Alexis Edwards
Lab 5

Table 1: Flops

Mode	Type	Size	Threads	Measured Time	Measured Throughput	Theoretical Throughput	Efficiency
flops	single	small	1	2.796098	3.576413	31.2	11.46%
flops	single	small	2	1.306328	7.655045	31.2	24.54%
flops	single	small	4	1.425644	7.014374	31.2	22.48%
flops	single	medium	1	17.425679	5.738657	31.2	18.39%
flops	single	medium	2	9.410161	10.626811	31.2	34.06%
flops	single	medium	4	6.942043	14.404981	31.2	46.17%
flops	single	large	1	164.913055	6.063801	31.2	19.44%
flops	single	large	2	82.190940	12.166791	31.2	39.00%
flops	single	large	4	55.346903	18.067858	31.2	57.91%
flops	double	small	1	3.736611	2.676222	31.2	8.58%
flops	double	small	2	1.535544	6.512350	31.2	20.87%
flops	double	small	4	1.449415	6.899335	31.2	22.11%
flops	double	medium	1	37.740393	2.649681	31.2	8.49%
flops	double	medium	2	19.053720	5.248319	31.2	16.82%
flops	double	medium	4	12.469743	8.019411	31.2	25.70%
flops	double	large	1	380.700989	2.626733	31.2	8.42%
flops	double	large	2	193.072198	5.179410	31.2	16.60%
flops	double	large	4	129.247366	7.737102	31.2	24.80%

Table 2: Matrix Multiplication

Mode	Type	Size	Threads	Measured Time	Measured Throughput	Theoretical Throughput	Efficiency
matrix	single	small	1	0.344434	2.903314	31.2	9.31%
matrix	single	small	2	0.188203	5.313412	31.2	17.03%
matrix	single	small	4	0.138654	7.212197	31.2	23.12%
matrix	single	medium	1	20.478272	3.125264	31.2	10.02%
matrix	single	medium	2	10.628123	6.021759	31.2	19.30%
matrix	single	medium	4	6.835662	9.362663	31.2	30.01%
matrix	single	large	1	1047.131980	3.911637	31.2	12.54%
matrix	single	large	2	582.894322	7.027003	31.2	22.52%
matrix	single	large	4	379.893725	10.781963	31.2	34.56%
matrix	double	small	1	0.378395	2.642741	31.2	8.47%
matrix	double	small	2	0.263880	3.789601	31.2	12.15%
matrix	double	small	4	0.192423	5.196884	31.2	16.66%
matrix	double	medium	1	22.166788	2.887202	31.2	9.25%
matrix	double	medium	2	10.989338	5.823827	31.2	18.67%
matrix	double	medium	4	7.653960	8.361685	31.2	26.80%
matrix	double	large	1	1208.147412	3.390315	31.2	10.87%
matrix	double	large	2	606.869847	6.749388	31.2	21.63%
matrix	double	large	4	413.242771	9.911849	31.2	31.77%

Theoretical Throughput = (1 socket) * (3 cores per socket) * (2.6 GHz) * (4 FLOPS per cycle) = 31.2

```
alexis@alexis-VirtualBox:~$ lscpu
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   39 bits physical, 48 bits virtual
CPU(s):                          3
On-line CPU(s) list:             0-2
Thread(s) per core:              1
Core(s) per socket:              3
Socket(s):                       1
NUMA node(s):                    1
Vendor ID:                       GenuineIntel
CPU family:                      6
Model:                           158
Model name:                      Intel(R) Core(TM) i7-9750H CPU @ 2.60GHz
Stepping:                        10
CPU MHz:                         2592.000
BogoMIPS:                        5184.00
Hypervisor vendor:               KVM
Virtualization type:             full
L1d cache:                       96 KiB
L1i cache:                       96 KiB
L2 cache:                        768 KiB
L3 cache:                        36 MiB
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Intel Core (Merom, Penryn) Intel Nehalem[7] (Nehalem, Westmere)	SSE4 (128-bit)	4

Summary

I evaluated these benchmarks using my Linux VM. I made use of malloc and vectors for both modes. My efficiency ranges from 8-57%, depending on the benchmark. For flops, I was able to optimize by performing multiple operations in a single loop. I was able to optimize matrix multiplication by performing operations in blocks, which eliminated excessive, repeat operations. Using multiple threads also provides an optimization, which can be seen consistently in my results.