Performance analysis on GPUs with NVIDIA tools

Dominik Ernst

NHR FAU

Example: 2D Jacobi

Get the Source:

```
git clone https://github.com/te42kyfo/omp_jacobi
```

or

```
cp -r ../r49n000/omp_jacobi .
```

Load the compiler module

```
module load nvhpc
module load cuda
```

Build and run the CPU base line

```
make main1
./main1
```

Run likwid-bench

```
module load likwid
likwid-bench -t copy -W S0:1GB
```

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Analysis: 2D Jacobi

3 ADDs, 1 MUL per iteration:

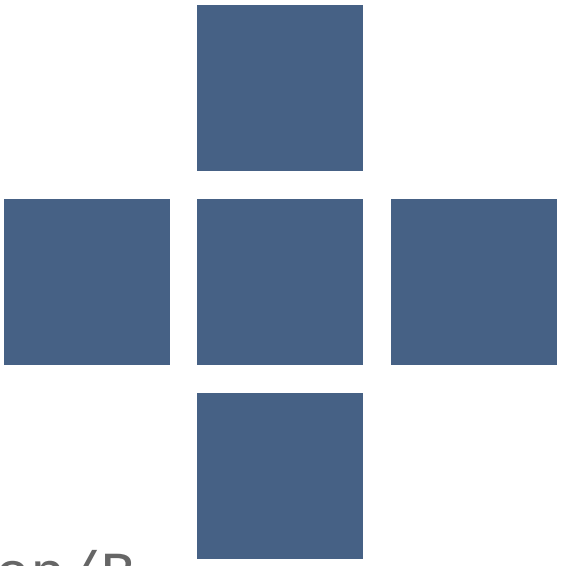
```
A[o] = 0.25 * (B[^] + B[v] + B[<] + B[>])
```

Read entire grid A and B once each → on average: one value per iteration

```
= 2x8B / iteration
```

