TELECOM SudParis

Institut Mines-Télécom

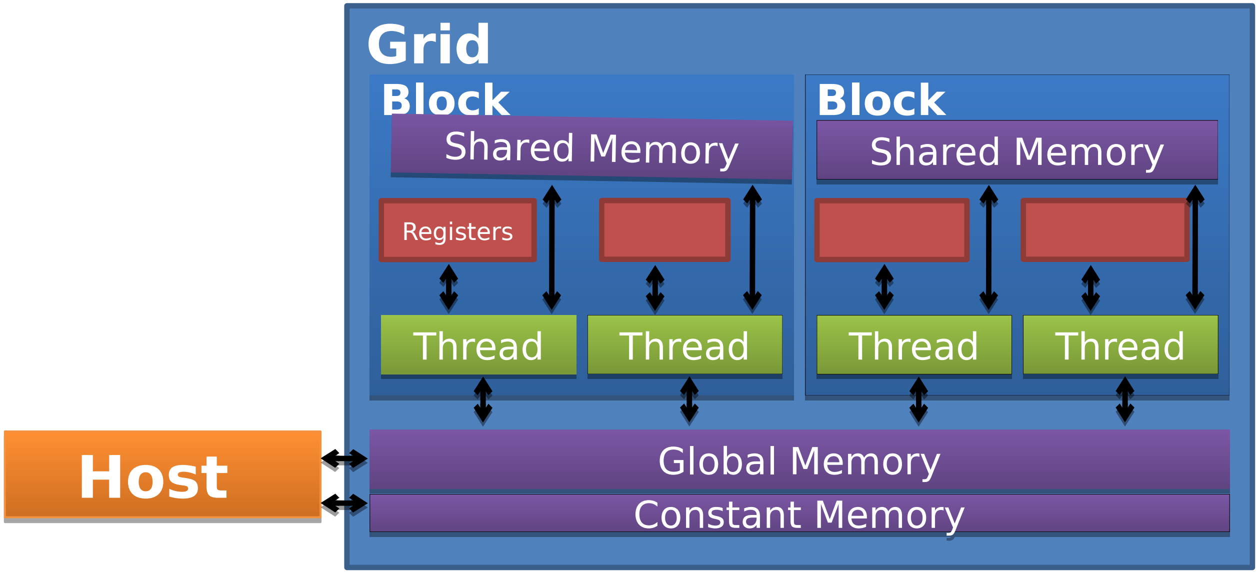
GPU for Deep Learning

GPU Memory Architecture

Elisabeth Brunet

GPU Memory Architecture

CPU and GPU memory spaces physically separated



- Explicit transferts between the two spaces
- Two entry points on the GPU
  - Global and constant memories

GPU memory hierarchy

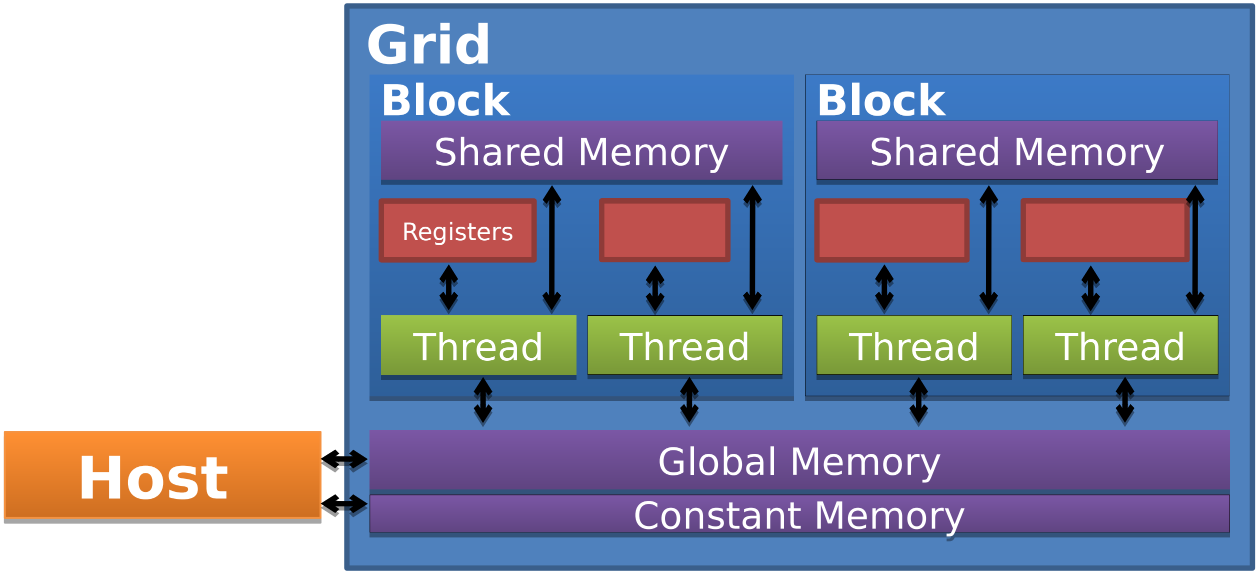
- On GPU, 4 levels of memory [+ texture memory]

  A) Global memory [__device__]

  B) Constant memory [__device__] __constant__

  C) Shared memory [__device__] __shared__

  D) Registers



A) Global Memory

- Large, high latency, no cache

- Data
  - Accessible by all the threads of the grid
  - Lifespan : as required by the application

