**Cairo University**
**Faculty of**
**Engineering**

**Department of Computer**
**Engineering**

# Parallel Computing

# Lab 2

## Submitted to

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## Submitted by

| Name | Sec | BN | Code |
|------|-----|-----|------|
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# Trials made.

For matrix 100 x 300

Kernel 1:

```
==39804== NVPROF is profiling process 39804, command: ./k1 ./matrix.txt ./test1_out.txt
==39804== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==39804== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   51.61%  25.152us         2  12.576us  12.352us  12.800us  [CUDA memcpy HtoD]
                   25.08%  12.224us         1  12.224us  12.224us  12.224us  k1(float*, float*, float*, int, int)
                   23.31%  11.360us         1  11.360us  11.360us  11.360us  [CUDA memcpy DtoH]
      API calls:   99.31%  100.91ms         3  33.637ms  3.5150us  100.90ms  cudaMalloc
                    0.22%  220.48us         3  73.492us  45.707us  125.51us  cudaMemcpy
                    0.17%  176.52us         1  176.52us  176.52us  176.52us  cudaLaunchKernel
                    0.15%  148.51us       114  1.3020us     151ns  61.528us  cuDeviceGetAttribute
                    0.13%  132.30us         3  44.099us  5.5870us  108.62us  cudaFree
                    0.01%  11.540us         1  11.540us  11.540us  11.540us  cuDeviceGetName
                    0.01%  5.1020us         1  5.1020us  5.1020us  5.1020us  cuDeviceGetPCIBusId
                    0.00%  4.6190us         1  4.6190us  4.6190us  4.6190us  cuDeviceTotalMem
                    0.00%  1.6360us         3     545ns     181ns  1.1250us  cuDeviceGetCount
                    0.00%  1.5260us         2     763ns     183ns  1.3430us  cuDeviceGet
                    0.00%     479ns         1     479ns     479ns     479ns  cuModuleGetLoadingMode
                    0.00%     239ns         1     239ns     239ns     239ns  cuDeviceGetUuid
```

Kernel 2:

```
==39859== NVPROF is profiling process 39859, command: ./k2 ./matrix.txt ./test2_out.txt
==39859== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==39859== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   81.24%  156.13us         1  156.13us  156.13us  156.13us  k2(float*, float*, float*, int, int)
                   12.87%  24.736us         2  12.368us  12.224us  12.512us  [CUDA memcpy HtoD]
                    5.89%  11.327us         1  11.327us  11.327us  11.327us  [CUDA memcpy DtoH]
      API calls:   99.11%  120.32ms         3  40.107ms  5.3130us  120.29ms  cudaMalloc
                    0.36%  442.29us         3  147.43us  73.044us  291.85us  cudaMemcpy
                    0.22%  263.57us         1  263.57us  263.57us  263.57us  cudaLaunchKernel
                    0.16%  194.58us       114  1.7060us     209ns  79.075us  cuDeviceGetAttribute
                    0.13%  154.02us         3  51.340us  6.5540us  126.67us  cudaFree
                    0.01%  12.439us         1  12.439us  12.439us  12.439us  cuDeviceGetName
                    0.01%  8.8800us         1  8.8800us  8.8800us  8.8800us  cuDeviceGetPCIBusId
                    0.00%  5.6840us         1  5.6840us  5.6840us  5.6840us  cuDeviceTotalMem
                    0.00%  2.1970us         3     732ns     339ns  1.4920us  cuDeviceGetCount
                    0.00%  1.2880us         2     644ns     328ns     960ns  cuDeviceGet
                    0.00%     742ns         1     742ns     742ns     742ns  cuModuleGetLoadingMode
                    0.00%     451ns         1     451ns     451ns     451ns  cuDeviceGetUuid
```

