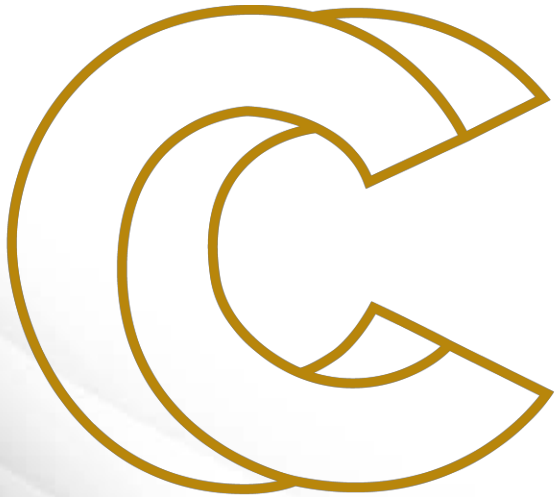
TÜBİTAK

Sabancı Üniversitesi



EURO^2

Performance Engineering on CPUs and GPUs:

- GPUs: Things to be Careful for Performance -

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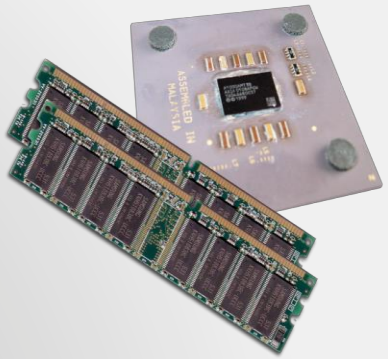
Terminology

- *Host* The CPU and its memory (host memory)
- *Device* The GPU and its memory (device memory)



Host

Device

Hello World! with Device Code

```
__global__ void gpu_kernel() {…}

int main() {
        gpu_kernel<<<1,1>>>();
        printf("Hello to the GPU!\n");
        return 0;
}
```

main() runs on the CPU.

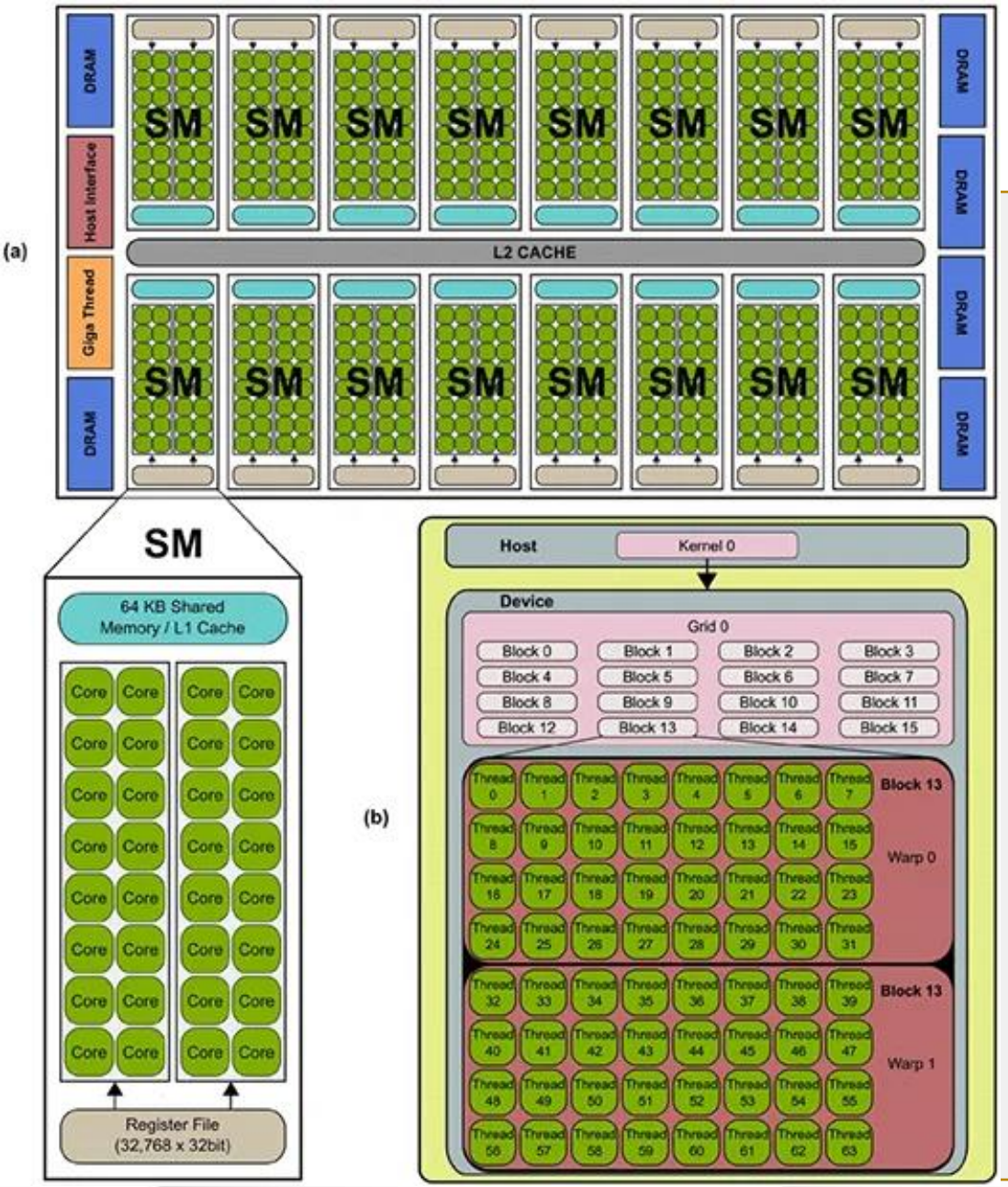
gpu_kernel() runs on the GPU.

