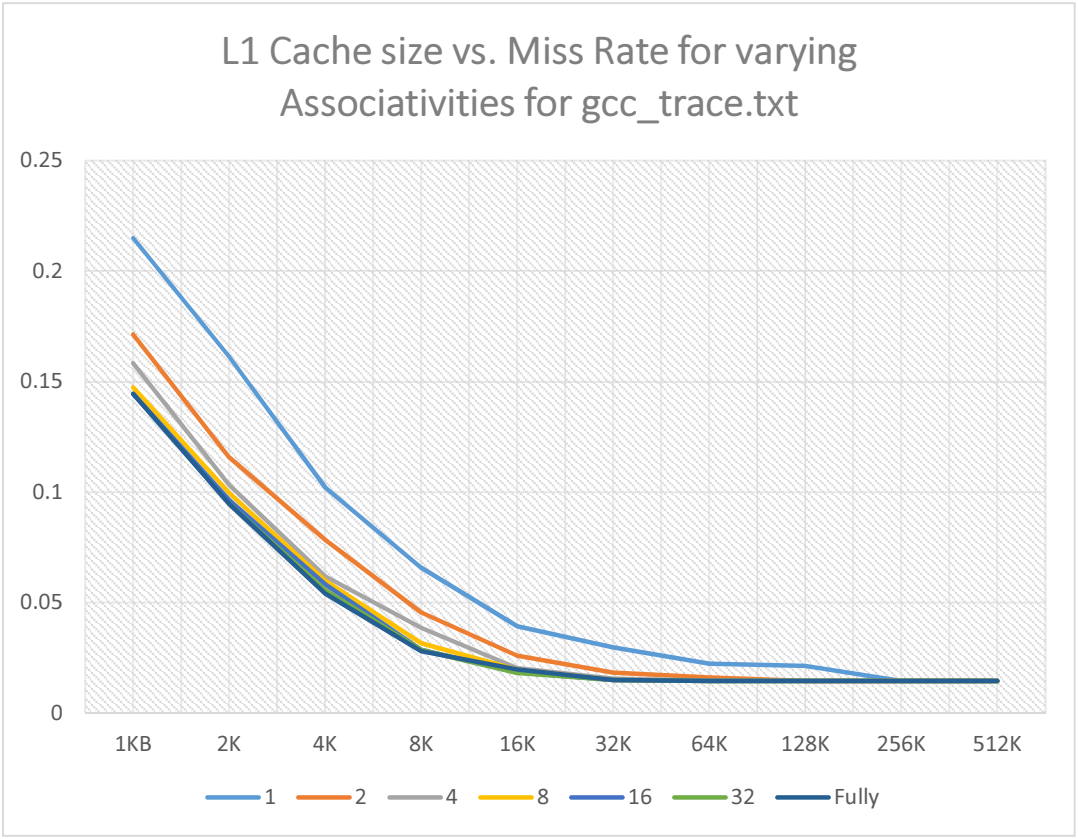
ECE 521 Project 1 Report

Trends of miss rate with varying L1 cache sizes and associativities

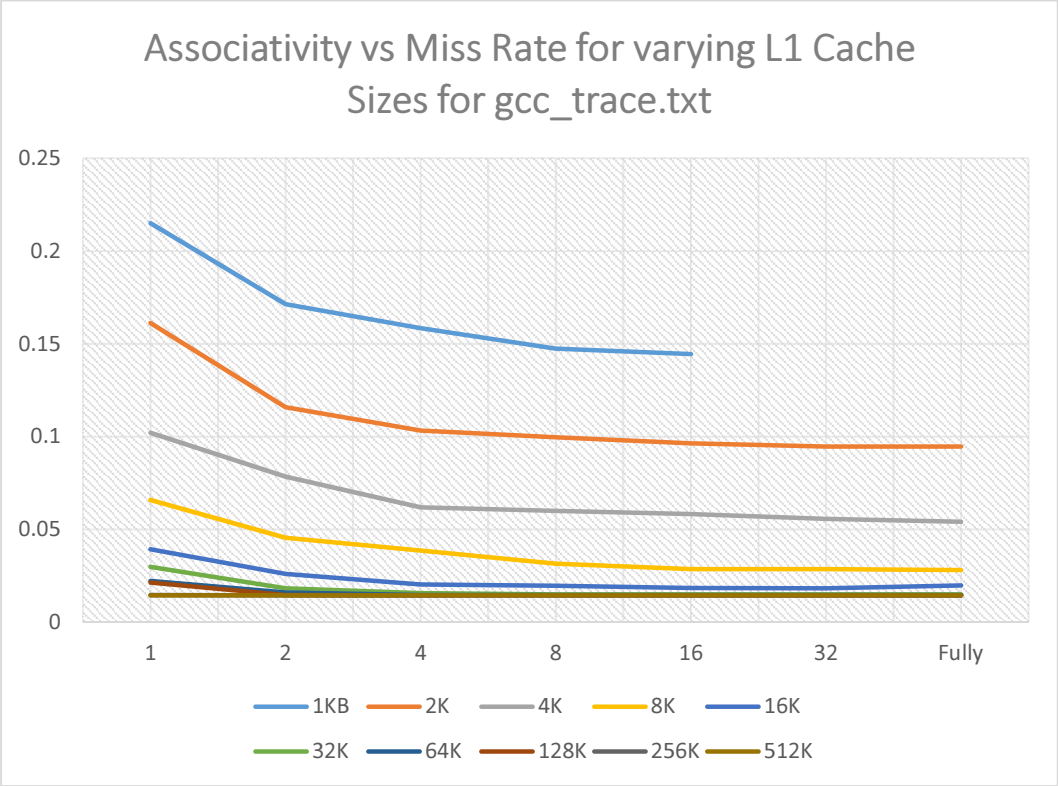
1. For the first trace, gcc_trace.txt, the miss rates for a block size of 64B that were generated are as follows

Block size 64B	L1 size										
Assoc		1KB	2K	4K	8K	16K	32K	64K	128K	256K	512K
	1	0.2149	0.1612	0.1021	0.0658	0.0393	0.0298	0.0223	0.0214	0.0146	0.0145
	2	0.1714	0.1158	0.0784	0.0455	0.026	0.0183	0.0161	0.0146	0.0145	0.0145
	4	0.1584	0.1033	0.0619	0.0386	0.0204	0.0156	0.0147	0.0145	0.0145	0.0145
	8	0.1473	0.0996	0.0599	0.0316	0.0196	0.015	0.0146	0.0145	0.0145	0.0145
	16	0.1444	0.0963	0.0583	0.0286	0.0184	0.015	0.0146	0.0145	0.0145	0.0145
	32		0.0947	0.0557	0.0286	0.0182	0.015	0.0146	0.0145	0.0145	0.0145
	Fully	0.1444	0.0947	0.0541	0.028	0.0198	0.015	0.0146	0.0145	0.0145	0.0145

The corresponding plots for L1 size vs miss rate for each of the associativity is:

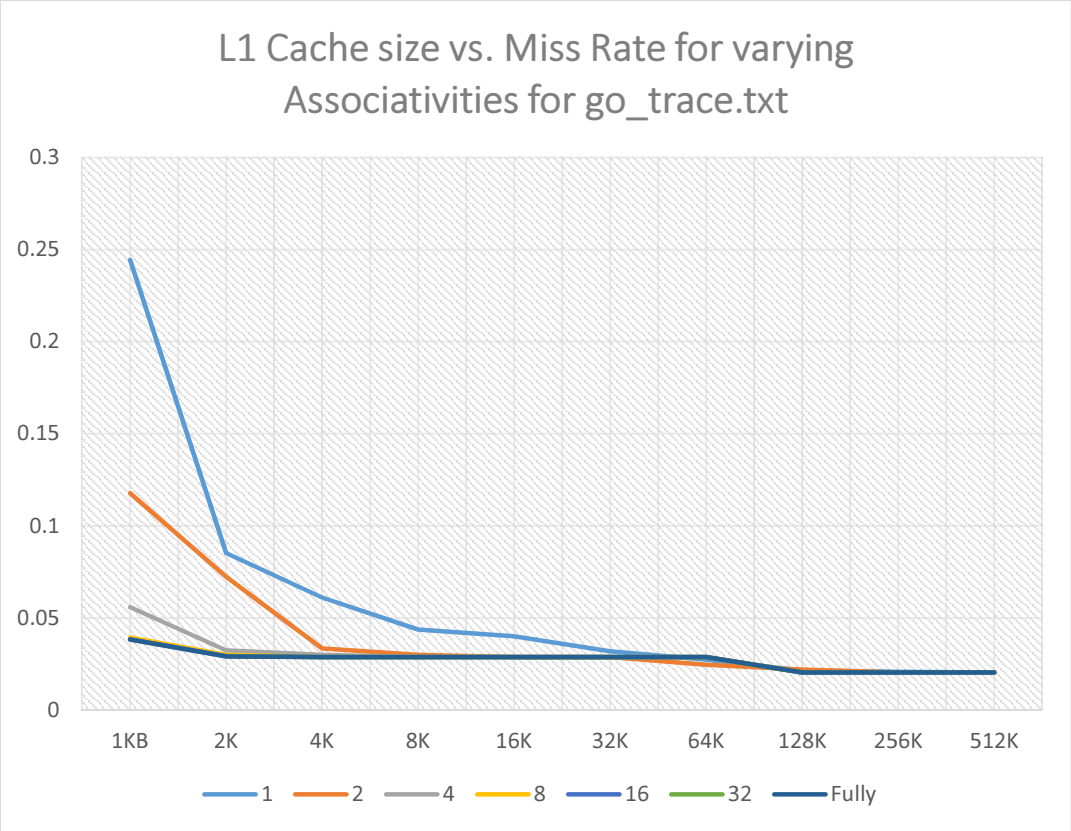


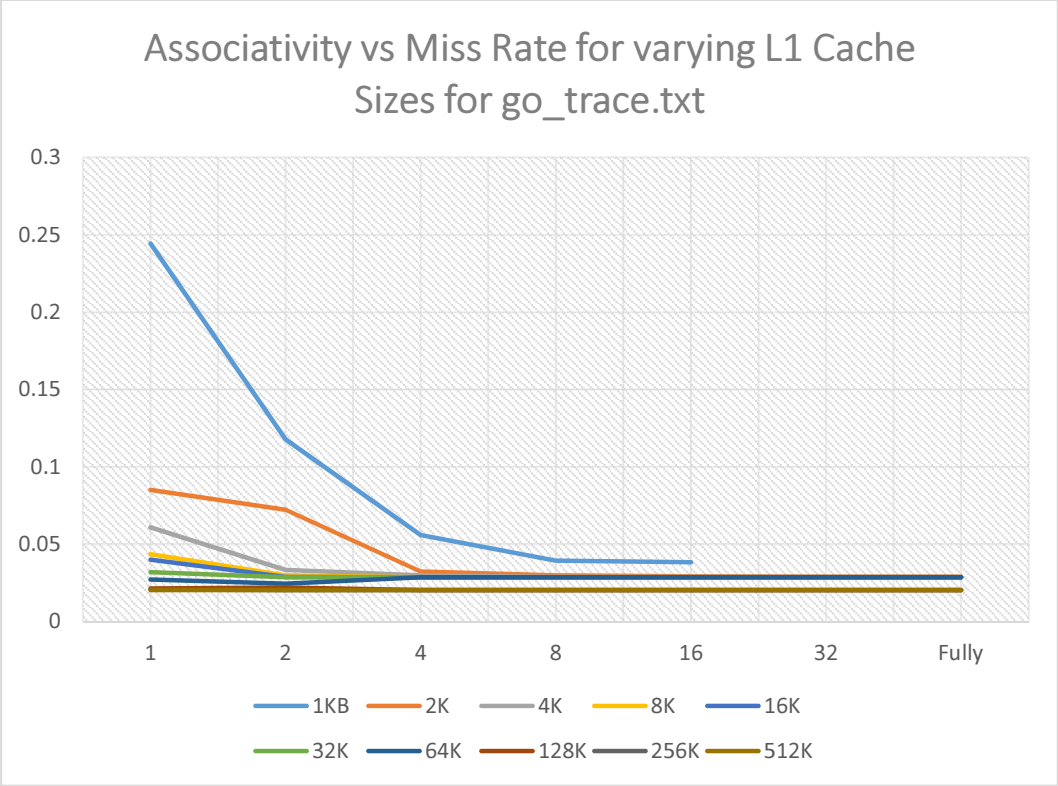
The corresponding plot for associativity vs miss rate for varying cache sizes is:



2. For the go_trace.txt, the values are as follows.

Block size 64B	L1 size										
Assoc		1KB	2K	4K	8K	16K	32K	64K	128K	256K	512K
	1	0.2443	0.0852	0.0610	0.0436	0.0401	0.0319	0.0273	0.0215	0.0207	0.0203
	2	0.1177	0.0723	0.0335	0.0299	0.0288	0.0287	0.0245	0.0220	0.0203	0.0203
	4	0.0559	0.0323	0.0299	0.0287	0.0287	0.0287	0.0287	0.0203	0.0203	0.0203
	8	0.0394	0.0299	0.0288	0.0287	0.0287	0.0287	0.0287	0.0203	0.0203	0.0203
	16	0.0383	0.0292	0.0288	0.0287	0.0287	0.0287	0.0287	0.0203	0.0203	0.0203
	32		0.0290	0.0288	0.0287	0.0287	0.0287	0.0287	0.0203	0.0203	0.0203
	Fully	0.0383	0.0290	0.0288	0.0287	0.0287	0.0287	0.0287	0.0203	0.0203	0.0203

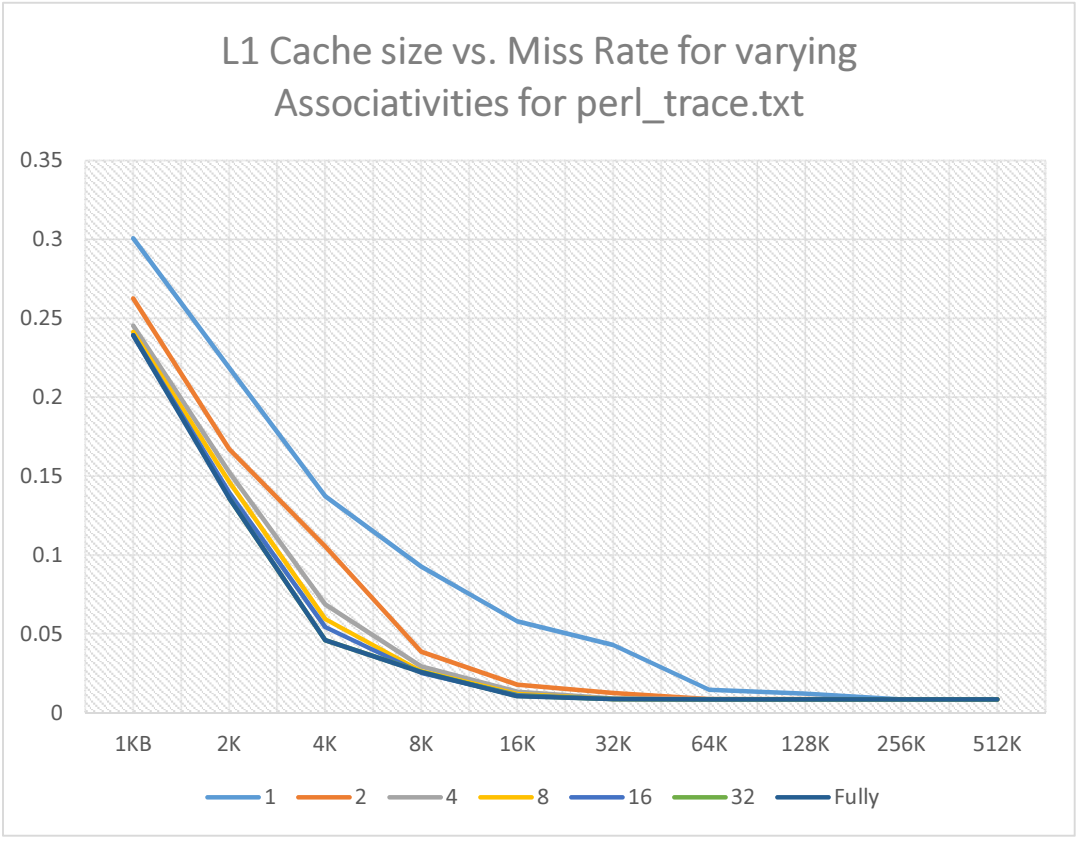


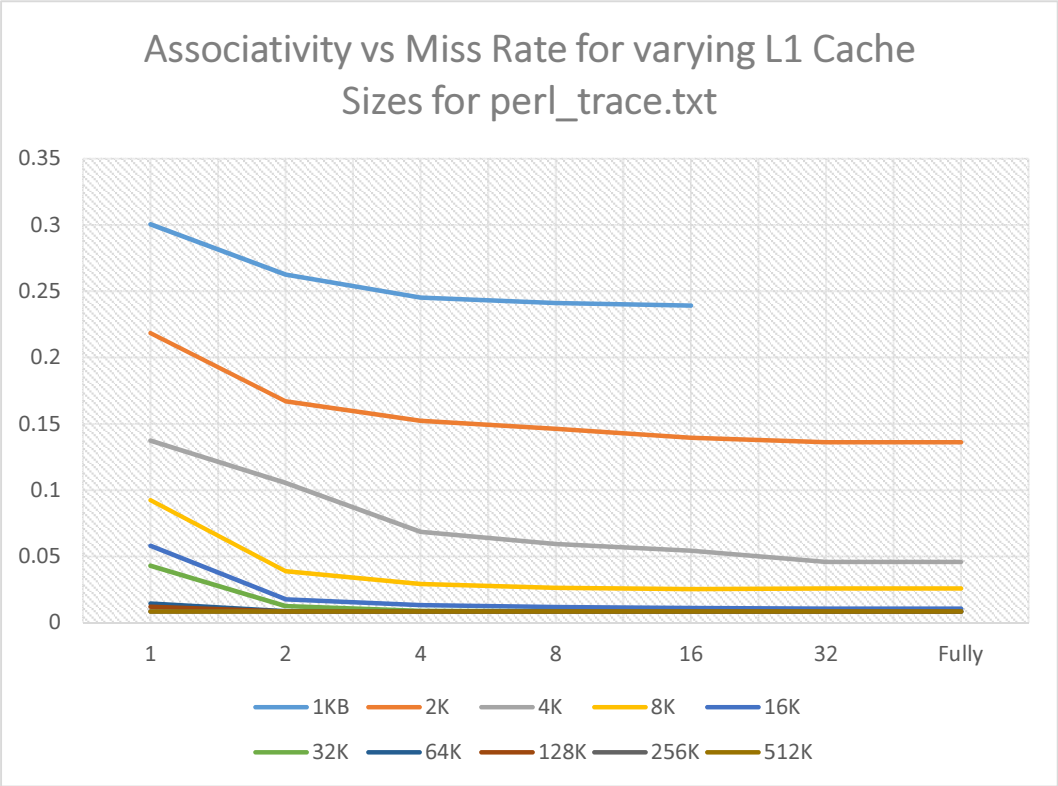


For higher L1 sizes, the change in associativity does not really affect the miss rate. This shows that the go_trace might be having a high number of capacity misses.