Code Intensity:

```
4 Flop / 16 B = 0.25 Flop/B
```



A100 Machine Intensity:

```
9.7 Tflop/s / 1555 GB/s = 6.2 Flop/B
```

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Build/Run/Profile

Build and run the Nth version

```
make main<N>
./main<N>
```

Create a profile

```
nsys profile main<N>
```

Launch the profiling GUI

```
nsys-ui
```

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Kernel Profiling

Kernel profiling

```
ncu <application>
```

List metric sections

```
ncu --list-sections
```

Collect all sections

```
ncu --set full -f -o <output file> <application>
```

Launch the ncu profiling GUI

```
ncu-ui
```

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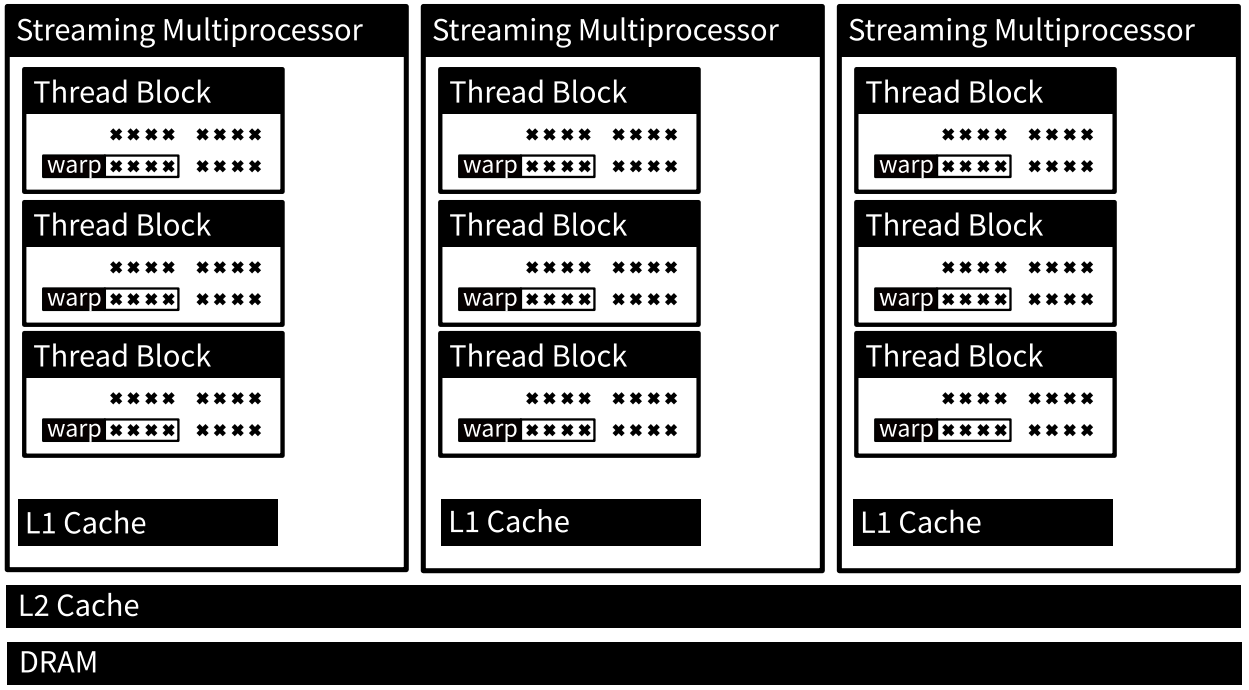
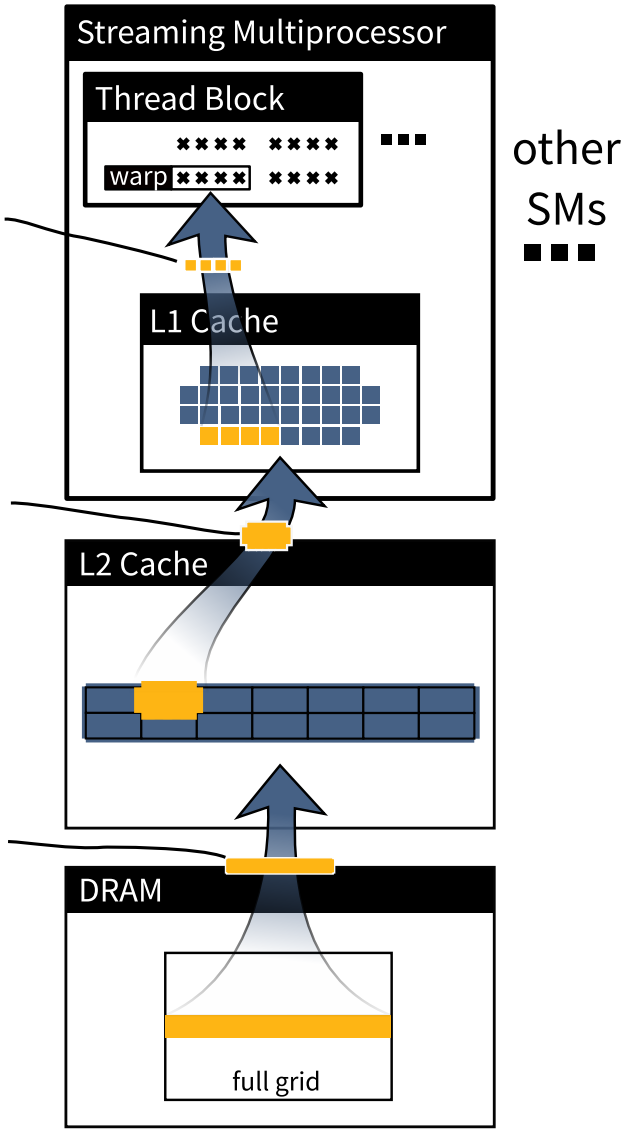
GPU Architecture

32 threads → 1 warp
up to 1024 threads / 32 warps → 1 thread block
up to 64 warps / 2048 threads → 1 SM
108 SM → A100 GPU

2048 threads / SM * 108SM → ~200‘000 threads / GPU



GPU Architecture



per SM: 192 kB L1 cache
shared for all SM: 40MB L2 cache
shared for all SM: 40 GB DRAM

(A100-SXM4-40GB)

