Parallel Computing Workshop

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Roadmap

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

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- Thread organization (Grids, Blocks, Threads, 1D/2D) :
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WARP

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- Warp threads are fully synchronized there is an implicit barrier after each instruction

SIMD

```
__global__ void Mykernel()
{
Printf(“Thread id = %d” ,
threadIdx.x);
}
int main() {
Mykernel<<<1,33>>>();
CDS();
return 0;
}
```

SIMD

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Output :

Thread id = 32

Thread id = 0

Thread id = 1

…

Thread id = 31

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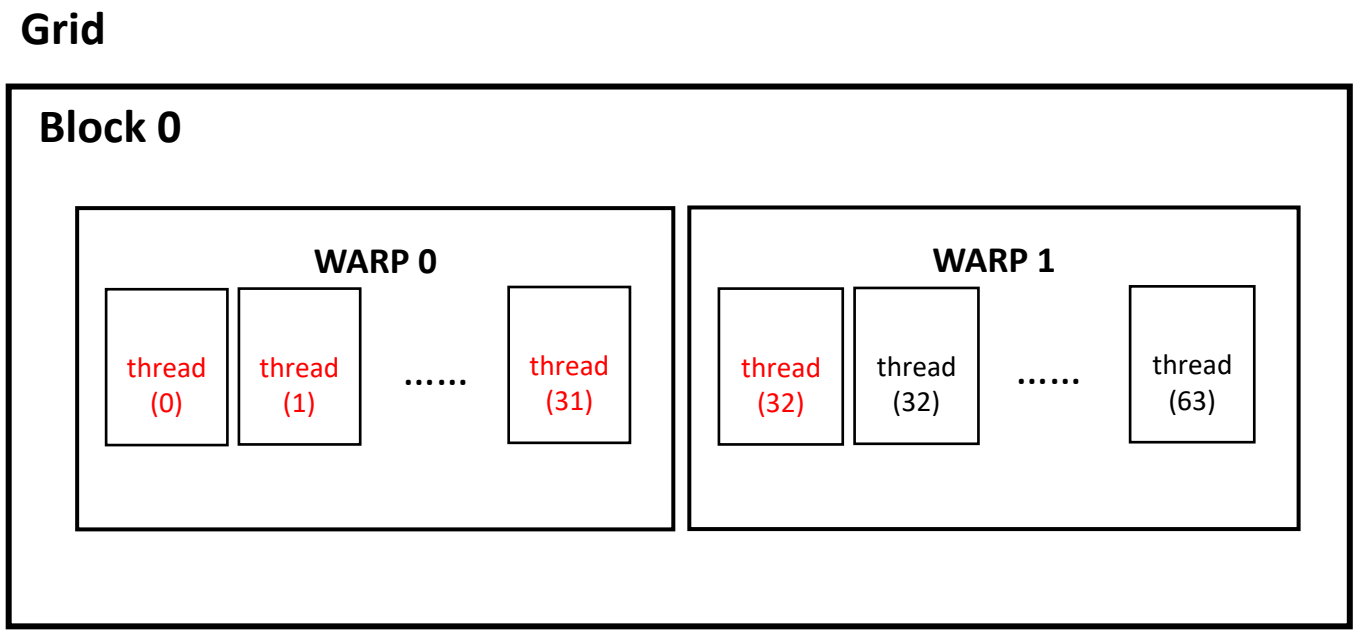

Thread id's are unique per thread blocks.

