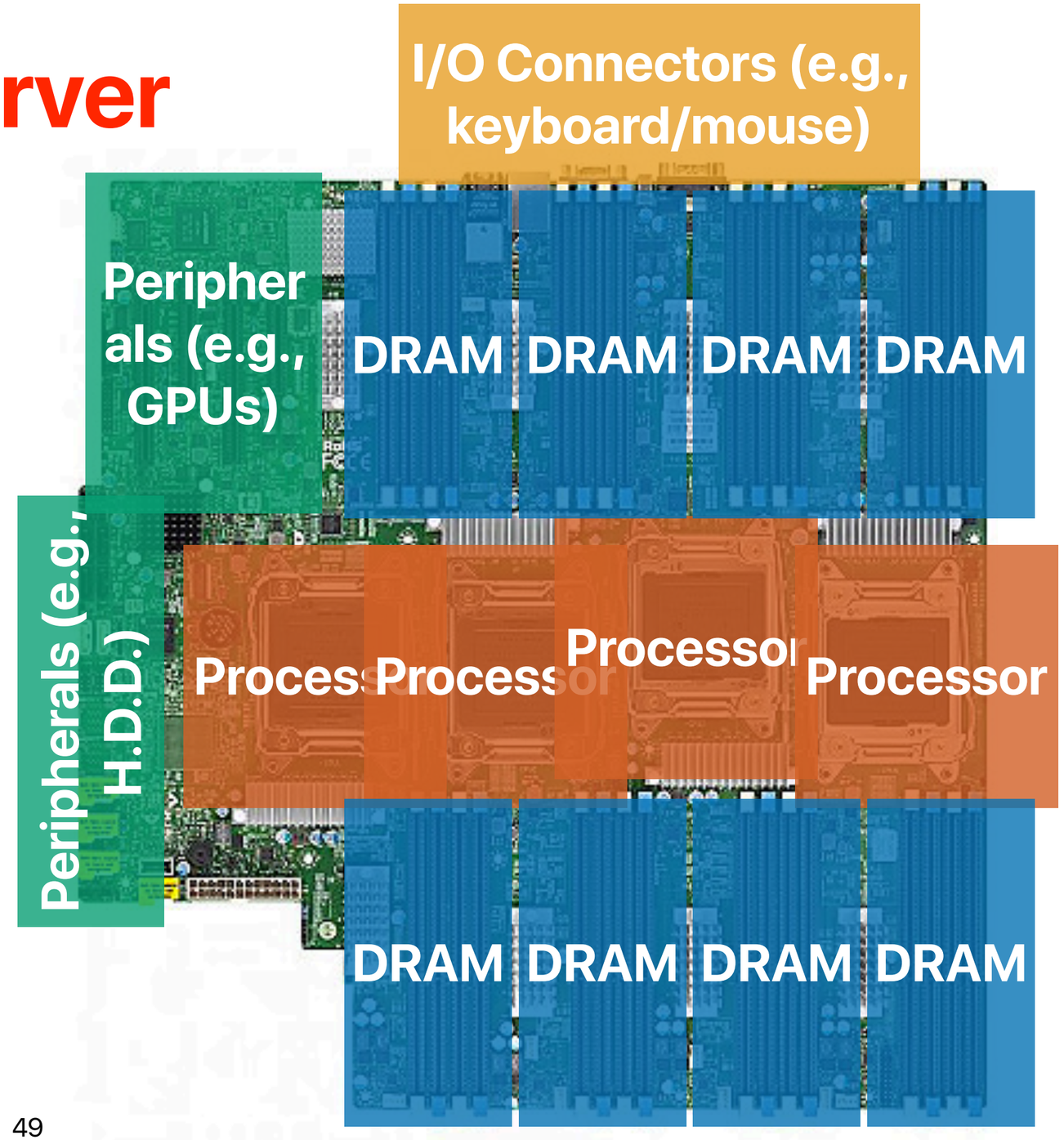
Desktop Computer



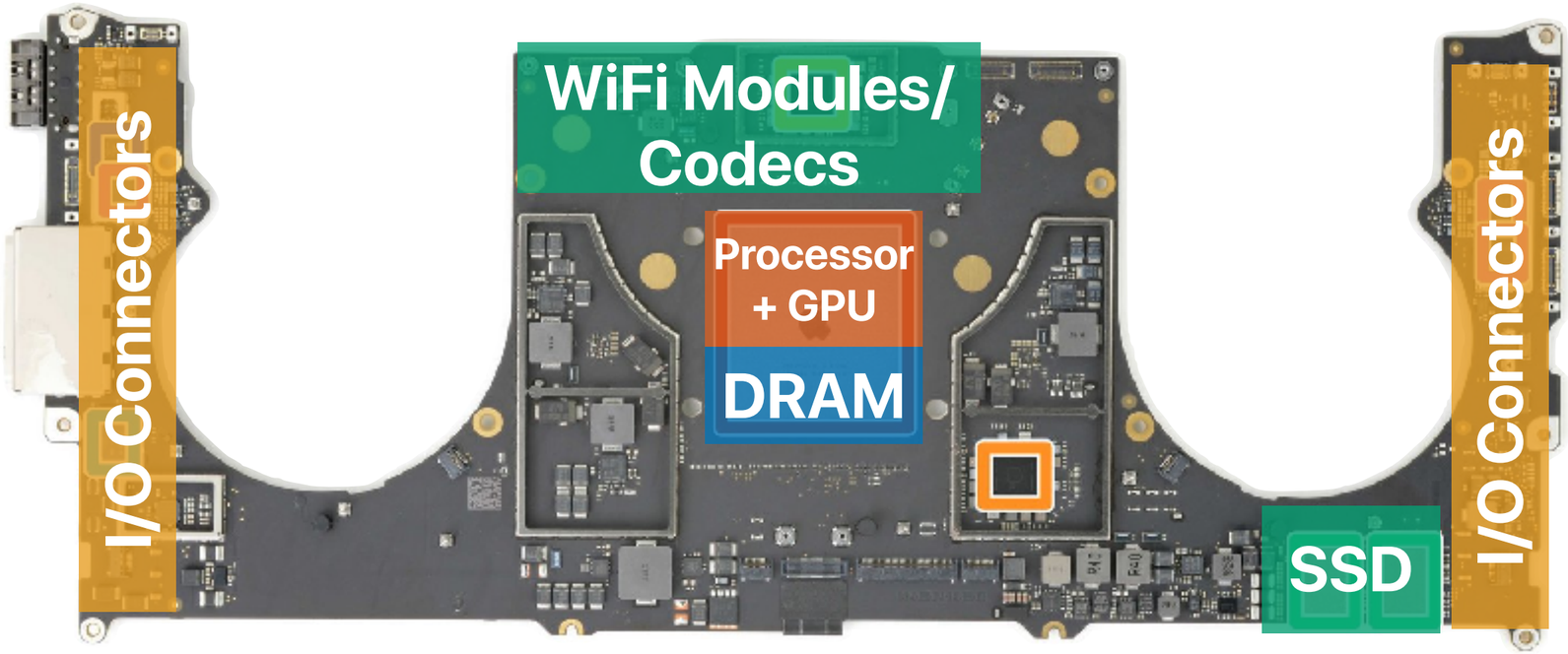
Server






I/O Connectors (e.g., keyboard/mouse)
Peripherals (e.g., GPUs)
DRAM
DRAM
DRAM
DRAM
Peripherals (e.g., H.D.D.)
Processor
Processor
Processor
Processor
DRAM
DRAM
DRAM
DRAM

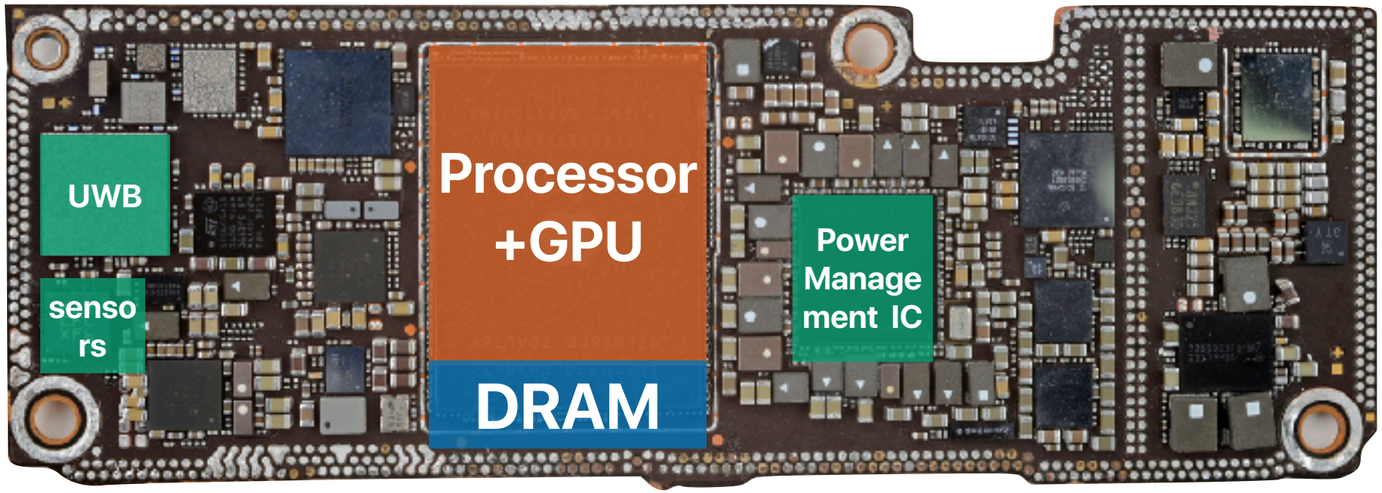
MacBook Pro M3

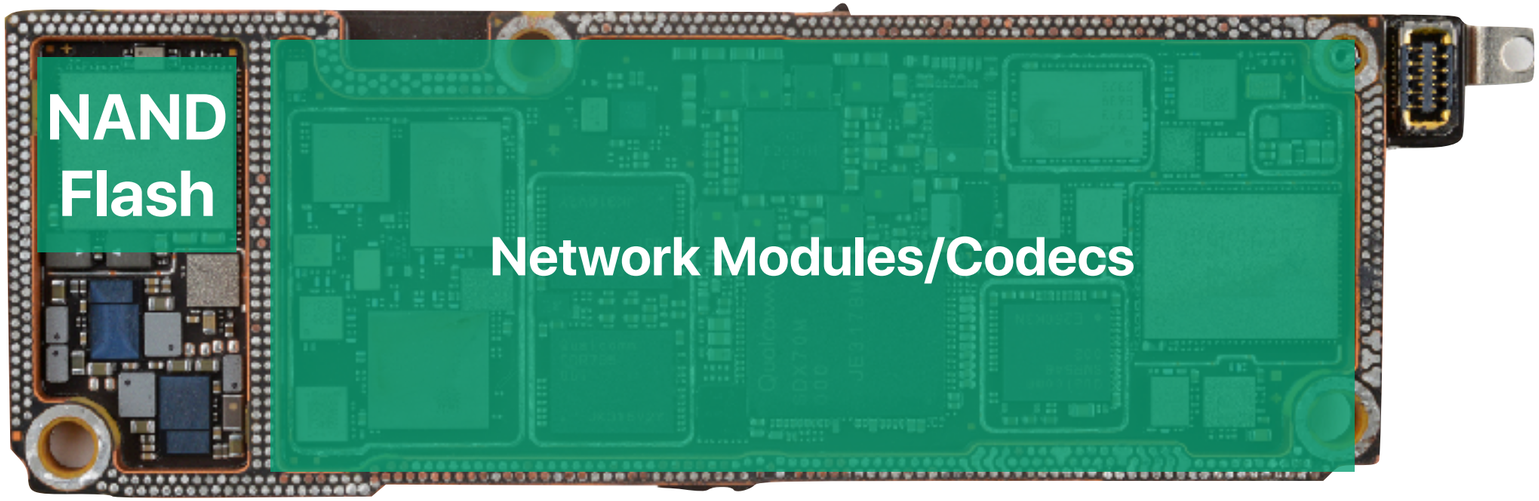


https://zh.ifixit.com/Device/MacBook_Pro_14%22_Late_2023_%28M3_Pro_and_M3_Max%29

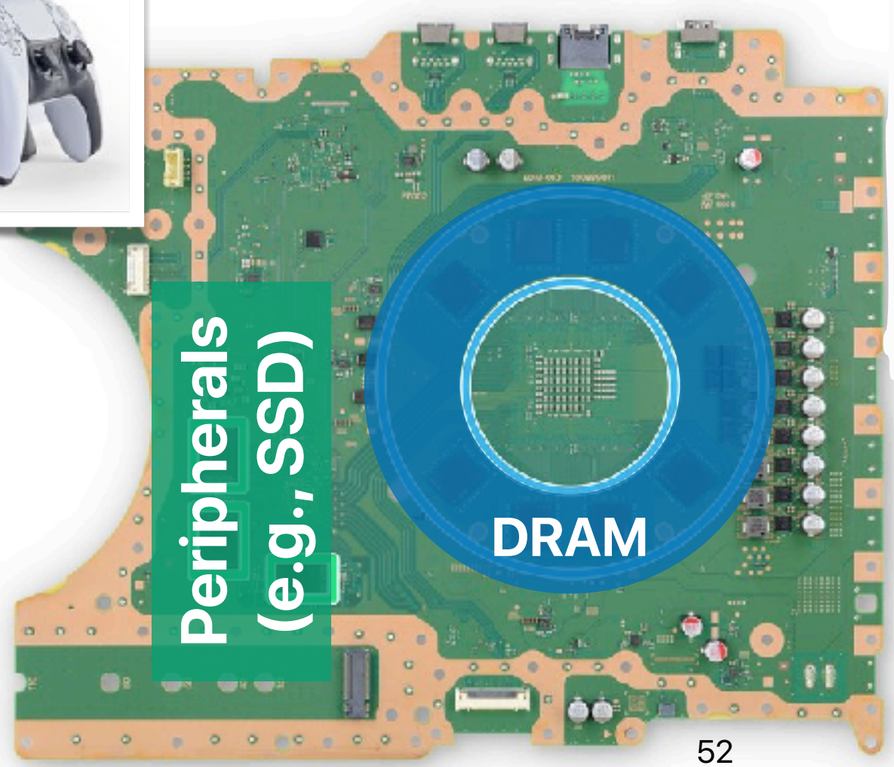
https://www.ifixit.com/News/82867/iphone-15-teardown-reveals-software-lockdown

