Lec 1 Hello CUDA

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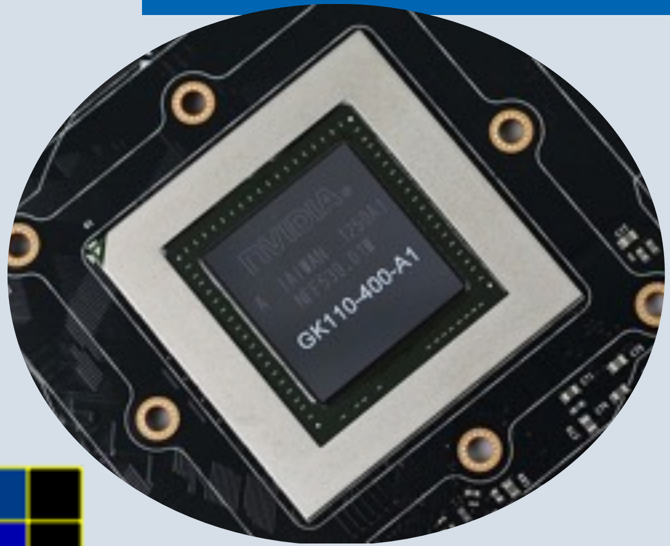
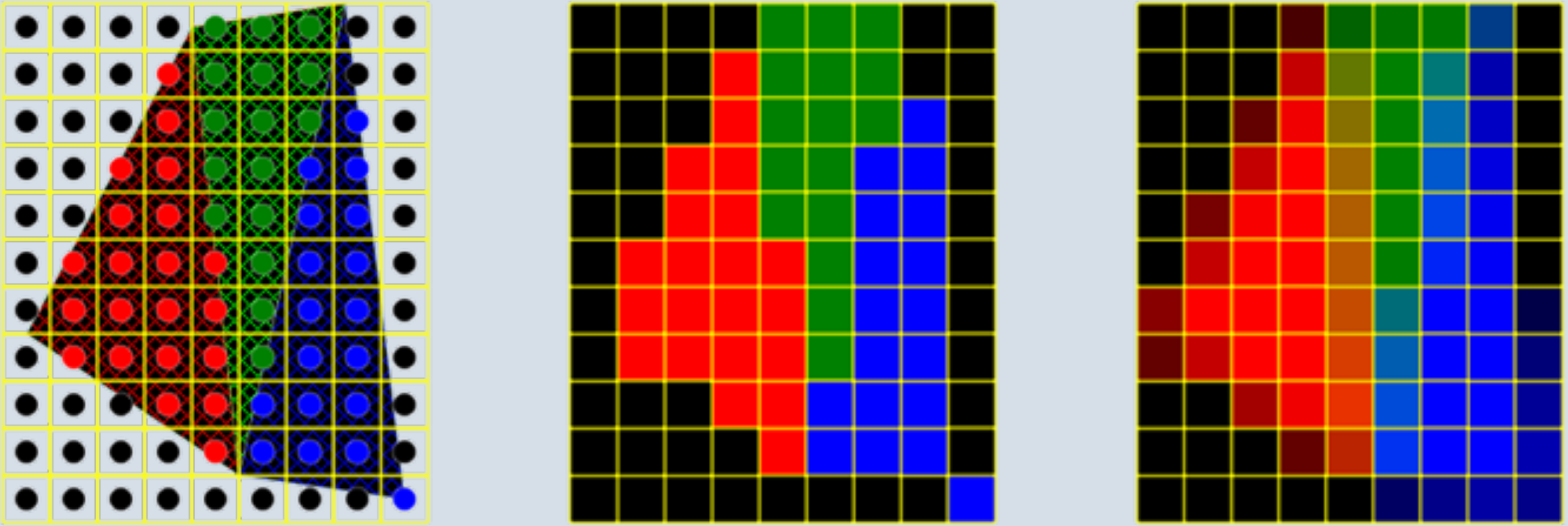
Outline



What is GPU

- **Specialized electronic circuit**
  - ✓ Accelerate the building of images intended for display