Kernel 3:

```
==39916== NVPROF is profiling process 39916, command: ./k3 ./matrix.txt ./test3_out.txt
==39916== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==39916== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   53.80%  42.560us         1  42.560us  42.560us  42.560us  k3(float*, float*, float*, int, int)
                   31.84%  25.184us         2  12.592us  12.416us  12.768us  [CUDA memcpy HtoD]
                   14.36%  11.360us         1  11.360us  11.360us  11.360us  [CUDA memcpy DtoH]
      API calls:   99.18%  93.241ms         3  31.080ms  3.1300us  93.231ms  cudaMalloc
                    0.27%  257.91us         3  85.970us  46.717us  163.80us  cudaMemcpy
                    0.19%  183.10us         1  183.10us  183.10us  183.10us  cudaLaunchKernel
                    0.19%  179.57us       114  1.5750us     168ns  88.780us  cuDeviceGetAttribute
                    0.12%  116.43us         3  38.808us  4.5820us  97.230us  cudaFree
                    0.01%  12.342us         1  12.342us  12.342us  12.342us  cuDeviceGetName
                    0.01%  5.5240us         1  5.5240us  5.5240us  5.5240us  cuDeviceTotalMem
                    0.01%  5.3060us         1  5.3060us  5.3060us  5.3060us  cuDeviceGetPCIBusId
                    0.00%  3.1680us         2  1.5840us     352ns  2.8160us  cuDeviceGet
                    0.00%  1.8000us         3     600ns     213ns  1.1630us  cuDeviceGetCount
                    0.00%     738ns         1     738ns     738ns     738ns  cuModuleGetLoadingMode
                    0.00%     416ns         1     416ns     416ns     416ns  cuDeviceGetUuid
```

For 300 * 300

Kernel 1:

```
==40781== NVPROF is profiling process 40781, command: ./k1 ./matrix.txt ./test1_out.txt
==40781== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==40781== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   49.39%   63.392us         2   31.696us  31.456us  31.936us  [CUDA memcpy HtoD]
                   30.42%   39.040us         1   39.040us  39.040us  39.040us  [CUDA memcpy DtoH]
                   20.19%   25.920us         1   25.920us  25.920us  25.920us  k1(float*, float*, float*, int, int)
      API calls:   98.98%   109.51ms         3   36.503ms  3.2050us  109.50ms  cudaMalloc
                    0.50%   550.44us         3   183.48us  99.532us  336.55us  cudaMemcpy
                    0.20%   218.67us         1   218.67us  218.67us  218.67us  cudaLaunchKernel
                    0.15%   169.10us       114   1.4830us     163ns  74.593us  cuDeviceGetAttribute
                    0.14%   158.88us         3   52.959us  4.9880us  132.51us  cudaFree
                    0.01%   11.735us         1   11.735us  11.735us  11.735us  cuDeviceGetName
                    0.01%   6.1700us         1   6.1700us  6.1700us  6.1700us  cuDeviceGetPCIBusId
                    0.00%   4.9160us         1   4.9160us  4.9160us  4.9160us  cuDeviceTotalMem
                    0.00%   2.4010us         3     800ns     262ns  1.8670us  cuDeviceGetCount
                    0.00%   1.1330us         2     566ns     178ns     955ns  cuDeviceGet
                    0.00%     733ns         1     733ns     733ns     733ns  cuModuleGetLoadingMode
                    0.00%     288ns         1     288ns     288ns     288ns  cuDeviceGetUuid
```

Kernel 2:

```
==40836== NVPROF is profiling process 40836, command: ./k2 ./matrix.txt ./test2_out.txt
==40836== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==40836== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   83.05%   503.74us         1   503.74us  503.74us  503.74us  k2(float*, float*, float*, int, int)
                   10.65%   64.576us         2   32.288us  31.840us  32.736us  [CUDA memcpy HtoD]
                    6.30%   38.239us         1   38.239us  38.239us  38.239us  [CUDA memcpy DtoH]
      API calls:   98.39%   97.945ms         3   32.648ms  3.7070us  97.936ms  cudaMalloc
                    1.05%   1.0492ms         3   349.72us  100.96us  831.41us  cudaMemcpy
                    0.22%   221.88us         1   221.88us  221.88us  221.88us  cudaLaunchKernel
                    0.16%   160.47us       114   1.4070us     163ns  60.308us  cuDeviceGetAttribute
                    0.14%   134.70us         3   44.899us  5.1440us  110.94us  cudaFree
                    0.01%   14.822us         1   14.822us  14.822us  14.822us  cuDeviceGetName
                    0.01%   7.1210us         1   7.1210us  7.1210us  7.1210us  cuDeviceTotalMem
                    0.01%   6.9530us         1   6.9530us  6.9530us  6.9530us  cuDeviceGetPCIBusId
                    0.00%   3.1220us         2   1.5610us     203ns  2.9190us  cuDeviceGet
                    0.00%   2.2160us         3     738ns     251ns  1.6470us  cuDeviceGetCount
                    0.00%     734ns         1     734ns     734ns     734ns  cuModuleGetLoadingMode
                    0.00%     301ns         1     301ns     301ns     301ns  cuDeviceGetUuid
```

