AI 芯片 – AI 芯片基础

算力与带宽

ZOMI

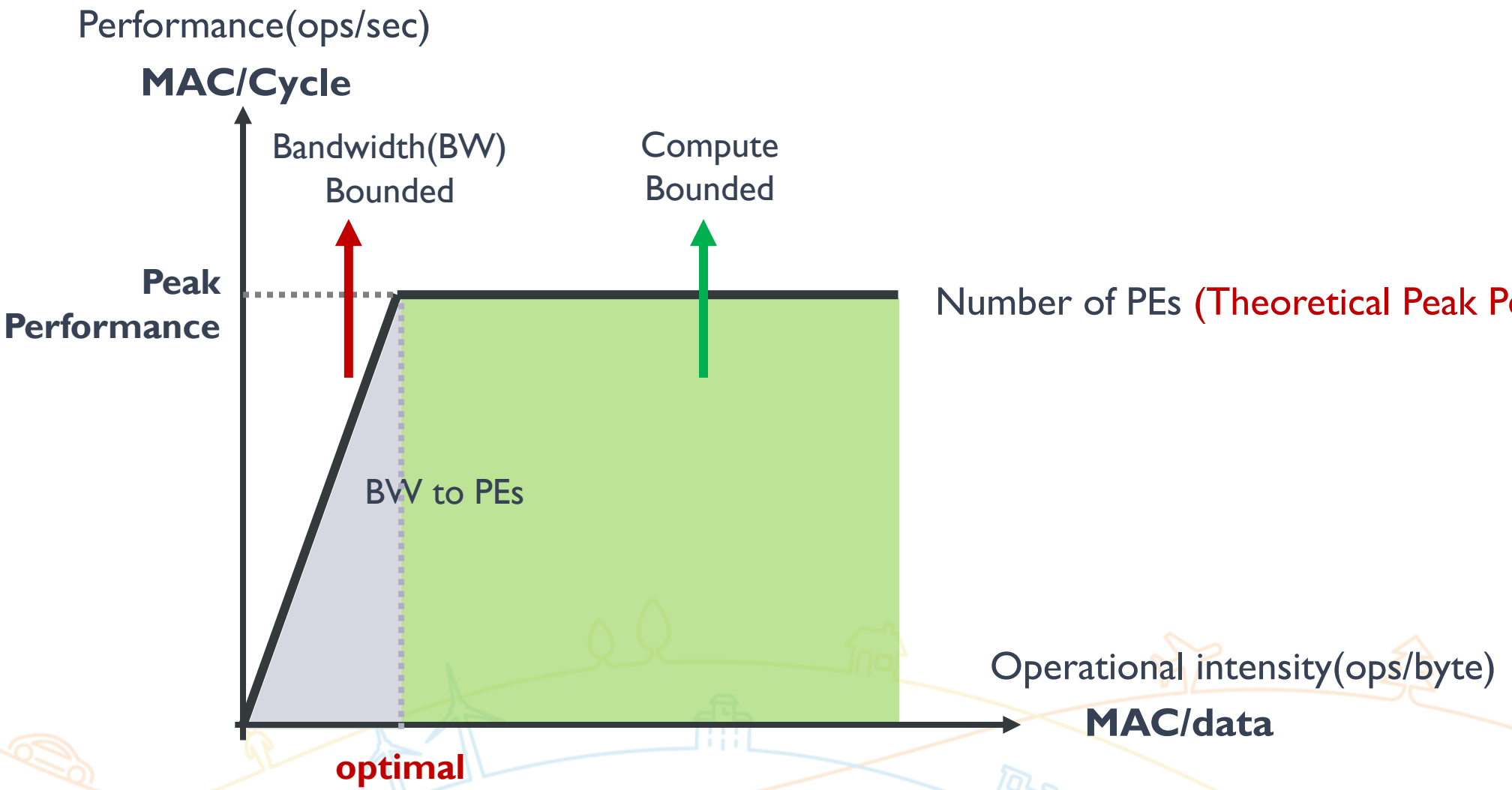
Talk Overview

1. AI 计算体系

- 深度学习计算模式
- 计算体系与矩阵运算

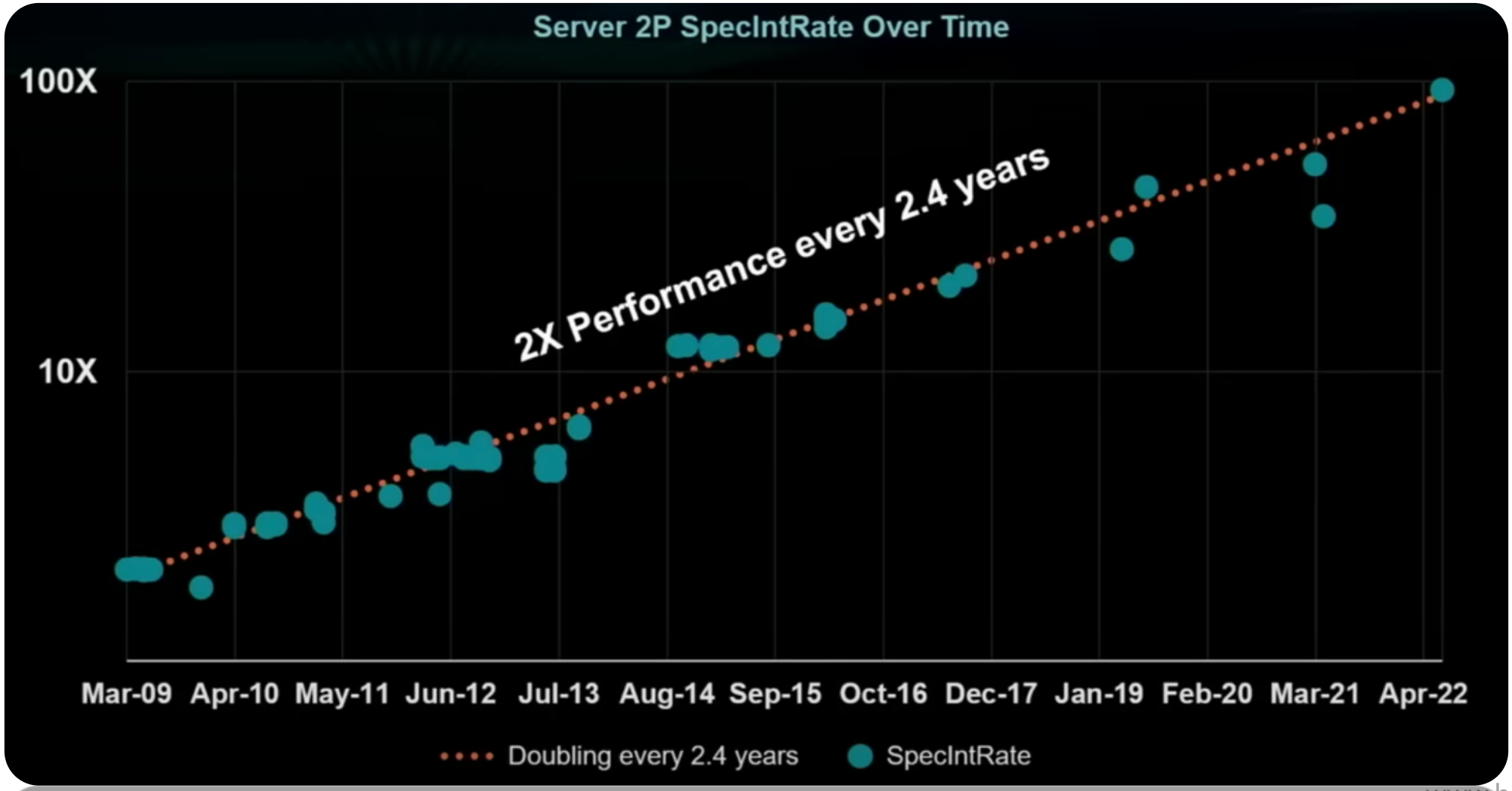
2. AI 芯片基础

- 通用处理器 CPU
- 从数据看 CPU 计算
- 通用图形处理器 GPU
- AI专用处理器 NPU/TPU
- 计算体系架构的黄金10年

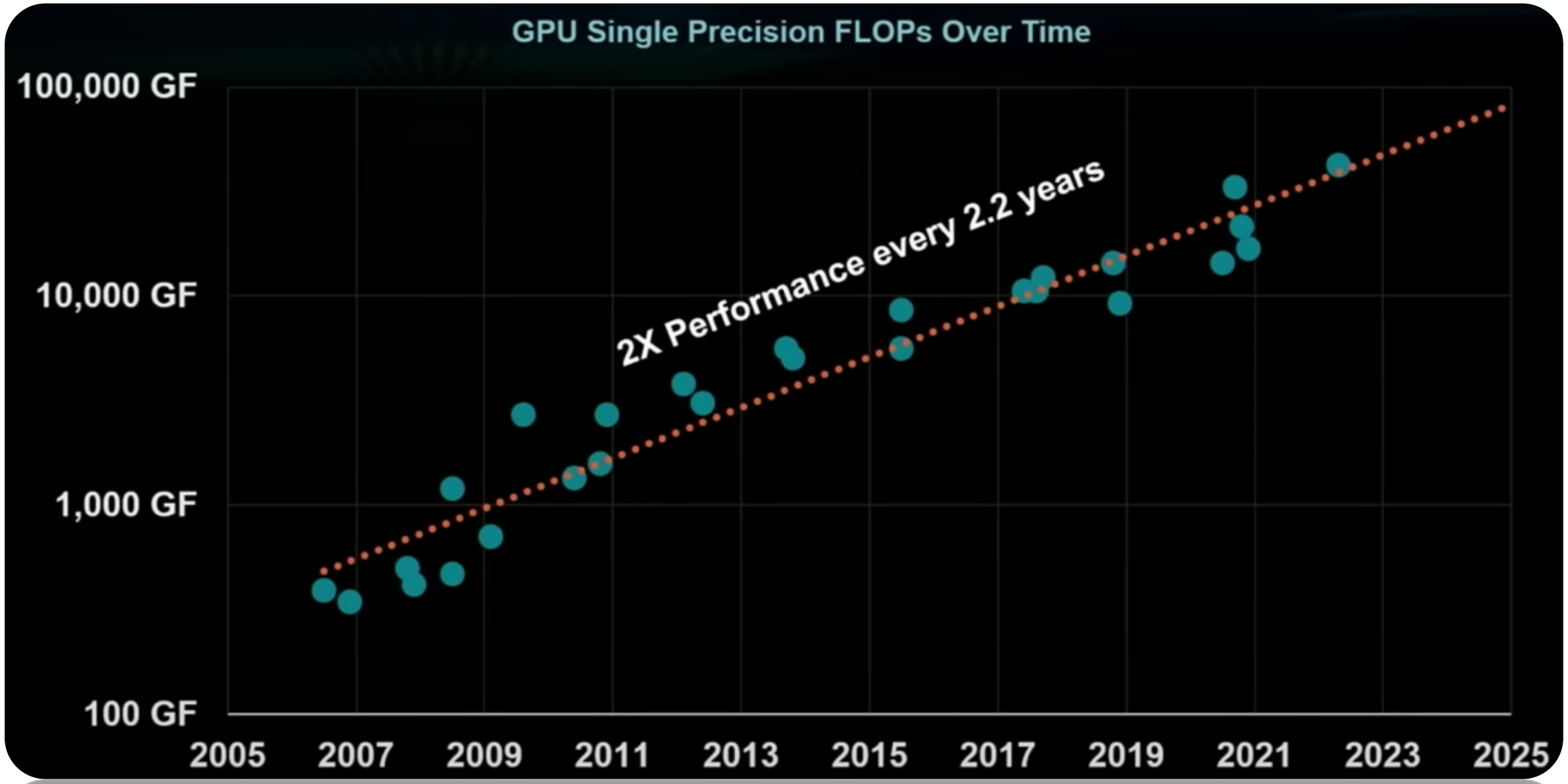


https://arxiv.org/abs/1807.07928

服务器的性能趋势



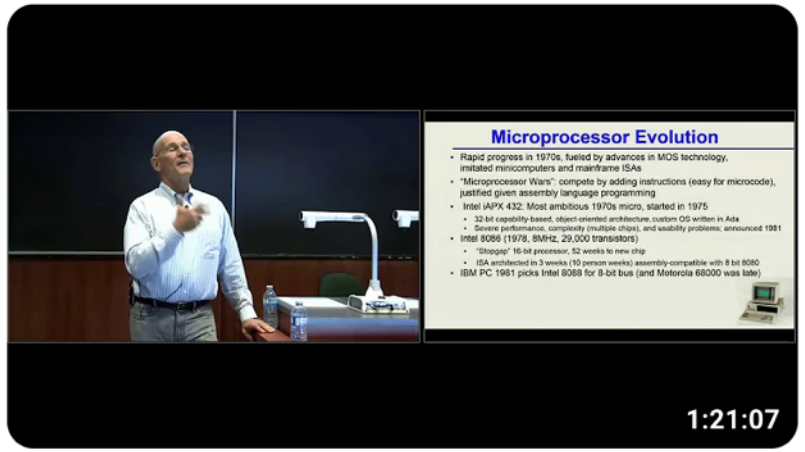
GPU 性能趋势



计算机架构的新黄金时代

- A New Golden Age for Computer Architecture: History, Challenges and Opportunities

  https://www.youtube.com/watch?v=kFT54hO1X8M



David Patterson - A New Golden Age for Computer Architecture: History, Challenges and Opportunities

7.1万次观看 · 3年前

UBC Computer Science

Abstract: In the 1980s, Mead and Conway democratized chip design and high-level language programming surpassed assembly ...

Turing Awards | What is Computer Architecture | IBM System360 | Semiconductors | Microprocessor... 44 个章节

编译器的黄金时代

- The Golden Age of Compiler Design in an Era of HW/SW Co-design
- https://www.youtube.com/watch?v=4HgShra-KnY

ASPLOS Keynote: The Golden Age of Compiler Design in an Era of HW/SW Co-design by Dr. Chris Lattner

