GPU Teaching Kit

Accelerated Computing

Lecture 10.3 – Parallel Computation Patterns (scan)

A Work-Efficient Parallel Scan Kernel

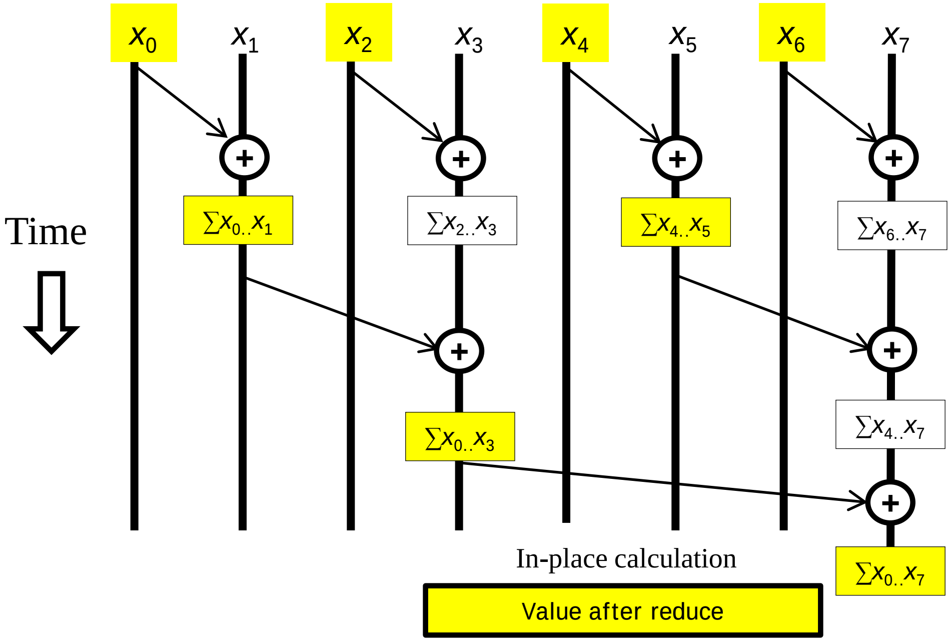
Objective

- To learn to write a work-efficient scan kernel
  - Two-phased balanced tree traversal
  - Aggressive re-use of intermediate results
  - Reducing control divergence with more complex thread index to data index mapping

Improving Efficiency

- *Balanced Trees*
  - Form a balanced binary tree on the input data and sweep it to and from the root
  - Tree is not an actual data structure, but a concept to determine what each thread does at each step
- For scan:
  - Traverse down from leaves to the root building partial sums at internal nodes in the tree
    - The root holds the sum of all leaves
  - Traverse back up the tree building the output from the partial sums

Parallel Scan - Reduction Phase



Reduction Phase Kernel Code

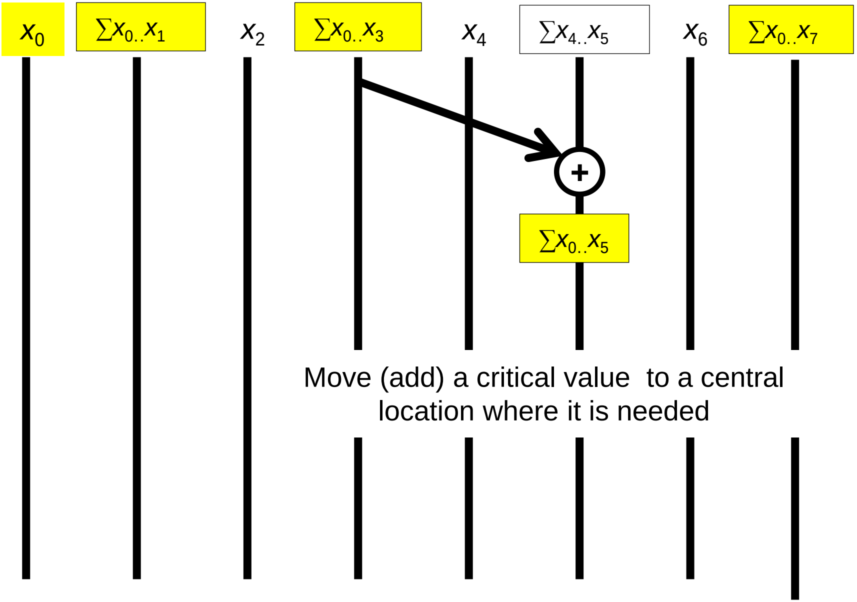
```
// XY[2*BLOCK_SIZE] is in shared memory

for (unsigned int stride = 1;stride <= BLOCK_SIZE; stride *= 2)
{
    int index = (threadIdx.x+1)*stride*2 - 1;
    if(index < 2*BLOCK_SIZE)
        XY[index] += XY[index-stride];
    __syncthreads();
}
```

threadIdx.x+1 = 1, 2, 3, 4….

