

Computer architecture memory design

Assignment 1: Cache

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Problem statement a

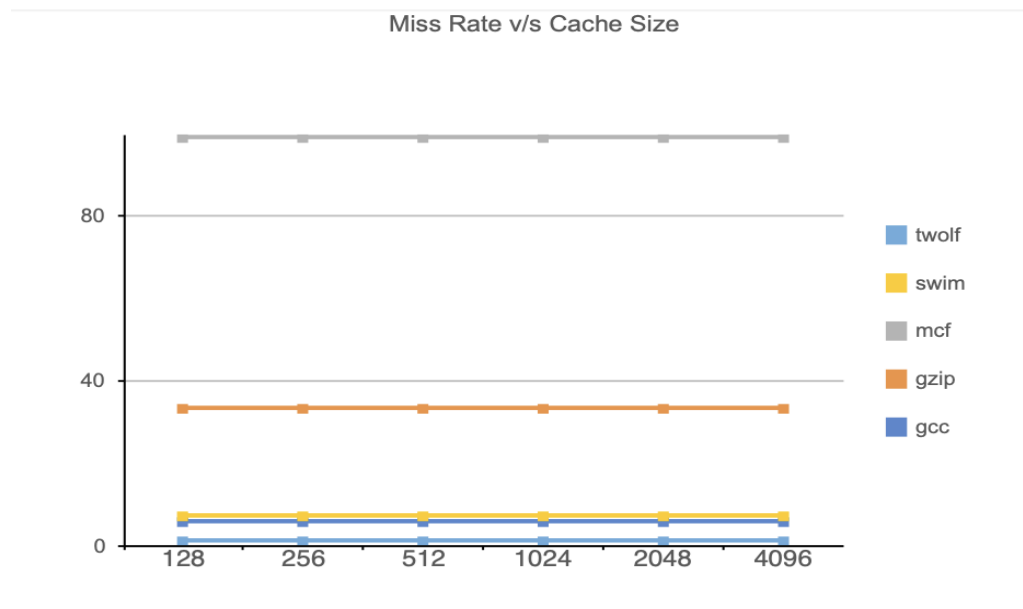
Design a 4-way set associative cache of size 1024kilobytes. Block size: 4 bytes. Assume a 32-bit address. Figure out how many cache lines you need.

Trace File	Cache Size (KB)	Block Size	Associativity	Hit Rate (%)	Miss Rate (%)
gcc.trace	1024	4	4	93.8356	6.16445
gzip.trace	1024	4	4	66.7055	33.2945
mcf.trace	1024	4	4	1.03241	98.9676
swim.trace	1024	4	4	92.6225	7.37748
twolf.trace	1024	4	4	98.7615	1.23855

Problem statement b

Vary the cache size from 128kB to 4096 kB and repeat the experiment. Note the change in hit/miss rates and plot a graph of miss rate vs cache size. Plot the miss rates for all traces on the same graph. Do all traces behave the same way?

Trace File	Cache Size (KB)	Block Size (Bytes)	Associativity	Hit Rate (%)	Miss Rate (%)
gcc.trace	128	4	4	93.8016	6.19838
gcc.trace	256	4	4	93.8311	6.16891
gcc.trace	512	4	4	93.8354	6.16464
gcc.trace	1024	4	4	93.8356	6.16445
gcc.trace	2048	4	4	93.8356	6.16445
gcc.trace	4096	4	4	93.8356	6.16445
gzip.trace	128	4	4	66.7055	33.2945
gzip.trace	256	4	4	66.7055	33.2945
gzip.trace	512	4	4	66.7055	33.2945
gzip.trace	1024	4	4	66.7055	33.2945
gzip.trace	2048	4	4	66.7055	33.2945
gzip.trace	4096	4	4	66.7055	33.2945
mcf.trace	128	4	4	1.03241	98.9676
mcf.trace	256	4	4	1.03241	98.9676
mcf.trace	512	4	4	1.03241	98.9676
mcf.trace	1024	4	4	1.03241	98.9676
mcf.trace	2048	4	4	1.03241	98.9676
mcf.trace	4096	4	4	1.04547	98.9545
swim.trace	128	4	4	92.6199	7.38012
swim.trace	256	4	4	92.6225	7.37748
swim.trace	512	4	4	92.6225	7.37748
swim.trace	1024	4	4	92.6225	7.37748
swim.trace	2048	4	4	92.6225	7.37748
swim.trace	4096	4	4	92.6225	7.37748
twolf.trace	128	4	4	98.7612	1.23875
twolf.trace	256	4	4	98.7615	1.23855
twolf.trace	512	4	4	98.7615	1.23855
twolf.trace	1024	4	4	98.7615	1.23855
twolf.trace	2048	4	4	98.7615	1.23855
twolf.trace	4096	4	4	98.7615	1.23855



