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CACHE AND MEMORY HIERARCHY SIMULATOR

Direct mapped

|  |  |  |
| --- | --- | --- |
|  |  | |
| L1 size | x | miss rate |
| 1024 | 10 | 0.19346 |
| 2048 | 11 | 0.14774 |
| 4096 | 12 | 0.10017 |
| 8192 | 13 | 0.067 |
| 16384 | 14 | 0.04609 |
| 32768 | 15 | 0.03768 |
| 65536 | 16 | 0.03292 |
| 131072 | 17 | 0.03233 |
| 262144 | 18 | 0.02584 |
| 524288 | 19 | 0.02584 |
| 1048576 | 20 | 0.02584 |

2-way set-associativity

|  |  |  |
| --- | --- | --- |
| L1 size | x | miss rate |
| 1024 | 10 | 0.15603 |
| 2048 | 11 | 0.10714 |
| 4096 | 12 | 0.07528 |
| 8192 | 13 | 0.04734 |
| 16384 | 14 | 0.03384 |
| 32768 | 15 | 0.02881 |
| 65536 | 16 | 0.02713 |
| 131072 | 17 | 0.0259 |
| 262144 | 18 | 0.02584 |
| 524288 | 19 | 0.02582 |
| 1048576 | 20 | 0.02582 |

4-way set-associativity

|  |  |  |
| --- | --- | --- |
| L1 size | x | miss rate |
| 1024 | 10 | 0.1427 |
| 2048 | 11 | 0.09622 |
| 4096 | 12 | 0.05992 |
| 8192 | 13 | 0.04247 |
| 16384 | 14 | 0.02832 |
| 32768 | 15 | 0.0264 |
| 65536 | 16 | 0.02595 |
| 131072 | 17 | 0.02582 |
| 262144 | 18 | 0.02582 |
| 524288 | 19 | 0.02582 |
| 1048576 | 20 | 0.02582 |

8-way set-associativity

|  |  |  |
| --- | --- | --- |
| L1 size | x | miss rate |
| 1024 | 10 | 0.13627 |
| 2048 | 11 | 0.09069 |
| 4096 | 12 | 0.05365 |
| 8192 | 13 | 0.03954 |
| 16384 | 14 | 0.02774 |
| 32768 | 15 | 0.02625 |
| 65536 | 16 | 0.02589 |
| 131072 | 17 | 0.02582 |
| 262144 | 18 | 0.02582 |
| 524288 | 19 | 0.02582 |
| 1048576 | 20 | 0.02582 |

Fully-associativity

|  |  |  |  |
| --- | --- | --- | --- |
| L1 size | associtivity | x | miss rate |
| 1024 | 32 | 10 | 0.13696 |
| 2048 | 64 | 11 | 0.0886 |
| 4096 | 128 | 12 | 0.04954 |
| 8192 | 256 | 13 | 0.03912 |
| 16384 | 512 | 14 | 0.02634 |
| 32768 | 1024 | 15 | 0.02624 |
| 65536 | 2048 | 16 | 0.02583 |
| 131072 | 4096 | 17 | 0.02582 |
| 262144 | 8192 | 18 | 0.02582 |
| 524288 | 16384 | 19 | 0.02582 |
| 1048576 | 32768 | 20 | 0.02582 |

Graph 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| x | direct | 2 way | 4-way | 8-way | full |
| 10 | 0.19346 | 0.15603 | 0.1427 | 0.13627 | 0.13696 |
| 11 | 0.14774 | 0.10714 | 0.09622 | 0.09069 | 0.0886 |
| 12 | 0.10017 | 0.07528 | 0.05992 | 0.05365 | 0.04954 |
| 13 | 0.067 | 0.04734 | 0.04247 | 0.03954 | 0.03912 |
| 14 | 0.04609 | 0.03384 | 0.02832 | 0.02774 | 0.02634 |
| 15 | 0.03768 | 0.02881 | 0.0264 | 0.02625 | 0.02624 |
| 16 | 0.03292 | 0.02713 | 0.02595 | 0.02589 | 0.02583 |
| 17 | 0.03233 | 0.0259 | 0.02582 | 0.02582 | 0.02582 |
| 18 | 0.02584 | 0.02584 | 0.02582 | 0.02582 | 0.02582 |
| 19 | 0.02584 | 0.02582 | 0.02582 | 0.02582 | 0.02582 |
| 20 | 0.02584 | 0.02582 | 0.02582 | 0.02582 | 0.02582 |

Discussion

Q1.

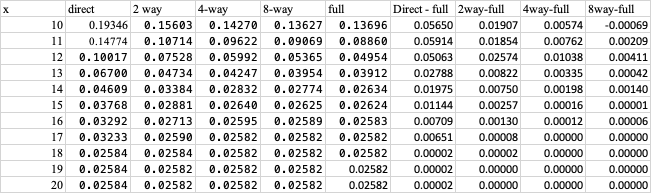
* Higher the associativity lower the miss rate. As each set will have more number of blocks, hence less chance of a conflict between two blocks. This will reduce AAT and memory stall cycles. This is because capacity miss rate decreases.
* Larger the cache size, lesser the chance that there will be conflict. So, as the miss rate decreases, AAT and number of memory stall cycles also decreases.
* The above graph shows that with increase in cache size the miss rate decreases.
* We can observe in the graph from associativity 4096 i.e, 17, the miss rate is constant. So as the size becomes larger the miss rate becomes constant.

Q2.

* Compulsory miss occur when the data has never requested before.
* Compulsory misses are difficult to avoid.
* Compulsory misses can be reduced by increasing cache size lines, hardware prefetching, software prefetching.
* Compulsory miss is the miss rate for the larger cache i.e, fully associative.
* So according to the graph compulsory miss is estimated as 0.02582

Q3.