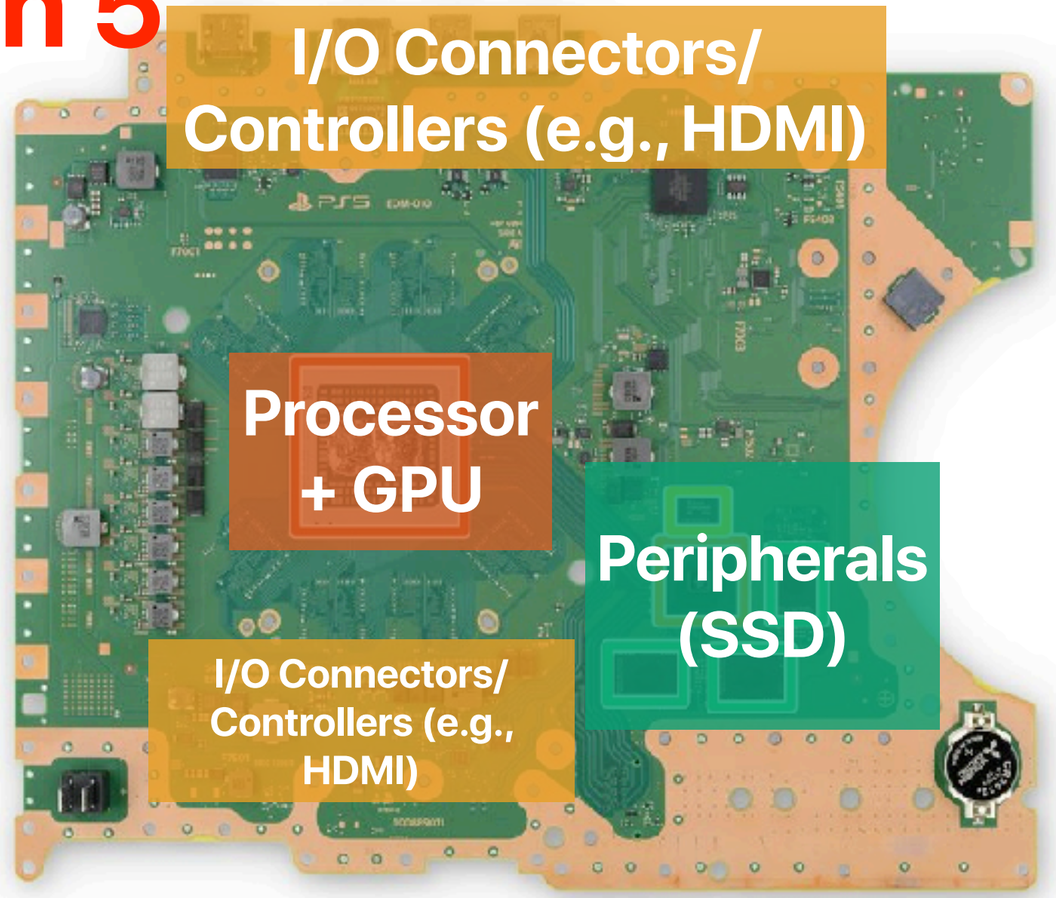
iPhone 15 Pro



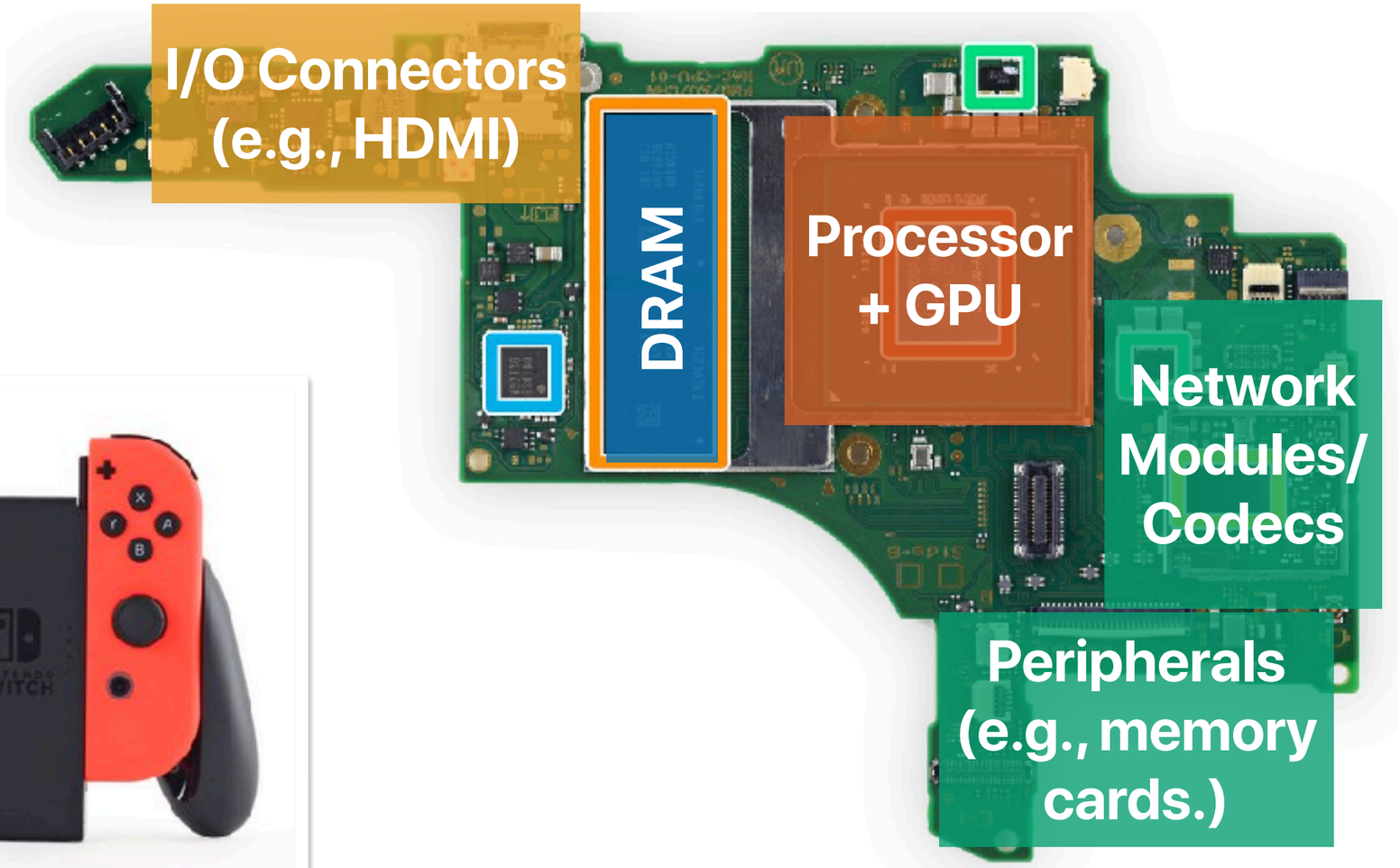


Play Station 5

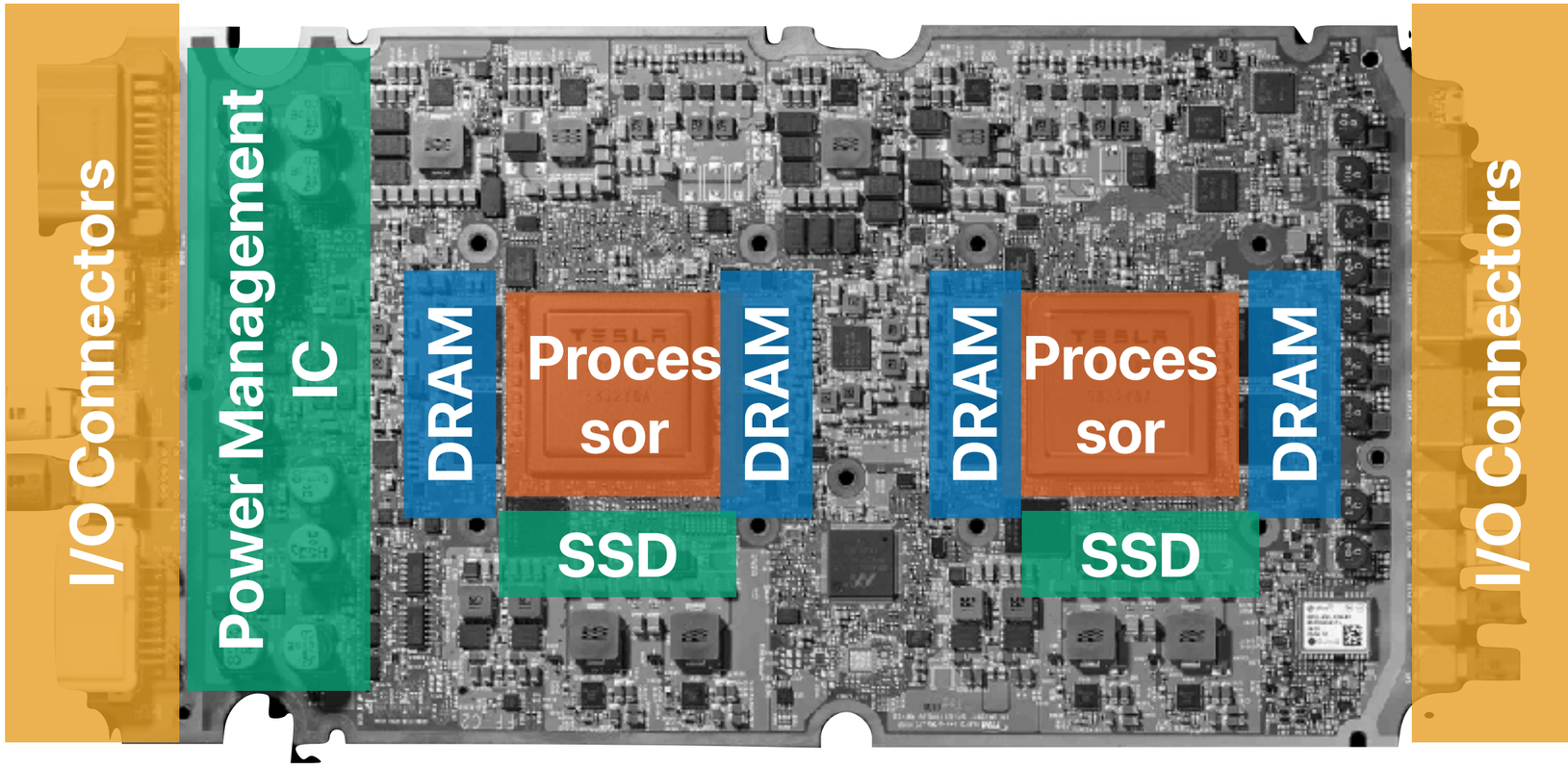




Nintendo Switch

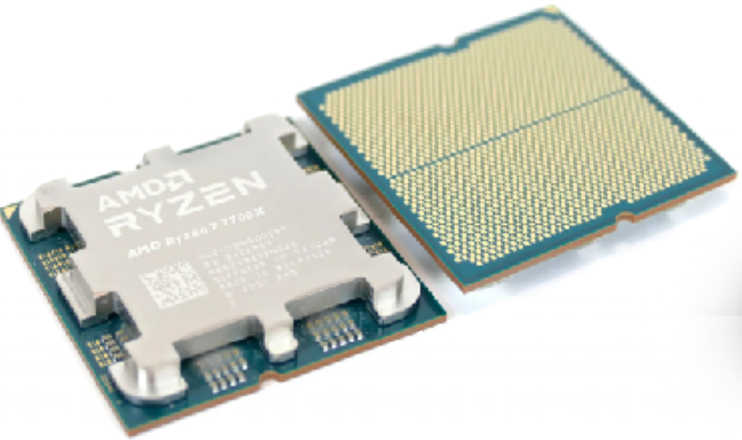


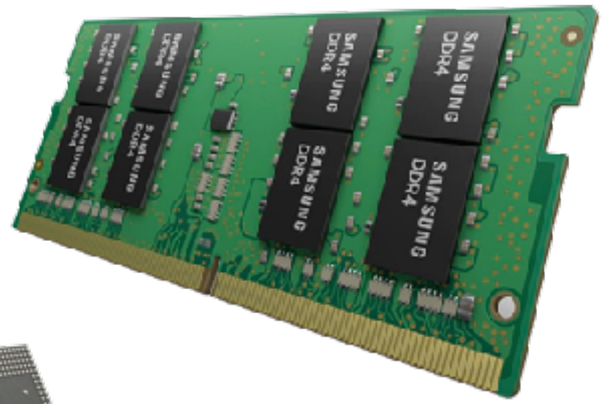
Tesla Model 3



Processors and memory modules are everywhere!

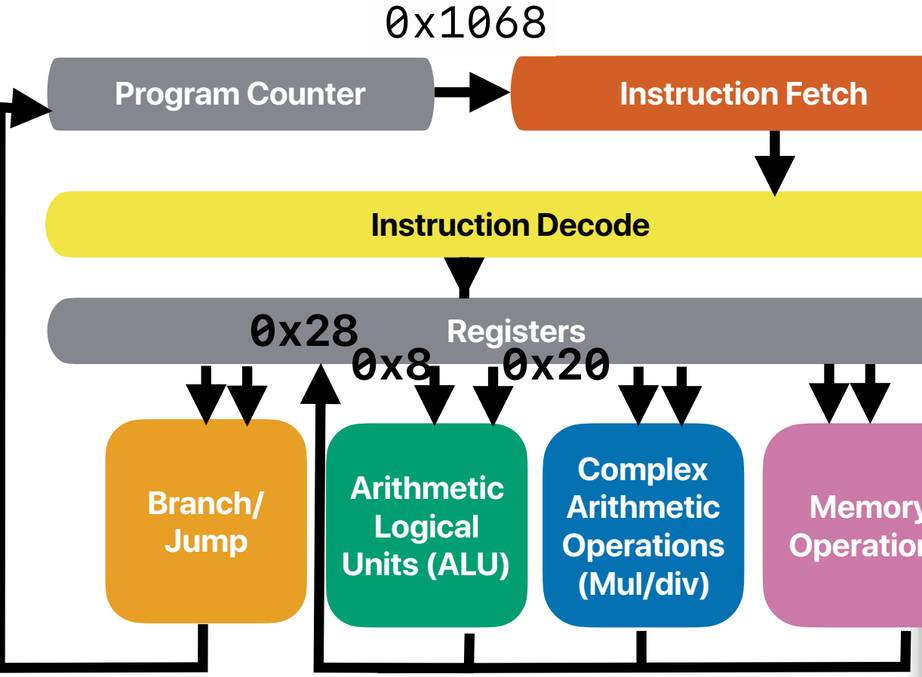
Processors





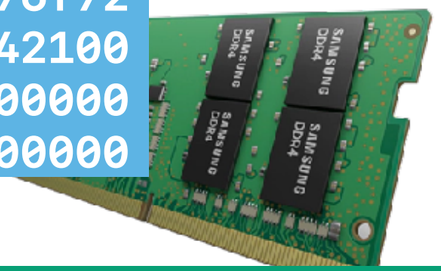
Memory

von Neumann architecture



Processor

Instructions	Data
f30f1efa	08400000
4883ec08	00000100
488d3d95	02004865
0f0000e8	6c6c6f2c
dcffffff	20776f72
31c04883	6c642100
c408c30f	00000000
1f440000	00000000



