Project 4

Introduction

In this project, we are asked to implement a two layer NN in order to use OpenAcc & Triton to accelerate machine learning algorithms. Specifically, we use MINST to do handwriting recognition. We will implement forward pass and backward propagation in both sequential and parallel format, and then do optimization to it.

Compilation and Execution

To compile the program, please do the following steps:

```
cd project4
mkdir build && cd build
cmake ..
make
```

After compilation, in order to batch process the project in order to get the execution time, you can simply `sbatch` at the project root directory:

```
cd /path/to/project4
sbatch ./test.sh
```

The result is stored in `Project4-Results.txt`. You can use `vim` to open it.

In order to get profiling result, you can simply run the following commands using `nsys`:

```
#!/bin/bash
mkdir -p ./perf_results

# Path to the dataset
TRAIN_X=./MINST/train-images-idx3-ubyte
TRAIN_Y=./MINST/train-labels-idx1-ubyte
TEST_X=./MINST/t10k-images-idx3-ubyte
TEST_Y=./MINST/t10k-labels-idx1-ubyte

# Hyperparameters
HIDDEN_DIM=400
EPOCHS=10
LEARNING_RATE=0.001
BATCH=32

# Sequential
srun -n 1 --cpus-per-task 1 perf record -e cpu-cycles,cache-misses,page-faults -
g -o ./perf_results/sequential.data ./build/sequential $TRAIN_X $TRAIN_Y $TEST_X
$TEST_Y $HIDDEN_DIM $EPOCHS $LEARNING_RATE $BATCH

# Kernel
srun -n 1 --gpus 1 nsys profile -t cuda,nvtx,osrt,openacc -o
./perf_results/openacc_kernel.qdrep ./build/openacc_kernel $TRAIN_X $TRAIN_Y
$TEST_X $TEST_Y $HIDDEN_DIM $EPOCHS $LEARNING_RATE $BATCH
```

```
# Fusion
srun -n 1 --gpus 1 nsys profile -t cuda,nvtx,osrt,openacc -o
./perf_results/openacc_fusion.qdrep ./build/openacc_fusion $TRAIN_X $TRAIN_Y
$TEST_X $TEST_Y $HIDDEN_DIM $EPOCHS $LEARNING_RATE $BATCH
```

For sequential version, we can use `perf report` to view the results under the `perf_results` folder. For OpenACC, we can use `nsys stats` to visualize the results as well.

Parallel Principle and Optimization

1. For sequential version, we implement the forward pass and back propagation using nested loops and chain rule. No speed up here.
2. For kernel version, we apply OpenACC pragma to each of the kernel function separately. For loops, we use `#pragma acc parallel loop` and `#pragma acc parallel loop collapse(2)` if two nested loop unfold is needed. Since each function only need to access its part of data, so a `copyin` and a `copyout` are needed for each function. Also, functions such as `update_bias` and `update_weights` need `#pragma acc loop reduction(+ : grad_sum)` to accelerate accumulation as well.
3. For fusion version, we aim to transfer all necessary data to the GPU at the start of the MLP training process and using a single `#pragma acc`. Therefore, we only copy all the data needed at the beginning of the training block.

