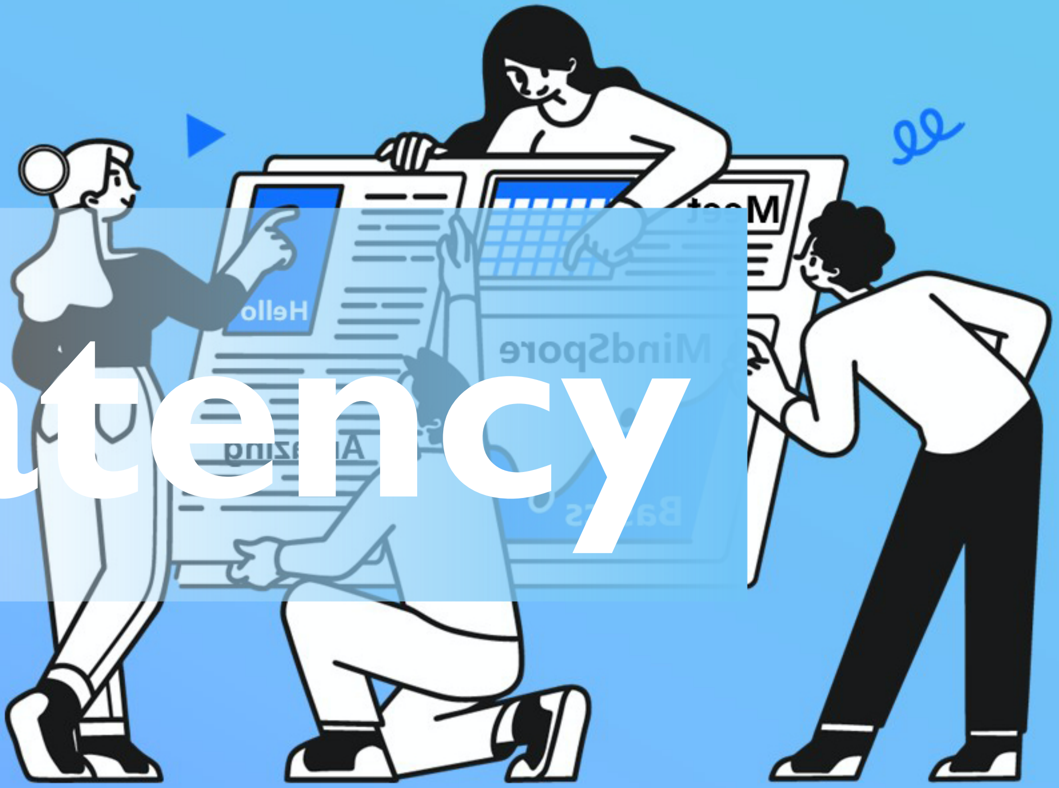
AI 芯片 – AI 芯片基础

计算时延 Latency

ZOMI



BUILDING A BETTER CONNECTED WORLD

Ascend & MindSpore

www.hiascend.com
www.mindspore.cn

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

计算强度

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

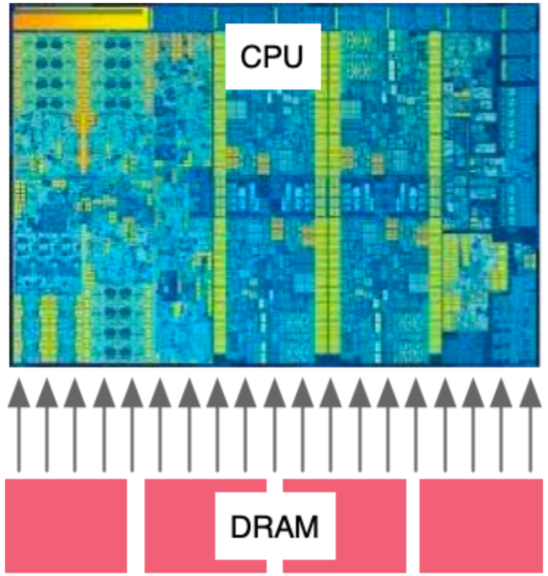
$$\text{Required Compute Intensity} = \frac{FLOPs}{Data\ Rate} = 80$$