3. For the perl_trace.txt, the values are as follows.

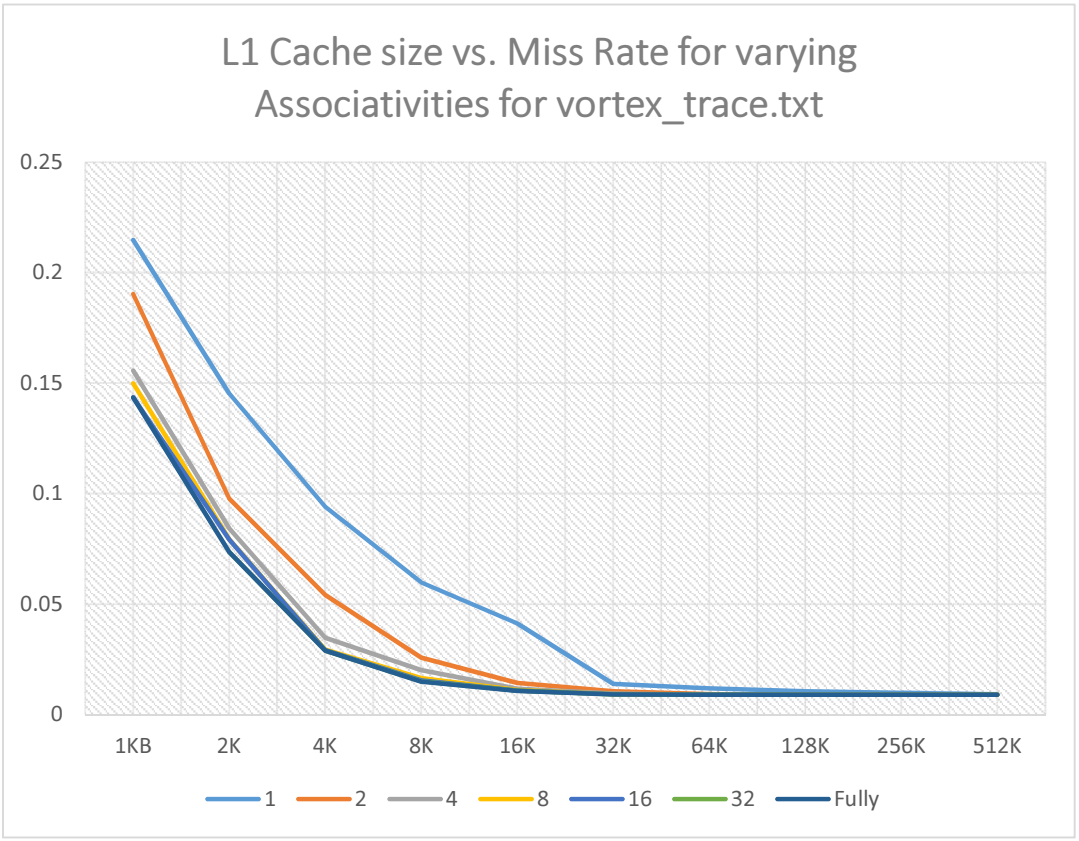
Block size 64B	L1 size										
Assoc		1KB	2K	4K	8K	16K	32K	64K	128K	256K	512K
	1	0.3006	0.2185	0.1373	0.0926	0.0579	0.0429	0.0145	0.0122	0.0085	0.0085
	2	0.2626	0.1670	0.1055	0.0388	0.0178	0.0126	0.0088	0.0086	0.0085	0.0085
	4	0.2453	0.1524	0.0687	0.0293	0.0134	0.0091	0.0086	0.0085	0.0085	0.0085
	8	0.2412	0.1464	0.0594	0.0263	0.0120	0.0088	0.0085	0.0085	0.0085	0.0085
	16	0.2392	0.1395	0.0543	0.0254	0.0112	0.0086	0.0085	0.0085	0.0085	0.0085
	32		0.1361	0.0460	0.0259	0.0108	0.0086	0.0085	0.0085	0.0085	0.0085
	Fully	0.2392	0.1361	0.0460	0.0258	0.0106	0.0086	0.0085	0.0085	0.0085	0.0085

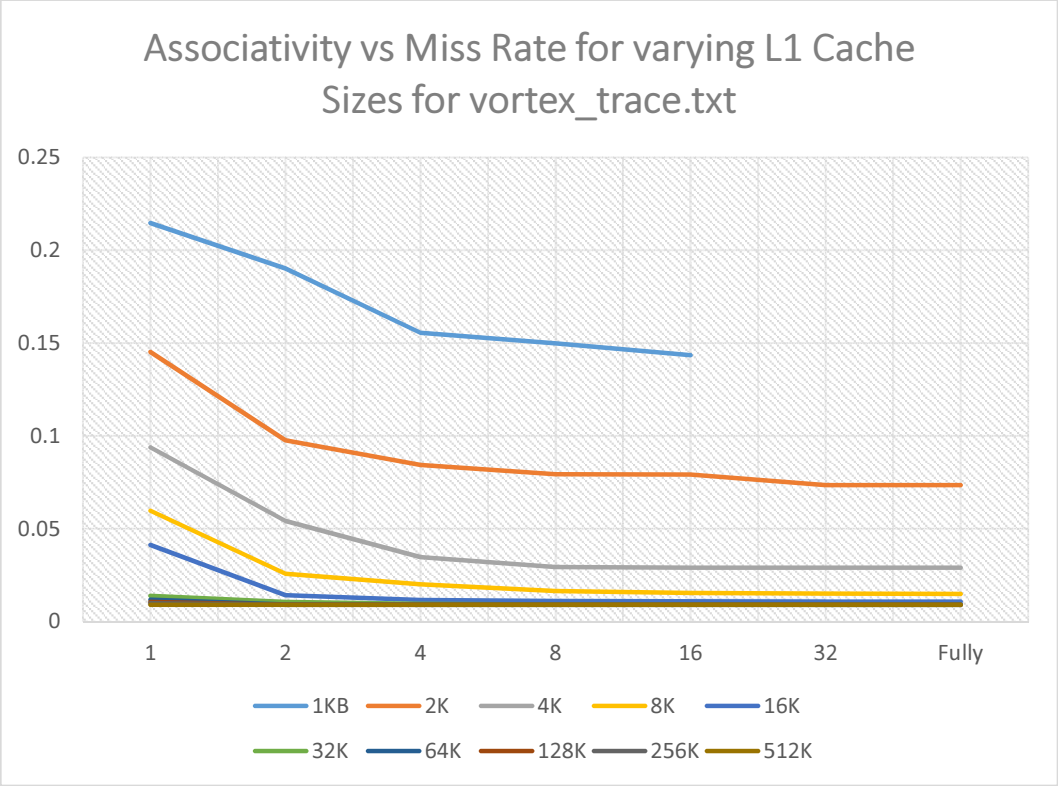



Associativity vs Miss Rate for varying L1 Cache Sizes for perl_trace.txt
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
2
4
8
16
32
Fully
1KB
2K
4K
8K
16K
32K
64K
128K
256K
512K

4. For the vortex_trace.txt, the values are as follows.

Block size 64B	L1 size										
Assoc		1KB	2K	4K	8K	16K	32K	64K	128K	256K	512K
	1	0.2147	0.1453	0.0939	0.0598	0.0412	0.0139	0.0118	0.0106	0.0099	0.0091
	2	0.1903	0.0977	0.0542	0.0257	0.0143	0.0106	0.0093	0.0090	0.0090	0.0090
	4	0.1556	0.0843	0.0347	0.0201	0.0117	0.0095	0.0090	0.0090	0.0090	0.0090
	8	0.1498	0.0794	0.0294	0.0165	0.0112	0.0093	0.0090	0.0090	0.0090	0.0090
	16	0.1435	0.0792	0.0291	0.0155	0.0109	0.0092	0.0090	0.0090	0.0090	0.0090
	32		0.0735	0.0290	0.0150	0.0108	0.0091	0.0090	0.0090	0.0090	0.0090
	Fully	0.1435	0.0735	0.0290	0.0149	0.0107	0.0091	0.0090	0.0090	0.0090	0.0090



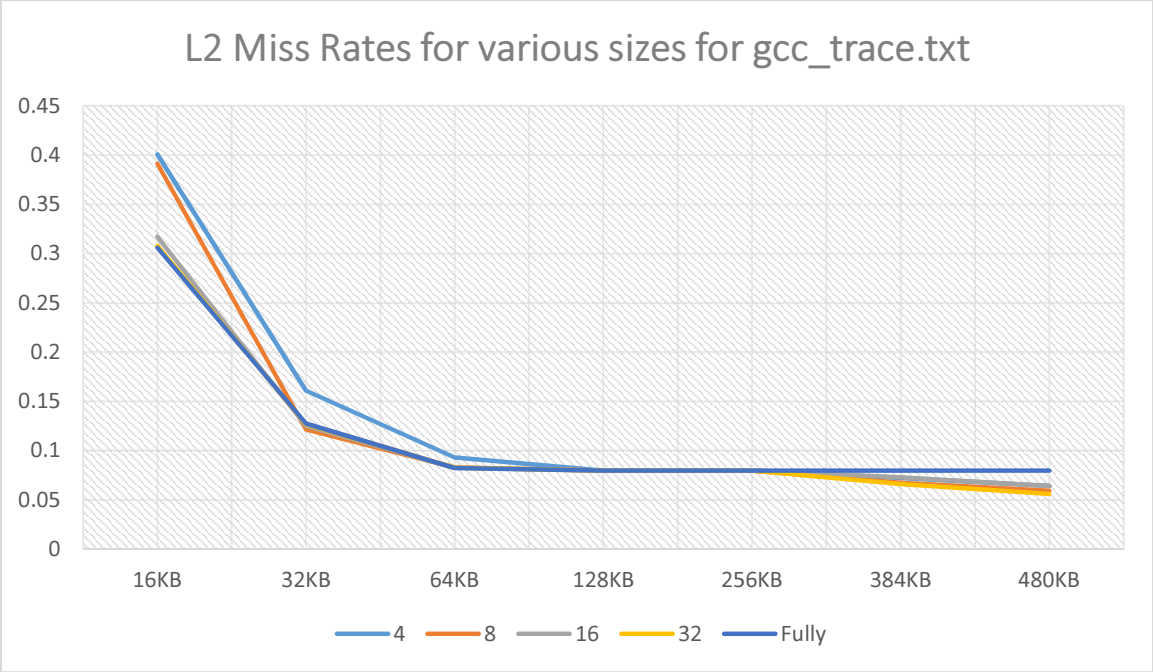

Associativity vs Miss Rate for varying L1 Cache Sizes for vortex_trace.txt
0.25
0.2
0.15
0.1
0.05
0
1
2
4
8
16
32
Fully
1KB
2K
4K
8K
16K
32K
64K
128K
256K
512K

