CS224 - SPRING 2023 -

Lab Report

Lab-06

Section 5

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# Report for matrix 1 size (N = 100)

a) **Direct Mapped Caches**:

(N = 100 column-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2521 | Miss Rate = 12%  Number of misses = 1262 | Miss Rate = 6%  Number of misses = 634 | Miss Rate = 3%  Number of misses = 318 |
| 512 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2521 | Miss Rate = 12%  Number of misses = 1262 | Miss Rate = 6%  Number of misses = 632 | Miss Rate = 3%  Number of misses = 318 |
| 1024 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2521 | Miss Rate = 12%  Number of misses = 1262 | Miss Rate = 6%  Number of misses = 632 | Miss Rate = 3%  Number of misses = 318 |
| 2048 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2521 | Miss Rate = 12%  Number of misses = 1262 | Miss Rate = 6%  Number of misses = 634 | Miss Rate = 3%  Number of misses = 318 |
| 4096 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2521 | Miss Rate = 12%  Number of misses = 1262 | Miss Rate = 6%  Number of misses = 632 | Miss Rate = 3%  Number of misses = 318 |

*Table 1.1: Column-major summation miss rates of matrix size N = 100*

*Figure 1.1: Graph presentation for table 1.1*

(N = 100 row-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 98%  Number of misses = 10034 | Miss Rate = 98%  Number of misses = 10020 | Miss Rate = 98%  Number of misses = 10012 | Miss Rate = 98%  Number of misses = 10009 | Miss Rate = 98%  Number of misses = 10006 |
| 512 | Miss Rate = 98%  Number of misses = 10034 | Miss Rate = 98%  Number of misses = 10020 | Miss Rate = 98%  Number of misses = 10012 | Miss Rate = 98%  Number of misses = 10009 | Miss Rate = 98%  Number of misses = 10006 |
| 1024 | Miss Rate = 85%  Number of misses = 8634 | Miss Rate = 78%  Number of misses = 7920 | Miss Rate = 98%  Number of misses = 10012 | Miss Rate = 98%  Number of misses = 10007 | Miss Rate = 98%  Number of misses = 10008 |
| 2048 | Miss Rate = 49%  Number of misses = 5035 | Miss Rate = 25%  Number of misses = 2520 | Miss Rate = 77%  Number of misses = 7912 | Miss Rate = 98%  Number of misses = 10007 | Miss Rate = 98%  Number of misses = 10006 |
| 4096 | Miss Rate = 49%  Number of misses = 5034 | Miss Rate = 25%  Number of misses = 2520 | Miss Rate = 68%  Number of misses = 6940 | Miss Rate = 83%  Number of misses = 8471 | Miss Rate = 98%  Number of misses = 10006 |

*Table 1.2: Row-major summation miss rates of matrix size N = 100*

*Figure 1.2: Graph representation of table 1.2*

b) **Fully Associative Caches**:

(N = 100 row-major addition)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Good Hit Rate  Cache size = 2048 bytes  Block size = 4 words | Medium Hit Rate  Cache size = 2048 bytes  Block size = 8 words | Bad Hit Rate  Cache size = 2048 bytes  Block size = 16 words |
| Fully Associative with LRU | Miss rate = 25%  Number of misses = 2520 | Miss rate = 98%  Number of misses = 10012 | Miss rate = 98%  Number of misses = 10009 |
| Fully Associative with Random | Miss rate = 43%  Number of misses = 4347 | Miss rate = 69%  Number of misses = 7086 | Miss rate = 94%  Number of misses = 9551 |
| Direct Mapped | Miss rate = 25%  Number of misses = 2520 | Miss rate = 77%  Number of misses = 7912 | Miss rate = 98%  Number of misses = 10007 |

*Table 1.3: Comparison of fully associative cache and direct mapping on various points from table 1.2*

*Figure 1.3: Graph representation of table 1.3*

c) **N-way Set Associative Caches**:

N = 100 row-major addition

|  |  |  |  |
| --- | --- | --- | --- |
| Set size | Good Hit Rate  Cache size = 2048 bytes  Block size = 4 words | Medium Hit Rate  Cache size = 2048 bytes  Block size = 8 words | Bad Hit Rate  Cache size = 2048 bytes  Block size = 16 words |
| 2 | Miss rate = 25%  Number of misses = 2520 | Miss rate = 93%  Number of misses = 9520 | Miss rate = 98%  Number of misses = 10007 |
| 4 | Miss rate = 25%  Number of misses = 2520 | Miss rate = 98%  Number of misses = 10012 | Miss rate = 98%  Number of misses = 10009 |
| 8 | Miss rate = 25%  Number of misses = 2520 | Miss rate = 98%  Number of misses = 10012 | Miss rate = 98%  Number of misses = 10007 |
| 16 | Miss rate = 25%  Number of misses = 2520 | Miss rate = 98%  Number of misses = 10012 | Miss rate = 98%  Number of misses = 10009 |

*Table 1.4: N-way associative cache comparison on various points from table 1.2*

# Report for matrix 2 size (N = 20)

a) **Direct Mapped Caches**:

(N = 20 column-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 48%  Number of misses = 235 | Miss Rate = 19%  Number of misses = 121 | Miss Rate = 10%  Number of misses = 62 | Miss Rate = 5%  Number of misses = 32 | Miss Rate = 3%  Number of misses = 18 |
| 512 | Miss Rate = 48%  Number of misses = 235 | Miss Rate = 19%  Number of misses = 121 | Miss Rate = 10%  Number of misses = 62 | Miss Rate = 5%  Number of misses = 34 | Miss Rate = 3%  Number of misses = 18 |
| 1024 | Miss Rate = 48%  Number of misses = 235 | Miss Rate = 19%  Number of misses = 121 | Miss Rate = 10%  Number of misses = 62 | Miss Rate = 5%  Number of misses = 32 | Miss Rate = 3%  Number of misses = 20 |
| 2048 | Miss Rate = 48%  Number of misses = 235 | Miss Rate = 19%  Number of misses = 121 | Miss Rate = 10%  Number of misses = 62 | Miss Rate = 5%  Number of misses = 34 | Miss Rate = 3%  Number of misses = 18 |
| 4096 | Miss Rate = 47%  Number of misses = 231 | Miss Rate = 19%  Number of misses = 118 | Miss Rate = 10%  Number of misses = 60 | Miss Rate = 5%  Number of misses = 31 | Miss Rate = 3%  Number of misses = 17 |

*Table 2.1: Column-major summation miss rates of matrix size N = 20*

*Figure 2.1: Graph representation of table 2.1*

(N = 20 row-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 51%  Number of misses = 314 | Miss Rate = 39%  Number of misses = 240 | Miss Rate = 65%  Number of misses = 400 | Miss Rate = 67%  Number of misses = 409 | Miss Rate = 43%  Number of misses = 262 |
| 512 | Miss Rate = 38%  Number of misses = 234 | Miss Rate = 20%  Number of misses = 120 | Miss Rate = 36%  Number of misses = 220 | Miss Rate = 66%  Number of misses = 401 | Miss Rate = 43%  Number of misses = 264 |
| 1024 | Miss Rate = 38%  Number of misses = 234 | Miss Rate = 20%  Number of misses = 120 | Miss Rate = 34%  Number of misses = 206 | Miss Rate = 41%  Number of misses = 250 | Miss Rate = 43%  Number of misses = 201 |
| 2048 | Miss Rate = 38%  Number of misses = 234 | Miss Rate = 20%  Number of misses = 120 | Miss Rate = 10%  Number of misses = 62 | Miss Rate = 5%  Number of misses = 32 | Miss Rate = 3%  Number of misses = 21 |
| 4096 | Miss Rate = 38%  Number of misses = 230 | Miss Rate = 19%  Number of misses = 117 | Miss Rate = 10%  Number of misses = 60 | Miss Rate = 5%  Number of misses = 32 | Miss Rate = 3%  Number of misses = 18 |

