

Problem 2 : Matrix Multiplication

- The processor/execution environment is described in Problem 1 report.

Analysis

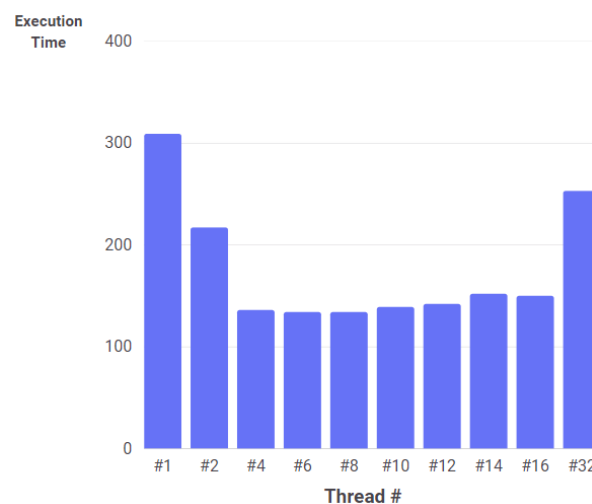
- Result Table
- The input data uses a given 500x500 matrix.

Thread#	1	2	4	6	8
Exec time	309	217	136	134	134

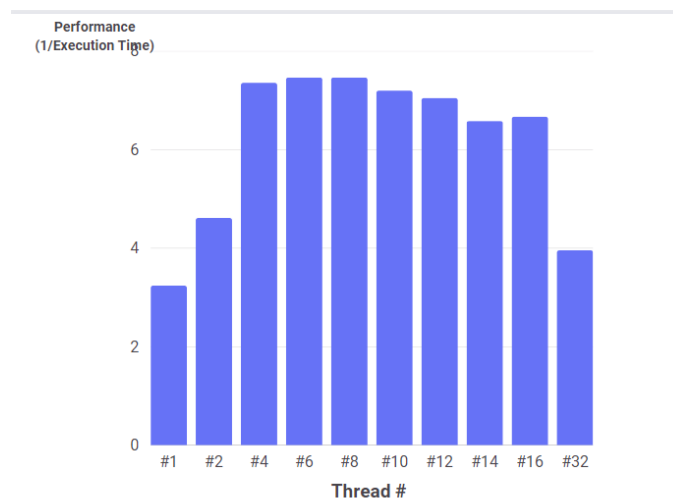
Thread#	10	12	14	16	32
Exec time	139	142	152	150	253

Unit : ms

- Result Graph



<Execution Time>



<Performance Time>

- Static load balancing

```
Thread #1 Program Excution Time : 99ms
Thread #5 Program Excution Time : 78ms
Thread #0 Program Excution Time : 110ms
Thread #6 Program Excution Time : 87ms
Thread #2 Program Excution Time : 109ms
Thread #3 Program Excution Time : 92ms
Thread #7 Program Excution Time : 78ms
Thread #4 Program Excution Time : 68ms
Matrix[500][500]

Matrix Sum = 125231132

[thread_no]: 8 , [Time]: 134 ms

Process finished with exit code 0
```

<Thread #8>

```
Thread #7 Program Excution Time : 86ms
Thread #1 Program Excution Time : 65ms
Thread #3 Program Excution Time : 66ms
Thread #4 Program Excution Time : 97ms
Thread #9 Program Excution Time : 58ms
Thread #2 Program Excution Time : 62ms
Thread #0 Program Excution Time : 101ms
Thread #8 Program Excution Time : 66ms
Thread #5 Program Excution Time : 84ms
Thread #6 Program Excution Time : 63ms
Matrix[500][500]

Matrix Sum = 125231132

[thread_no]:10 , [Time]: 139 ms

Process finished with exit code 0
```