Trends of miss rates with varying L2 cache sizes and associativities (L1 cache size and associativity fixed)

For all the runs, the L1 cache size has been fixed at 8KB, with associativity 4. The block size for both the L1 and L1 is 256B.

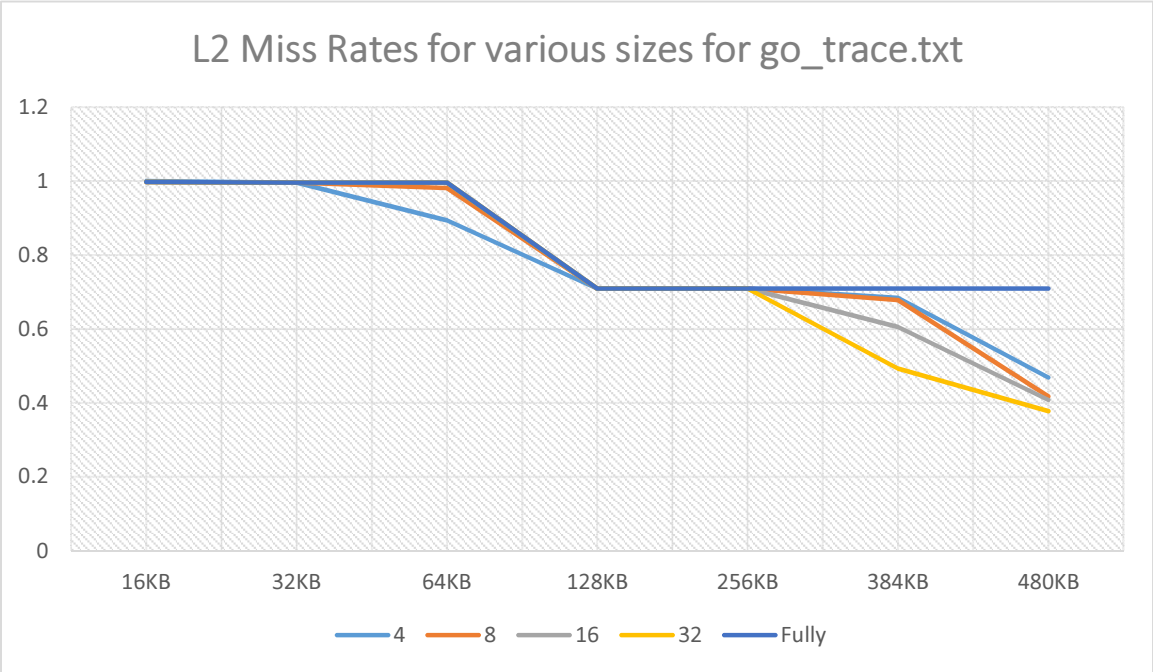
1. For the gcc_trace.txt, the values are as follows.

Block size 256B	L2size							
Assoc		16KB	32KB	64KB	128KB	256K	384K	480K
	4	0.4005	0.1610	0.0933	0.0799	0.0799	0.0723	0.0643
	8	0.3912	0.1218	0.0830	0.0800	0.0799	0.0676	0.0595
	16	0.3170	0.1252	0.0828	0.0799	0.0799	0.0730	0.0642
	32	0.3078	0.1271	0.0827	0.0799	0.0799	0.0663	0.0561
	Fully	0.3058	0.1275	0.0825	0.0799	0.0799	0.0799	0.0799



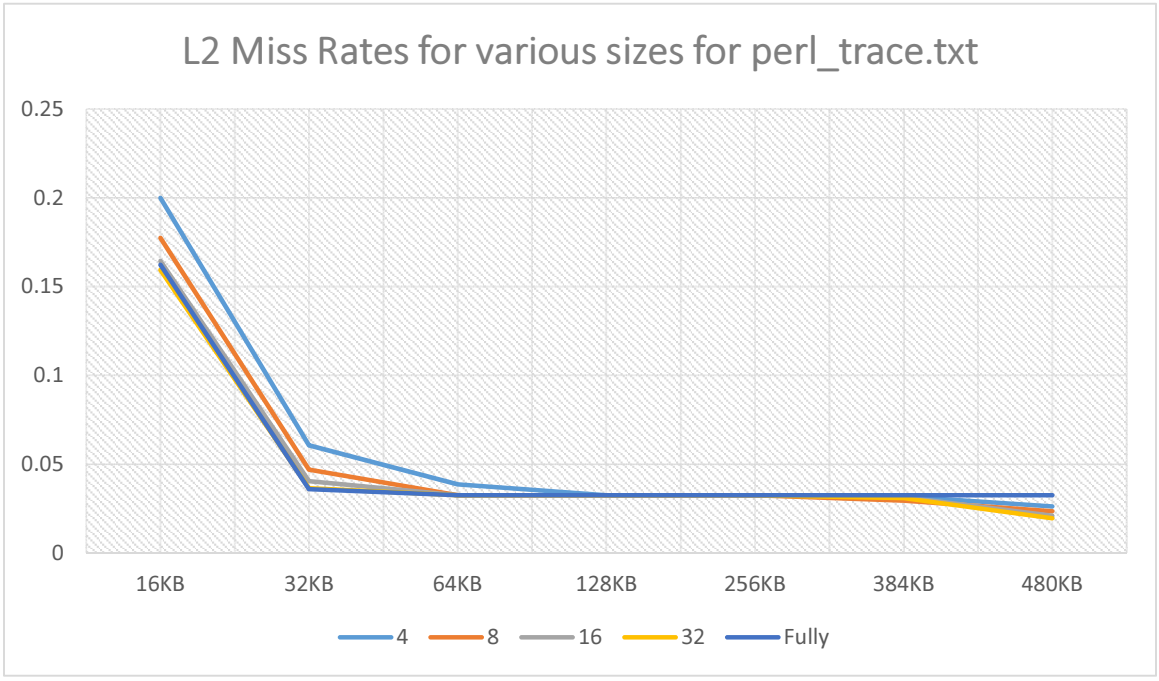
2. For the go_trace.txt, the values are as follows.

Block size 256B	L2size							
Assoc		16KB	32KB	64KB	128KB	256K	384K	480K
	4	1.000	0.9959	0.8932	0.7095	0.7095	0.6838	0.4689
	8	0.9973	0.9959	0.9811	0.7095	0.7095	0.6784	0.4176
	16	0.9973	0.9959	0.9959	0.7095	0.7095	0.6054	0.4081
	32	0.9973	0.9959	0.9959	0.7095	0.7095	0.4932	0.3781
	Fully	0.9973	0.9959	0.9959	0.7095	0.7095	0.7095	0.7095



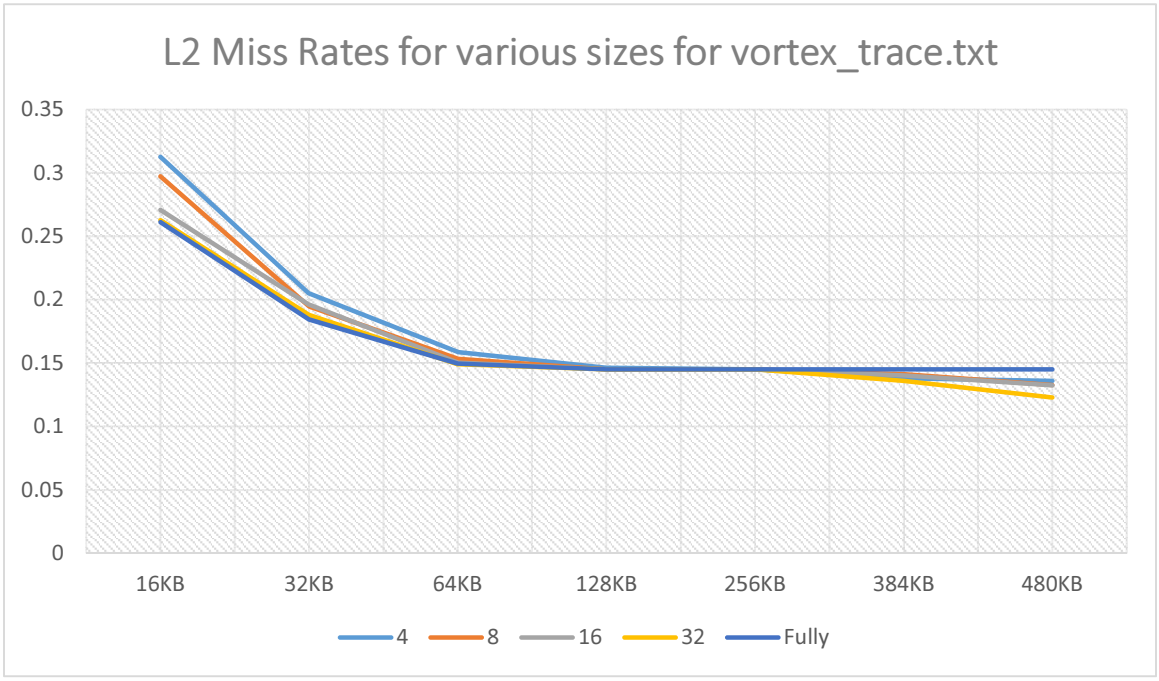
3. For the perl_trace.txt, the values are as follows.