2000 GFLOPs FP64

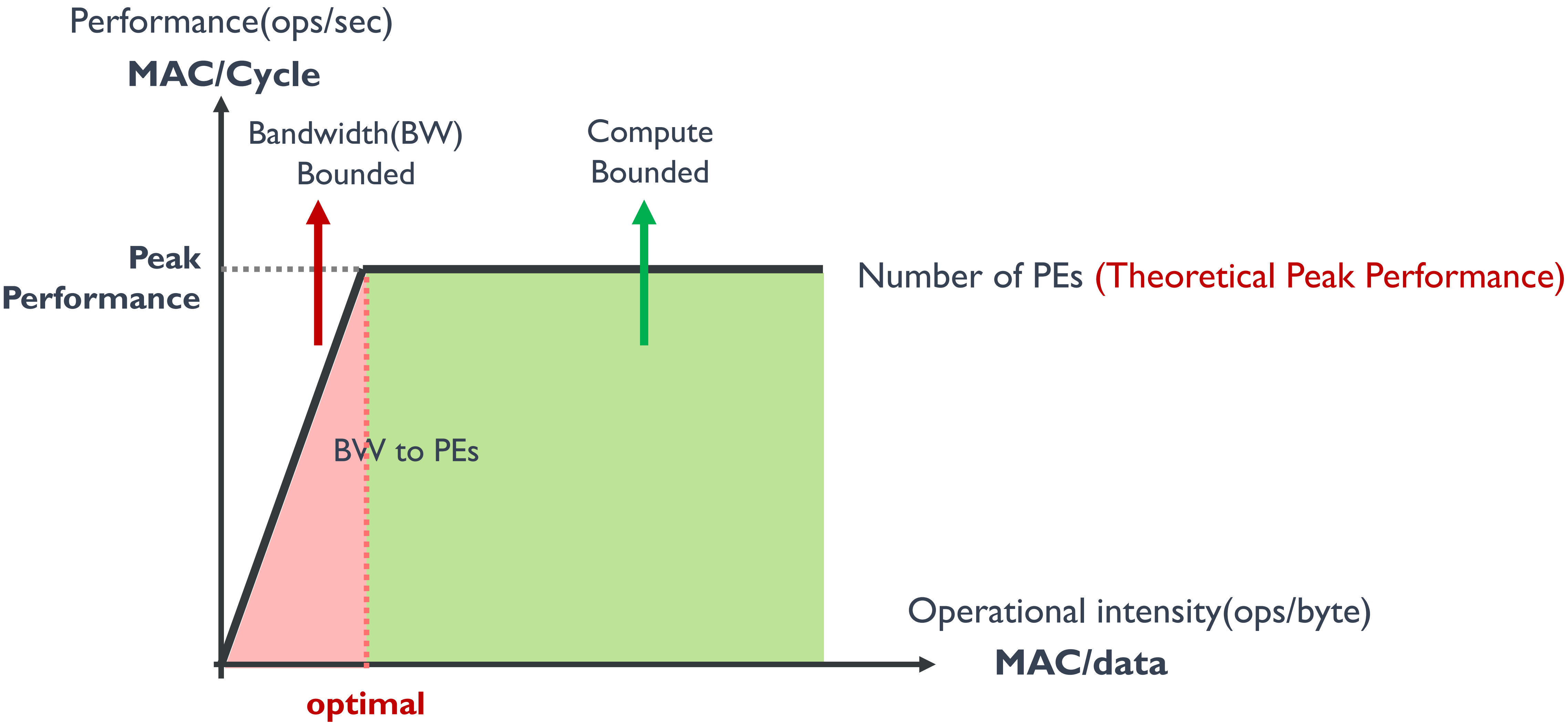
200 GBytes / sec

= 25 Giga-FP64 / sec

(FP64 = 8 bytes)



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



Performance(ops/sec)

MAC/Cycle

Bandwidth(BW)
Bounded

Compute
Bounded

Peak Performance

Number of PEs (Theoretical Peak Performance)

BW to PEs

Operational intensity(ops/byte)