Result

The result is shown below:

```
Sequential (Optimized with -O2)
Training two layer neural network 400 hidden units
| Epoch |  Acc Rate   |  Training Time
|     1 |   92.040%   |   45837 ms
|     2 |   93.670%   |   45834 ms
|     3 |   94.560%   |   45834 ms
|     4 |   95.390%   |   45848 ms
|     5 |   95.880%   |   45839 ms
|     6 |   96.270%   |   45839 ms
|     7 |   96.710%   |   45836 ms
|     8 |   96.860%   |   45841 ms
|     9 |   97.080%   |   45839 ms
|    10 |   97.250%   |   45842 ms
Execution Time: 503778 milliseconds

OpenACC kernel
Training two layer neural network 400 hidden units
| Epoch |  Acc Rate   |  Training Time
|     1 |   91.960%   |   7706 ms
|     2 |   93.590%   |   6461 ms
|     3 |   94.650%   |   6459 ms
|     4 |   95.360%   |   6478 ms
|     5 |   95.910%   |   6481 ms
|     6 |   96.280%   |   6511 ms
|     7 |   96.650%   |   6511 ms
|     8 |   96.850%   |   6550 ms
|     9 |   97.040%   |   6562 ms
|    10 |   97.150%   |   6566 ms
Execution Time: 68535 milliseconds
```

```
OpenACC fusion
Training two layer neural network 400 hidden units
| Epoch |  Acc Rate  |  Training Time
|     1 |   92.040%  |   4822 ms
|     2 |   93.690%  |   4883 ms
|     3 |   94.560%  |   4785 ms
|     4 |   95.390%  |   4821 ms
|     5 |   95.880%  |   4841 ms
|     6 |   96.280%  |   4836 ms
|     7 |   96.680%  |   4872 ms
|     8 |   96.830%  |   4881 ms
|     9 |   97.060%  |   4873 ms
|    10 |   97.270%  |   4858 ms
Execution Time: 50678 milliseconds
```

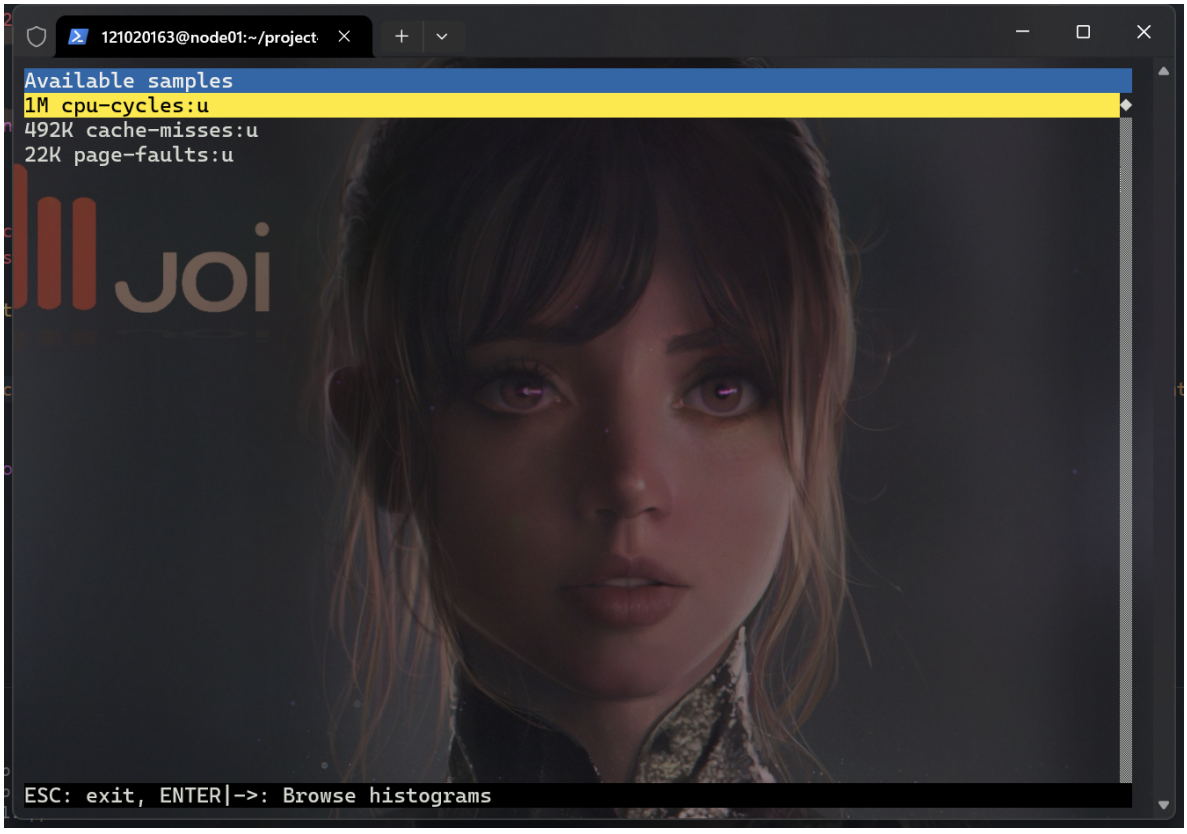
The first epoch speedup factors are shown as followed, using $S(p) = \frac{t_s}{t_p}$ and Sequential performance (45837 ms) as a baseline.