Block size 256B	L2size							
Assoc		16KB	32KB	64KB	128KB	256K	384K	480K
	4	0.1999	0.0606	0.0385	0.0324	0.0324	0.0317	0.0261
	8	0.1774	0.0469	0.0324	0.0324	0.0324	0.0294	0.0234
	16	0.1645	0.0403	0.0324	0.0324	0.0324	0.0314	0.0209
	32	0.1593	0.0365	0.0324	0.0324	0.0324	0.0308	0.0195
	Fully	0.1622	0.0359	0.0324	0.0324	0.0324	0.0324	0.0324



4. For the vortex_trace.txt, the values and plot are as follows.

Block size 256B	L2size							
Assoc		16KB	32KB	64KB	128KB	256K	384K	480K
	4	0.3126	0.2050	0.1586	0.1462	0.1451	0.1381	0.1359
	8	0.2973	0.1947	0.1533	0.1451	0.1451	0.1412	0.1327
	16	0.2708	0.1961	0.1504	0.1451	0.1451	0.1402	0.1324
	32	0.2627	0.1880	0.1490	0.1451	0.1451	0.1359	0.1228
	Fully	0.2612	0.1844	0.1497	0.1451	0.1451	0.1451	0.1451

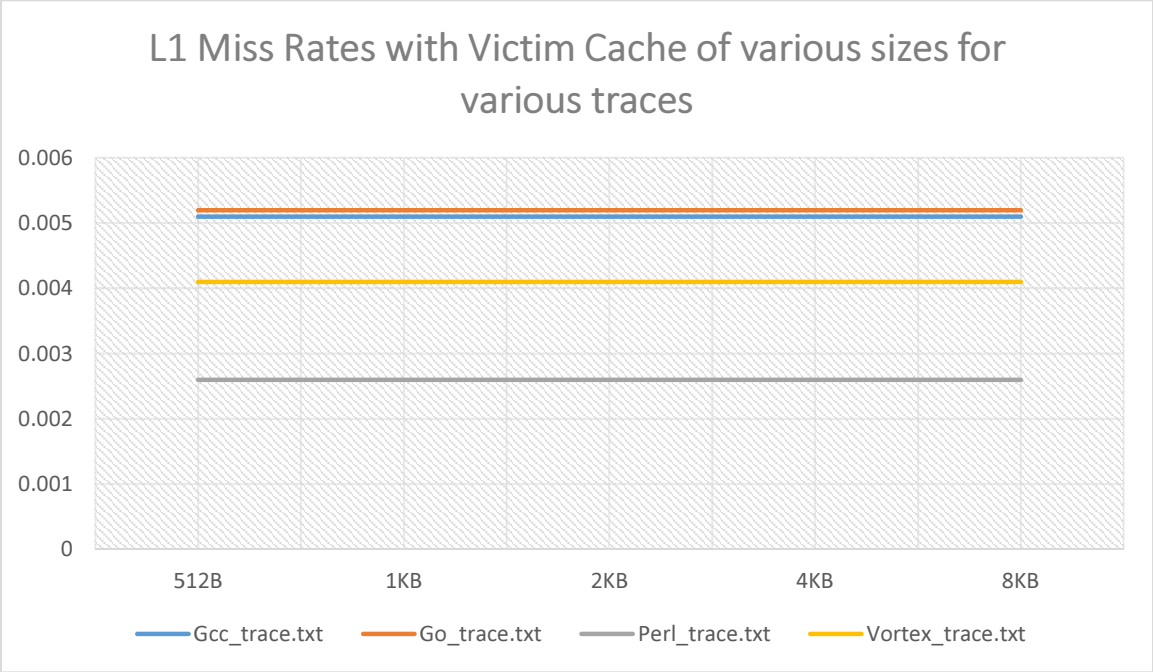


Trends of miss rates when a victim cache is added with fixed L1 and L2 caches.

The L1 is fixed at 128KB, 4-way and the L2 is fixed at 256KB, 8-way. The block size is 256B. For each of the traces, the L1 and L2 miss rates are tabulated below.

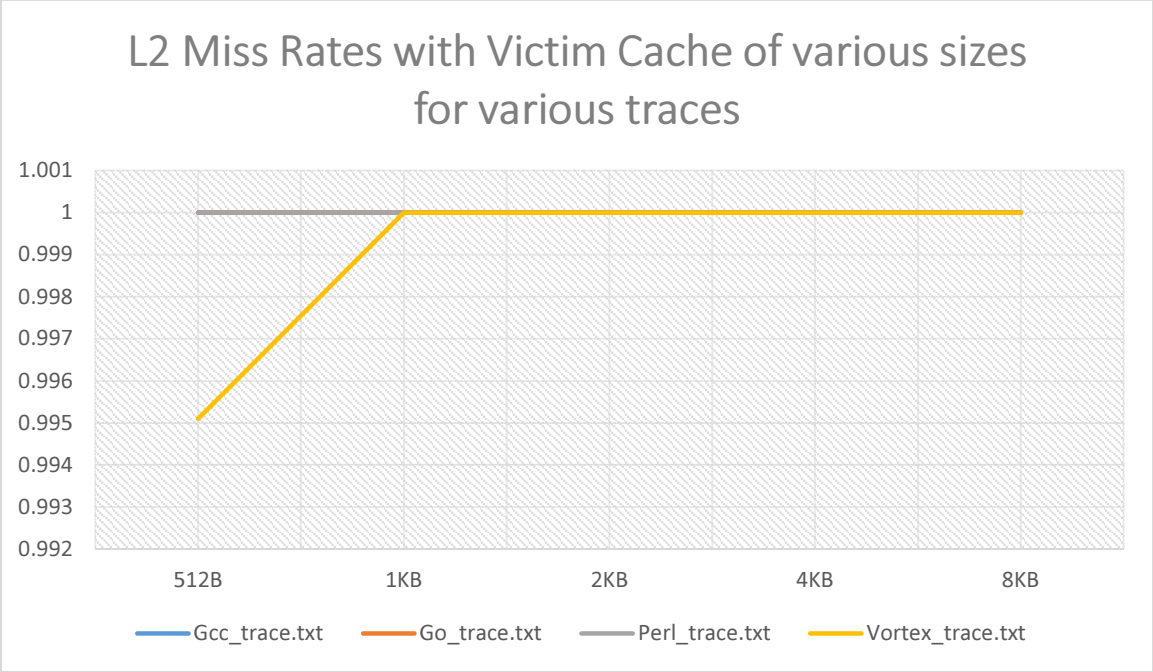
L1 Miss Rates:

Victim sizes	Gcc_trace.txt	Go_trace.txt	Perl_trace.txt	Vortex_trace.txt
512B	0.0051	0.0052	0.0026	0.0041
1KB	0.0051	0.0052	0.0026	0.0041
2KB	0.0051	0.0052	0.0026	0.0041
4KB	0.0051	0.0052	0.0026	0.0041
8KB	0.0051	0.0052	0.0026	0.0041



L2 Miss Rates:

Victim sizes	Gcc_trace.txt	Go_trace.txt	Perl_trace.txt	Vortex_trace.txt
512B	1.000	1.000	1.000	0.9951
1KB	1.000	1.000	1.000	1.000
2KB	1.000	1.000	1.000	1.000
4KB	1.000	1.000	1.000	1.000
8KB	1.000	1.000	1.000	1.000



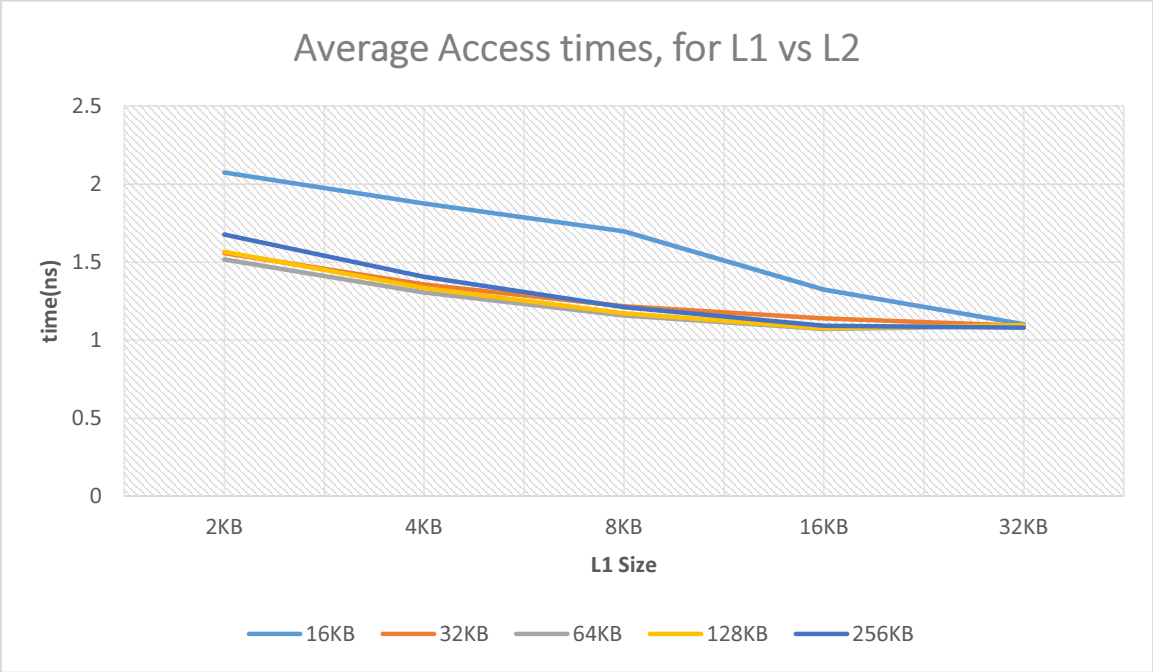
Average Access Time trends with varying L1 and L2 cache sizes.