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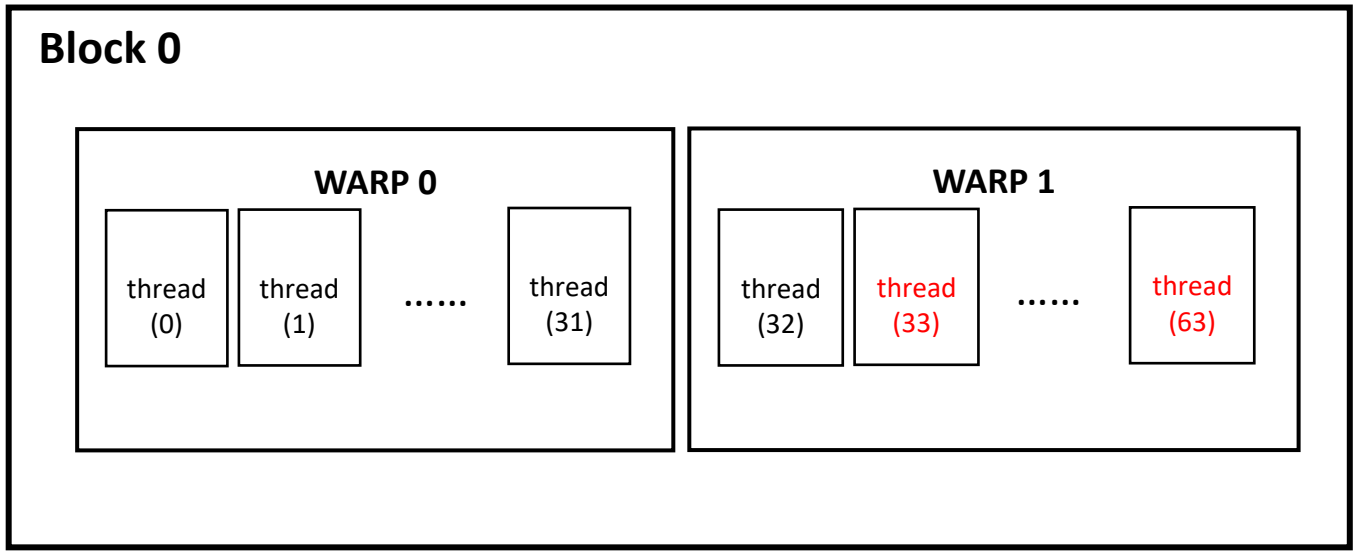

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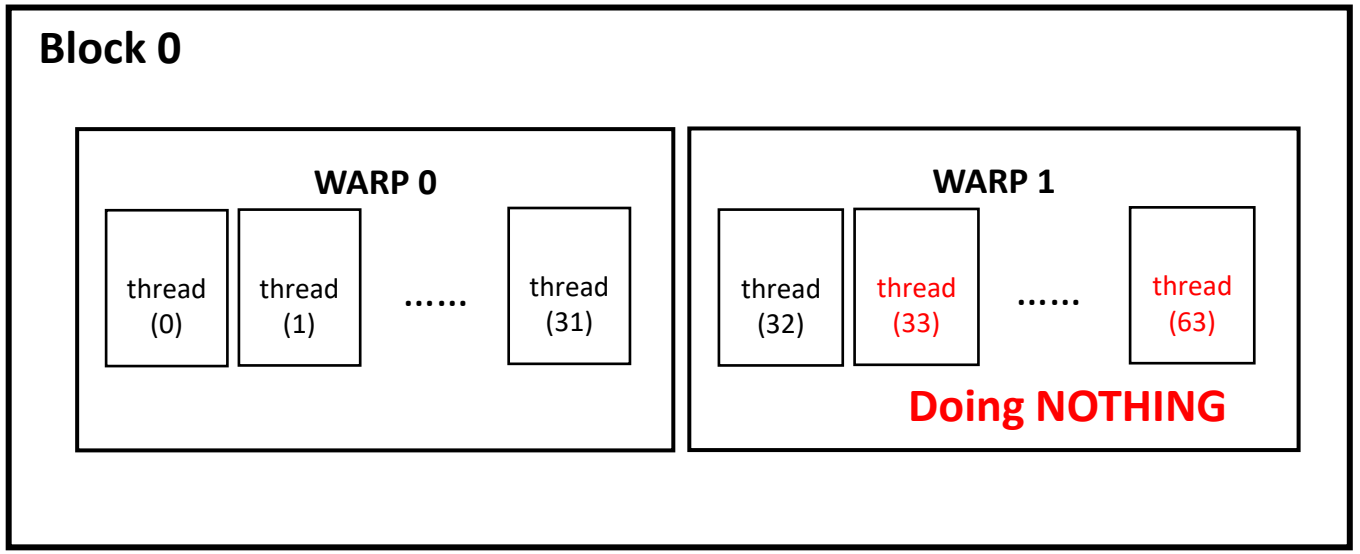

