**Lab Assignment 7**

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1. **L1 (8,8)**
2. **Blocks = 2, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| b | Program 1 | | | | Program 2 | | | |
| Number of Lines | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 49 | 17 | 66 | **0.7424** | 2 | 64 | 66 | **0.0303** |
| 2 | 49 | 17 | 66 | **0.7424** | 2 | 64 | 66 | **0.0303** |
| 3 | 49 | 17 | 66 | **0.7424** | 3 | 63 | 66 | **0.0454** |
| 4 | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| 5 | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |

1. **Lines = 3, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Blocks | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 33 | 33 | 66 | **0.5000** | 1 | 65 | 66 | **0.0152** |
| 2 | 49 | 17 | 66 | **0.7424** | 3 | 63 | 66 | **0.0454** |
| 3 | 57 | 9 | 66 | **0.8636** | 57 | 9 | 66 | **0.8636** |
| 4 | 61 | 5 | 66 | **0.9242** | 61 | 5 | 66 | **0.9242** |
| 5 | 63 | 3 | 66 | **0.9545** | 63 | 3 | 66 | **0.9545** |

1. **Blocks = 2, Lines = 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Ways | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 0 | 49 | 17 | 66 | **0.7424** | 3 | 63 | 66 | **0.0454** |
| 1 | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| 2 | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |

1. **Different combinations of Write-Through and Write-Back policies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Write Through + Write Allocate | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| Write Through + No Write Allocate | 3 | 63 | 66 | **0.0454** | 3 | 63 | 66 | **0.0454** |
| Write Back + Write Allocate | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| Write Back + No Write Allocate | 3 | 63 | 66 | **0.0454** | 3 | 63 | 66 | **0.0454** |

1. **Associativity**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| 2-way Associative | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |
| Fully Associative | 49 | 17 | 66 | **0.7424** | 49 | 17 | 66 | **0.7424** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Program 3 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 2 | 128 | 130 | **0.0154** |
| 2-way Associative | 96 | 34 | 130 | **0.7385** |
| Fully Associative | 96 | 34 | 130 | **0.7385** |

**Observations:**

Increasing the number of lines doesn’t impact the running of P1 because the amount of memory it needs to access still fits irrespective of the number of lines. However, changing the number of blocks allows more spatial locality, as we are within certain memory locations. In specific, we are accessing 8 bytes away each time from the location we wish to load from.

In P2, we access 64 bytes (slli x15, x5 ,3) away from the memory we wish to load from. Thus, increasing the number of lines/blocks allow more data in the cache, which increases the hit rate.

Again, associativity doesn’t play much of a role because the range of memory locations we wish to access are not particularly large, however, it will have an impact on the hit time.

Write allocate tends to perform better than no allocate because on every miss, we tend to bring the accessed block into the cache, in case it is referenced again, which increases the number of hits. Write back and Write through perform exactly the same, because it only differs in how values are updated, whether both main memory and cache are updated simultaneously (Write Through), or if cache is updated first and then main memory (Write Back). This results in a change in the miss penalty, and not in the number of hits and misses.

P3 has a lower hit rate because we wish to access the 1024th byte from the memory location each time. However, increasing the associativity means, instead of replacing the block every time we access a faraway location, there is a chance it might reside under the same index, thus increasing the amount of data we can access under the same index, avoiding multiple replacements.

**---------------------------------------------------------------------------------------------------------**

1. **L1 (8,16)**
2. **Blocks = 2, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Lines | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 2 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 3 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 4 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 5 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |

1. **Lines = 3, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Blocks | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 65 | 65 | 130 | **0.5000** | 1 | 129 | 130 | **0.0077** |
| 2 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 3 | 113 | 17 | 130 | **0.8692** | 2 | 128 | 130 | **0.0154** |
| 4 | 121 | 9 | 130 | **0.9307** | 2 | 128 | 130 | **0.0154** |
| 5 | 125 | 5 | 130 | **0.9615** | 122 | 8 | 130 | **0.9384** |

1. **Blocks = 2, Lines = 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Ways | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 0 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 1 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 2 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |

1. **Different combinations of Write-Through and Write-Back policies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Write Through + Write Allocate | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| Write Through + No Write Allocate | 3 | 127 | 130 | **0.0230** | 3 | 127 | 130 | **0.0230** |
| Write Back + Write Allocate | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| Write Back + No Write Allocate | 3 | 127 | 130 | **0.0230** | 3 | 127 | 130 | **0.0230** |

1. **Associativity**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 2-way Associative | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| Fully Associative | 97 | 33 | 130 | **0.7461** | 82 | 148 | 230 | **0.6307** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Program 3 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 3 | 255 | 258 | **0.0116** |
| 2-way Associative | 192 | 66 | 258 | **0.7442** |
| Fully Associative | 192 | 66 | 258 | **0.7442** |

**Observations:**

A lot of the observations from the previous case apply for this case as well, especially for how associativity, the different combinations of write hits and write miss conditions and changing number of lines and blocks impact the programs.

As we change the data from (8,8) to (8,16), we find that the hit rate decreases for Program2 because we tend to access memory locations that are 128 bytes away from the memory location in cache, as compared to the 64 bytes earlier. Thus, again increasing the lines and blocks tend to increase the hit rate, as we found out in the previous case. For program1, it tends to remain almost the same because only the number of accesses is increasing, and the memory locations being accessed are independent of the data. Same goes for program3.