Memory

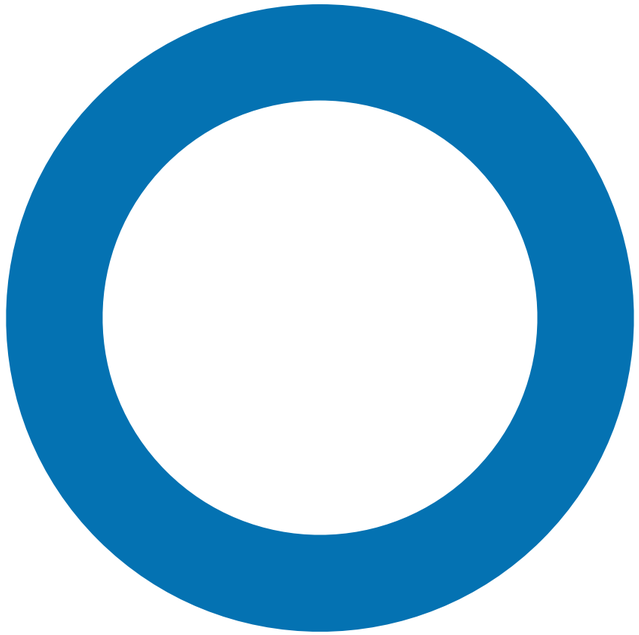
```
int main(){
    printf("Hello, world!\n");
}
```

Instructions	Data
f30f1efa	08400000
4883ec08	00000100
488d3d95	02004865
0f0000e8	6c6c6f2c
dcffffff	20776f72
31c04883	6c642100
c408c30f	00000000
1f440000	00000000

Storage

By loading different programs into memory, your computer can perform different functions

Processors and memories are essential for most modern general-purpose computers



Start with this simple program in C

```
int A[] =
{1,2,3,4,5,6,7,8,9,10,1,2,3,4
,5,6,7,8,9,10};
```

Compiler

```
Contents of section .data:
 0000 01000000 02000000 03000000 04000000
 0010 05000000 06000000 07000000 08000000
 0020 09000000 0a000000 01000000 02000000
 0030 03000000 04000000 05000000 06000000
 0040 07000000 08000000 09000000 0a000000
```

Data

```
int main()
{
    int i=0, sum=0;
    for(i = 0; i < 20; i++)
    {
        sum += A[i];
    }
    return 0;
}
```

control flow operations

logical operations

memory access

arithmetic operations

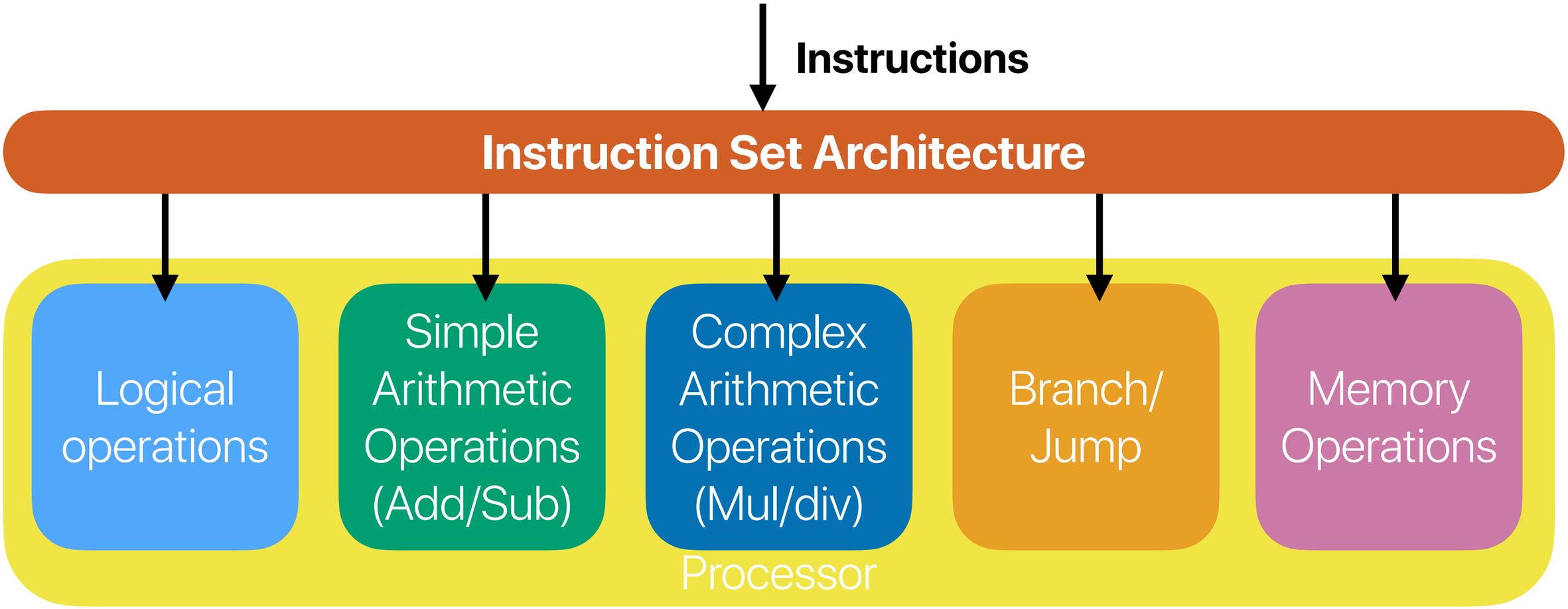
```
main:
.LFB0:
    endbr64
    pushq   %rbp
    movq %rsp, %rbp
    movl $0, -8(%rbp)
    movl $0, -4(%rbp)
    movl $0, -8(%rbp)
    jmp  .L2
.L3:
    movl -8(%rbp), %eax
    cltq
    leaq 0(,%rax,4), %rdx
    leaq A(%rip), %rax
    movl (%rdx,%rax),
%eax
    addl %eax, -4(%rbp)
    addl $1, -8(%rbp)
.L2:
    cmpl $19, -8(%rbp)
    jle  .L3
    movl $0, %eax
    popq %rbp
    ret
```

Compiler

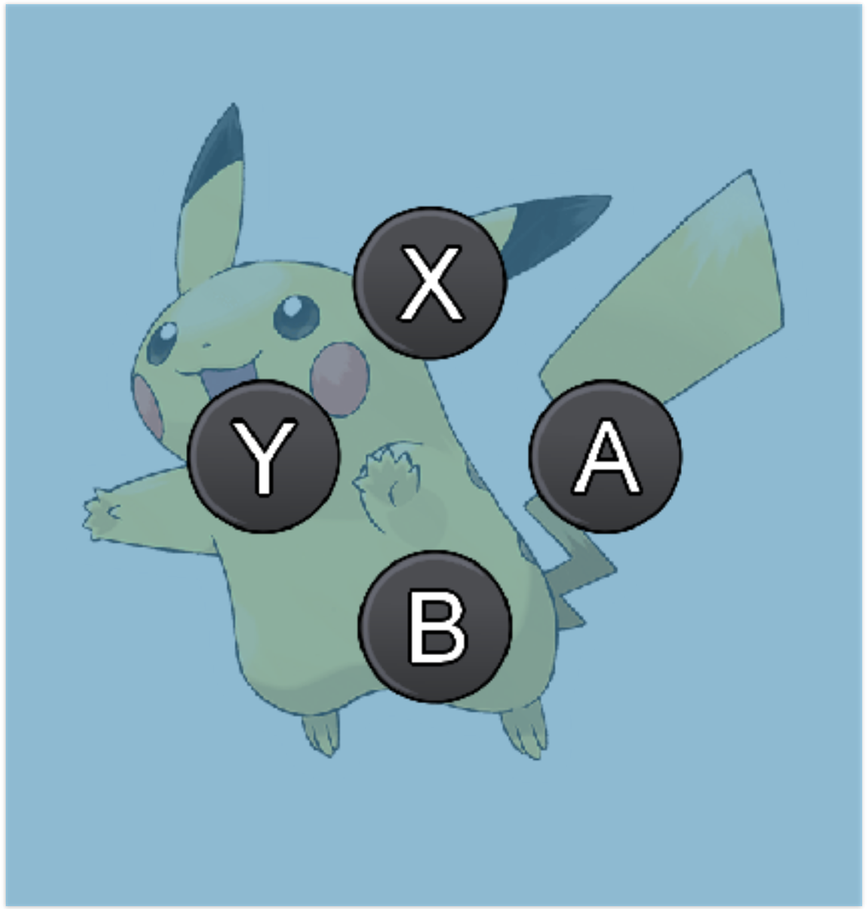
```
Contents of section .text:
 0000 f30f1efa 554889e5 c745f800 000000c7
 0010 45fc0000 0000c745 f8000000 00eb1e8b
 0020 45f84898 488d1425 00000000 488d0500
 0030 0000008b 04020145 fc8345f8 01837df8
 0040 137edcb8 00000000 5dc3
```

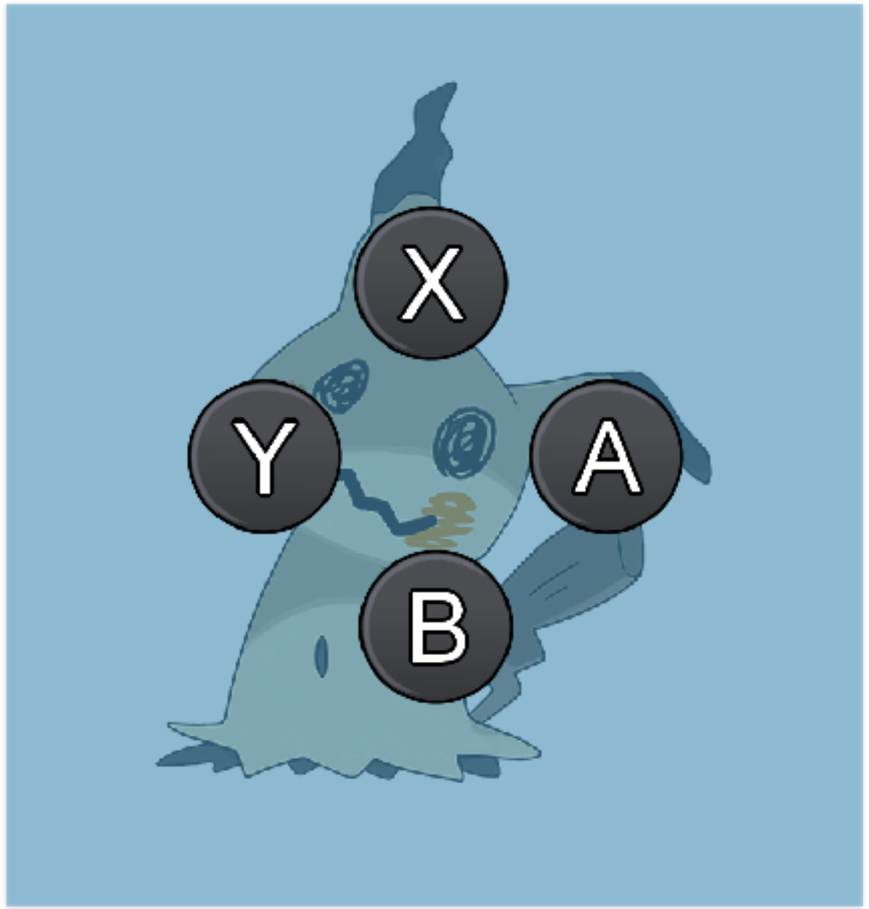
Instructions

Microprocessor — a collection of functional units



ISA — the “abstraction” of processor features





Challenges of von Neumann Architecture

Moore's Law[1]

- The number of transistors we can build in a fixed area of silicon doubles every 12 ~ 24 months.

Moore's Law[1]

Present and future

By integrated electronics, I mean
technologies which are referred to
tronics today as well as any additi
result in electronics functions suppli
to miniaturize electronics equipment
creasingly complex electronic functi
space with minimum weight. Sever
evolved, including microassembly
individual components, thin-film
semiconductor integrated circuits.

ICs are increasingly p

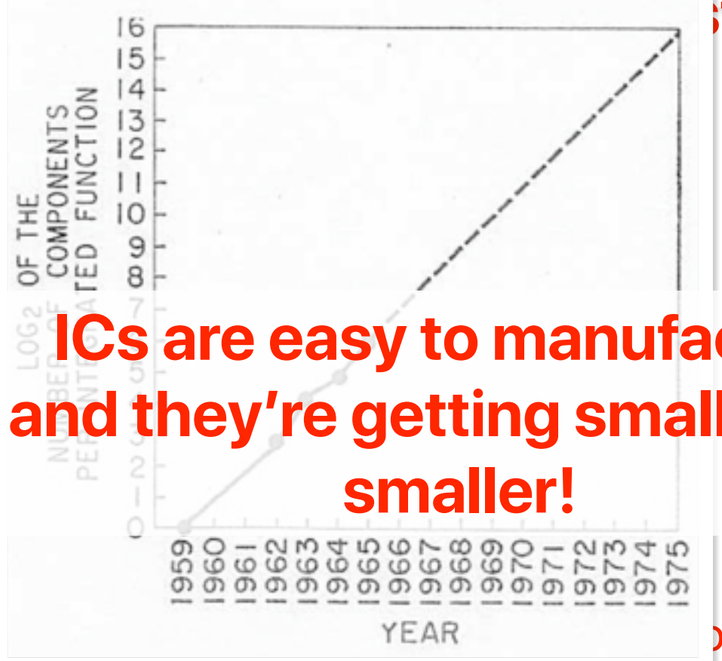
The establishment

ished
or nev
and
vable
llo, fo
he reli
that
ilure as the

stablish

Increasing the yield

There is no fundamental obstacle to achieving device yields of 100%. At present, packaging costs so far exceed the cost of the semiconductor structure itself that there is no incentive to improve yields, but they can be raised as high as is economically justified. No barrier exists comparable to the thermodynamic equilibrium considerations



ICs are easy to manufacture and they're getting smaller and smaller!