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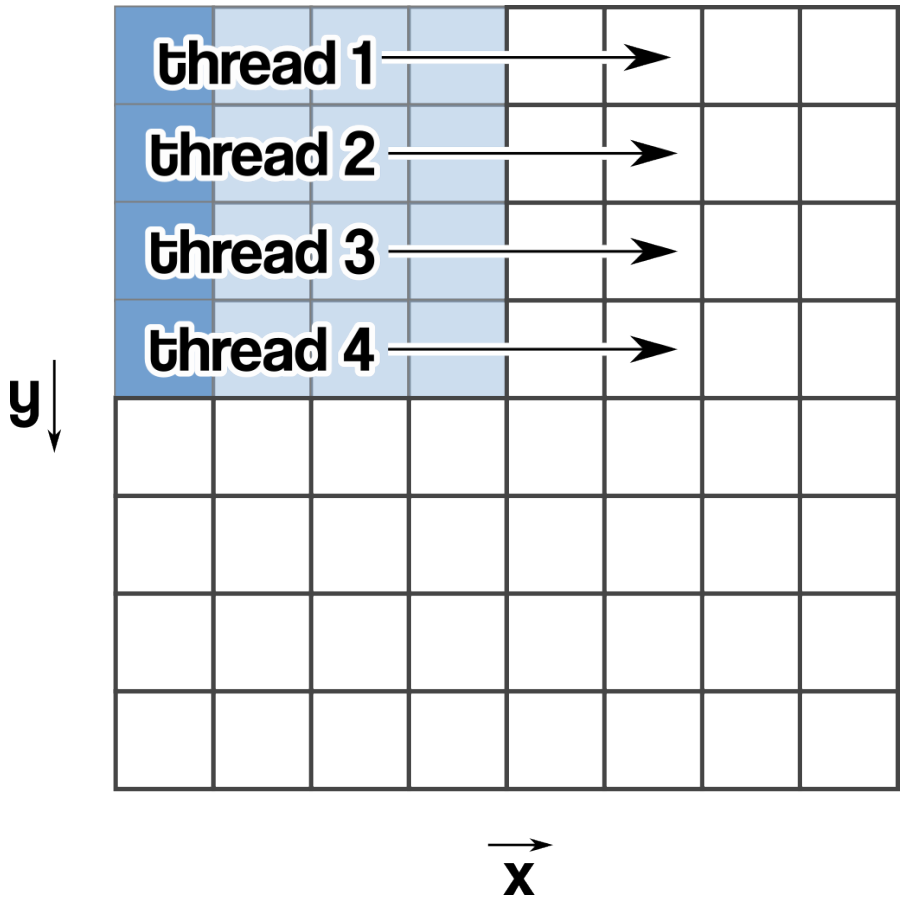
OpenMP Loop main4

```
#pragma omp target parallel for
for (int y = 1; y < height - 1; y++)
  for (int x = 1; x < width - 1; x++)
    ...
```