`__global__` indicates a function:
runs on the device that
is called from host code (main)

When compiled with **nvcc:**

- Host and device codes are separated..
  - Device functions (e.g., **gpu_kernel()**) processed by Nvidia compiler.
  - Host functions (e.g. **main()**) processed by standard host compiler (e.g., **gcc)**

GPU Architecture




```
gpu_kernel<<<grid_dims, block_dims>>>();
```

- A **kernel** is executed by a **grid** (a set of blocks ordered in 3d)
- A **block** (a set of threads organized in 3d) is assigned to an SM.
- A **warp** is a set of threads controlled by a single controller.

To fully use the device, we need both blocks and threads.

GPU: IDs and Dimensions

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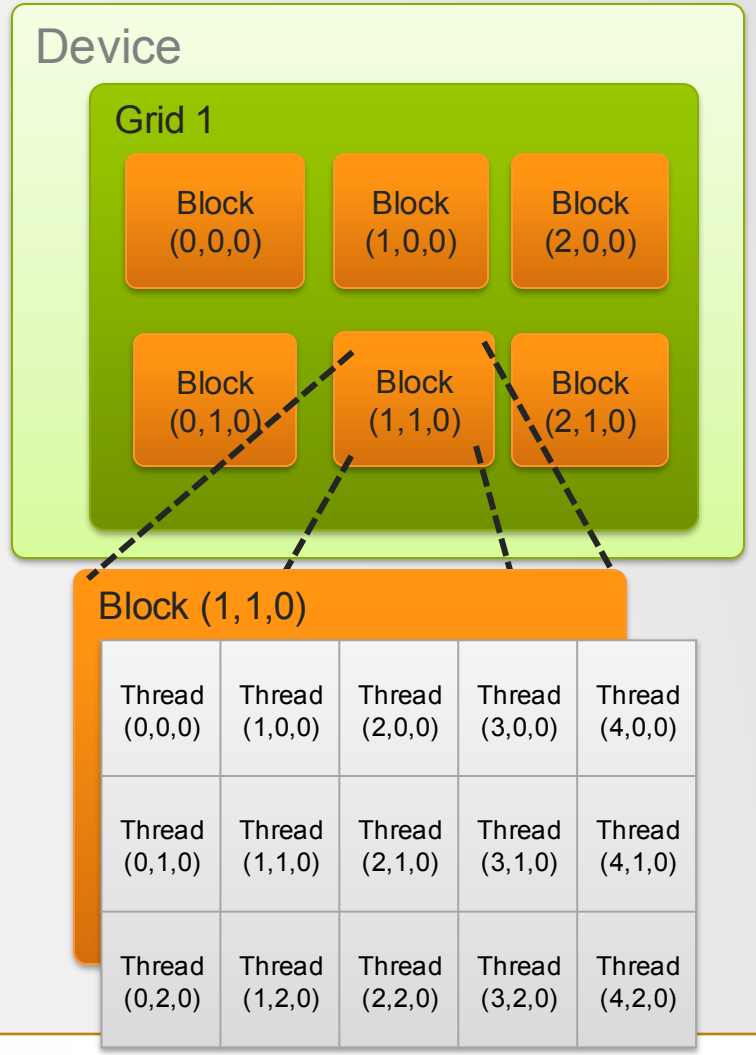
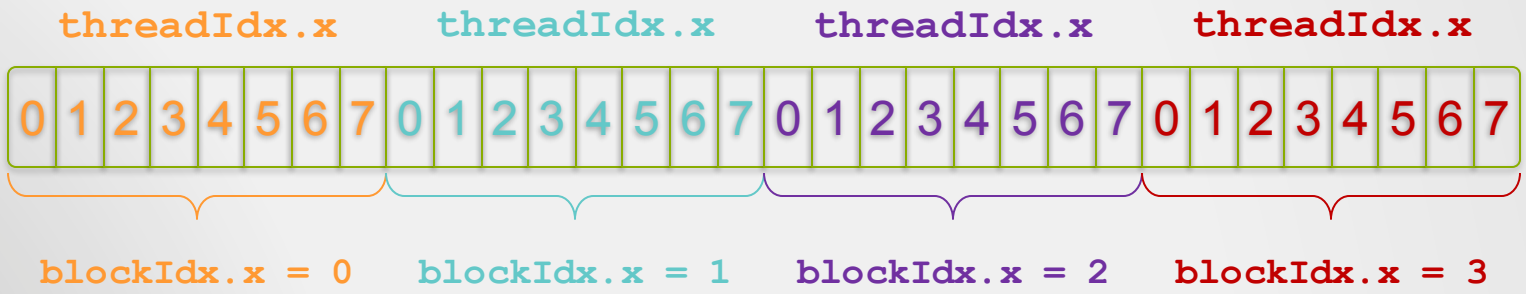
- A kernel is launched as a grid of blocks of threads
  - `blockIdx` and `threadIdx` are 3D
  - We showed only one dimension (`x`)

