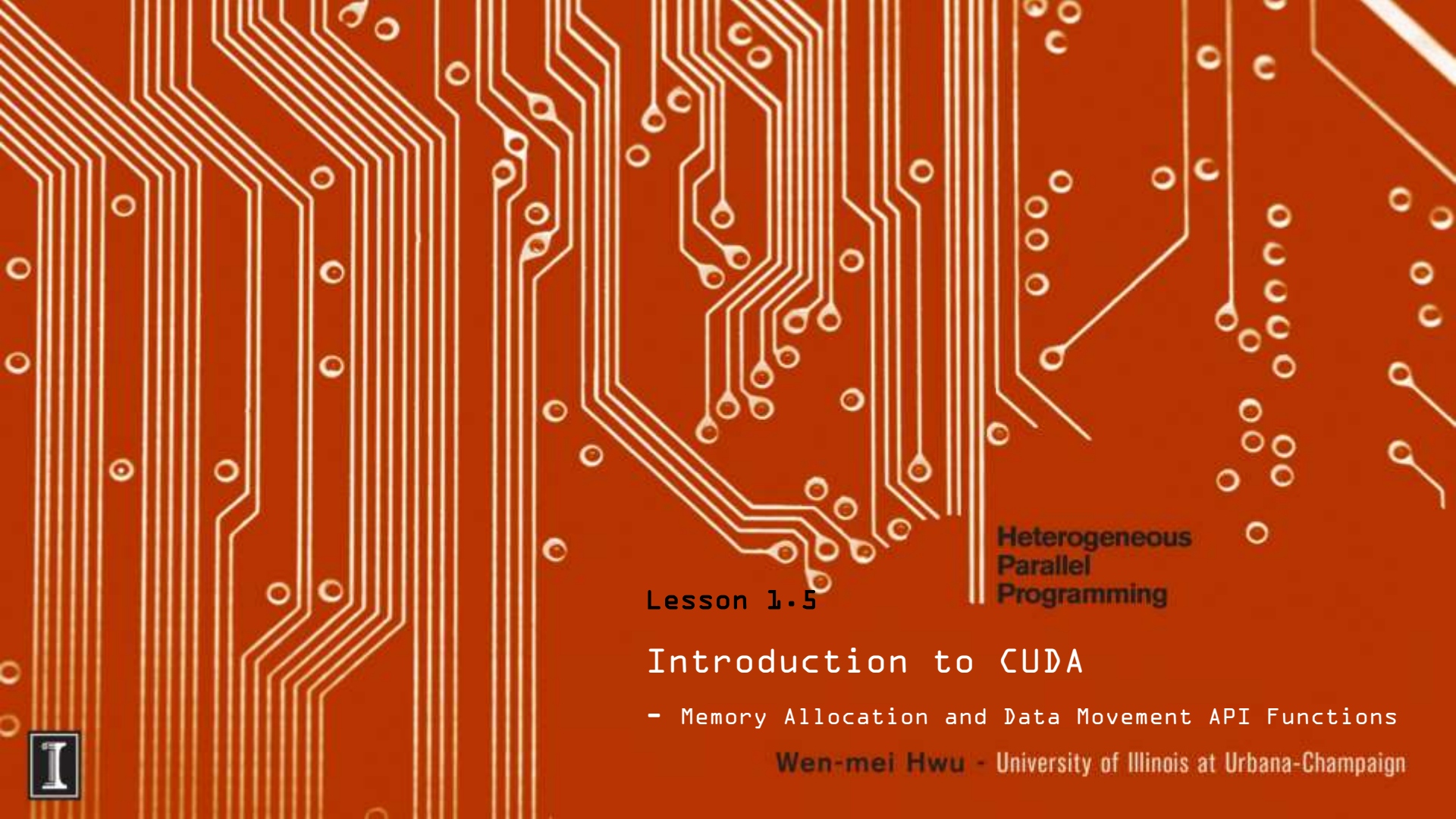

Lesson 1.5

Introduction to CUDA

- Memory Allocation and Data Movement API Functions

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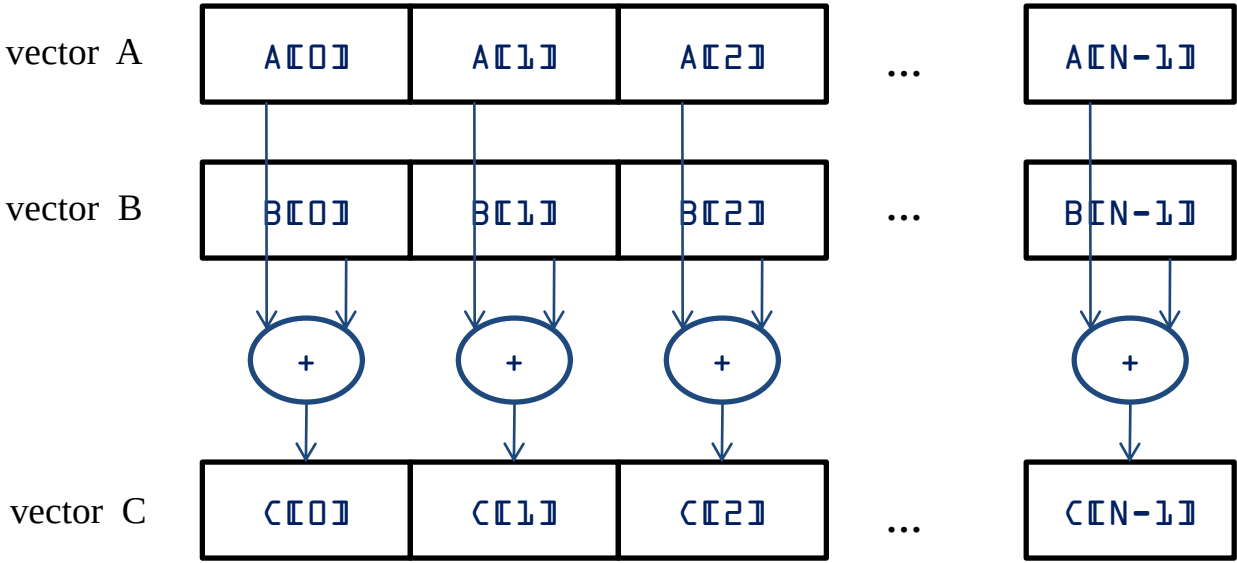
Objective

- To learn the basic API functions in CUDA host code
  - Device Memory Allocation
  - Host-Device Data Transfer

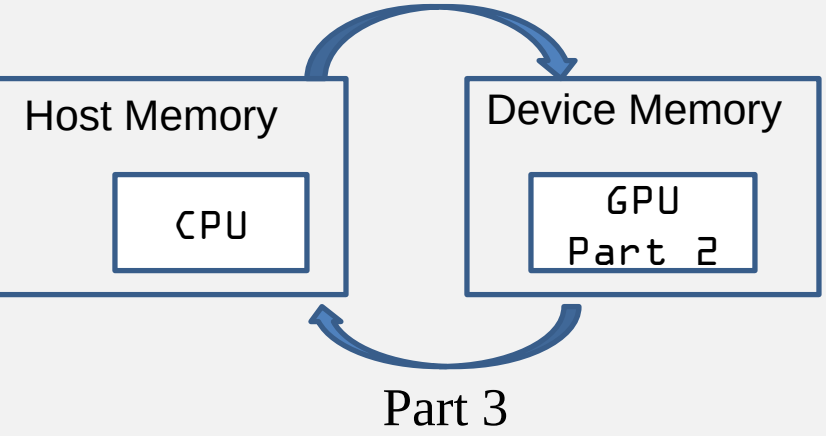