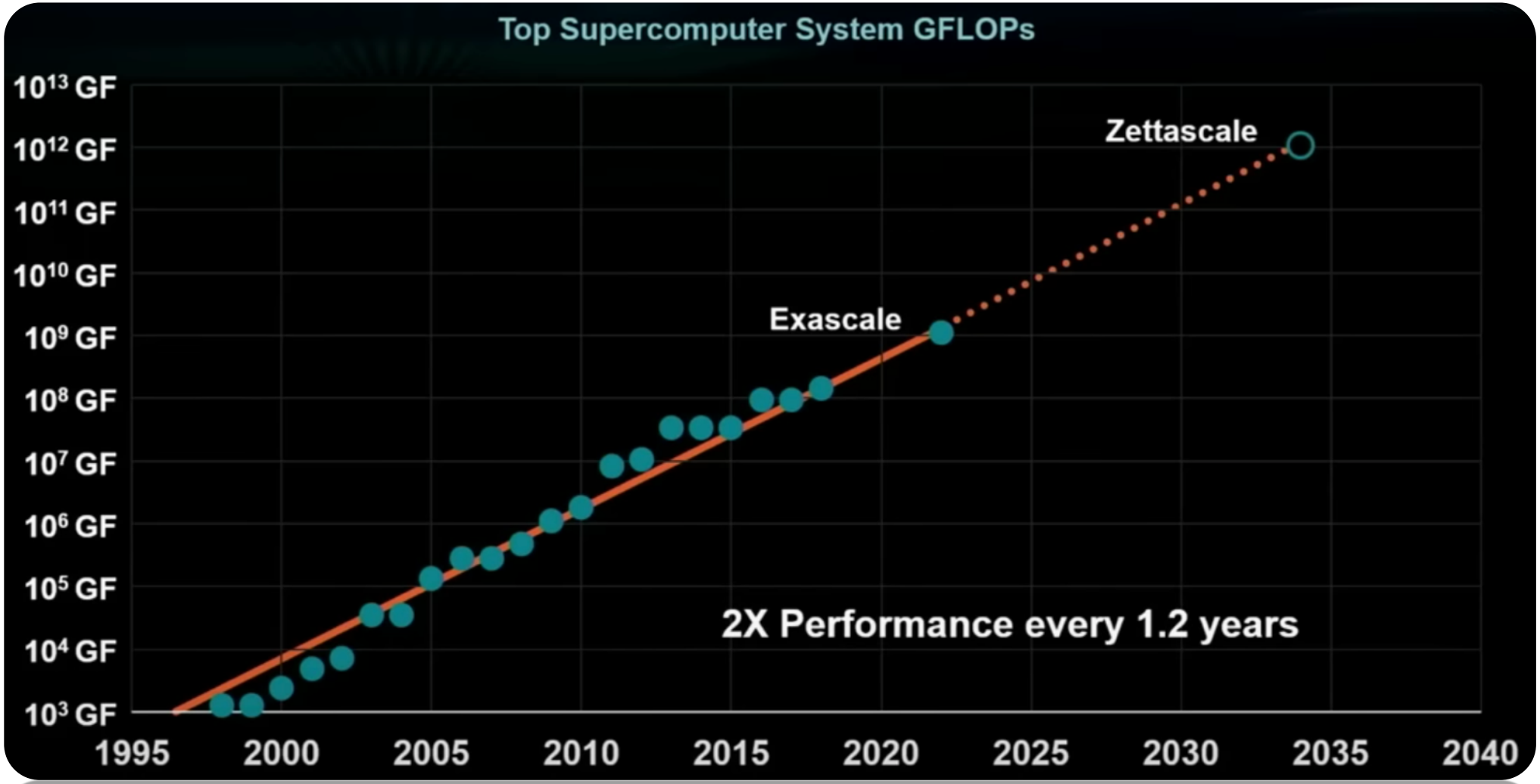
2.7万次观看 · 1年前

SiFiveInc

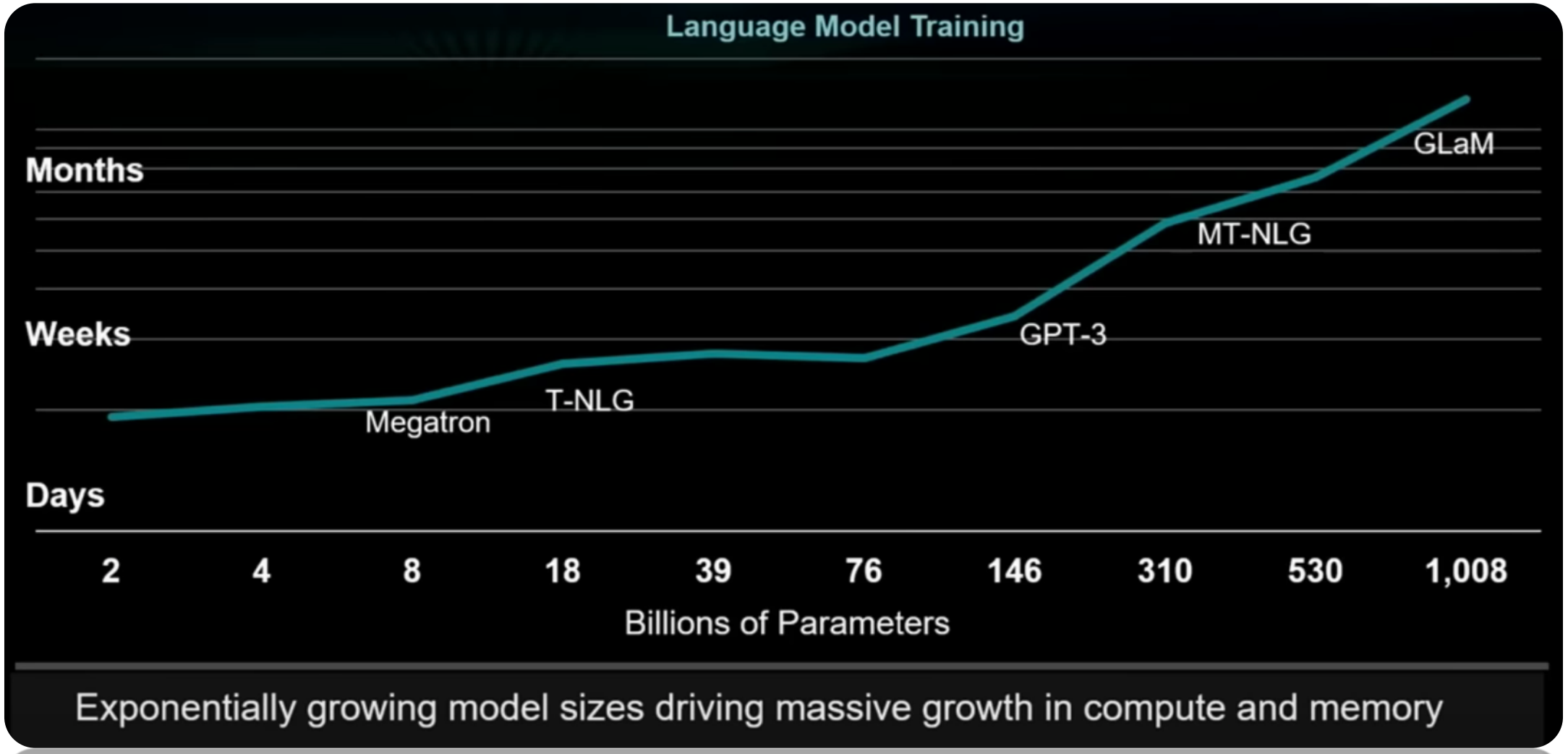
This week at the ASPLOS 2021 conference, Dr. Chris Lattner gave the keynote address to open the event with a discussion of the ...

A New Golden Age for Computer Architecture John L. Hennessy, David A. Patterson June 2018 End o... 22 个章节