Kernel 3:

```
==40891== NVPROF is profiling process 40891, command: ./k3 ./matrix.txt ./test3_out.txt
==40891== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==40891== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   55.64%   122.21us         1   122.21us  122.21us  122.21us  k3(float*, float*, float*, int, int)
                   28.92%   63.518us         2   31.759us  31.551us  31.967us  [CUDA memcpy HtoD]
                   15.44%   33.919us         1   33.919us  33.919us  33.919us  [CUDA memcpy DtoH]
      API calls:   98.70%   89.819ms         3   29.940ms  4.4360us  89.808ms  cudaMalloc
                    0.70%   636.00us         3   212.00us  100.32us  421.39us  cudaMemcpy
                    0.22%   203.51us         1   203.51us  203.51us  203.51us  cudaLaunchKernel
                    0.20%   184.77us       114   1.6200us     145ns  102.76us  cuDeviceGetAttribute
                    0.15%   133.21us         3   44.403us  4.7770us  108.93us  cudaFree
                    0.01%   11.369us         1   11.369us  11.369us  11.369us  cuDeviceGetName
                    0.01%   5.0120us         1   5.0120us  5.0120us  5.0120us  cuDeviceGetPCIBusId
                    0.01%   4.6410us         1   4.6410us  4.6410us  4.6410us  cuDeviceTotalMem
                    0.00%   2.6940us         2   1.3470us     206ns  2.4880us  cuDeviceGet
                    0.00%   1.5730us         3     524ns     209ns  1.1360us  cuDeviceGetCount
                    0.00%     480ns         1     480ns     480ns     480ns  cuModuleGetLoadingMode
                    0.00%     237ns         1     237ns     237ns     237ns  cuDeviceGetUuid
```

For 1000 * 1000

Kernel 1:

```
==41884== NVPROF is profiling process 41884, command: ./k1 ./matrix.txt ./test1_out.txt
==41884== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==41884== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   52.40%   1.8002ms        1   1.8002ms  1.8002ms  1.8002ms  [CUDA memcpy DtoH]
                   40.76%   1.4004ms        2   700.18us  691.80us  708.57us  [CUDA memcpy HtoD]
                    6.84%   234.85us        1   234.85us  234.85us  234.85us  k1(float*, float*, float*, int, int)
      API calls:   93.85%   95.220ms        3   31.740ms  71.120us  95.069ms  cudaMalloc
                    5.13%   5.2072ms        3   1.7357ms  884.72us  3.4020ms  cudaMemcpy
                    0.65%   659.41us        3   219.80us  208.69us  228.42us  cudaFree
                    0.19%   194.20us        1   194.20us  194.20us  194.20us  cudaLaunchKernel
                    0.15%   151.77us      114   1.3310us     170ns  58.859us  cuDeviceGetAttribute
                    0.01%   12.368us        1   12.368us  12.368us  12.368us  cuDeviceGetName
                    0.01%   5.5470us        1   5.5470us  5.5470us  5.5470us  cuDeviceGetPCIBusId
                    0.00%   4.8130us        1   4.8130us  4.8130us  4.8130us  cuDeviceTotalMem
                    0.00%   1.8050us        3     601ns     266ns  1.2030us  cuDeviceGetCount
                    0.00%    978ns          2     489ns     195ns     783ns  cuDeviceGet
                    0.00%    678ns          1     678ns     678ns     678ns  cuModuleGetLoadingMode
                    0.00%    284ns          1     284ns     284ns     284ns  cuDeviceGetUuid
```

