



GPU Teaching Kit

Accelerated Computing



Lecture 10.3 – Parallel Computation Patterns (scan)

A Work-Efficient Parallel Scan Kernel

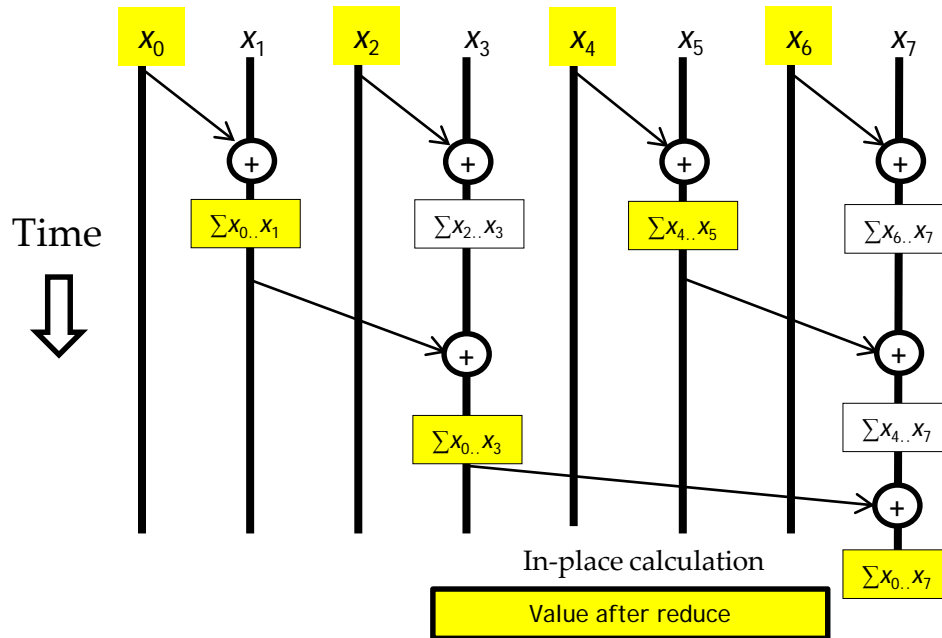
Objective

- 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

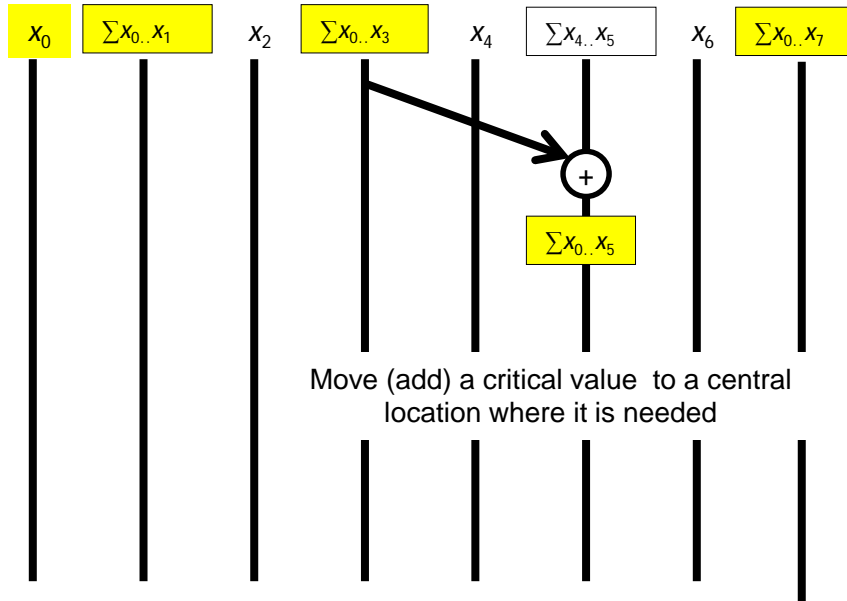
for (unsigned int stride = 1; stride <= BLOCK_SIZE; stride *= 2)
{
    int index = (threadIdx.x+1)*stride*2 - 1;
    if(index < 2*BLOCK_SIZE)
        XY[index] += XY[index-stride];
