TÜBİTAK

Sabancı Üniversitesi

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Offloading Computation to a GPU with OpenMP

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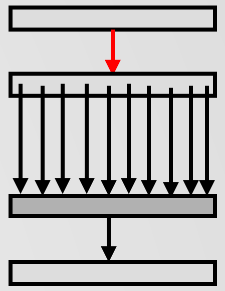
Offloading to GPU – More detail
Work sharing

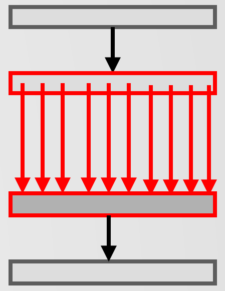
#pragma omp teams num_teams (K)

- Coarse grain parallelism
- Generates multiple, single-thread teams,
- Teams map to SMs in HW (similar to blocks in CUDA)
- No synchronization among the teams (similar to blocks in CUDA)



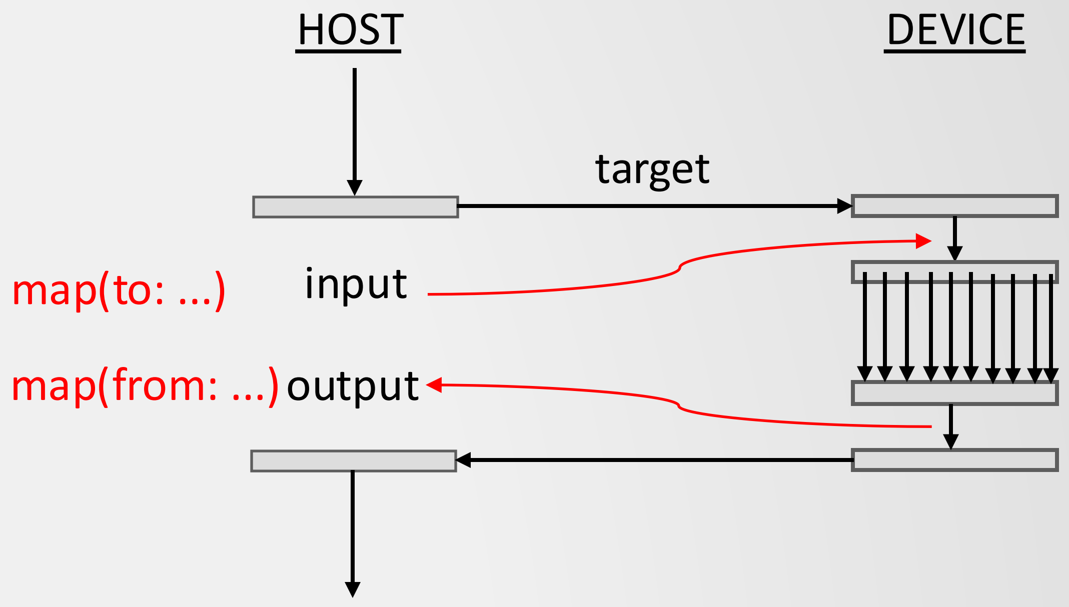
#pragma omp parallel

- Fine grain parallelism
- Generates many threads in a team
- Threads map to CUDA cores in HW (similar to threads in CUDA)
- Synchronization inside a team is possible (similar to block-level sync. in CUDA)



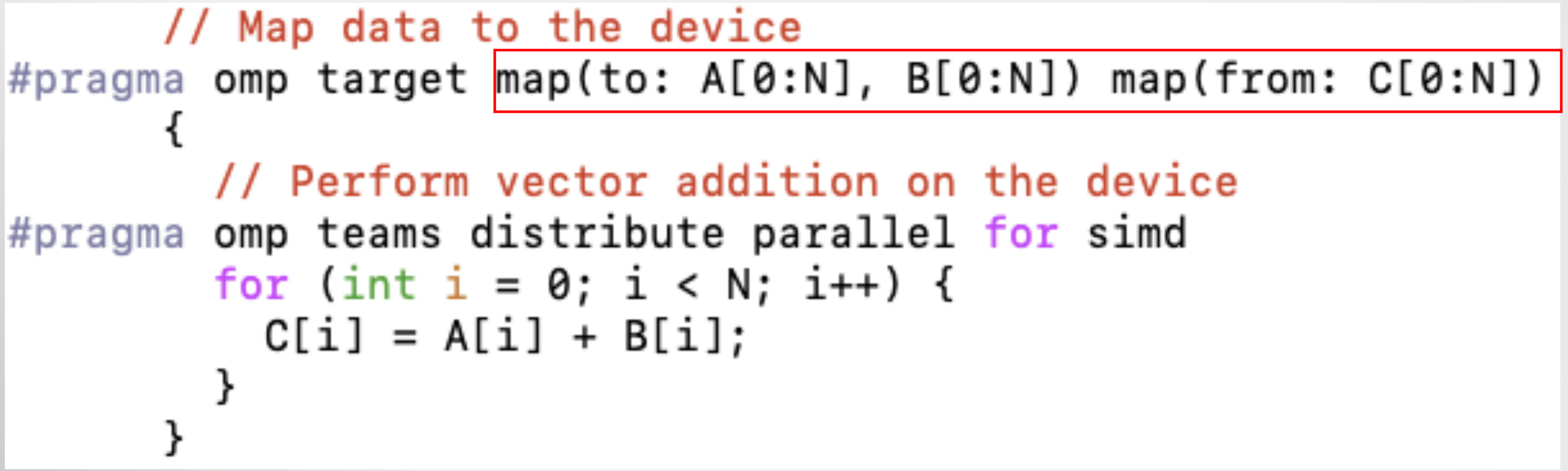
Offloading to GPU – More detail
Data mapping

