Parallel Computing Workshop

Ms. Kranti Ingale

Prime Minister's Research Fellows (**PMRF**) Scholar

CSE, IIT Madras

Roadmap

- Introduction to GPU
- CUDA Program Flow and CPU-GPU Communication
- Thread organization (Grids, Blocks, Threads, 1D/2D)
- CUDA Memory Model
- CUDA Functions
- CUDA Thrust

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A simple kernel to add two integers

- addition() will execute on the **device**
- addition() will be called from the **host**

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__global__ void addition(int *num1, int *num2, int *result)
{
        *result = *num1 + *num2;
}
```

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We need to allocate memory on the GPU

CUDA API for handling device memory

- cudaMalloc()
- cudaFree()
- cudaMemcpy()

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- Similar to the C equivalents malloc(), free(), memcpy()

cudaMalloc()

Syntax :

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- Returns : cudaSuccess , cudaErrorMemoryAllocation

cudaFree()

Syntax :

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- Parameters :

  devPtr : deallocates device memory pointed by devPtr

- Returns : cudaSuccess , cudaErrorInvalidValue

cudaMemcpy()

Syntax :

```
cudaError_t  cudaMemcpy (void* dst, const void * src ,
                         size_t size, cudaMemcpyType  kind ) {}
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Kind : type of transfer

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- Parameters :

  dst, src : Destination & Source memory address

  Kind : Type of transfer

- Returns : cudaSuccess , cudaErrorInvalidValue , cudaErrorInvalidMemcpyDirection,

Let’s back to our problem of addition

```
main() {
        int a=10,b=20,c;
        int *d_a,*d_b,*d_c;

        cudaMalloc(&d_a,sizeof(int));
        cudaMalloc(&d_b,sizeof(int));
        cudaMalloc(&d_c,sizeof(int));
```

Let’s back to our problem of addition

```
main() {
        int a=10,b=20,c;          ──────►  Host copies of a, b, c
        int *d_a,*d_b,*d_c;       ──────►  Device copies of a, b, c

        cudaMalloc(&d_a,sizeof(int));
        cudaMalloc(&d_b,sizeof(int));
        cudaMalloc(&d_c,sizeof(int));
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main() {
        int a=10,b=20,c;          ──────►  Host copies of a, b, c
        int *d_a,*d_b,*d_c;       ──────►  Device copies of a, b, c

        cudaMalloc(&d_a,sizeof(int));
        cudaMalloc(&d_b,sizeof(int));      }  Allocate space for
        cudaMalloc(&d_c,sizeof(int));      }  device copies of a,
                                           }   b, c
```

Let’s back to our problem of addition

```
    cudaMemcpy(d_a, &a, sizeof(int), cudaMemcpyHostToDevice);
    cudaMemcpy(d_b, &b, sizeof(int), cudaMemcpyHostToDevice);

    addition<<<1,1>>>(d_a,d_b,d_c);

    cudaMemcpy(&c, d_c, sizeof(int), cudaMemcpyDeviceToHost);
    cudaFree(d_a); cudaFree(d_b); cudaFree(d_c);

}// end main
```

Let’s back to our problem of addition

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    cudaMemcpy(d_a, &a, sizeof(int), cudaMemcpyHostToDevice);
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Copy inputs to device

Let’s back to our problem of addition

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Copy inputs to device

kernel Launch

Let’s back to our problem of addition

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cudaMemcpy(d_a, &a, sizeof(int), cudaMemcpyHostToDevice);
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cudaMemcpy(&c, d_c, sizeof(int), cudaMemcpyDeviceToHost);
cudaFree(d_a); cudaFree(d_b); cudaFree(d_c);

}// end main
```

Copy inputs to device

kernel Launch

Copy result to Host

Let’s back to our problem of addition

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cudaMemcpy(d_a, &a, sizeof(int), cudaMemcpyHostToDevice);
cudaMemcpy(d_b, &b, sizeof(int), cudaMemcpyHostToDevice);

addition<<<1,1>>>(d_a,d_b,d_c);

cudaMemcpy(&c, d_c, sizeof(int), cudaMemcpyDeviceToHost);
cudaFree(d_a); cudaFree(d_b); cudaFree(d_c);

}// end main
```

Copy inputs to device

kernel Launch

Copy result to Host

Clean-up

Write a CUDA code corresponding to the following sequential C code

```
#include <stdio.h>
#define N 100
int main() {
        int a[N], i;
        for (i = 0; i < N; ++i)
        a[i] = i * i *i ;
        return 0;
}
```

Write a CUDA code corresponding to the following sequential C code

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}
```

```
#define N 100
int main() {
int a[N], *d_a, i;
cudaMalloc(&d_a, N * sizeof(int));
return 0;
}
```

Allocate space for array on device

Write a CUDA code corresponding to the following sequential C code