    __syncthreads();
}
```

threadIdx.x+1 = 1, 2, 3, 4....

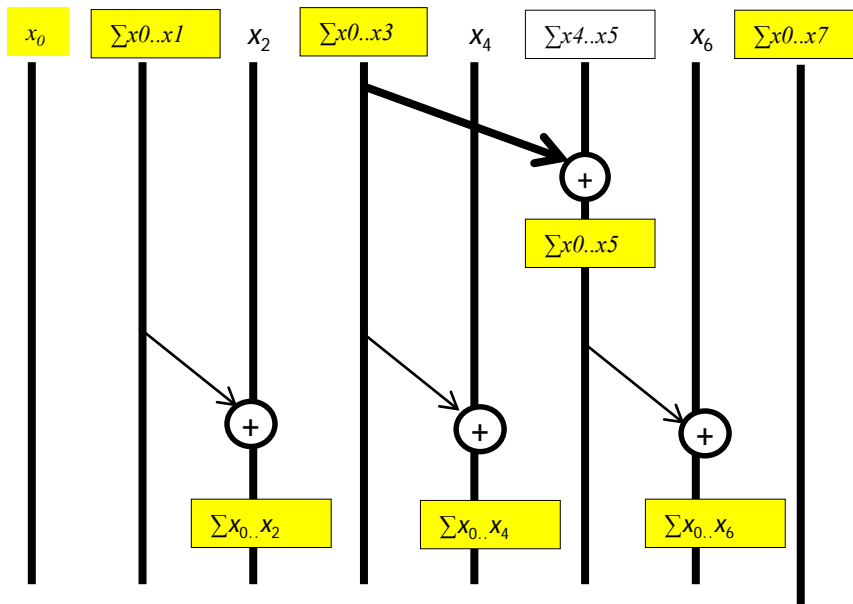
stride = 1,

index = 1, 3, 5, 7, ...

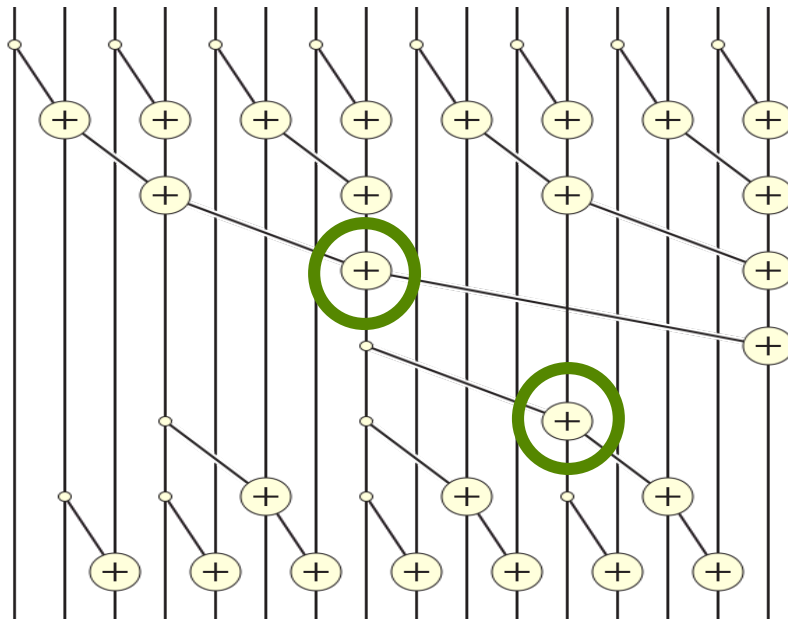
Parallel Scan - Post Reduction Reverse Phase



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

$\text{threadIdx.x} = 0$

$\text{stride} = \text{BLOCK_SIZE}/2 = 8/2 = 4$

$\text{index} = 8-1 = 7$



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