Lec 1 Hello CUDA

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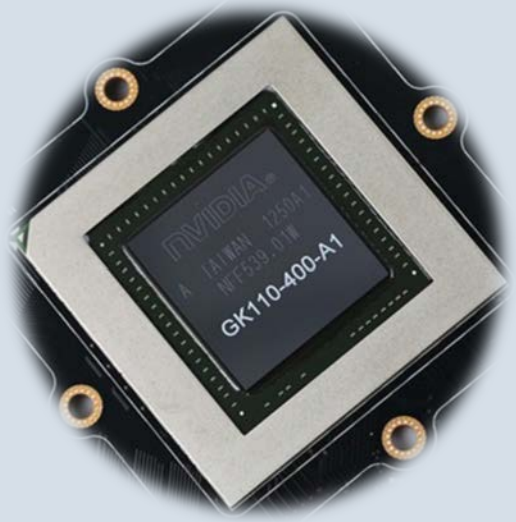
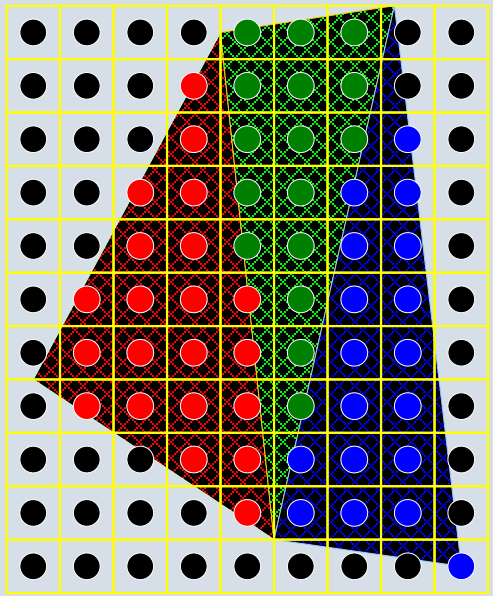
Outline