Thread-Divergence

```
__global__ void Mykernel (int *arr )
{
unsigned id = blockIdx.x * blockDim.x + threadIdx.x;
If(id%2==0) arr[id]=0;
else arr[id]=1;
printf(“ From gpu side ”);
}
Mykernel<<<1,32>>>(arr);
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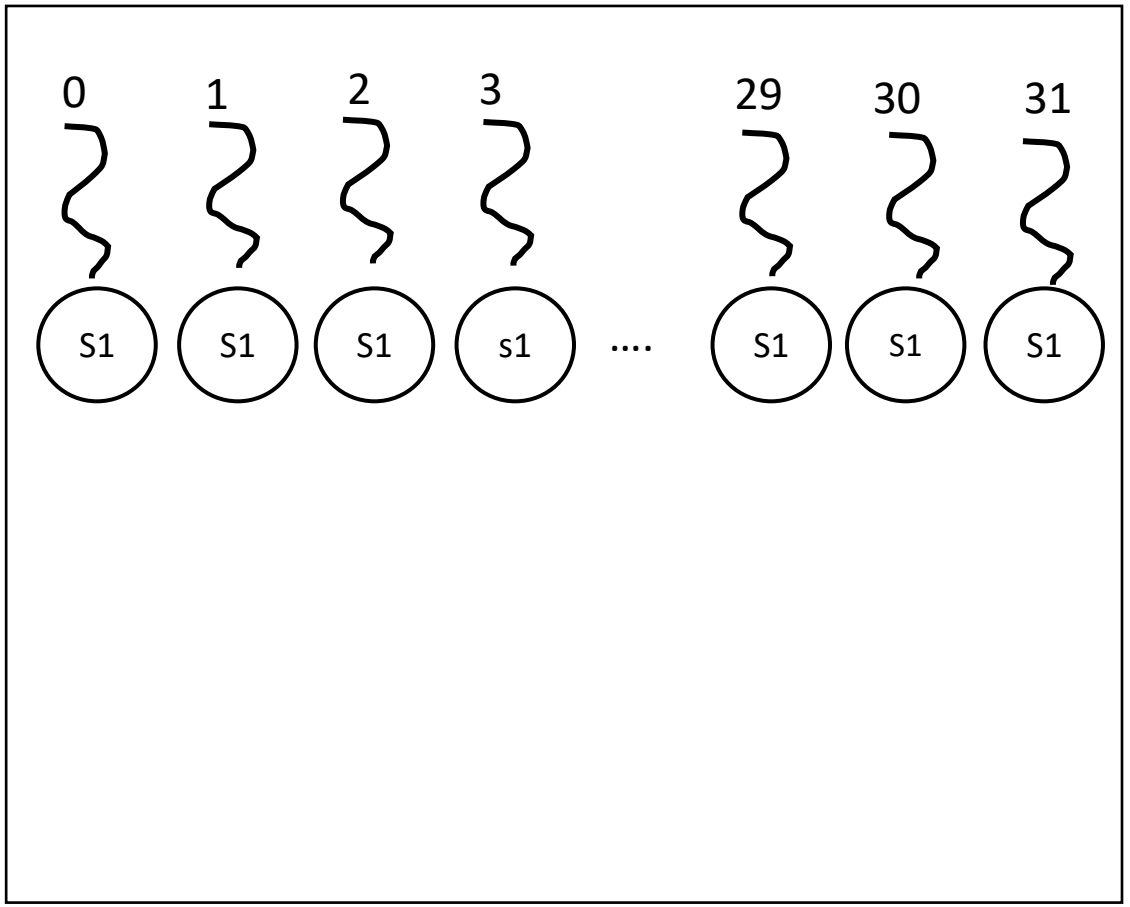

WARP DIVERGENCE

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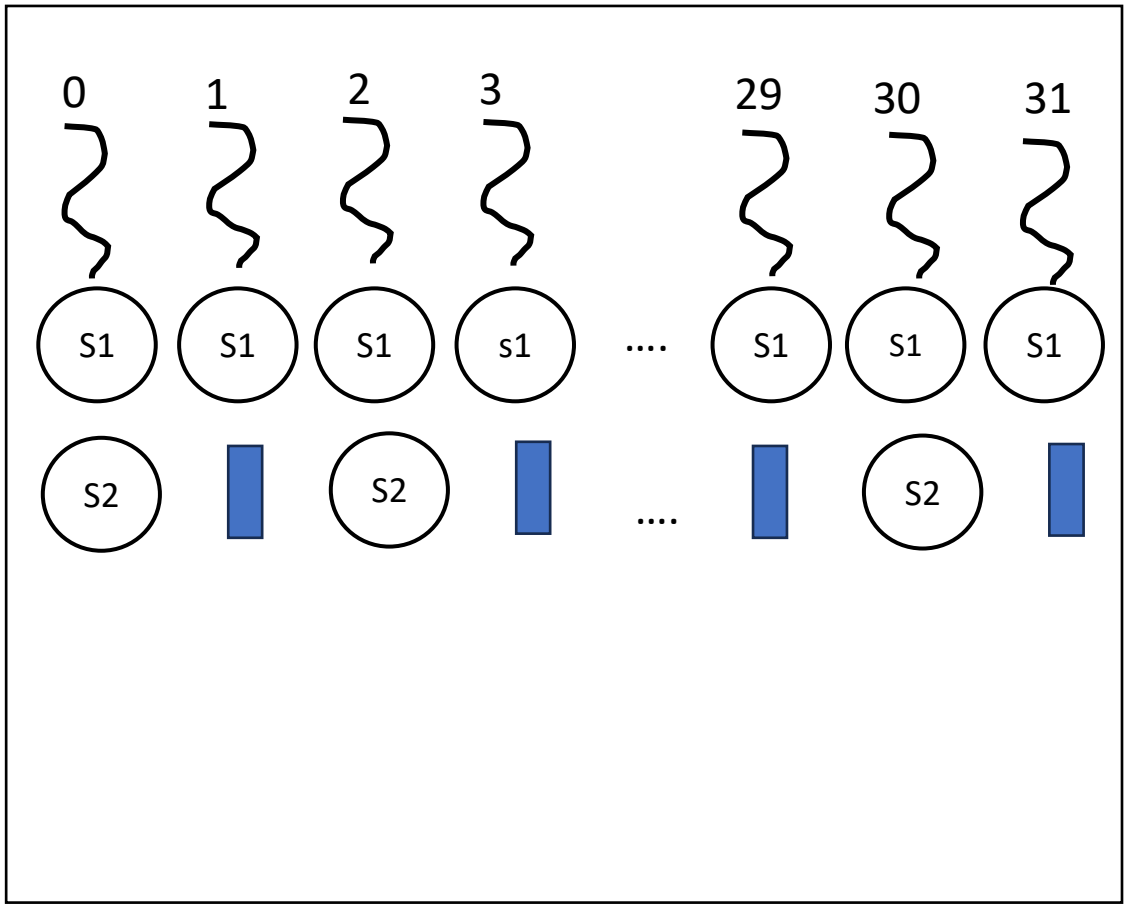

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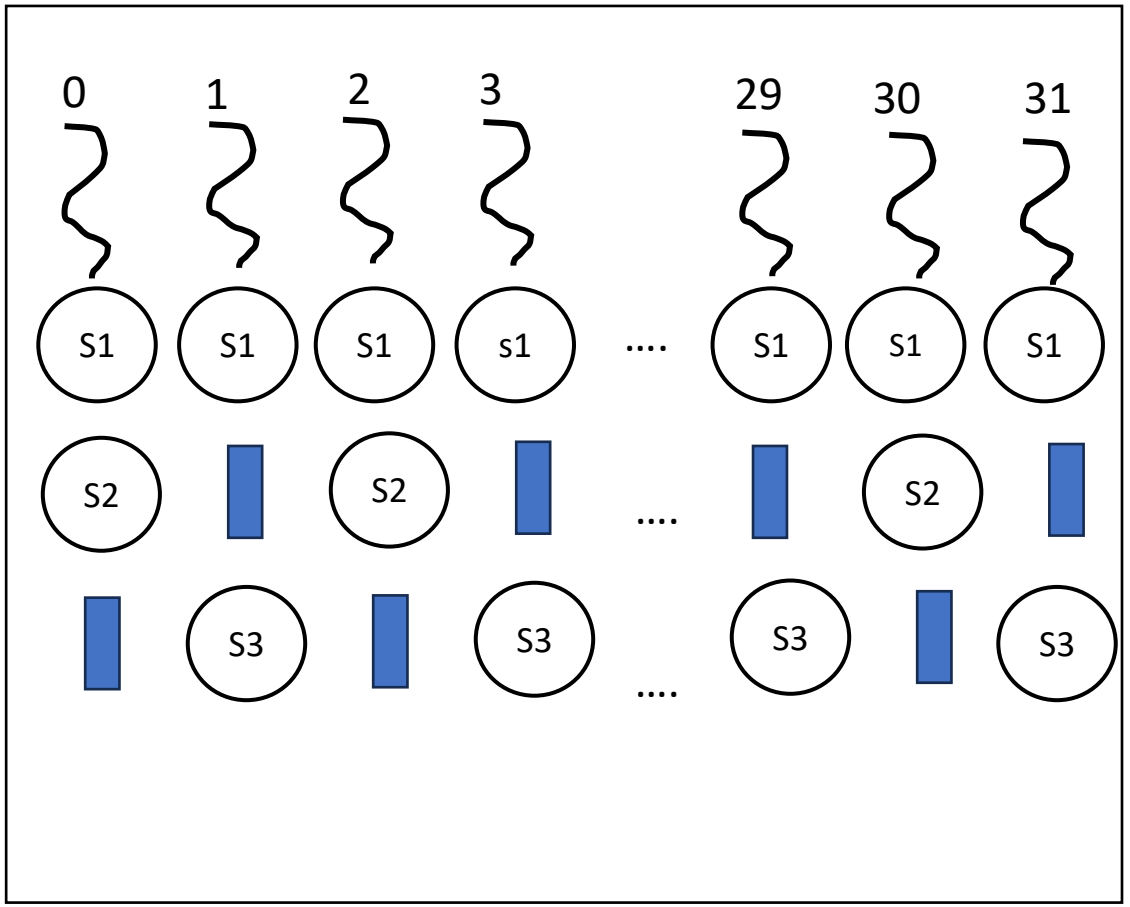