Two-mil squares

With the dimensional tolerances already being employed in integrated circuits, isolated high-per formance transistors can be built on centers two thousandths of an inch apart. Such a two-mil square can also contain several kilohms of resistance o

ICs are small

Linear circuitry

Integration will not change linear systems as radically as digital systems. Still, a considerable degree of integration will be achieved with linear

ICs are widely applicable

Reliability coun

In almost e
demonstrated h
level of production—low compared to that of discrete components—it offers reduced systems cost, and in many systems improved performance has been realized.

ICs are more reliable

Heat problem

Will it be possible to remove the heat generated by tens of thousands of components in a single silicon chip

Heat is a solvable issue

Moore's
impo
histor

Day of reckoning

Clearly, we will be able to build such component-crammed equipment. Next, we ask under what circumstances we should do it. The total cost of making a particular system function must be minimized. To do so, we could amortize the engineering over several identical items, or evolve flexible techniques for the engineering of large functions so that no disproportionate expense need be borne by a particular array. Perhaps newly devised de-

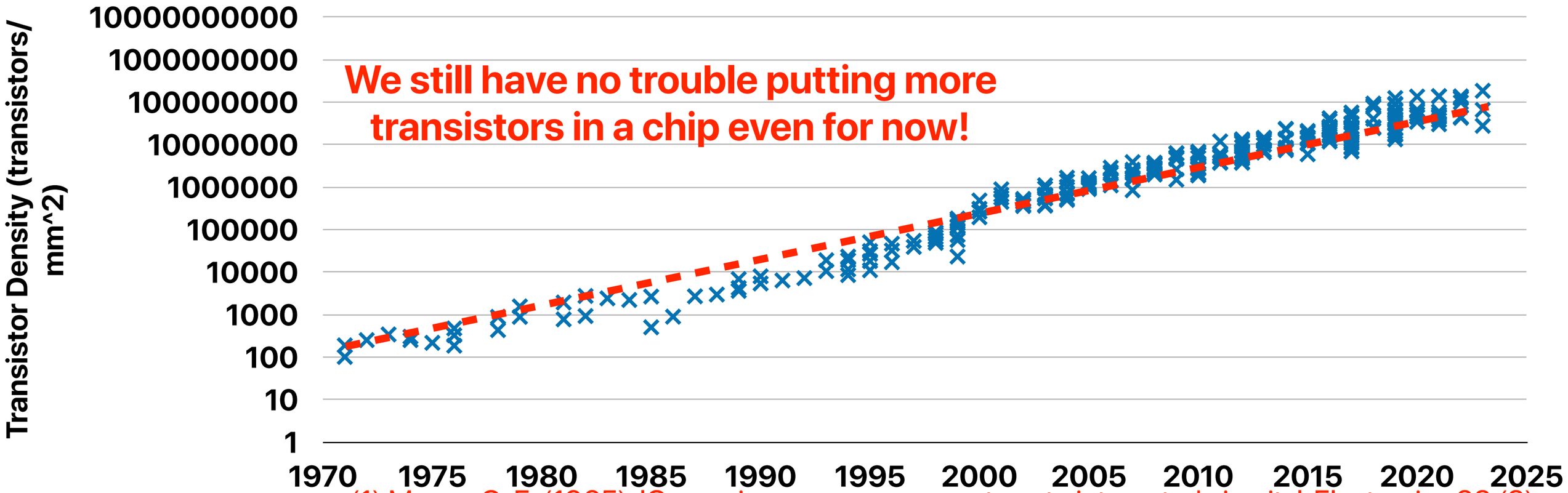
Designing ICs can be easy

(1) Mo mponents onto integrated circuits', Electronics 38 (8) .

Moore's Law Alive and Well

Moore's Law[1]

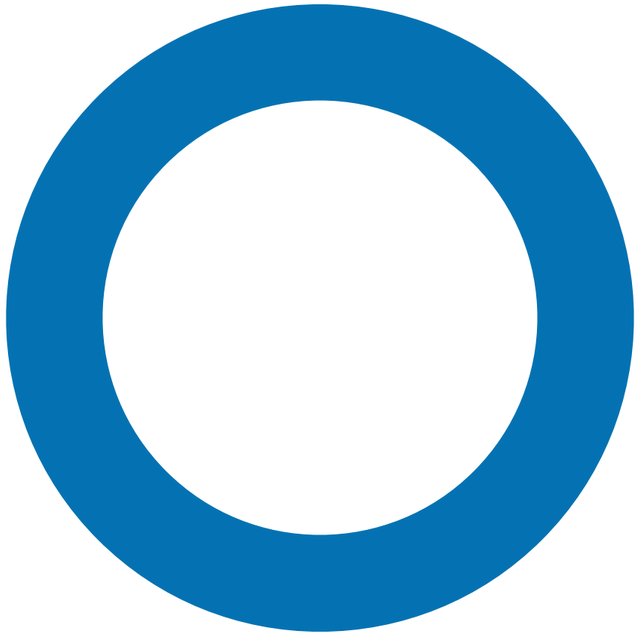
- The number of transistors we can build in a fixed area of silicon doubles every 12 ~ 24 months.
- Moore's Law "was" the most important driver for historic CPU performance gains



(1) Moore, G. E. (1965), 'Cramming more components onto integrated circuits', Electronics 38 (8) .

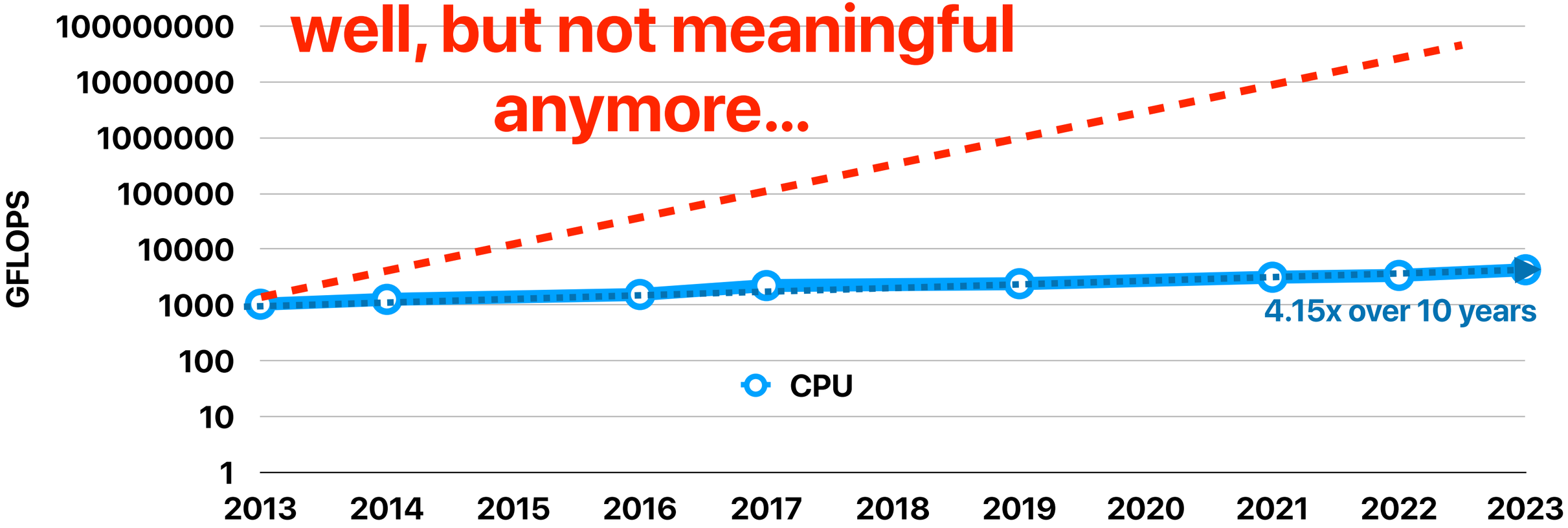
Plot based on https://en.wikipedia.org/wiki/Transistor_count by Hung-Wei Tseng

Moore’s Law is still alive

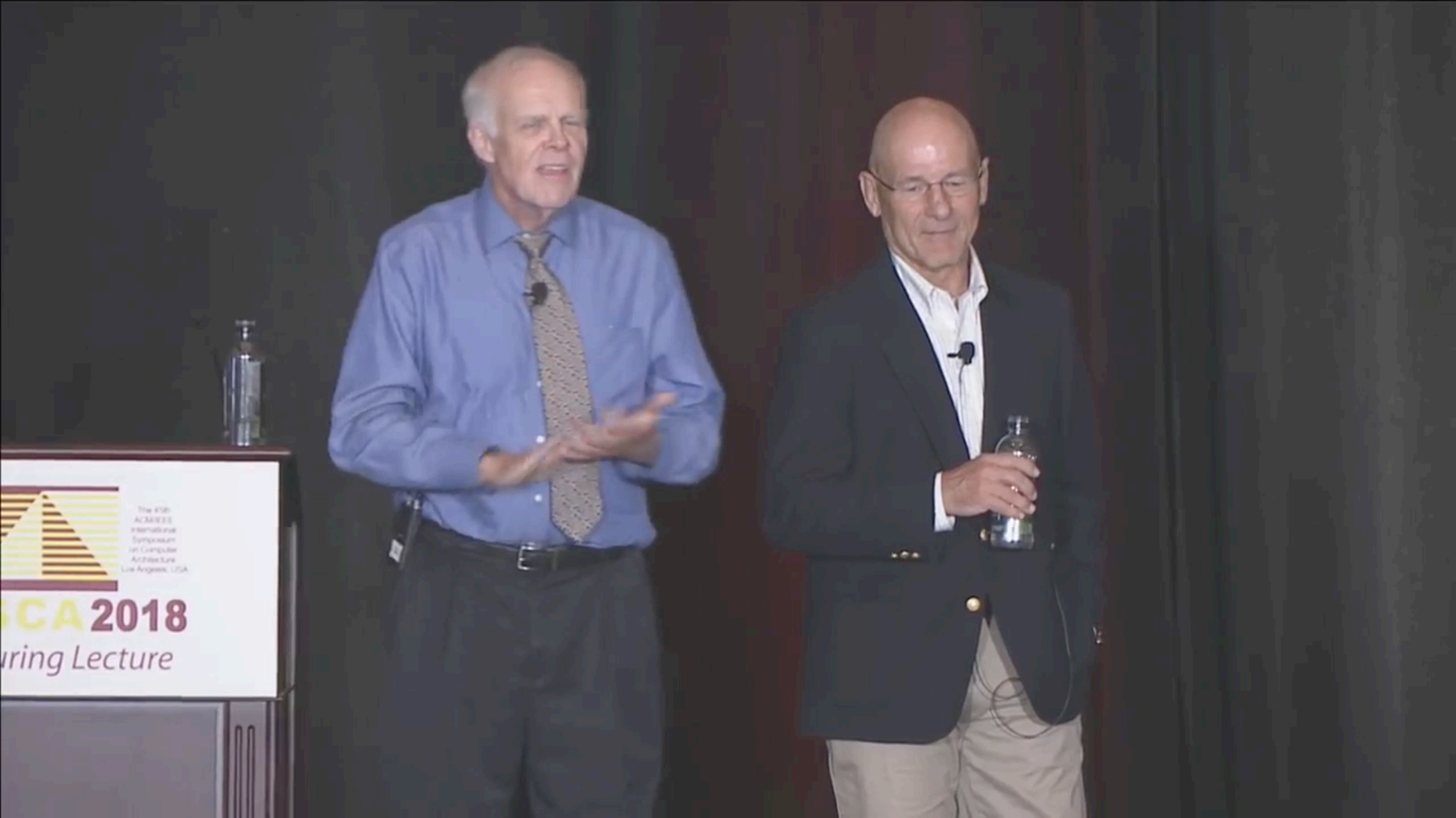


CPU Performance v.s. Moore's Law

Moore's Law is alive and well, but not meaningful anymore...



https://ourworldindata.org/grapher/artificial-intelligence-training-computation


The 45th
ACM/IEEE
International
Symposium
on Computer
Architecture
Los Angeles, USA
CA 2018
uring Lecture

Power consumption per transistor

GB200 GPU Is The Full Blackwell Specs, 500W More Power Than Hopper

During the launch, there was a particularly big confusion surrounding all the Blackwell GPU and platform variants. Jensen stated that Blackwell isn't a GPU, it's an entire platform & the platform has a range of products but they are still based on GPUs. As of right now, NVIDIA has announced three official Blackwell GPU variants.

These include the flagship and full-spec B200 which is being used by the GB200 Superchip platforms. This chip has the highest-rated computing capabilities and has a maximum TDP of 1200W. This is 500 Watts more than the Hopper H100 which featured a 700W TDP. The entire Superchip is equipped with two of these B200 GPUs and a Grace CPU for up to 2700W power (1200W x 2 for B200 + 300W CPU/IO).

› **World's Most Powerful Chip** — Packed with 208 billion transistors, Blackwell-architecture GPUs are manufactured using a custom-built 4NP TSMC process with two-reticle limit GPU dies connected by 10 TB/second chip-to-chip link into a single, unified GPU.