**---------------------------------------------------------------------------------------------------------**

1. **L1 (16,8)**
2. **Blocks = 2, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Lines | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 2 | 97 | 33 | 130 | **0.7461** | 2 | 128 | 130 | **0.0154** |
| 3 | 97 | 33 | 130 | **0.7461** | 5 | 125 | 130 | **0.0384** |
| 4 | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| 5 | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |

1. **Lines = 3, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Blocks | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 65 | 65 | 130 | **0.5000** | 1 | 129 | 130 | **0.0077** |
| 2 | 97 | 33 | 130 | **0.7461** | 5 | 125 | 130 | **0.0384** |
| 3 | 113 | 17 | 130 | **0.8692** | 120 | 10 | 130 | **0.9230** |
| 4 | 121 | 9 | 130 | **0.9307** | 125 | 5 | 130 | **0.9615** |
| 5 | 125 | 5 | 130 | **0.9615** | 127 | 3 | 130 | **0.9769** |

1. **Blocks = 2, Lines = 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Ways | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 0 | 97 | 33 | 130 | **0.7461** | 5 | 125 | 130 | **0.0384** |
| 1 | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| 2 | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |

1. **Different combinations of Write-Through and Write-Back policies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Write Through + Write Allocate | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| Write Through + No Write Allocate | 3 | 127 | 130 | **0.0230** | 3 | 127 | 130 | **0.0230** |
| Write Back + Write Allocate | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| Write Back + No Write Allocate | 3 | 127 | 130 | **0.0230** | 3 | 127 | 130 | **0.0230** |

1. **Associativity**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| 2-way Associative | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |
| Fully Associative | 97 | 33 | 130 | **0.7461** | 111 | 19 | 130 | **0.8538** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Program 3 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 3 | 255 | 258 | **0.0116** |
| 2-way Associative | 192 | 66 | 258 | **0.7442** |
| Fully Associative | 192 | 66 | 258 | **0.7442** |

**Observations:**

We see that for P1, the hit rates are almost the same, which goes on to show that the memory locations being accessed are independent of the data. However, for P2, the hit rates are higher for (16,8) rather than (8,16) because in (16,8), It will be accessing memory locations 64 bytes away, whereas in (8,16) it will be accessing memory locations 128 bytes away, accounting for the command “slli x15, x10, 3”. The slight changes from case 1 to case 3 can be accounted for by the increase in number of accesses.

P3 for (8,16) performs exactly similar to P3 for (16,8) because again the memory locations being accessed are independent of the data, similar to P1.

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1. **L1 (16,16)**
2. **Blocks = 2, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Lines | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 2 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 3 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 4 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 5 | 193 | 65 | 258 | **0.7480** | 3 | 256 | 258 | **0.0116** |

1. **Lines = 3, Ways = 0**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Blocks | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 1 | 129 | 129 | 258 | **0.5000** | 1 | 257 | 258 | **0.0038** |
| 2 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 3 | 225 | 33 | 258 | **0.8721** | 2 | 256 | 258 | **0.0077** |
| 4 | 241 | 17 | 130 | **0.9341** | 3 | 255 | 258 | **0.0116** |
| 5 | 249 | 9 | 258 | **0.9651** | 247 | 11 | 258 | **0.9573** |

1. **Blocks = 2, Lines = 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
| Number of Ways | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| 0 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 1 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| 2 | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |

1. **Different combinations of Write-Through and Write-Back policies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Write Through + Write Allocate | 193 | 65 | 258 | **0.7480** | 3 | 255 | 258 | **0.0116** |
| Write Through + No Write Allocate | 3 | 255 | 258 | **0.0116** | 3 | 255 | 258 | **0.0116** |
| Write Back + Write Allocate | 193 | 65 | 258 | **0.7480** | 3 | 255 | 258 | **0.0116** |
| Write Back + No Write Allocate | 3 | 255 | 258 | **0.0116** | 3 | 255 | 258 | **0.0116** |

1. **Associativity**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Program 1 | | | | Program 2 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 193 | 65 | 258 | **0.7480** | 3 | 255 | 258 | **0.0116** |
| 2-way Associative | 193 | 65 | 258 | **0.7480** | 2 | 256 | 258 | **0.0077** |
| Fully Associative | 193 | 65 | 258 | **0.7480** | 178 | 80 | 258 | **0.6900** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Program 3 | | | |
|  | Number of Hits | Number of Misses | Total Accesses | **Hit Rate** |
| Direct Mapping | 35 | 479 | 514 | **0.0680** |
| 2-way Associative | 384 | 130 | 514 | **0.7470** |
| Fully Associative | 384 | 130 | 514 | **0.7470** |

**Observations:**

P1 and P3 again have similar hit rates to the previous cases because the memory locations being accessed are independent of the data. The hit rates for P2 go down further because earlier one parameter was 8, which meant we were accessing the 64th byte from one memory location and depending on whether the other was 8 or 16, we were accessing the 64th or 128th byte from the memory location respectively. Here, the data is (16,16), which means we are accessing the 128th byte both the times, which means we need more data in our cache to get ample number of hits, and thus the hit rate goes down.

**---------------------------------------------------------------------------------------------------------**