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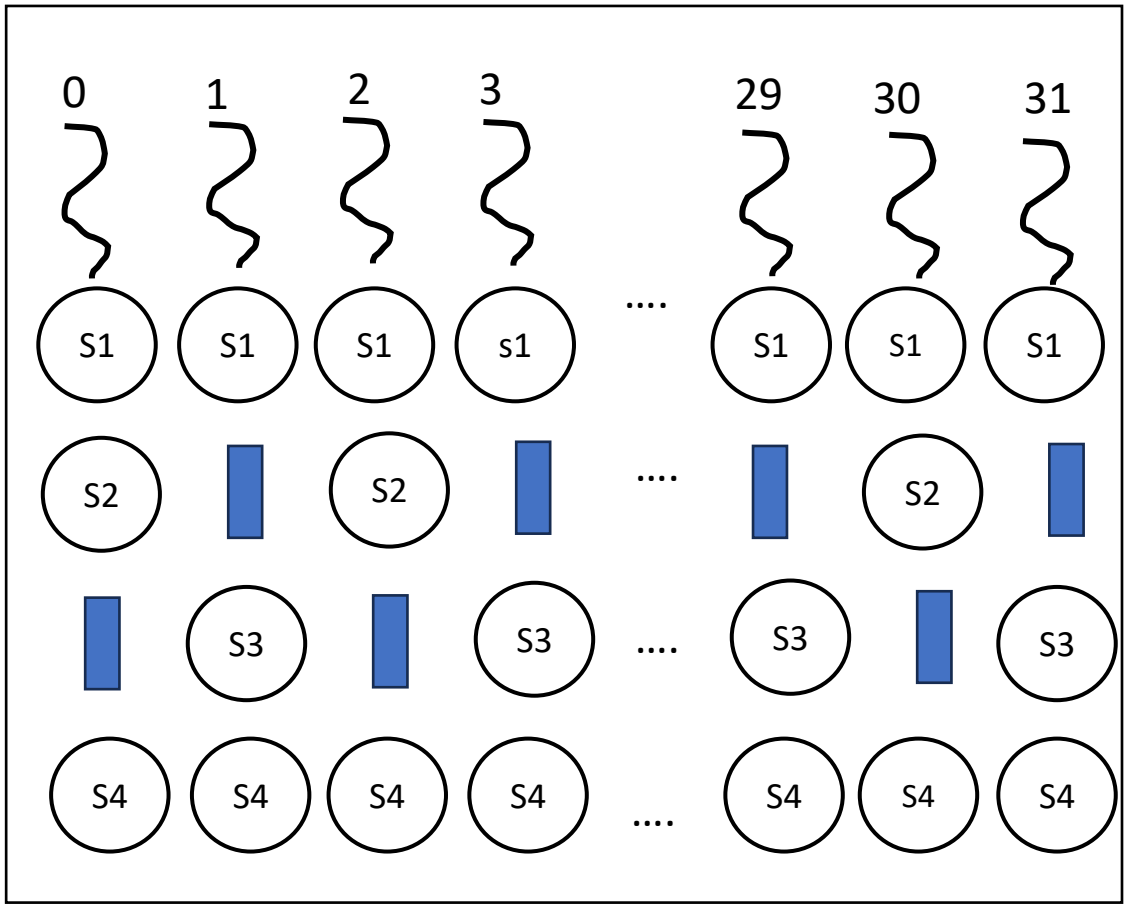

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- Warps are the smallest execution units in GPUs.
- In GPU warps, all threads within a warp must execute the same instruction simultaneously.
- Warp divergence occurs when threads within a warp follow different instruction sequences, often due to branch instructions.
- This adds sequentially to the execution.

Is there is Thread-Divergence here ?