5.77 W/1B transistors

TSMC 4nm

61 billion transistors

The XCC has 61 billion transistors. The MCC die for Emerald Rapids has up to 32 cores exposed to the outside world, and probably has 36 cores in the design, again to improve yield. Dec 14, 2023

The Next Platform
https://www.nextplatform.com › Compute

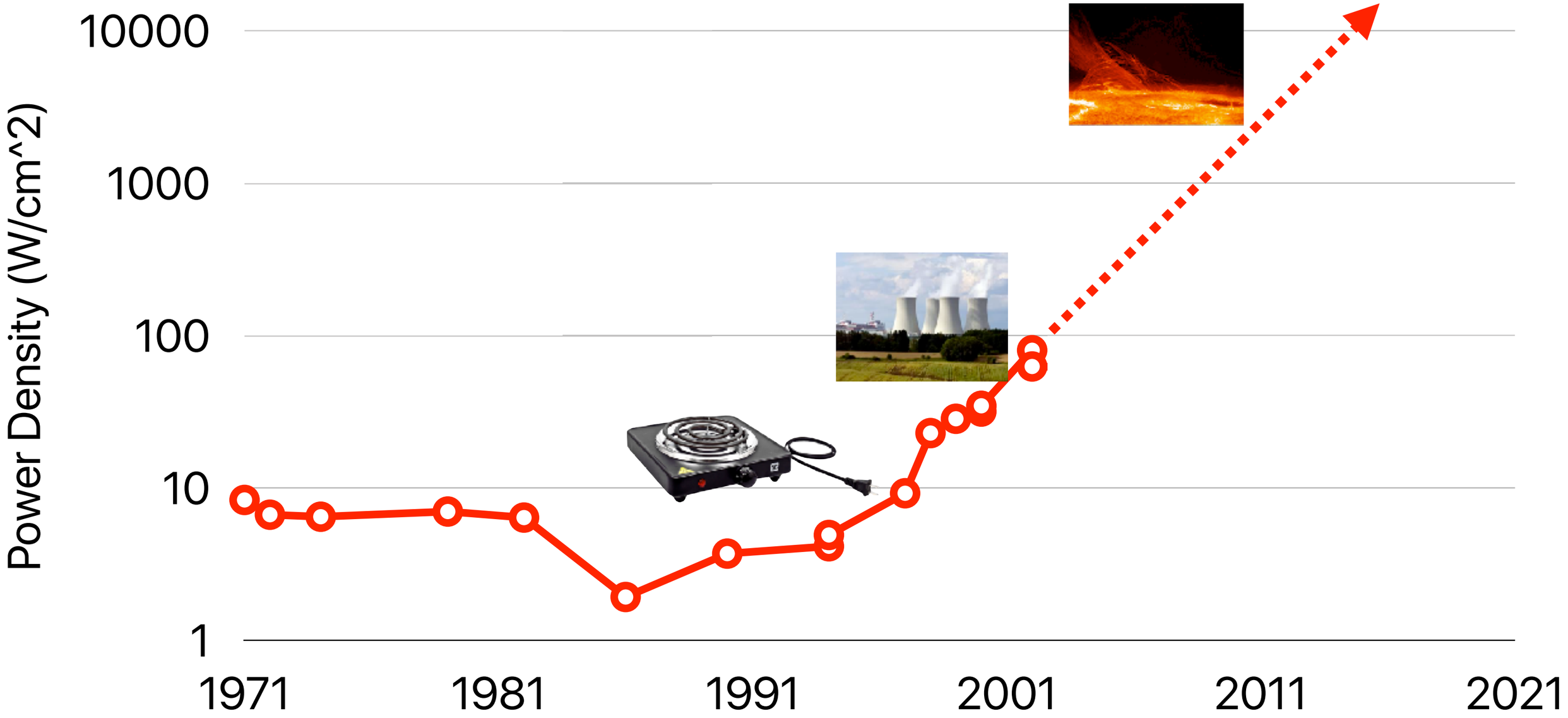
Intel "Emerald Rapids" Xeon SPs: A Little More Bang, A Little ...

The top-line Emerald Rapids chip, the 5th gen Xeon 8592+, will have 64 cores, an improvement from the 60 cores in Sapphire Rapids. The chip will operate at a 1.9GHz frequency that can max out at 3.9GHz in turbo mode. It has 320MB of cache, draws 350 watts of power, and fits into two-socket systems. It costs a whopping $11,600.

5.73 W/1B transistors

Intel 7nm

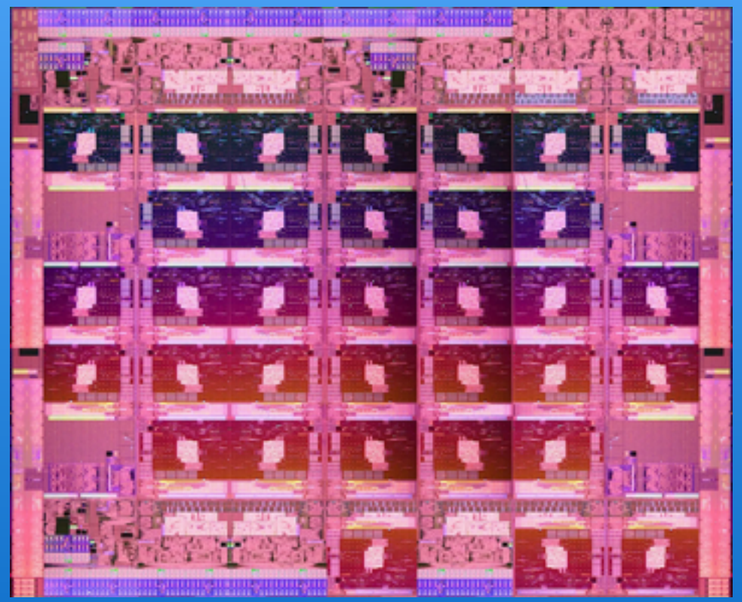
Power Density of Processors



The smaller size of a transistor, the smaller power consumption of it

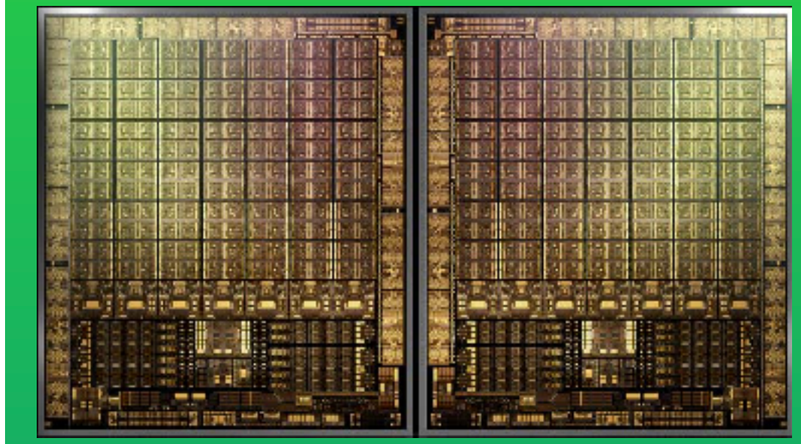
Alternatives to scaling single cores

Multicore Processors

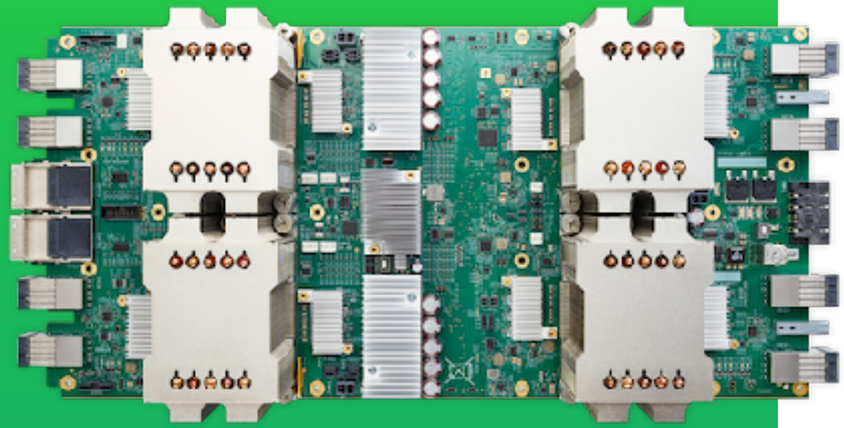


34-core Intel
Sapphire Rapids

Hardware Accelerators



NVIDIA H100
Graphic Processing Units

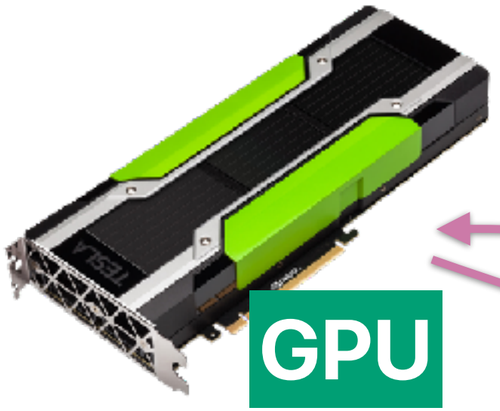


Google
Tensor Processing Units

Thread-level parallelism

Data-level parallelism

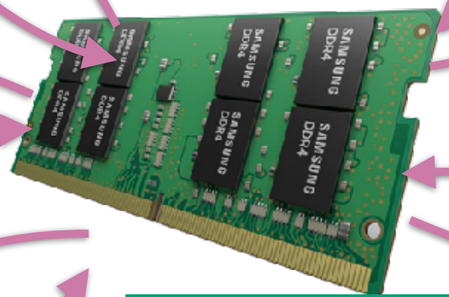
Heterogeneous Computer Architecture



GPU

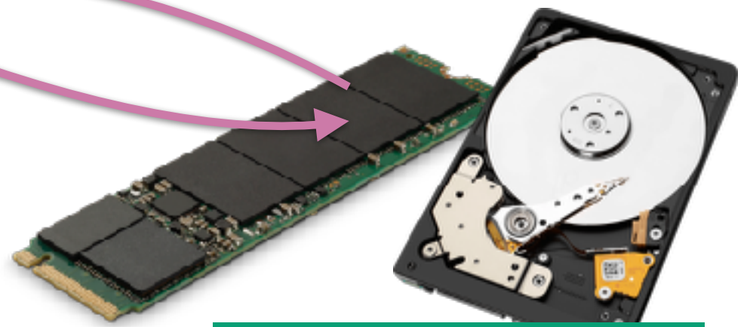
FPGA

Processor



Memory

TPU



Storage

But still limited by the power consumption

NVIDIA Accelerator Specification Comparison

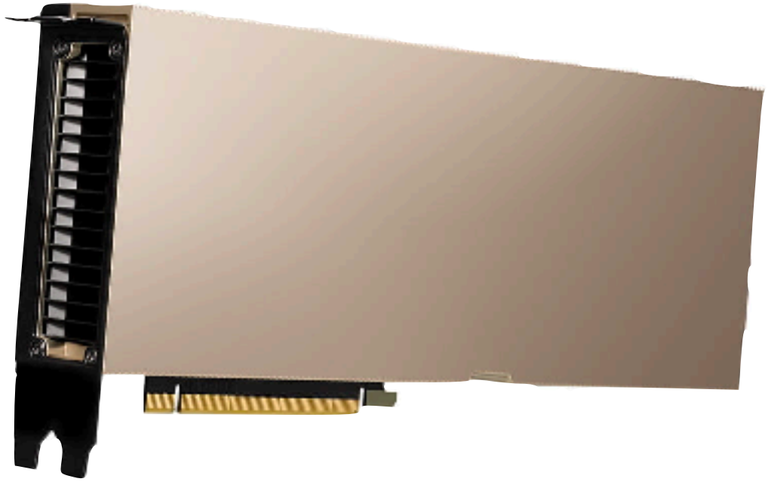
	H100	A100 (80GB)	V100
FP32 CUDA Cores	16896	6912	5120
Tensor Cores	528	432	640
GPU	GH100 (814mm2)	GA100 (826mm2)	GV100 (815mm2)
Transistor Count	80B	54.2B	21.1B
TDP	700W	400W	300W/350W
Manufacturing Process	TSMC 4N	TSMC 7N	TSMC 12nm F
Interface	SXM5	SXM4	SXM2/SXM3
Architecture	Hopper	Ampere	Volta