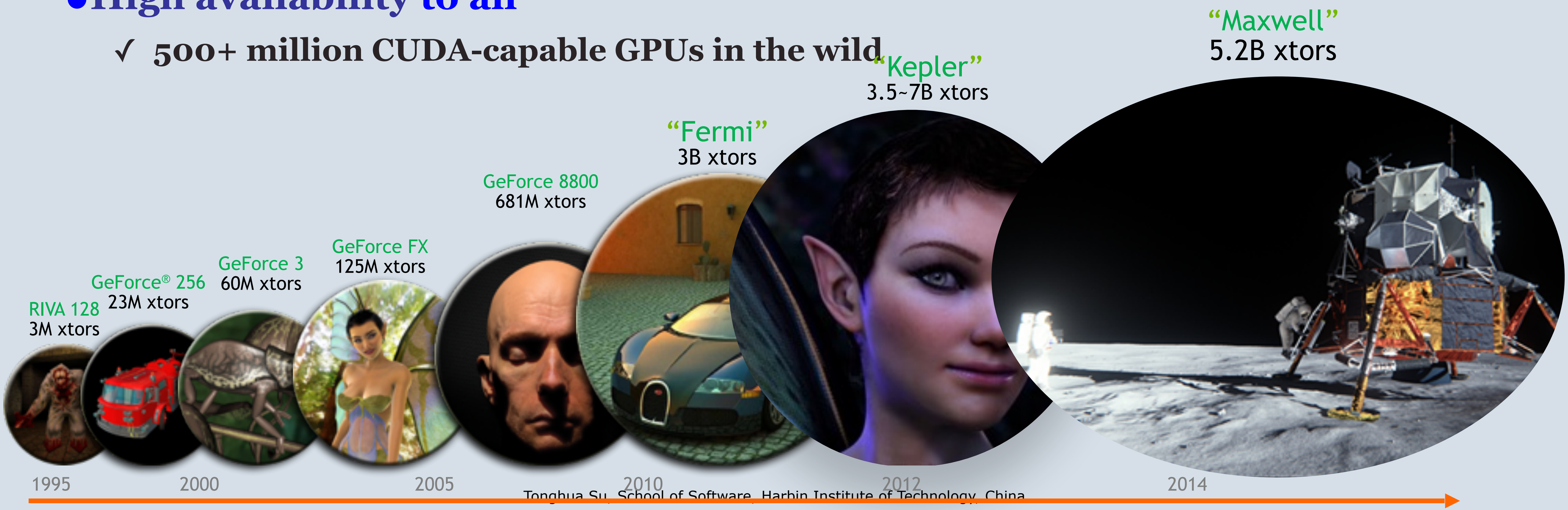


Triangle Geometry　　Aliased　　Anti-Aliased

  - ✓ But now, it is used for general-purpose computation!

What is GPU

- High throughput computation
  - ✓ GeForce GTX 980: 4,612 GFLOP/s
- High bandwidth memory
  - ✓ GeForce GTX 980: 224 GB/s
- High availability to all
  - ✓ 500+ million CUDA-capable GPUs in the wild



Quiz

- **GPU与CPU计算峰值比较**
  - ✓ 等价位：~￥**4000**
  - ✓ **GPU**：**GTX980**
  - ✓ **CPU**：至强**E5 2640 v2**
- **请问，前者的浮点运算能力（FLOPS）是后者的多少倍?**