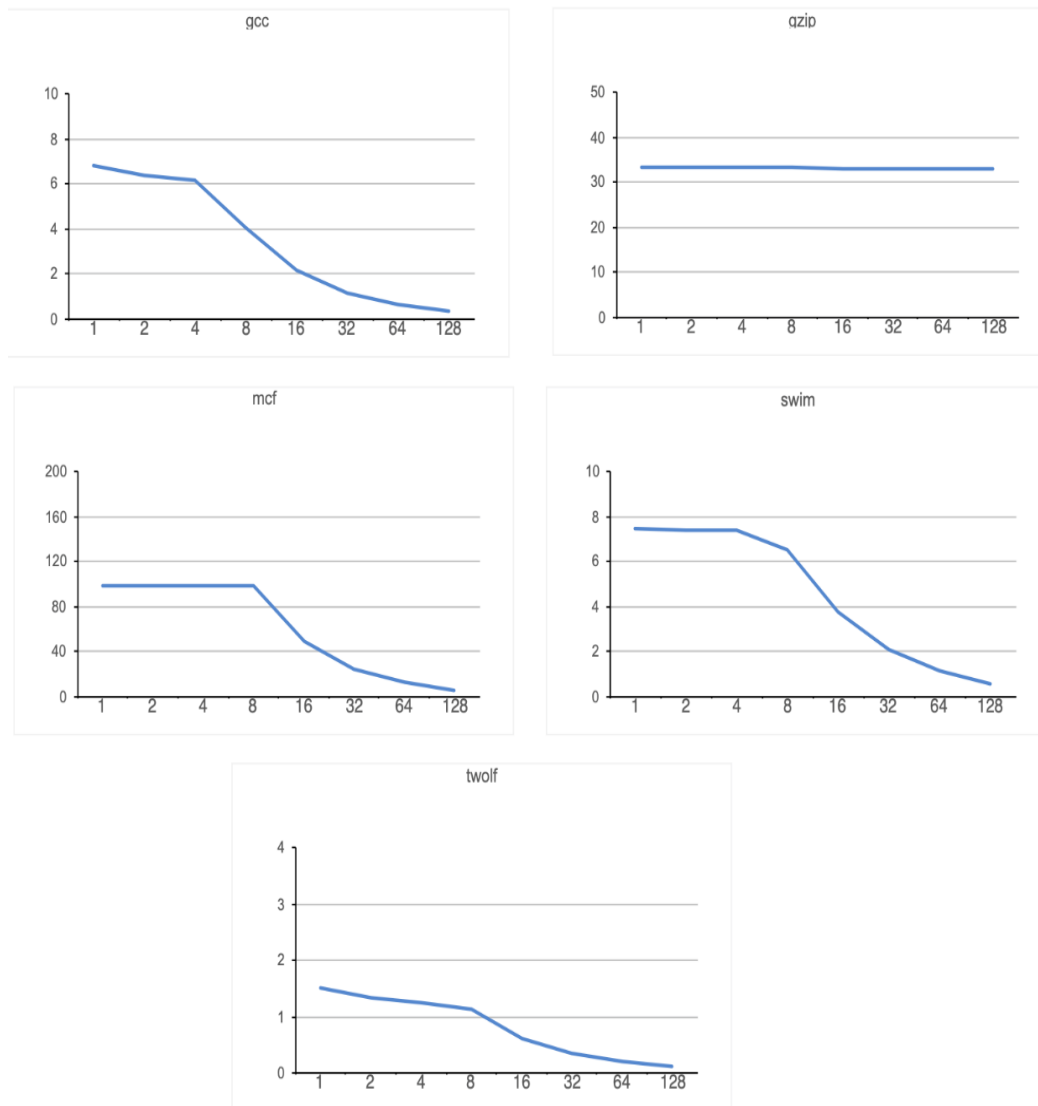
Here all the traces behave the same.