Data Parallelism - Vector Addition Example



Vector Addition - Traditional C Code

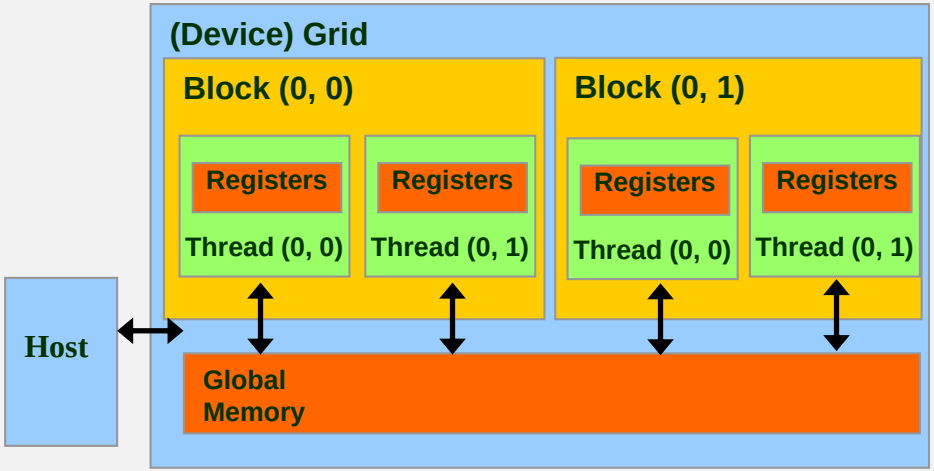
```
// Compute vector sum C = A+B
void vecAdd(float* h_A, float* h_B, float* h_C,
    int n)
{
  int i;
  for (i = 0; i<n; i++) h_C[i] = h_A[i]+h_B[i];
}

int main()
{
    // Memory allocation for h_A, h_B, and h_C
     // I/O to read h_A and h_B, N elements
     …
    vecAdd(h_A, h_B, h_C, N);
}
```