Quiz

- **比较GTX980显存带宽与DDR3 2133的带宽**

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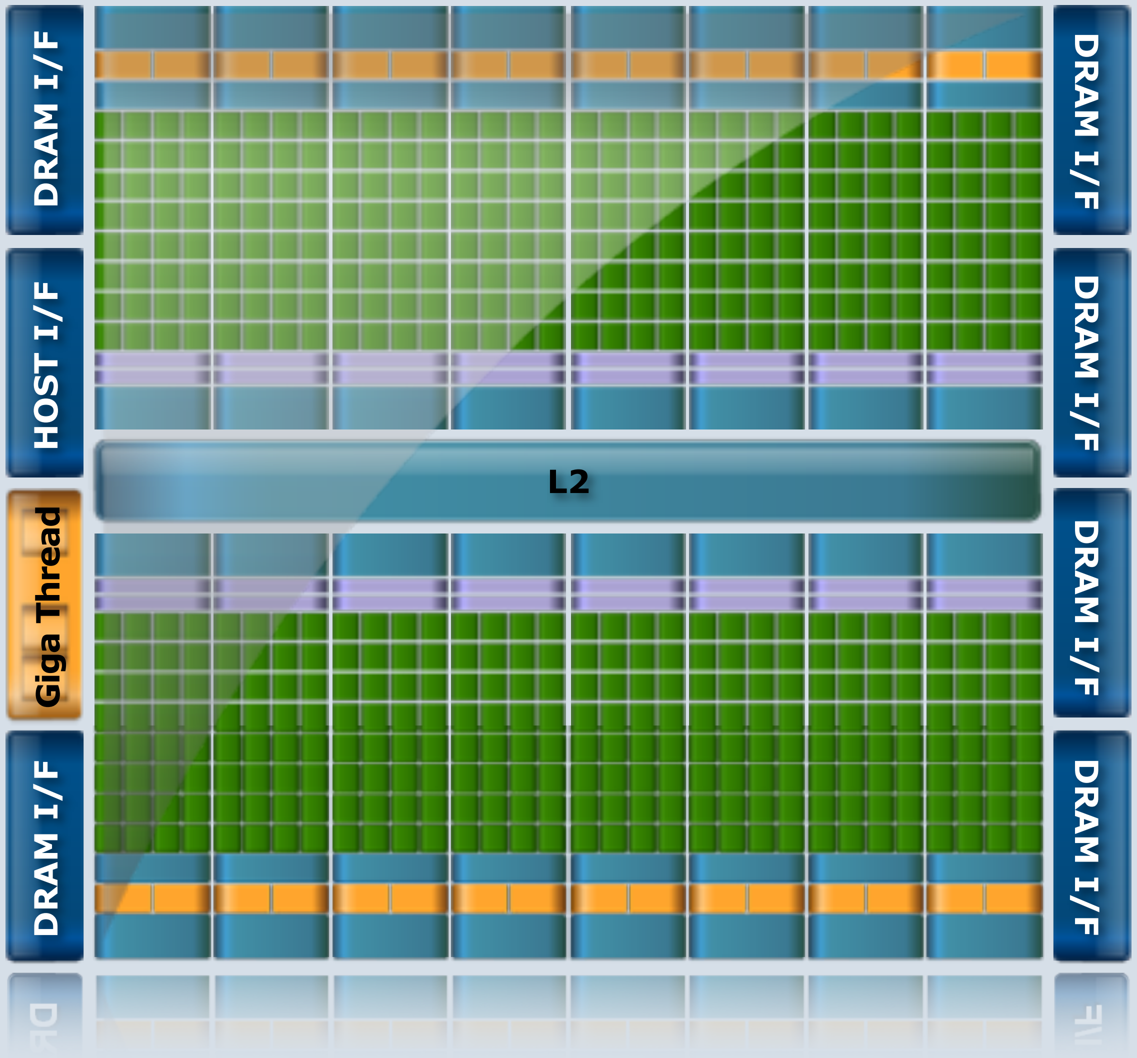