MAC/data

optimal

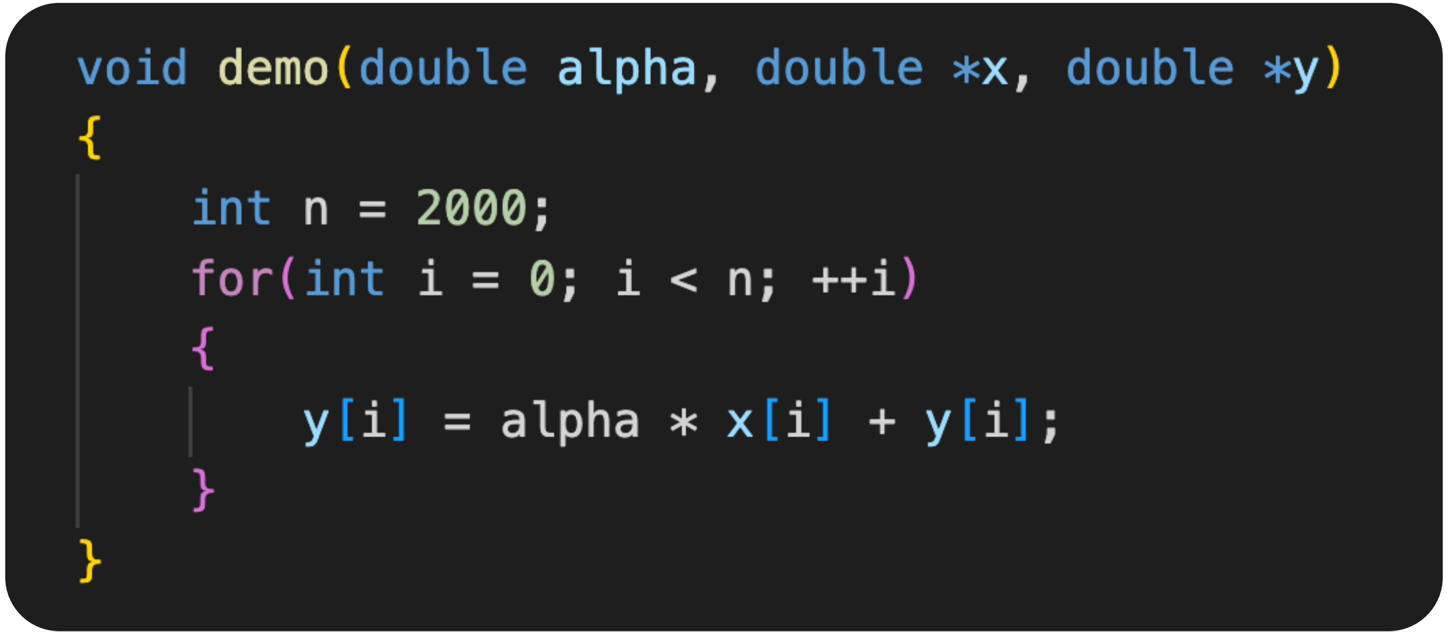
https://arxiv.org/abs/1807.07928

更应该关注

内存、带宽 >> 时延

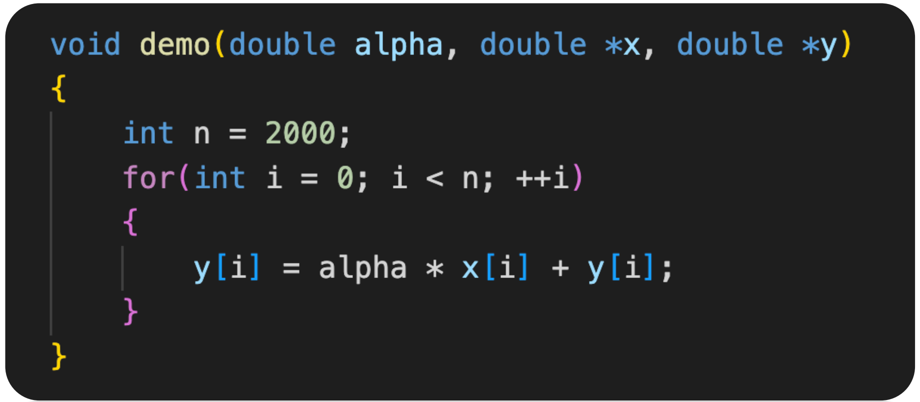
DAXPY 计算 DEMO

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



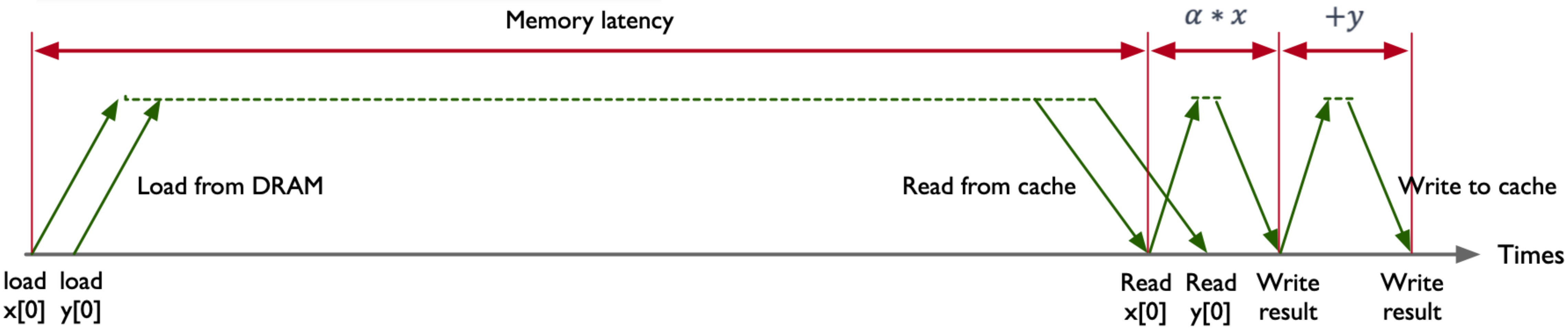
```
