Lab4 CUDA Advance

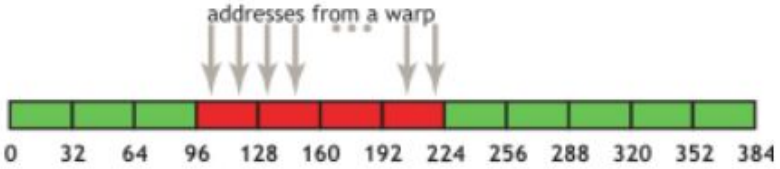
Nov, 2024 Parallel Programming

Overview

- Techniques that can further optimize a CUDA program
  - Coalesced Memory Access
  - Lower Precision
  - Shared Memory
  - Multiple Blocks
- Lab4

Coalesced Memory Access

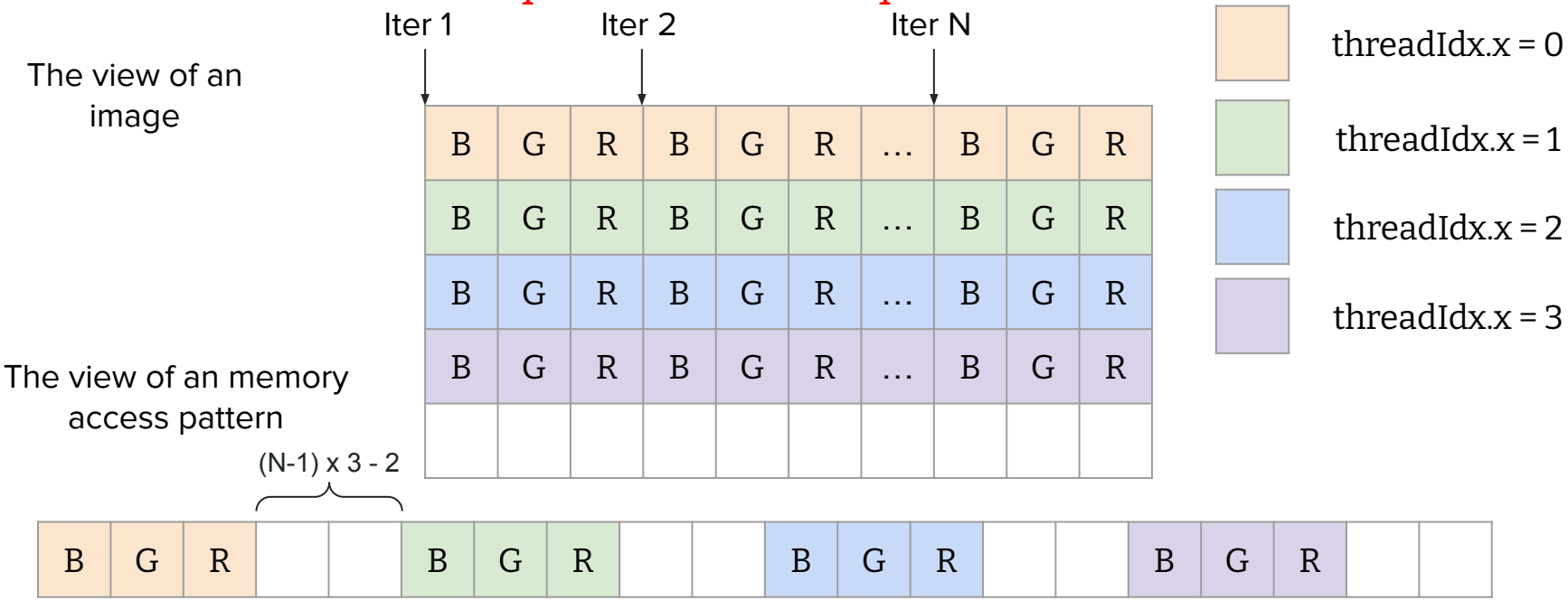
- In short,
  - Concurrent memory accesses in a warp should be continuous



- Why
  - GPU has L2 (32 bytes), L1 (128 bytes) cache
  - If memory accesses in a warp are continuous, it can
    - merge memory requests from all threads into a single memory request
    - utilize the cache
- Details
  - CUDA Best Practices

