**Cache Simulator Project Report**

Group 11: Bilal **Siddiqui**, Zhongxiu **Yang**, Trung **Dinh**

CS 5513

05/03/2019

• **A brief description of the implementation of the simulator**

This cache simulator is to simulate set associative caches with different replacement policy. This simulator reads memory one by one, and simulates their accesses to cache. The simulator would take command-line parameter of memory trace file name, with optional choice of cache line size, cache size, associativity, and replacement policy including LRU, Second Chance, FIFO and LIFO, then read these memory addresses line by line and simulate their accesses to cache. By default, this simulator is configured with an LRU write-back cache of 1 MB with 16-ways. The parser.py handles reading in cache sequence from the file. The sim.py is the main program reads optional configuration and take the tag bits from sequence, determine if cache hit or cache miss in cache.py, with different kind of replacement policy.

• **A description of your experiments and the experiment results with figures and/or tables**

We extensively tested our cache implementation with many different parameters. The testing serves both as a comparison between different caching techniques and as a sanity check on the correctness of our implementation. The testing simulates the memory accesses from many memory traces obtained, some obtained from real applications while others are synthetic. We test different cache sizes, cache line sizes, n-way associativity and replacement policies.

**1KB\_64B:** **(line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **32 KB** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **256 KB** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **1 MB** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **4 MB** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |

**1KB\_64B: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **64 Bytes** | 50.0% | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% | 50.0% | | 50.0% | 50.0% | 50.0% |
| **128 Bytes** | 25.0% | 25.0% | 25.0% | 25.0% | 25.0% | | 25.0% | 25.0% | 25.0% | 25.0% | | 25.0% | 25.0% | 25.0% | 25.0% | | 25.0% | 25.0% | 25.0% |
| **512 Bytes** | 6.25% | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% |
| **1024 Bytes** | 3.12% | 3.12% | 3.12% | 3.12% | 3.12% | | 3.12% | 3.12% | 3.12% | 3.12% | | 3.12% | 3.12% | 3.12% | 3.12% | | 3.12% | 3.12% | 3.12% |

**4MB\_4:** **(line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 6.25% | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% |
| **32 KB** | 6.25% | 6.25% | 6.25% | 6.23% | 6.25% | | 6.25% | 6.25% | 6.23% | 6.25% | | 6.25% | 6.25% | 6.22% | 6.25% | | 6.25% | 6.25% | 6.22% |
| **256 KB** | 6.25% | 6.25% | 6.25% | 6.12% | 6.25% | | 6.25% | 6.25% | 6.05% | 6.25% | | 6.25% | 6.25% | 6.02% | 6.25% | | 6.25% | 6.25% | 6.01% |
| **1 MB** | 6.25% | 6.25% | 6.25% | 5.73% | 6.25% | | 6.25% | 6.25% | 5.47% | 6.25% | | 6.25% | 6.25% | 5.34% | 6.25% | | 6.25% | 6.25% | 5.27% |
| **4 MB** | 2.08% | 2.08% | 2.08% | 2.08% | 2.08% | | 2.08% | 2.08% | 2.08% | 2.08% | | 2.08% | 2.08% | 2.08% | 2.08% | | 2.08% | 2.08% | 2.08% |

**4MB\_4: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 25.0% | 25.0% | 25.0% | 22.92% | | 25.0% | 25.0% | 25.0% | 21.88% | | 25.0% | 25.0% | 25.0% | 21.35% | | 25.0% | 25.0% | 25.0% | 21.09% |
| **64 Bytes** | 6.25% | 6.25% | 6.25% | 5.73% | | 6.25% | 6.25% | 6.25% | 5.47% | | 6.25% | 6.25% | 6.25% | 5.34% | | 6.25% | 6.25% | 6.25% | 5.27% |
| **128 Bytes** | 3.12% | 3.12% | 3.12% | 2.86% | | 3.12% | 3.12% | 3.12% | 2.73% | | 3.12% | 3.12% | 3.12% | 2.67% | | 3.12% | 3.12% | 3.12% | 2.64% |
| **512 Bytes** | 0.78% | 0.78% | 0.78% | 0.72% | | 0.78% | 0.78% | 0.78% | 0.68% | | 0.78% | 0.78% | 0.78% | 0.67% | | 0.78% | 0.78% | 0.78% | 0.66% |
| **1024 Bytes** | 0.39% | 0.39% | 0.39% | 0.36% | | 0.39% | 0.39% | 0.39% | 0.34% | | 0.39% | 0.39% | 0.39% | 0.33% | | 0.39% | 0.39% | 0.39% | 0.33% |