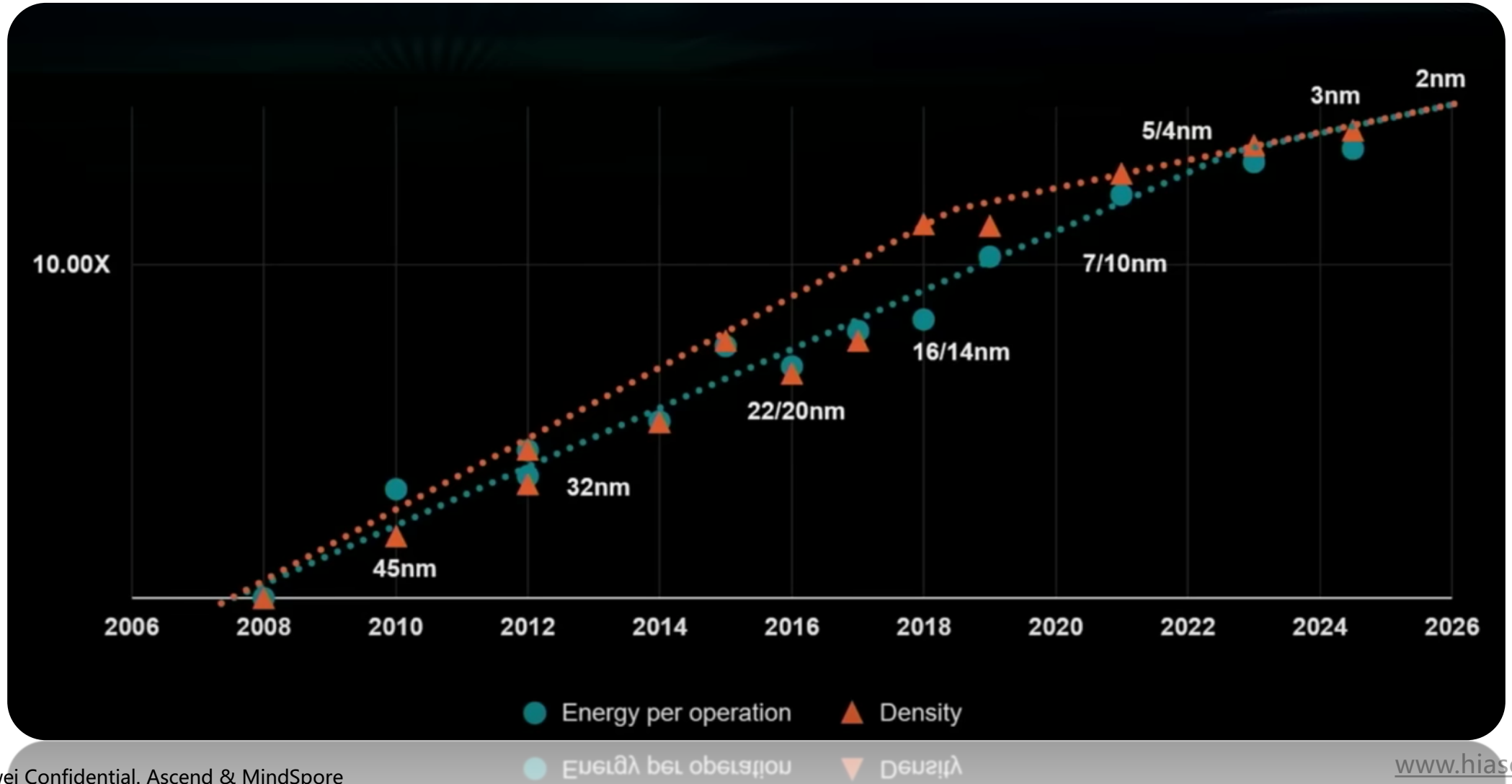
超算中心的性能



训练 AI 大模型的时间



逻辑电路技术趋势预测



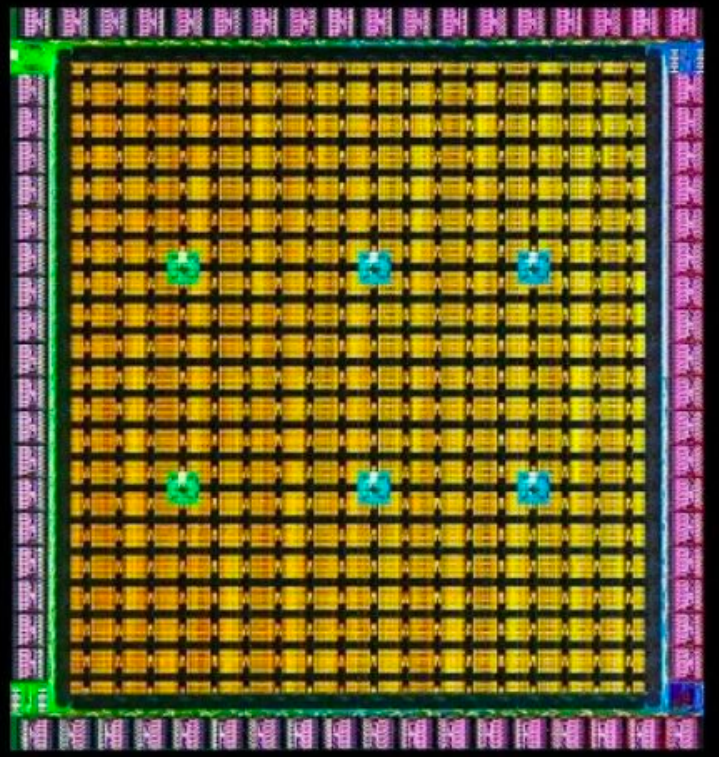
谁会在乎算力呢？

D1 Chip

362 TFLOPs BF16/CFP8
22.6 TFLOPs FP32

10TBps/dir. On-Chip Bandwidth
4TBps/edge. Off-Chip Bandwidth

400W TDP



645mm²
7nm Technology

50 Billion
Transistors

11+ Miles
Of Wires

BOW: 3RD GENERATION IPU SYSTEMS

SHIPPING TO CUSTOMERS TODAY

BOW POD16

4x Bow-2000
5.6 PetaFLOPS
1 CPU server

BOW POD32

8x Bow-2000
11.2 PetaFLOPS
1 CPU server

BOW POD64

16x Bow-2000
22.4 PetaFLOPS
1-4 CPU server(s)

BOW POD256

64x Bow-2000
89.6 PetaFLOPS
4-16 CPU server(s)

BOW POD1024

256x Bow-2000
358.4 PetaFLOPS
16 - 64 CPU server(s)
Early access

LATEST GPU vs. COLOSSUS Mk2 IPU

	NVIDIA DGX-A100 (8x A100)	GRAPHCORE 8x M2000	
FP32 compute	156TFLOP	2PFLOP	**>12 x**
AI compute	2.5PFLOP[1]	8PFLOP[2]	**>3x**
AI Memory	320GB[3]	3.6TB[4]	**>10x**
System Price	$199,000 MSRP	$259,600 MSRP	

NOTES:
[1] Actual figure for TF32/FP16. NVIDIA 8xA100 5PFlop reference is for 50% sparsity which includes Pflops for operations that aren't run
[2] Graphcore AI Float with IEEE FP16.16 multiply.accumulate and IEEE FP16.SR 16bit float with stochastic rounding, with equivalent accuracy performance as FP32
[3] 40GB HBM memory on A100 modules *8 modules per DGX-A100 system
[4] IPU-Exchange Memory which includes attached DRAM and IPU In-Processor-Memory with 100x bandwidth vs. HBM memory sub-system

你真的在乎算力？

读取数据与计算的计算换算

How many operations must I do on some data to make it worth the cost of loading it?

