

# CS 4111 Introduction to Parallel Computing

## HW4: Bitcoin Miner (CUDA)

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Name, Student ID

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### Implementation & Parallelization Techniques

In this assignment, I modified the sequential version of code and convert it into a parallel version using OpenMP and CUDA. I would explain the keypoint of my implementation following the procedure section of sequential code (similar to p15 in *HW4.pdf*).

#### Step 1. Read Input

I did not modify the coding logic in the I/O part since it seems to be always sequential, there is no more efficient ways to handle it or they are not feasible for me.

The only thing I do is to move it to the `main` function because I had modified the `solve` function to be a kernel function. Since the input can only be read once and all kernel functions would share the same input (block information), there is no need and is more intelligent to move this part to `main` and let CPU to do the task.

#### Step 2. Calculate Merkle Root

This part of code is originally in `solve` function in the sequential version. Again, I moved it to `main` and keep it as a host function. The reason why I choose to let CPU do the task is because I think the task is not heavy enough for GPU to do. There are only a few transactions in most datasets, if we convert it to be handled in a kernel function, there will be much communication cost.

Note: I did not do experiment on it. Yet, CPU did not run for a significantly long time in this function.

Although I let CPU to do the task, I have tried to make it more efficient by using **OpenMP** to distribute the for loop on calculating the address of merkle branch.

#### Step 3. Decode Find Out the Target Difficulty

This part is kept in `solve` (kernel) function in my implementation. Since every worker needs to know the target difficulty and that it does not take long time to calculate. I simply make all workers calculate by themselves as local variables.

#### Step 4. Proof-of-Work: FindNonce

This is the main parallel section of the program. Since this part is independent and is entirely a job that does not require much communication unless you find the target nonce, I distribute the works statically that every thread has a designated range of nonces to try. The only communication flag is `__device__ bool flag`,

which would only be false when someone find a target nonce. So, the logic is quite simple: do your job until you find a target nonce or someone found it and raise the flag (to false).

To make this part of code able the perform concurrently in a kernel function, I have made all functions which will be used to be both `_host_` and `_device_` (not only `_device_` since some functions are also used in calculating merkle root, which is a host function). Also, all variables that will be used in this part is copied into the kernel function in advance using `cudaMemcpyAsync()`. After a worker finds the nonce the raise the flag (to false), only `ans_cuda` which is set to be `block.nonce` will be copied back to the host for CPU to write.

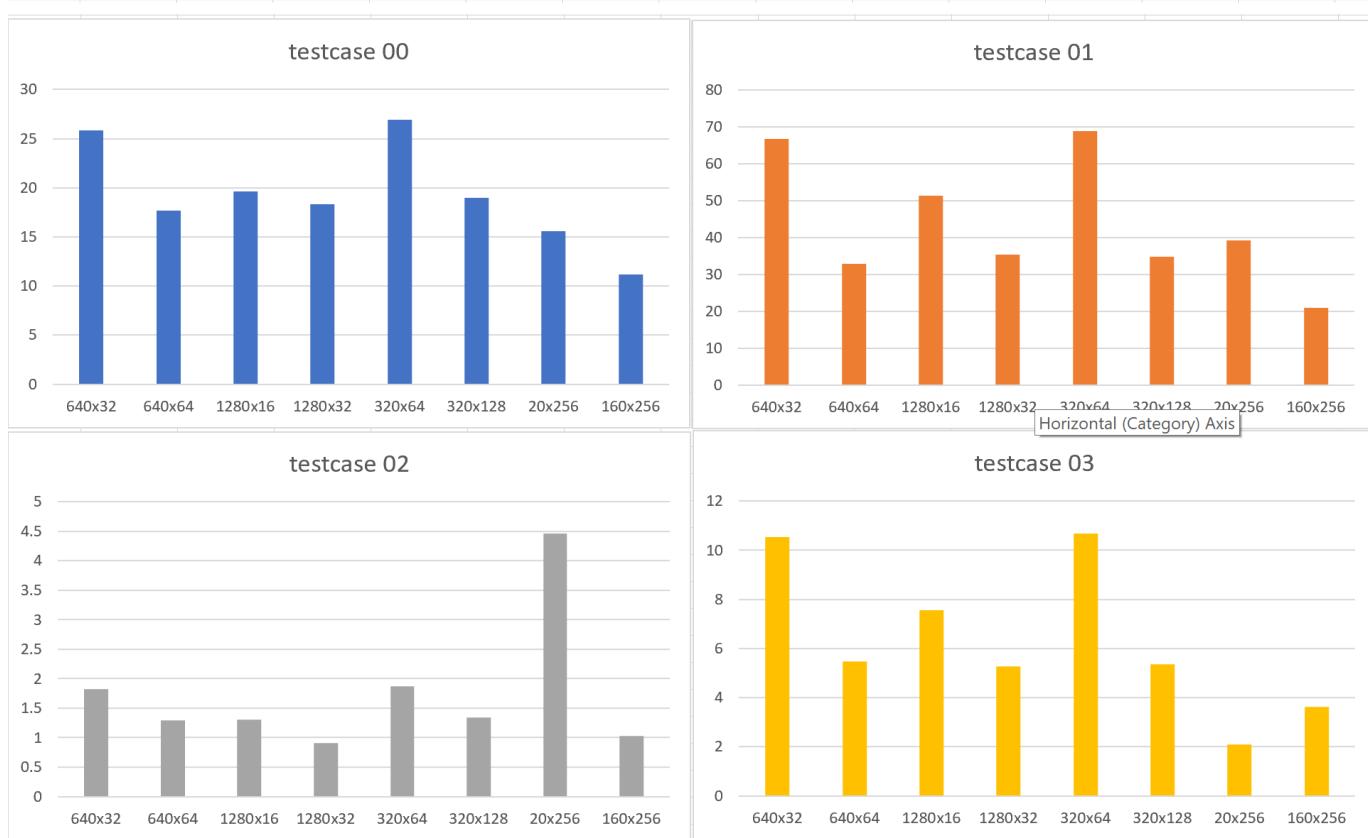
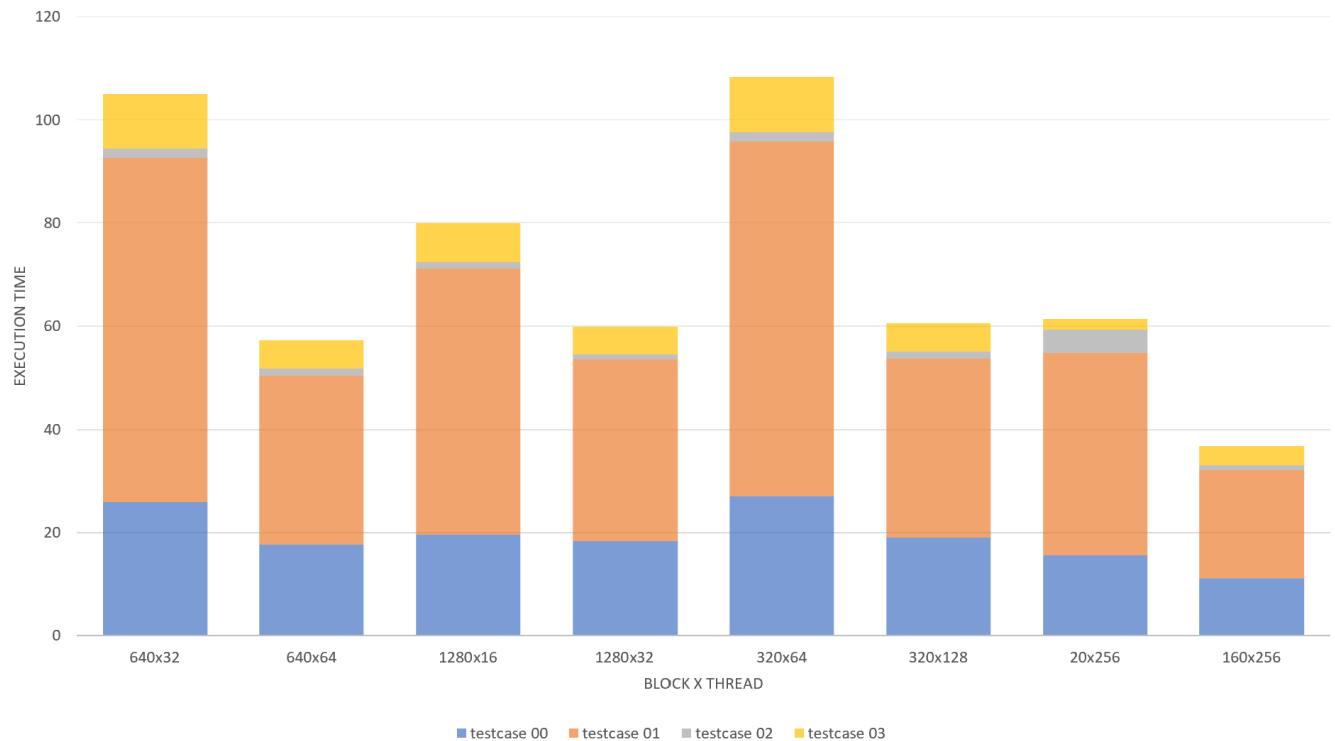
## Experiments of various combinations of the number of blocks & threads

I have tried the following combinations and recorded the execution time:

<b>block x thread</b>	<b>testcase 00</b>	<b>testcase 01</b>	<b>testcase 02</b>	<b>testcase 03</b>
640x32	25.8161	66.8161	1.82485	10.54
640x64	17.66	32.7903	1.2999	5.47785
1280x16	19.5876	51.4497	1.30588	7.56998
1280x32	18.2875	35.3564	<b>0.91367</b>	5.26826
320x64	26.9197	68.8197	1.87652	10.6844
320x128	18.9491	34.824	1.34041	5.35344
20x256	15.6041	39.2305	4.46654	2.08276
160x256	<b>11.1814</b>	<b>20.8962</b>	1.02685	<b>3.61493</b>

For the screen captures of each result, please refer to the **Appendix** (at the end of this report).