**32MB\_4B:** **(line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 6.25% | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% |
| **32 KB** | 6.25% | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% |
| **256 KB** | 6.25% | 6.25% | 6.25% | 6.23% | 6.25% | | 6.25% | 6.25% | 6.23% | 6.25% | | 6.25% | 6.25% | 6.22% | 6.25% | | 6.25% | 6.25% | 6.22% |
| **1 MB** | 6.25% | 6.25% | 6.25% | 6.18% | 6.25% | | 6.25% | 6.25% | 6.15% | 6.25% | | 6.25% | 6.25% | 6.14% | 6.25% | | 6.25% | 6.25% | 6.13% |
| **4 MB** | 6.25% | 6.25% | 6.25% | 5.99% | 6.25% | | 6.25% | 6.25% | 5.86% | 6.25% | | 6.25% | 6.25% | 5.79% | 6.25% | | 6.25% | 6.25% | 5.76% |

**32MB\_4B: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 25.0% | 25.0% | 25.0% | 24.74% | | 25.0% | 25.0% | 25.0% | 24.61% | | 25.0% | 25.0% | 25.0% | 24.54% | | 25.0% | 25.0% | 25.0% | 24.51% |
| **64 Bytes** | 6.25% | 6.25% | 6.25% | 6.18% | | 6.25% | 6.25% | 6.25% | 6.15% | | 6.25% | 6.25% | 6.25% | 6.14% | | 6.25% | 6.25% | 6.25% | 6.13% |
| **128 Bytes** | 3.12% | 3.12% | 3.12% | 3.09% | | 3.12% | 3.12% | 3.12% | 3.08% | | 3.12% | 3.12% | 3.12% | 3.07% | | 3.12% | 3.12% | 3.12% | 3.06% |
| **512 Bytes** | 0.78% | 0.78% | 0.78% | 0.77% | | 0.78% | 0.78% | 0.78% | 0.77% | | 0.78% | 0.78% | 0.78% | 0.77% | | 0.78% | 0.78% | 0.78% | 0.77% |
| **1024 Bytes** | 0.39% | 0.39% | 0.39% | 0.39% | | 0.39% | 0.39% | 0.39% | 0.38% | | 0.39% | 0.39% | 0.39% | 0.38% | | 0.39% | 0.39% | 0.39% | 0.38% |

**bw\_mem: (line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 1.57% | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% |
| **32 KB** | 1.57% | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% |
| **256 KB** | 1.57% | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.57% | 1.57% | | 1.57% | 1.57% | 1.56% | 1.57% | | 1.57% | 1.57% | 1.56% |
| **1 MB** | 1.56% | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% |
| **4 MB** | 1.56% | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% |

**bw\_mem.traces: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 6.25% | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% | 6.25% | | 6.25% | 6.25% | 6.25% |
| **64 Bytes** | 1.56% | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% | 1.56% | | 1.56% | 1.56% | 1.56% |
| **128 Bytes** | 0.78% | 0.78% | 0.78% | 0.78% | 0.78% | | 0.78% | 0.78% | 0.78% | 0.78% | | 0.78% | 0.78% | 0.78% | 0.78% | | 0.78% | 0.78% | 0.78% |
| **512 Bytes** | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% | | 0.2% | 0.2% | 0.2% | 0.2% | | 0.2% | 0.2% | 0.2% | 0.2% | | 0.2% | 0.2% | 0.2% |
| **1024 Bytes** | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | | 0.1% | 0.1% | 0.1% | 0.1% | | 0.1% | 0.1% | 0.1% | 0.1% | | 0.1% | 0.1% | 0.1% |