1.46x

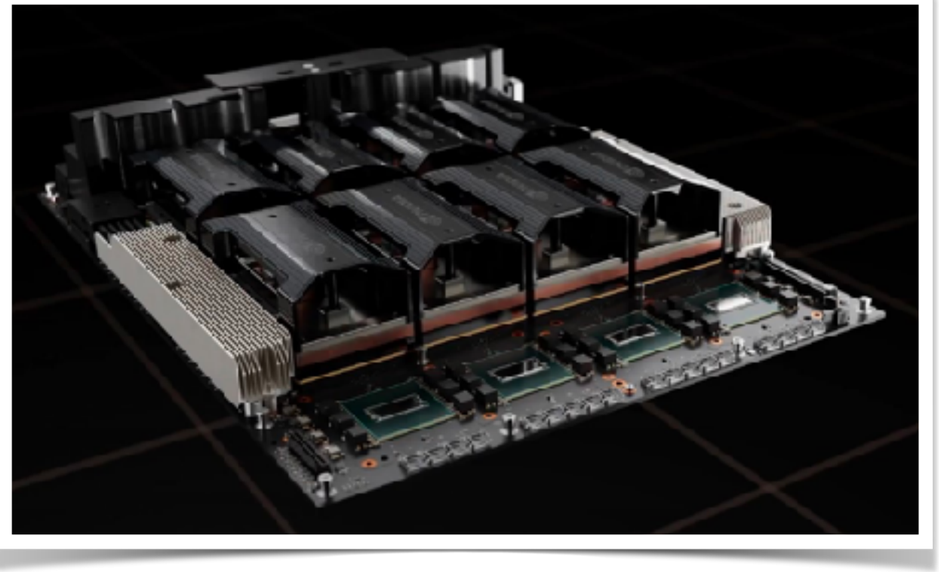
1.75x

8.75 W/ B Transistors

7.38 W/ B Transistors

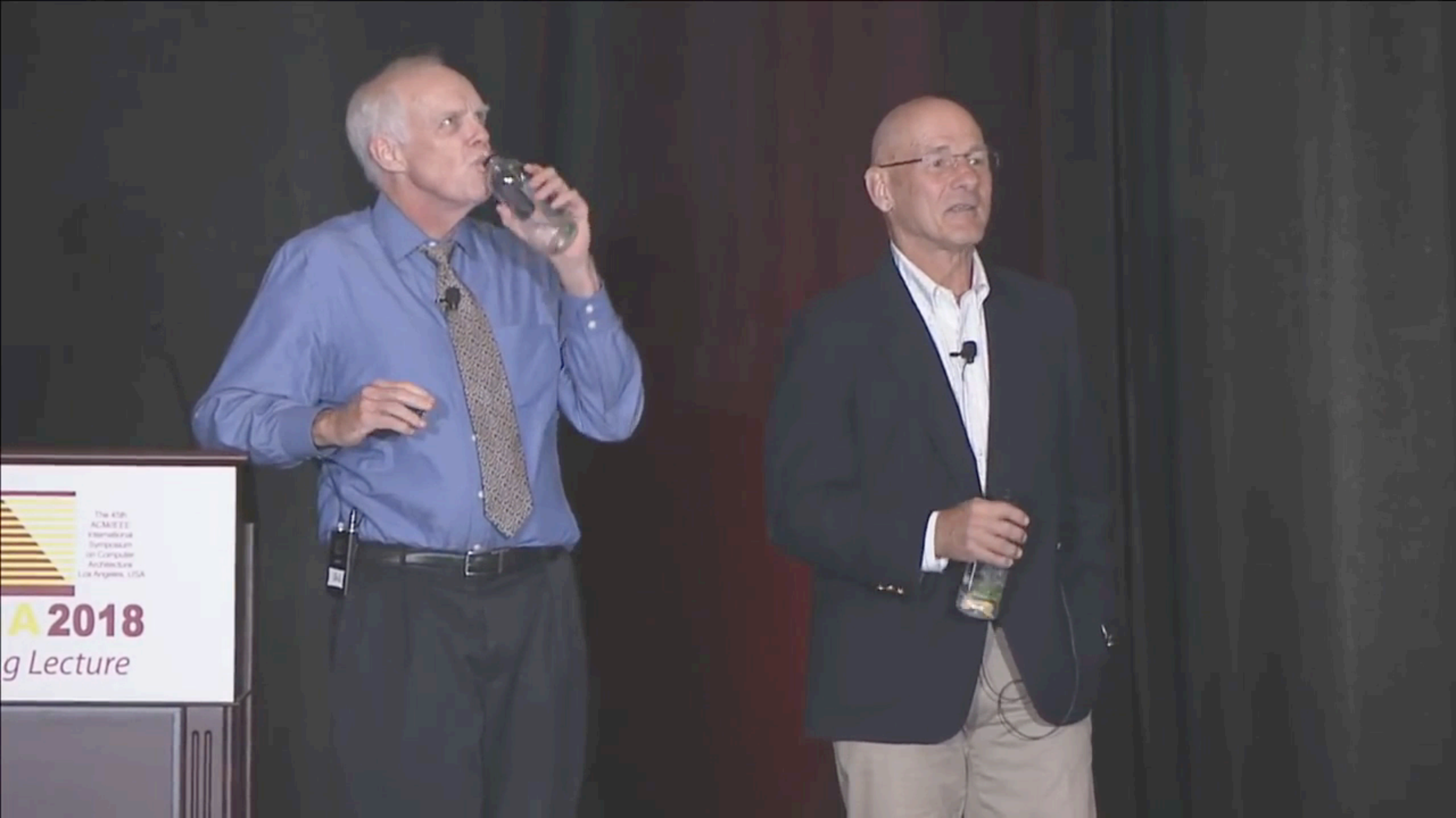


https://www.workstationspecialist.com/product/nvidia-tesla-a100/

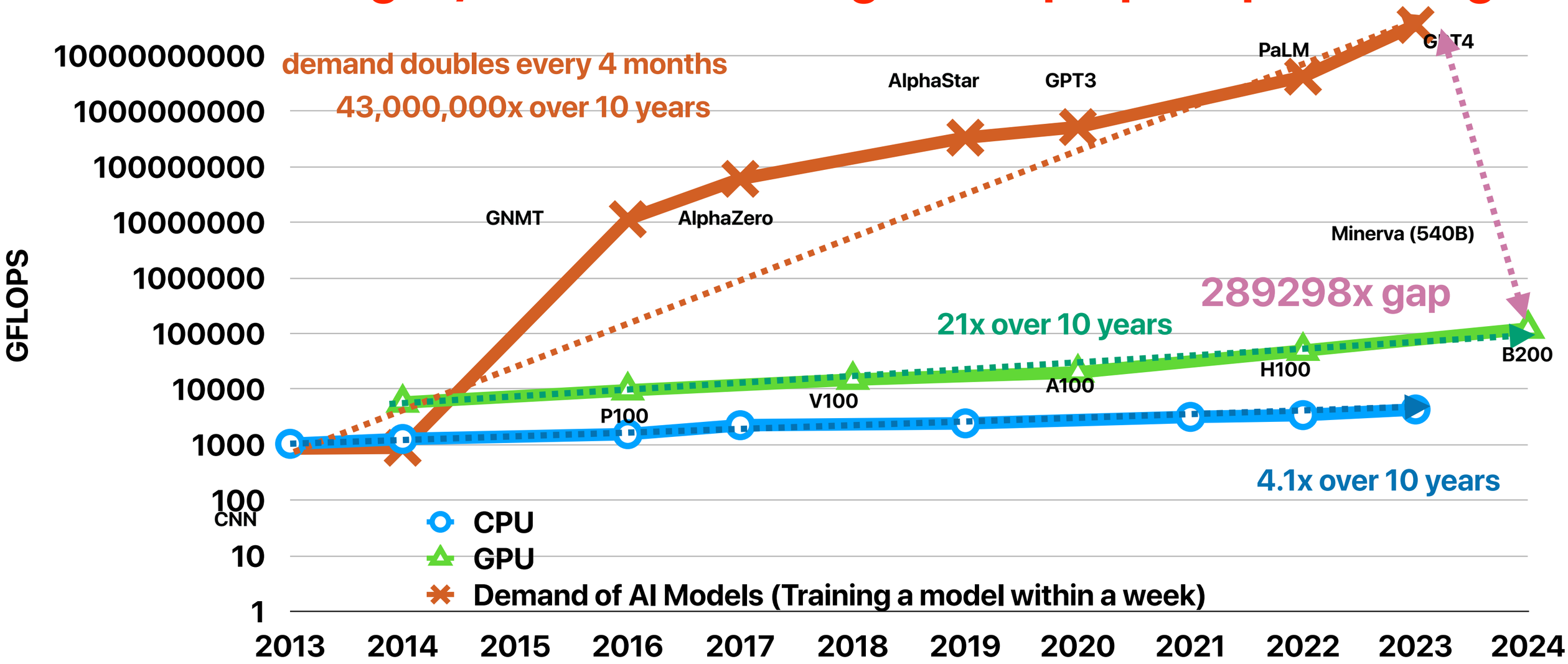


https://www.servethehome.com/wp-content/uploads/2022/03/NVIDIA-GTC-2022-H100-in-HGX-H100.jpg

GPUs are not limited by Moore’s Law


The 45th
ACM/IEEE
International
Symposium
on Computer
Architecture
Los Angeles, USA
A 2018
g Lecture

Mis-matching AI/ML demand and general-purpose processing



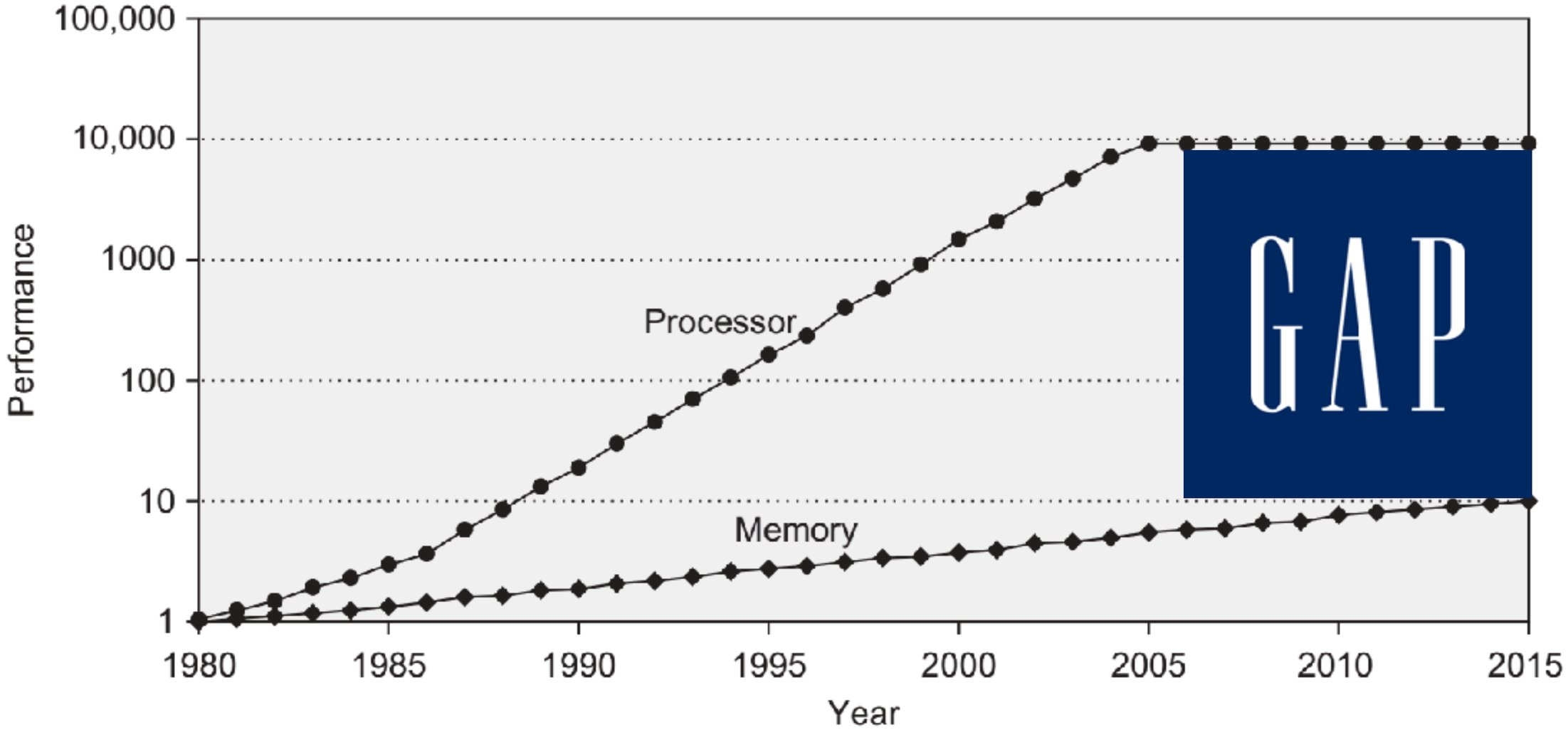
https://ourworldindata.org/grapher/artificial-intelligence-training-computation

The performance growth of recent GPU architectures can match the demand of efficient AI/ML training

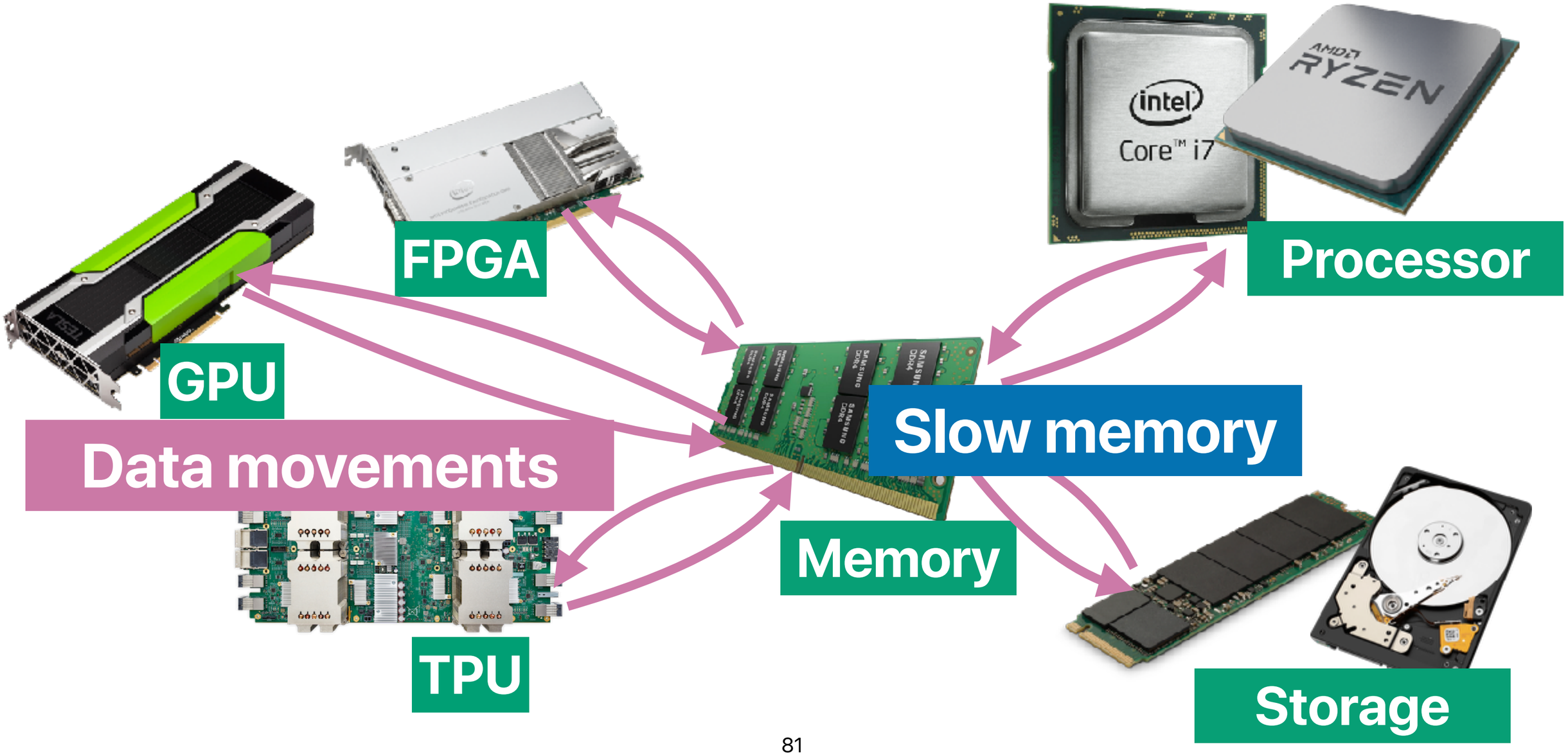
Take-aways: Why CS203?

- Algorithm complexity does not work well on “real” computers
- Processors/memories are essential for modern computer systems but their performance improves slowly in recent decades
  - Moore’s Law continues, but Dennard Scaling discontinues
  - Cannot catch up the demand of applications — programmers need to do something!

Performance gap between Processor/Memory



Heterogeneous Computer Architecture



Take-aways: Why CS203?

