HPC Profiling Report

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Profiling Using Gprof

Flat profile:

% time	cumulative seconds	self seconds	calls	self s/call	total s/call	name
61.00	39.17	39.17	30	1.31	1.31	backward_pass -- **HOTSPOT**
37.17	63.03	23.86	4268971	0.00	0.00	attention_score -- **HOTSPOT**
1.73	64.14	1.11	30	0.04	0.83	gnn_layer
0.10	64.21	0.07	12000	0.00	0.00	softmax
0.00	64.21	0.00	12001	0.00	0.00	sigmoid
0.00	64.21	0.00	12000	0.00	0.00	binary_cross_entropy
0.00	64.21	0.00	12000	0.00	0.00	layer_norm
0.00	64.21	0.00	12000	0.00	0.00	relu
0.00	64.21	0.00	30	0.00	0.00	clip_gradients
0.00	64.21	0.00	30	0.00	0.00	update_parameters
0.00	64.21	0.00	2	0.00	0.00	initialize_parameters
0.00	64.21	0.00	1	0.00	0.00	predict_link

Inferences

The **backward_pass (61%)** and **attention_score (37.17%)** dominate execution time, making them key optimization targets. **The attention_score function is called ~4.27M times and that function is mostly consists matrix multiplication**, heavily impacting performance. Parallelizing or optimizing these functions could significantly improve efficiency.

Call graph

```
index % time    self  children    called     name
                                   <spontaneous>
[1]    100.0    0.00   64.21                 main [1]
               39.17    0.00      30/30        backward_pass [2]
                1.11   23.93      30/30        gnn_layer [3]
                0.00    0.00       1/1         predict_link [6]
                0.00    0.00   12000/12001      sigmoid [7]
                0.00    0.00   12000/12000      binary_cross_entropy [8]
                0.00    0.00      30/30         clip_gradients [11]
                0.00    0.00      30/30         update_parameters [12]
                0.00    0.00       2/2          initialize_parameters [13]
-----------------------------------------------
               39.17    0.00      30/30         main [1]
[2]     61.0   39.17    0.00      30            backward_pass [2]
-----------------------------------------------
                1.11   23.93      30/30         main [1]
[3]     39.0    1.11   23.93      30            gnn_layer [3]
               23.86    0.00 4268970/4268971     attention_score [4]
                0.07    0.00   12000/12000      softmax [5]
                0.00    0.00   12000/12000      layer_norm [9]
                0.00    0.00   12000/12000      relu [10]
-----------------------------------------------
                0.00    0.00       1/4268971    predict_link [6]
               23.86    0.00 4268970/4268971     gnn_layer [3]
[4]     37.2   23.86    0.00 4268971            attention_score [4]
-----------------------------------------------
                0.07    0.00   12000/12000      gnn_layer [3]
```

```
[5]     0.1    0.07    0.00   12000        softmax [5]
-----------------------------------------------
           0.00    0.00      1/1          main [1]
[6]     0.0    0.00    0.00      1        predict_link [6]
           0.00    0.00      1/4268971     attention_score [4]
           0.00    0.00      1/12001      sigmoid [7]
-----------------------------------------------
           0.00    0.00      1/12001      predict_link [6]
           0.00    0.00   12000/12001      main [1]
[7]     0.0    0.00    0.00   12001        sigmoid [7]
-----------------------------------------------
           0.00    0.00   12000/12000      main [1]
[8]     0.0    0.00    0.00   12000        binary_cross_entropy [8]
-----------------------------------------------
           0.00    0.00   12000/12000      gnn_layer [3]
[9]     0.0    0.00    0.00   12000        layer_norm [9]
-----------------------------------------------
           0.00    0.00   12000/12000      gnn_layer [3]
[10]    0.0    0.00    0.00   12000        relu [10]
-----------------------------------------------
           0.00    0.00     30/30          main [1]
[11]    0.0    0.00    0.00     30         clip_gradients [11]
-----------------------------------------------
           0.00    0.00     30/30          main [1]
[12]    0.0    0.00    0.00     30         update_parameters [12]
-----------------------------------------------
           0.00    0.00      2/2           main [1]
[13]    0.0    0.00    0.00      2         initialize_parameters [13]
-----------------------------------------------
```

Profiling Using Gcov

CODE : gcov -b -c main.c

File 'main.c'

Lines executed:100.00% of 170

Branches executed:100.00% of 90

Taken at least once:95.56% of 90

Calls executed:100.00% of 27

Creating 'main.c.gcov'

Lines executed:100.00% of 170

Code: gcov -a main.c

File 'main.c'

Lines executed:100.00% of 170

Creating 'main.c.gcov'

Lines executed:100.00% of 170

Inference:

The code in main.c achieved 100% line execution coverage (170/170) and 100% function call execution (27/27). Branch execution is also 100%, with 95.56% of branches taken at least once, indicating thorough testing with minor uncovered branch paths.

