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**ECE 786 Final Project**

**Task 1 - Cache Efficiency Analysis**

Formula used to calculate Percentage change of comparing the IPC with / without cache bypassing.

(IPC with cache bypassing – IPC with no cache bypassing) \* 100 / IPC with no cache bypassing

Assumptions for benchmark category

* less than 0% is Cache Friendly.
* 0 - 5% difference is Cache Insensitive.
* More than 5% Cache Unfriendly.

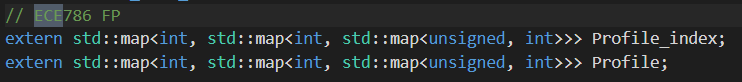
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Benchmark name | kernel\_name | kernel\_  launch \_uid | IPC with no cache bypassing | IPC with cache bypassing | Percentage change | benchmark category |
| Rodinia | | | | | | |
| HS | \_Z14calculate\_tempiPfS\_S\_iiiiffffff | 1 | 701.3718 | 707.6299 | 0.8923 | Cache Insensitive |
| BP | \_Z22bpnn\_layerforward\_CUDAPfS\_S\_S\_ii | 1 | 670.1913 | 666.3648 | -0.571 | Cache Insensitive |
| BP | \_Z24bpnn\_adjust\_weights\_cudaPfiS\_iS\_S\_ | 2 | 424.712 | 192.2678 | -54.7298 | Cache Friendly |
| LUD | \_Z12lud\_diagonalPfii | 1 | 0.7026 | 0.7176 | 2.1349 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 2 | 9.2446 | 9.1103 | -1.4527 | Cache Insensitive |
| LUD | \_Z12lud\_internalPfii | 3 | 501.2445 | 567.1572 | 13.1498 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 4 | 0.7558 | 0.7742 | 2.4345 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 5 | 10.9464 | 11.8102 | 7.8912 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 6 | 497.3745 | 574.7466 | 15.5561 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 7 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 8 | 10.1697 | 10.9718 | 7.8872 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 9 | 473.0808 | 557.2787 | 17.7978 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 10 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 11 | 9.3893 | 10.1287 | 7.8749 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 12 | 462.4784 | 529.6388 | 14.5218 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 13 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 14 | 8.6082 | 9.2874 | 7.8902 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 15 | 378.4012 | 504.6895 | 33.3742 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 16 | 0.7558 | 0.7742 | 2.4345 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 17 | 7.8294 | 8.4467 | 7.8844 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 18 | 357.2093 | 493.737 | 38.2206 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 19 | 0.7558 | 0.7742 | 2.4345 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 20 | 7.0473 | 7.604 | 7.8995 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 21 | 338.0277 | 453.3258 | 34.1091 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 22 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 23 | 6.264 | 6.7609 | 7.9326 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 24 | 324.1251 | 467.1097 | 44.114 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 25 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 26 | 5.4832 | 5.9163 | 7.8987 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 27 | 290.9933 | 405.2074 | 39.2497 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 28 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 29 | 4.7006 | 5.0733 | 7.9288 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 30 | 246.8571 | 344.3503 | 39.4938 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 31 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 32 | 3.9172 | 4.2288 | 7.9547 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 33 | 208.6225 | 253.2766 | 21.4043 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 34 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 35 | 3.1348 | 3.3833 | 7.9271 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 36 | 142.2966 | 172.1319 | 20.967 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 37 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 38 | 2.3514 | 2.5387 | 7.9655 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 39 | 111.9498 | 134.8471 | 20.4532 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 40 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 41 | 1.5679 | 1.6926 | 7.9533 | Cache Unfriendly |
| LUD | \_Z12lud\_internalPfii | 42 | 39.4499 | 44.9208 | 13.868 | Cache Unfriendly |
| LUD | \_Z12lud\_diagonalPfii | 43 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
| LUD | \_Z13lud\_perimeterPfii | 44 | 0.8583 | 0.8467 | -1.3515 | Cache Insensitive |
| LUD | \_Z12lud\_internalPfii | 45 | 16.2623 | 16.6957 | 2.6651 | Cache Insensitive |
| LUD | \_Z12lud\_diagonalPfii | 46 | 0.7558 | 0.7741 | 2.4213 | Cache Insensitive |
|  | | | | | | |
| ISPASS | | | | | | |
| NQU | \_Z24solve\_nqueen\_cuda\_kerneliiPjS\_S\_S\_i | 1 | 30.4185 | 30.7699 | 1.1552 | Cache Insensitive |
| LPS | \_Z13GPU\_laplace3diiiiPfS\_ | 1 | 383.1095 | 408.8568 | 6.7206 | Cache Unfriendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 1 | 217.5687 | 167.9066 | -22.8259 | Cache Friendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 2 | 206.0139 | 146.9099 | -28.6893 | Cache Friendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 3 | 165.9271 | 112.0179 | -32.4897 | Cache Friendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 4 | 76.2236 | 61.3361 | -19.5314 | Cache Friendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 5 | 21.3021 | 36.1667 | 69.78 | Cache Unfriendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 6 | 22.5533 | 44.4395 | 97.0421 | Cache Unfriendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 7 | 46.5675 | 86.5094 | 85.7721 | Cache Unfriendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 8 | 354.4445 | 455.3303 | 28.4631 | Cache Unfriendly |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 9 | 473.1056 | 486.792 | 2.8929 | Cache Insensitive |

**Task 2 - Profiling-based Cache Bypassing**

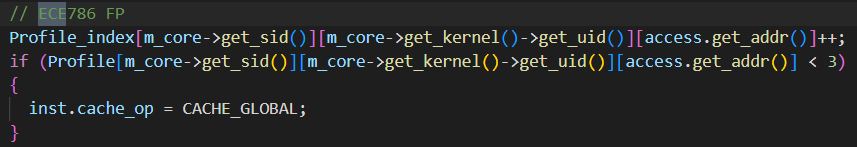
Profile-based cache bypass implementation is divided into two major steps – statistics collecting and bypass implementing.