## EXPERIMENT RESULT



Therefore, I picked the combination <<<160,256>>> to be my configuration of number of blocks & threads.

**Appendix: Screenshots of nvprof results of every combinations**

- # block: 640, # thread: 32, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/00/case00.in 00.out
==10504== NVPROF is profiling process 10504, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 640 Thread: 32
==10504== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==10504== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 25.8161s           1 25.8161s  25.8161s  25.8161s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 7.7450us        6 1.2900us  1.0880us  1.9200us [CUDA memcpy HtoD]
          0.00% 1.0880us        1 1.0880us  1.0880us  1.0880us clearflag(void)
          0.00% 928ns          1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls: 99.42% 25.8161s           1 25.8161s  25.8161s  25.8161s cudaMemcpy
          0.58% 150.40ms        9 16.711ms  3.5780us 150.36ms  cudaMalloc
          0.00% 543.33us        4 135.83us  6.4700us 521.11us  cudaHostAlloc
          0.00% 212.65us        1 212.65us  212.65us  212.65us cuDeviceTotalMem
          0.00% 155.66us        96 1.6210us  155ns   64.791us  cuDeviceGetAttribute
          0.00% 134.07us        1 134.07us  134.07us  134.07us  cudaGetDeviceProperties
          0.00% 114.51us        9 12.723us  3.0960us 72.999us  cudaFree
          0.00% 86.462us        2 43.231us  27.373us  59.089us  cudaLaunchKernel
          0.00% 33.540us        6 5.5900us  1.8960us 17.291us  cudaMemcpyAsync
          0.00% 22.477us        1 22.477us  22.477us  22.477us  cuDeviceGetName
          0.00% 21.752us        4 5.4380us  427ns   8.6800us  cudaFreeHost
          0.00% 14.791us        1 14.791us  14.791us  14.791us  cudaGetDevice
          0.00% 12.416us        1 12.416us  12.416us  12.416us  cuDeviceGetPCIBusId
          0.00% 8.6020us        1 8.6020us  8.6020us  8.6020us  cudaDeviceSynchronize
          0.00% 1.1680us        3   389ns   135ns   798ns  cuDeviceGetCount
          0.00% 696ns          2   348ns   138ns   558ns  cuDeviceGet
          0.00% 219ns          1   219ns   219ns   219ns  cuDeviceGetUuid
```

- # block: 640, # thread: 32, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/01/case01.in 01.out
==10454== NVPROF is profiling process 10454, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 640 Thread: 32
==10454== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==10454== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 66.8161s           4 16.7040s  6.96524s 37.7725s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 15.872us        24   661ns   512ns  1.1840us [CUDA memcpy HtoD]
          0.00% 4.3520us        4 1.0880us  1.0880us  1.0880us clearflag(void)
          0.00% 3.3920us        4   848ns   736ns   992ns [CUDA memcpy DtoH]
API calls: 99.77% 66.8161s           4 16.7040s  6.96524s 37.7725s cudaMemcpy
          0.23% 155.40ms        36 4.3166ms  3.6750us 155.01ms  cudaMalloc
          0.00% 626.02us        16 39.126us  5.6260us 519.10us  cudaHostAlloc
          0.00% 409.43us        36 11.372us  2.8160us 77.091us  cudaFree
          0.00% 216.63us        1 216.63us  216.63us  216.63us  cuDeviceTotalMem
          0.00% 171.70us        8 21.462us  10.140us 57.976us  cudaLaunchKernel
          0.00% 156.10us        96 1.6260us  155ns   64.409us  cuDeviceGetAttribute
          0.00% 135.91us        1 135.91us  135.91us  135.91us  cudaGetDeviceProperties
          0.00% 96.616us        24 4.0250us  1.8820us 17.373us  cudaMemcpyAsync
          0.00% 75.170us        16 4.6980us  489ns   9.1080us  cudaFreeHost
          0.00% 25.654us        1 25.654us  25.654us  25.654us  cuDeviceGetName
          0.00% 18.703us        4 4.6750us  3.2360us 7.7070us  cudaDeviceSynchronize
          0.00% 14.862us        1 14.862us  14.862us  14.862us  cudaGetDevice
          0.00% 12.577us        1 12.577us  12.577us  12.577us  cuDeviceGetPCIBusId
          0.00% 1.1560us        3   385ns   165ns   776ns  cuDeviceGetCount
          0.00% 624ns          2   312ns   155ns   469ns  cuDeviceGet
          0.00% 276ns          1   276ns   276ns   276ns  cuDeviceGetUuid
```

- # block: 640, # thread: 32, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/02/case02.in 02.out
==32110== NVPROF is profiling process 32110, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 640 Thread: 32
==32110== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==32110== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 1.82485s           1 1.82485s  1.82485s  1.82485s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.8400us        6   640ns   544ns   896ns  [CUDA memcpy HtoD]
          0.00% 1.0880us        1 1.0880us  1.0880us  1.0880us clearflag(void)
          0.00% 928ns          1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls: 92.15% 1.82485s           1 1.82485s  1.82485s  1.82485s cudaMemcpy
          7.78% 154.09ms        9 17.121ms  3.7440us 154.05ms  cudaMalloc
          0.03% 572.17us        4 143.04us  6.4360us 551.00us  cudaHostAlloc
          0.01% 191.69us        96 1.9960us  111ns   82.495us  cuDeviceGetAttribute
          0.01% 178.01us        1 178.01us  178.01us  178.01us  cudaGetDeviceProperties
          0.01% 170.02us        1 170.02us  170.02us  170.02us  cuDeviceTotalMem
          0.01% 106.61us        9 11.845us  2.9960us 72.142us  cudaFree
          0.00% 71.840us        2 35.920us  14.007us 57.833us  cudaLaunchKernel
          0.00% 34.026us        6 5.6710us  1.9430us 17.776us  cudaMemcpyAsync
          0.00% 22.546us        1 22.546us  22.546us  22.546us  cuDeviceGetName
          0.00% 18.738us        4 4.6840us  547ns   7.4160us  cudaFreeHost
          0.00% 11.744us        1 11.744us  11.744us  11.744us  cudaGetDevice
          0.00% 7.1360us        1 7.1360us  7.1360us  7.1360us  cuDeviceGetPCIBusId
          0.00% 6.4480us        1 6.4480us  6.4480us  6.4480us  cudaDeviceSynchronize
          0.00% 995ns          3   331ns   104ns   714ns  cuDeviceGetCount
          0.00% 483ns          2   241ns   108ns   375ns  cuDeviceGet
          0.00% 178ns          1   178ns   178ns   178ns  cuDeviceGetUuid
```

- # block: 640, # thread: 32, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==32138== NVPROF is profiling process 32138, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 640 Thread: 32
==32138== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==32138== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 10.5400s           1 10.5400s 10.5400s 10.5400s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.8080us      6   634ns   544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.1200us      1  1.1200us  1.1200us  1.1200us clearflag(void)
          0.00% 960ns        1   960ns   960ns   960ns [CUDA memcpy DtoH]
API calls:  98.50% 10.5400s           1 10.5400s 10.5400s 10.5400s cudaMemcpy
          1.48% 158.75ms      9 17.639ms  3.7090us 158.71ms cudaMalloc
          0.01% 570.12us      4 142.53us  6.2700us 550.12us cudaHostAlloc
          0.00% 183.74us     96 1.9140us  111ns 79.033us cuDeviceGetAttribute
          0.00% 173.59us      1 173.59us 173.59us 173.59us cudaGetDeviceProperties
          0.00% 166.88us      1 166.88us 166.88us 166.88us cuDeviceTotalMem
          0.00% 123.97us      9 13.774us  2.7690us 83.904us cudaFree
          0.00% 80.962us      2 40.481us  24.197us 56.765us cudaLaunchKernel
          0.00% 32.953us      6 5.4920us 1.9000us 17.426us cudaMemcpyAsync
          0.00% 24.773us      1 24.773us 24.773us 24.773us cuDeviceGetName
          0.00% 19.657us      4 4.9140us 484ns 7.7030us cudaFreeHost
          0.00% 11.958us      1 11.958us 11.958us 11.958us cudaGetDevice
          0.00% 7.2660us      1 7.2660us 7.2660us 7.2660us cudaDeviceSynchronize
          0.00% 7.0170us      1 7.0170us 7.0170us 7.0170us cuDeviceGetPCIBusId
          0.00% 893ns         3   297ns   96ns   621ns cuDeviceGetCount
          0.00% 398ns         2   199ns   109ns   289ns cuDeviceGet
          0.00% 157ns         1   157ns   157ns   157ns cuDeviceGetUuid
```