```
#include <stdio.h>
#define N 100
int main() {
        int a[N], i;
        for (i = 0; i < N; ++i)
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```
#define N 100
int main() {
int a[N], *d_a, i;
cudaMalloc(&d_a, N * sizeof(int));
fun<<<1, N>>>(d_a);
return 0;
}
```

Kernel launch

Write a CUDA code corresponding to the following sequential C code

```
#include <stdio.h>
#define N 100
int main() {
        int a[N], i;
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}
```

```
#define N 100
int main() {
int a[N], *d_a, i;
cudaMalloc(&d_a, N * sizeof(int));
fun<<<1, N>>>(d_a);
cudaMemcpy(a, d_a, N * sizeof(int), cudaMemcpyDeviceToHost );
return 0;
}
```

Copy result to host

Write a CUDA code corresponding to the following sequential C code

```
#include <stdio.h>
#define N 100
int main() {
        int a[N], i;
        for (i = 0; i < N; ++i)
        a[i] = i * i *i ;
        return 0;
}
```

```
#define N 100
int main() {
int a[N], *d_a, i;
cudaMalloc(&d_a, N * sizeof(int));
fun<<<1, N>>>(d_a);
cudaMemcpy(a, da, N * sizeof(int), cudaMemcpyDeviceToHost );
return 0;
}
```

Write a CUDA code corresponding to the following sequential C code

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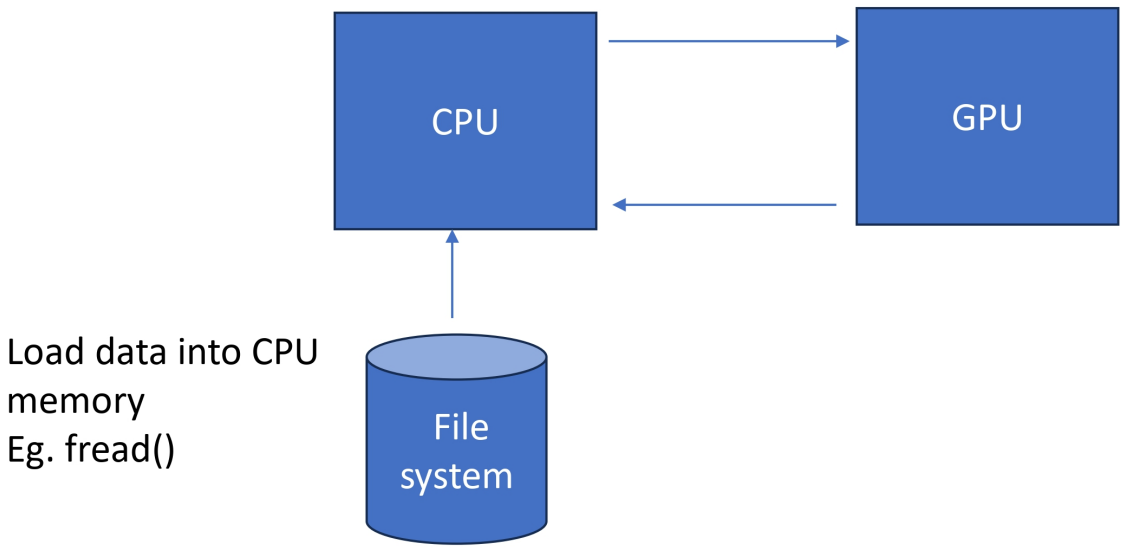
#include <stdio.h>
#define N 100
int main() {
        int a[N], i;
        for (i = 0; i < N; ++i)
        a[i] = i * i *i ;
        return 0;
}
```

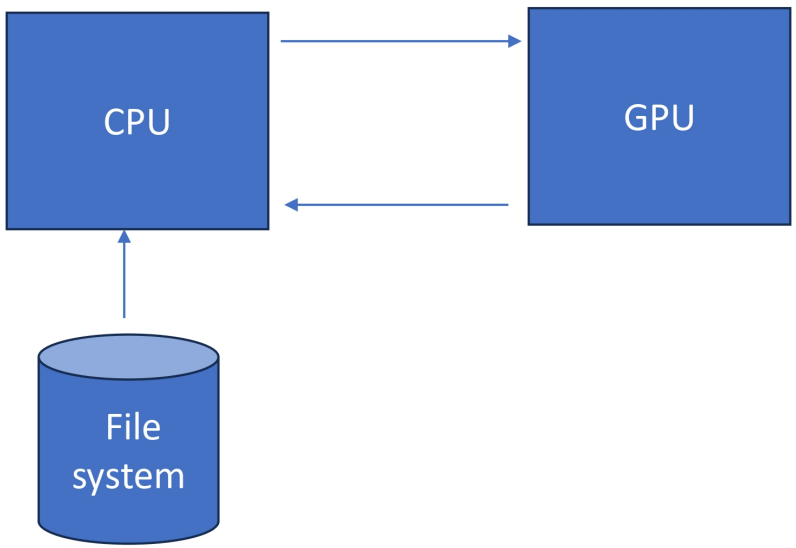
```
__global__ void fun(int *a) {
a[threadIdx.x] = threadIdx.x * threadIdx.x * threadIdx.x;
}
```