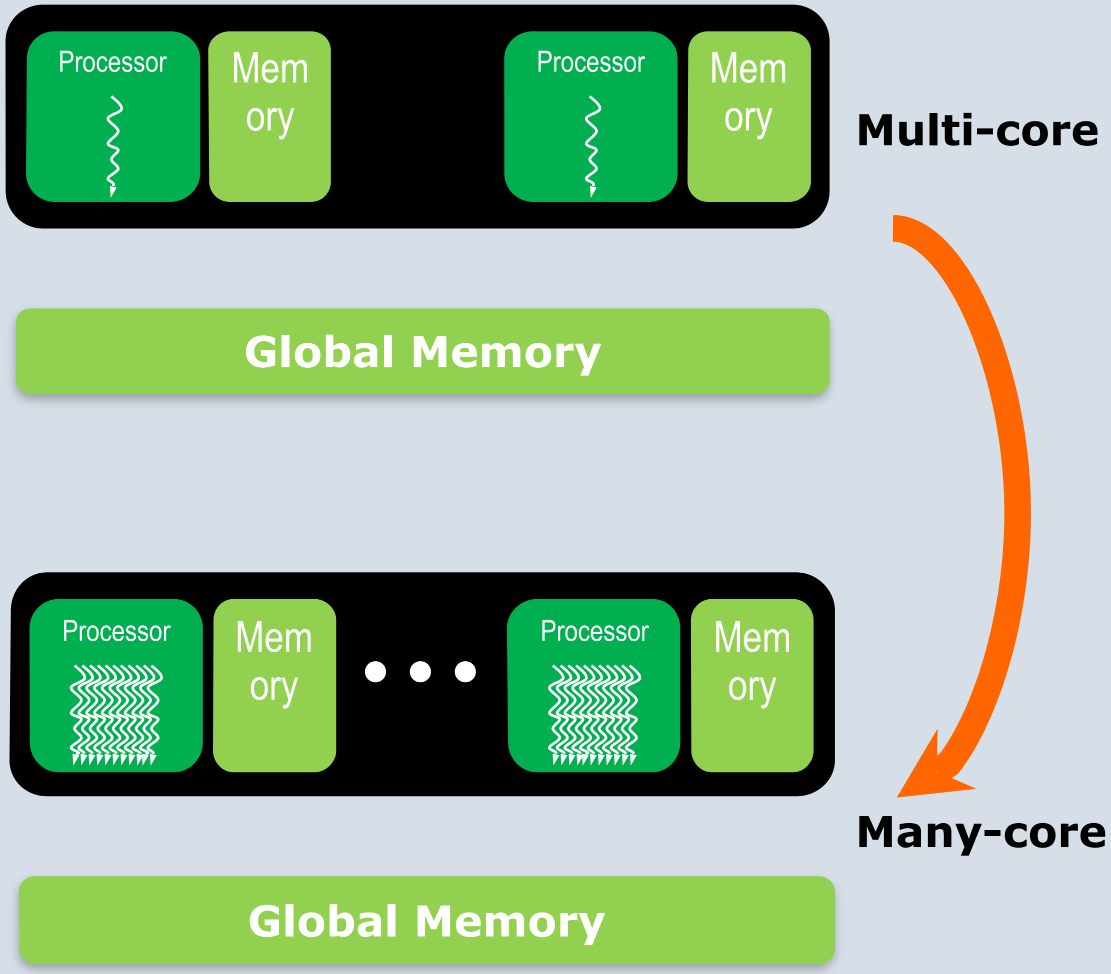
1. What is GPU?
2. NVIDIA GPU Architecture (briefly)
3. Hello CUDA
4. Amdahl's Law
5. Lab 1