- # block: 640, # thread: 64, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/00/case00.in 00.out
==8747== NVPROF is profiling process 8747, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 640 Thread: 64
==8747== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==8747== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 17.6600s           1 17.6600s 17.6600s 17.6600s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.5360us      6   922ns   800ns 1.2160us [CUDA memcpy HtoD]
          0.00% 1.2800us      1  1.2800us 1.2800us 1.2800us [CUDA memcpy DtoH]
          0.00% 1.1200us      1  1.1200us 1.1200us 1.1200us clearflag(void)
API calls:  99.18% 17.6600s           1 17.6600s 17.6600s 17.6600s cudaMemcpy
          0.82% 145.21ms      9 16.134ms 3.7820us 145.17ms cudaMalloc
          0.00% 547.44us      4 136.86us 6.1500us 524.99us cudaHostAlloc
          0.00% 211.66us      1 211.66us 211.66us 211.66us cuDeviceTotalMem
          0.00% 154.19us     96 1.6060us 154ns 64.192us cuDeviceGetAttribute
          0.00% 134.76us      1 134.76us 134.76us 134.76us cudaGetDeviceProperties
          0.00% 119.06us      9 13.229us 3.0900us 73.554us cudaFree
          0.00% 82.640us      2 41.320us 24.902us 57.738us cudaLaunchKernel
          0.00% 33.627us      6 5.6040us 1.8630us 17.376us cudaMemcpyAsync
          0.00% 21.731us      4 5.4320us 473ns 8.5010us cudaFreeHost
          0.00% 20.195us      1 20.195us 20.195us 20.195us cuDeviceGetName
          0.00% 15.249us      1 15.249us 15.249us 15.249us cudaGetDevice
          0.00% 12.605us      1 12.605us 12.605us 12.605us cuDeviceGetPCIBusId
          0.00% 8.4450us      1 8.4450us 8.4450us 8.4450us cudaDeviceSynchronize
          0.00% 1.1300us      3   376ns   150ns 753ns cuDeviceGetCount
          0.00% 733ns         2   366ns   168ns 565ns cuDeviceGet
          0.00% 230ns         1   230ns   230ns 230ns cuDeviceGetUuid
```

- # block: 640, # thread: 64, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/01/case01.in 01.out
==8796== NVPROF is profiling process 8796, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 640 Thread: 64
==8796== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==8796== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 32.7903s           4 8.19758s 3.47354s 17.9828s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 16.096us     24   670ns   512ns 1.2160us [CUDA memcpy HtoD]
          0.00% 4.3520us     4  1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 3.3920us     4   848ns   736ns 960ns [CUDA memcpy DtoH]
API calls:  99.55% 32.7903s           4 8.19758s 3.47355s 17.9828s cudaMemcpy
          0.45% 146.81ms     36 4.0781ms 3.7350us 146.41ms cudaMalloc
          0.00% 621.08us     16 38.817us 5.4670us 513.29us cudaHostAlloc
          0.00% 403.45us     36 11.207us 2.7890us 75.056us cudaFree
          0.00% 166.71us      1 166.71us 166.71us 166.71us cuDeviceTotalMem
          0.00% 166.23us      1 166.23us 166.23us 166.23us cudaGetDeviceProperties
          0.00% 164.20us      8 20.524us 9.4360us 60.804us cudaLaunchKernel
          0.00% 120.62us     96 1.2560us 110ns 50.681us cuDeviceGetAttribute
          0.00% 96.341us     24 4.0140us 1.9690us 17.769us cudaMemcpyAsync
          0.00% 74.408us     16 4.6500us 506ns 8.0880us cudaFreeHost
          0.00% 17.516us     4 4.3790us 2.9090us 7.5640us cudaDeviceSynchronize
          0.00% 16.780us     1 16.780us 16.780us 16.780us cuDeviceGetName
          0.00% 11.576us     1 11.576us 11.576us 11.576us cudaGetDevice
          0.00% 6.5690us     1 6.5690us 6.5690us 6.5690us cuDeviceGetPCIBusId
          0.00% 1.3050us     3   435ns   93ns 1.0500us cuDeviceGetCount
          0.00% 472ns         2   236ns   111ns 361ns cuDeviceGet
          0.00% 187ns         1   187ns   187ns 187ns cuDeviceGetUuid
```

- # block: 640, # thread: 64, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./ testcase/02/case02.in 02.out
==8955== NVPROF is profiling process 8955, command: ./cuda_miner ./ testcase/02/case02.in 02.out
Block: 640 Thread: 64
==8955== Profiling application: ./cuda_miner ./ testcase/02/case02.in 02.out
==8955== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 1.29990s           1 1.29990s 1.29990s 1.29990s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.5360us      6    922ns   800ns 1.2160us [CUDA memcpy HtoD]
          0.00% 1.2160us      1  1.2160us 1.2160us 1.2160us clearflag(void)
          0.00% 992ns        1    992ns   992ns 992ns [CUDA memcpy DtoH]
API calls: 89.76% 1.29990s      1 1.29990s 1.29990s 1.29990s cudaMemcpy
          10.14% 146.86ms      9 16.318ms 3.7430us 146.82ms cudaMalloc
          0.04% 565.82us      4 141.45us 5.8030us 545.43us cudaHostAlloc
          0.01% 214.96us      1 214.96us 214.96us 214.96us cuDeviceTotalMem
          0.01% 155.30us      96 1.6170us 155ns 63.974us cuDeviceGetAttribute
          0.01% 136.78us      1 136.78us 136.78us 136.78us cudaGetDeviceProperties
          0.01% 92.477us      9 10.275us 2.9350us 58.158us cudaFree
          0.01% 73.684us      2 36.842us 15.973us 57.711us cudaLaunchKernel
          0.00% 33.599us      6 5.5990us 2.0080us 17.453us cudaMemcpyAsync
          0.00% 22.601us      1 22.601us 22.601us 22.601us cuDeviceGetName
          0.00% 21.618us      4 5.4040us 453ns 10.909us cudaFreeHost
          0.00% 18.790us      1 18.790us 18.790us 18.790us cuDeviceGetPCIBusId
          0.00% 15.287us      1 15.287us 15.287us 15.287us cudaGetDevice
          0.00% 6.7800us      1 6.7800us 6.7800us 6.7800us cuDeviceSynchronize
          0.00% 1.1300us      3 376ns   135ns 777ns cuDeviceGetCount
          0.00% 613ns        2 306ns   132ns 481ns cuDeviceGet
          0.00% 257ns        1 257ns   257ns 257ns cuDeviceGetUuid
```

- # block: 640, # thread: 64, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./ testcase/03/case03.in 03.out
==9105== NVPROF is profiling process 9105, command: ./cuda_miner ./ testcase/03/case03.in 03.out
Block: 640 Thread: 64
==9105== Profiling application: ./cuda_miner ./ testcase/03/case03.in 03.out
==9105== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 5.47785s           1 5.47785s 5.47785s 5.47785s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.5040us      6    917ns   800ns 1.2160us [CUDA memcpy HtoD]
          0.00% 1.0880us      1  1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 960ns        1    960ns   960ns 960ns [CUDA memcpy DtoH]
API calls: 97.23% 5.47785s      1 5.47785s 5.47785s 5.47785s cudaMemcpy
          2.75% 154.91ms      9 17.212ms 3.9260us 154.85ms cudaMalloc
          0.01% 560.06us      4 140.02us 6.8110us 538.42us cudaHostAlloc
          0.00% 214.59us      1 214.59us 214.59us 214.59us cuDeviceTotalMem
          0.00% 155.19us      96 1.6160us 153ns 64.189us cuDeviceGetAttribute
          0.00% 135.73us      1 135.73us 135.73us 135.73us cudaGetDeviceProperties
          0.00% 109.21us      9 12.134us 2.9360us 70.178us cudaFree
          0.00% 83.853us      2 41.926us 23.540us 60.313us cudaLaunchKernel
          0.00% 35.237us      6 5.8720us 2.1250us 18.524us cudaMemcpyAsync
          0.00% 22.075us      1 22.075us 22.075us 22.075us cuDeviceGetName
          0.00% 20.209us      4 5.0520us 551ns 7.8490us cudaFreeHost
          0.00% 14.684us      1 14.684us 14.684us 14.684us cudaGetDevice
          0.00% 12.059us      1 12.059us 12.059us 12.059us cuDeviceGetPCIBusId
          0.00% 6.9700us      1 6.9700us 6.9700us 6.9700us cuDeviceSynchronize
          0.00% 1.2200us      3 406ns   145ns 815ns cuDeviceGetCount
          0.00% 629ns        2 314ns   145ns 484ns cuDeviceGet
          0.00% 256ns        1 256ns   256ns 256ns cuDeviceGetUuid
```