- Algorithm complexity does not work well on "real" computers
- Processors/memories are essential for modern computer systems but their performance improves slowly in recent decades
  - Moore's Law continues, but Dennard Scaling discontinues
  - Cannot catch up the demand of applications — programmers need to do something!
- We have to rethink about programming as computers become more parallel, heterogeneous, application-specific

CS203's vision and missions

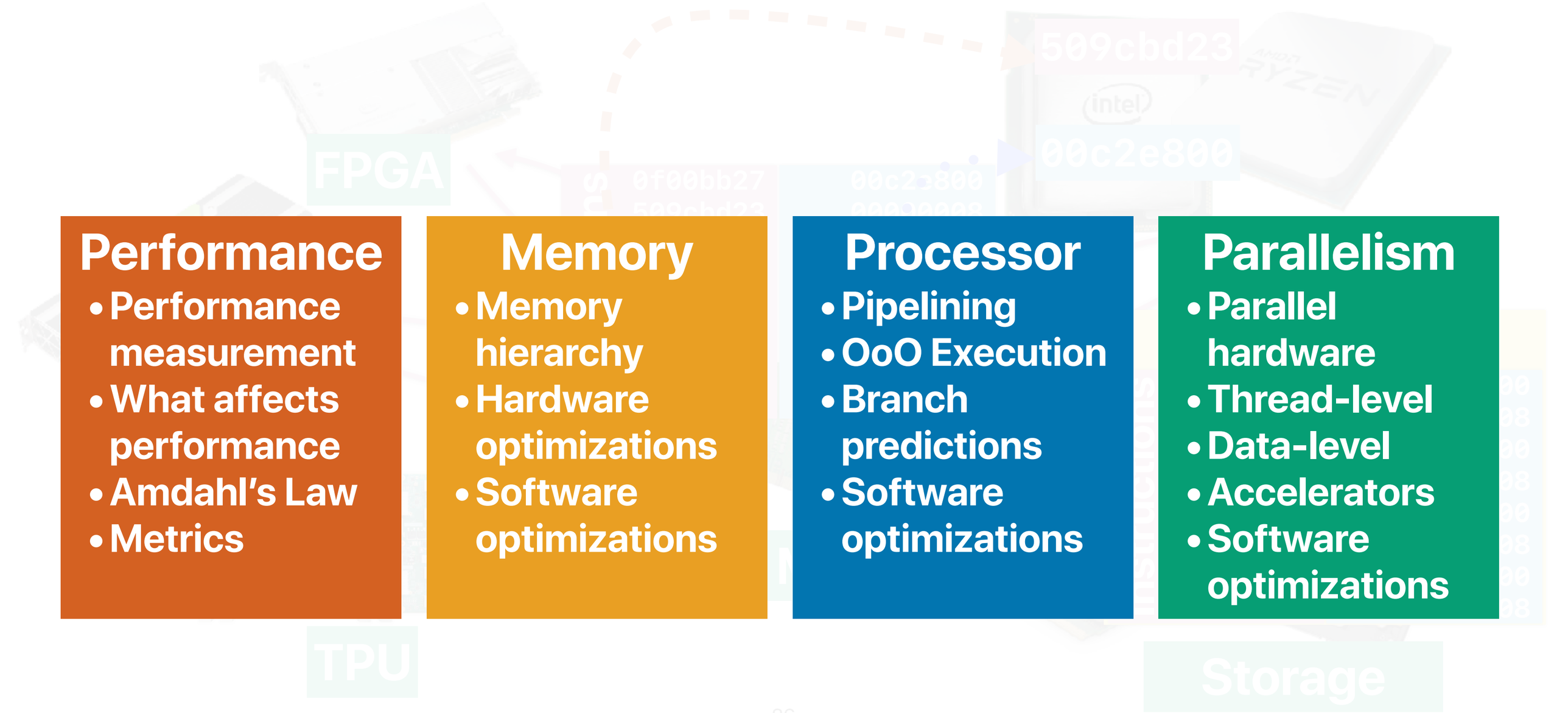
Vision

- Be programmers who write efficient programs that save time, power, energy, carbon footprint.

Missions

- Using the knowledge of computer architecture and the general guidelines to identify performance problems and design solutions to tackle the challenges of real-world applications

Heterogeneous Computer Architecture



Performance

- Performance measurement
- What affects performance
- Amdahl's Law
- Metrics

Memory

- Memory hierarchy
- Hardware optimizations
- Software optimizations

Processor

- Pipelining
- OoO Execution
- Branch predictions
- Software optimizations

Parallelism

- Parallel hardware
- Thread-level
- Data-level
- Accelerators
- Software optimizations

Tentative Schedule

	Topic	Due Dates
1/7/2025	Introduction	
1/9/2025	Performance Evaluation (I)	Reading Quiz #1
1/14/2025	Performance Evaluation (II)	Reading Quiz #2
1/16/2025	Performance Evaulation (III)	Programming Assignment #1 due
1/21/2025	Memory Hierarchy (1): The Basics	Reading Quiz #3
1/23/2025	Memory Hierarchy (2)	Assignment 1 due
1/28/2025	Memory Hierarchy (3): Optimizing Cache Performance Applications	Reading Quiz #4
1/30/2025	Memory Hierarchy (4): Programmer's optimizations	
2/4/2025	Virtual Memory	Reading Quiz #5
2/6/2025	Virtual Memory (II)	Assignment 2 due
2/11/2025	Basic Processor Design & Branch Prediction	Reading Quiz #6
2/13/2025	Advanced Branch Prediction	Assignment 3 due & Programming Assignment #2
2/18/2025	OOO Scheduling	Reading Quiz #7
2/20/2025	OOO Scheduling	
2/25/2025	OOO Scheduling	Reading Quiz #8
2/27/2025	SMT & Chip Multiprocessors	Assignment 4 due
3/4/2025	Midterm	
3/6/2025	Chip Multiprocessors	
3/11/2025	Dark Silicon	Reading Quiz #9
3/13/2025	TPU, FPGA	Assignment #5
3/20/2025 7p-10p	Final Exam	

Performance

Memory

Processor

Parallelism

Learning eXperience

Most lectures today ...

I expect the lecture to be...

Peer instruction

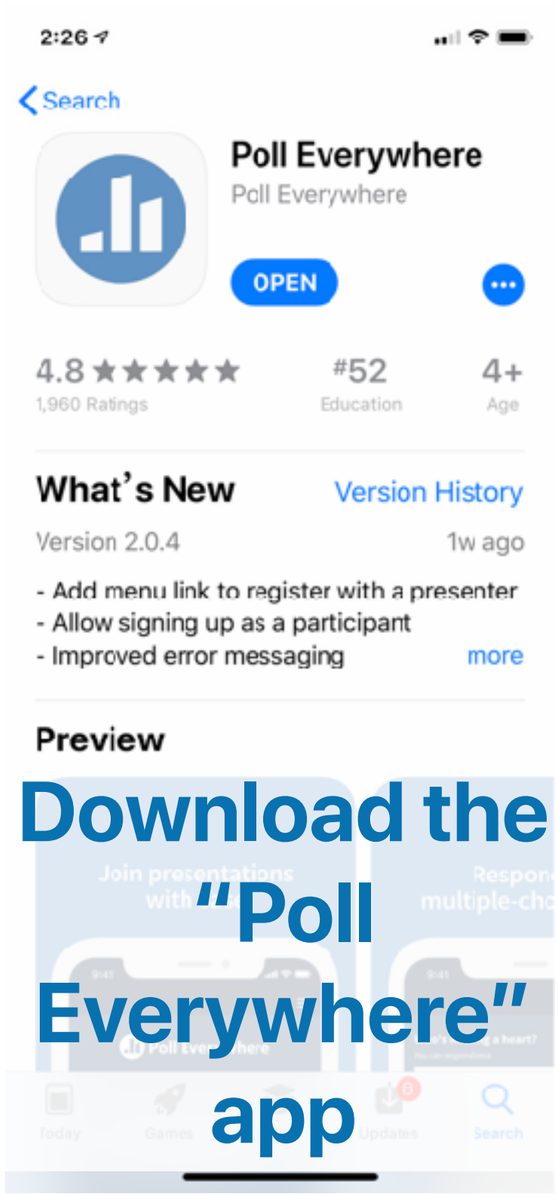
- Before the lecture — You need to complete the required **reading**
- During the lecture — I'll bring in activities to ENGAGE you in exploring your understanding of the material
  - Popup questions
  - Individual **thinking** — use **poll everywhere** to express your opinion
  - Group discussion — **discuss** with your surroundings and use your clicker to express your group's opinion
  - Whole-classroom **discussion** — we would like to hear from you

Read **Think** **Discuss**

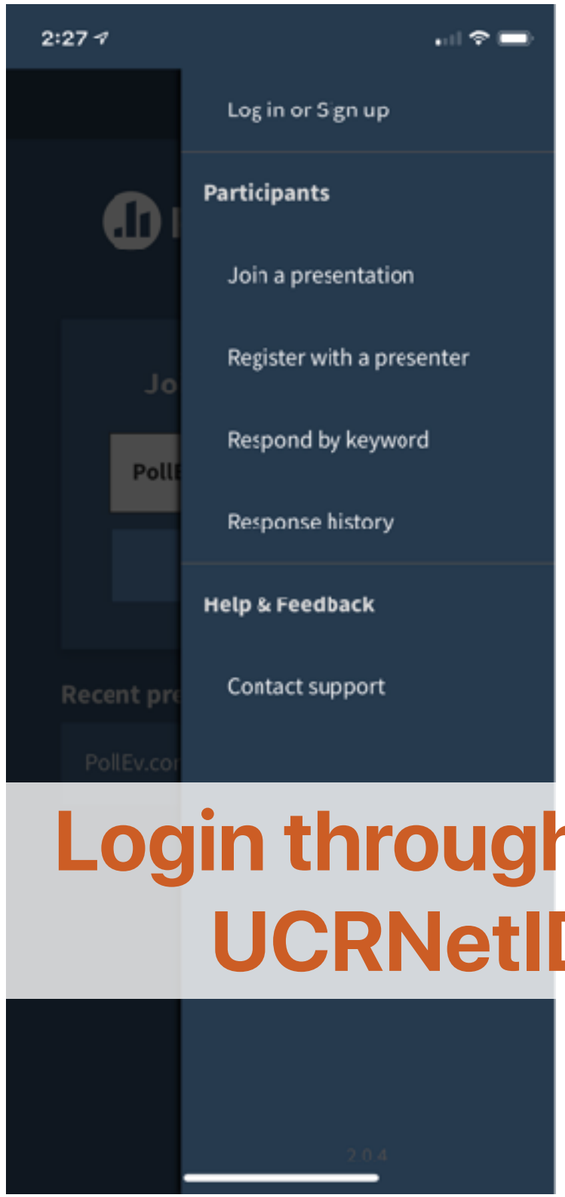
Before lectures: reading quizzes

- We need to prepare you for peer instruction activities and discussions!
- Reading assignments from
  - Patterson & Hennessy, Computer Architecture: A Quantitative Approach, David Patterson & John Hennessy, Morgan Kaufmann, 6th Edition
  - Assigned research papers/documents
- Reading quizzes — 15% of your grades:
  - On Gradescope
  - Due before the lecture, usually once a week. Check the schedule on our webpage
  - No time limitation until the deadline
  - No make up reading quizzes — we will drop probably your lowest two at least

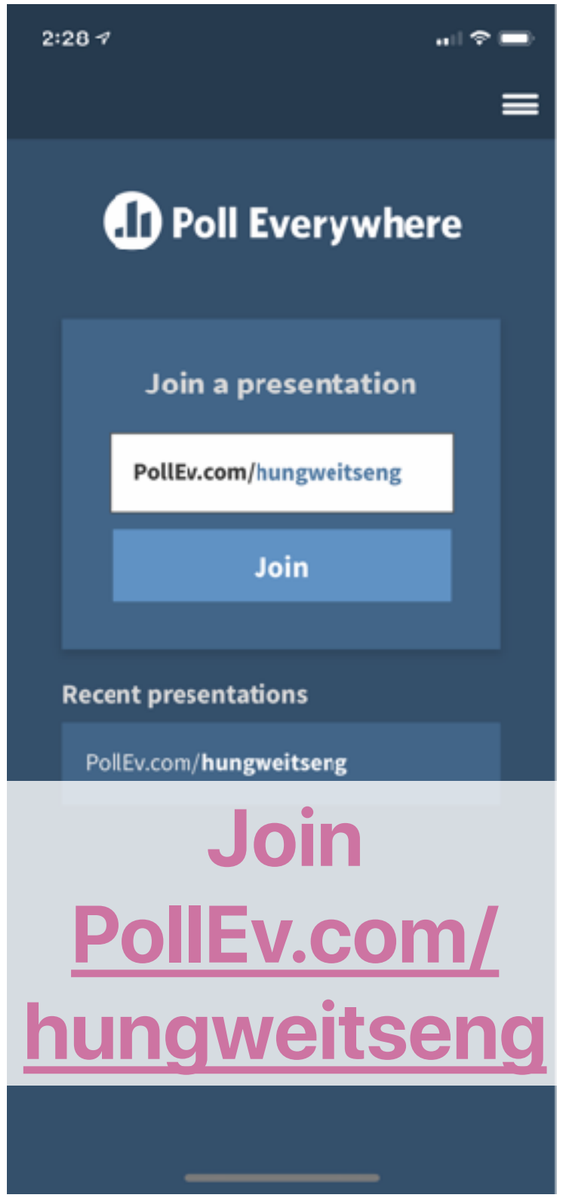
About the time of the Lecture — Setup Poll Everywhere



Download the "Poll Everywhere" app



Login through the app using UCRNetID@ucr.edu



Join PollEv.com/hungweitseng

Peer instruction questions

- The activities to ENGAGE you in exploring your understanding of the material
  - Let you practice
  - Bring out misconceptions
  - Let us LEARN from each other about difficult parts.
- You will be GET CREDIT for your efforts to learn in class
  - By answering questions with **Poll Everywhere**
  - Answer **50%** of the **clicker questions** in class, get **a full-credit assignment**
    - Typically more than 50% of questions are individual thinking questions as individual thinking comes first
    - If you don’t feel comfortable to talk with others, you can still get full credits if you made choices on all individual thinking questions

Inc.

NEWSLETTERS SUBSCRIBE

TECHNOLOGY

Amazon's CEO Just Declared the Era of Hybrid Work Finally Over

The company is going back to how things were before the pandemic.

EXPERT OPINION BY JASON ATEN, TECH COLUMNIST @JASONATEN

SEP 17, 2024

FORTUNE SIGN IN Subscribe Now

ance Leadership Well Recommends Fortune 500

Google's ex-CEO blames working from home for the company's AI struggles: 'Google decided that work-life balance was more important than winning'

BY ORIANNA ROSA ROYLE

August 14, 2024 at 4:06 AM PDT

'Working from home was more important than winning,' Google's former CEO Eric Schmidt says.

SEAN GALLUP—GETTY IMAGES

Assignments

- Measure/Analysis/Programing using Jupyterhub/Jupyter notebooks
- Watch this before your first assignment! https://youtu.be/m7OoY8y_Isk
- Submit through gradescope
  - You have to click the GitHub classroom link to begin with (will post the link of each assignment on the course webpage once released)
  - You should use the escalab.org/datahub service to finish your assignment
  - Submit your GitHub repo contains the CS203 assignment through Gradescope
  - An autograder will grade your assignment immediately and you can resubmit as many times as you want before the deadline—the earlier you start, the higher chances you can get full credits
  - There is no regrading after the deadline

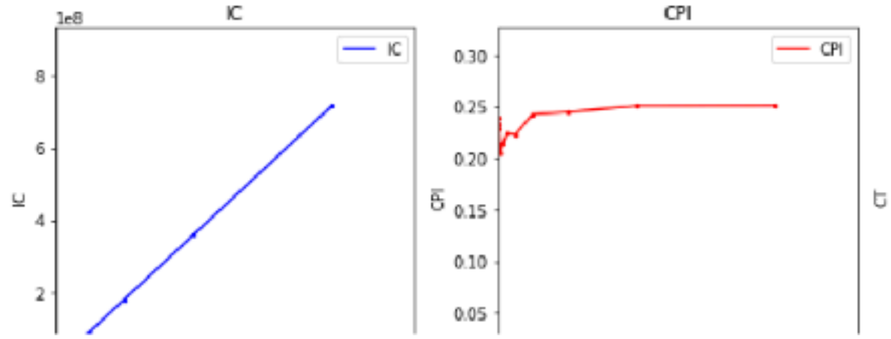
The total execution time is

$$ET = IC \times CPI \times CT = 5602640 \times 0.2$$

Now, let's plot the result and verify your prediction and see how ev

```
[9]: df=render_csv("array_size.csv", columns=columns, averag
     plotPE(df=df, lines=True, what=[ ('size', "IC"), ("size
     display_mono(df)
```

	size	ET	IC	CPI	M
0	10000	0.000042	703477.840000	0.238585	3995.2118
1	20000	0.000083	1404491.760000	0.233374	3970.8904
2	40000	0.000160	2803566.080000	0.228001	3983.0703
3	80000	0.000287	5604217.320000	0.204585	3988.8586
4	160000	0.000600	11204847.920000	0.213550	3988.0087
5	320000	0.001257	22406745.080000	0.223729	3989.3769
6	640000	0.002506	44812777.640000	0.222840	3985.2323
7	1280000	0.005459	89617166.120000	0.242636	3983.1877
8	2560000	0.011036	179228929.520000	0.244669	3973.7334
9	5120000	0.022575	358452827.360000	0.250542	3978.1896
10	10240000	0.045183	716890078.920000	0.250808	3979.4285



3 hrs.