Here, the L1 associativity is fixed to 4 and L2 associativity is fixed to 8. The block size is fixed to 256B.

By observing the below graphs we can infer that the access times slowly dip and then rise. For all the given traces, the best configuration is for values of L1 size around 16KB. The increase in the L1 size above this increases the hit time also for L1, which will make the average access time reduce. This is mainly due to the larger number of comparisons that need to be done in case of the L1.

Here is are values for gcc_trace.txt(in ns).

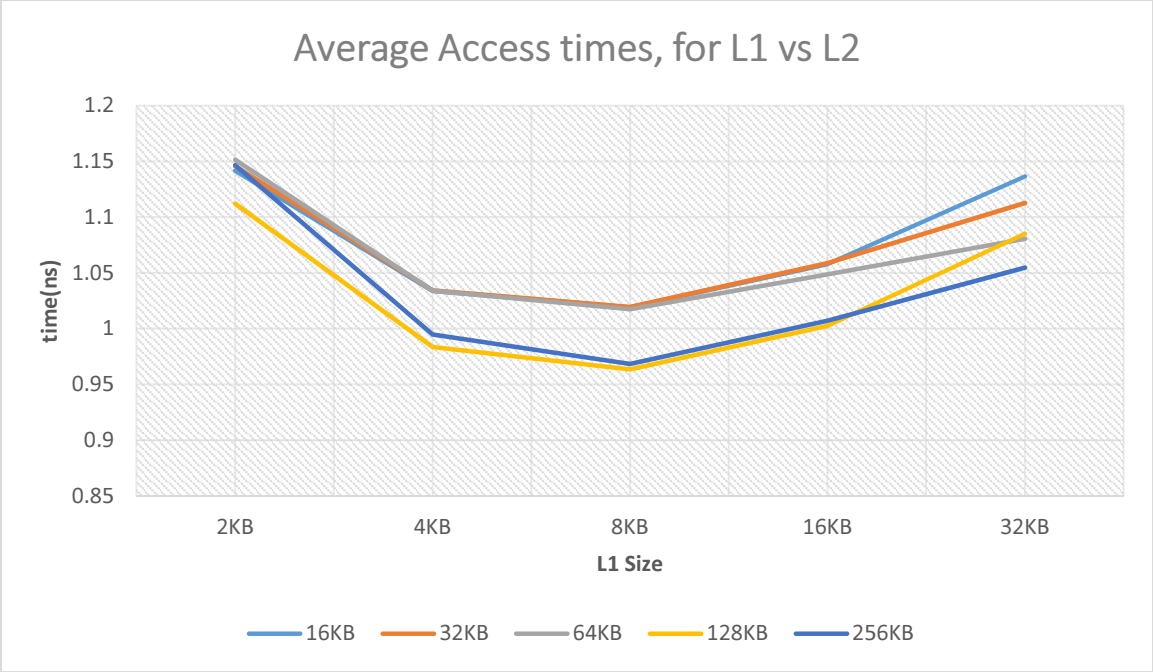
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	2.0746	1.5568	1.5160	1.5662	1.6771
4KB	1.8759	1.3569	1.3049	1.3349	1.4053
8KB	1.6968	1.2171	1.1575	1.1722	1.2121
16KB	1.3242	1.1393	1.0722	1.0750	1.0921
32KB	1.1016	1.0917	1.0894	1.0961	1.0794



The best AAT for this trace is at: 1.0722ns, which is occurring for L1 size – 16KB and L2 size – 64KB.

Following are values for go_trace.txt

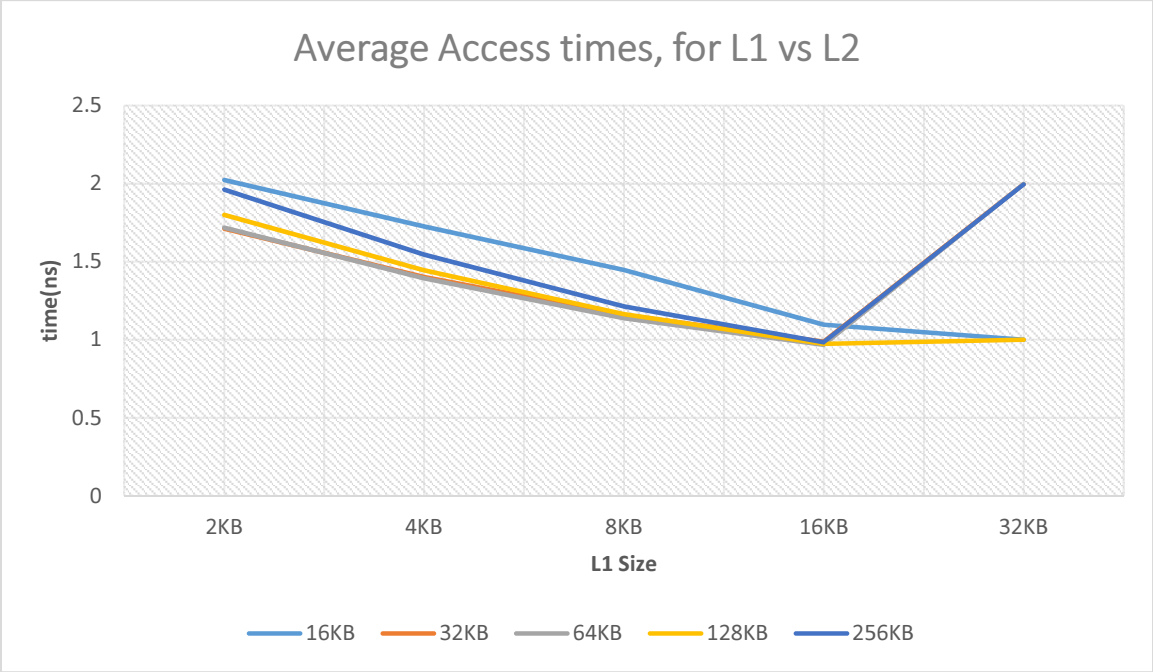
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	1.1416	1.1457	1.1515	1.1122	1.1466
4KB	1.0337	1.0345	1.0342	0.9836	0.9948
8KB	1.0192	1.0195	1.0176	0.9636	0.9683
16KB	1.0579	1.0589	1.0487	1.0026	1.0072
32KB	1.1366	1.1128	1.0807	1.0853	1.0547



The best AAT for this trace is at: 1.0026ns, which is occurring for L1 size – 8KB and L2 size – 128KB.

Following are values for perl_trace.txt

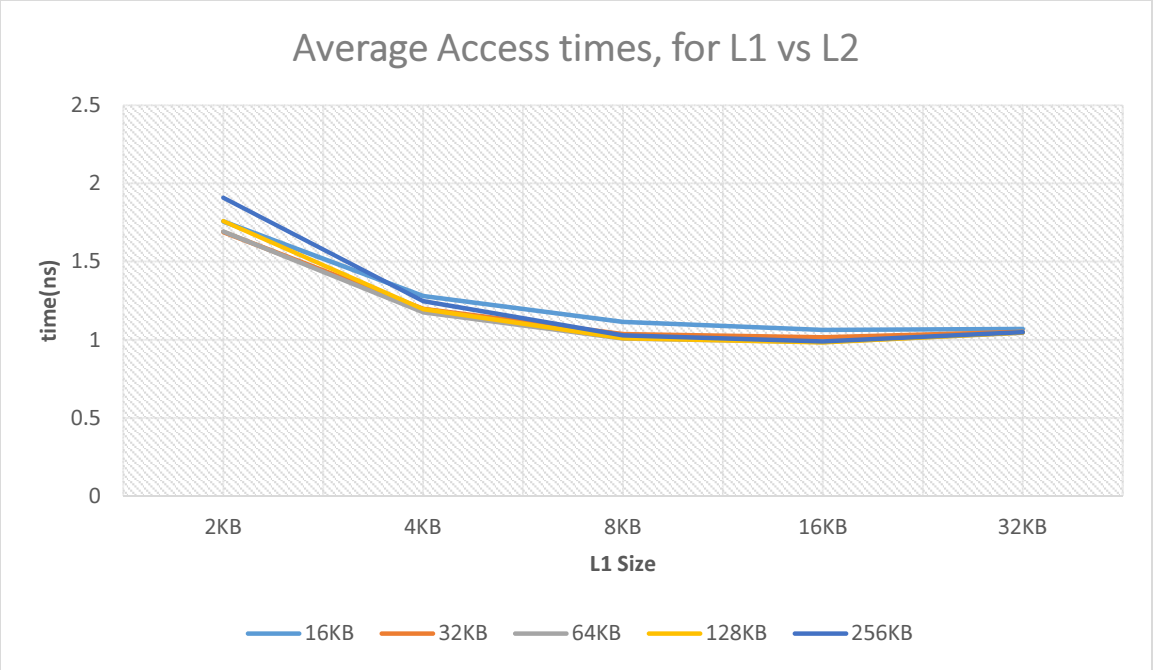
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	2.0233	1.7106	1.7178	1.7988	1.9608
4KB	1.7250	1.4016	1.3938	1.4442	1.5451
8KB	1.4475	1.1585	1.1383	1.1636	1.2141
16KB	1.0960	0.9877	0.9666	0.9726	0.9845
32KB	1.0004	1.9964	1.9980	1.0011	1.9934



The best AAT for this trace is at: 0.9666ns, which is occurring for L1 size – 16KB and L2 size – 64KB.