Methods	Speedup
Kernel	5.95
Fusion	9.51

We can see that the OpenACC Fusion method has the fastest speed, since it has already cache the memory inside GPU in one time, avoiding unnecessary overheads.

Profiling Results

Sequential:



Kernel:

```
Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/cudaapisum.py openacc_kernel.sqlite]...

 Time(%)  Total Time (ns)  Num Calls    Average      Minimum     Maximum
StdDev            Name
 -------  ---------------  ---------  ------------  ----------  ----------  ----
-----  --------------------
    88.0   50,469,912,090    834,520      60,477.8         710   3,932,584
309,590.8  cuStreamSynchronize
     3.9    2,230,766,410    459,450       4,855.3       2,884     730,235
3,243.7  cuMemcpyHtoDAsync_v2
     3.7    2,118,680,060    278,180       7,616.2       4,620     851,179
3,421.0  cuLaunchKernel
     2.6    1,519,261,251    278,170       5,461.6       3,363     833,328
2,937.8  cuMemcpyDtoHAsync_v2
     1.3      731,231,878    282,452       2,588.9       1,862     191,732
1,131.2  cuEventRecord
     0.4      241,215,466    282,450         854.0         457     123,749
945.4  cuEventSynchronize
     0.0       26,952,151          1  26,952,151.0  26,952,151  26,952,151
0.0  cuMemHostAlloc
     0.0        1,220,469          1   1,220,469.0   1,220,469   1,220,469
0.0  cuMemAllocHost_v2
     0.0          415,124         14      29,651.7       4,270     145,985
48,886.2  cuMemAlloc_v2
     0.0          387,827          1     387,827.0     387,827     387,827
0.0  cuModuleLoadDataEx
     0.0           84,346         10       8,434.6       6,386      12,343
2,016.0  cuMemsetD32Async
     0.0           22,877          1      22,877.0      22,877      22,877
0.0  cuStreamCreate
     0.0           17,721          4       4,430.3         647       9,821
4,007.7  cuEventCreate

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpukernsum.py openacc_kernel.sqlite]...

 Time(%)  Total Time (ns)  Instances    Average    Minimum   Maximum     StdDev
                                        Name

 -------  ---------------  ---------  -----------  -------  ---------  ---------
--  ------------------------------------------------------------------------
------------------------
    88.7   39,754,166,488     37,500  1,060,111.1   27,456  3,930,745
1,033,670.1  update_weight_133_gpu(float*, float const*, float const*, unsigned
long, float, unsigned long, unsi…
     8.4    3,777,858,373     43,760     86,331.3   54,208    206,880
28,356.2  gemm_6_gpu(float const*, float const*, float*, unsigned long, unsigned
long, unsigned long)

     1.6      726,849,551     43,760     16,609.9    2,175     57,696
14,335.1  add_bias_24_gpu(float*, float*, float const*, unsigned long, unsigned
long)

     0.5      206,461,576     18,750     11,011.3   10,496     20,448
460.2  Softmax_49_gpu(float*, float*, unsigned long, unsigned long)
```

```
     0.3      139,474,430     37,500      3,719.3    2,527      8,704
1,108.3  update_bias_99_gpu(float*, float const*, unsigned long, float, unsigned
long)

     0.1       60,283,057     18,750      3,215.1    3,072      5,664