void demo(double alpha, double *x, double *y)
{
    int n = 2000;
    for(int i = 0; i < n; ++i)
    {
        y[i] = alpha * x[i] + y[i];
    }
}
```

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

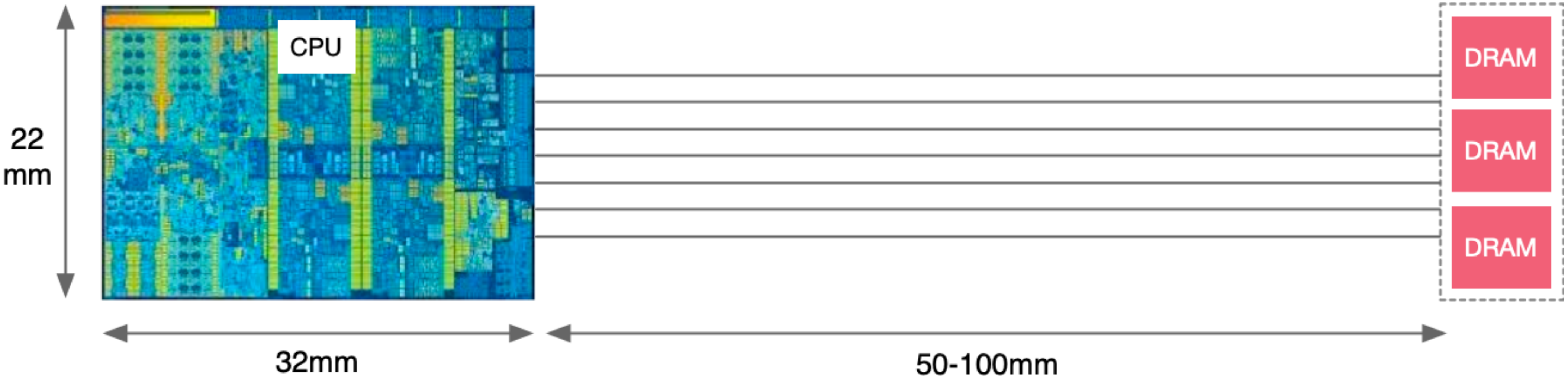
所以在一个时钟周期电流的传播速度为 20mm (~0.8 inches)