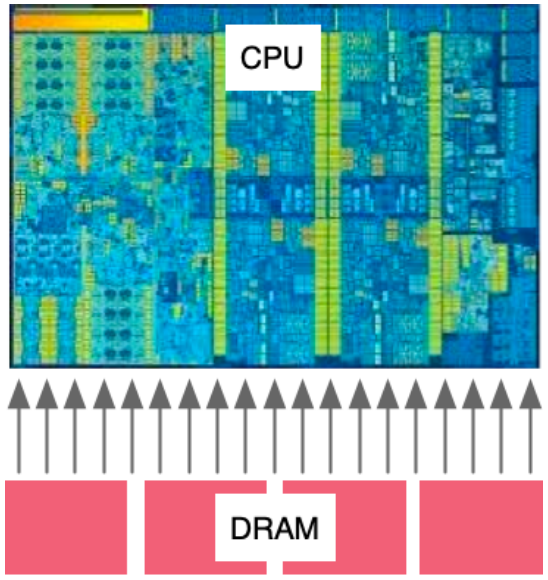
Required Compute Intensity = $\frac{FLOPs}{Data\ Rate}$ = 80

2000 GFLOPs FP64

200 GBytes / sec

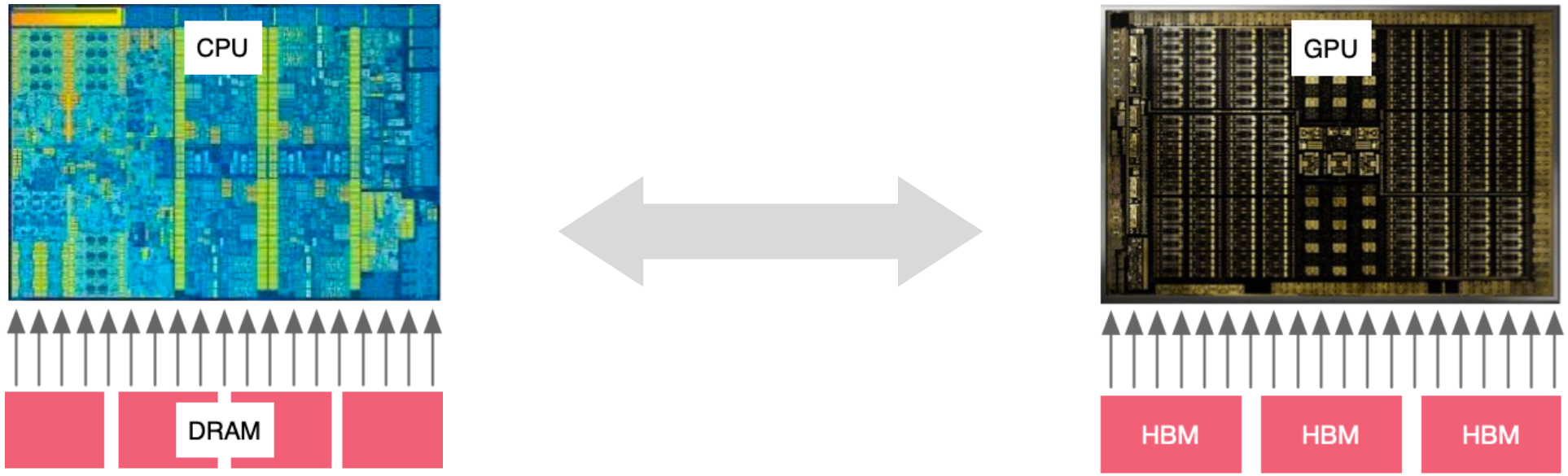
= 25 Giga-FP64 / sec

(FP64 = 8 bytes)



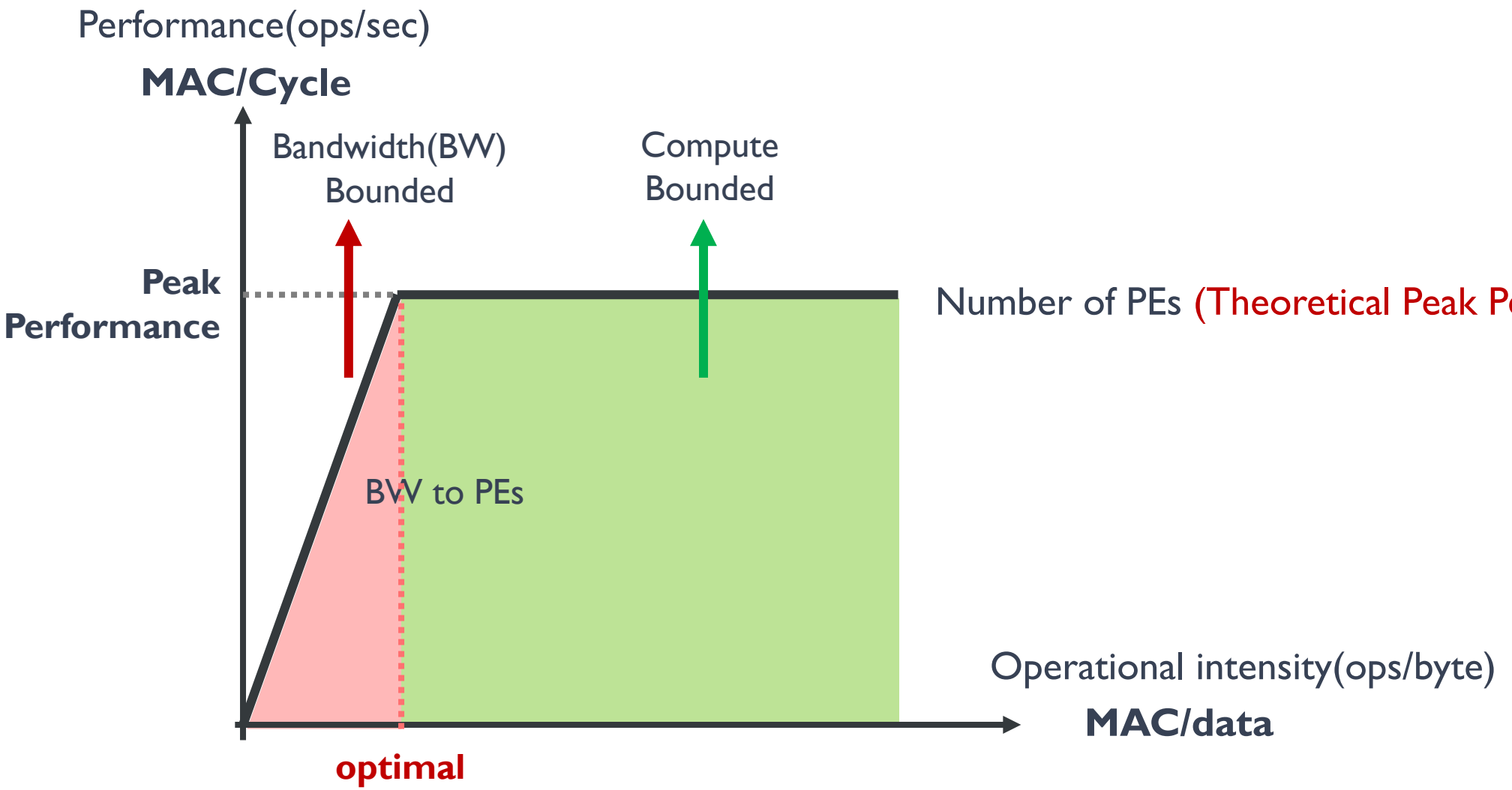
So for every number load from memory, Need to do 80 Operations on it to break even.