**ls: (line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 17.3% | 18.43% | 18.43% | 28.8% | 16.25% | | 16.93% | 17.38% | 37.46% | 15.97% | | 16.52% | 17.25% | 50.3% | 16.18% | | 16.71% | 17.18% | 62.8% |
| **32 KB** | 2.52% | 2.66% | 2.66% | 4.33% | 2.24% | | 2.34% | 2.43% | 4.4% | 2.19% | | 2.28% | 2.41% | 5.41% | 2.17% | | 2.22% | 2.39% | 7.09% |
| **256 KB** | 1.65% | 1.69% | 1.69% | 1.75% | 1.61% | | 1.63% | 1.63% | 1.74% | 1.6% | | 1.61% | 1.62% | 1.86% | 1.59% | | 1.61% | 1.61% | 1.85% |
| **1 MB** | 1.59% | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% |
| **4 MB** | 1.59% | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% |

**ls.traces: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 5.5% | 5.5% | 5.5% | 5.5% | 5.5% | | 5.5% | 5.5% | 5.5% | 5.5% | | 5.5% | 5.5% | 5.5% | 5.5% | | 5.5% | 5.5% | 5.5% |
| **64 Bytes** | 1.59% | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% | 1.59% | | 1.59% | 1.59% | 1.59% |
| **128 Bytes** | 0.87% | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% |
| **512 Bytes** | 0.28% | 0.28% | 0.28% | 0.28% | 0.27% | | 0.27% | 0.27% | 0.27% | 0.27% | | 0.27% | 0.27% | 0.27% | 0.27% | | 0.27% | 0.27% | 0.27% |
| **1024 Bytes** | 0.16% | 0.16% | 0.16% | 0.17% | 0.16% | | 0.16% | 0.16% | 0.16% | 0.16% | | 0.16% | 0.16% | 0.16% | 0.16% | | 0.16% | 0.16% | 0.16% |

**gcc: (line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | **4-ways** | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 13.15% | 13.9% | 13.9% | 25.43% | 11.94% | 12.6% | 13.06% | 35.67% | 11.46% | 12.02% | 12.74% | 47.78% | 11.34% | | 11.87% | 12.83% | 60.61% |
| **32 KB** | 2.06% | 2.16% | 2.16% | 3.15% | 1.94% | 2.02% | 2.08% | 3.8% | 1.91% | 1.97% | 2.07% | 5.91% | 1.89% | | 1.93% | 2.04% | 7.93% |
| **256 KB** | 1.34% | 1.36% | 1.36% | 1.4% | 1.31% | 1.33% | 1.34% | 1.4% | 1.3% | 1.32% | 1.32% | 1.47% | 1.29% | | 1.31% | 1.32% | 1.54% |
| **1 MB** | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | | 1.29% | 1.29% | 1.29% |
| **4 MB** | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | | 1.29% | 1.29% | 1.29% |

**gcc.traces: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 4.6% | 4.6% | 4.6% | 4.6% | 4.6% | | 4.6% | 4.6% | 4.6% | 4.6% | | 4.6% | 4.6% | 4.6% | 4.6% | | 4.6% | 4.6% | 4.6% |
| **64 Bytes** | 1.29% | 1.29% | 1.29% | 1.29% | 1.29% | | 1.29% | 1.29% | 1.29% | 1.29% | | 1.29% | 1.29% | 1.29% | 1.29% | | 1.29% | 1.29% | 1.29% |
| **128 Bytes** | 0.69% | 0.69% | 0.69% | 0.69% | 0.69% | | 0.69% | 0.69% | 0.69% | 0.69% | | 0.69% | 0.69% | 0.69% | 0.69% | | 0.69% | 0.69% | 0.69% |
| **512 Bytes** | 0.22% | 0.22% | 0.22% | 0.23% | 0.21% | | 0.22% | 0.22% | 0.22% | 0.21% | | 0.21% | 0.21% | 0.21% | 0.21% | | 0.21% | 0.21% | 0.21% |
| **1024 Bytes** | 0.13% | 0.13% | 0.13% | 0.16% | 0.13% | | 0.13% | 0.13% | 0.13% | 0.13% | | 0.13% | 0.13% | 0.13% | 0.13% | | 0.13% | 0.13% | 0.13% |