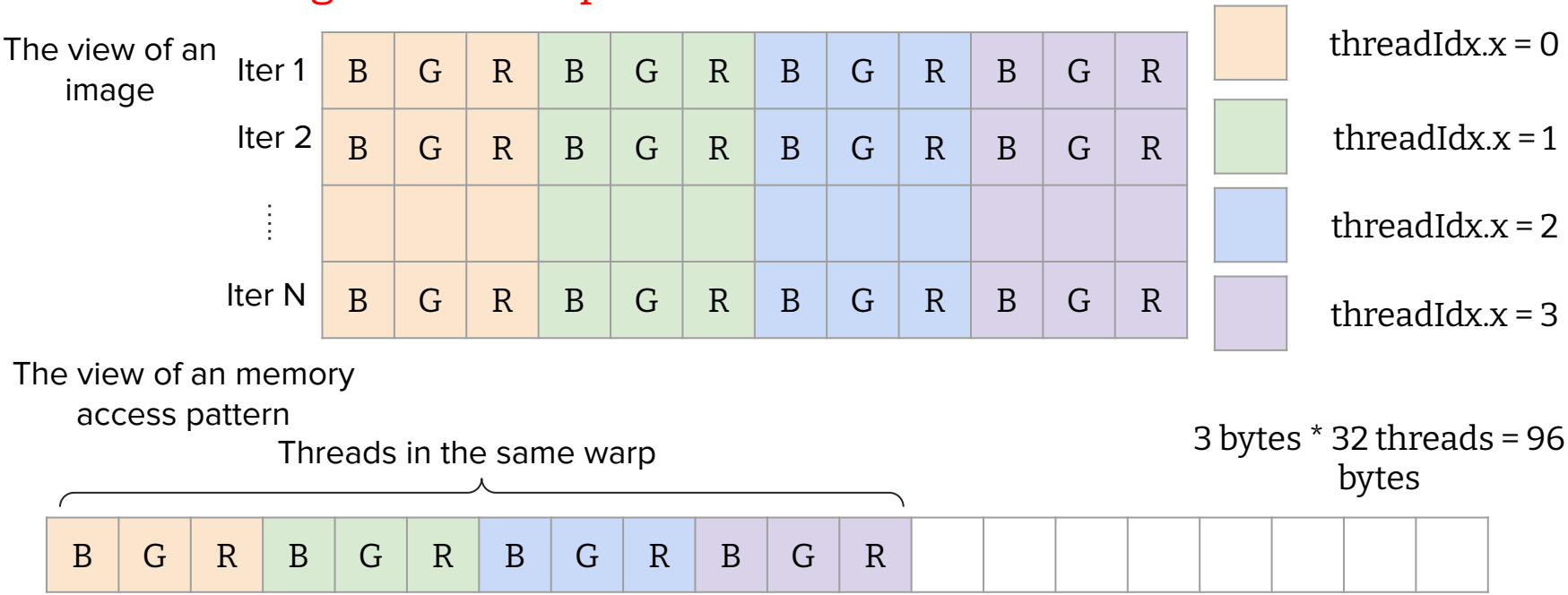
Access without Coalesced Memory

- If each thread compute a single row ->
  Failed to combine requests into one request



Coalesced Memory Access

- The accesses can be combined into a single request if we change the access pattern