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

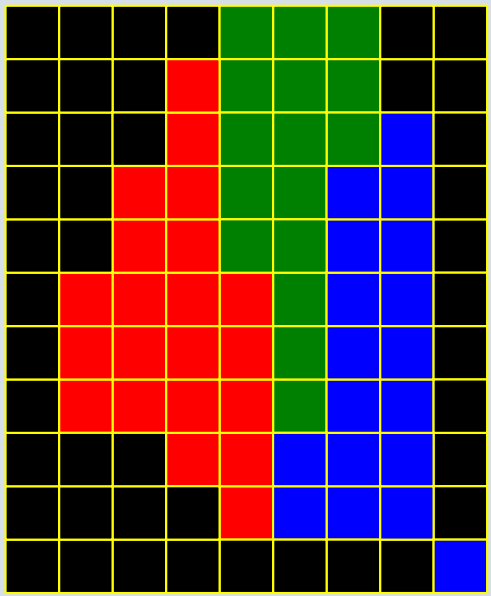
What is GPU

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

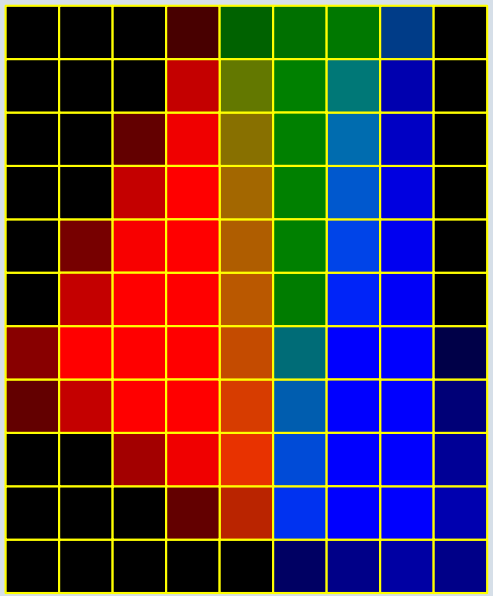