计算密集型



	AMD Rome 7742	Intel Xeon 8280	NVIDIA A100
Peak FP64 Giga Flops	2,190	2,300	19,500
Memory B/W (GB/sec)	131	204	1,555
Compute Intensity	134	90	100

ZOMI并不是很在乎算力

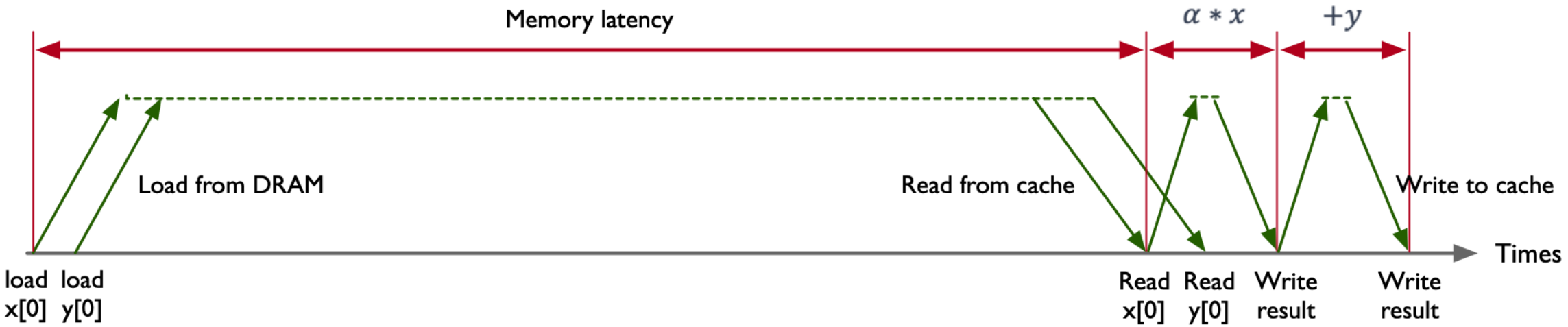


https://arxiv.org/abs/1807.07928

更应该关注

内存、带宽、时延

DAXPY 计算 DEMO




```
void demo(double alpha, double *x, double *y)
{
    int n = 2000;
    for(int i = 0; i < n; ++i)
    {
        y[i] = alpha * x[i] + y[i];
    }
}
```

- 2FLOPs：multiply & add
- 2 Memory Loads: x[i] & y[i] (per element)
- Single Operation: FMA(fused multiply-add)

光与电的传播速度

Speed of Light = 300,000,000 M/S

Computer Clock = 3,000,000,000 Hz

所以在一个时钟周期内光的传播速度为 100mm (~4 inches)

光与电的传播速度

Speed of Light = 300,000,000 M/S

Computer Clock = 3,000,000,000 Hz

Speed of Electricity = 60,000,000 M/S

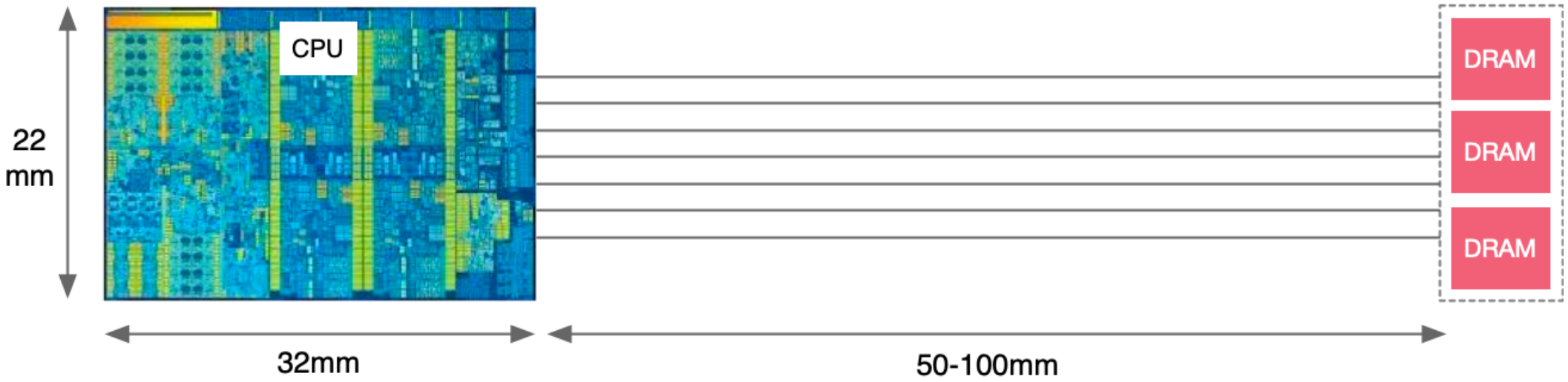
所以在一个时钟周期电流的传播速度为 20mm (~0.8 inches)