* For statistics collecting
  + A triple-nested map is used to collect the number of accesses on each address on each SMs and each kernel which is written to a dump file.
* Profile-based cache bypass implementation
  + If the dump file exists it is read, another triple-nested map will be created to record the data in the dump file.
  + Then when memory needs to be accessed, the map will be accessed based on current SM, kernel, and accessing address to determine if bypass will be used.

Modified code shown below (line 72 of shader.h).



Modified code shown below (line 54, 2042 of shader.cc).



Modified code shown below (line 48, 202, 277 of gpgpusim\_entrypoint).



A screenshot of a computer

Description automatically generated

Text

Description automatically generated

Assumptions for Performance category

Formula used to calculate Percentage change of comparing the IPC with / without Profiling-based cache bypassing.

(IPC with cache bypassing – IPC with no cache bypassing) \* 100 / IPC with no cache bypassing

* Less than 0% is Deterioration.
* More than 0% Improvement.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Benchmark name | kernel\_name | kernel\_  launch \_uid | IPC with no cache bypassing | IPC with profile bypassing | Percentage change | Performance  category |
| Rodinia | | | | | | |
| LUD | \_Z12lud\_internalPfii | 3 | 712.5299 | 721.2603 | 1.2253 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 5 | 13.6126 | 14.3418 | 5.3568 | Improvement |
| LUD | \_Z12lud\_internalPfii | 6 | 637.3949 | 642.5734 | 0.8124 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 8 | 12.6459 | 13.3236 | 5.359 | Improvement |
| LUD | \_Z12lud\_internalPfii | 9 | 556.1233 | 557.6649 | 0.2772 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 11 | 11.6784 | 12.3045 | 5.3612 | Improvement |
| LUD | \_Z12lud\_internalPfii | 12 | 502.3962 | 506.7778 | 0.8721 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 14 | 10.7269 | 11.3033 | 5.3734 | Improvement |
| LUD | \_Z12lud\_internalPfii | 15 | 423.2689 | 429.6447 | 1.5063 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 17 | 9.7561 | 10.2805 | 5.3751 | Improvement |
| LUD | \_Z12lud\_internalPfii | 18 | 352.6066 | 357.2629 | 1.3205 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 20 | 8.7844 | 9.2568 | 5.3777 | Improvement |
| LUD | \_Z12lud\_internalPfii | 21 | 290.0794 | 293.3001 | 1.1103 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 23 | 7.8118 | 8.2322 | 5.3816 | Improvement |
| LUD | \_Z12lud\_internalPfii | 24 | 232.6988 | 235.2133 | 1.0806 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 26 | 6.8493 | 7.2186 | 5.3918 | Improvement |
| LUD | \_Z12lud\_internalPfii | 27 | 178.1328 | 180.4473 | 1.2993 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 29 | 5.8735 | 6.1903 | 5.3937 | Improvement |
| LUD | \_Z12lud\_internalPfii | 30 | 131.4149 | 132.7995 | 1.0536 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 32 | 4.8967 | 5.161 | 5.3975 | Improvement |
| LUD | \_Z12lud\_internalPfii | 33 | 91.527 | 92.7536 | 1.3402 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 35 | 3.9191 | 4.1308 | 5.4018 | Improvement |
| LUD | \_Z12lud\_internalPfii | 36 | 58.4963 | 59.3623 | 1.4804 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 38 | 2.9442 | 3.1034 | 5.4072 | Improvement |
| LUD | \_Z12lud\_internalPfii | 39 | 33.1178 | 33.585 | 1.4107 | Improvement |
| LUD | \_Z13lud\_perimeterPfii | 41 | 1.966 | 2.0726 | 5.4222 | Improvement |
| LUD | \_Z12lud\_internalPfii | 42 | 14.7418 | 14.943 | 1.3648 | Improvement |
| ISPASS | | | | | | |
| LPS | \_Z13GPU\_laplace3diiiiPfS\_ | 1 | 638.116 | 667.4357 | 4.5947 | Improvement |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 5 | 87.2392 | 66.722 | -23.5183 | Deterioration |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 6 | 86.6631 | 66.8945 | -22.8109 | Deterioration |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 7 | 145.4857 | 111.03 | -23.6832 | Deterioration |
| BFS | \_Z6KernelP4NodePiPbS2\_S1\_S2\_i | 8 | 229.1067 | 175.9334 | -23.209 | Deterioration |

**Result**

Benchmarks LUD & LPS have an average Improvement of 3.1908% & 4.5947%

Benchmark BFS have an average Deterioration of -23.3054%