Heterogeneous Computing vecAdd CUDA Host Code




```
#include <cuda.h>
void vecAdd(float* h_A, float* h_B, float* h_C,
    int n)
{
   int size = n* sizeof(float);
     float* d_A, d_B, d_C;
1. // Allocate device memory for A, B, and C
   // copy A and B to device memory

2. // Kernel launch code – the device performs the
actual vector addition

3. // copy C from the device memory  // Free device
vectors
}
```

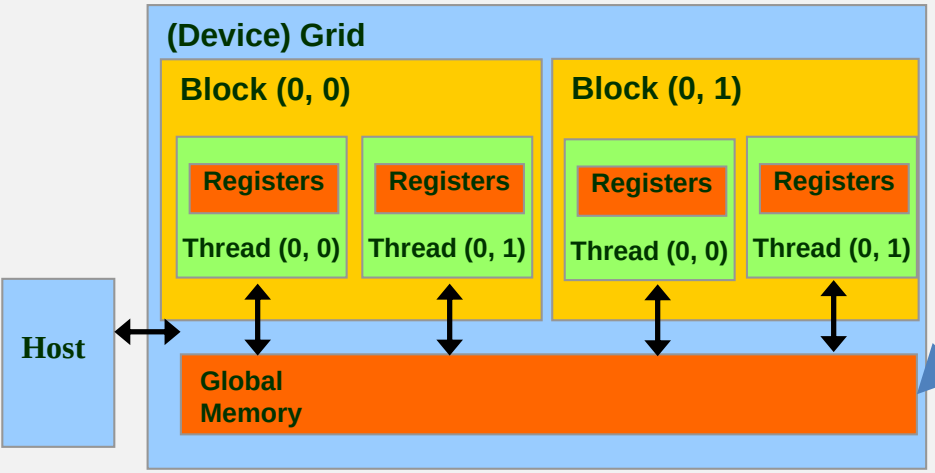

Partial Overview of CUDA Memories



- Device code can:
  - R/W per-thread registers
  - R/W all-shared global memory
- Host code can
  - Transfer data to/from per grid global memory

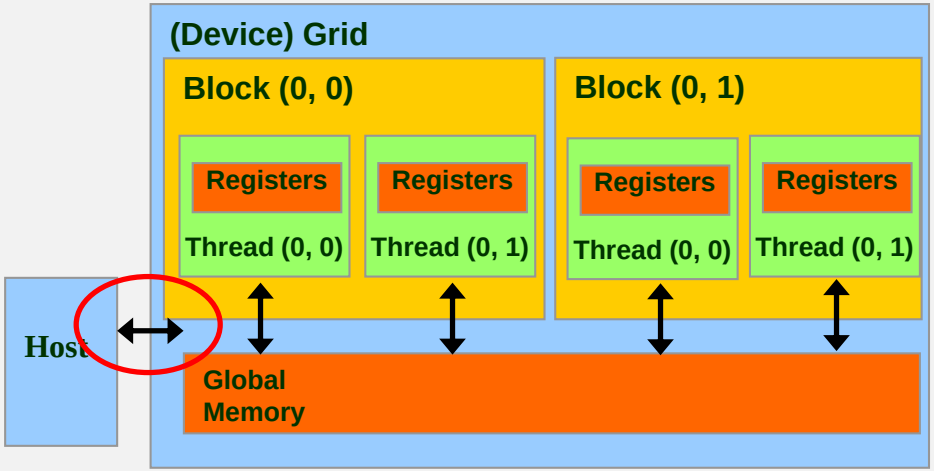
We will cover more memory types later.

CUDA Device Memory Management API functions



- cudaMalloc()
  - Allocates object in the device global memory
  - Two parameters
    - **Address of a pointer** to the allocated object
    - **Size of** allocated object in terms of bytes
- cudaFree()
  - Frees object from device global memory
    - **Pointer** to freed object