- Data mapping is a mechanism provided to share variables between the host and device;
  - Memory may or may not be shared; the implementation determines whether data is copied or not.
  - A mapped data represents the device-side counterpart of a host data in the device data environment, similar to shared data.



Offloading to GPU – More detail
Data mapping

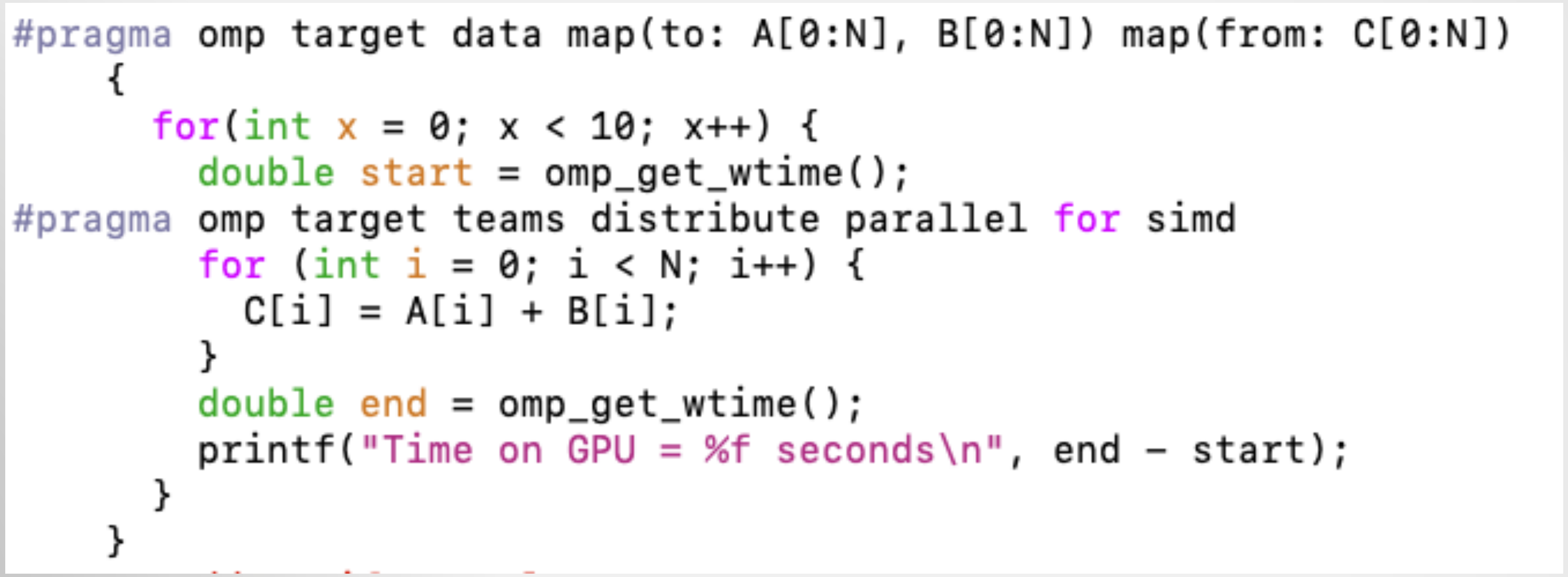
- Arrays can be mapped by using [,] syntax as shown below for a vector addition.



```
      // Map data to the device
#pragma omp target map(to: A[0:N], B[0:N]) map(from: C[0:N])
      {
        // Perform vector addition on the device
#pragma omp teams distribute parallel for simd
        for (int i = 0; i < N; i++) {
          C[i] = A[i] + B[i];
        }
      }
```

