Report for Lab 3

Task 1 – ERT

a) 3 levels of cache is available in the machine.

```
lscpu |grep -i cache
L1d cache:           32K
L1i cache:           32K
L2 cache:            256K
L3 cache:            6144K
```

b) Memory Bandwith: L1: 441.2 GiB/s, L2: 55.81 GiB/s, L3: 41.94 GiB/s, DRAM: 31.21 GiB/s

Machine Performance: 64.8 GFLOPs/sec

Task 2 – Calculating AI using SDE

a) According to the Intel Sde tool, the total number of Flops for different numbers of threads and problem sizes is given in Table 1.

	Problem Sizes			
Threads	0.5 M	1 M	10 M	100 M
1	9 000 942 FLOP	18 000 974 FLOP	180 000 950 FLOP	1 800 000 934 FLOP
2	9 000 926 FLOP	18 000 974 FLOP	180 000 918 FLOP	1 800 000 914 FLOP
4	9 000 906 FLOP	18 000 942 FLOP	180 000 926 FLOP	1 800 000 918 FLOP

Table 1: FLOP numbers for different configurations.

b) Furthermore, the total number of bytes (read and write) is given in Table 2.

	Problem Sizes			
Threads	0.5 M	1 M	10 M	100 M
1	120 896 483 B	240 897 640 B	2 400 901 149 B	24 000 894 174 B
2	126 182 868 B	246 130 313 B	2 408 254 332 B	24 012 186 264 B
4	145 309 375 B	260 864 133 B	2 426 388 194 B	24 034 106 726 B

Table 2: Number of Bytes for different configurations.

c) According to the Intel Sde tool, the running times of the `stream` benchmark for different configurations is given in Table 3.

d) The arithmetic intensity (AI) can then calculated by

$$\mathrm{AI} = \frac{\mathrm{FLOP}}{\mathrm{Bytes}} \ . \tag{1}$$

The arithmetic intensities for different configurations are given in Table 4.

	Problem Sizes			
Threads	0.5 M	1 M	10 M	100 M
1	0.051 645 s	0.101 378 s	0.878 443 s	8.699 119 s
2	0.040 350 s	0.060 514 s	0.467 490 s	4.452 410 s
4	0.045 516 s	0.057 817 s	0.275 754 s	2.329 622 s

Table 3: Running times for different configurations.

	Problem Sizes			
Threads	0.5 M	1 M	10 M	100 M
1	0.074 451 FLOP/B	0.074 724 FLOP/B	0.074 972 FLOP/B	0.074 997 FLOP/B
2	0.071 332 FLOP/B	0.073 136 FLOP/B	0.074 743 FLOP/B	0.074 962 FLOP/B
4	0.061 943 FLOP/B	0.069 005 FLOP/B	0.074 185 FLOP/B	0.074 893 6 FLOP/B

Table 4: Arithmetic Intensities for different configurations.

e) The performance is then

$$\text{Perf} = \frac{\text{FLOP}}{\text{s}} \quad . \tag{2}$$

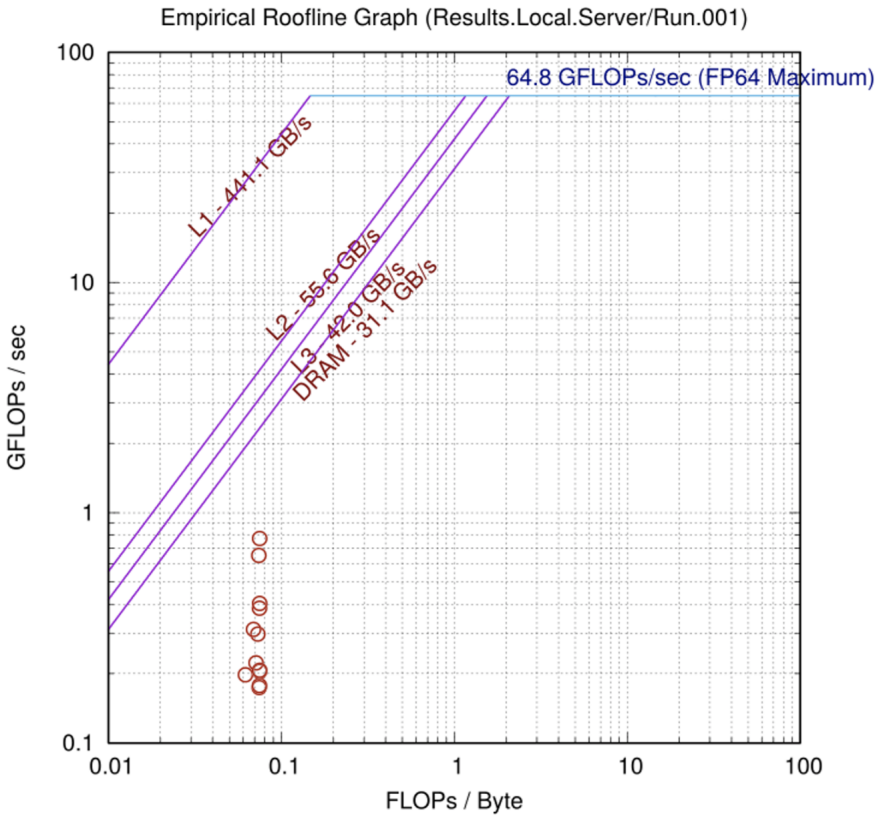
The performances for different configurations are given Table 5.

	Problem Sizes			
Threads	0.5 M	1 M	10 M	100 M
1	0.174 285 GFLOP/s	0.177 563 GFLOP/s	0.204 909 GFLOP/s	0.206 918 GFLOP/s
2	0.223 071 GFLOP/s	0.297 468 GFLOP/s	0.385 037 GFLOP/s	0.404 276 GFLOP/s
4	0.197 753 GFLOP/s	0.311 343 GFLOP/s	0.652 759 GFLOP/s	0.772 658 GFLOP/s

Table 5: Performances for different configurations.

Task 3 – Performance Analysis Results

a) The figure below shows the roofline model and the obtained measurements. We observed that the GFLOP/s increased with an increasing number of threads and also increased with an increasing size of the stream file. The GFLOP/s obtained shows the application is memory bound, however, it did not reach the maximum performance, i.e. the algorithm can still be improved.


Empirical Roofline Graph (Results.Local.Server/Run.001)
64.8 GFLOPs/sec (FP64 Maximum)
L1 - 441.1 GB/s
L2 - 55.6 GB/s
L3 - 42.0 GB/s
DRAM - 31.1 GB/s
GFLOPs / sec
FLOPs / Byte
100
10
1
0.1
0.01
0.1
1
10
100