Computer Architecture #4

Cache

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이 름 : 정 용 훈

1. 실험 내용

각각의 프로그램의 적합한 cache가 왜 다른 건지 비교

다음 문항의 답은 이번 실험만 가지고 설명하기에는 역부족이라고 생각된다. 하지만 각각의 일을 처리하는 Benchmark가 다르고, 여러 개인 것처럼 특정 일을 수행하는 cache를 사용함으로써 동작을 훨씬 효율적으로 사용할 수 있기 때문에 사용한다.

(1) NN-test

다음은 NN-test를 시간부족으로 인한 case한가지를 돌린 실험결과를 나타낸 것이다. 아래는 실험 과정을 capture한 것이다.

```
sim-cache: SimpleScalar/PISA Tool Set version 3.0 of August, 2003.
Copyright (c) 1994-2003 by Todd M. Austin, Ph.D. and SimpleScalar, LLC.
All Rights Reserved. This version of SimpleScalar is licensed for academic
non-commercial use.  No portion of this work may be used by any commercial
entity, or for any commercial purpose, without the prior written permission
of SimpleScalar, LLC (info@simplescalar.com).

sim: command line: ./sim-cache -config ./config/mycache.cfg knn

sim: simulation started @ Sat Jun 15 20:58:22 2019, options follow:

sim-cache: This simulator implements a functional cache simulator.  Cache
statistics are generated for a user-selected cache and TLB configuration,
which may include up to two levels of instruction and data cache (with any
levels unified), and one level of instruction and data TLBs.  No timing
information is generated.

# -config                        # load configuration from a file
# -dumpconfig                     # dump configuration to a file
# -h                       false # print help message
# -v                       false # verbose operation
# -d                       false # enable debug message
# -i                       false # start in Dlite debugger
-seed                          1 # random number generator seed (0 for timer seed)
# -q                       false # initialize and terminate immediately
# -chkpt              <null> # restore EIO trace execution from <fname>
# -redir:sim          <null> # redirect simulator output to file (non-interactive only)
# -redir:prog         <null> # redirect simulated program output to file
-nice                          0 # simulator scheduling priority
-max:inst                      0 # maximum number of inst's to execute
-cache:dl1        dl1:1:8:1:l # l1 data cache config, i.e., {<config>|none}
-cache:dl2        dl2:64:8:1:l # l2 data cache config, i.e., {<config>|none}
-cache:il1        il1:1:8:1:l # l1 inst cache config, i.e., {<config>|dl1|dl2|none}
-cache:il2        il2:64:8:1:l # l2 instruction cache config, i.e., {<config>|dl2|none}
-tlb:itlb             none # instruction TLB config, i.e., {<config>|none}
-tlb:dtlb             none # data TLB config, i.e., {<config>|none}
-flush                   false # flush caches on system calls
-cache:icompress         false # convert 64-bit inst addresses to 32-bit inst equivalents
# -pcstat             <null> # profile stat(s) against text addr's (mult uses ok)

  The cache config parameter <config> has the following format:

    <name>:<nsets>:<bsize>:<assoc>:<repl>

    <name>   - name of the cache being defined
    <nsets>  - number of sets in the cache
    <bsize>  - block size of the cache
    <assoc>  - associativity of the cache
    <repl>   - block replacement strategy, 'l'-LRU, 'f'-FIFO, 'r'-random
```