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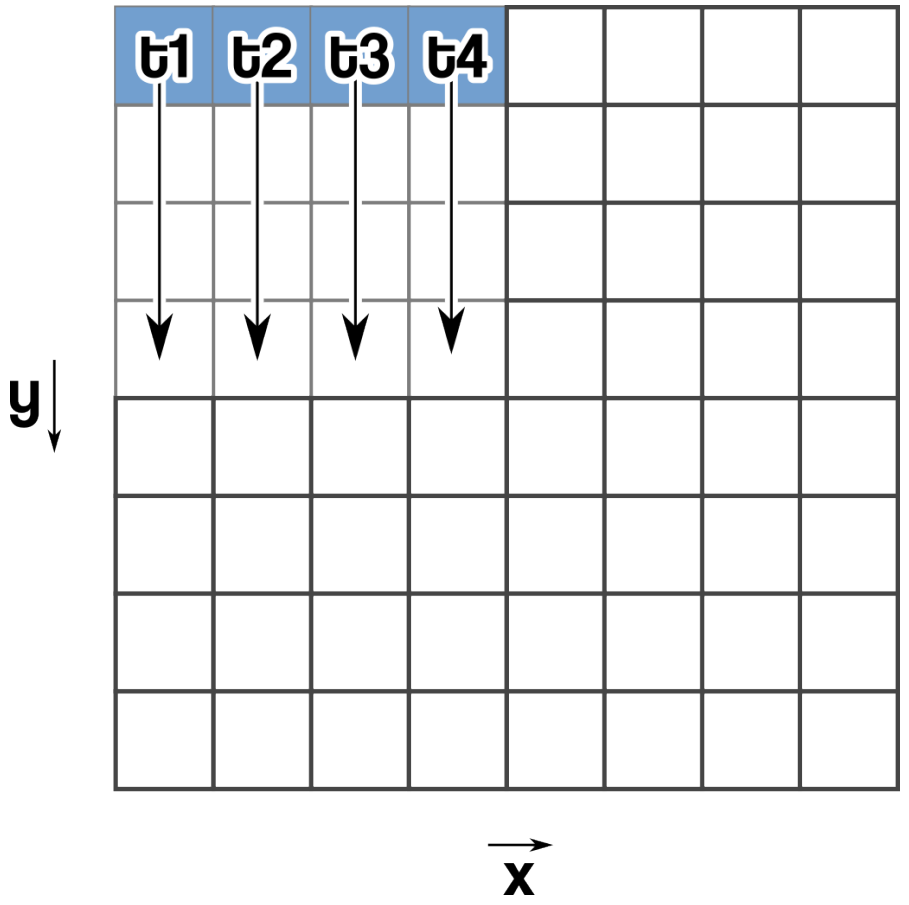
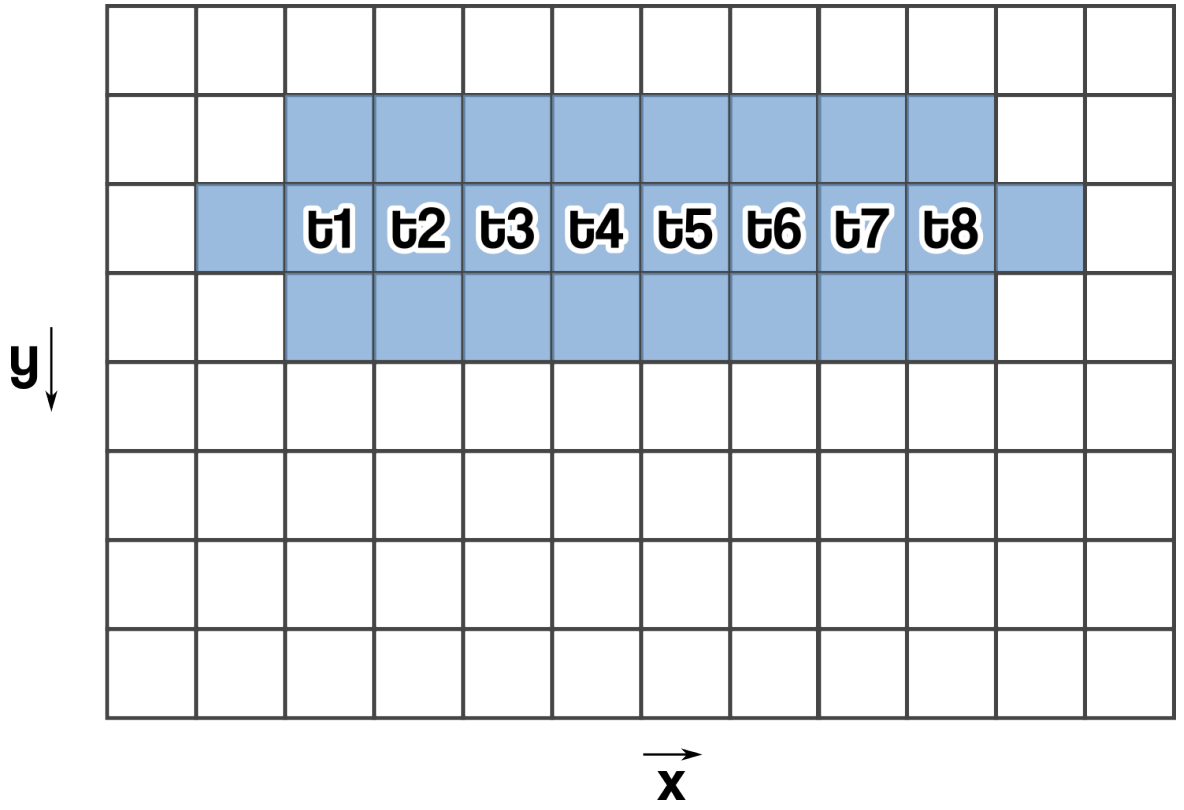
OpenMP Loop main41

```
#pragma omp target parallel for
for (int x = 1; x < width - 1; x++)
  for (int y = 1; y < height - 1; y++)
    ...
```



OpenMP main51

```
#pragma omp target parallel for collapse(2)
for (int y = 1; y < height - 1; y++)
  for (int x = 1; x < width - 1; x++)
    ...
```