Triangle Geometry



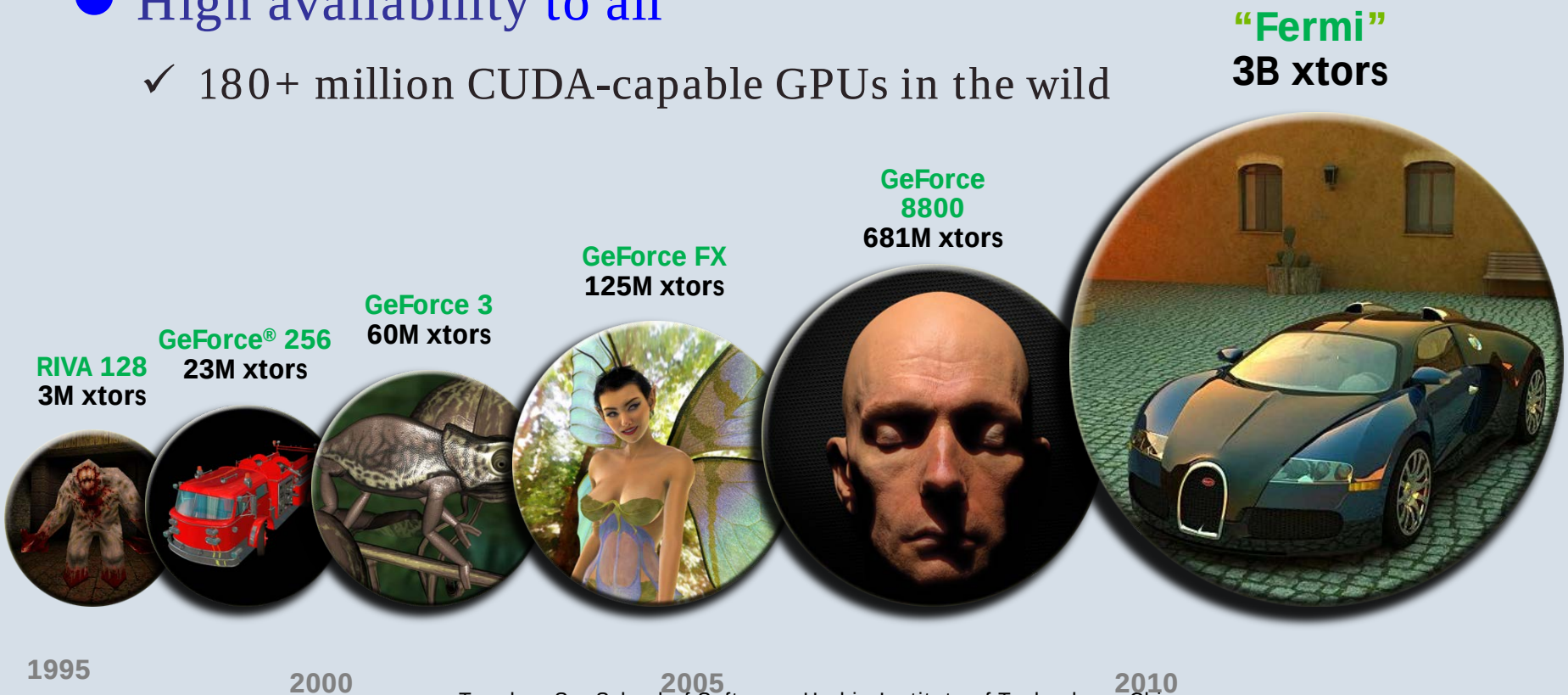
Aliased



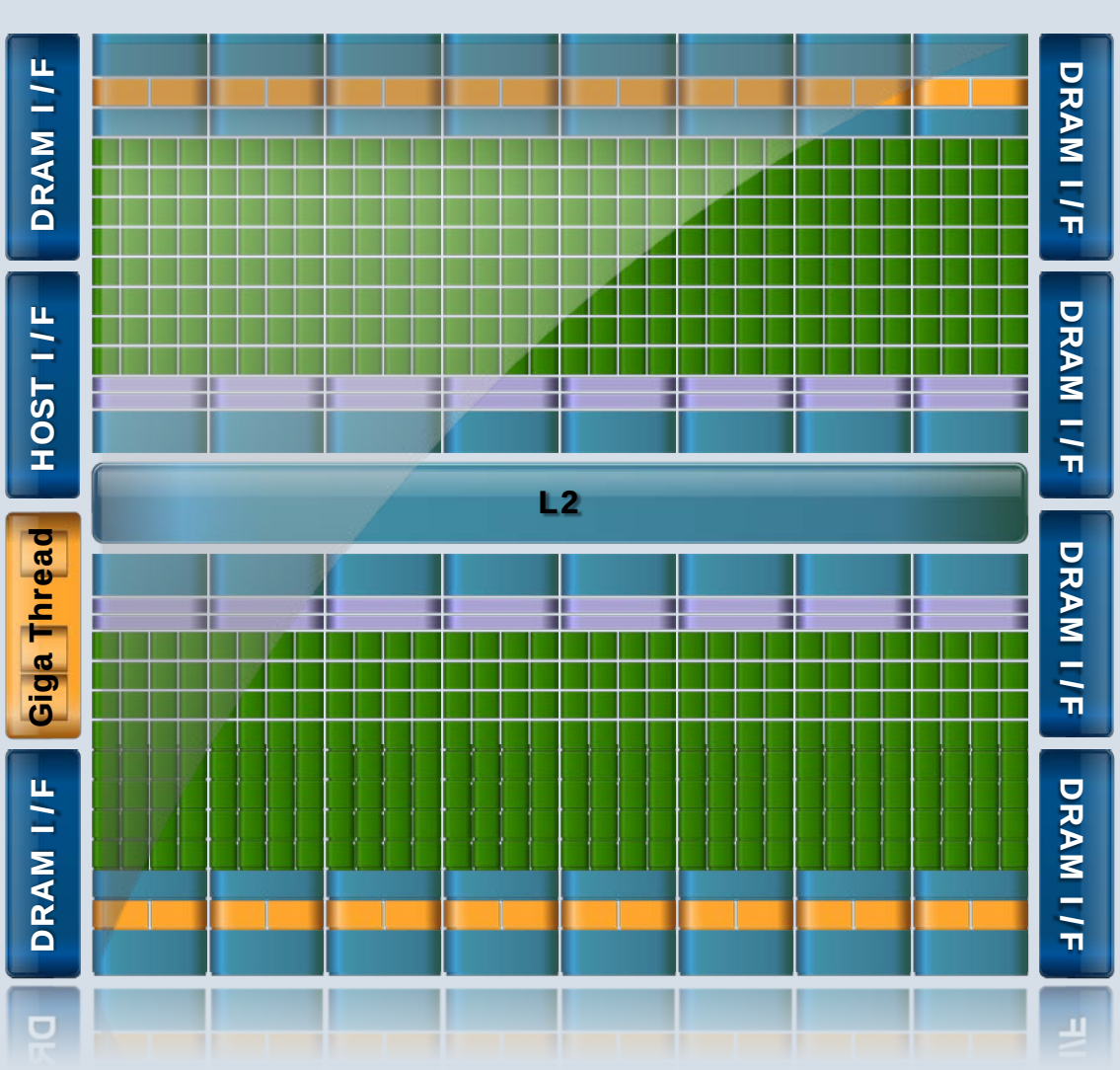
Anti-Aliased

What is GPU

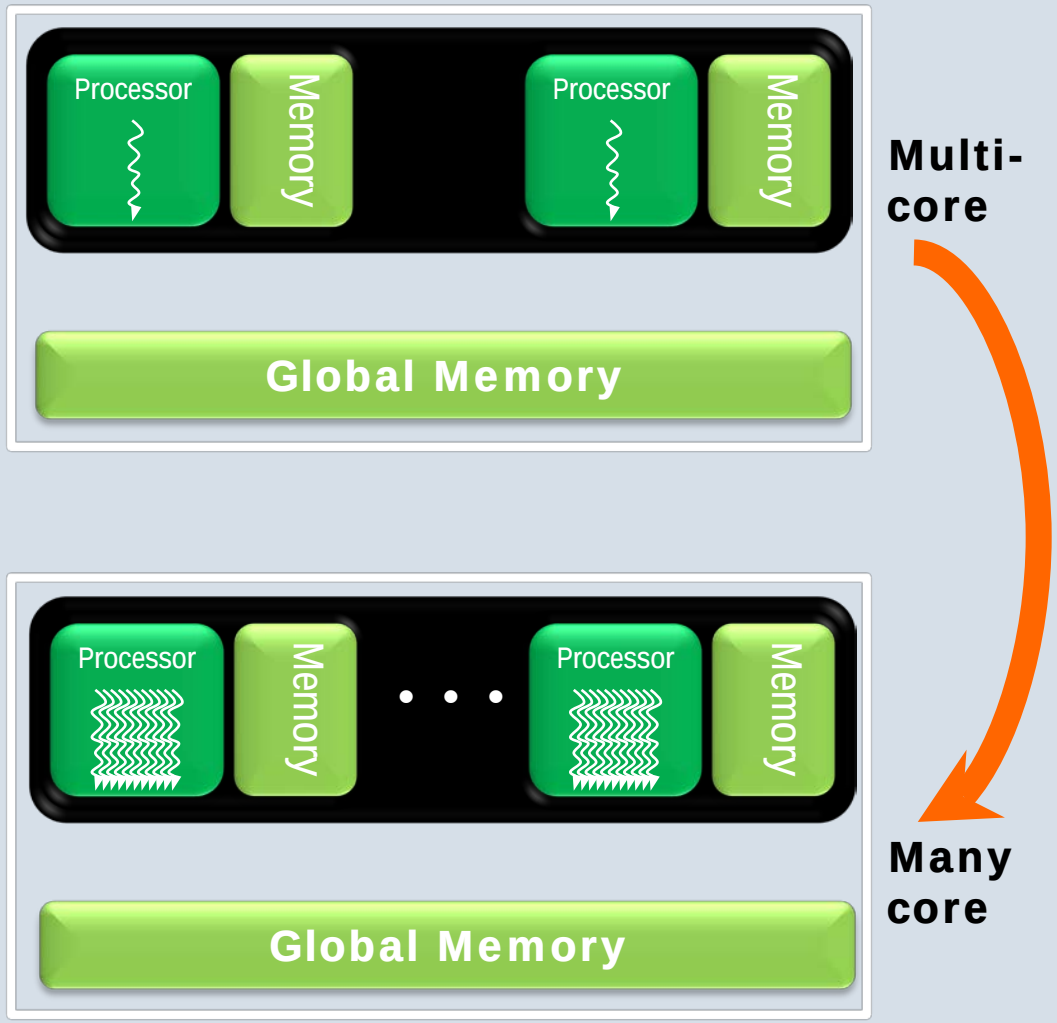
- High throughput computation
  - ✓ GeForce GTX 280: 933 GFLOP/s
- High bandwidth memory
  - ✓ GeForce GTX 280: 140 GB/s
- High availability to all
  - ✓ 180+ million CUDA-capable GPUs in the wild