- # block: 1280, # thread: 16, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./ testcase/00/case00.in 00.out
==488== NVPROF is profiling process 488, command: ./cuda_miner ./ testcase/00/case00.in 00.out
Block: 1280 Thread: 16
==488== Profiling application: ./cuda_miner ./ testcase/00/case00.in 00.out
==488== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 19.5876s           1 19.5876s 19.5876s 19.5876s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.6800us      6    613ns   544ns 768ns [CUDA memcpy HtoD]
          0.00% 1.2160us      1  1.2160us 1.2160us 1.2160us clearflag(void)
          0.00% 960ns        1    960ns   960ns 960ns [CUDA memcpy DtoH]
API calls: 99.16% 19.5876s      1 19.5876s 19.5876s 19.5876s cudaMemcpy
          0.83% 163.51ms      9 18.168ms 3.6160us 163.47ms cudaMalloc
          0.00% 573.18us      4 143.30us 6.3870us 550.87us cudaHostAlloc
          0.00% 206.49us      1 206.49us 206.49us 206.49us cudaGetDeviceProperties
          0.00% 190.86us      96 1.9880us 111ns 82.529us cuDeviceGetAttribute
          0.00% 167.00us      1 167.00us 167.00us 167.00us cuDeviceTotalMem
          0.00% 124.50us      9 13.833us 3.0990us 83.477us cudaFree
          0.00% 82.169us      2 41.084us 25.947us 56.222us cudaLaunchKernel
          0.00% 34.245us      6 5.7070us 1.9160us 17.612us cudaMemcpyAsync
          0.00% 24.262us      1 24.262us 24.262us 24.262us cuDeviceGetName
          0.00% 23.008us      4 5.7520us 547ns 9.0780us cudaFreeHost
          0.00% 11.557us      1 11.557us 11.557us 11.557us cudaGetDevice
          0.00% 7.0980us      1 7.0980us 7.0980us 7.0980us cudaDeviceSynchronize
          0.00% 6.6360us      1 6.6360us 6.6360us 6.6360us cuDeviceGetPCIBusId
          0.00% 917ns        3 305ns   96ns 598ns cuDeviceGetCount
          0.00% 553ns        2 276ns   107ns 446ns cuDeviceGet
          0.00% 175ns        1 175ns   175ns 175ns cuDeviceGetUuid
```

- # block: 1280, # thread: 16, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/01/case01.in 01.out
==544== NVPROF is profiling process 544, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 1280 Thread: 16
==544== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==544== Profiling result:
      Type Time(%)     Time    Calls      Avg      Min      Max   Name
GPU activities: 100.00% 51.4497s           4 12.8624s  5.34319s 29.4091s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
              0.00% 14.112us    24    588ns   544ns   864ns [CUDA memcpy HtoD]
              0.00% 4.4480us     4 1.1120us  1.0880us  1.1200us clearflag(void)
              0.00% 3.3600us     4    840ns   736ns   960ns [CUDA memcpy DtoH]
API calls:  99.71% 51.4497s           4 12.8624s  5.34320s 29.4091s cudaMemcpy
              0.28% 145.38ms    36 4.0383ms  3.6210us 144.95ms cudaMalloc
              0.00% 659.36us    16 41.210us  5.4940us 552.90us cudaHostAlloc
              0.00% 461.14us    36 12.809us  2.8000us 89.772us cudaFree
              0.00% 181.70us    96 1.8920us  109ns  75.946us cuDeviceGetAttribute
              0.00% 178.19us     8 22.273us  9.8230us 57.621us cudaLaunchKernel
              0.00% 173.78us     1 173.78us  173.78us 173.78us cudaGetDeviceProperties
              0.00% 167.36us     1 167.36us  167.36us 167.36us cuDeviceTotalMem
              0.00% 97.348us    24 4.0560us  1.9010us 17.477us cudaMemcpyAsync
              0.00% 75.142us    16 4.6960us  455ns   8.4130us cudaFreeHost
              0.00% 48.616us     1 48.616us  48.616us 48.616us cuDeviceGetName
              0.00% 18.917us     4 4.7290us  3.2640us 7.3820us cudaDeviceSynchronize
              0.00% 11.657us     1 11.657us  11.657us 11.657us cudaGetDevice
              0.00% 6.8260us     1 6.8260us  6.8260us 6.8260us cuDeviceGetPCIBusId
              0.00% 852ns        3    284ns   94ns   622ns cuDeviceGetCount
              0.00% 507ns        2    253ns   122ns   385ns cuDeviceGet
              0.00% 158ns        1    158ns   158ns   158ns cuDeviceGetUuid
```

- # block: 1280, # thread: 16, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/02/case02.in 02.out
==596== NVPROF is profiling process 596, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 1280 Thread: 16
==596== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==596== Profiling result:
      Type Time(%)     Time    Calls      Avg      Min      Max   Name
GPU activities: 100.00% 1.30588s          1 1.30588s  1.30588s 1.30588s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
              0.00% 3.7440us    6    624ns   544ns   768ns [CUDA memcpy HtoD]
              0.00% 1.1200us    1 1.1200us  1.1200us 1.1200us clearflag(void)
              0.00% 928ns       1    928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  88.72% 1.30589s          1 1.30589s  1.30589s 1.30589s cudaMemcpy
           11.18% 164.53ms    9 18.281ms  3.6900us 164.49ms cudaMalloc
           0.04% 543.63us     4 135.91us  6.0130us 523.02us cudaHostAlloc
           0.02% 242.11us    96 2.5220us  154ns  106.40us cuDeviceGetAttribute
           0.01% 218.07us     1 218.07us  218.07us 218.07us cudaGetDeviceProperties
           0.01% 211.51us     1 211.51us  211.51us 211.51us cuDeviceTotalMem
           0.01% 116.36us     9 12.928us  2.8300us 80.751us cudaFree
           0.01% 75.477us     2 37.738us  18.142us 57.335us cudaLaunchKernel
           0.00% 33.497us     6 5.5820us  1.8840us 17.642us cudaMemcpyAsync
           0.00% 30.572us     1 30.572us  30.572us 30.572us cuDeviceGetName
           0.00% 20.124us     4 5.0310us  530ns  7.7020us cudaFreeHost
           0.00% 15.435us     1 15.435us  15.435us 15.435us cudaGetDevice
           0.00% 12.499us     1 12.499us  12.499us 12.499us cuDeviceGetPCIBusId
           0.00% 7.1250us     1 7.1250us  7.1250us 7.1250us cudaDeviceSynchronize
           0.00% 1.1780us     3    392ns   141ns   824ns cuDeviceGetCount
           0.00% 619ns        2    309ns   141ns   478ns cuDeviceGet
           0.00% 251ns        1    251ns   251ns   251ns cuDeviceGetUuid
```

- # block: 1280, # thread: 16, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==636== NVPROF is profiling process 636, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 1280 Thread: 16
==636== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==636== Profiling result:
      Type Time(%)     Time    Calls      Avg      Min      Max   Name
GPU activities: 100.00% 7.56998s          1 7.56998s  7.56998s 7.56998s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
              0.00% 3.7440us    6    624ns   544ns   800ns [CUDA memcpy HtoD]
              0.00% 1.0880us    1 1.0880us  1.0880us 1.0880us clearflag(void)
              0.00% 928ns       1    928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  97.89% 7.56999s          1 7.56999s  7.56999s 7.56999s cudaMemcpy
           2.09% 161.56ms    9 17.951ms  3.7830us 161.52ms cudaMalloc
           0.01% 544.78us     4 136.20us  6.1640us 524.29us cudaHostAlloc
           0.00% 225.73us     1 225.73us  225.73us 225.73us cuDeviceTotalMem
           0.00% 192.88us    96 2.0090us  111ns  83.388us cuDeviceGetAttribute
           0.00% 178.54us     1 178.54us  178.54us 178.54us cudaGetDeviceProperties
           0.00% 120.46us     9 13.384us  3.0070us 80.479us cudaFree
           0.00% 80.775us     2 40.387us  24.560us 56.215us cudaLaunchKernel
           0.00% 32.555us     6 5.4250us  1.9250us 17.577us cudaMemcpyAsync
           0.00% 24.613us     1 24.613us  24.613us 24.613us cuDeviceGetName
           0.00% 19.922us     4 4.9800us  579ns  7.9530us cudaFreeHost
           0.00% 11.559us     1 11.559us  11.559us 11.559us cudaGetDevice
           0.00% 7.5520us     1 7.5520us  7.5520us 7.5520us cudaDeviceSynchronize
           0.00% 7.1930us     1 7.1930us  7.1930us 7.1930us cuDeviceGetPCIBusId
           0.00% 880ns        3    293ns   103ns   633ns cuDeviceGetCount
           0.00% 434ns        2    217ns   126ns   308ns cuDeviceGet
           0.00% 162ns        1    162ns   162ns   162ns cuDeviceGetUuid
```

- # block: 1280, # thread: 32, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/00/case00.in 00.out
==31371== NVPROF is profiling process 31371, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 1280 Thread: 32
==31371== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==31371== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 18.2875s           1 18.2875s 18.2875s 18.2875s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.7440us      6   624ns  544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.0880us      1  1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 960ns        1   960ns  960ns   960ns [CUDA memcpy DtoH]
API calls:  99.09% 18.2875s           1 18.2875s 18.2875s 18.2875s cudaMemcpy
          0.90% 165.79ms      9 18.421ms 3.6070us 165.75ms cudaMalloc
          0.00% 603.16us      4 150.79us 7.7160us 568.15us cudaHostAlloc
          0.00% 218.75us      1 218.75us 218.75us 218.75us cuDeviceTotalMem
          0.00% 209.74us      96 2.1840us 138ns 90.028us cuDeviceGetAttribute
          0.00% 192.28us      1 192.28us 192.28us 192.28us cudaGetDeviceProperties
          0.00% 126.19us      9 14.020us 3.0150us 84.932us cudaFree
          0.00% 82.540us      2 41.270us 24.525us 58.015us cudaLaunchKernel
          0.00% 34.625us      6 5.7700us 1.9510us 17.948us cudaMemcpyAsync
          0.00% 31.543us      1 31.543us 31.543us 31.543us cuDeviceGetName
          0.00% 20.643us      4 5.1600us 508ns 7.8980us cudaFreeHost
          0.00% 13.164us      1 13.164us 13.164us 13.164us cudaGetDevice
          0.00% 12.383us      1 12.383us 12.383us 12.383us cuDeviceGetPCIBusId
          0.00% 8.3370us      1 8.3370us 8.3370us 8.3370us cudaDeviceSynchronize
          0.00% 1.3140us      3 438ns   144ns 882ns cuDeviceGetCount
          0.00% 743ns        2   371ns  140ns 603ns cuDeviceGet
          0.00% 200ns        1   200ns  200ns 200ns cuDeviceGetUuid
```

- # block: 1280, # thread: 32, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/01/case01.in 01.out
==31264== NVPROF is profiling process 31264, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 1280 Thread: 32
==31264== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==31264== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 35.3564s           4 8.83911s 3.71065s 20.0632s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 14.048us      24   585ns  512ns   768ns [CUDA memcpy HtoD]
          0.00% 4.3840us      4  1.0960us 1.0880us 1.1200us clearflag(void)
          0.00% 3.3600us      4   840ns  704ns   960ns [CUDA memcpy DtoH]
API calls:  99.48% 35.3564s           4 8.83911s 3.71065s 20.0632s cudaMemcpy
          0.52% 183.28ms      36 5.0912ms 3.7380us 182.87ms cudaMalloc
          0.00% 693.09us      16 43.318us 5.4750us 585.78us cudaHostAlloc
          0.00% 451.43us      36 12.539us 2.7850us 83.972us cudaFree
          0.00% 191.62us      96 1.9960us 111ns 83.086us cuDeviceGetAttribute
          0.00% 175.39us      1 175.39us 175.39us 175.39us cudaGetDeviceProperties
          0.00% 174.12us      8 21.764us 9.8870us 56.798us cudaLaunchKernel
          0.00% 166.13us      1 166.13us 166.13us 166.13us cuDeviceTotalMem
          0.00% 98.774us      24 4.1150us 1.9460us 17.775us cudaMemcpyAsync
          0.00% 76.387us      16 4.7740us 505ns 8.1080us cudaFreeHost
          0.00% 24.063us      1 24.063us 24.063us 24.063us cuDeviceGetName
          0.00% 19.201us      4 4.8000us 3.6210us 7.2510us cudaDeviceSynchronize
          0.00% 10.846us      1 10.846us 10.846us 10.846us cudaGetDevice
          0.00% 6.9080us      1 6.9080us 6.9080us 6.9080us cuDeviceGetPCIBusId
          0.00% 868ns        3   289ns  108ns 555ns cuDeviceGetCount
          0.00% 546ns        2   273ns  125ns 421ns cuDeviceGet
          0.00% 170ns        1   170ns  170ns 170ns cuDeviceGetUuid
```