```
__global__ void Mykernel() {
int id = unsigned id = blockIdx.x * blockDim.x + threadIdx.x;;
switch(id) {
case 0: … ;        thread 0 of WARP-X & Remaining threads NOP
case 1: … ;
.
case n: …. ;
}
}
```

Is there is Thread-Divergence here ?

```
__global__ void Mykernel() {
int id = unsigned id = blockIdx.x * blockDim.x + threadIdx.x;;
switch(id) {
case 0: … ;
case 1: … ;     thread 1 of WARP-X & Remaining threads NOP
.
case n: …. ;
}
}
```

Is there is Thread-Divergence here ?

```
__global__ void Mykernel() {
int id = unsigned id = blockIdx.x * blockDim.x + threadIdx.x;;
switch(id) {
case 0: … ;
case 1: … ;
.
case n: …. ;    thread n of WARP-X & Remaining threads NOP
}
}
```

Is there is Thread-Divergence here ?

```
__global__ void Mykernel() {
int id = unsigned id = blockIdx.x * blockDim.x + threadIdx.x;;
switch(id) {
case 0: … ;
case 1: … ;
.
case n: …. ;    thread n of WARP-X & Remaining threads NOP
}
}
```

sequentially to the execution

Is there is thread divergence here ?

```
__global__ void Mykernel()
{
id = … ;
if(id/32) {
printf(“ if ”);
} else  printf(“else”);
}
```

Is there is thread divergence here ?

```
__global__ void Mykernel()
{
id = … ;
if(id/32) {
printf(“ if ”);
} else  printf(“else”);
}
```

Output :

No , because we are getting same truth values for the warp

Is there is thread divergence here ?

```
__global__ void Mykernel ()
{
if(size < N){
printf(“%d”,threadIdx.x);
} else  printf(“else”);
}
```

Is there is thread divergence here ?

```
__global__ void Mykernel ()
{
if(size < N){
printf(“if”);
} else  printf(“else”);
}
```

Output :

No , because we are getting same truth values for the warps.

Is there is thread divergence here ?

```
__global__ void Mykernel()
{
id = … ;
if(id/2) {
printf(“if”);
}else  printf(“else”);
}
```

Is there is thread divergence here ?

```
__global__ void Mykernel()
{
id = … ;
if(id/2) {
printf(“if”);
}else  printf(“else”);
}
```

Output :

Yes , because we are getting different truths for different threads of warps

Can we remove thread divergence ?

```
if( A = = B )
A = C + 10;
else
A = B + 10;
```

Assumption (A==B||A==C)

Can we remove thread divergence ?

```
if( A = = B )
A = C + 10;
else
A = B + 10;
```

Assumption (A==B||A==C)

Output :

A = B + C + 10 – A

Can we remove thread divergence ?

```
if( A = = B )
A = C + W;
else if (A = = C)
A = W + B;
else
A= B + C ;
```

Assumption (A==B||A==W || A==C)

Can we remove thread divergence ?

```
if( A = = B )
A = C + W;
else if (A = = C)
A = W + B;
else
A= B + C ;
```

Assumption (A==B||A==W || A==C)

Output :

A = B + C + W – A

Can we remove thread divergence ?

```
if((tx & 1) = = 0) {
tx_index  = tx + 1 ;
} else
tx_index  = tx – 1;
```

Can we remove thread divergence ?

```
if((tx & 1) = = 0) {
tx_index  = tx + 1 ;
} else
tx_index  = tx – 1;
```

Output :

```
int tx_index = tx ^ 1 ;
```

Can we remove thread divergence ?

```
if((tx &1)== 0) {
    A[tx+1] = B[tx] * A[tx+1];
} else
    A[tx-1] = B[tx] * A[tx-1];
```

Can we remove thread divergence ?

```
if((tx &1)== 0) {
    A[tx+1] = B[tx] * A[tx+1];
} else
    A[tx-1] = B[tx] * A[tx-1];
```

Output :

```
int tx_index = tx ^ 1 ;
A[tx_index] = B[tx] * A[tx_index];
```

Can we remove thread divergence ?

```
if( id<=0)
arr[id] = 0;
else
arr[id] = 1;

dkernel<<<1,32>>>()
```

Can we remove thread divergence ?

```
if( id<=0)
arr[id] = 0;
else
arr[id] = 1;

dkernel<<<1,32>>>()
```

Output :

Id = 0 or positive number(1..31)

arr[id] = [1+(-id>>31)] * -1 +1

ID=1,2…31

1….0001>>31 ➔ 111…11111

-1+1 ➔ 0

→1

Thank You