123.3  input_grad_115_gpu(float const*, float const*, float*, float*, unsigned
long, unsigned long, unsign…
     0.1       42,395,897     18,750      2,261.1    2,175      4,096
89.7  cross_entropy_loss_grad_87_gpu(float const*, float const*, float*,
unsigned long, unsigned long)

     0.1       40,364,083     21,880      1,844.8    1,408      3,329
72.6  Relu_38_gpu(float*, float*, unsigned long)

     0.1       37,462,913     18,750      1,998.0    1,919      3,552
83.8  relu_grad_154_gpu(float const*, float*, unsigned long, unsigned long)

     0.1       35,833,267     18,750      1,911.1    1,823      8,064
93.1  vector_to_one_hot_matrix_68_gpu(unsigned char const*, float*, unsigned
long, unsigned long)

     0.0           25,505         10      2,550.5    2,496      2,592
30.4  argmax_182_gpu(float const*, unsigned char*, unsigned long, unsigned long)

     0.0           21,856         10      2,185.6    2,144      2,272
37.1  mean_acc_168_gpu(unsigned char const*, unsigned char const*, unsigned
long, unsigned long)

     0.0           21,504         10      2,150.4    2,112      2,240
36.3  mean_acc_168_gpu__red(unsigned char const*, unsigned char const*, unsigned
long, unsigned long)


Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpumemtimesum.py openacc_kernel.sqlite]...

 Time(%)  Total Time (ns)  Operations  Average  Minimum  Maximum   StdDev
Operation

 -------  ---------------  ----------  -------  -------  -------  --------  ----
--------------
    61.9    3,985,089,015     459,450  8,673.6      703  131,743  21,801.6
[CUDA memcpy HtoD]
    38.1    2,450,970,939     278,170  8,811.1      831  105,984  23,852.4
[CUDA memcpy DtoH]
     0.0            7,777          10    777.7      736      992      76.9
[CUDA memset]


Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpumemsizesum.py openacc_kernel.sqlite]...

     Total       Operations  Average  Minimum   Maximum   StdDev       Operation
 -------------  ----------  -------  -------  ---------  -------  -------------
-----
 39,595,542.188     459,450   86.180    0.031  1,225.000  256.472  [CUDA memcpy
HtoD]
```

```
 28,573,095.742     278,170  102.718    0.004  1,225.000  302.560  [CUDA memcpy
DtoH]
          0.039          10    0.004    0.004      0.004    0.000  [CUDA memset]

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/osrtsum.py openacc_kernel.sqlite]...

 Time(%)  Total Time (ns)  Num Calls     Average       Minimum      Maximum
  StdDev               Name
 -------  ---------------  ---------  -------------  -----------  -----------  -
-----------  ----------------------
    49.9   76,954,346,193        780   98,659,418.2        9,075  100,297,321
11,949,652.0  poll
    49.7   76,522,594,428        153  500,147,676.0  500,076,238  500,588,801
   51,992.9  pthread_cond_timedwait
     0.3      472,164,285         23   20,528,882.0        1,880  401,889,856
84,315,999.9  read
     0.1      111,231,786        720      154,488.6        1,038   27,337,755
1,419,408.5  ioctl
     0.0        3,821,251         68       56,194.9        4,148    1,675,569
  200,199.7  mmap64