NVIDIA GPU Architecture

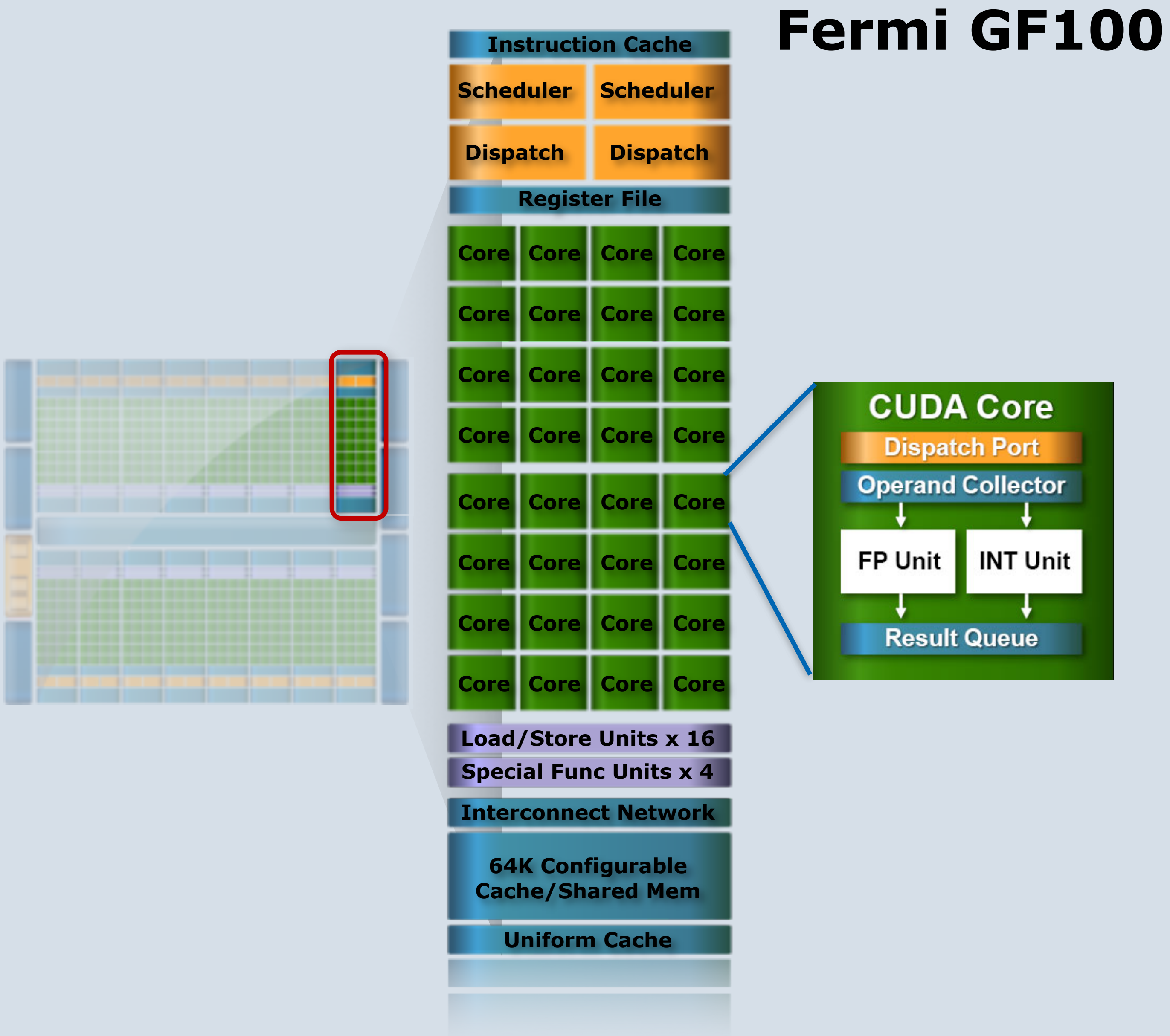


Fermi GF100

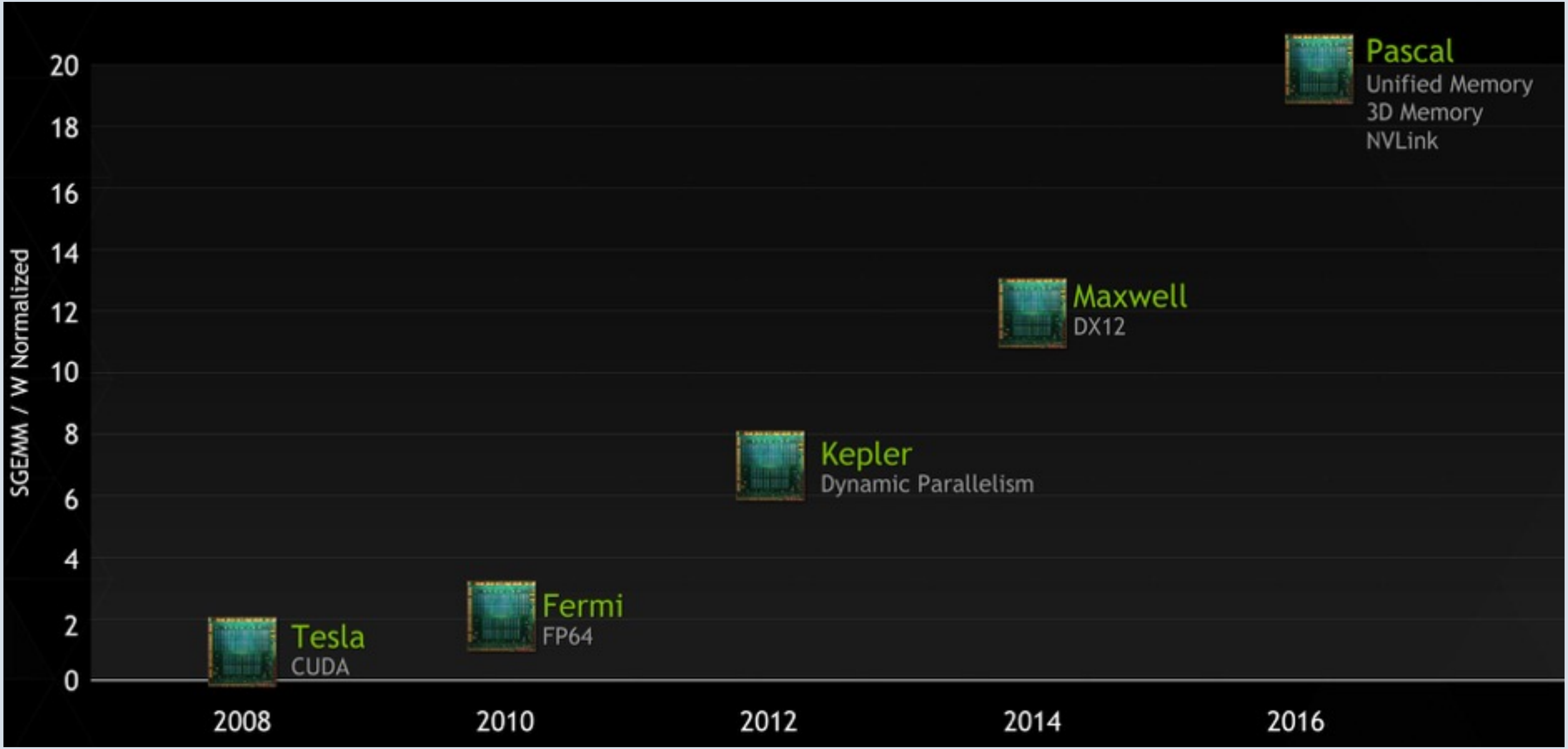


Streaming Multi-processor (SM)

- 32 CUDA Cores per SM (512 total)
- 8x peak FP64 performance
  - ✓ 50% of peak FP32 performance
- Direct load/store to memory
  - ✓ Usual linear sequence of bytes
  - ✓ High bandwidth (Hundreds GB/sec)
- 64KB of fast, on-chip RAM
  - ✓ Software or hardware-managed
  - ✓ Shared amongst CUDA cores
  - ✓ Enables thread communication



GPU Roadmap


SGEMM / W Normalized
20
18
16
14
12
10
8
6
4
2
0
2008
2010
2012
2014
2016
Tesla
CUDA
Fermi
FP64
Kepler
Dynamic Parallelism
Maxwell
DX12
Pascal
Unified Memory
3D Memory
NVLink

Lab 1.1 Device Query

- 查询你机器上GPU设备的参数
  - ✓ 新建.cu文件
  - ✓ 调用cudaGetDeviceCount()得到GPU设备的数量
  - ✓ 调用cudaGetDeviceProperties()函数得到GPU设备的属性结构体
  - ✓ 解释关键属性的含义，至少包括设备名称、计算能力为多少、设备可用全局内存、每线程块最大线程数、设备可用全局内存容量、每线程块可用共享内存容量、每线程块可用寄存器数量、每线程块最大线程数、每个处理器簇最大驻留线程数、设备中的处理器簇数量等
  - ✓ 可参考WILT 3.2节