Kernel 2:

```
==41945== NVPROF is profiling process 41945, command: ./k2 ./matrix.txt ./test2_out.txt
==41945== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==41945== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   35.87%   1.7266ms        1   1.7266ms  1.7266ms  1.7266ms  k2(float*, float*, float*, int, int)
                   34.85%   1.6774ms        1   1.6774ms  1.6774ms  1.6774ms  [CUDA memcpy DtoH]
                   29.28%   1.4094ms        2   704.71us  698.10us  711.32us  [CUDA memcpy HtoD]
      API calls:   91.92%   87.276ms        3   29.092ms  86.917ms  87.102ms  cudaMalloc
                    7.01%   6.6547ms        3   2.2182ms  895.87us  4.8188ms  cudaMemcpy
                    0.65%   618.42us        3   206.14us  203.13us  208.66us  cudaFree
                    0.25%   232.74us        1   232.74us  232.74us  232.74us  cudaLaunchKernel
                    0.14%   137.15us      114   1.2030us     137ns  55.091us  cuDeviceGetAttribute
                    0.01%   11.124us        1   11.124us  11.124us  11.124us  cuDeviceGetName
                    0.01%   6.7660us        1   6.7660us  6.7660us  6.7660us  cuDeviceGetPCIBusId
                    0.00%   4.3230us        1   4.3230us  4.3230us  4.3230us  cuDeviceTotalMem
                    0.00%   1.9560us        3     652ns     224ns  1.5020us  cuDeviceGetCount
                    0.00%   1.1040us        2     552ns     187ns     917ns  cuDeviceGet
                    0.00%    543ns          1     543ns     543ns     543ns  cuModuleGetLoadingMode
                    0.00%    240ns          1     240ns     240ns     240ns  cuDeviceGetUuid
```

Kernel 3:

```
==42004== NVPROF is profiling process 42004, command: ./k3 ./matrix.txt ./test3_out.txt
==42004== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==42004== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   43.70%   1.6222ms        1   1.6222ms  1.6222ms  1.6222ms  [CUDA memcpy DtoH]
                   40.06%   1.4870ms        2   743.48us  702.97us  783.99us  [CUDA memcpy HtoD]
                   16.24%   602.78us        1   602.78us  602.78us  602.78us  k3(float*, float*, float*, int, int)
      API calls:   92.70%   81.923ms        3   27.308ms  72.442us  81.771ms  cudaMalloc
                    6.05%   5.3447ms        3   1.7816ms  870.68us  3.4464ms  cudaMemcpy
                    0.84%   740.40us        3   246.80us  242.38us  249.41us  cudaFree
                    0.24%   213.65us        1   213.65us  213.65us  213.65us  cudaLaunchKernel
                    0.15%   132.28us      114   1.1600us     145ns  52.738us  cuDeviceGetAttribute
                    0.01%   10.972us        1   10.972us  10.972us  10.972us  cuDeviceGetName
                    0.01%   5.5150us        1   5.5150us  5.5150us  5.5150us  cuDeviceGetPCIBusId
                    0.00%   4.3880us        1   4.3880us  4.3880us  4.3880us  cuDeviceTotalMem
                    0.00%   1.8690us        3     623ns     210ns  1.4050us  cuDeviceGetCount
                    0.00%    941ns          2     470ns     183ns     758ns  cuDeviceGet
                    0.00%    626ns          1     626ns     626ns     626ns  cuModuleGetLoadingMode
                    0.00%    249ns          1     249ns     249ns     249ns  cuDeviceGetUuid
```