- # block: 1280, # thread: 32, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/02/case02.in 02.out
==31035== NVPROF is profiling process 31035, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 1280 Thread: 32
==31035== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==31035== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 913.67ms           1 913.67ms 913.67ms 913.67ms solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 4.1600us      6   693ns  544ns   992ns [CUDA memcpy HtoD]
          0.00% 1.0890us      1  1.0890us 1.0890us 1.0890us clearflag(void)
          0.00% 896ns        1   896ns  896ns   896ns [CUDA memcpy DtoH]
API calls:  85.18% 913.68ms           1 913.68ms 913.68ms 913.68ms cudaMemcpy
          14.69% 157.58ms      9 17.509ms 3.6870us 157.54ms cudaMalloc
          0.05% 544.59us      4 136.15us 6.1640us 523.85us cudaHostAlloc
          0.02% 195.37us      96 2.0350us 114ns 84.765us cuDeviceGetAttribute
          0.02% 179.01us      1 179.01us 179.01us 179.01us cudaGetDeviceProperties
          0.01% 157.76us      1 157.76us 157.76us 157.76us cuDeviceTotalMem
          0.01% 99.963us      9 11.107us 2.9360us 67.379us cudaFree
          0.01% 67.403us      2 33.701us 10.443us 56.960us cudaLaunchKernel
          0.00% 32.712us      6 5.4520us 2.0250us 17.162us cudaMemcpyAsync
          0.00% 26.994us      1 26.994us 26.994us 26.994us cuDeviceGetName
          0.00% 16.884us      4 4.2210us 462ns 6.7000us cudaFreeHost
          0.00% 11.832us      1 11.832us 11.832us 11.832us cudaGetDevice
          0.00% 7.0220us      1 7.0220us 7.0220us 7.0220us cuDeviceGetPCIBusId
          0.00% 5.5990us      1 5.5990us 5.5990us 5.5990us cudaDeviceSynchronize
          0.00% 892ns        2   446ns  117ns 775ns cuDeviceGet
          0.00% 827ns        3   275ns  98ns 588ns cuDeviceGetCount
          0.00% 177ns        1   177ns  177ns 177ns cuDeviceGetUuid
```

- # block: 1280, # thread: 32, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==31096== NVPROF is profiling process 31096, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 1280 Thread: 32
==31096== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==31096== Profiling result:
      Type Time(%)      Time     Calls      Avg       Min       Max     Name
GPU activities: 100.00% 5.26826s           1 5.26826s 5.26826s 5.26826s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.7120us      6   618ns   544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.0880us      1 1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 960ns        1   960ns   960ns   960ns [CUDA memcpy DtoH]
API calls: 96.96% 5.26827s           1 5.26827s 5.26827s 5.26827s cudaMemcpy
          3.01% 163.74ms      9 18.193ms 3.8050us 163.70ms cudaMalloc
          0.01% 586.25us      4 146.56us 6.3380us 565.63us cudaHostAlloc
          0.00% 199.03us     96 2.0730us 114ns 84.590us cuDeviceGetAttribute
          0.00% 181.30us      1 181.30us 181.30us 181.30us cudaGetDeviceProperties
          0.00% 157.36us      1 157.36us 157.36us 157.36us cuDeviceTotalMem
          0.00% 115.37us      9 12.818us 2.8310us 77.372us cudaFree
          0.00% 79.953us      2 39.976us 23.742us 56.211us cudaLaunchKernel
          0.00% 33.127us      6 5.5210us 1.9350us 17.727us cudaMemcpyAsync
          0.00% 25.627us      1 25.627us 25.627us 25.627us cuDeviceGetName
          0.00% 19.343us      4 4.8350us 572ns 7.3920us cudaFreeHost
          0.00% 11.912us      1 11.912us 11.912us 11.912us cudaGetDevice
          0.00% 7.3870us      1 7.3870us 7.3870us 7.3870us cudaDeviceSynchronize
          0.00% 7.2240us      1 7.2240us 7.2240us 7.2240us cuDeviceGetPCIBusId
          0.00% 892ns         3   297ns   94ns   615ns cuDeviceGetCount
          0.00% 624ns         2   312ns   107ns   517ns cuDeviceGet
          0.00% 185ns         1   185ns   185ns   185ns cuDeviceGetUuid
```

- # block: 320, # thread: 64, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/00/case00.in 00.out
==725== NVPROF is profiling process 725, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 320 Thread: 64
==725== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==725== Profiling result:
      Type Time(%)      Time     Calls      Avg       Min       Max     Name
GPU activities: 100.00% 26.9197s           1 26.9197s 26.9197s 26.9197s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.6800us      6   613ns   544ns   768ns [CUDA memcpy HtoD]
          0.00% 1.1200us      1 1.1200us 1.1200us 1.1200us clearflag(void)
          0.00% 960ns        1   960ns   960ns   960ns [CUDA memcpy DtoH]
API calls: 99.42% 26.9198s           1 26.9198s 26.9198s 26.9198s cudaMemcpy
          0.58% 155.99ms      9 17.332ms 3.7500us 155.95ms cudaMalloc
          0.00% 541.15us      4 135.29us 5.9930us 518.96us cudaHostAlloc
          0.00% 210.73us      1 210.73us 210.73us 210.73us cudaGetDeviceProperties
          0.00% 192.09us     96 2.0000us 112ns 83.587us cuDeviceGetAttribute
          0.00% 167.43us      1 167.43us 167.43us 167.43us cuDeviceTotalMem
          0.00% 128.54us      9 14.282us 3.0990us 86.908us cudaFree
          0.00% 82.482us      2 41.241us 25.146us 57.336us cudaLaunchKernel
          0.00% 34.521us      6 5.7530us 1.9460us 17.548us cudaMemcpyAsync
          0.00% 22.891us      1 22.891us 22.891us 22.891us cuDeviceGetName
          0.00% 21.778us      4 5.4440us 557ns 8.5230us cudaFreeHost
          0.00% 11.812us      1 11.812us 11.812us 11.812us cudaGetDevice
          0.00% 10.333us      1 10.333us 10.333us 10.333us cudaDeviceSynchronize
          0.00% 6.8880us      1 6.8880us 6.8880us 6.8880us cuDeviceGetPCIBusId
          0.00% 914ns         3   304ns   97ns   660ns cuDeviceGetCount
```

- # block: 320, # thread: 64, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/01/case01.in 01.out
==880== NVPROF is profiling process 880, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 320 Thread: 64
==880== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==880== Profiling result:
      Type Time(%)      Time     Calls      Avg       Min       Max     Name
GPU activities: 100.00% 68.8197s           4 17.2049s 7.41277s 38.3595s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 14.240us      24   593ns   544ns   768ns [CUDA memcpy HtoD]
          0.00% 4.4800us      4 1.1200us 1.0880us 1.1520us clearflag(void)
          0.00% 3.3930us      4   848ns   736ns   960ns [CUDA memcpy DtoH]
API calls: 99.77% 68.8197s           4 17.2049s 7.41278s 38.3595s cudaMemcpy
          0.22% 155.12ms      36 4.3089ms 3.6610us 154.69ms cudaMalloc
          0.00% 627.37us      16 39.210us 5.3440us 521.92us cudaHostAlloc
          0.00% 483.77us      36 13.438us 2.7660us 86.527us cudaFree
          0.00% 193.37us      96 2.0140us 112ns 84.125us cuDeviceGetAttribute
          0.00% 185.70us       8 23.212us 10.000us 56.978us cudaLaunchKernel
          0.00% 178.43us       1 178.43us 178.43us 178.43us cudaGetDeviceProperties
          0.00% 167.41us       1 167.41us 167.41us 167.41us cuDeviceTotalMem
          0.00% 97.092us      24 4.0450us 1.9570us 17.361us cudaMemcpyAsync
          0.00% 78.694us       16 4.9180us 502ns 9.5280us cudaFreeHost
          0.00% 22.970us       1 22.970us 22.970us 22.970us cuDeviceGetName
          0.00% 21.445us       4 5.3610us 4.1080us 8.2410us cudaDeviceSynchronize
          0.00% 12.047us       1 12.047us 12.047us 12.047us cudaGetDevice
          0.00% 6.9360us       1 6.9360us 6.9360us 6.9360us cuDeviceGetPCIBusId
          0.00% 861ns         3   287ns   100ns   561ns cuDeviceGetCount
```