Following are values for vortex_trace.txt

L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	1.7581	1.6902	1.6923	1.7598	1.9084
4KB	1.2793	1.1985	1.1762	1.1956	1.2479
8KB	1.1140	1.0351	1.0067	1.0091	1.0267
16KB	1.0617	1.0161	0.9855	0.9817	0.9883
32KB	1.0688	1.0493	1.0436	1.0471	1.0473

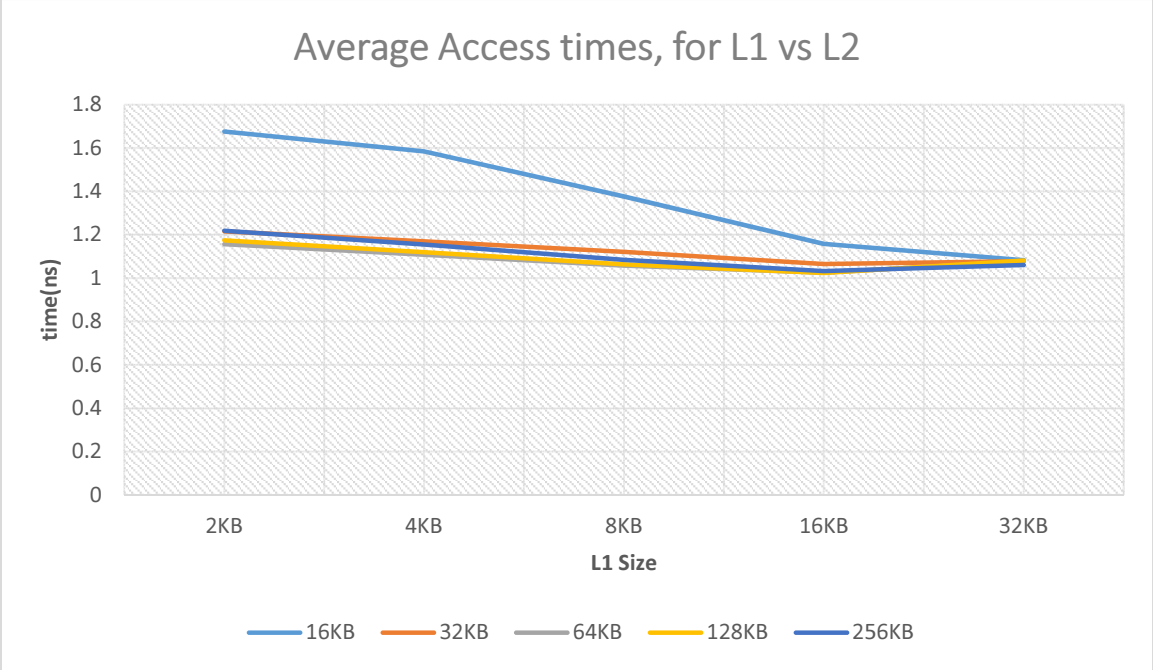


The best AAT for this trace is at: 0.9817ns, which is occurring for L1 size – 16KB and L2 size – 128KB.

Including a victim cache

Now including a victim cache of size 4KB, the AAT values are as follows.
Here is are values for gcc_trace.txt(in ns).

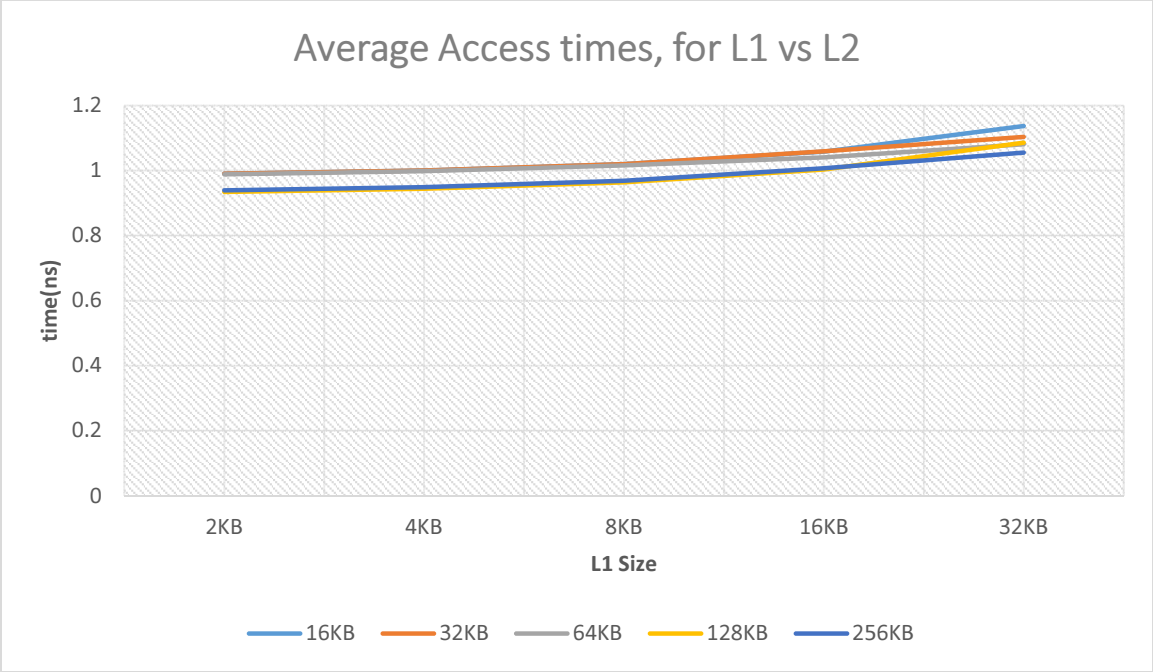
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	1.6761	1.2147	1.1566	1.1736	1.2187
4KB	1.5840	1.1692	1.1081	1.1198	1.1542
8KB	1.3763	1.1206	1.0577	1.0630	1.0846
16KB	1.1572	1.0651	1.0255	1.0240	1.0324
32KB	1.0829	1.0781	1.0761	1.0805	1.0605



The best AAT for this trace is at: 1.0240ns, which is occurring for L1 size – 16KB and L2 size – 128KB.

Following are values for go_trace.txt

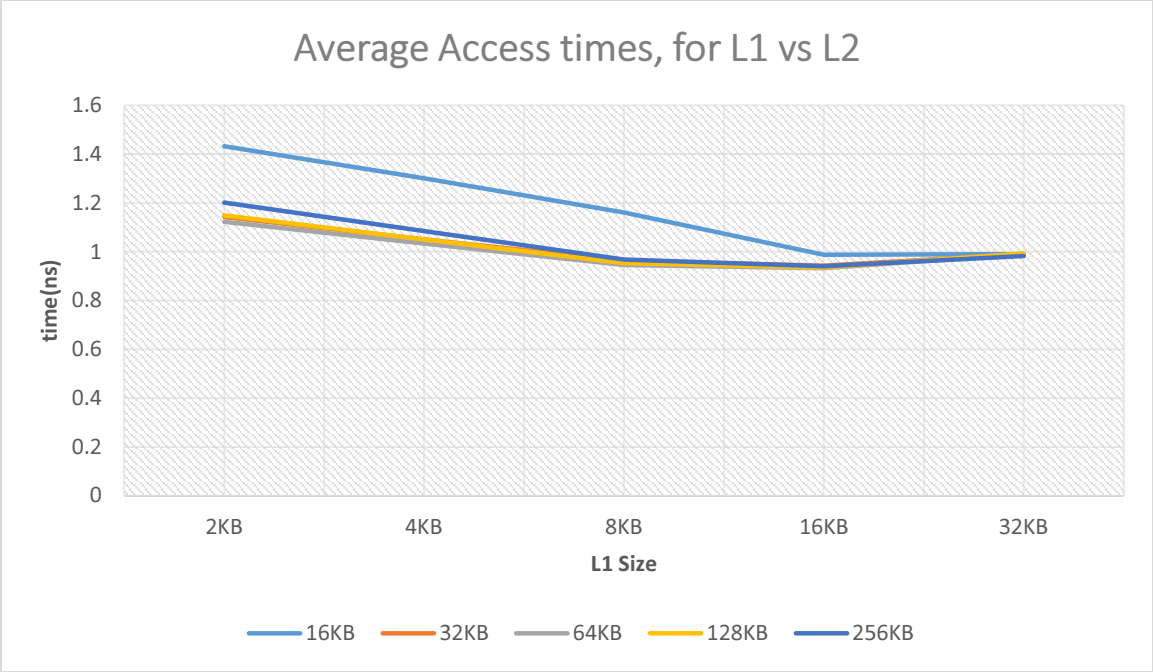
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	0.9899	0.9902	0.9883	0.9343	0.9390
4KB	0.9997	1.0000	0.9981	0.9441	0.9487
8KB	1.0192	1.0195	1.0161	0.9636	0.9682
16KB	1.0579	1.0585	1.0403	1.0026	1.0072
32KB	1.1366	1.1033	1.0807	1.0853	1.0547



The best AAT for this trace is at: 0.9636ns, which is occurring for L1 size – 8KB and L2 size – 128KB.