     0.0        2,841,419         50       56,828.4        1,434      466,161
   62,038.5  pthread_mutex_lock
     0.0        1,959,214         10      195,921.4      105,205      935,069
  259,860.4  sem_timedwait
     0.0        1,371,819         28       48,993.5        4,228      281,332
   74,711.7  fclose
     0.0        1,120,734          4      280,183.5      171,967      560,934
  187,863.9  fopen64
     0.0          650,551         88        7,392.6        3,020       21,474
    2,980.5  open64
     0.0          496,566         24       20,690.3        2,395      147,316
   33,872.2  mmap
     0.0          429,120          5       85,824.0       75,784       95,851
    9,375.8  pthread_create
     0.0          311,543         30       10,384.8        1,730       56,409
    9,882.7  fopen
     0.0          123,286         12       10,273.8        6,139       11,600
    1,468.5  fflush
     0.0          106,680          2       53,340.0       10,554       96,126
   60,508.5  socket
     0.0           98,125          9       10,902.8        1,415       49,468
   14,943.7  fgetc
     0.0           50,755          6        8,459.2        5,115       12,762
    2,791.9  open
     0.0           46,096         11        4,190.5        2,765        6,440
    1,161.0  write
     0.0           42,972          1       42,972.0       42,972       42,972
        0.0  fgets
     0.0           41,565         11        3,778.6        1,218       18,679
    5,081.5  fwrite
     0.0           23,706          7        3,386.6        2,513        4,609
      717.7  munmap
     0.0           13,699          5        2,739.8        2,427        3,120
      274.6  mprotect
     0.0            9,732          1        9,732.0        9,732        9,732
        0.0  fread
```

```
     0.0            8,282          6        1,380.3        1,025        2,131
      457.2  fcntl
     0.0            7,284          1        7,284.0        7,284        7,284
        0.0  connect
     0.0            6,206          1        6,206.0        6,206        6,206
        0.0  pipe2
     0.0            1,987          1        1,987.0        1,987        1,987
        0.0  bind
     0.0            1,275          1        1,275.0        1,275        1,275
        0.0  listen

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/nvtxsum.py openacc_kernel.sqlite]... SKIPPED:
openacc_kernel.sqlite does not contain NV Tools Extension (NVTX) data

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/openmpevtsum.py openacc_kernel.sqlite]... SKIPPED:
openacc_kernel.sqlite does not contain OpenMP event data.

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/vulkanmarkerssum.py openacc_kernel.sqlite]... SKIPPED:
openacc_kernel.sqlite does not contain Vulkan Debug Extension (Vulkan Debug
Util) data

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/pixsum.py openacc_kernel.sqlite]... SKIPPED:
openacc_kernel.sqlite does not contain DX11/DX12 CPU debug markers

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/khrdebugsum.py openacc_kernel.sqlite]... SKIPPED:
openacc_kernel.sqlite does not contain KHR Extension (KHR_DEBUG) data
```