For 10000*100

Kernel 1:

```
==43162== NVPROF is profiling process 43162, command: ./k1 ./matrix.txt ./test1_out.txt
==43162== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==43162== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   50.43%   1.6242ms         1   1.6242ms  1.6242ms  1.6242ms  [CUDA memcpy DtoH]
                   42.52%   1.3692ms         2   684.60us  681.88us  687.32us  [CUDA memcpy HtoD]
                    7.05%   227.10us         1   227.10us  227.10us  227.10us  k1(float*, float*, float*, int, int)
      API calls:   93.98%   92.316ms         3   30.772ms  76.044us  92.156ms  cudaMalloc
                    5.00%   4.9080ms         3   1.6360ms  864.32us  3.1301ms  cudaMemcpy
                    0.64%   629.20us         3   209.73us  201.86us  219.40us  cudaFree
                    0.21%   207.54us         1   207.54us  207.54us  207.54us  cudaLaunchKernel
                    0.14%   139.28us       114   1.2210us     136ns  55.701us  cuDeviceGetAttribute
                    0.01%   12.012us         1   12.012us  12.012us  12.012us  cuDeviceGetName
                    0.01%   5.7310us         1   5.7310us  5.7310us  5.7310us  cuDeviceGetPCIBusId
                    0.00%   4.6690us         1   4.6690us  4.6690us  4.6690us  cuDeviceTotalMem
                    0.00%   1.6210us         3     540ns     224ns  1.1290us  cuDeviceGetCount
                    0.00%   1.1040us         2     552ns     232ns     872ns  cuDeviceGet
                    0.00%     671ns         1     671ns     671ns     671ns  cuModuleGetLoadingMode
                    0.00%     207ns         1     207ns     207ns     207ns  cuDeviceGetUuid
```

Kernel 2:

```
==43221== NVPROF is profiling process 43221, command: ./k2 ./matrix.txt ./test2_out.txt
==43221== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==43221== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   48.39%   1.7316ms         1   1.7316ms  1.7316ms  1.7316ms  [CUDA memcpy DtoH]
                   39.47%   1.4125ms         2   706.26us  704.76us  707.77us  [CUDA memcpy HtoD]
                   12.14%   434.23us         1   434.23us  434.23us  434.23us  k2(float*, float*, float*, int, int)
      API calls:   93.29%   88.873ms         3   29.624ms  81.887us  88.678ms  cudaMalloc
                    5.60%   5.3394ms         3   1.7798ms  878.79us  3.5357ms  cudaMemcpy
                    0.68%   645.09us         3   215.03us  205.26us  226.50us  cudaFree
                    0.23%   222.26us         1   222.26us  222.26us  222.26us  cudaLaunchKernel
                    0.16%   154.50us       114   1.3550us     135ns  55.086us  cuDeviceGetAttribute
                    0.01%   13.533us         1   13.533us  13.533us  13.533us  cuDeviceGetName
                    0.01%   6.2270us         1   6.2270us  6.2270us  6.2270us  cuDeviceTotalMem
                    0.01%   5.4860us         1   5.4860us  5.4860us  5.4860us  cuDeviceGetPCIBusId
                    0.00%   2.0180us         3     672ns     245ns  1.4800us  cuDeviceGetCount
                    0.00%   1.0860us         2     543ns     231ns     855ns  cuDeviceGet
                    0.00%     544ns         1     544ns     544ns     544ns  cuModuleGetLoadingMode
                    0.00%     233ns         1     233ns     233ns     233ns  cuDeviceGetUuid
```

Kernel 3:

```
==43286== NVPROF is profiling process 43286, command: ./k3 ./matrix.txt ./test3_out.txt
==43286== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==43286== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   65.46%   5.7072ms         1   5.7072ms  5.7072ms  5.7072ms  k3(float*, float*, float*, int, int)
                   18.55%   1.6173ms         1   1.6173ms  1.6173ms  1.6173ms  [CUDA memcpy DtoH]
                   15.99%   1.3938ms         2   696.92us  691.80us  702.04us  [CUDA memcpy HtoD]
      API calls:   88.88%   90.702ms         3   30.234ms  71.165us  90.553ms  cudaMalloc
                   10.15%   10.358ms         3   3.4527ms  877.47us  8.5654ms  cudaMemcpy
                    0.61%   621.91us         3   207.30us  203.67us  209.39us  cudaFree
                    0.19%   194.96us         1   194.96us  194.96us  194.96us  cudaLaunchKernel
                    0.14%   147.71us       114   1.2950us     159ns  58.500us  cuDeviceGetAttribute
                    0.01%   11.740us         1   11.740us  11.740us  11.740us  cuDeviceGetName
                    0.01%   5.6760us         1   5.6760us  5.6760us  5.6760us  cuDeviceGetPCIBusId
                    0.00%   4.7420us         1   4.7420us  4.7420us  4.7420us  cuDeviceTotalMem
                    0.00%   1.7850us         3     595ns     222ns  1.2030us  cuDeviceGetCount
                    0.00%   1.0910us         2     545ns     202ns     889ns  cuDeviceGet
                    0.00%     584ns         1     584ns     584ns     584ns  cuModuleGetLoadingMode
                    0.00%     265ns         1     265ns     265ns     265ns  cuDeviceGetUuid
```