Host-Device Data Transfer API functions



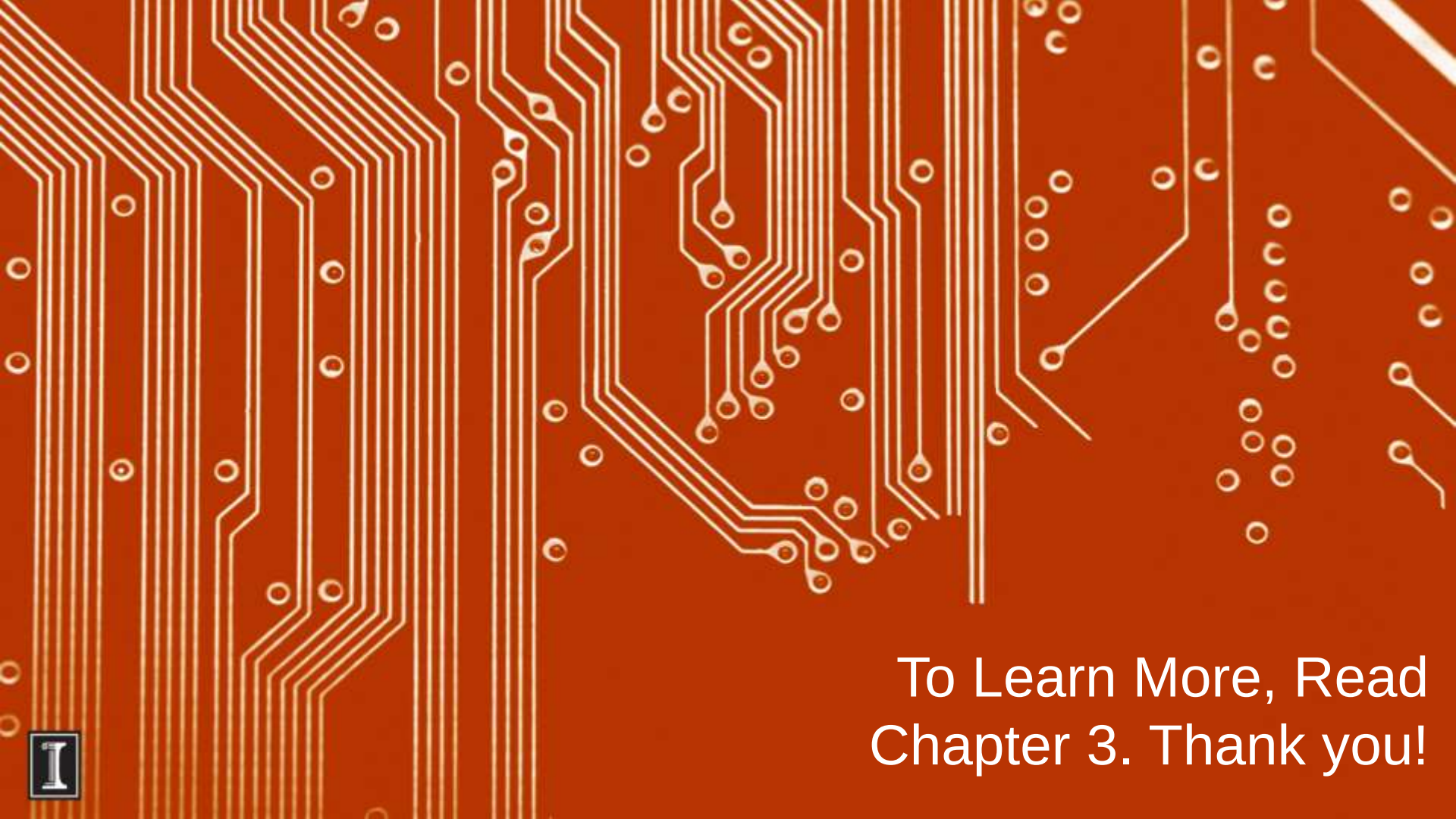
- cudaMemcpy()
  - memory data transfer
  - Requires four parameters
    - Pointer to destination
    - Pointer to source
    - Number of bytes copied
    - Type/Direction of transfer
  - Transfer to device is asynchronous

Vector Addition Host Code

```
void vecAdd(float* h_A, float* h_B, float* h_C, int n)
{
    int size = n * sizeof(float); float* d_A, d_B, d_C;

    cudaMalloc((void **) &d_A, size);
    cudaMemcpy(d_A, h_A, size, cudaMemcpyHostToDevice);
    cudaMalloc((void **) &d_B, size);
     cudaMemcpy(d_B, h_B, size, cudaMemcpyHostToDevice);
     cudaMalloc((void **) &d_C, size);

     // Kernel invocation code - to be shown later

     cudaMemcpy(h_C, d_C, size, cudaMemcpyDeviceToHost);
     cudaFree(d_A); cudaFree(d_B); cudaFree (d_C);
}
```


In Practice, Check for API Errors in Host Code

```
cudaError_t  err = cudaMalloc((void **)
&d_A, size);

if (err != cudaSuccess)  {
   printf("%s in %s at line %d\n",
       cudaGetErrorString(err), __FILE__,
       __LINE__);
   exit(EXIT_FAILURE);
}
```



To Learn More, Read
Chapter 3. Thank you!