NVIDIA GPU Architecture

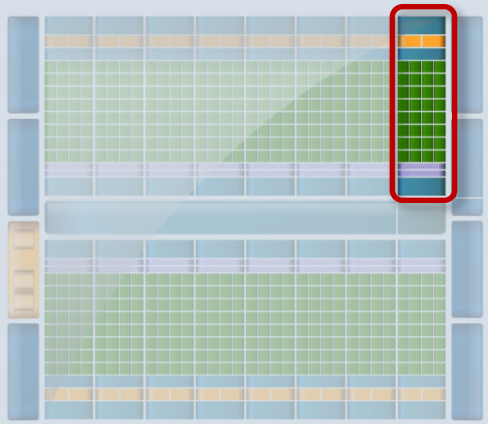


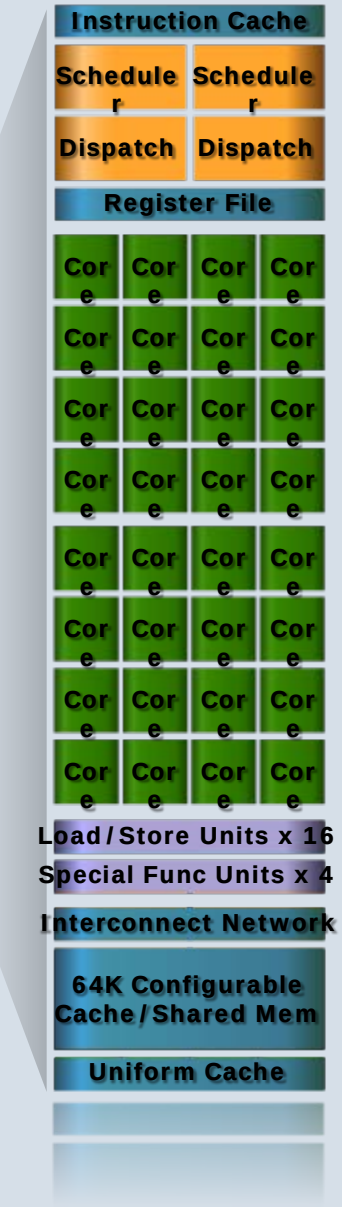
Fermi GF100



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



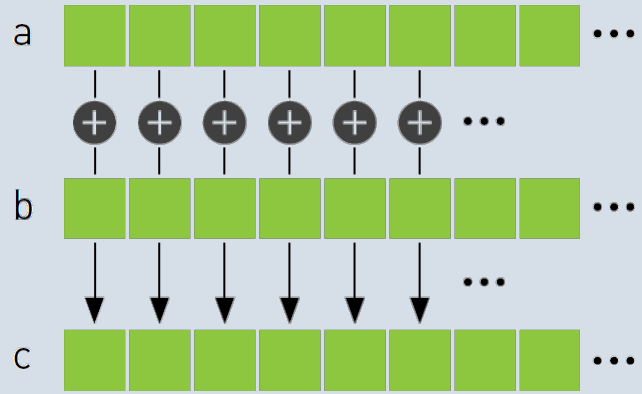


Lab 1.1 Device Query

- 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

Hello CUDA

- Vector Sum



✓ Serial code

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

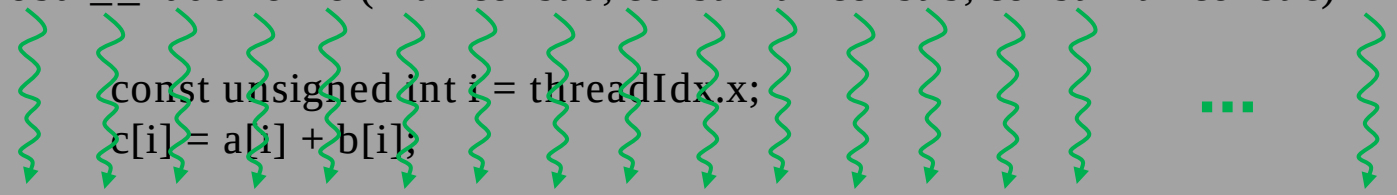
✓ Translate into CUDA threads

```
__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];
}
```