1. 실험 내용

```
    Examples:    -cache:dl1 dl1:4096:32:1:l
                 -dtlb dtlb:128:4096:32:r

 Cache levels can be unified by pointing a level of the instruction cache
 hierarchy at the data cache hiearchy using the "dl1" and "dl2" cache
 configuration arguments.  Most sensible combinations are supported, e.g.,

   A unified l2 cache (il2 is pointed at dl2):
     -cache:il1 il1:128:64:1:l -cache:il2 dl2
     -cache:dl1 dl1:256:32:1:l -cache:dl2 ul2:1024:64:2:l

   Or, a fully unified cache hierarchy (il1 pointed at dl1):
     -cache:il1 dl1
     -cache:dl1 ul1:256:32:1:l -cache:dl2 ul2:1024:64:2:l



sim: ** starting functional simulation w/ caches **
rows of training data set : 19900
rows of test data set : 100
----------------RESULT-----------------
Power of Distance is 1.000000
This subject belongs to class: [Z], prediction is class: [Z], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [J], prediction is class: [J], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [V], prediction is class: [V], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [V], prediction is class: [V], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [H], prediction is class: [H], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [C], prediction is class: [C], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [X], prediction is class: [X], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [Y], prediction is class: [Y], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [D], prediction is class: [D], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [U], prediction is class: [U], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [I], prediction is class: [I], CORRECT!
Power of Distance is 1.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
```

```
Power of Distance is 1.000000
This subject belongs to class: [J], prediction is class: [J], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [G], prediction is class: [G], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [U], prediction is class: [U], CORRECT!
Power of Distance is 15.000000
This subject belongs to class: [X], prediction is class: [X], CORRECT!
Power of Distance is 9.000000
This subject belongs to class: [P], prediction is class: [L], WRONG!
Power of Distance is 2.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 7.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [Y], prediction is class: [Y], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [G], prediction is class: [G], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [K], prediction is class: [K], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [N], prediction is class: [N], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [M], prediction is class: [M], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [G], prediction is class: [G], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [X], prediction is class: [X], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 15.000000
This subject belongs to class: [V], prediction is class: [V], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [P], prediction is class: [P], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [K], prediction is class: [K], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [W], prediction is class: [W], CORRECT!
Power of Distance is 1.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
Power of Distance is 1.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
```

```
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
Power of Distance is 10.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [H], prediction is class: [H], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [W], prediction is class: [W], CORRECT!
Power of Distance is 8.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [Y], prediction is class: [Y], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [G], prediction is class: [G], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [E], prediction is class: [E], CORRECT!
Power of Distance is 10.000000
This subject belongs to class: [J], prediction is class: [J], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [N], prediction is class: [N], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [M], prediction is class: [M], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 10.000000
This subject belongs to class: [A], prediction is class: [A], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [N], prediction is class: [N], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [F], prediction is class: [F], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [P], prediction is class: [P], CORRECT!
Power of Distance is 7.000000
This subject belongs to class: [U], prediction is class: [U], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [H], prediction is class: [H], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
```

```
Power of Distance is 5.000000
This subject belongs to class: [J], prediction is class: [J], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [B], prediction is class: [B], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [F], prediction is class: [F], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [E], prediction is class: [E], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [F], prediction is class: [F], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [A], prediction is class: [A], CORRECT!
Power of Distance is 7.000000
This subject belongs to class: [Q], prediction is class: [Q], CORRECT!
Power of Distance is 9.000000
This subject belongs to class: [C], prediction is class: [C], CORRECT!
Power of Distance is 9.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [F], prediction is class: [P], WRONG!
Power of Distance is 4.000000
This subject belongs to class: [C], prediction is class: [C], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [V], prediction is class: [V], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [N], prediction is class: [N], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [E], prediction is class: [E], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [A], prediction is class: [A], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [K], prediction is class: [K], CORRECT!