Profiling Using LIKWID

Architecture Topology

```
--------------------------------------------------------------------------------
CPU name:       Intel(R) Xeon(R) E-2224 CPU @ 3.40GHz
CPU type:       Intel Coffeelake processor
CPU stepping:   10
********************************************************************************
Hardware Thread Topology
********************************************************************************
Sockets:                1
CPU dies:               1
Cores per socket:       4
Threads per core:       1
--------------------------------------------------------------------------------
HWThread        Thread        Core        Die        Socket        Available
0               0             0           0          0             *
1               0             1           0          0             *
2               0             2           0          0             *
3               0             3           0          0             *
--------------------------------------------------------------------------------
Socket 0:               ( 0 1 2 3 )
--------------------------------------------------------------------------------
********************************************************************************
Cache Topology
********************************************************************************
Level:                  1
Size:                   32 kB
Cache groups:           ( 0 ) ( 1 ) ( 2 ) ( 3 )
--------------------------------------------------------------------------------
Level:                  2
Size:                   256 kB
Cache groups:           ( 0 ) ( 1 ) ( 2 ) ( 3 )
--------------------------------------------------------------------------------
Level:                  3
Size:                   8 MB
Cache groups:           ( 0 1 2 3 )
--------------------------------------------------------------------------------
```

Instruction Cache Miss Rate Ratio

Code: likwid-perfctr -C 0-4 -g ICACHE ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	26.0570	26.0570	26.0570	26.0570
Runtime unhalted [s]	2.2556	3.1531	3.7764	2.5084
Clock [MHz]	3588.1734	3674.2707	3726.4274	3720.9319
CPI	0.3259	0.3359	0.3165	0.3549
L1I request rate	0.3174	0.1033	0.5298	0.4189
L1I miss rate	0.0055	0.0045	0.0033	0.0072
L1I miss ratio	0.0174	0.0432	0.0062	0.0173
L1I stalls	93272105	118340532	53394713	106609063
L1I stall rate	0.0040	0.0037	0.0013	0.0044

This provides us with the number of requests, misses and stalls made by the L1 Cache for fetching instruction

L2 Cache Miss Rate Ratio

Code: likwid-perfctr -C 0-4 -g L2CACHE ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	26.0957	26.0957	26.0957	26.0957
Runtime unhalted [s]	24.5578	6.3337	5.0144	4.3816
Clock [MHz]	3973.2675	4058.3729	4030.5244	4052.9554
CPI	0.2982	0.3626	0.3800	0.3969
L2 request rate	0.0008	0.0096	0.0107	0.0121
L2 miss rate	0.0001	0.0025	0.0026	0.0029
L2 miss ratio	0.1066	0.2664	0.2399	0.2390

L3 Cache Miss Rate Ratio

Code: likwid-perfctr -C 0-4 -g L3CACHE ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	27.6293	27.6293	27.6293	27.6293
Runtime unhalted [s]	0	0	0	0
Clock [MHz]	0	0	0	0
CPI	0	0	0	0
L3 request rate	0	0	0	0
L3 miss rate	0	0	0	0
L3 miss ratio	0	0	0	0

Clock, Energy and Power Consumption

Code: likwid-perfctr -C 0-4 -g CLOCK ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	26.1036	26.1036	26.1036	26.1036
Runtime unhalted [s]	4.6508	5.4036	26.4333	3.1935
Clock [MHz]	3947.6067	4025.5031	4033.0823	4017.5239
Uncore Clock [MHz]	21.8932	0	0	0
CPI	0.3375	0.3800	0.3007	0.3764
Energy [J]	793.0748	0	0	0
Power [W]	30.3818	0	0	0
Energy DRAM [J]	14.9349	0	0	0
Power DRAM [W]	0.5721	0	0	0

Data TLB - Translation Look aside Buffer for Data

Code: likwid-perfctr -C 0-4 -g TLB_DATA ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	25.1795	25.1795	25.1795	25.1795
Runtime unhalted [s]	3.6680	28.9056	3.7907	4.5477
Clock [MHz]	4116.7440	4219.6560	4146.2134	4142.0872
CPI	0.4287	0.2980	0.3944	0.3824
L1 DTLB load misses	3035890	468840	2560996	1791869
L1 DTLB load miss rate	0.0001	1.418353e-06	0.0001	4.421237e-05
L1 DTLB load miss duration [Cyc]	37.9882	27.9908	46.0517	43.1638
L1 DTLB store misses	338680	76548	223686	199961
L1 DTLB store miss rate	1.161612e-05	2.315759e-07	6.830206e-06	4.933814e-06
L1 DTLB store miss duration [Cyc]	32.1219	31.5354	36.0575	35.4463

Instruction TLB - Translation Look aside Buffer for Instructions

Code: likwid-perfctr -C 0-4 -g TLB_INSTR ./main

Metric	HWThread 0	HWThread 1	HWThread 2	HWThread 3
Runtime (RDTSC) [s]	25.5393	25.5393	25.5393	25.5393
Runtime unhalted [s]	9.6532	24.6370	3.1336	1.3918
Clock [MHz]	4004.0057	4107.3875	3984.3872	4064.2646
CPI	0.3210	0.3009	0.4255	0.4979
L1 ITLB misses	847720	515494	1293684	1661785
L1 ITLB miss rate	8.271758e-06	1.847307e-06	0.0001	0.0002
L1 ITLB miss duration [Cyc]	36.1503	36.9468	39.3722	38.8982