For 100 * 10000

Kernel 1:

```
==44074== NVPROF is profiling process 44074, command: ./k1 ./matrix.txt ./test1_out.txt
==44074== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==44074== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   50.26%   1.6463ms         1   1.6463ms  1.6463ms  1.6463ms  [CUDA memcpy DtoH]
                   41.80%   1.3692ms         2   684.61us  681.21us  688.02us  [CUDA memcpy HtoD]
                    7.94%   260.16us         1   260.16us  260.16us  260.16us  k1(float*, float*, float*, int, int)
      API calls:   93.90%   90.191ms         3   30.064ms  73.837us  90.041ms  cudaMalloc
                    5.11%   4.9050ms         3   1.6350ms  862.30us  3.1399ms  cudaMemcpy
                    0.63%   608.50us         3   202.83us  193.15us  211.31us  cudaFree
                    0.19%   179.41us         1   179.41us  179.41us  179.41us  cudaLaunchKernel
                    0.15%   144.61us       114   1.2680us    147ns   54.191us  cuDeviceGetAttribute
                    0.01%   11.645us         1   11.645us  11.645us  11.645us  cuDeviceGetName
                    0.01%   5.8310us         1   5.8310us  5.8310us  5.8310us  cuDeviceGetPCIBusId
                    0.01%   4.9080us         1   4.9080us  4.9080us  4.9080us  cuDeviceTotalMem
                    0.00%   1.9290us         3     643ns    269ns   1.3890us  cuDeviceGetCount
                    0.00%   1.1500us         2     575ns    182ns    968ns  cuDeviceGet
                    0.00%     614ns         1     614ns    614ns    614ns  cuModuleGetLoadingMode
                    0.00%     216ns         1     216ns    216ns    216ns  cuDeviceGetUuid
```

Kernel 2:

```
==44133== NVPROF is profiling process 44133, command: ./k2 ./matrix.txt ./test2_out.txt
==44133== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==44133== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   66.59%   5.8969ms         1   5.8969ms  5.8969ms  5.8969ms  k2(float*, float*, float*, int, int)
                   17.94%   1.5889ms         1   1.5889ms  1.5889ms  1.5889ms  [CUDA memcpy DtoH]
                   15.46%   1.3692ms         2   684.61us  676.66us  692.57us  [CUDA memcpy HtoD]
      API calls:   87.56%   81.398ms         3   27.133ms  82.670us  81.230ms  cudaMalloc
                   11.31%   10.513ms         3   3.5045ms  862.43us  8.7420ms  cudaMemcpy
                    0.68%   630.05us         3   210.02us  208.31us  212.00us  cudaFree
                    0.28%   259.86us         1   259.86us  259.86us  259.86us  cudaLaunchKernel
                    0.15%   138.38us       114   1.2130us    145ns   54.378us  cuDeviceGetAttribute
                    0.01%   11.371us         1   11.371us  11.371us  11.371us  cuDeviceGetName
                    0.01%   8.1590us         1   8.1590us  8.1590us  8.1590us  cuDeviceGetPCIBusId
                    0.00%   4.2680us         1   4.2680us  4.2680us  4.2680us  cuDeviceTotalMem
                    0.00%   1.6130us         3     537ns    184ns   1.1890us  cuDeviceGetCount
                    0.00%     925ns         2     462ns    183ns    742ns  cuDeviceGet
                    0.00%     563ns         1     563ns    563ns    563ns  cuModuleGetLoadingMode
                    0.00%     238ns         1     238ns    238ns    238ns  cuDeviceGetUuid
```