Power of Distance is 9.000000
This subject belongs to class: [M], prediction is class: [M], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [R], prediction is class: [R], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [Y], prediction is class: [Y], CORRECT!
Power of Distance is 7.000000
This subject belongs to class: [V], prediction is class: [V], CORRECT!
```

```
Power of Distance is 2.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [M], prediction is class: [M], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [L], prediction is class: [L], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [D], prediction is class: [D], CORRECT!
Power of Distance is 6.000000
This subject belongs to class: [P], prediction is class: [F], WRONG!
Power of Distance is 8.000000
This subject belongs to class: [W], prediction is class: [W], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [O], prediction is class: [O], CORRECT!
Power of Distance is 9.000000
This subject belongs to class: [E], prediction is class: [E], CORRECT!
Power of Distance is 4.000000
This subject belongs to class: [J], prediction is class: [J], CORRECT!
Power of Distance is 5.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 3.000000
This subject belongs to class: [D], prediction is class: [D], CORRECT!
Power of Distance is 8.000000
This subject belongs to class: [C], prediction is class: [C], CORRECT!
Power of Distance is 2.000000
This subject belongs to class: [T], prediction is class: [T], CORRECT!
Power of Distance is 0.000000
This subject belongs to class: [S], prediction is class: [S], CORRECT!
---------------RESULT SUMMARY----------------
right prediction: 97
wrong prediction: 3
accuracy: 97.000% [0.970000]

sim: ** simulation statistics **
sim_num_insn            640600213572 # total number of instructions executed
sim_num_refs            190937408068 # total number of loads and stores executed
sim_elapsed_time              111854 # total simulation time in seconds
sim_inst_rate           5727110.4616 # simulation speed (in insts/sec)
il1.accesses            640600213572 # total number of accesses
il1.hits                           0 # total number of hits
il1.misses              640600213572 # total number of misses
il1.replacements        640600213571 # total number of replacements
il1.writebacks                     0 # total number of writebacks
il1.invalidations                  0 # total number of invalidations
il1.miss_rate                 1.0000 # miss rate (i.e., misses/ref)
il1.repl_rate                 1.0000 # replacement rate (i.e., repls/ref)
il1.wb_rate                   0.0000 # writeback rate (i.e., wrbks/ref)
il1.inv_rate                  0.0000 # invalidation rate (i.e., invs/ref)
il2.accesses            640600213572 # total number of accesses
il2.hits                364950804026 # total number of hits
```

```
il2.misses                 275649409546 # total number of misses
il2.replacements           275649409482 # total number of replacements
il2.writebacks                        0 # total number of writebacks
il2.invalidations                     0 # total number of invalidations
il2.miss_rate                    0.4303 # miss rate (i.e., misses/ref)
il2.repl_rate                    0.4303 # replacement rate (i.e., repls/ref)
il2.wb_rate                      0.0000 # writeback rate (i.e., wrbks/ref)
il2.inv_rate                     0.0000 # invalidation rate (i.e., invs/ref)
dl1.accesses               190938151266 # total number of accesses
dl1.hits                    86202138653 # total number of hits
dl1.misses                 104736012613 # total number of misses
dl1.replacements           104736012612 # total number of replacements
dl1.writebacks              41281817008 # total number of writebacks
dl1.invalidations                     0 # total number of invalidations
dl1.miss_rate                    0.5485 # miss rate (i.e., misses/ref)
dl1.repl_rate                    0.5485 # replacement rate (i.e., repls/ref)
dl1.wb_rate                      0.2162 # writeback rate (i.e., wrbks/ref)
dl1.inv_rate                     0.0000 # invalidation rate (i.e., invs/ref)
dl2.accesses               146017829621 # total number of accesses
dl2.hits                   114479111874 # total number of hits
dl2.misses                  31538717747 # total number of misses
dl2.replacements            31538717683 # total number of replacements
dl2.writebacks               8783404542 # total number of writebacks
dl2.invalidations                     0 # total number of invalidations
dl2.miss_rate                    0.2160 # miss rate (i.e., misses/ref)
dl2.repl_rate                    0.2160 # replacement rate (i.e., repls/ref)
dl2.wb_rate                      0.0602 # writeback rate (i.e., wrbks/ref)
dl2.inv_rate                     0.0000 # invalidation rate (i.e., invs/ref)
ld_text_base                 0x00400000 # program text (code) segment base
ld_text_size                     101984 # program text (code) size in bytes
ld_data_base                 0x10000000 # program initialized data segment base
ld_data_size                    1452304 # program init'ed `.data' and uninit'ed `.bss' size in bytes
ld_stack_base                0x7fffc000 # program stack segment base (highest address in stack)
ld_stack_size                     16384 # program initial stack size
ld_prog_entry                0x00400140 # program entry point (initial PC)
ld_environ_base              0x7fff8000 # program environ base address address
ld_target_big_endian                  0 # target executable endian-ness, non-zero if big endian
mem.page_count                      389 # total number of pages allocated
mem.page_mem                      1556k # total size of memory pages allocated
mem.ptab_misses                     392 # total first level page table misses
mem.ptab_accesses          2944277795845 # total page table accesses
mem.ptab_miss_rate               0.0000 # first level page table miss rate
```