**native\_dgemm:** **(line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 56.44% | 58.75% | 58.75% | 61.55% | 56.44% | | 56.45% | 58.0% | 66.69% | 56.44% | | 56.44% | 56.44% | 77.21% | 56.44% | | 56.44% | 56.44% | 99.31% |
| **32 KB** | 50.27% | 50.27% | 50.27% | 49.23% | 50.27% | | 50.27% | 50.27% | 48.61% | 50.27% | | 50.27% | 50.27% | 48.5% | 50.27% | | 50.27% | 50.27% | 49.15% |
| **256 KB** | 50.25% | 50.26% | 50.26% | 38.36% | 50.25% | | 50.25% | 50.25% | 32.24% | 50.25% | | 50.25% | 50.25% | 29.2% | 50.25% | | 50.25% | 50.25% | 27.72% |
| **1 MB** | 0.87% | 0.88% | 0.88% | 0.93% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% |
| **4 MB** | 0.87% | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% |

**native\_dgemm.traces: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 3.48% | 3.51% | 3.51% | 3.54% | 3.48% | | 3.48% | 3.48% | 3.48% | 3.48% | | 3.48% | 3.48% | 3.48% | 3.48% | | 3.48% | 3.48% | 3.48% |
| **64 Bytes** | 0.87% | 0.88% | 0.88% | 0.93% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% | 0.87% | | 0.87% | 0.87% | 0.87% |
| **128 Bytes** | 0.43% | 0.44% | 0.44% | 0.49% | 0.43% | | 0.43% | 0.43% | 0.43% | 0.43% | | 0.43% | 0.43% | 0.43% | 0.43% | | 0.43% | 0.43% | 0.43% |
| **512 Bytes** | 0.11% | 0.11% | 0.11% | 0.16% | 0.11% | | 0.11% | 0.11% | 0.11% | 0.11% | | 0.11% | 0.11% | 0.11% | 0.11% | | 0.11% | 0.11% | 0.11% |
| **1024 Bytes** | 0.05% | 0.06% | 0.06% | 0.11% | 0.05% | | 0.05% | 0.05% | 0.05% | 0.05% | | 0.05% | 0.05% | 0.05% | 0.05% | | 0.05% | 0.05% | 0.05% |

**native\_dgemm\_full:** **(line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 55.48% | 57.74% | 57.74% | 60.82% | | 55.47% | 55.48% | 57.0% | 66.15% | | 55.47% | 55.47% | 55.47% | 76.81% | | 55.47% | 55.47% | 55.47% | 98.12% |
| **32 KB** | 49.4% | 49.4% | 49.4% | 49.56% | | 49.4% | 49.4% | 49.4% | 49.73% | | 49.4% | 49.4% | 49.4% | 50.06% | | 49.39% | 49.4% | 49.4% | 51.1% |
| **256 KB** | 49.38% | 49.38% | 49.38% | 49.4% | | 49.38% | 49.38% | 49.38% | 49.4% | | 49.37% | 49.38% | 49.38% | 49.43% | | 49.37% | 49.37% | 49.37% | 49.49% |
| **1 MB** | 0.13% | 0.15% | 0.15% | 0.64% | | 0.13% | 0.15% | 0.17% | 24.95% | | 0.13% | 0.15% | 0.17% | 25.6% | | 0.13% | 0.15% | 0.17% | 21.0% |
| **4 MB** | 0.08% | 0.08% | 0.08% | 0.08% | | 0.08% | 0.08% | 0.08% | 0.08% | | 0.08% | 0.08% | 0.08% | 0.08% | | 0.08% | 0.08% | 0.08% | 0.08% |