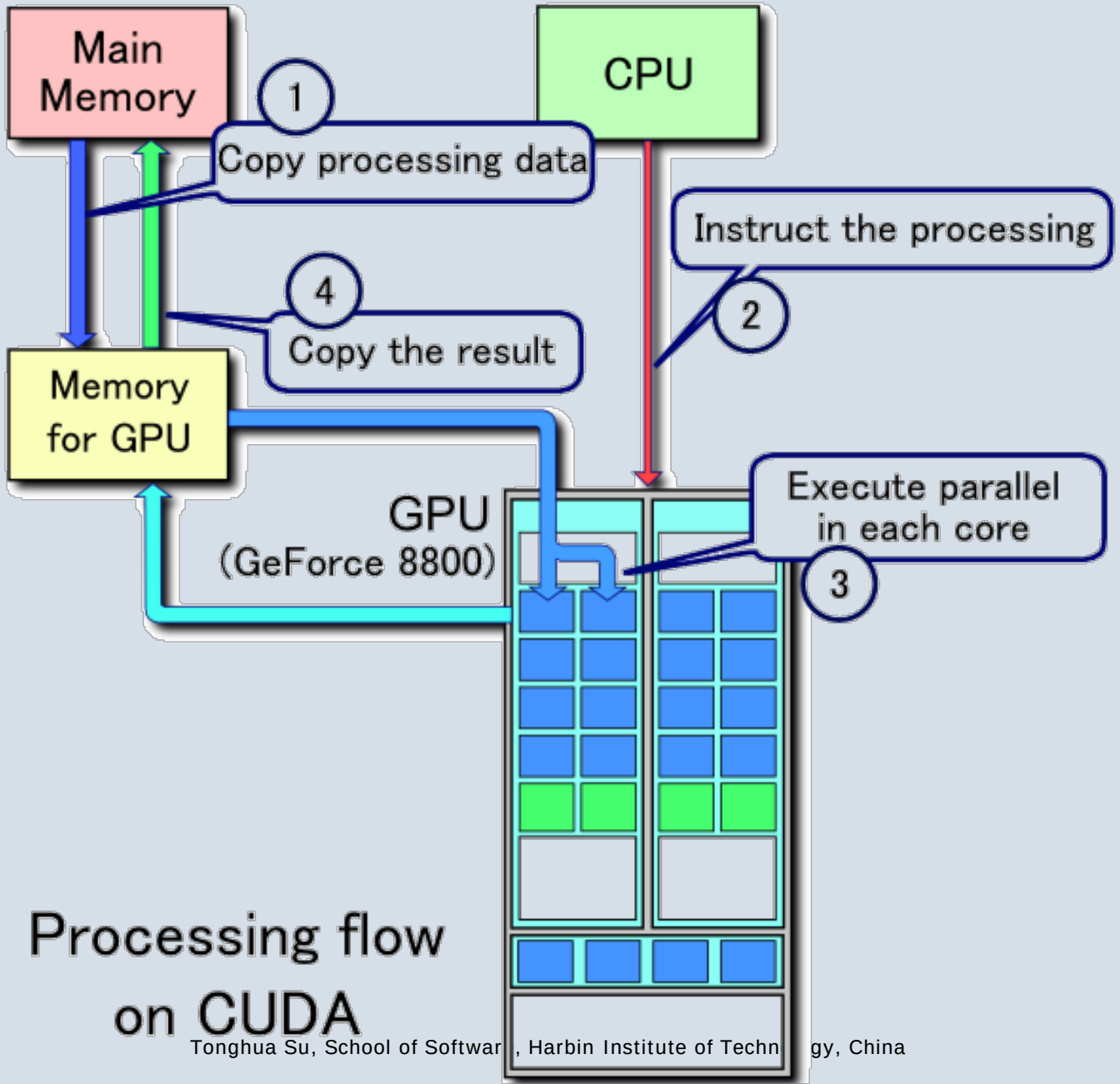


  - ✓ Invoke CUDA kernel
    - kernel_function<<<num_blocks, num_threads>>>(param1, param2, .)
    - E.g. addKernel<<< 1, 128 >>>(a, b, c);

Hello CUDA

- Demo 1

Hello CUDA


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

Hello CUDA

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

```
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));
        cudaMalloc((void**)&dev_a, 128* sizeof(int));
        cudaMalloc((void**)&dev_b, 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);
        cudaFree(dev_a);
        cudaFree(dev_b);
}
```

Lab 1.2 Error Handling

- 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

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.