Offloading to GPU – More detail
Data mapping

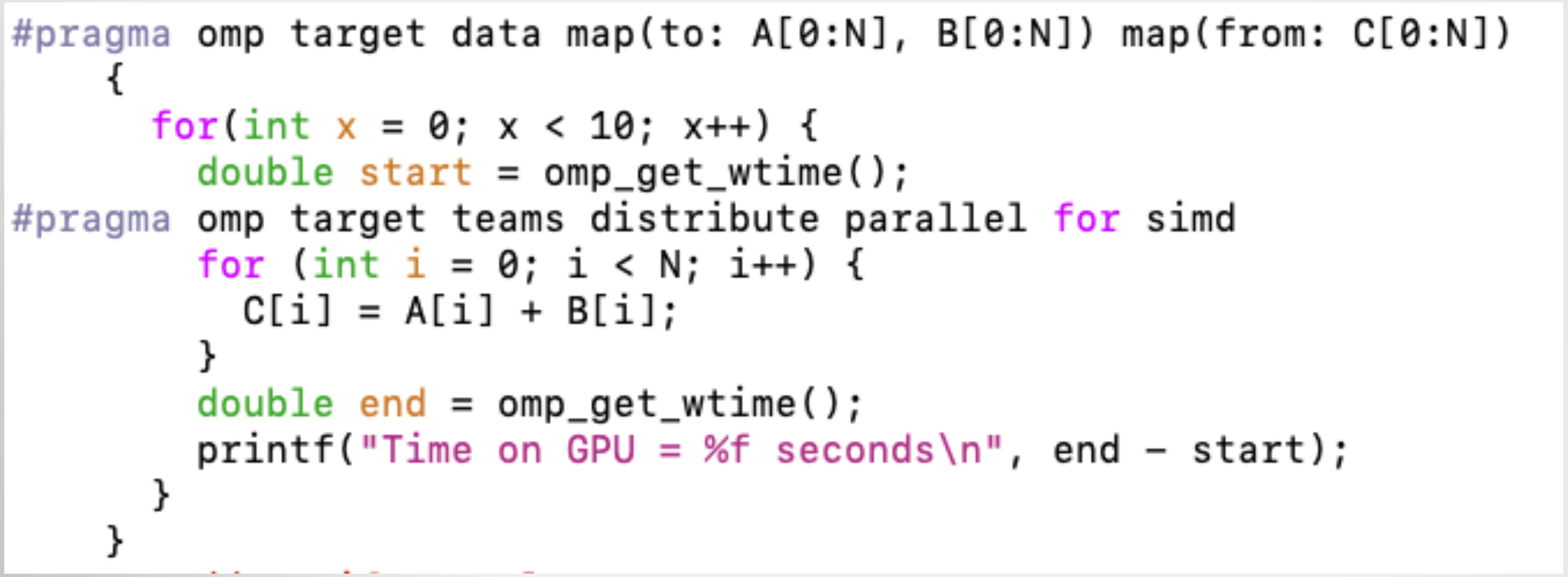
- Data transfers are slow, we need to minimize as much as possible.
- We can use **target data** to reuse the data on the GPU.



```
#pragma omp target data map(to: A[0:N], B[0:N]) map(from: C[0:N])
    {
      for(int x = 0; x < 10; x++) {
        double start = omp_get_wtime();
#pragma omp target teams distribute parallel for simd
        for (int i = 0; i < N; i++) {
          C[i] = A[i] + B[i];
        }
        double end = omp_get_wtime();
        printf("Time on GPU = %f seconds\n", end - start);
      }
    }
```

Offloading to GPU – More detail
Data mapping

- Data transfers are slow, we need to minimize as much as possible.
- We can use **target data** to reuse the data on the GPU.
    - and use **target update** when required.



```
#pragma omp target data map(to: A[0:N], B[0:N]) map(from: C[0:N])
    {
      for(int x = 0; x < 10; x++) {
        double start = omp_get_wtime();
#pragma omp target teams distribute parallel for simd
        for (int i = 0; i < N; i++) {
          C[i] = A[i] + B[i];
        }
        double end = omp_get_wtime();
        printf("Time on GPU = %f seconds\n", end - start);
      }
    }
```

Offloading to GPU – More detail
Work sharing – simd

simd

```
"Requested Global Load Throughput", 118.694765MB/s, 119.051373MB/s, 118.872715MB/s
"Requested Global Store Throughput", 191.918411MB/s, 192.680808MB/s, 192.298853MB/s
"Global Load Throughput", 830.751312MB/s, 852.950066MB/s, 841.872691MB/s
"Global Store Throughput", 1.133424GB/s, 1.175496GB/s, 1.154501GB/s
```

no simd

```
"Requested Global Load Throughput", 4.358355MB/s, 4.361329MB/s, 4.359840MB/s
"Requested Global Store Throughput", 6.945406MB/s, 6.953836MB/s, 6.949618MB/s
"Global Load Throughput", 32.433474MB/s, 32.759454MB/s, 32.596562MB/s
"Global Store Throughput", 42.796398MB/s, 42.872280MB/s, 42.834362MB/s
```

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Thanks

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