光与电的传播速度

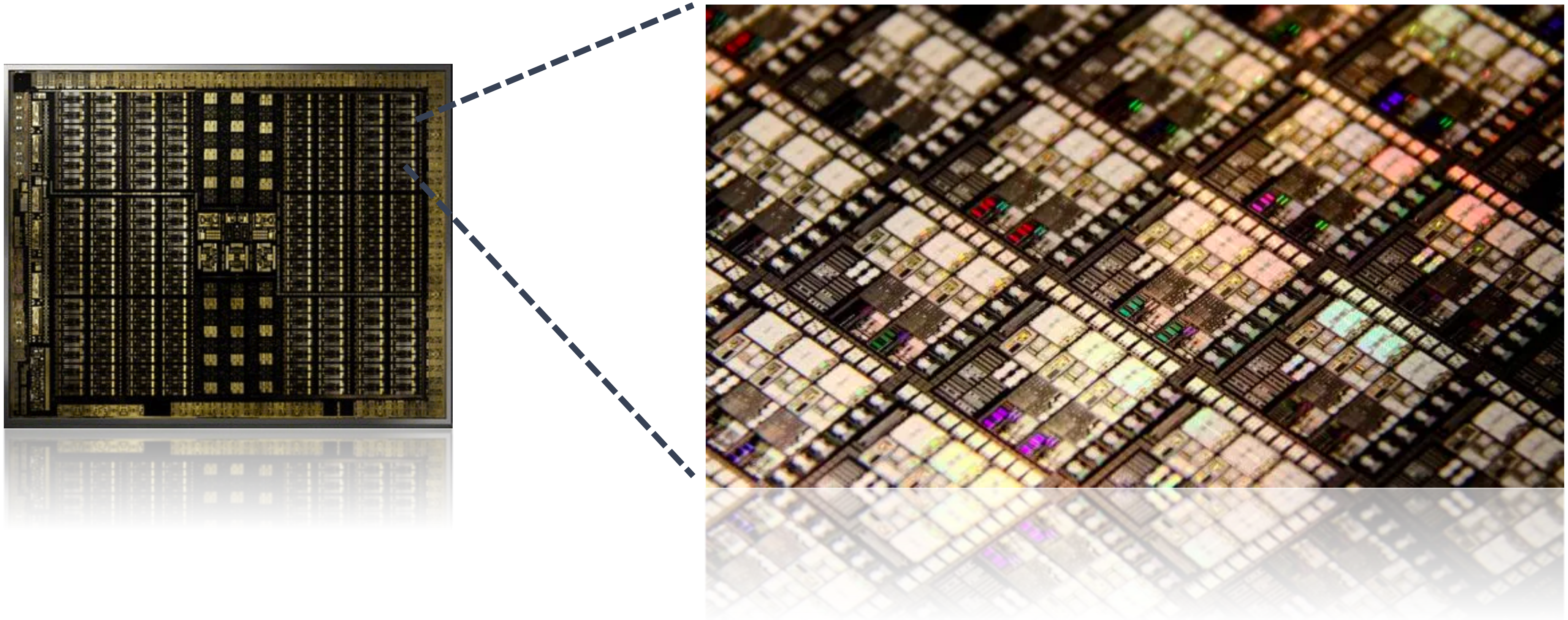
Speed of Light = 300,000,000 M/S

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%

DAXPY 计算 DEMO

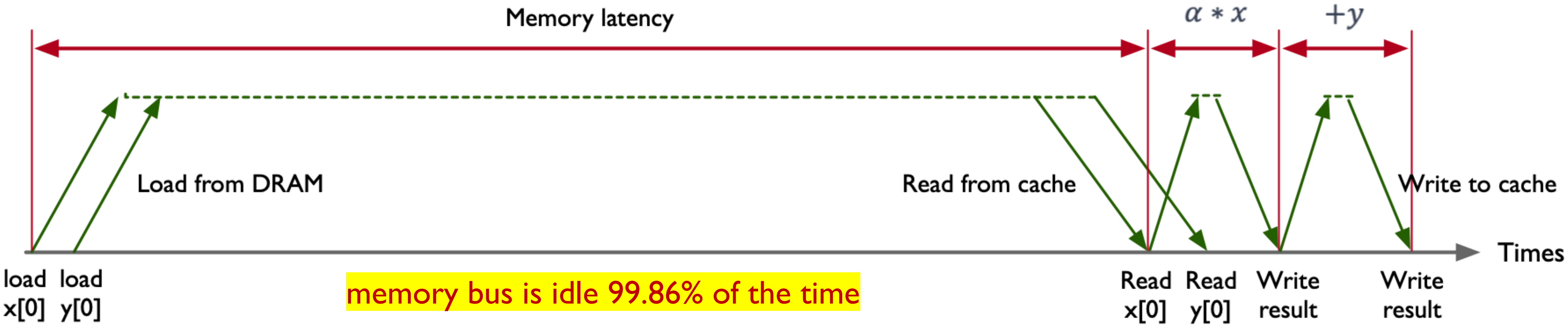
Memory Bandwidth: 131 GB/sec