다음은 주어진 데이터를 비교하면서 데이터가 있는 경우 CORRECT이 반환되며, 찾지 못하면 WORNG이 반환된다. 결과는 100개중에 3개가 WORNG이 반환되는 것을 확인할 수 있었으며, 각각의 결과는 대략 20분정도의 시간이 소요되었다. 다음 NN test를 하나 돌리는데 대략 26시간 정도의 시간이 소요되었으며, 시간이 많이 부족한 것이 사실이다.

Benchmark의 최적의 cache와 성능 차이가 나는 이유

해당 실험에서는 시간부족으로 정확한 실험을 하지 못했지만 특정 일에 대한 처리에서 최적화 된 Benchmark를 사용할 때 cache성능 차이가 있는 이유는 각각의 Benchmark들이 특정일을 처리하는데 있어 특화되어있는 것이 다르기 때문이다. 간단한 얘로 int를 처리하는 것과 float을 처리하는데 있어 해당 처리속도를 check하는 Benchmark의 속도가 다른 것처럼 글자를 인식하는 프로그램에서도 해당 일을 처리하는데 최적화 되어있는 것과 아닌 것의 차이는 성능을 직접 비교하면 쉽게 알 수 있다.

(2) Benchmark

Benchmark	Application Area	Specific Task
099.go	Game playing	Plays the game Go against itself.
129.compress	Compression	Compresses large text files(about 16MB) using adaptive Lempel-Ziv coding
134.perl	Shell interpreter	Performs text numeric manipulations (anagrams/prime number factoring).

099.go : CINT95 벤치 마크 099.go는 인공 지능 분야에서 흔히 사용되는 여러 기술을 사용하여 고대 아시아 게임 인 Go를 사용합니다. David Fotland가 작성한 프로그램은 'Cosmos'와 'The Many Faces of Go'라는 이름으로 판매 된 상업적으로 성공한 프로그램을 기반으로 합니다. 이 규범의 버전은 국제 경쟁에서 경쟁자들을 이끌어 왔습니다.

129.compress : 일반적인 UN * X 압축 유틸리티를 기반으로 합니다.

이 버전은 파일을 읽고 쓰는 대신 메모리에서 작업하도록 수정되었습니다.

큰 버퍼 - 전체 데이터를 생성 한 다음 다른 메모리 버퍼로 압축 한 다음 결과를 확인하고 메모리 버퍼로 다시 압축 해제합니다.

134.perl :. 이 버전의 Perl 은 다양한 운영 체제에서 벤치마킹을 단순화하기 위해 UN * Xisms (/ etc / passwd 조회 및 setuid 동작과 같은)의 많은 부분을 스트라이프 처리했습니다.

우리는 연관 배열에서 몇 가지 기본 수학 계산 및 단어 조회를 수행하는 스크립트에 대해 이를 벤치마킹합니다.

시간의 10 %는 libc.a 에 일반적으로 있는 루틴 (malloc, free, memcpy 등)에 사용할 수 있습니다.

2. 검증 전략, 분석 및 결과

다음은 각각의 Benchmark를 통해 unified와 split의 table을 작성하여, 최적의 크기를 찾은 결과이다. 다음 아래는 각각의 benchmark와 해당 table을 작성한 결과이다.

129.Compress

(split n-way)

	I_Miss_r1	I_Miss_r2		D_Miss_r1	D_Miss_r3		Mean_AMAT
A/1	1	0.5637	133.74	0.8341	0.1355	40.28611	87.013055
B/1	1	0.7342	167.84	0.7508	0.1949	45.282184	106.561092
C/1	0.9993	0.7795	176.77687	0.6042	0.4014	61.589176	119.183023
D/1	0.9329	0	187.58	0.4874	0	98.48	143.03
A/2	1	0.5362	128.24	0.7382	0.121	33.62844	80.93422
B/2	1	0.6943	159.86	0.7382	0.1807	42.442548	101.151274
C/2	1	0.7811	177.22	0.5966	0.3808	58.369056	117.794528
D/2	0.9464		190.28	0.442		89.4	139.84
A/4	1	0.6144	143.88	0.5414	0.1575	28.8821	86.38105
B/4	0.5499	0.2222	36.435556	0	0	1	18.717778
C/4	1	0.8009	181.18	0.5414	0.3805	53.02854	117.10427
D/4	0.977	0	196.4	0.4304	0	87.08	141.74
A/8	0.9952	0.6366	147.612864	0.4095	0.202	25.7338	86.673332
B/8	0.9952	0.6568	151.633472	0.4095	0.2447	29.23093	90.432201
C/8	0.9952	0.8047	181.071488	0.4095	0.5177	51.58963	116.330559
D/8	0.9952	0	200.04	0.4095	0	82.9	141.47