Typical CUDA Program flow



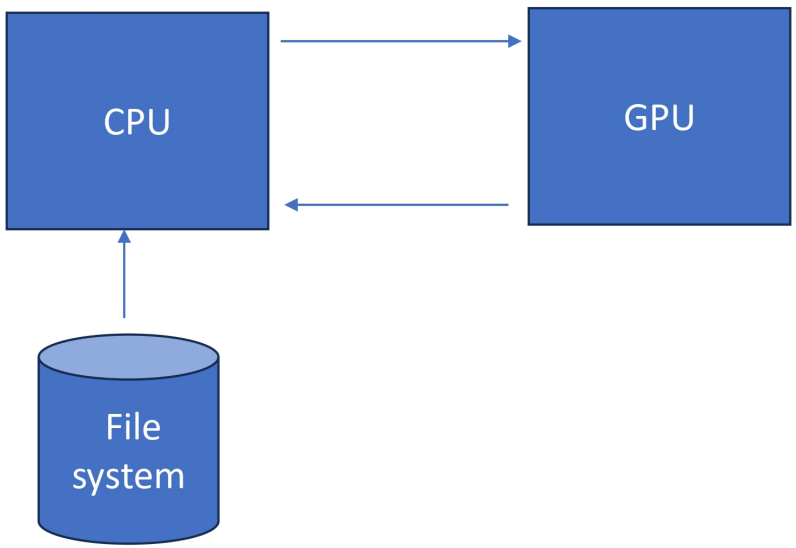
Typical CUDA Program flow

Copy data from CPU to GPU memory



Typical CUDA Program flow

Copy data from CPU to GPU memory
cudaMemcpy(.., cudaMemcpyHostToDevice)



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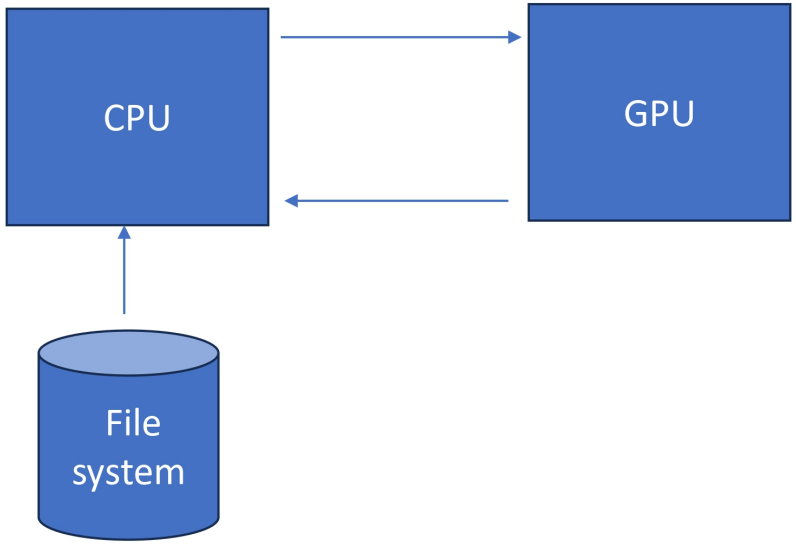
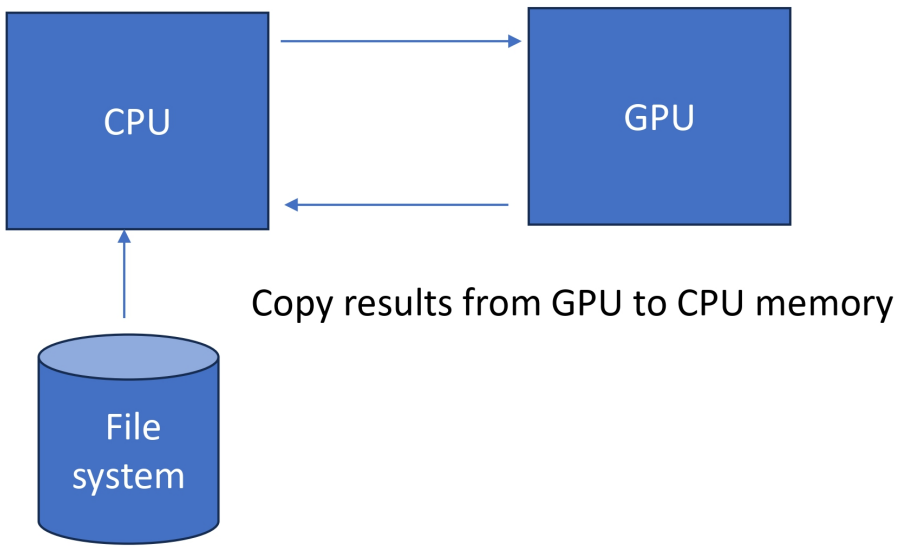