- From host,
  - Allocation/Free + copies in both ways

- Static declaration from the GPU with keyword __device__

Global memory management

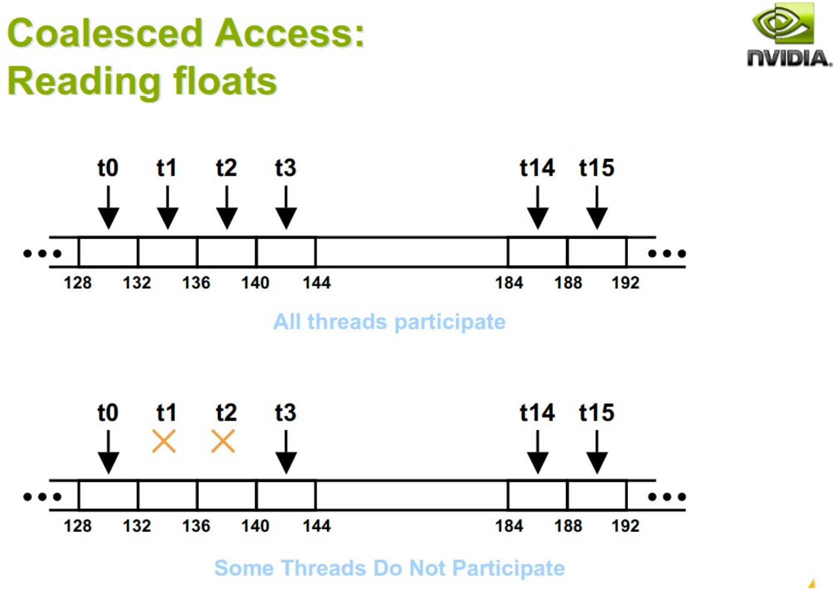
- Allocation : **cudaMalloc**(void ** pointer, size_t nbytes)
- Desallocation : **cudaFree**(void* p)
- Cleaning : **cudaMemset**(void * p, int val, size_t nbytes)
- Copy of the data from host :

  cudaMemcpy(void *dst, void *src,
                 size_t nbytes,
                 enum cudaMemcpyKind direction);

  with enum **cudaMemcpyKind**
       ={*cudaMemcpyHostToDevice,*
         cudaMemcpyDeviceToHost,
         cudaMemcpyDeviceToDevice}

Global Memory coalescing

- **Multiple memory accesses into a single transaction**

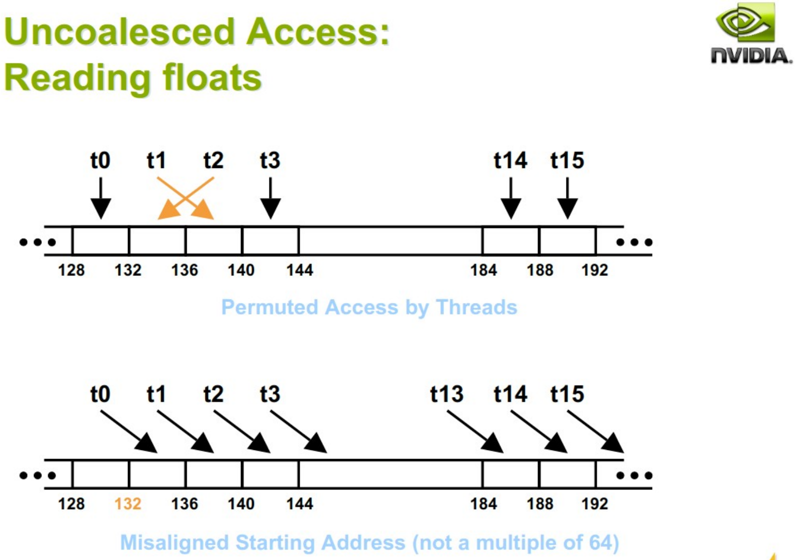


Coalesced Access:
Reading floats

All threads participate

Some Threads Do Not Participate

- **Uncoalesced load,**
  ie serialized memory access,
  when memory accesses
  - are not sequential
  - are sparse
  - are misaligned



Uncoalesced Access:
Reading floats

Permuted Access by Threads

Misaligned Starting Address (not a multiple of 64)

B) Constant Memory

- For data that will not change over a kernel execution
- Read-only, pretty small memory, slow, cached
  - The first read from constant memory costs one memory read from global memory ; after, costs one read from the constant cache
  - Cache for each multiprocessor very small

  → Optimized when warp of threads read same location

- Data accessible by all the threads of the grid

Constant memory management

- Declaration : __constant__ float buffer [size];

- Copy of the data from the host :

  cudaError_t **cudaMemcpytoSymbol**

  (const char * symbol,
  const void * src, size_t count ,
  size_t offset=0,
  enum cudaMemcpyKind)

with enum **cudaMemcpyKind**
={*cudaMemcpyHostToDevice,*
cudaMemcpyDeviceToHost,
cudaMemcpyDeviceToDevice}

C) Shared Memory

- Keyword __shared__
  - Separate space with very low latency

```
// case a
__global__void myKernel(){
        __shared__int shared[32];
        ...
}
```

- Data
  - Accessible by all threads of the same block
  - Lifetime: kernel run

- Static allocation
  - From the GPU device
  - Static size given

    at compile time (case a)

    or at the kernel launch (case b)

```
// case b
__global__void myKernel(){
        extern __shared__int s[];
        ...
}
int main() {
int size= numThreadsPerBlock* sizeof(int);
myKernel<<< dimGrid, dimBlock, size>>>();}
```

Shared memory management

- All operations on the device within a same kernel

- Static allocation from device : __shared__ int tab[4] ;

- Classic explicit initialization/modification in kernel

  ```
  for (int i = 0 ; i< 4 ; i++) tab[i]=i ;
  ```

D) Registers

- Fast, only for one thread
- For local kernel variables
  - Allocation of scalar variables in registers
  - Allocation of arrays of more than 4 elements in the global memory
- No specific keyword