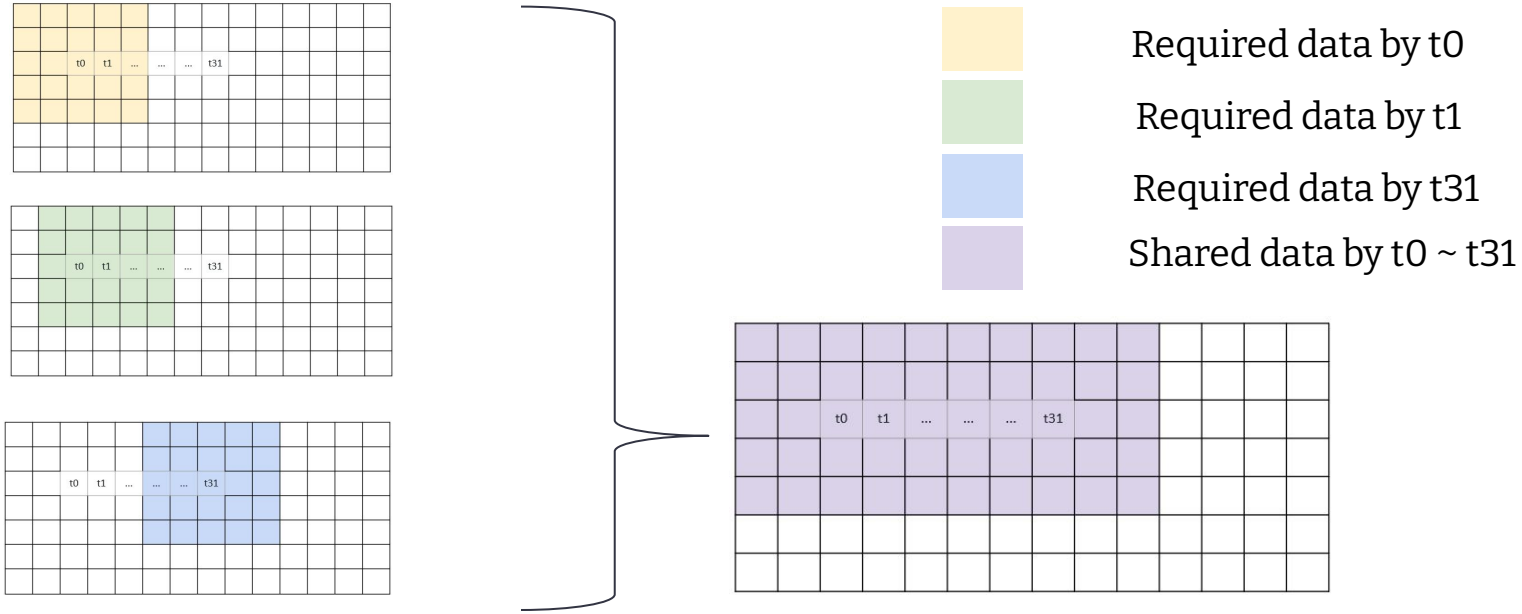
Mixed-Precision

- Lower the precision of variables could reduce the computing time and also the computing accuracy

- Try to
  - Use float to replace double
  - Use fp16 to replace float
  - Make sure using lower precision does not corrupt the results

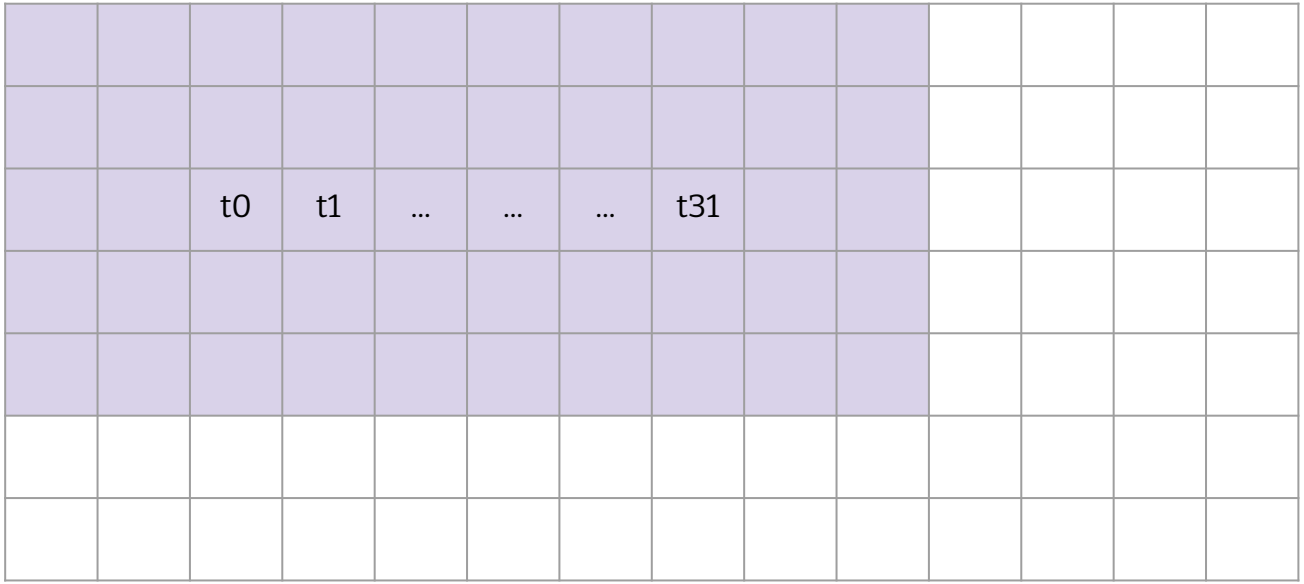
Shared Memory

- Shared memory can greatly reduce the access time of a reused data item



Using Shared Memory in Sobel

- Move the required data into shared memory
- Compute
- Update shared memory



Multiple Blocks

- The number of threads per block is limited comparing to the number of blocks per grid.
  - Therefore, we can launch more blocks for the higher level of parallelism
  - E.g., Break the computation into multiple blocks with the size of 32 x 32

```
Maximum number of threads per block:           1024
Max dimension size of a thread block (x,y,z): (1024, 1024, 64)
Max dimension size of a grid size    (x,y,z): (2147483647, 65535, 65535)
```

- Denoting the x, y coordinate of a pixel by threadIdx and blockIdx
  - E.g., int x=blockIdx*blockDim+threadIdx;
  - **Hint: you should choose the right indexing method to ensure coalesced memory access**

Lab4

- Optimize the sobel operator with the following
  - Coalesced Memory
  - Lower Precision
  - Shared Memory
- TAs provided a sample CUDA program
  - optimize it to be at least **13x faster**
  - ➢ Materials : /home/pp24/share/lab-sobel/sobel.basic.cu
- Name your kernel as “sobel_opt.cu”
- We accept little pixel errors

Submission

- Finish it before 11/7 23:59
- Submit your code and Makefile (optional) to eeclass
- You can use lab-sobel-opt-judge for pre-check