Fusion:

```
Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/cudaapisum.py openacc_fusion.sqlite]...

 Time(%)  Total Time (ns)  Num Calls    Average      Minimum     Maximum
StdDev            Name
 -------  ---------------  ---------  ------------  ----------  ----------  ----
-----  --------------------
    96.0   47,290,488,091    306,411     154,336.8         734   3,929,891
521,457.7  cuStreamSynchronize
     3.5    1,740,531,561    278,180       6,256.9       4,082   1,012,970
2,636.8  cuLaunchKernel
     0.2       85,315,489     15,770       5,410.0       3,046   1,322,382
10,636.2  cuMemcpyDtoHAsync_v2
     0.1       60,725,024     12,686       4,786.8       3,314     120,110
2,613.1  cuMemcpyHtoDAsync_v2
     0.1       40,979,282     15,950       2,569.2       1,610     168,254
2,223.1  cuEventRecord
     0.1       26,269,826          1  26,269,826.0  26,269,826  26,269,826
0.0  cuMemHostAlloc
     0.0       13,250,564     15,948         830.9         411      90,951
1,178.7  cuEventSynchronize
     0.0        1,234,759          1   1,234,759.0   1,234,759   1,234,759
0.0  cuMemAllocHost_v2
```

```
     0.0        1,052,234         24      43,843.1       2,028     370,261
91,252.0  cuMemAlloc_v2
     0.0          419,185          1     419,185.0     419,185     419,185
0.0  cuModuleLoadDataEx
     0.0           87,633         10       8,763.3       6,854      11,673
1,819.1  cuMemsetD32Async
     0.0           30,654         13       2,358.0         474      12,268
3,588.8  cuEventCreate
     0.0           24,463          1      24,463.0      24,463      24,463
0.0  cuStreamCreate

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpukernsum.py openacc_fusion.sqlite]...

 Time(%)  Total Time (ns)  Instances    Average    Minimum   Maximum     StdDev
                                                                          Name

 -------  ---------------  ---------  -----------  -------  ---------  ---------
--  ------------------------------------------------------------------------------
-----------------------
    88.5   41,636,003,242     37,500  1,110,293.4   28,960  3,928,452
1,081,382.9  update_weight_133_gpu(float*, float const*, float const*, unsigned
long, float, unsigned long, unsi…
     8.6    4,045,601,678     43,760     92,449.8   59,264    307,712
31,525.9  gemm_6_gpu(float const*, float const*, float*, unsigned long, unsigned
long, unsigned long)

     1.6      769,403,166     43,760     17,582.3    2,335     61,856
15,115.1  add_bias_24_gpu(float*, float*, float const*, unsigned long, unsigned
long)

     0.5      218,941,444     18,750     11,676.9   11,359     20,736
362.1  Softmax_49_gpu(float*, float*, unsigned long, unsigned long)

     0.3      147,383,205     37,500      3,930.2    2,687      8,672
1,139.3  update_bias_99_gpu(float*, float const*, unsigned long, float, unsigned
long)

     0.1       63,802,626     18,750      3,402.8    3,263      5,856
103.1  input_grad_115_gpu(float const*, float const*, float*, float*, unsigned
long, unsigned long, unsign…
     0.1       45,703,993     18,750      2,437.5    2,335      3,968
75.5  cross_entropy_loss_grad_87_gpu(float const*, float const*, float*,
unsigned long, unsigned long)

     0.1       42,375,368     21,880      1,936.7    1,824      3,232
60.0  Relu_38_gpu(float*, float*, unsigned long)

     0.1       39,508,462     18,750      2,107.1    1,951      3,968
94.7  vector_to_one_hot_matrix_68_gpu(unsigned char const*, float*, unsigned
long, unsigned long)

     0.1       39,484,954     18,750      2,105.9    2,015      3,455
68.6  relu_grad_154_gpu(float const*, float*, unsigned long, unsigned long)

     0.0           27,263         10      2,726.3    2,688      2,753
25.3  argmax_182_gpu(float const*, unsigned char*, unsigned long, unsigned long)
```

```
     0.0           25,857         10      2,585.7    2,560      2,656
39.3  mean_acc_168_gpu__red(unsigned char const*, unsigned char const*, unsigned
long, unsigned long)

     0.0           23,967         10      2,396.7    2,368      2,432
27.9  mean_acc_168_gpu(unsigned char const*, unsigned char const*, unsigned
long, unsigned long)


Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpumemtimesum.py openacc_fusion.sqlite]...

 Time(%)  Total Time (ns)  Operations  Average   Minimum   Maximum    StdDev
   Operation
 -------  ---------------  ----------  --------  -------  ---------  ---------
------------------
    81.9      219,697,345      12,686  17,318.1      768  1,390,145  128,199.7
[CUDA memcpy HtoD]