* As the associativity increases the conflict miss reduces.
* Conflict misses occur when the data we need was in the cache previously but got evicted.



Direct

|  |  |  |
| --- | --- | --- |
|  | direct |  |
| L1 size | x | AAT |
| 1024 | 10 | 5.509468372 |
| 2048 | 11 | 4.246738243 |
| 4096 | 12 | 2.937039509 |
| 8192 | 13 | 2.02885339 |
| 16384 | 14 | 1.47979196 |
| 32768 | 15 | 1.279600259 |
| 65536 | 16 | 1.206687879 |
| 131072 | 17 | 1.260181356 |
| 262144 | 18 | 1.155863898 |
| 524288 | 19 | 1.272411426 |
| 1048576 | 20 | 1.404828021 |
| 2-way set-associativity   |  |  |  | | --- | --- | --- | |  | 2-WAY SET-ASSOCIATIVITY | | | L1 size | x | AAT | | 1024 | 10 | 4.487273466 | | 2048 | 11 | 3.144287426 | | 4096 | 12 | 2.275335458 | | 8192 | 13 | 1.510521809 | | 16384 | 14 | 1.163859649 | | 32768 | 15 | 1.061564931 | | 65536 | 16 | 1.052208276 | | 131072 | 17 | 1.090100782 | | 262144 | 18 | 1.157926195 | | 524288 | 19 | 1.27604485 | | 1048576 | 20 | 1.410775892 | |  |  |

4-way set-associativity

|  |  |  |
| --- | --- | --- |
|  | 4-WAY SET-ASSOCIATIVITY | |
| L1 size | x |  |
| 1024 | 10 | 4.121468786 |
| 2048 | 11 | 2.833790395 |
| 4096 | 12 | 1.852318755 |
| 8192 | 13 | 1.391364483 |
| 16384 | 14 | 1.020270932 |
| 32768 | 15 | 1.003289 |
| 65536 | 16 | 1.037790468 |
| 131072 | 17 | 1.09342117 |
| 262144 | 18 | 1.168827573 |
| 524288 | 19 | 1.272804727 |
| 1048576 | 20 | 1.404503147 |

8-WAY SET ASSOCIATIVITY

|  |  |  |
| --- | --- | --- |
|  | 8-WAY SET-ASSOCIATIVITY | |
| L1 size | x | AAT |
| 1024 | 10 |  |
| 2048 | 11 | 2.703619587 |
| 4096 | 12 | 1.681121663 |
| 8192 | 13 | 1.311612499 |
| 16384 | 14 | 1.02401822 |
| 32768 | 15 | 1.015937586 |
| 65536 | 16 | 1.057298995 |
| 131072 | 17 | 1.113836086 |
| 262144 | 18 | 1.170035557 |
| 524288 | 19 | 1.28620847 |
| 1048576 | 20 | 1.410554753 |

Fully Associativity

|  |  |  |  |
| --- | --- | --- | --- |
|  | FULLY-ASSOCIATIVITY | |  |
| L1 size | associtivity | x | AAT |
| 1024 | 32 | 10 | 3.969068911 |
| 2048 | 64 | 11 | 2.641675771 |
| 4096 | 128 | 12 | 1.561004756 |
| 8192 | 256 | 13 | 1.286172511 |
| 16384 | 512 | 14 | 0.937712285 |
| 32768 | 1024 | 15 | 0.953562822 |
| 65536 | 2048 | 16 | 0.992384662 |
| 131072 | 4096 | 17 | 1.037119411 |
| 262144 | 8192 | 18 | 1.108744048 |
| 524288 | 16384 | 19 | 1.186404703 |
| 1048576 | 32768 | 20 | 1.296239601 |

GRAPH 2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | GRAPH 2 |  |  |
| x | direct | 2-way | 4-way | 8-way | full |
| 10 | 5.50946837 | 4.48727347 | 4.12146879 |  | 3.96906891 |
| 11 | 4.24673824 | 3.14428743 | 2.83379039 | 2.70361959 | 2.64167577 |
| 12 | 2.93703951 | 2.27533546 | 1.85231875 | 1.68112166 | 1.56100476 |
| 13 | 2.02885339 | 1.51052181 | 1.39136448 | 1.3116125 | 1.28617251 |
| 14 | 1.47979196 | 1.16385965 | 1.02027093 | 1.02401822 | 0.93771229 |
| 15 | 1.27960026 | 1.06156493 | 1.003289 | 1.01593759 | 0.95356282 |
| 16 | 1.20668788 | 1.05220828 | 1.03779047 | 1.057299 | 0.99238466 |
| 17 | 1.26018136 | 1.09010078 | 1.09342117 | 1.11383609 | 1.03711941 |
| 18 | 1.1558639 | 1.15792619 | 1.16882757 | 1.17003556 | 1.10874405 |
| 19 | 1.27241143 | 1.27604485 | 1.27280473 | 1.28620847 | 1.1864047 |
| 20 | 1.40482802 | 1.41077589 | 1.40450315 | 1.41055475 | 1.2962396 |

GRAPH 2 Discussion

Q1.

* AAT = Hit time + Miss Rate \* Miss Penalty.
* Miss penalty is constant
* Hit time increases with the cache size
* Miss rate decreases with size
* Lowest AAT is for fully associativity with the following configuration
* Size : 16kb
* Number of blocks: 512
* Associativity : Fully Associativity
* AAT : 0.937712285
* Fully associativity cache provides flexibility to place blocks and hence it utilizes the full cache.