(uni n-way)

Uni_Miss_r1	Uni_Miss_r1	Mean_AMAT
0.5728	0.3477	52.288512
0.568	0.5679	76.87344
0.5728	0.7044	93.152064
0.4355	0	88.1
0.5728	0.1596	30.739776
0.5728	0.531	73.28736
0.544	0.7151	89.68288
0.4265	0	86.3
1	0.2222	65.44
0.5499	0.6095	79.03081
0.5499	0.6861	87.455278
0.4364	0	88.28

(Split block)

	I_Miss_r1	I_Miss_r2		D_Miss_r1	D_Miss_r3		Mean_AMAT
A/16	1	0.6144	143.88	0.5414	0.1575	28.8821	86.38105
B/16	1	0.6718	155.36	0.5414	0.1995	33.4299	94.39493
C/16	1	0.8009	181.18	0.5414	0.3805	53.0285	117.10427
D/16	0.977	0	196.4	0.4304	0	87.08	141.74
A/64	0.2679	0.7111	44.4587	0.4462	0.2306	30.5027	37.480741
B/64	0.2679	0.8905	54.071	0.446	0.4837	53.066	53.568515
C/64	0.2679	1	59.938	0.4462	0.9132	91.418	75.677984
D/64	0.2385	0	48.7	0.2852	0	58.04	53.37
A/128	0.1513	0.7683	27.2748	0.387	0.4364	42.5174	34.896059
B/128	0.1513	1	34.286	0.387	0.8498	74.5145	54.40026
C/128	0.1513	1	34.286	0.387	0.8498	74.5145	54.40026
D/128	0.1513	0	31.26	0.387	0	78.4	54.83
A/256	0.0956	0.8	18.208	0.3537	0.7826	63.4351	40.821562
B/256	0.0956	0.8	18.208	0.3537	0.7826	63.4351	40.821562
C/256	0.0956	0.8	18.208	0.3537	0.7826	63.4351	40.821562
D/256	0.0956	0	20.12	0.3537	0	71.74	45.93
A/512	0.0381	0.98	9.2296	0.2846	0.7732	50.7025	29.966072
B/512	0.0381	0.98	9.2296	0.2846	0.7732	50.7025	29.966072
C/512	0.0381	0.98	9.2296	0.2846	0.7732	50.7025	29.966072
D/512	0.0381	0	8.62	0.2846	0	57.92	33.27

(uni block)

Uni_Miss_r1	Uni_Miss_r1	Mean_AMAT
0.5499	0.2222	36.43556
0.5499	0.6095	79.03081
0.5499	0.6861	87.45528
0.3773	0	76.46
0.1513	0.5286	20.02144
0.1513	0.7683	27.27476
0.1513	1	34.286
0.1513	0	31.26
0.0541	1	12.902
0.0956	0.8	18.208
0.0956	0.8	18.208
0.0956	0	20.12
0.0381	0.98	9.2296
0.0381	0.98	9.2296
0.0381	0.98	9.2296
0.0381	0	8.62
0.0123	0.0742	1.428532
0.0123	0.0742	1.428532
0.0123	0.0742	1.428532
0.0123	0	1.246