*Table 2.2: Row-major summation miss rates of matrix size N = 20*

*Figure 2.2: Graph representation of table 2.2*

b) **Fully Associative Caches**:

N = 20 row-major addition

|  |  |  |  |
| --- | --- | --- | --- |
|  | Good Hit Rate  Cache size = 2048 bytes  Block size = 16 words | Medium Hit Rate  Cache size = 1024 bytes  Block size = 4 words | Bad Hit Rate  Cache size = 256 bytes  Block size = 2 words |
| Fully Associative with LRU | Miss rate = 5%  Number of misses = 31 | Miss rate = 20%  Number of misses = 120 | Miss rate = 38%  Number of misses = 234 |
| Fully Associative with Random | Miss rate = 5%  Number of misses = 32 | Miss rate = 20%  Number of misses = 123 | Miss rate = 48%  Number of misses = 296 |
| Direct Mapped | Miss rate = 5%  Number of misses = 31 | Miss rate = 20%  Number of misses = 120 | Miss rate = 51%  Number of misses = 314 |

*Table 2.3: Comparison of fully associative cache and direct mapping on various points from table 2.2*

*Figure 2.3: Graph representation of table 2.3*

c) **N-way Set Associative Caches**:

(N = 20 row-major addition)

|  |  |  |  |
| --- | --- | --- | --- |
| Set size | Good Hit Rate  Cache size = 2048 bytes  Block size = 16 words | Medium Hit Rate  Cache size = 1024 bytes  Block size = 4 words | Bad Hit Rate  Cache size = 256 bytes  Block size = 2 words |
| 2 | Miss rate = 6%  Number of misses = 34 | Miss rate = 20%  Number of misses = 120 | Miss rate = 58%  Number of misses = 354 |
| 4 | Miss rate = 5%  Number of misses = 31 | Miss rate = 20%  Number of misses = 120 | Miss rate = 71%  Number of misses = 434 |
| 8 | Miss rate = 5%  Number of misses = 32 | Miss rate = 20%  Number of misses = 120 | Miss rate = 71%  Number of misses = 434 |
| 16 | Miss rate = 5%  Number of misses = 31 | Miss rate = 20%  Number of misses = 120 | Miss rate = 71%  Number of misses = 434 |

Table 2.4: *N-way associative cache comparison on various points from table 2.2*

# Report for matrix 3 size (N = 40)

a) **Direct Mapped Caches**:

(N = 40 column-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 46%  Number of misses = 835 | Miss Rate = 23%  Number of misses = 421 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 6%  Number of misses = 109 | Miss Rate = 3%  Number of misses = 55 |
| 512 | Miss Rate = 46%  Number of misses = 835 | Miss Rate = 23%  Number of misses = 421 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 6%  Number of misses = 109 | Miss Rate = 3%  Number of misses = 55 |
| 1024 | Miss Rate = 46%  Number of misses = 835 | Miss Rate = 23%  Number of misses = 421 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 6%  Number of misses = 107 | Miss Rate = 3%  Number of misses = 57 |
| 2048 | Miss Rate = 46%  Number of misses = 835 | Miss Rate = 23%  Number of misses = 421 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 6%  Number of misses = 109 | Miss Rate = 3%  Number of misses = 55 |
| 4096 | Miss Rate = 46%  Number of misses = 835 | Miss Rate = 23%  Number of misses = 421 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 6%  Number of misses = 107 | Miss Rate = 3%  Number of misses = 55 |