Here we can see that the miss rate is not getting affected by the cache size
Though the miss rate is different for different traces

Problem statement c

Keeping the cache size at 1024kB, vary the block size from 1 byte to 128 bytes. Note that the number of cache lines will reduce, if you increase the block size keeping the cache size same. Repeat the experiment for all the trace files. Plot the miss rate vs block size. What is the observation? Do all traces behave the same way?

Trace File	Cache Size (KB)	Block Size (Bytes)	Associativity	Hit Rate (%)	Miss Rate (%)
gcc.trace	1024	1	4	93.1989	6.80108
gcc.trace	1024	2	4	93.6248	6.37523
gcc.trace	1024	4	4	93.8356	6.16445
gcc.trace	1024	8	4	95.9266	4.07343
gcc.trace	1024	16	4	97.825	2.17498
gcc.trace	1024	32	4	98.8289	1.17107
gcc.trace	1024	64	4	99.3459	0.654084
gcc.trace	1024	128	4	99.6209	0.379109
gzip.trace	1024	1	4	66.7039	33.2961
gzip.trace	1024	2	4	66.7041	33.2959
gzip.trace	1024	4	4	66.7055	33.2945
gzip.trace	1024	8	4	66.7072	33.2928
gzip.trace	1024	16	4	66.7856	33.2144
gzip.trace	1024	32	4	66.8253	33.1747
gzip.trace	1024	64	4	66.8461	33.1539
gzip.trace	1024	128	4	66.8565	33.1435
mcf.trace	1024	1	4	1.02457	98.9754
mcf.trace	1024	2	4	1.0287	98.9713
mcf.trace	1024	4	4	1.03241	98.9676
mcf.trace	1024	8	4	1.03832	98.9617
mcf.trace	1024	16	4	50.503	49.497
mcf.trace	1024	32	4	75.2378	24.7622
mcf.trace	1024	64	4	87.608	12.392
mcf.trace	1024	128	4	93.7955	6.2045
swim.trace	1024	1	4	92.5444	7.45565
swim.trace	1024	2	4	92.5935	7.4065
swim.trace	1024	4	4	92.6225	7.37748
swim.trace	1024	8	4	93.4642	6.53577
swim.trace	1024	16	4	96.2324	3.76757
swim.trace	1024	32	4	97.8905	2.10955
swim.trace	1024	64	4	98.8611	1.13888
swim.trace	1024	128	4	99.3977	0.602257
twolf.trace	1024	1	4	98.4769	1.52312
twolf.trace	1024	2	4	98.6608	1.3392
twolf.trace	1024	4	4	98.7615	1.23855
twolf.trace	1024	8	4	98.8598	1.14017
twolf.trace	1024	16	4	99.388	0.612024
twolf.trace	1024	32	4	99.6599	0.340083
twolf.trace	1024	64	4	99.8024	0.197588
twolf.trace	1024	128	4	99.8809	0.119091