099.go

(split n-way)

	i_miss_rate1	i_miss_rate2		d_miss_rate1	d_miss_rate2		AMAT
A/1	1	0.7507	171.14	0.8834	0.3337	77.62612	124.3831
B/1	1	0.8424	189.48	0.8181	0.4538	91.61276	140.5464
C/1	0.9962	0.9068	201.5948	0.7372	0.592	103.0285	152.3117
D/1	0.9644	0	193.88	0.6563	0	132.26	163.07
A/2	1	0.7421	169.42	0.8118	0.3201	69.20744	119.3137
B/2	1	0.8386	188.72	0.8118	0.4246	86.17406	137.447
C/2	0.9992	0.9083	202.4987	0.7164	0.5782	98.1725	150.3356
D/2	0.9751	0	196.02	0.6337	0	127.74	161.88
A/4	0.5014	0	101.28	0	0	0	101.28
B/4	0.5396	0.6288	79.6521	0	0	0	79.6521
C/4	0.9998	0.9125	203.4595	0.6981	0.5787	95.76009	149.6098
D/4	0.9778	0	196.56	0.6193	0	124.86	160.71
A/8	0.9789	0.7605	169.4687	0.6159	0.3744	59.43659	114.4526
B/8	0.9789	0.8593	188.8118	0.6159	0.5218	77.59332	133.2025
C/8	0.9789	0.9298	202.6142	0.6159	0.6684	95.65151	149.1329
D/8	0.9789	0	196.78	0.6159	0	124.18	160.48

(Uni N-way)

	miss_rate1	miss_rate2	AMAT
A/1	0.5492	0.639	82.17176
B/1	0.5489	0.7425	93.48965
C/1	0.5492	0.8364	103.8542
D/1	0.4957	0	100.14
A/2	0.5492	0.6254	80.67794
B/2	0.5492	0.73	92.1672
C/2	0.5372	0.8584	103.9705
D/2	0.5014	0	101.28
A/4	0.5396	0.6288	79.6521
B/4	0.5396	0.742	91.86864
C/4	0.5396	0.8472	103.2218
D/4	0.5095	0	102.9
A/8	0.5195	0.6533	79.26787
B/8	0.5195	0.7753	91.94367
C/8	0.5195	0.8831	103.1441
D/8	0.5195	0	104.9

(Split block)

	i_miss_rate1	i_miss_rate2		d_miss_rate1	d_miss_rate2		AMAT
A/16	0.9998	0.7396	168.8864	0.6981	0.3439	62.97732	115.9319
B/16	0.9998	0.8363	188.2225	0.6981	0.4644	79.80153	134.012
C/16	0.9998	0.9125	203.4595	0.6981	0.5787	95.76009	149.6098
D/16	0.9778	0	196.56	0.6193	0	124.86	160.71
A/64	0.3016	0.7529	52.44693	0.5807	0.5285	73.99399	63.22046
B/64	0.3016	0.872	59.63104	0.5807	0.6691	90.32327	74.97716
C/64	0.3016	0.9997	67.3339	0.5807	0.8894	115.9089	91.62141
D/64	0.2631	0	53.62	0.4906	0	99.12	76.37
A/128	0.1773	0.7871	32.45657	0.5377	0.659	82.62286	57.53971
B/128	0.1773	0.9979	39.93153	0.5377	0.8849	106.9161	73.42384
C/128	0.1773	0.9979	39.93153	0.5377	0.8849	106.9161	73.42384
D/128	0.1773	0	36.46	0.5377	0	108.54	72.5
A/256	0.0921	0.9791	20.87702	0.5025	0.8761	99.09805	59.98754
B/256	0.0921	0.9791	20.87702	0.5025	0.8761	99.09805	59.98754
C/256	0.0921	0.9791	20.87702	0.5025	0.8761	99.09805	59.98754
D/256	0.0921	0	19.42	0.5025	0	101.5	60.46
A/512	0.0505	0.9513	11.61813	0.471	0.8683	92.21386	51.916
B/512	0.0505	0.9513	11.61813	0.471	0.8683	92.21386	51.916
C/512	0.0505	0.9513	11.61813	0.471	0.8683	92.21386	51.916
D/512	0.0505	0	11.1	0.471	0	95.2	53.15