**native\_dgemm\_full: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | **4-ways** | | | | **8-ways** | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 0.5% | 0.6% | 0.6% | 1.11% | 0.51% | 0.6% | 0.69% | 23.76% | 0.51% | 0.6% | 0.68% | 23.95% | 0.51% | 0.6% | 0.67% | 19.78% |
| **64 Bytes** | 0.13% | 0.15% | 0.15% | 0.64% | 0.13% | 0.15% | 0.17% | 24.95% | 0.13% | 0.15% | 0.17% | 25.6% | 0.13% | 0.15% | 0.17% | 21% |
| **128 Bytes** | 0.06% | 0.08% | 0.08% | 0.57% | 0.06% | 0.08% | 0.09% | 25.86% | 0.07% | 0.08% | 0.09% | 26.85% | 0.07% | 0.08% | 0.09% | 21.99% |
| **512 Bytes** | 0.02% | 0.02% | 0.02% | 0.55% | 0.02% | 0.02% | 0.02% | 29.23% | 0.02% | 0.02% | 0.02% | 30.8% | 0.02% | 0.02% | 0.02% | 25.35% |
| **1024 Bytes** | 0.01% | 0.01% | 0.01% | 0.58% | 0.01% | 0.01% | 0.01% | 30.68% | 0.01% | 0.01% | 0.01% | 32.66% | 0.01% | 0.01% | 0.01% | 27.68% |

**openblas\_dgemm: (line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** | **LRU** | | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 62.75% | 62.84% | 62.84% | 67.19% | 61.72% | | 61.8% | 61.85% | 79.71% | 61.76% | | 61.85% | 61.95% | 81.49% | 61.78% | | 61.8% | 61.93% | 83.08% |
| **32 KB** | 18.43% | 19.45% | 19.45% | 17.94% | 13.44% | | 21.47% | 22.2% | 19.81% | 16.33% | | 23.11% | 23.16% | 16.2% | 22.13% | | 25.05% | 25.01% | 14.38% |
| **256 KB** | 8.34% | 9.12% | 9.12% | 7.75% | 8.3% | | 8.39% | 9.08% | 7.43% | 8.3% | | 8.37% | 9.06% | 7.71% | 8.3% | | 8.35% | 9.1% | 7.98% |
| **1 MB** | 4.03% | 4.08% | 4.08% | 3.38% | 5.17% | | 4.95% | 5.04% | 3.41% | 6.57% | | 6.19% | 6.34% | 3.32% | 8.06% | | 7.97% | 8.01% | 3.13% |
| **4 MB** | 2.27% | 2.27% | 2.27% | 2.27% | 2.27% | | 2.27% | 2.27% | 2.27% | 2.27% | | 2.27% | 2.27% | 2.27% | 2.27% | | 2.27% | 2.27% | 2.27% |

**openblas\_dgemm: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | **4-ways** | | | | **8-ways** | | | | **16-ways** | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 7.39% | 7.54% | 7.54% | 6.61% | 8.93% | 8.76% | 9.0% | 6.35% | 10.54% | 10.15% | 10.43% | 6.17% | 14.06% | 13.52% | 13.78% | 6.09% |
| **64 Bytes** | 4.03% | 4.08% | 4.08% | 3.38% | 5.17% | 4.95% | 5.04% | 3.41% | 6.57% | 6.19% | 6.34% | 3.32% | 8.06% | 7.91% | 8.01% | 3.13% |
| **128 Bytes** | 2.03% | 2.05% | 2.05% | 1.71% | 2.61% | 2.49% | 2.54% | 1.73% | 3.31% | 3.11%3 | 3.19% | 1.69% | 4.04% | 3.96% | 4.01% | 1.6% |
| **512 Bytes** | 0.54% | 0.53% | 0.53% | 0.46% | 0.68% | 0.65% | 0.66% | 0.48% | 0.86% | 0.8% | 0.82% | 0.49% | 1.02% | 1.0% | 1.02% | 0.49% |
| **1024 Bytes** | 0.28% | 0.28% | 0.28% | 0.24% | 0.36% | 0.36% | 034% | 0.27% | 0.45% | 0.45% | 0.42% | 0.28% | 0.52% | 0.51% | 0.52% | 0.3% |