Attending the Lecture

4 hrs.

Reading the textbook/ papers

5 hrs.

Assignments

Logistics

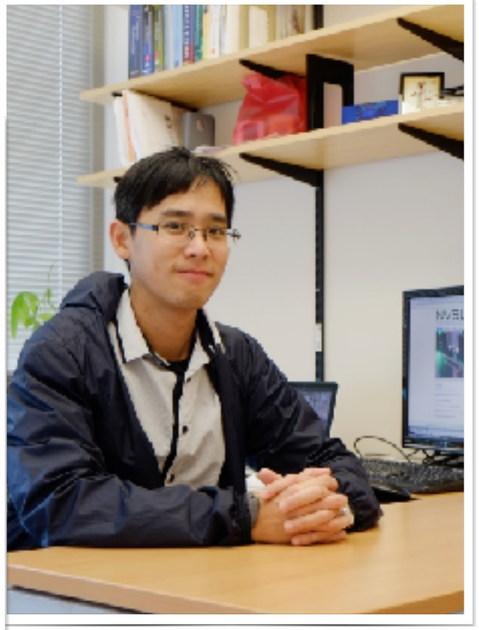
Grading Breakdown

	In-person session
Reading Quizzes	15% Drop lowest 2
Assignments & Midterm	50% Drop lowest 1
Participation	Count as one assignment. Get full credit if you show up on 50% of PI questions If you don't show up, please do well on every assignment!
Midterm	Count as one assignment.
Final	35% In-person only test — closed book

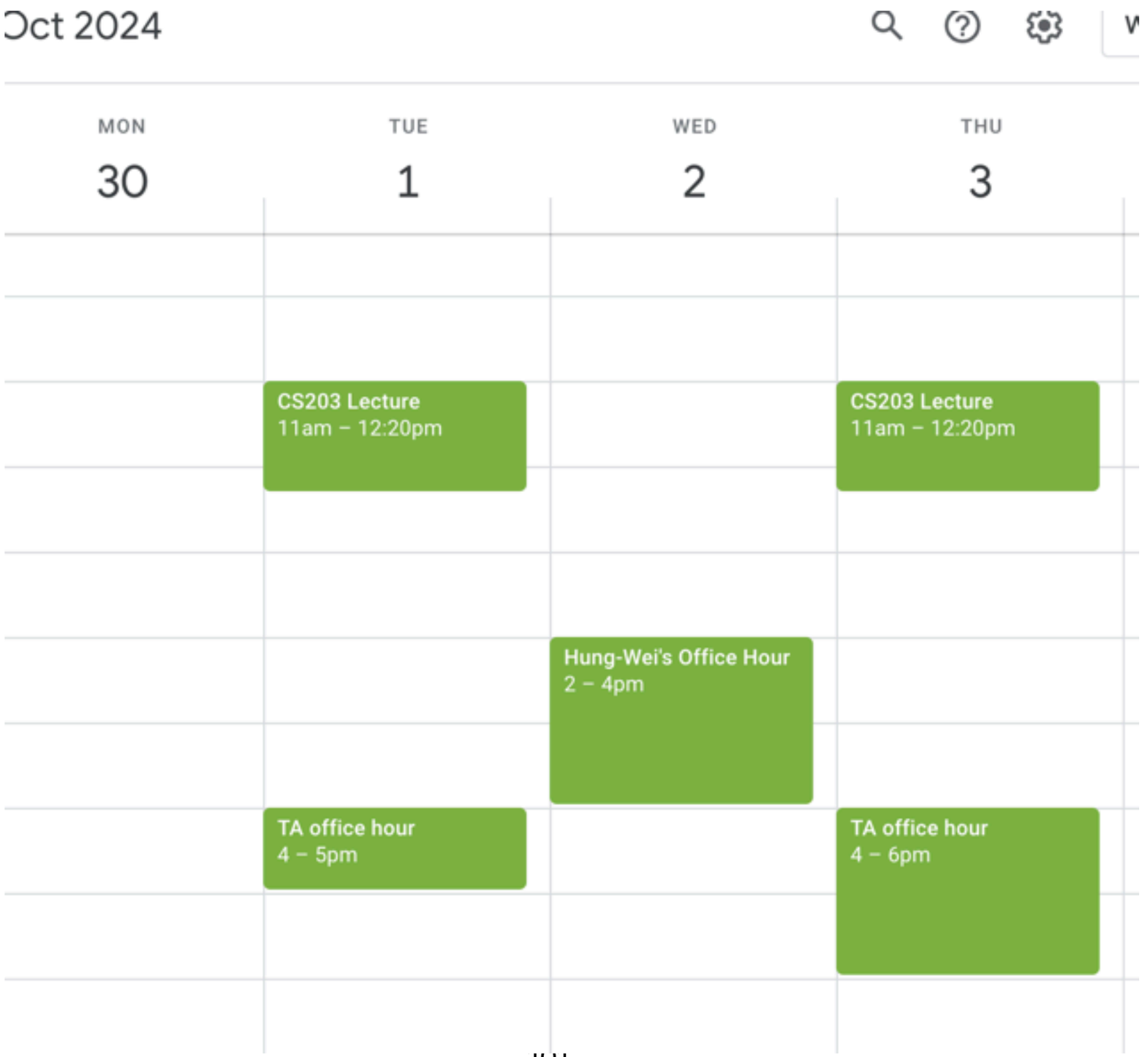
- Review the course website for policies
- Check your grades https://www.escalab.org/my_grades/

Instructor — Hung-Wei Tseng

- Associate Professor @ UC Riverside, 05/2019—
- Website: https://intra.engr.ucr.edu/~htseng/
- E-mail: cs203 @ escal.org
- Visiting Researcher @ Google, 01/2023—03/2023
  - Working for TensorFlow Lite
- PhD in **Computer Science**, University of California, San Diego, 2014
- Research Interests
  - General-purpose computing on AI/ML/NN/RayTracing accelerators
  - Or anything else fun — we have an OpenUVR project recently
- Fun fact: Hung-Wei was once considering a career path as a singer but went back to academia due to the unsuccessful trial

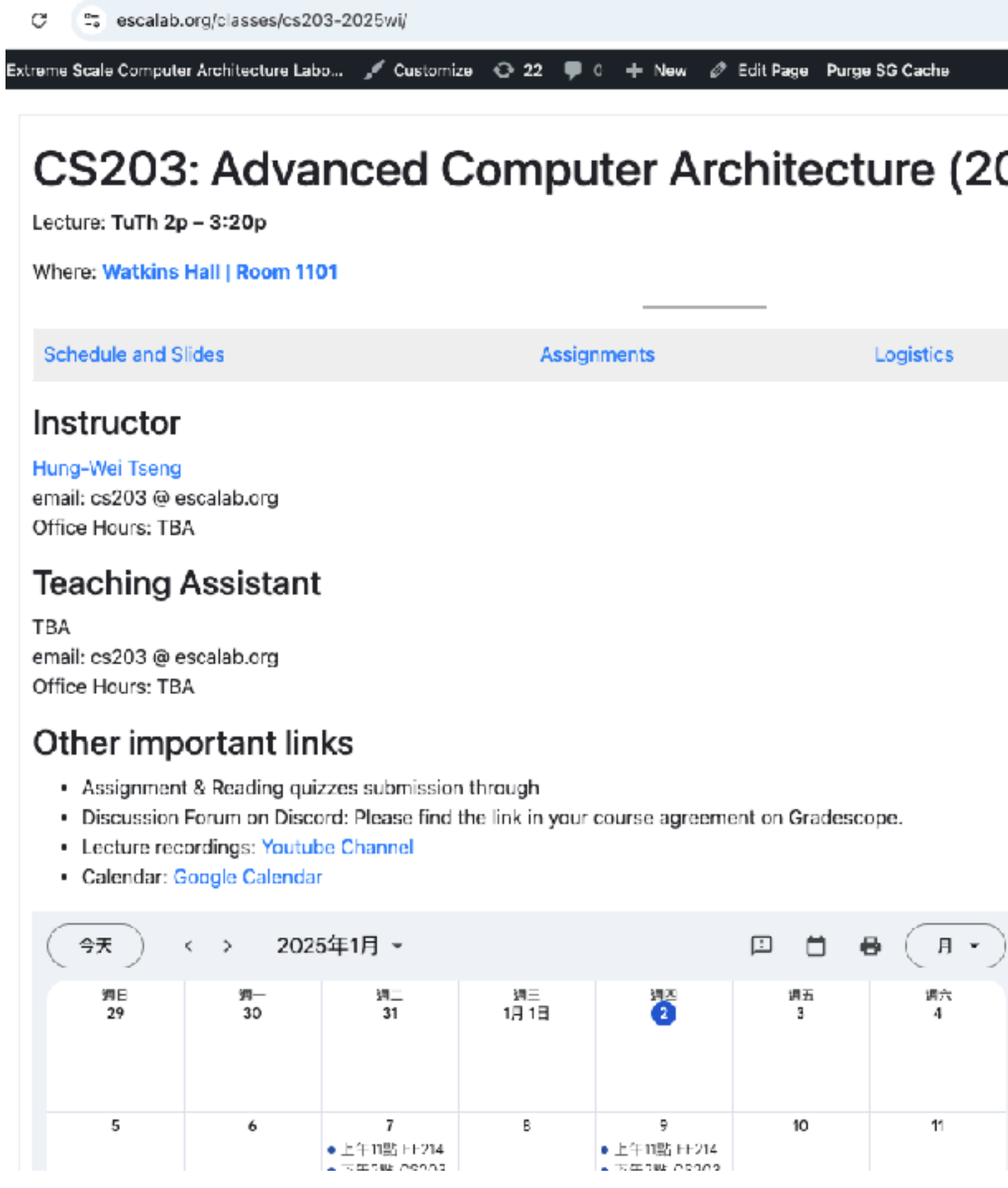


Subscribe to our google calendar!



The website

- https://www.escalab.org/classes/cs203-2025wi/
- Calendar
- Schedule
- Slides
  - Preview — for the ease of note taking
  - Release — the actual slides



Summary of course resources

- Lectures:
  - In-person @ Watkins Hall | Room 1101
  - Repository on **Youtube**: https://www.youtube.com/profusagi
- Schedule, slides, grades on **course webpage**: https://www.escalab.org/classes/cs203-2025wi/
- Discussion on **discord — link in gradescope's course agreement**
- Reading quizzes and assignments through **gradescope**: https://www.gradescope.com/courses/928407
- Working environment on https://escalab.org/datahub
- Office Hours & Locations
  - Hung-Wei Tseng — W 2p-5p WCH 406

Academic Honesty

- Don’t cheat.
  - Cheating on a test will get you an F in the class and no option to drop, and a visit with your college dean.
  - Cheating on homework means you don’t have to turn them in any more, but you don’t get points either. You will also take at least 25% penalty on the exam grades.
- Copying solutions of the internet or a solutions manual is cheating
  - They are incorrect sometimes
- Review the UCR student handbook
- When in doubt, ask.

Frequently asked questions (FAQs)

- Do I need to attend every lecture?
  - Attending the lecture is never "required", but strongly encouraged
  - In-person students have better learning outcome even though given the same difficulty of midterm/final examines based on the experience last year
  - We encourage you to participate in in-class learning activities (peer instructions) through giving you a "full-credit assignment" if you can answer 50% of the PI questions.
  - If you have difficulties coming to the 50% of class, you can still earn all credits if you ace all assignments.
  - Please **do not** email the staff regarding individual instances of no show
- Do we podcast the class online?
  - We record all lectures and post them on the same day as the lecture on YouTube https://www.youtube.com/profusagi
- Are examines in-person?
  - Yes — for fairness and logistics regarding proctoring

FAQs (cont.)

- When will I know my assignment grade?
  - A few minutes after your submission — everything is automatically graded
- How many times can I submit my assignment?
  - As many times as you want before the deadline
  - Start early and get feedback early — more chances to ace the assignments
- Do we have an eLearn/canvas page?
  - No — eLearn/canvas is broken in many aspects and the grade book is never accurate
  - Please refer to the class webpage for the most comprehensive links

FAQs (cont.)

- I cannot login escalab.org/datahub
  - Please email cs203@escalab.org as soon as possible (M-F 9a-5p)
- I cannot login Gradescope
  - You need to officially enrolled to have access to the Gradescope of the class — I cannot help you unfortunately
- Are textbooks required?
  - Yes
- Do we have Zoom office hours
  - No
  - Please use discord to ask questions!
- What if I need help during the weekend?
  - Unfortunately, we don't guarantee we can answer you questions either through piazza or e-mail during the weekend — you should plan your schedule carefully


Thank you all for this great quarter!
Let's take a group photo now!
Thank you all for this great quarter!
Let's take a group photo now!
Thank you all for this great quarter!
UCR

2025 Winter

Announcements

- Check our website
- Login to datahub, gradescope, discord
  - Let us know if you have any issue — cs203@escalab.org
- Complete the course agreement by **tomorrow**
  - Please make sure your gradescope account is associated with your UCRNetID@ucr.edu — you cannot receive any credit if there is a mismatch
- Reading quiz on Gradescope due **next Tuesday before the lecture**
  - Unlimited time before Tuesday's lecture — one trial only
- Programming assignment #1 & Assignment #1 are released — working on datahub!
  - Watch this video before you start! https://youtu.be/m7OoY8y_lsk

Computer
Science &
Engineering

203

つづく