- # block: 320, # thread: 64, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/02/case02.in 02.out
==961== NVPROF is profiling process 961, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 320 Thread: 64
==961== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==961== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 1.87652s           1  1.87652s  1.87652s  1.87652s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.7120us      6   618ns   544ns   768ns [CUDA memcpy HtoD]
          0.00% 1.0880us      1  1.0880us  1.0880us  1.0880us clearflag(void)
          0.00% 960ns        1   960ns   960ns   960ns [CUDA memcpy DtoH]
API calls:  91.57% 1.87652s           1  1.87652s  1.87652s  1.87652s cudaMemcpy
          8.36% 171.32ms       9 19.036ms  3.6630us 171.28ms cudaMalloc
          0.03% 545.13us       4 136.28us  6.0570us 524.34us cudaHostAlloc
          0.01% 238.31us      96 2.4820us 153ns 101.90us cuDeviceGetAttribute
          0.01% 221.08us      1 221.08us 221.08us 221.08us cudaGetDeviceProperties
          0.01% 212.11us      1 212.11us 212.11us 212.11us cuDeviceTotalMem
          0.00% 102.27us       9 11.363us 2.9300us 69.902us cudaFree
          0.00% 69.287us       2 34.643us 12.677us 56.610us cudaLaunchKernel
          0.00% 33.229us       6 5.5380us 1.8750us 17.430us cudaMemcpyAsync
          0.00% 30.227us      1 30.227us 30.227us 30.227us cuDeviceGetName
          0.00% 17.745us       4 4.4360us 498ns 7.1550us cudaFreeHost
          0.00% 15.005us       1 15.005us 15.005us 15.005us cuDeviceGetDevice
          0.00% 12.165us       1 12.165us 12.165us 12.165us cuDeviceGetPCIBusId
          0.00% 6.4240us       1 6.4240us 6.4240us 6.4240us cuDeviceSynchronize
          0.00% 1.3270us       3   442ns   152ns   903ns cuDeviceGetCount
```

- # block: 320, # thread: 64, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==989== NVPROF is profiling process 989, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 320 Thread: 64
==989== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==989== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 10.6844s          1 10.6844s 10.6844s 10.6844s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.6800us      6   613ns   544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.1200us      1  1.1200us 1.1200us 1.1200us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  98.48% 10.6844s          1 10.6844s 10.6844s 10.6844s cudaMemcpy
          1.51% 163.88ms      9 18.209ms 3.7500us 163.84ms cudaMalloc
          0.00% 539.46us      4 134.87us 6.1860us 519.33us cudaHostAlloc
          0.00% 194.06us      96 2.0210us 111ns 84.094us cuDeviceGetAttribute
          0.00% 181.38us      1 181.38us 181.38us 181.38us cudaGetDeviceProperties
          0.00% 166.99us      1 166.99us 166.99us 166.99us cuDeviceTotalMem
          0.00% 123.29us      9 13.698us 2.8600us 82.098us cudaFree
          0.00% 80.878us      2 40.439us 25.551us 55.327us cudaLaunchKernel
          0.00% 32.653us      6 5.4420us 1.9100us 16.996us cudaMemcpyAsync
          0.00% 24.469us      1 24.469us 24.469us 24.469us cuDeviceGetName
          0.00% 19.245us      4 4.8110us 598ns 7.4190us cudaFreeHost
          0.00% 11.733us      1 11.733us 11.733us 11.733us cudaGetDevice
          0.00% 7.3460us      1 7.3460us 7.3460us 7.3460us cuDeviceSynchronize
          0.00% 7.0140us      1 7.0140us 7.0140us 7.0140us cuDeviceGetPCIBusId
          0.00% 817ns         3   272ns   107ns   571ns cuDeviceGetCount
```

- # block: 320, # thread: 128, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/00/case00.in 00.out
==1036== NVPROF is profiling process 1036, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 320 Thread: 128
==1036== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==1036== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max   Name
GPU activities: 100.00% 18.9491s          1 18.9491s 18.9491s 18.9491s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.7440us      6   624ns   544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.0880us      1  1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  99.19% 18.9491s          1 18.9491s 18.9491s 18.9491s cudaMemcpy
          0.81% 153.94ms      9 17.104ms 3.6510us 153.90ms cudaMalloc
          0.00% 574.65us      4 143.66us 6.1440us 552.46us cudaHostAlloc
          0.00% 201.20us      96 2.0950us 110ns 87.871us cuDeviceGetAttribute
          0.00% 187.84us      1 187.84us 187.84us 187.84us cudaGetDeviceProperties
          0.00% 167.38us      1 167.38us 167.38us 167.38us cuDeviceTotalMem
          0.00% 125.03us      9 13.892us 3.0950us 84.812us cudaFree
          0.00% 80.155us      2 40.077us 23.781us 56.374us cudaLaunchKernel
          0.00% 38.056us      1 38.056us 38.056us 38.056us cuDeviceGetName
          0.00% 33.319us      6 5.5530us 1.9010us 17.210us cudaMemcpyAsync
          0.00% 21.957us      4 5.4890us 571ns 8.8660us cudaFreeHost
          0.00% 14.325us      1 14.325us 14.325us 14.325us cuDeviceGetPCIBusId
          0.00% 11.205us      1 11.205us 11.205us 11.205us cudaGetDevice
          0.00% 7.1090us      1 7.1090us 7.1090us 7.1090us cuDeviceSynchronize
          0.00% 824ns         3   274ns   93ns   535ns cuDeviceGetCount
```

- # block: 320, # thread: 128, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/01/case01.in 01.out
==1065== NVPROF is profiling process 1065, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 320 Thread: 128
==1065== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==1065== Profiling result:
      Type  Time(%)    Time   Calls    Avg     Min     Max   Name
GPU activities: 100.00% 34.8240s          4 8.70599s 3.71097s 19.4821s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 14.080us   24    586ns  512ns   800ns [CUDA memcpy HtoD]
          0.00% 4.4810us   4   1.1200us 1.0880us 1.1840us clearflag(void)
          0.00% 3.2960us   4    824ns  704ns   928ns [CUDA memcpy DtoH]
API calls: 99.56% 34.8240s          4 8.70600s 3.71098s 19.4821s cudaMemcpy
          0.44% 153.46ms   36 4.2627ms 3.5418us 153.05ms cudaMalloc
          0.00% 671.71us   16 41.981us 5.3820us 551.70us cudaHostAlloc
          0.00% 434.08us   36 12.057us 2.6980us 83.454us cudaFree
          0.00% 229.61us   96 2.3910us 155ns 98.088us cuDeviceGetAttribute
          0.00% 211.07us   1 211.07us 211.07us 211.07us cuDeviceTotalMem
          0.00% 208.18us   1 208.18us 208.18us 208.18us cudaGetDeviceProperties
          0.00% 163.47us   8 20.433us 10.046us 56.596us cudaLaunchKernel
          0.00% 94.335us   24 3.9300us 1.9010us 17.497us cudaMemcpyAsync
          0.00% 70.998us   16 4.4370us 445ns 7.9850us cudaFreeHost
          0.00% 30.043us   1 30.043us 30.043us 30.043us cuDeviceGetName
          0.00% 18.362us   4 4.5900us 2.9130us 7.4650us cudaDeviceSynchronize
          0.00% 14.792us   1 14.792us 14.792us 14.792us cudaGetDevice
          0.00% 12.241us   1 12.241us 12.241us 12.241us cuDeviceGetPCIBusId
          0.00% 1.1470us   3 382ns 143ns 758ns cuDeviceGetCount
          0.00% 753ns     2 376ns 161ns 592ns cuDeviceGet
          0.00% 244ns     1 244ns 244ns 244ns cuDeviceGetUuid
```

- # block: 320, # thread: 128, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/02/case02.in 02.out
==11773== NVPROF is profiling process 11773, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 320 Thread: 128
==11773== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==11773== Profiling result:
      Type  Time(%)    Time   Calls    Avg     Min     Max   Name
GPU activities: 100.00% 1.34041s          1 1.34041s 1.34041s 1.34041s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.5040us   6   917ns  768ns 1.2160us [CUDA memcpy HtoD]
          0.00% 1.2160us   1 1.2160us 1.2160us 1.2160us clearflag(void)
          0.00% 992ns     1   992ns  992ns 992ns [CUDA memcpy DtoH]
API calls: 89.57% 1.34042s          1 1.34042s 1.34042s 1.34042s cudaMemcpy
          10.35% 154.84ms   9 17.204ms 3.7910us 154.80ms cudaMalloc
          0.04% 530.16us   4 132.54us 6.0170us 509.66us cudaHostAlloc
          0.01% 192.85us   1 192.85us 192.85us 192.85us cuDeviceTotalMem
          0.01% 141.26us   96 1.4710us 134ns 58.795us cuDeviceGetAttribute
          0.01% 123.20us   1 123.20us 123.20us 123.20us cudaGetDeviceProperties
          0.01% 92.398us   9 10.266us 2.9260us 58.344us cudaFree
          0.00% 72.736us   2 36.368us 13.780us 58.956us cudaLaunchKernel
          0.00% 33.867us   6 5.6440us 1.9690us 17.569us cudaMemcpyAsync
          0.00% 22.641us   1 22.641us 22.641us 22.641us cuDeviceGetName
          0.00% 17.157us   4 4.2890us 505ns 6.7650us cudaFreeHost
          0.00% 13.550us   1 13.550us 13.550us 13.550us cudaGetDevice
          0.00% 11.782us   1 11.782us 11.782us 11.782us cuDeviceGetPCIBusId
          0.00% 6.0260us   1 6.0260us 6.0260us 6.0260us cudaDeviceSynchronize
          0.00% 968ns     3 322ns 121ns 669ns cuDeviceGetCount
          0.00% 565ns     2 282ns 140ns 425ns cuDeviceGet
          0.00% 193ns     1 193ns 193ns 193ns cuDeviceGetUuid
```

- # block: 320, # thread: 128, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==1169== NVPROF is profiling process 1169, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 320 Thread: 128
==1169== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==1169== Profiling result:
      Type  Time(%)    Time   Calls    Avg     Min     Max   Name
GPU activities: 100.00% 5.35344s          1 5.35344s 5.35344s 5.35344s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.8400us   6   640ns  544ns   800ns [CUDA memcpy HtoD]
          0.00% 1.1200us   1 1.1200us 1.1200us 1.1200us clearflag(void)
          0.00% 960ns     1   960ns  960ns 960ns [CUDA memcpy DtoH]
API calls: 97.13% 5.35344s          1 5.35344s 5.35344s 5.35344s cudaMemcpy
          2.85% 156.98ms   9 17.442ms 3.6810us 156.94ms cudaMalloc
          0.01% 540.43us   4 135.11us 6.2590us 519.87us cudaHostAlloc
          0.00% 218.19us   96 2.2720us 110ns 185.91us cuDeviceGetAttribute
          0.00% 165.84us   1 165.84us 165.84us 165.84us cuDeviceTotalMem
          0.00% 159.21us   1 159.21us 159.21us 159.21us cudaGetDeviceProperties
          0.00% 120.53us   9 13.392us 2.8380us 81.309us cudaFree
          0.00% 84.325us   2 42.162us 23.254us 61.071us cudaLaunchKernel
          0.00% 33.261us   6 5.5430us 1.9320us 17.712us cudaMemcpyAsync
          0.00% 21.908us   1 21.908us 21.908us 21.908us cuDeviceGetName
          0.00% 20.042us   4 5.0100us 570ns 8.0610us cudaFreeHost
          0.00% 11.144us   1 11.144us 11.144us 11.144us cudaGetDevice
          0.00% 8.1000us   1 8.1000us 8.1000us 8.1000us cudaDeviceSynchronize
          0.00% 7.5460us   1 7.5460us 7.5460us 7.5460us cuDeviceGetPCIBusId
          0.00% 1.2490us   3 413ns 101ns 994ns cuDeviceGetCount
          0.00% 476ns     2 238ns 118ns 358ns cuDeviceGet
          0.00% 184ns     1 184ns 184ns 184ns cuDeviceGetUuid
```