Kernel 3:

```
==44192== NVPROF is profiling process 44192, command: ./k3 ./matrix.txt ./test3_out.txt
==44192== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==44192== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   51.95%   1.6214ms         1   1.6214ms  1.6214ms  1.6214ms  [CUDA memcpy DtoH]
                   45.48%   1.4195ms         2   709.77us  699.41us  720.12us  [CUDA memcpy HtoD]
                    2.57%   80.286us         1   80.286us  80.286us  80.286us  k3(float*, float*, float*, int, int)
      API calls:   94.41%   100.16ms         3   33.386ms  74.580us  100.00ms  cudaMalloc
                    4.63%   4.9068ms         3   1.6356ms  891.18us  3.0862ms  cudaMemcpy
                    0.62%   661.96us         3   220.65us  209.61us  230.91us  cudaFree
                    0.18%   190.84us         1   190.84us  190.84us  190.84us  cudaLaunchKernel
                    0.13%   141.19us       114   1.2380us    143ns   54.283us  cuDeviceGetAttribute
                    0.01%   11.482us         1   11.482us  11.482us  11.482us  cuDeviceGetName
                    0.01%   5.6850us         1   5.6850us  5.6850us  5.6850us  cuDeviceGetPCIBusId
                    0.00%   5.0010us         1   5.0010us  5.0010us  5.0010us  cuDeviceTotalMem
                    0.00%   1.5720us         3     524ns    180ns   1.1100us  cuDeviceGetCount
                    0.00%     959ns         2     479ns    169ns    790ns  cuDeviceGet
                    0.00%     573ns         1     573ns    573ns    573ns  cuModuleGetLoadingMode
                    0.00%     219ns         1     219ns    219ns    219ns  cuDeviceGetUuid
```

For 3 test cases 30*50

Kernel 1:

```
==44705== NVPROF is profiling process 44705, command: ./k1 ./matrix.txt ./test1_out.txt
==44705== Profiling application: ./k1 ./matrix.txt ./test1_out.txt
==44705== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   61.86%  22.943us         3  7.6470us  7.4240us  7.7760us  k1(float*, float*, float*, int, int)
                   20.71%  7.6800us         6  1.2800us  1.0880us  1.5360us  [CUDA memcpy HtoD]
                   17.43%  6.4640us         3  2.1540us  1.9520us  2.5280us  [CUDA memcpy DtoH]
      API calls:   99.16%  91.049ms         9  10.117ms  2.7580us  90.852ms  cudaMalloc
                    0.29%  267.00us         9  29.666us  2.9100us  95.781us  cudaFree
                    0.21%  193.85us         3  64.615us  12.663us  164.14us  cudaLaunchKernel
                    0.16%  145.65us         9  16.183us  8.9560us  27.316us  cudaMemcpy
                    0.15%  137.16us       114  1.2030us     146ns  55.057us  cuDeviceGetAttribute
                    0.01%  10.552us         1  10.552us  10.552us  10.552us  cuDeviceGetName
                    0.01%  5.9880us         1  5.9880us  5.9880us  5.9880us  cuDeviceGetPCIBusId
                    0.00%  4.4420us         1  4.4420us  4.4420us  4.4420us  cuDeviceTotalMem
                    0.00%  1.6330us         3     544ns     197ns  1.0590us  cuDeviceGetCount
                    0.00%     913ns         2     456ns     198ns     715ns  cuDeviceGet
                    0.00%     600ns         1     600ns     600ns     600ns  cuModuleGetLoadingMode
                    0.00%     234ns         1     234ns     234ns     234ns  cuDeviceGetUuid
```