Here the miss rate is affected by the change in the block size as follows

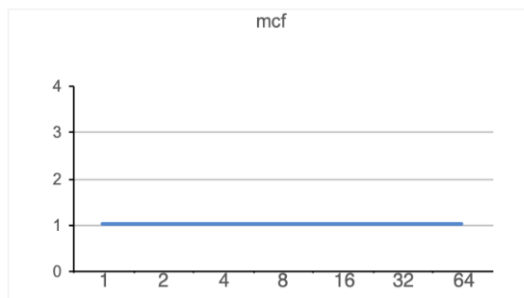
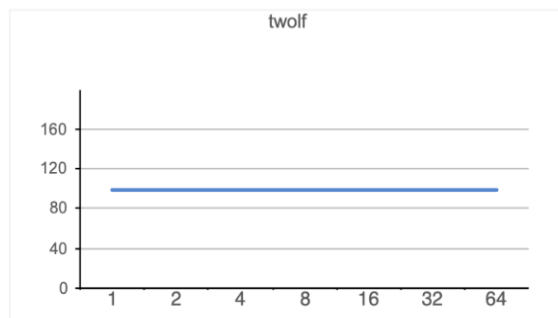
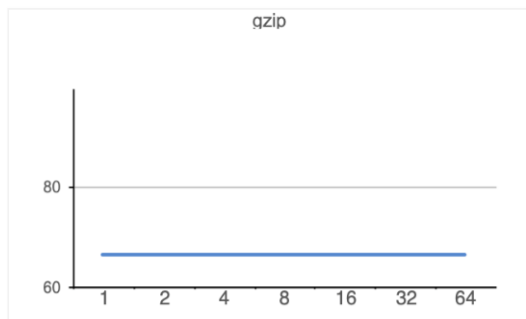
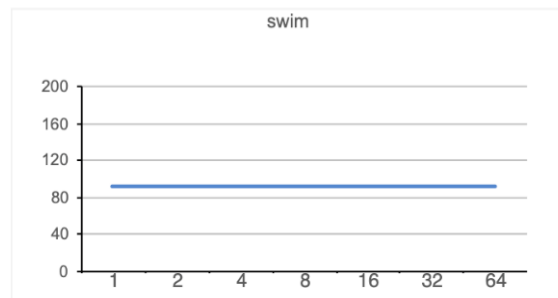
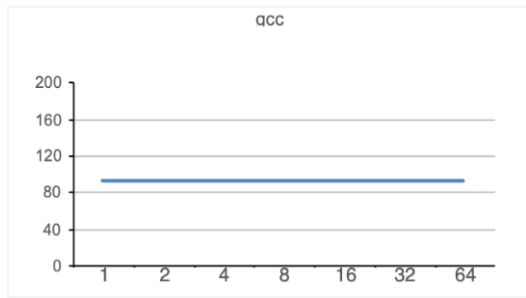
For trace gcc, swim, mcf, twolf the miss rate is getting decreased linearly at first as we increase the block size and then after a certain block size the miss rate is decreasing exponentially.

For trace gzip the change in miss rate as we change the block size is almost negligible

Problem statement d

Vary the associativity from 1-way to 64-way, for a fixed cache size of 1024kB, and plot the variation of hit rates vs associativity. What is the observation? Why do some traces behave differently?

Trace File	Cache Size (KB)	Block Size (Bytes)	Associativity	Hit Rate (%)	Miss Rate (%)
gcc.trace	1024	4	1	93.8305	6.16949
gcc.trace	1024	4	2	93.8348	6.16522
gcc.trace	1024	4	4	93.8356	6.16445
gcc.trace	1024	4	8	93.8356	6.16445
gcc.trace	1024	4	16	93.8357	6.16425
gcc.trace	1024	4	32	93.8359	6.16406
gcc.trace	1024	4	64	93.8359	6.16406
gzip.trace	1024	4	1	66.7055	33.2945
gzip.trace	1024	4	2	66.7055	33.2945
gzip.trace	1024	4	4	66.7055	33.2945
gzip.trace	1024	4	8	66.7055	33.2945
gzip.trace	1024	4	16	66.7055	33.2945
gzip.trace	1024	4	32	66.7055	33.2945
gzip.trace	1024	4	64	66.7055	33.2945
mcf.trace	1024	4	1	1.032	98.968
mcf.trace	1024	4	2	1.03227	98.9677
mcf.trace	1024	4	4	1.03241	98.9676
mcf.trace	1024	4	8	1.03241	98.9676
mcf.trace	1024	4	16	1.03241	98.9676
mcf.trace	1024	4	32	1.03241	98.9676
mcf.trace	1024	4	64	1.03241	98.9676
swim.trace	1024	4	1	92.6205	7.37946
swim.trace	1024	4	2	92.6225	7.37748
swim.trace	1024	4	4	92.6225	7.37748
swim.trace	1024	4	8	92.6225	7.37748
swim.trace	1024	4	16	92.6225	7.37748
swim.trace	1024	4	32	92.6225	7.37748
swim.trace	1024	4	64	92.6225	7.37748
twolf.trace	1024	4	1	98.7463	1.25367
twolf.trace	1024	4	2	98.7608	1.23917
twolf.trace	1024	4	4	98.7615	1.23855
twolf.trace	1024	4	8	98.7615	1.23855
twolf.trace	1024	4	16	98.7615	1.23855
twolf.trace	1024	4	32	98.7615	1.23855
twolf.trace	1024	4	64	98.7615	1.23855



Here the traces all behave the same.

The miss rate is not affected by the associativity as we change the associativity from 1-way to 64-way for a fixed cache size of 1024kB.