- # block: 20, # thread: 256, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 --device-buffer-size 1 ./cuda_miner ./testcase/00/case00.in 00.out
==11040== NVPROF is profiling process 11040, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 20 Thread: 256
==11040== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==11040== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 15.6041s           1 15.6041s 15.6041s 15.6041s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.4720us      6   912ns   800ns  1.2160us [CUDA memcpy HtoD]
          0.00% 1.1200us      1  1.1200us 1.1200us 1.1200us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  98.99% 15.6041s           1 15.6041s 15.6041s 15.6041s cudaMemcpy
          1.00% 157.91ms      9  17.546ms 3.6530ms 157.87ms cudaMalloc
          0.00% 539.04us      4  134.76us 6.2800us 516.82us cudaHostAlloc
          0.00% 211.74us      1  211.74us 211.74us 211.74us cuDeviceTotalMem
          0.00% 155.78us      96  1.6220us 155ns  64.828us cuDeviceGetAttribute
          0.00% 135.38us      1  135.38us 135.38us 135.38us cudaGetDeviceProperties
          0.00% 117.15us      9  13.016us 3.1660us 75.176us cudaFree
          0.00% 86.262us      2  43.131us 26.385us 59.877us cudaLaunchKernel
          0.00% 34.932us      6  5.8220us 1.9560us 18.036us cudaMemcpyAsync
          0.00% 23.341us      1  23.341us 23.341us 23.341us cuDeviceGetName
          0.00% 22.511us      4  5.6270us 479ns  8.7770us cudaFreeHost
          0.00% 14.692us      1  14.692us 14.692us 14.692us cudaGetDevice
          0.00% 12.067us      1  12.067us 12.067us 12.067us cuDeviceGetPCIBusId
          0.00% 8.1160us      1  8.1160us 8.1160us 8.1160us cudaDeviceSynchronize
          0.00% 1.1880us      3   396ns   132ns   757ns cuDeviceGetCount
          0.00% 668ns        2   334ns   159ns   509ns cuDeviceGet
          0.00% 232ns        1   232ns   232ns   232ns cuDeviceGetUuid
```

- # block: 20, # thread: 256, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/01/case01.in 01.out
==11150== NVPROF is profiling process 11150, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 20 Thread: 256
==11150== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==11150== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 39.2305s           4 9.80762s 205.53ms 21.6536s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 16.032us      24   668ns   512ns  1.2160us [CUDA memcpy HtoD]
          0.00% 4.3520us      4  1.0880us 1.0560us 1.1200us clearflag(void)
          0.00% 3.3600us      4   840ns   736ns   960ns [CUDA memcpy DtoH]
API calls:  99.51% 39.2305s           4 9.80763s 205.53ms 21.6536s cudaMemcpy
          0.48% 190.64ms      36  5.2955ms 3.7710us 190.25ms cudaMalloc
          0.00% 632.72us      16  39.545us 5.5230us 521.86us cudaHostAlloc
          0.00% 392.50us      36  10.902us 2.6820us 74.102us cudaFree
          0.00% 177.32us      96  1.8470us 113ns  107.46us cuDeviceGetAttribute
          0.00% 168.43us      1  168.43us 168.43us 168.43us cuDeviceTotalMem
          0.00% 164.58us      8   20.572us 7.5300us 57.604us cudaLaunchKernel
          0.00% 104.86us      1  104.86us 104.86us 104.86us cudaGetDeviceProperties
          0.00% 94.366us      24  3.9310us 1.8120us 17.376us cudaMemcpyAsync
          0.00% 71.564us      16  4.4720us 437ns  7.6460us cudaFreeHost
          0.00% 20.446us      4   5.1110us 3.7780us 7.7930us cudaDeviceSynchronize
          0.00% 17.603us      1  17.603us 17.603us 17.603us cuDeviceGetName
          0.00% 11.555us      1  11.555us 11.555us 11.555us cudaGetDevice
          0.00% 7.2740us      1  7.2740us 7.2740us 7.2740us cuDeviceGetPCIBusId
          0.00% 867ns        3   289ns   109ns   566ns cuDeviceGetCount
          0.00% 424ns        2   212ns   128ns   296ns cuDeviceGet
          0.00% 179ns        1   179ns   179ns   179ns cuDeviceGetUuid
```

- # block: 20, # thread: 256, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/02/case02.in 02.out
==11108== NVPROF is profiling process 11108, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 20 Thread: 256
==11108== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==11108== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 4.46654s           1 4.46654s 4.46654s 4.46654s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 5.6960us      6   949ns   800ns  1.4080us [CUDA memcpy HtoD]
          0.00% 1.0880us      1  1.0880us 1.0880us 1.0880us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  96.79% 4.46655s           1 4.46655s 4.46655s 4.46655s cudaMemcpy
          3.19% 147.01ms      9  16.334ms 3.8410us 146.97ms cudaMalloc
          0.01% 535.07us      4  133.77us 6.3010us 514.74us cudaHostAlloc
          0.00% 210.63us      1  210.63us 210.63us 210.63us cuDeviceTotalMem
          0.00% 154.77us      96  1.6120us 155ns  64.611us cuDeviceGetAttribute
          0.00% 139.05us      1  139.05us 139.05us 139.05us cudaGetDeviceProperties
          0.00% 107.40us      9  11.933us 2.8940us 66.840us cudaFree
          0.00% 80.365us      2  40.182us 21.464us 58.901us cudaLaunchKernel
          0.00% 33.722us      6  5.6200us 1.8740us 17.934us cudaMemcpyAsync
          0.00% 21.641us      1  21.641us 21.641us 21.641us cuDeviceGetName
          0.00% 19.771us      4  4.9420us 546ns  8.1310us cudaFreeHost
          0.00% 15.404us      1  15.404us 15.404us 15.404us cudaGetDevice
          0.00% 11.774us      1  11.774us 11.774us 11.774us cuDeviceGetPCIBusId
          0.00% 6.6640us      1  6.6640us 6.6640us 6.6640us cudaDeviceSynchronize
          0.00% 1.0810us      3   360ns   167ns   723ns cuDeviceGetCount
          0.00% 610ns        2   305ns   161ns   449ns cuDeviceGet
          0.00% 241ns        1   241ns   241ns   241ns cuDeviceGetUuid
```

- # block: 20, # thread: 256, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==32497== NVPROF is profiling process 32497, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 20 Thread: 256
==32497== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==32497== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 2.08276s           1 2.08276s 2.08276s 2.08276s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 3.5200us      6   586ns   512ns   704ns [CUDA memcpy HtoD]
          0.00% 1.1840us      1  1.1840us  1.1840us  1.1840us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  93.78% 2.08277s        1 2.08277s 2.08277s 2.08277s cudaMemcpy
          6.16% 136.74ms      9 15.193ms  3.8700us 136.70ms cudaMalloc
          0.03% 592.59us      4 148.15us  6.6560us 571.23us cudaHostAlloc
          0.01% 173.05us      1 173.05us  173.05us 173.05us cuDeviceTotalMem
          0.01% 163.49us      96 1.7020us  118ns 69.347us cuDeviceGetAttribute
          0.01% 147.67us      1 147.67us  147.67us 147.67us cudaGetDeviceProperties
          0.01% 112.10us      9 12.45us   3.0580us 73.573us cudaFree
          0.00% 77.539us      2 38.769us  17.482us 60.057us cudaLaunchKernel
          0.00% 35.142us      1 35.142us  35.142us 35.142us cuDeviceGetName
          0.00% 33.700us      6 5.6160us  2.0160us 17.736us cudaMemcpyAsync
          0.00% 18.412us      4 4.6030us  523ns 7.0980us cudaFreeHost
          0.00% 12.405us      1 12.405us  12.405us 12.405us cudaGetDevice
          0.00% 7.0560us      1 7.0560us  7.0560us 7.0560us cuDeviceGetPCIBusId
          0.00% 6.9280us      1 6.9280us  6.9280us 6.9280us cudaDeviceSynchronize
          0.00% 1.0010us      3 333ns    105ns 675ns cuDeviceGetCount
          0.00% 506ns         2 253ns    145ns 361ns cuDeviceGet
          0.00% 182ns         1 182ns    182ns 182ns cuDeviceGetUuid
```