Kernel 2:

```
==44760== NVPROF is profiling process 44760, command: ./k2 ./matrix.txt ./test2_out.txt
==44760== Profiling application: ./k2 ./matrix.txt ./test2_out.txt
==44760== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   79.84%  56.030us         3  18.676us  18.176us  19.263us  k2(float*, float*, float*, int, int)
                   11.17%  7.8400us         6  1.3060us  1.1520us  1.5680us  [CUDA memcpy HtoD]
                    8.98%  6.3040us         3  2.1010us  1.9520us  2.4000us  [CUDA memcpy DtoH]
      API calls:   98.87%  78.184ms         9  8.6871ms  2.8240us  77.959ms  cudaMalloc
                    0.37%  296.54us         9  32.949us  2.9710us  98.267us  cudaFree
                    0.29%  232.42us         3  77.472us  13.983us  202.23us  cudaLaunchKernel
                    0.23%  185.69us         9  20.631us  9.0460us  37.748us  cudaMemcpy
                    0.18%  138.75us       114  1.2170us     152ns  55.288us  cuDeviceGetAttribute
                    0.03%  23.100us         1  23.100us  23.100us  23.100us  cuDeviceGetPCIBusId
                    0.01%  11.775us         1  11.775us  11.775us  11.775us  cuDeviceGetName
                    0.01%  4.6120us         1  4.6120us  4.6120us  4.6120us  cuDeviceTotalMem
                    0.00%  1.7970us         3     599ns     186ns  1.2400us  cuDeviceGetCount
                    0.00%  1.0840us         2     542ns     215ns     869ns  cuDeviceGet
                    0.00%     652ns         1     652ns     652ns     652ns  cuModuleGetLoadingMode
                    0.00%     241ns         1     241ns     241ns     241ns  cuDeviceGetUuid
```

Kernel 3:

```
==44815== NVPROF is profiling process 44815, command: ./k3 ./matrix.txt ./test3_out.txt
==44815== Profiling application: ./k3 ./matrix.txt ./test3_out.txt
==44815== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   74.89%  42.559us         3  14.186us  13.887us  14.432us  k3(float*, float*, float*, int, int)
                   13.80%  7.8400us         6  1.3060us  1.1200us  1.5680us  [CUDA memcpy HtoD]
                   11.32%  6.4320us         3  2.1440us  1.9520us  2.5280us  [CUDA memcpy DtoH]
      API calls:   99.15%  99.667ms         9  11.074ms  2.7310us  99.412ms  cudaMalloc
                    0.29%  293.26us         9  32.584us  2.8020us  96.534us  cudaFree
                    0.21%  212.88us         3  70.961us  14.931us  181.00us  cudaLaunchKernel
                    0.17%  169.02us         9  18.780us  9.3350us  33.343us  cudaMemcpy
                    0.16%  156.47us       114  1.3720us     144ns  53.970us  cuDeviceGetAttribute
                    0.01%  10.889us         1  10.889us  10.889us  10.889us  cuDeviceGetName
                    0.01%  6.6980us         1  6.6980us  6.6980us  6.6980us  cuDeviceGetPCIBusId
                    0.00%  4.0000us         1  4.0000us  4.0000us  4.0000us  cuDeviceTotalMem
                    0.00%  1.7860us         3     595ns     285ns  1.1810us  cuDeviceGetCount
                    0.00%  1.0330us         2     516ns     208ns     825ns  cuDeviceGet
                    0.00%     664ns         1     664ns     664ns     664ns  cuModuleGetLoadingMode
                    0.00%     326ns         1     326ns     326ns     326ns  cuDeviceGetUuid
```

# Conclusion

**For test case 1: 100 * 300**

we had number of rows < number of columns.

1. K1 will be faster.
2. K3 faster than k2 because number threads are larger in k3, so the threads compute fewer numbers than in k2.

**For test case 2: 300 * 300:**

we had number of rows = number of columns.

1. K1 will be faster.
2. K3 is faster as it moves by rows to calculate column which may be faster them k2 which moves by columns to calculate the row.

**For test case 3: 1000 * 1000:**

we had number of rows = number of columns.

1. K1 will be faster.
2. K3 is faster as it moves by rows to calculate column which may be faster them k2 which moves by columns to calculate the row.

**For test case 4: 10000*100:**

we had number of rows > number of columns.

1. K1 will be faster.
2. K2 faster than k3 because number threads are larger in k2, so the threads compute fewer numbers than in k3.

**For test case 5: 100 * 10000:**

we had number of rows < number of columns.

1. K1 will be faster.
2. K3 faster than k2 because number threads are larger in k3, so the threads compute fewer numbers than in k2.

**For test case 6: 3 test cases 30 * 50:**

we had number of rows < number of columns.

1. K1 will be faster.
2. K3 faster than k2 because number threads are larger in k3, so the threads compute fewer numbers than in k2.