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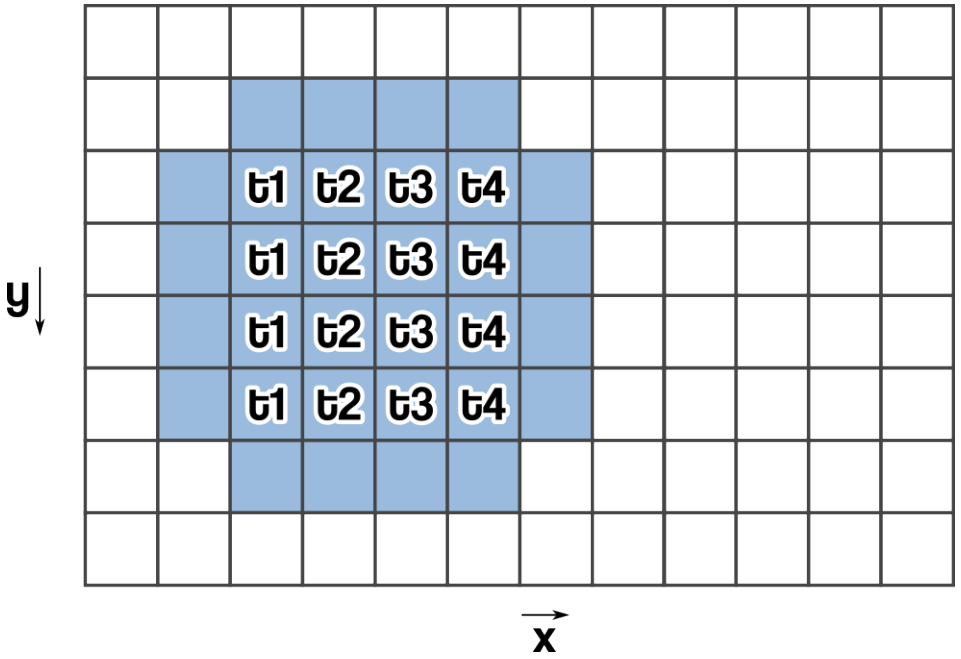
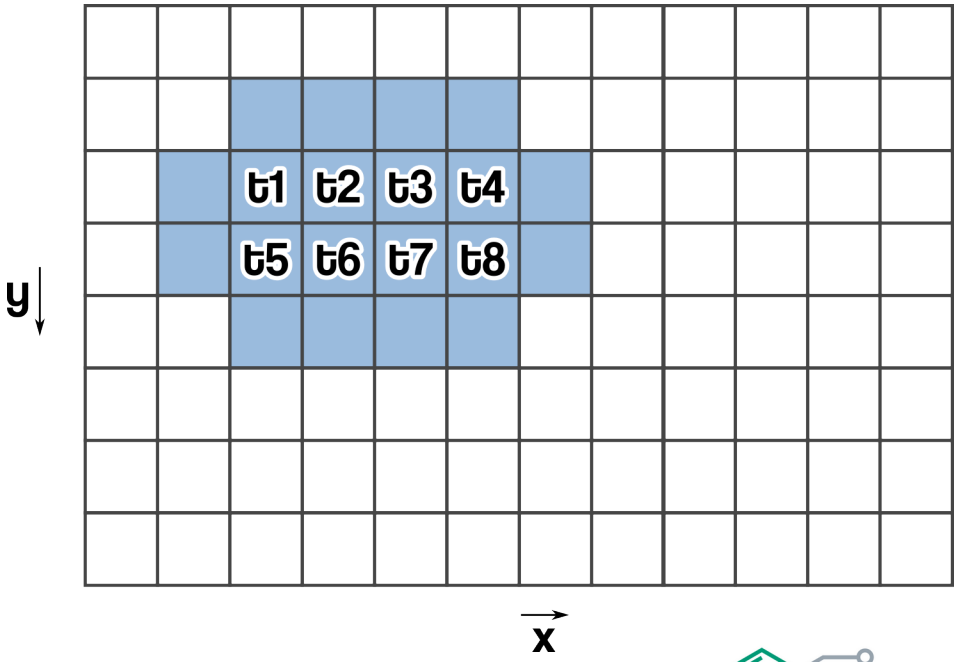
OpenMP Loop main6 / main7

```
#pragma omp target parallel for collapse(2)
for (int oy = 1; oy < height - 1; oy += 4)
  for (int x = 1; x < width - 1; x++)
    for (int iy = 0; iy < 4; iy++) {
      int y = oy + iy;
```





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