Following are values for perl_trace.txt

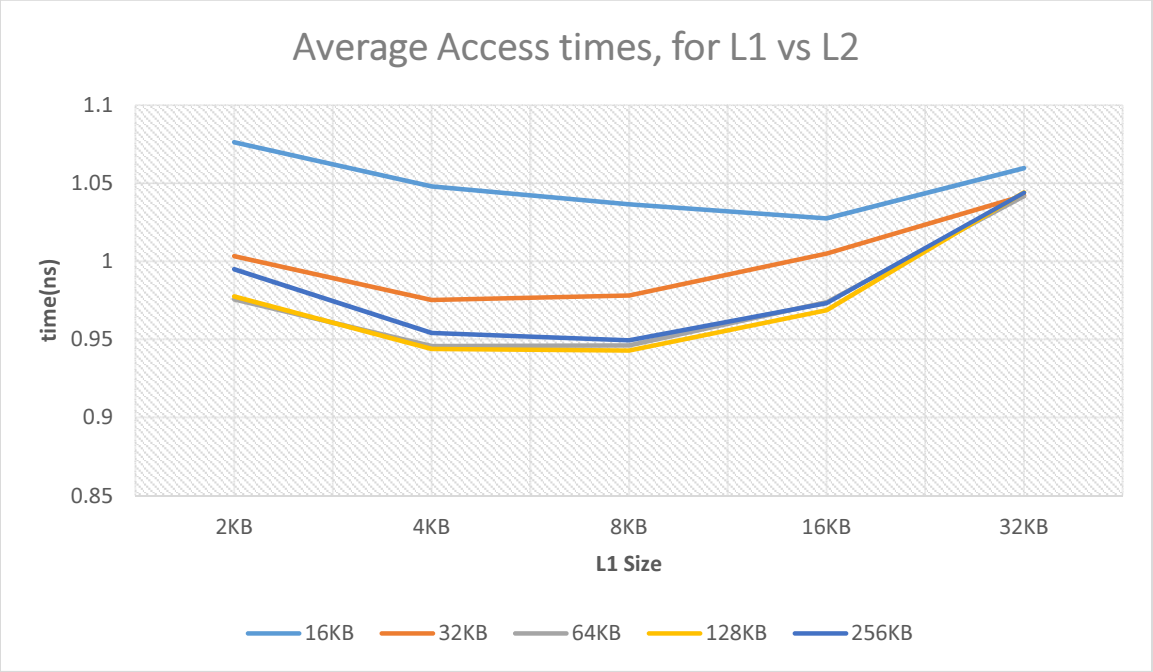
L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	1.4320	1.1418	1.1223	1.1487	1.2017
4KB	1.3015	1.0510	1.0328	1.0502	1.0850
8KB	1.1610	0.9624	0.9452	0.9528	0.9680
16KB	0.9880	0.9430	0.9321	0.9349	0.9405
32KB	0.9905	0.9896	0.9905	0.9923	0.9827



The best AAT for this trace is at: 0.9321ns, which is occurring for L1 size – 16KB and L2 size – 64KB.

Following are values for vortex_trace.txt

L1 Sizes\L2 Sizes	16KB	32KB	64KB	128KB	256KB
2KB	1.0764	1.0033	0.9757	0.9776	0.9949
4KB	1.0481	0.9752	0.9458	0.9440	0.9541
8KB	1.0366	0.9781	0.9461	0.9429	0.9495
16KB	1.0275	1.0050	0.9739	0.9688	0.9732
32KB	1.0597	1.042	1.0417	1.0442	1.0439



The best AAT for this trace is at: 0.9440ns, which is occurring for L1 size – 4KB and L2 size – 128KB.

Comparison

In the case where there is not victim cache, from the above values we can see that the capacity misses for perl_trace and vortex trace are higher than for gcc_trace and go_trace. This can be observed from the fact that the lower access time for the 2 traces occurs when the L1 size if increased as compared to gcc_trace and go_trace.

When the victim cache comes into picture, the AAT reduces by a considerable value for all the traces, but we can observe that the optimum cache size also reduces in the case of the vortex_trace considerably. This could be attributed to the continuous evictions, whose reaccess time is reduced by the addition of the victim cache. For the gcc_trace, the L2 size is higher for the lowest optimum time.

Thic can because, temporal locality exists, but the size of the victim is not enough to actually overcome the miss penalty. This by increasing the L2 size, victim misses are also taken care of properly. In case of the other traces, not much of a difference in noticed.

Appendix

Raw measurements:

1. For gcc_trace
    a. without victim:

```
====== Simulation results (raw) ======
  a. number of L1 reads:     63640
  b. number of L1 read misses:      1767
  c. number of L1 writes:     36360
  d. number of L1 write misses:       997
  e. L1 miss rate:    0.0276
  f. number of swaps:0
  g. number of victim cache writeback:0
  h. number of L2 reads:      2764
  i. number of L2 read misses:       535
  j. number of L2 writes:      1218
  k. number of L2 write misses:         0
  l. L2 miss rate:    0.1936
  m. number of L2 writebacks:       165
  n. total memory traffic:        700
  ==== Simulation results (performance) ====
  1. average access time:    1.0722 ns
```

    b. with victim

```
  ====== Simulation results (raw) ======
  a. number of L1 reads:     63640
  b. number of L1 read misses:       867
  c. number of L1 writes:     36360
  d. number of L1 write misses:       528
  e. L1 miss rate:    0.0139
  f. number of swaps:1369
  g. number of victim cache writeback:655
  h. number of L2 reads:      1395
  i. number of L2 read misses:       514
  j. number of L2 writes:       655
  k. number of L2 write misses:         0
  l. L2 miss rate:    0.3685
  m. number of L2 writebacks:        16
  n. total memory traffic:        530
  ==== Simulation results (performance) ====
  1. average access time:    1.0240 ns
```

2. For go_trace
    a. Without victim:

```
====== Simulation results (raw) ======
a. number of L1 reads:     60613
b. number of L1 read misses:       327
c. number of L1 writes:     39387
d. number of L1 write misses:       413
e. L1 miss rate:    0.0074
f. number of swaps:0
g. number of victim cache writeback:0
h. number of L2 reads:       740
i. number of L2 read misses:       525
j. number of L2 writes:       579
k. number of L2 write misses:         0
l. L2 miss rate:    0.7095
m. number of L2 writebacks:         2
n. total memory traffic:        527
==== Simulation results (performance) ====
1. average access time:    0.9636 ns
```

    b. With victim:

```
====== Simulation results (raw) ======
a. number of L1 reads:     60613
b. number of L1 read misses:       325
c. number of L1 writes:     39387
d. number of L1 write misses:       413
e. L1 miss rate:    0.0074
f. number of swaps:2
g. number of victim cache writeback:563
h. number of L2 reads:       738
i. number of L2 read misses:       525
j. number of L2 writes:       563
k. number of L2 write misses:         0
l. L2 miss rate:    0.7114
m. number of L2 writebacks:         2
n. total memory traffic:        527
==== Simulation results (performance) ====
1. average access time:    0.9636 ns
```

3. For perl_trace
    a. With victim:

```
====== Simulation results (raw) ======
a. number of L1 reads:     70107
b. number of L1 read misses:      1535
c. number of L1 writes:     29893
d. number of L1 write misses:       374
e. L1 miss rate:    0.0191
f. number of swaps:0
g. number of victim cache writeback:0
h. number of L2 reads:      1909
i. number of L2 read misses:       262
j. number of L2 writes:       581
k. number of L2 write misses:         0
l. L2 miss rate:    0.1372
m. number of L2 writebacks:         7
n. total memory traffic:        269
==== Simulation results (performance) ====
1. average access time:    0.9666 ns
```

    b. Without victim:

```
====== Simulation results (raw) ======
a. number of L1 reads:    70107
b. number of L1 read misses:      717
c. number of L1 writes:    29893
d. number of L1 write misses:      180
e. L1 miss rate:    0.0090
f. number of swaps:1012
g. number of victim cache writeback:246
h. number of L2 reads:      897
i. number of L2 read misses:      262
j. number of L2 writes:      246
k. number of L2 write misses:       1
l. L2 miss rate:    0.2921
m. number of L2 writebacks:       5
n. total memory traffic:       268
==== Simulation results (performance) ====
1. average access time:    0.9321 ns
```

4. For vortex_trace
    a. Without victim

```
====== Simulation results (raw) ======
a. number of L1 reads:     70871
b. number of L1 read misses:       776
c. number of L1 writes:     29129
d. number of L1 write misses:       266
e. L1 miss rate:    0.0104
f. number of swaps:0
g. number of victim cache writeback:0
h. number of L2 reads:      1042
i. number of L2 read misses:       410
j. number of L2 writes:       357
k. number of L2 write misses:         0
l. L2 miss rate:    0.3935
m. number of L2 writebacks:        10
n. total memory traffic:        420
==== Simulation results (performance) ====
1. average access time:    0.9817 ns
```

    b. With victim

```
      ====== Simulation results (raw) ======
    a. number of L1 reads:     70871
    b. number of L1 read misses:      1181
    c. number of L1 writes:     29129
    d. number of L1 write misses:       422
    e. L1 miss rate:    0.0160
    f. number of swaps:6754
    g. number of victim cache writeback:629
    h. number of L2 reads:      1603
    i. number of L2 read misses:       410
    j. number of L2 writes:       629
    k. number of L2 write misses:         0
    l. L2 miss rate:    0.2558
    m. number of L2 writebacks:        10
    n. total memory traffic:        420
    ==== Simulation results (performance) ====
    1. average access time:    0.9440 ns
```