(Uni block)

	miss_rate1	miss_rate2	AMAT
A/16	0.5396	0.6288	79.6521
B/16	0.5396	0.742	91.86864
C/16	0.5396	0.8472	103.2218
D/16	0.4572	0	92.44
A/64	0.1773	0.6392	27.21203
B/64	0.1773	0.7871	32.45657
C/64	0.1773	0.9979	39.93153
D/64	0.1773	0	36.46
A/128	0.0733	0.9738	16.74191
B/128	0.0921	0.9791	20.87702
C/128	0.0921	0.9791	20.87702
D/128	0.0921	0	19.42
A/256	0.0505	0.9513	11.61813
B/256	0.0505	0.9513	11.61813
C/256	0.0505	0.9513	11.61813
D/256	0.0505	0	11.1
A/512	0.0285	0.9176	6.80032
B/512	0.0285	0.9176	6.80032
C/512	0.0285	0.9176	6.80032
D/512	0.0285	0	6.7

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(Split N-way)

	i_miss_rate1	i_miss_rate2		d_miss_rate1	d_miss_rate2		AMAT
A/1	1	0.7652	174.04	0.7578	0.256	54.95536	114.4977
B/1	0.9949	0.8231	184.6784	0.6822	0.3501	62.41164	123.545
C/1	0.9528	0.8926	190.1499	0.6026	0.4876	71.81755	130.9837
D/1	0.9211		185.22	0.4985		100.7	142.96
A/2	1	0.7782	176.64	0.6665	0.2473	47.29509	111.9675
B/2	1	0.8124	183.48	0.6665	0.3223	57.29259	120.3863
C/2	0.9564	0.8605	184.7244	0.5638	0.4752	65.85955	125.292
D/2	0.9287		186.74	0.4752		96.04	141.39
A/4	0.957	0.8255	178.1407	0.5505	0.2772	42.52972	110.3352
B/4	0.957	0.8493	182.696	0.5505	0.3671	52.42771	117.5619
C/4	0.957	0.8639	185.4905	0.5505	0.4714	63.91114	124.7008
D/4	0.9361		188.22	0.4685		94.7	141.46
A/8	0.9374	0.849	178.9185	0.4673	0.3103	39.34664	109.1326
B/8	0.9374	0.8675	182.3869	0.4673	0.416	49.22536	115.8061
C/8	0.9374	0.8796	184.6554	0.4673	0.5642	63.07613	123.8658
D/8	0.9374		188.48	0.4673		94.46	141.47

(Uni N-way)

	miss_rate1	miss_rate2	AMAT
A/1	0.5653	0.6653	87.52482
B/1	0.5463	0.7859	97.79343
C/1	0.5653	0.81	103.8846
D/1	0.4803		97.06
A/2	0.5532	0.6827	87.59793
B/2	0.5532	0.7874	99.18194
C/2	0.5235	0.8661	102.1507
D/2	0.4707		95.14
A/4	0.5242	0.7235	87.33574
B/4	0.5242	0.8383	99.37137
C/4	0.5242	0.8638	102.0448
D/4	0.4798		96.96
A/8	0.4938	0.7803	87.93843
B/8	0.4938	0.894	99.16744
C/8	0.4938	0.9174	101.4784
D/8	0.4938		99.76

(Split block)

	i_miss_rate1	i_miss_rate2		d_miss_rate1	d_miss_rate2		AMAT
A/16	0.957	0.8255	178.1407	0.5505	0.2772	42.52972	110.3352
B/16	0.957	0.8493	182.696	0.5505	0.3671	52.42771	117.5619
C/16	0.957	0.8639	185.4905	0.5505	0.4714	63.91114	124.7008
D/16	0.9361		188.22	0.4685		94.7	141.46
A/64	0.298	0.8735	59.0206	0.3437	0.4019	35.50061	47.2606
B/64	0.298	0.9003	60.61788	0.3437	0.5581	46.23779	53.42784
C/64	0.298	1	66.56	0.3437	0.8423	65.7737	66.16685
D/64	0.2682		54.64	0.2693		6.386	30.513
A/128	0.1734	0.9235	36.49498	0.2708	0.5665	55.16	45.82749
B/128	0.1734	0.9983	39.08904	0.2708	0.8211	50.88678	44.98791
C/128	0.1734	0.9983	39.08904	0.2708	0.8211	50.88678	44.98791
D/128	0.1138		23.76	0.2472		50.44	37.1
A/256	0.1138	0.9988	26.00869	0.2472	0.8065	45.81736	35.91302
B/256	0.1138	0.9988	26.00869	0.2472	0.8065	45.81736	35.91302
C/256	0.1138	0.9988	26.00869	0.2472	0.8065	45.81736	35.91302
D/256	0.1138		23.76	0.2472		50.44	37.1
A/512	0.0741	0.9959	17.24124	0.2276	0.7844	41.25789	29.24956
B/512	0.0741	0.9959	17.24124	0.2276	0.7844	41.25789	29.24956
C/512	0.0741	0.9959	17.24124	0.2276	0.7844	41.25789	29.24956
D/512	0.0741		15.82	0.2276		46.52	31.17