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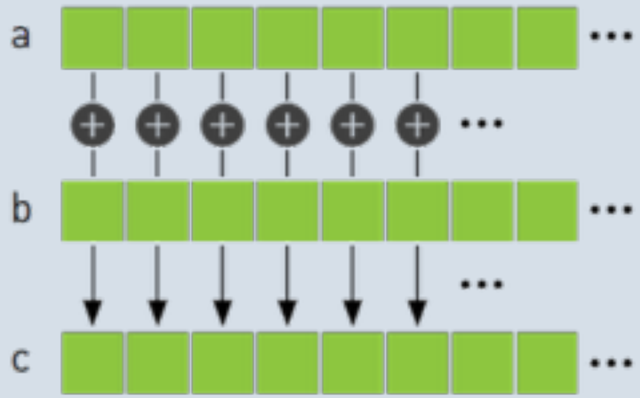
Hello CUDA

- **Vector Sum**



- **Serial code**

```
for (i=0;i<128;i++)
{
		c[i] = a[i] + b[i];
}
```

- **Translate into CUDA threads**

```
__global__ void addKernel(int * const a, const int * const b, const int * const c)
{
		c[i] = a[i] + b[i];
}
```

Hello CUDA

•Vector Sum

✓ **Identify thread id**

```
__global__  addKernel(int * const a, const int * const b, const int * const c)
{
        const unsigned int i = threadIdx.x;
        c[i] = a[i] + b[i];
}
```

✓ **Invoke CUDA kernel**

- kernel_function<<<num_blocks, num_threads>>>(param1, param2, .)
- E.g. addKernel<<< 1, 128 >>>(a, b, c);

Hello CUDA

- **Demo 1**

Hello CUDA

```
  global   addKernel(int * const a, const int * const b, const int * const c)
{
          const unsigned int i = threadIdx.x;
          c[i] = a[i] + b[i];
}
```

线程**ID**，同时索引数据元素

```
void main(){
        ......
        int *dev_a,*dev_b,*dev_c;
        // Allocate GPU buffers for three vectors (two input, one output)    .
        cudaMalloc((void**)&dev_c, 128* sizeof(int));
         ......
        // Copy input vectors from host memory to GPU buffers.
        cudaMemcpy(dev_a, a, 128* sizeof(int), cudaMemcpyHostToDevice);
        cudaMemcpy(dev_b, b, 128* sizeof(int), cudaMemcpyHostToDevice);

        // Launch a kernel on the GPU with one thread for each element.
        addKernel<<<1, 128>>>(dev_c, dev_a, dev_b);

        // Copy output vector from GPU buffer to host memory.
        cudaMemcpy(c, dev_c, 128* sizeof(int), cudaMemcpyDeviceToHost);

        cudaFree(dev_c);
         ......
}
```