(N = 40 row-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 90%  Number of misses = 1634 | Miss Rate = 89%  Number of misses = 1620 | Miss Rate = 89%  Number of misses = 1612 | Miss Rate = 89%  Number of misses = 1607 | Miss Rate = 89%  Number of misses = 1608 |
| 512 | Miss Rate = 90%  Number of misses = 1634 | Miss Rate = 89%  Number of misses = 1620 | Miss Rate = 89%  Number of misses = 1612 | Miss Rate = 89%  Number of misses = 1609 | Miss Rate = 89%  Number of misses = 1606 |
| 1024 | Miss Rate = 64%  Number of misses = 1154 | Miss Rate = 50%  Number of misses = 900 | Miss Rate = 43%  Number of misses = 772 | Miss Rate = 89%  Number of misses = 1609 | Miss Rate = 89%  Number of misses = 1606 |
| 2048 | Miss Rate = 46%  Number of misses = 834 | Miss Rate = 23%  Number of misses = 420 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 64%  Number of misses = 1159 | Miss Rate = 89%  Number of misses = 1608 |
| 4096 | Miss Rate = 46%  Number of misses = 834 | Miss Rate = 23%  Number of misses = 420 | Miss Rate = 12%  Number of misses = 212 | Miss Rate = 7%  Number of misses = 123 | Miss Rate = 49%  Number of misses = 890 |

b) **Fully Associative Caches**:

N = 40 row-major addition

|  |  |  |  |
| --- | --- | --- | --- |
|  | Good Hit Rate  Cache size = 4096 bytes  Block size = 16 words | Medium Hit Rate  Cache size = 4096 bytes  Block size = 4 words | Bad Hit Rate  Cache size = 4096 bytes  Block size = 2 words |
| Fully Associative with LRU | Miss rate = 7%  Number of misses = 129 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |
| Fully Associative with Random | Miss rate = 8%  Number of misses = 152 | Miss rate = 24%  Number of misses = 429 | Miss rate = 47%  Number of misses = 848 |
| Direct Mapped | Miss rate = 7%  Number of misses = 123 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |

c) **N-way Set Associative Caches**:

(N = 40 row-major addition)

|  |  |  |  |
| --- | --- | --- | --- |
| Set size | Good Hit Rate  Cache size = 4096 bytes  Block size = 16 words | Medium Hit Rate  Cache size = 4096 bytes  Block size = 4 words | Bad Hit Rate  Cache size = 4096 bytes  Block size = 2 words |
| 2 | Miss rate = 9%  Number of misses = 157 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |
| 4 | Miss rate = 7%  Number of misses = 127 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |
| 8 | Miss rate = 7%  Number of misses = 129 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |
| 16 | Miss rate = 7%  Number of misses = 127 | Miss rate = 23%  Number of misses = 420 | Miss rate = 46%  Number of misses = 834 |

# Report for matrix 4 size (N = 150)

a) **Direct Mapped Caches**:

(N = 150 column-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 50%  Number of misses = 11285 | Miss Rate = 25%  Number of misses = 5646 | Miss Rate = 12%  Number of misses = 2825 | Miss Rate = 6%  Number of misses = 1414 | Miss Rate = 3%  Number of misses = 711 |
| 512 | Miss Rate = 50%  Number of misses = 11285 | Miss Rate = 25%  Number of misses = 5646 | Miss Rate = 12%  Number of misses = 2825 | Miss Rate = 6%  Number of misses = 1416 | Miss Rate = 3%  Number of misses = 709 |
| 1024 | Miss Rate = 50%  Number of misses = 11285 | Miss Rate = 25%  Number of misses = 5646 | Miss Rate = 12%  Number of misses = 2825 | Miss Rate = 6%  Number of misses = 1414 | Miss Rate = 3%  Number of misses = 709 |
| 2048 | Miss Rate = 50%  Number of misses = 11285 | Miss Rate = 25%  Number of misses = 5646 | Miss Rate = 12%  Number of misses = 2825 | Miss Rate = 6%  Number of misses = 1416 | Miss Rate = 3%  Number of misses = 709 |
| 4096 | Miss Rate = 50%  Number of misses = 11285 | Miss Rate = 25%  Number of misses = 5646 | Miss Rate = 12%  Number of misses = 2825 | Miss Rate = 6%  Number of misses = 1414 | Miss Rate = 3%  Number of misses = 711 |