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%



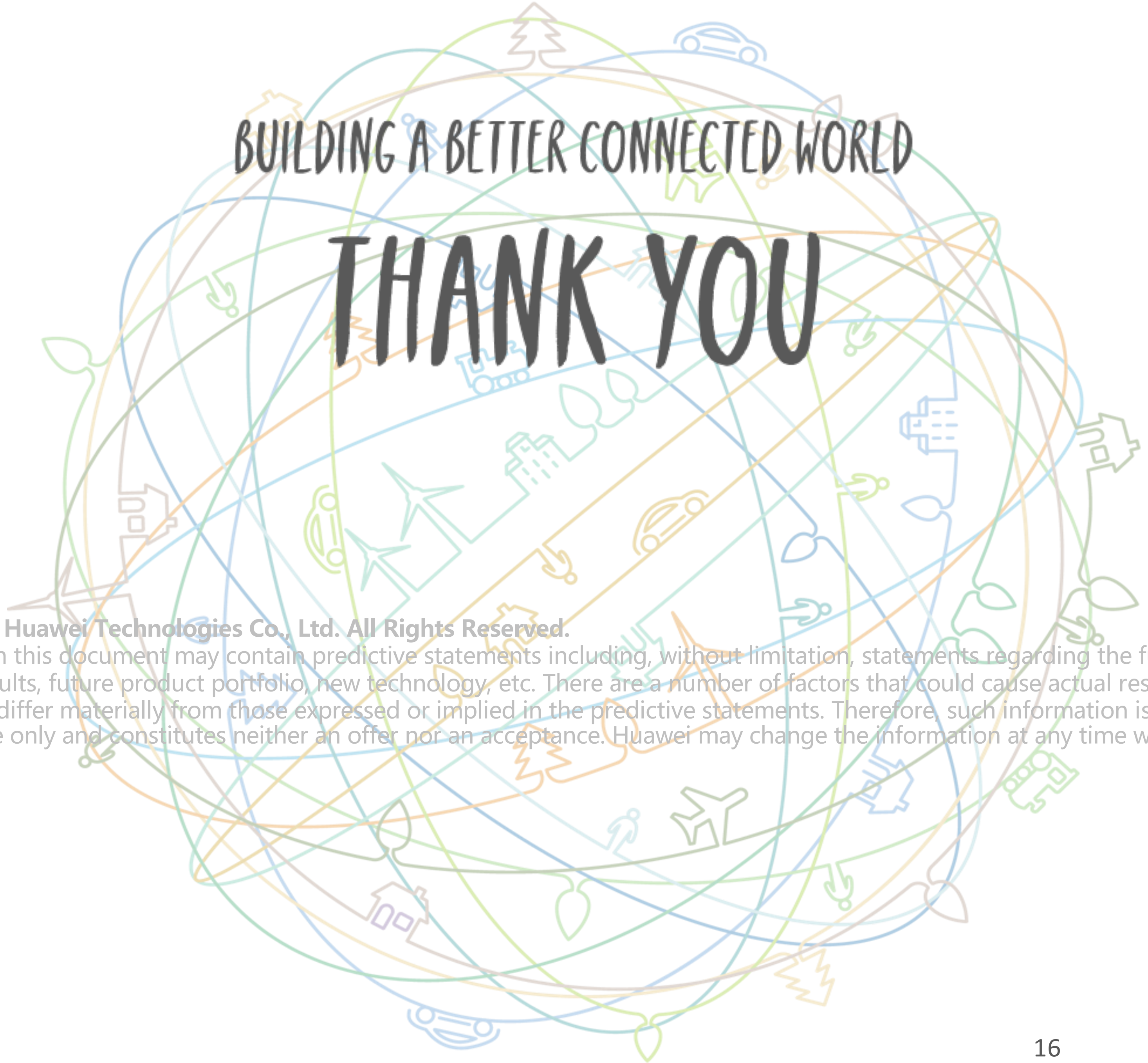
memory bus is idle 99.86% of the time

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



BUILDING A BETTER CONNECTED WORLD

THANK YOU