stride = 1,

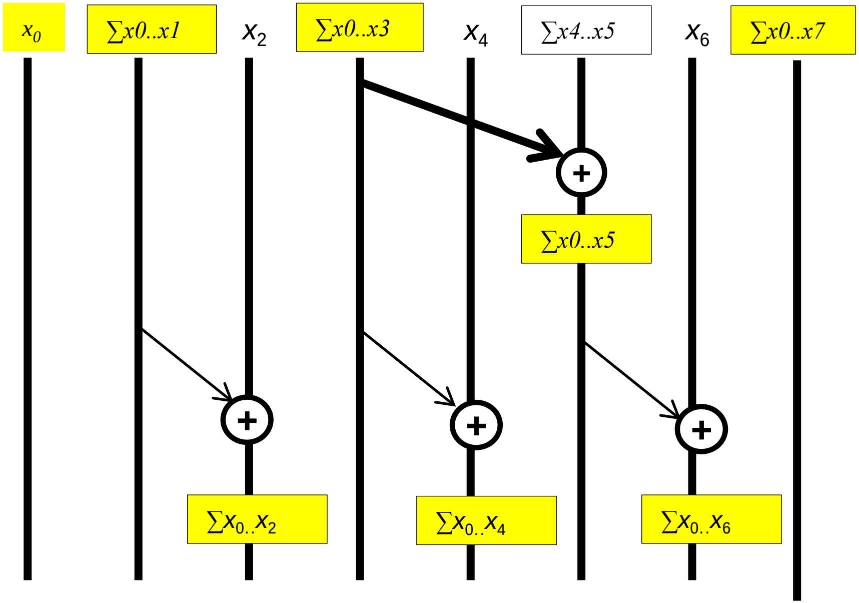
index = 1, 3, 5, 7, …

Parallel Scan - Post Reduction Reverse Phase

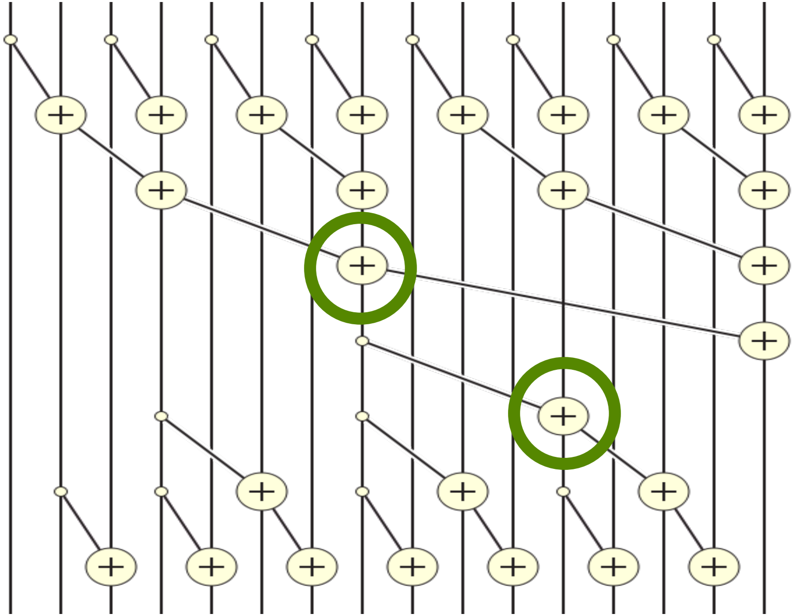


Move (add) a critical value to a central location where it is needed

Parallel Scan - Post Reduction Reverse Phase



Putting it Together



Post Reduction Reverse Phase Kernel Code

```
for (unsigned int stride = BLOCK_SIZE/2; stride > 0; stride /= 2) {
   __syncthreads();
   int index = (threadIdx.x+1)*stride*2 - 1;
   if(index+stride < 2*BLOCK_SIZE) {
    XY[index + stride] += XY[index];
   }
}
 __syncthreads();
if (i < InputSize) Y[i] = XY[threadIdx.x];
```

First iteration for 16-element section
threadIdx.x = 0
stride = BLOCK_SIZE/2 = 8/2 = 4
index = 8-1 = 7

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