光与电的传播速度

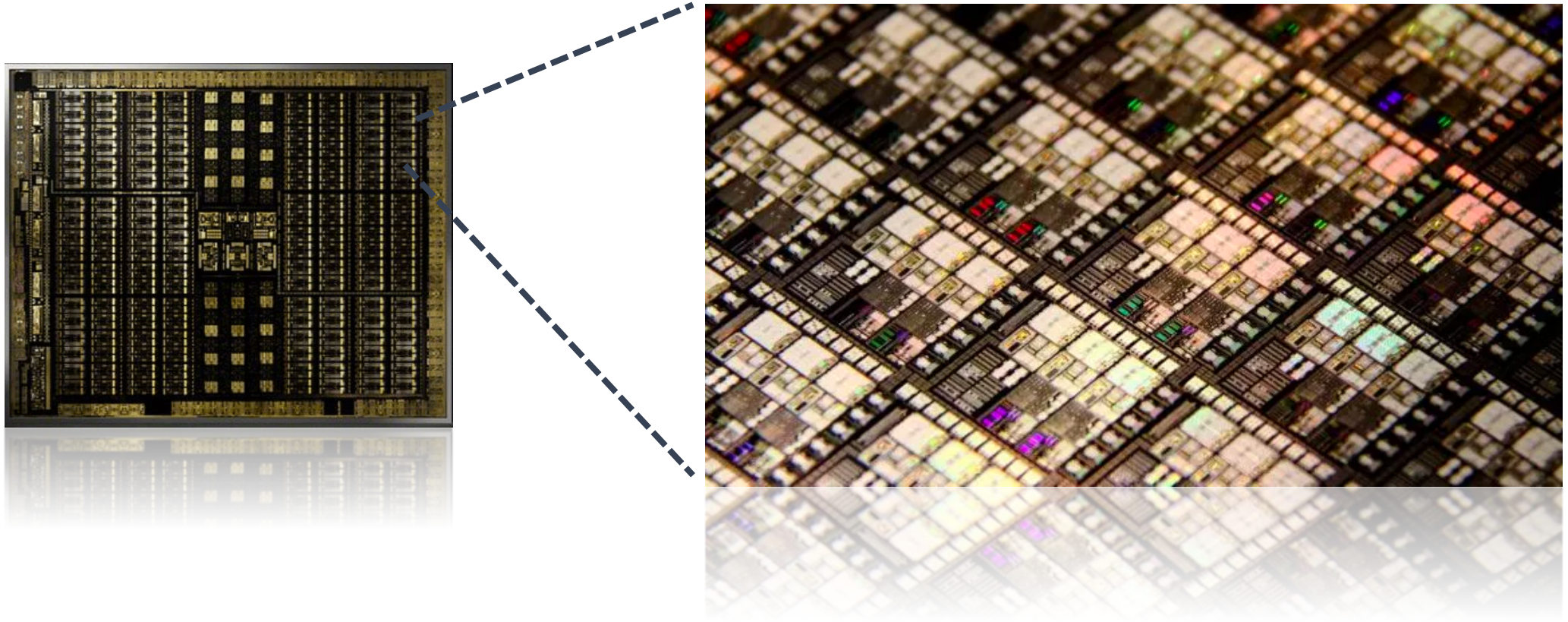
Speed of Light = 300,000,000 M/S

Computer Clock = 3,000,000,000 Hz

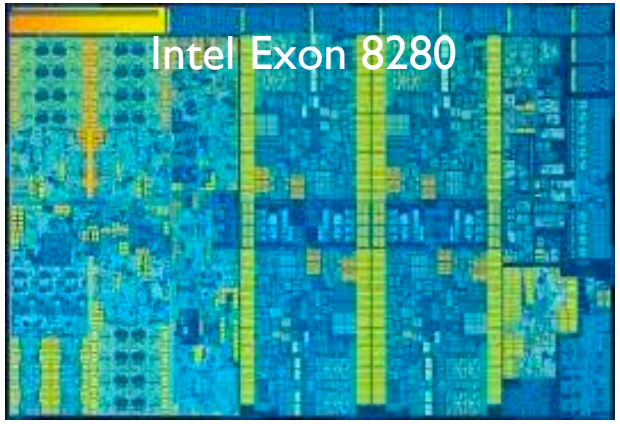
Speed of Electricity = 60,000,000 M/S



处理器内部



DAXPY 计算 DEMO



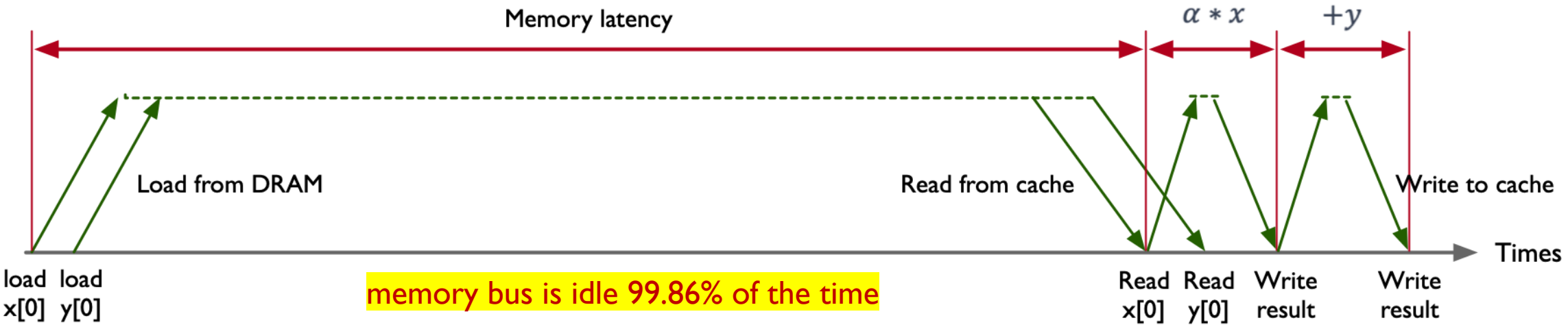
Memory Bandwidth: 131 GB/sec

Memory latency: 89 ns

} 11,659 bytes can be moved in 89 ns

AXY demo move 16 byes per 89 ns latency

Memory efficiency = 0.14%



memory bus is idle 99.86% of the time

不同芯片产品的计算性能

	AMD Rome 7742	Intel Xeon 8280	NVIDIA A100
Memory B/W(GB/sec)	204	131	1555
DRAM Latency(ns)	122	89	404
Peak bytes per latency	24,888	11,659	628,220
Memory Efficiency	0.064%	0.14%	0.0025%

引用

1. https://www.youtube.com/watch?v=3jHi8E5C-18
2. https://www.youtube.com/watch?v=-P28LKWTzrI
3. https://www.youtube.com/watch?v=3I10o0DYJXg