(Uni block)

	miss_rate1	miss_rate2	AMAT
A/16	0.5242	0.7235	87.33574
B/16	0.5242	0.8383	99.37137
C/16	0.5242	0.8638	102.0448
D/16	0.4528		91.56
A/64	0.1734	0.8458	33.80034
B/64	0.1734	0.9235	36.49498
C/64	0.1734	0.9983	39.08904
D/64	0.1734		35.68
A/128	0.1013	0.9946	23.1766
B/128	0.1138	0.9988	26.00869
C/128	0.1138	0.9988	26.00869
D/128	0.0741		15.82
A/256	0.0741	0.9959	17.24124
B/256	0.0741	0.9959	17.24124
C/256	0.0741	0.9959	17.24124
D/256	0.0741		15.82
A/512	0.05	0.992	11.92
B/512	0.05	0.992	11.92
C/512	0.05	0.992	11.92
D/512	0.05		11

다음 테이블에서의 AMAT는 설계시간에 배운 PDF를 참고하여, 식을 설계하였고, 다음 테이블을 에서 가장 빠른 AMAT를 찾은 결과 **129.Compres에 있는 Uni block 512에 위치하는 D의 AMAT**가 가장 빠른 것을 확인할 수 있다.

3. 문제점 및 고찰

이번 과제에서는 캐시 구성 시나리오에 근거하여, NN을 이용한 글자인식 프로그램, 벤치마크에 적합한 캐시를 찾고 성능 차이를 분석, unifed/split 조건의 테이블을 만들어 최적의 크기를 찾고, 4way에서의 최적 블락 사이즈 값을 찾는다. 구한 최적의 block size에서 associativity를 바꿔가며 최적의 associativity를 찾았다. 기말 시험을 통한 캐시의 일반적인 이해에서 그치지 않고 더욱 높은 이해도를 높일 수 있는 내용들이었다. 대부분의 내용이 속도, 최적의 형태 등 효율의 극대화를 위한 내용들이 주로 이뤘는데, 이 부분을 프로젝트를 통해 다시 한번 생각해 볼 수 있다.

캐시는 데이터를 미리 복사해 놓는 임시장소를 의미한다. 미리 복사해 놓은 데이터를 속도가 느린 대용량 메모리의 접근 시간을 해결 할 수 있다.

특정 데이터와 가까운 주소가 순서대로 접근되었을 경우를 공간적 지역성이라고 하는데, 가까울수록 캐시의 효율성이 크게 향상된다. 프로젝트의 내용처럼 레벨 1, 레벨2의 캐시를 통해 가까울수록 더욱 빠르며, 레벨이 낮을수록 더욱 cpu와 가깝고, 접근이 용이하다. 캐시의 블락을 접근하고 찾아내는데 direct mapped, set associative, fully associative 등의 방법이 이용되는 등 다양한 효율적 방법으로 설계되어왔다.

처음부터 효율과 속도를 위해 만들어졌고, 목표하는 기능을 구현하고 나서도 이를 높이기 위한 노력은 계속된 것은 당연한 것이다. 이번 프로젝트에서 이러한 점을 잘 반영했다고 생각한다. 부족한 시간 속에서도 해당 내용에 관한 생각을 여러 번 했다. 앞으로 부족하지 않은 시간 정도는 확보된 상태에서 이런 생각을 바탕으로 진행할 수 있는 과제가 늘었으면 한다.

4. 참고자료

AMAT에 관련한 개념 – 강의자료

각 Benchmark의 개념 – 위키피디아