分配显存

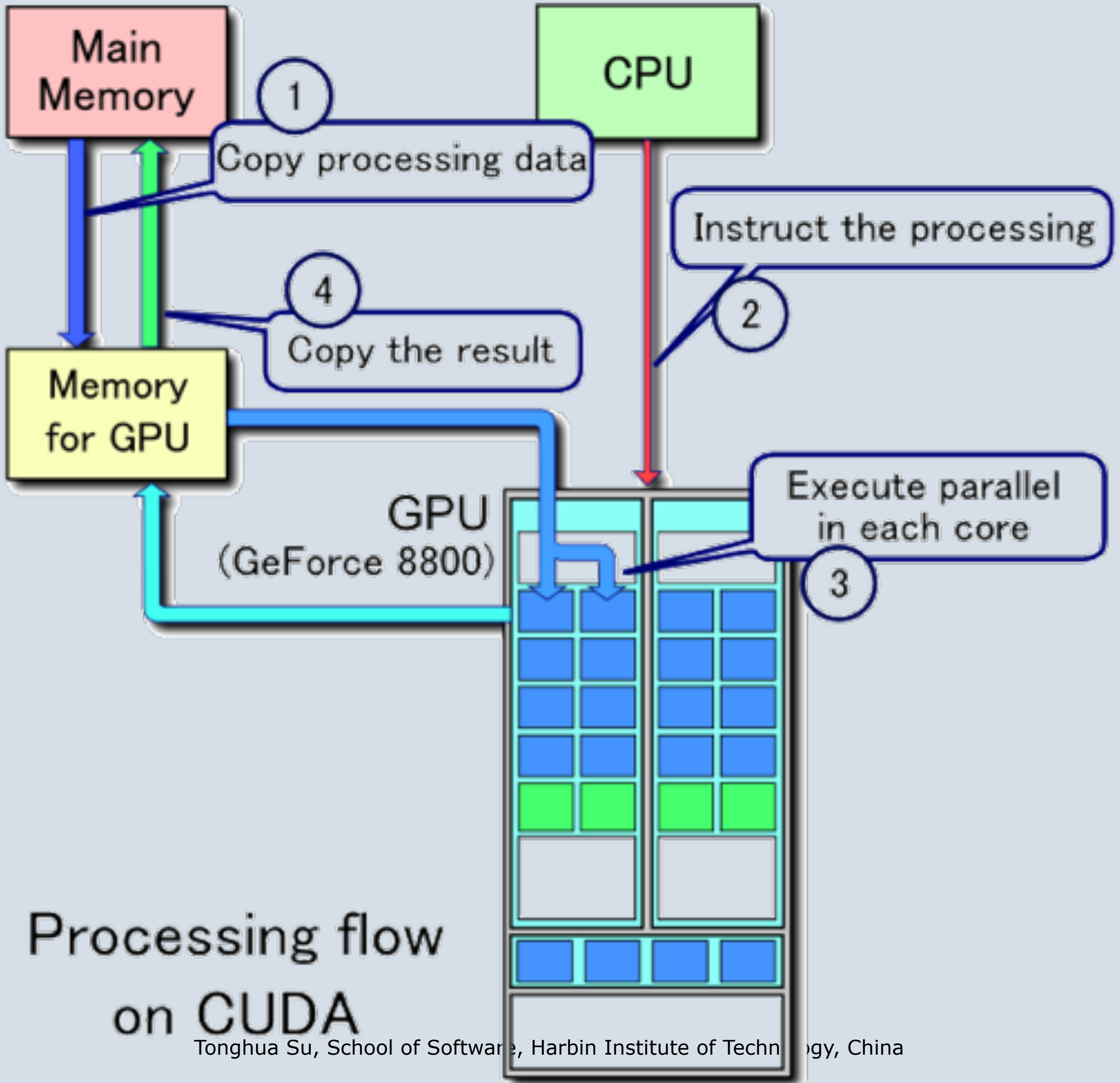
数据从主机复制到**GPU**

调用内核函数addKernel

数据从**GPU**复制回主机

释放显存

Hello CUDA


Main Memory
CPU
1
Copy processing data
Instruct the processing
2
4
Copy the result
Memory for GPU
GPU (GeForce 8800)
Execute parallel in each core
3
Processing flow on CUDA

Lab 1.2 Error Handling

- 自己从头编写并运行VectorSum内核
- 设置错误场景，并尝试多种查看错误的方式
  - ✓ 在内核函数内**printf**信息
  - ✓ 组合调用**cudaGetLastError()**和**cudaGetErrorString()**，返回出错字符串
  - ✓ 宏
  - ✓ 在内核启动时，使用非法参数，检验是否成功处理
  - ✓ 可参考**WILT** 附录**A.3**节

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Amdahl's Law

- **Gene Amdahl in 1967:**

$$Speedup = \frac{1}{r_s + \frac{r_p}{N}}$$

where $r_s + r_p = 1$ and r_s represents the ratio of the sequential portion.

✓ **Consider: 30% portion of time with 100X speedup through paralleling vs 99% portion with 100X**

Amdahl, Gene (1967). "Validity of the Single Processor Approach to Achieving Large-Scale Computing Capabilities". ***AFIPS Conference Proceedings*** **(30): 483–485.**

Quiz

- **请使用Amdahl 的公式计算下面程序的加速比**
  - ✓ 程序99%的部分可以使用无限多个核心计算，剩余的1%无法并行

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Lab 1

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Lab 1

- **1.2 自己从头编写并运行VectorSum内核**
- **1.2 设置错误场景，并尝试多种查看错误的方式**
  - ✓ 在内核函数内**printf**信息
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