Execute GPU kernel

Typical CUDA Program flow



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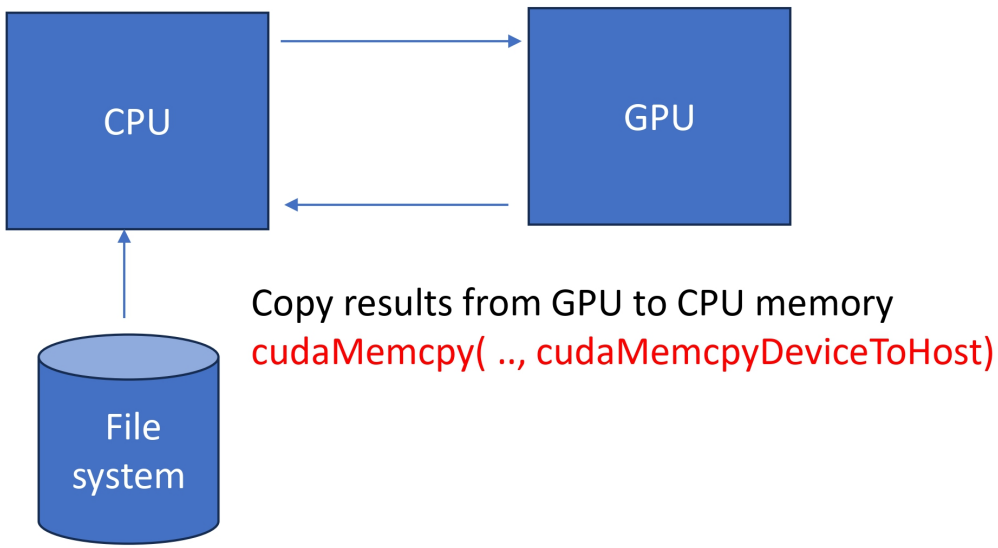
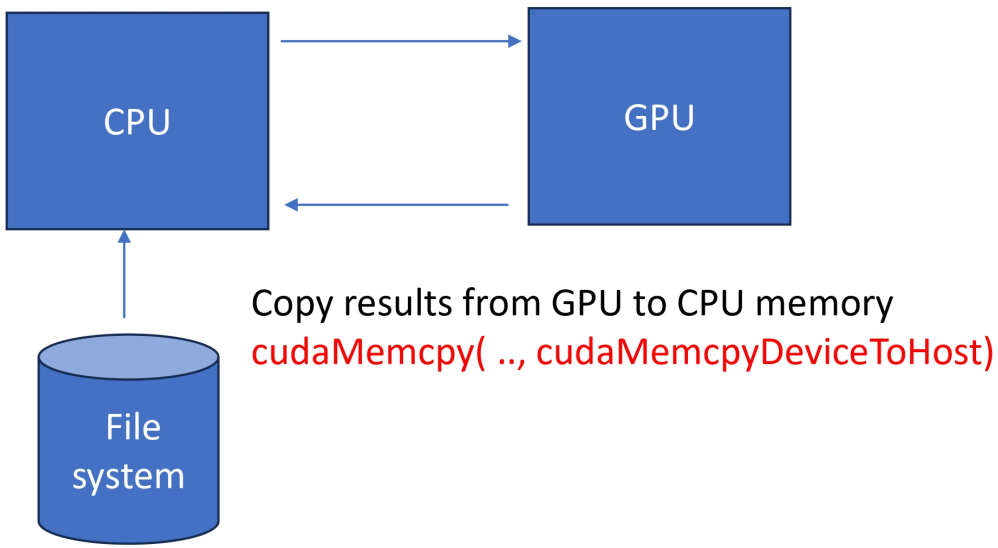


CPU-GPU COMMUNICATION

Copy data from CPU to GPU memory
cudaMemcpy(.., cudaMemcpyHostToDevice)



Copy results from GPU to CPU memory
cudaMemcpy(.., cudaMemcpyDeviceToHost)

Conclusion of Today's class

- We allocate memory on device with cudaMalloc().
- cudaFree() use to free the device memory.
- cudaMemcpy() is use to provide cpu-gpu communication.
- cudaMemcpy() acts as blocking call.
- Device variable is pointer on CPU, holds address of GPU memory.

Thank You