

Lab 4

CPE 315 - Winter '22
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Perf Line used

```
perf stat -e cache-misses -e cache-references -e branch-misses -e  
instructions -e cpu-cycles -e branch-instructions ./mm > out
```

1. matmul.s

16 matrix

```
Performance counter stats for './mm':  
  
      1782      cache-misses:u      #      0.135 % of all cache refs  
    1317439    cache-references:u  
     365524    branch-misses:u      #     31.71% of all branches  
    5819292    instructions:u      #      0.70  insn per cycle  
     8292306    cpu-cycles:u  
    1152646    branch-instructions:u  
  
    0.006798867 seconds time elapsed  
  
    0.005466000 seconds user  
    0.000000000 seconds sys
```

64 matrix

```
Performance counter stats for './mm':  
  
      3180      cache-misses:u      #      0.004 % of all cache refs  
    79341478    cache-references:u  
     24431503    branch-misses:u      #     31.91% of all branches  
    373826784    instructions:u      #      0.72  insn per cycle  
    521801931    cpu-cycles:u  
     76556389    branch-instructions:u  
  
    0.266800140 seconds time elapsed  
  
    0.252792000 seconds user  
    0.009722000 seconds sys
```

256 matrix

```
Performance counter stats for './mm':

      16858093      cache-misses:u      #      0.337 % of all cache refs
      5008672394    cache-references:u
      1625723821    branch-misses:u      #      32.42% of all branches
      24107027838    instructions:u      #      0.70  insn per cycle
      34595822173    cpu-cycles:u
      5015165613    branch-instructions:u

17.322210770 seconds time elapsed

17.307645000 seconds user
 0.000000000 seconds sys
```

1024 matrix

```
Performance counter stats for './mm':

      1078360327    cache-misses:u      #      0.338 % of all cache refs
      318878552583   cache-references:u
      101656516817   branch-misses:u      #      30.96% of all branches
      1563344853414   instructions:u      #      0.70  insn per cycle
      2234461380403   cpu-cycles:u
      328393050120    branch-instructions:u

1117.944734102 seconds time elapsed

1117.760770000 seconds user
 0.000000000 seconds sys
```

Table 1: Matrix Performance - intadd.s, intsub.s, intmul.s

Matrix Size	Time Elapsed (s)	Instructions
16	0.006798867	5819292
64	0.266800140	373826784
256	17.322210770	24107027838
1024	1117.944734102	1563344853414

Table 2: Actual vs. Expected Performance

Matrix Size	Expected	Actual	Percent Difference
16	0.004160798	0.006798867	63.4%
64	0.259861795	0.266800140	2.67%
256	17.23654214	17.322210770	0.50%
1024	1117.793	1117.944734102	0.01%

2. matmul-mul.s

16 matrix

```
Performance counter stats for './mm':

      1783      cache-misses:u      #      1.163 % of all cache refs
    153247      cache-references:u
       7845      branch-misses:u      #      16.11% of all branches
    430854      instructions:u      #      0.50  insn per cycle
    857128      cpu-cycles:u
     48685      branch-instructions:u

    0.012428223 seconds time elapsed

    0.000000000 seconds user
    0.002136000 seconds sys
```

64 matrix

```
Performance counter stats for './mm':

      2332      cache-misses:u      #      0.095 % of all cache refs
    2453542      cache-references:u
     40495      branch-misses:u      #      5.76% of all branches
    8336716      instructions:u      #      0.58  insn per cycle
    14365979      cpu-cycles:u
     702519      branch-instructions:u

    0.012512096 seconds time elapsed

    0.008685000 seconds user
    0.000000000 seconds sys
```

256 matrix

```
Performance counter stats for './mm':

    16857757      cache-misses:u      #     18.976 % of all cache refs
    88835210      cache-references:u
     545350      branch-misses:u      #      2.31% of all branches
    357807880      instructions:u      #      0.30  insn per cycle
    1203303466      cpu-cycles:u
    23574724      branch-instructions:u

    0.615782257 seconds time elapsed

    0.604778000 seconds user
    0.000000000 seconds sys
```

1024 matrix

```

Performance counter stats for './mm':

    1078386215      cache-misses:u          #    23.225 % of all cache refs
    4643260935      cache-references:u       #
    9529550         branch-misses:u          #    0.81% of all branches
    20222627738     instructions:u          #    0.28 insn per cycle
    72936680267     cpu-cycles:u             #
    1182987654      branch-instructions:u

    36.595339098 seconds time elapsed

    36.503311000 seconds user
    0.000000000 seconds sys

```

Table 3: Matrix Performance - Arm ISA add, sub, mul

Matrix Size	Time Elapsed (s)	Instructions
16	0.012428223	430854
64	0.012512096	8336716
256	0.615782257	357807880
1024	36.595339098	20222627738

$$Performance_{expected} = \frac{instructions}{(instructions/cycle)clockfrequency}$$

$$Clock\ frequency = 1.998\ GHz$$

Table 4: Actual vs. Expected Performance

Matrix Size	Expected	Actual	Percent Difference
16	0.000431285	0.012428223	2782%
64	0.007194018	0.012512096	73.9%
256	0.59694341	0.615782257	3.15%
1024	36.14798323	36.595339098	1.23%

Amdahl's Law

$$\text{Speedup}_{1024} = 1117.944 / 36.595 = 30.5x$$

$$\text{Speedup}_{256} = 17.322210770 / 0.615782257 = 28.13x$$

$$\text{Speedup}_{64} = 0.266800140 / 0.012512096 = 21.3x$$

$$\text{Speedup}_{16} = 0.006798867 / 0.012428223 = 0.547x$$

$$\text{Avg}(\text{Speedup}_{1024}, \text{Speedup}_{256}, \text{Speedup}_{64}) = 26.64x$$

note dropped Speedup₁₆ from avg. calculation

$$\text{Speedup} = \frac{\text{old execution time}}{\text{new execution time}} = \frac{1}{(1-F) + \frac{F}{E=1000}} = 26.64 \Rightarrow F = 0.963$$