- Built-in variables:
  - `threadIdx`
  - `blockIdx`
  - `blockDim`
  - `gridDim`



CUDA: Parallelism – Blocks/Threads

- Using `blockIdx.x` and `threadIdx.x`
  - Consider indexing an array with one element per thread (8 threads/block)

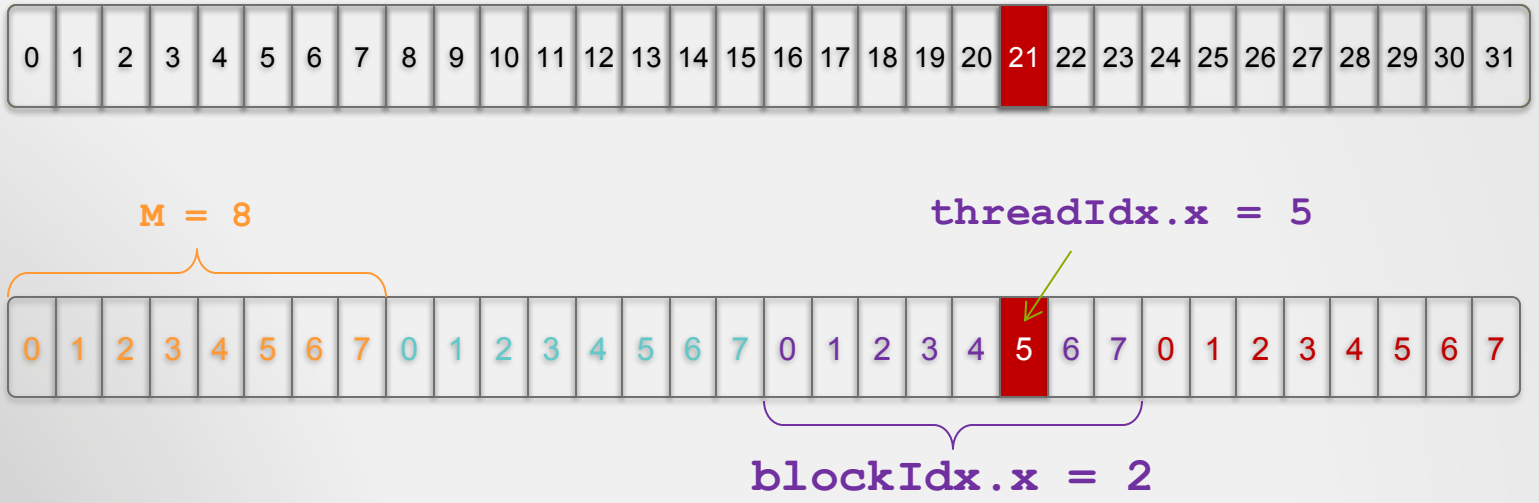


- With M threads/block a unique index for each thread is given by:

```
int index = threadIdx.x + blockIdx.x * M;
```

CUDA: Parallelism – Blocks/Threads

- Which thread will operate on the red element?




```
int index = threadIdx.x + blockIdx.x * M;
          =      5      +     2      * 8;
          = 21;
```

CUDA: Parallelism – Blocks/Threads

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- Use the built-in variable `blockDim.x` for threads per block

```
int index = threadIdx.x + blockIdx.x * blockDim.x;
```

- Combined version of `add()` to use parallel threads *and* parallel blocks

```
__global__ void add(int *a, int *b, int *c) {
    int index = threadIdx.x + blockIdx.x * blockDim.x;
    c[index] = a[index] + b[index];
}
```

CUDA: Parallelism – Blocks/Threads

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```
#define N (2048*2048)
#define THREADS_PER_BLOCK 512

                                    ....

                                    ....

add<<<N/THREADS_PER_BLOCK,,THREADS_PER_BLOCK>>>(d_a, d_b, d_c);
```

Thanks

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