- # block: 160, # thread: 256, testcase 00:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeout 60 ./cuda_miner ./testcase/00/case00.in 00.out
==12072== NVPROF is profiling process 12072, command: ./cuda_miner ./testcase/00/case00.in 00.out
Block: 160 Thread: 256
==12072== Profiling application: ./cuda_miner ./testcase/00/case00.in 00.out
==12072== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 11.1814s           1 11.1814s 11.1814s 11.1814s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 8.0000us      6   1.3330us  1.0880us 2.0800us [CUDA memcpy HtoD]
          0.00% 1.1520us      1  1.1520us  1.1520us 1.1520us clearflag(void)
          0.00% 928ns        1   928ns   928ns   928ns [CUDA memcpy DtoH]
API calls:  98.70% 11.1814s        1 11.1814s 11.1814s 11.1814s cudaMemcpy
          1.29% 145.84ms      9 16.205ms  3.7340us 145.80ms cudaMalloc
          0.00% 551.91us      4 137.98us  6.8120us 529.29us cudaHostAlloc
          0.00% 204.19us      1 204.19us  204.19us 204.19us cuDeviceTotalMem
          0.00% 150.60us      96 1.5680us  149ns 62.141us cuDeviceGetAttribute
          0.00% 133.05us      1 133.05us  133.05us 133.05us cudaGetDeviceProperties
          0.00% 110.95us      9 12.327us  3.0780us 71.200us cudaFree
          0.00% 83.117us      2 41.558us  24.183us 58.934us cudaLaunchKernel
          0.00% 33.843us      6 5.6400us  1.8610us 17.774us cudaMemcpyAsync
          0.00% 22.164us      1 22.164us  22.164us 22.164us cuDeviceGetName
          0.00% 20.975us      4 5.2430us  509ns 8.0010us cudaFreeHost
          0.00% 14.415us      1 14.415us  14.415us 14.415us cudaGetDevice
          0.00% 8.1390us      1 8.1390us  8.1390us 8.1390us cudaDeviceSynchronize
          0.00% 7.4880us      1 7.4880us  7.4880us 7.4880us cuDeviceGetPCIBusId
          0.00% 1.2170us      3 405ns    149ns 860ns cuDeviceGetCount
          0.00% 712ns         2 356ns    172ns 540ns cuDeviceGet
          0.00% 229ns         1 229ns    229ns 229ns cuDeviceGetUuid
```

- # block: 160, # thread: 256, testcase 01:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/01/case01.in 01.out
==1656== NVPROF is profiling process 1656, command: ./cuda_miner ./testcase/01/case01.in 01.out
Block: 160 Thread: 256
==1656== Profiling application: ./cuda_miner ./testcase/01/case01.in 01.out
==1656== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 20.8962s           4 5.22404s 2.21486s 11.9876s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
          0.00% 14.080us      24   586ns   512ns   800ns [CUDA memcpy HtoD]
          0.00% 4.6080us      4  1.1520us  1.1200us 1.2480us clearflag(void)
          0.00% 3.3600us      4   800ns   704ns   960ns [CUDA memcpy DtoH]
API calls:  99.22% 20.8962s        4 5.22404s 2.21487s 11.9876s cudaMemcpy
          0.77% 161.34ms      36 4.4816ms  3.6090us 160.93ms cudaMalloc
          0.00% 674.60us      16 42.162us  5.5560us 568.18us cudaHostAlloc
          0.00% 428.29us      36 11.896us  2.7790us 81.634us cudaFree
          0.00% 239.79us      96 2.4970us  154ns 102.72us cuDeviceGetAttribute
          0.00% 219.25us      1 219.25us  219.25us 219.25us cudaGetDeviceProperties
          0.00% 216.84us      1 216.84us  216.84us 216.84us cuDeviceTotalMem
          0.00% 155.54us      8 19.443us  9.2770us 57.405us cudaLaunchKernel
          0.00% 93.570us      24 3.8980us  1.8780us 17.342us cudaMemcpyAsync
          0.00% 70.596us      16 4.4120us  441ns 7.0790us cudaFreeHost
          0.00% 33.696us      1 33.696us  33.696us 33.696us cuDeviceGetName
          0.00% 19.230us      4 4.8070us  3.6140us 6.3280us cudaDeviceSynchronize
          0.00% 15.231us      1 15.231us  15.231us 15.231us cudaGetDevice
          0.00% 11.932us      1 11.932us  11.932us 11.932us cuDeviceGetPCIBusId
          0.00% 1.2550us      3 418ns    136ns 860ns cuDeviceGetCount
          0.00% 790ns         2 395ns    144ns 646ns cuDeviceGet
          0.00% 228ns         1 228ns    228ns 228ns cuDeviceGetUuid
```

- # block: 160, # thread: 256, testcase 02:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof ./cuda_miner ./testcase/02/case02.in 02.out
==12140== NVPROF is profiling process 12140, command: ./cuda_miner ./testcase/02/case02.in 02.out
Block: 160 Thread: 256
==12140== Profiling application: ./cuda_miner ./testcase/02/case02.in 02.out
==12140== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 1.02685s           1 1.02685s 1.02685s 1.02685s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
              0.00% 5.5050us      6   917ns   800ns 1.1840us [CUDA memcpy HtoD]
              0.00% 1.3120us      1  1.3120us 1.3120us 1.3120us clearflag(void)
              0.00% 1.0560us      1  1.0560us 1.0560us 1.0560us [CUDA memcpy DtoH]
API calls:  86.95% 1.02685s           1 1.02685s 1.02685s 1.02685s cudaMemcpy
              12.94% 152.82ms      9 16.980ms 3.6640us 152.78ms cudaMalloc
              0.04% 531.37us      4 132.84us 6.6010us 510.15us cudaHostAlloc
              0.02% 215.82us      1 215.82us 215.82us 215.82us cuDeviceTotalMem
              0.01% 156.12us      96 1.6260us 155ns 65.004us cuDeviceGetAttribute
              0.01% 134.66us      1 134.66us 134.66us 134.66us cudaGetDeviceProperties
              0.01% 89.710us      9 9.9670us 2.8660us 57.014us cudaFree
              0.01% 70.691us      2 35.345us 12.445us 58.246us cudaLaunchKernel
              0.00% 33.425us      6 5.5700us 1.9120us 17.892us cudaMemcpyAsync
              0.00% 24.550us      1 24.550us 24.550us 24.550us cuDeviceGetName
              0.00% 17.900us      4 4.4750us 538ns 7.3500us cudaFreeHost
              0.00% 15.561us      1 15.561us 15.561us 15.561us cudaGetDevice
              0.00% 12.418us      1 12.418us 12.418us 12.418us cuDeviceGetPCIBusId
              0.00% 6.1270us      1 6.1270us 6.1270us 6.1270us cudaDeviceSynchronize
              0.00% 1.1570us      3 385ns   146ns 779ns cuDeviceGetCount
              0.00% 772ns         2 386ns   151ns 621ns cuDeviceGet
              0.00% 250ns         1 250ns   250ns 250ns cuDeviceGetUuid
```

- # block: 160, # thread: 256, testcase 03:

```
[ipc20119@hades01 HW4]$ srun -ppp --gres=gpu:1 nvprof --timeoutout 60 ./cuda_miner ./testcase/03/case03.in 03.out
==12180== NVPROF is profiling process 12180, command: ./cuda_miner ./testcase/03/case03.in 03.out
Block: 160 Thread: 256
==12180== Profiling application: ./cuda_miner ./testcase/03/case03.in 03.out
==12180== Profiling result:
      Type Time(%)     Time    Calls      Avg       Min       Max     Name
GPU activities: 100.00% 3.61493s           1 3.61493s 3.61493s 3.61493s solve(char*, char*, char*, char*, unsigned char*, int&, unsigned int&)
              0.00% 5.8880us      6   981ns   800ns 1.2160us [CUDA memcpy HtoD]
              0.00% 1.1520us      1  1.1520us 1.1520us 1.1520us clearflag(void)
              0.00% 928ns         1  928ns   928ns 928ns [CUDA memcpy DtoH]
API calls:  95.87% 3.61494s           1 3.61494s 3.61494s 3.61494s cudaMemcpy
              4.09% 154.24ms      9 17.138ms 3.6640us 154.20ms cudaMalloc
              0.01% 530.74us      4 132.68us 6.0810us 510.99us cudaHostAlloc
              0.01% 212.34us      1 212.34us 212.34us 212.34us cuDeviceTotalMem
              0.00% 155.41us      96 1.6180us 155ns 64.838us cuDeviceGetAttribute
              0.00% 135.88us      1 135.88us 135.88us 135.88us cudaGetDeviceProperties
              0.00% 109.45us      9 12.160us 2.8970us 71.288us cudaFree
              0.00% 79.258us      2 39.629us 21.378us 57.880us cudaLaunchKernel
              0.00% 33.515us      6 5.5850us 1.9680us 18.213us cudaMemcpyAsync
              0.00% 23.563us      1 23.563us 23.563us 23.563us cuDeviceGetName
              0.00% 19.610us      4 4.9020us 494ns 7.5050us cudaFreeHost
              0.00% 15.071us      1 15.071us 15.071us 15.071us cudaGetDevice
              0.00% 12.735us      1 12.735us 12.735us 12.735us cuDeviceGetPCIBusId
              0.00% 7.0750us      1 7.0750us 7.0750us 7.0750us cudaDeviceSynchronize
              0.00% 1.2350us      3 411ns   149ns 860ns cuDeviceGetCount
              0.00% 789ns         2 394ns   155ns 634ns cuDeviceGet
              0.00% 225ns         1 225ns   225ns 225ns cuDeviceGetUuid
```