    18.1       48,487,260      15,770   3,074.7      863      4,960    1,752.0
[CUDA memcpy DtoH]
     0.0            8,000          10     800.0      800        800        0.0
[CUDA memset]

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/gpumemsizesum.py openacc_fusion.sqlite]...

     Total      Operations  Average  Minimum   Maximum     StdDev
Operation
 -------------  ----------  -------  -------  ----------  ---------  -----------
-------
   478,723.945      15,770   30.357    0.004      50.000     23.886  [CUDA
memcpy DtoH]
 2,346,710.977      12,686  184.984    0.039  16,384.000  1,530.555  [CUDA
memcpy HtoD]
         0.039          10    0.004    0.004       0.004      0.000  [CUDA
memset]

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/osrtsum.py openacc_fusion.sqlite]...

 Time(%)  Total Time (ns)  Num Calls     Average       Minimum      Maximum
  StdDev              Name
 -------  ---------------  ---------  -------------  -----------  -----------  -
-----------  ----------------------
    50.0   54,100,418,130        552   98,008,003.9        9,973  100,334,556
14,159,387.6  poll
    49.9   54,013,996,604        108  500,129,598.2  499,806,132  500,160,134
   32,724.5  pthread_cond_timedwait
     0.1      110,193,591        726      151,781.8        1,039   26,580,582
1,377,504.0  ioctl
     0.0       30,928,905         23    1,344,735.0        1,811   26,751,729
5,603,083.7  read
     0.0        3,573,675         68       52,554.0        4,313    1,533,507
  183,119.2  mmap64
     0.0        1,960,416         10      196,041.6      105,534      947,731
  264,186.5  sem_timedwait
     0.0        1,509,501          4      377,375.3      307,442      546,729
  114,171.9  fopen64
```

```
     0.0        1,394,078         28       49,788.5        4,307      265,443
  69,945.5  fclose
     0.0          673,555         88        7,654.0        3,051       27,531
   3,762.6  open64
     0.0          586,709         26       22,565.7        2,278      200,474
  43,109.7  mmap
     0.0          400,240          5       80,048.0       65,102       89,015
  10,076.2  pthread_create
     0.0          388,427          9       43,158.6       35,897       57,411
   8,002.8  pthread_mutex_lock
     0.0          310,072         30       10,335.7        1,337       51,147
   9,037.4  fopen
     0.0          191,954          2       95,977.0        9,920      182,034
 121,703.0  socket
     0.0          117,460         12        9,788.3        5,166       11,513
   1,672.0  fflush
     0.0           89,280         10        8,928.0        1,003       44,601
  12,951.4  fgetc
     0.0           57,882          6        9,647.0        5,275       17,440
   4,493.8  open
     0.0           48,709         12        4,059.1        1,216        6,851
   1,562.3  write
     0.0           37,695         11        3,426.8        1,422       15,554
   4,095.8  fwrite
     0.0           34,359          1       34,359.0       34,359       34,359
       0.0  fgets
     0.0           31,000          8        3,875.0        2,682        6,544
   1,289.3  munmap
     0.0           12,674          5        2,534.8        2,259        2,940
     285.2  mprotect
     0.0           10,159          1       10,159.0       10,159       10,159
       0.0  fread
     0.0            8,881          6        1,480.2        1,084        2,184
     427.7  fcntl
     0.0            7,573          1        7,573.0        7,573        7,573
       0.0  connect
     0.0            5,393          1        5,393.0        5,393        5,393
       0.0  pipe2
     0.0            3,055          1        3,055.0        3,055        3,055
       0.0  bind

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/nvtxsum.py openacc_fusion.sqlite]... SKIPPED:
openacc_fusion.sqlite does not contain NV Tools Extension (NVTX) data

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/openmpevtsum.py openacc_fusion.sqlite]... SKIPPED:
openacc_fusion.sqlite does not contain OpenMP event data.

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/vulkanmarkerssum.py openacc_fusion.sqlite]... SKIPPED:
openacc_fusion.sqlite does not contain Vulkan Debug Extension (Vulkan Debug
Util) data

Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/pixsum.py openacc_fusion.sqlite]... SKIPPED:
openacc_fusion.sqlite does not contain DX11/DX12 CPU debug markers
```

```
Running [/opt/nvidia/hpc_sdk/Linux_x86_64/21.7/profilers/Nsight_Systems/target-
linux-x64/reports/khrdebugsum.py openacc_fusion.sqlite]... SKIPPED:
openacc_fusion.sqlite does not contain KHR Extension (KHR_DEBUG) data
```