**openblas\_dgemm\_full: (line size=64B)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cache size** | **2-ways** | | | | **4-ways** | | | | | **8-ways** | | | | | **16-ways** | | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** |
| **1 KB** | 51.49% | 51.66% | 51.66% | 56.7% | | 50.65% | 50.75% | 50.88% | 68.36% | | 50.39% | 50.48% | 50.64% | 72.74% | | 50.41% | 50.43% | 50.63% | 75.65% |
| **32 KB** | 15.52% | 16.39% | 16.39% | 26.03% | | 11.58% | 18.05% | 18.58% | 30.88% | | 13.83% | 19.21% | 19.33% | 33.95% | | 18.42% | 20.76% | 20.83% | 38.64% |
| **256 KB** | 7.54% | 8.17% | 8.17% | 9.36% | | 7.5% | 7.53% | 8.13% | 11.09% | | 7.5% | 7.51% | 8.13% | 14.38% | | 7.5% | 7.51% | 8.15% | 25.99% |
| **1 MB** | 3.02% | 3.15% | 3.15% | 7.92% | | 4.26% | 4.16% | 4.32% | 8.35% | | 5.66% | 5.41% | 5.71% | 9.3% | | 7.2% | 6.83% | 7.11% | 11.02% |
| **4 MB** | 0.88% | 0.93% | 0.93% | 1.4% | | 0.94% | 0.94% | 0.93% | 2.17% | | 0.96% | 0.95% | 0.97% | 7.7% | | 0.98% | 0.96% | 0.98% | 8.12% |

**openblas\_dgemm\_full: (cache size=1MB)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Line size** | **2-ways** | | | | **4-ways** | | | | **8-ways** | | | | **16-ways** | | | | |
|  | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | **LRU** | **SC** | **FIFO** | **LIFO** | | **LRU** | **SC** | **FIFO** | **LIFO** |
| **16 Bytes** | 6.98% | 7.29% | 7.29% | 17.52% | 8.69% | 8.7% | 9.0% | 18.15% | 10.48% | 10.46% | 10.79% | 19.67% | | 13.71% | 13.64% | 13.98% | 22.24% |
| **64 Bytes** | 3.02% | 3.15% | 3.15% | 7.92% | 4.26% | 4.16% | 4.32% | 8.35% | 5.66% | 5.41% | 5.71% | 9.3% | | 7.2% | 6.83% | 7.11% | 11.08% |
| **128 Bytes** | 1.53% | 1.59% | 1.59% | 4.02% | 2.15% | 2.09% | 2.18% | 4.28% | 2.86% | 2.72% | 2.87% | 4.85% | | 3.61% | 3.42% | 3.56% | 3.91% |
| **512 Bytes** | 0.4% | 0.42% | 0.42% | 1.17% | 0.57% | 0.55% | 0.57% | 1.35% | 0.76% | 0.71% | 0.75% | 1.7% | | 0.93% | 0.87% | 0.92% | 2.37% |
| **1024 Bytes** | 0.22% | 0.22% | 0.22% | 0.72% | 0.3% | 0.29% | 0.3% | 0.9% | 0.41% | 0.37% | 0.4% | 1.27% | | 0.48% | 0.45% | 0.48% | 1.96% |

**• Individual contribution summary**

Many thanks to Bilal contributed the key part of the simulator program, including implements different types of replacement policies and the structure of cache. Zhongxiu handled the parsing sequence from file, tested the correctness of program and did the experiments for all memory trace files. Trung Dinh built shell to test program in experiments for all line size cases that are less than 1MB.