(N = 150 row-major addition)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Block Size (words) | 2 | 4 | 8 | 16 | 32 |
| Cache Size (bytes) |
| 256 | Miss Rate = 99%  Number of misses = 22534 | Miss Rate = 99%  Number of misses = 22520 | Miss Rate = 99%  Number of misses = 22512 | Miss Rate = 99%  Number of misses = 22509 | Miss Rate = 99%  Number of misses = 22506 |
| 512 | Miss Rate = 99%  Number of misses = 22534 | Miss Rate = 99%  Number of misses = 22520 | Miss Rate = 99%  Number of misses = 22512 | Miss Rate = 99%  Number of misses = 22507 | Miss Rate = 99%  Number of misses = 22506 |
| 1024 | Miss Rate = 64%  Number of misses = 14584 | Miss Rate = 91%  Number of misses = 20744 | Miss Rate = 99%  Number of misses = 22512 | Miss Rate = 99%  Number of misses = 22509 | Miss Rate = 99%  Number of misses = 22506 |
| 2048 | Miss Rate = 50%  Number of misses = 11284 | Miss Rate = 59%  Number of misses = 13320 | Miss Rate = 94%  Number of misses = 21361 | Miss Rate = 99%  Number of misses = 22507 | Miss Rate = 99%  Number of misses = 22508 |
| 4096 | Miss Rate = 50%  Number of misses = 11284 | Miss Rate = 25%  Number of misses = 5720 | Miss Rate = 49%  Number of misses = 11058 | Miss Rate = 97%  Number of misses = 21986 | Miss Rate = 99%  Number of misses = 22506 |

b) **Fully Associative Caches**:

N = 150 row-major addition

|  |  |  |  |
| --- | --- | --- | --- |
|  | Good Hit Rate  Cache size = 4096 bytes  Block size = 4 words | Medium Hit Rate  Cache size = 4096 bytes  Block size = 8 words | Bad Hit Rate  Cache size = 4096 bytes  Block size = 16 words |
| Fully Associative with LRU | Miss rate = 25%  Number of misses = 5720 | Miss rate = 99%  Number of misses = 22512 | Miss rate = 99%  Number of misses = 22509 |
| Fully Associative with Random | Miss rate = 41%  Number of misses = 9236 | Miss rate = 53%  Number of misses = 11969 | Miss rate = 87%  Number of misses = 19849 |
| Direct Mapped | Miss rate = 25%  Number of misses = 5720 | Miss rate = 49%  Number of misses = 11058 | Miss rate = 97%  Number of misses = 21984 |

c) **N-way Set Associative Caches**:

(N = 150 row-major addition)

|  |  |  |  |
| --- | --- | --- | --- |
| Set size | Good Hit Rate  Cache size = 4096 bytes  Block size = 4 words | Medium Hit Rate  Cache size = 4096 bytes  Block size = 8 words | Bad Hit Rate  Cache size = 4096 bytes  Block size = 16 words |
| 2 | Miss rate = 25%  Number of misses = 5720 | Miss rate = 61%  Number of misses = 13967 | Miss rate = 99%  Number of misses = 22509 |
| 4 | Miss rate = 25%  Number of misses = 5720 | Miss rate = 73%  Number of misses = 16626 | Miss rate = 99%  Number of misses = 22507 |
| 8 | Miss rate = 25%  Number of misses = 5720 | Miss rate = 89%  Number of misses = 20276 | Miss rate = 99%  Number of misses = 22509 |
| 16 | Miss rate = 25%  Number of misses = 5720 | Miss rate = 98%  Number of misses = 22208 | Miss rate = 99%  Number of misses = 22507 |