<Thread #10>

- The approach adopted here is Static load balancing BLOCK method. For a problem like Problem 1, where the time required for the task increases with the size of the input, block method may not be a good choice. However, matrix multiplication involves random numbers, and thus, even if divided into blocks, load balancing can still be achieved.
- Looking at the table above, we showed that the higher the number of threads, the better the performance improvement, but when there are more than 10 threads, it does not improve to some extent, and then suddenly decreases when there are 32. I think it's probably because the more threads there are, the more overhead there is, and these threads take matrix information, so it's more overhead.
- Overall, load balancing did not perform as well as expected. However, using a different approach may not necessarily improve load balancing, as I cannot predict how the matrix will be given.

```
for(int i = 0; i < thread_no; i++) {
    mat_threads[i] = new Mat_Thread(i, st, en, a, b); // Block 할당
    st += Block_Size;
    if (i == thread_no - 2)
        en = Matrix_Size;
    else
        en += Block_Size;
}
```

- Here, Block_Size is calculated as 500 divided by the number of threads since the result matrix has dimensions of 500 * 500. Moreover, for matrix multiplication, we multiply each row of matrix A by each column of matrix B and sum up the products. Therefore, we assigned each thread to handle a block of rows from matrix A.

```
public void run(){
    long startTime = System.currentTimeMillis();
    for(int i = 0; i < Matrix_Size; i++){
        for(int j = index_start; j < index_end; j++){
            for(int k = 0; k < Matrix_Size; k++){
                result[i][j] += a[i][k]*b[k][j];
            }
        }
    }
}
```

- In the run method of each thread, a specified range of calculations are performed and the results are stored in the result matrix.

- All Results Screenshot

Thread #0 Program Excution Time : 260ms	Thread #0 Program Excution Time : 156ms
Matrix[500][500]	Thread #1 Program Excution Time : 156ms
	Matrix[500][500]
Matrix Sum = 125231132	Matrix Sum = 125231132
[thread_no]: 1 , [Time]: 309 ms	[thread_no]: 2 , [Time]: 217 ms
Process finished with exit code 0	Process finished with exit code 0

```
Thread #1 Program Excution Time : 92ms
Thread #2 Program Excution Time : 83ms
Thread #3 Program Excution Time : 89ms
Thread #0 Program Excution Time : 77ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]: 4 , [Time]: 136 ms

Process finished with exit code 0

```
Thread #4 Program Excution Time : 104ms
Thread #5 Program Excution Time : 105ms
Thread #1 Program Excution Time : 101ms
Thread #2 Program Excution Time : 65ms
Thread #0 Program Excution Time : 82ms
Thread #3 Program Excution Time : 67ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]: 6 , [Time]: 134 ms

Process finished with exit code 0

```
Thread #1 Program Excution Time : 99ms
Thread #5 Program Excution Time : 78ms
Thread #0 Program Excution Time : 110ms
Thread #6 Program Excution Time : 87ms
Thread #2 Program Excution Time : 109ms
Thread #3 Program Excution Time : 92ms
Thread #7 Program Excution Time : 78ms
Thread #4 Program Excution Time : 68ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]: 8 , [Time]: 134 ms

Process finished with exit code 0

```
Thread #7 Program Excution Time : 86ms
Thread #1 Program Excution Time : 65ms
Thread #3 Program Excution Time : 66ms
Thread #4 Program Excution Time : 97ms
Thread #9 Program Excution Time : 58ms
Thread #2 Program Excution Time : 62ms
Thread #0 Program Excution Time : 101ms
Thread #8 Program Excution Time : 66ms
Thread #5 Program Excution Time : 84ms
Thread #6 Program Excution Time : 63ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]:10 , [Time]: 139 ms

Process finished with exit code 0

```
Thread #10 Program Excution Time : 72ms
Thread #1 Program Excution Time : 72ms
Thread #2 Program Excution Time : 59ms
Thread #3 Program Excution Time : 72ms
Thread #8 Program Excution Time : 61ms
Thread #0 Program Excution Time : 95ms
Thread #6 Program Excution Time : 63ms
Thread #9 Program Excution Time : 70ms
Thread #5 Program Excution Time : 86ms
Thread #7 Program Excution Time : 81ms
Thread #4 Program Excution Time : 81ms
Thread #11 Program Excution Time : 54ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]:12 , [Time]: 142 ms

Process finished with exit code 0

```
Thread #10 Program Excution Time : 49ms
Thread #1 Program Excution Time : 85ms
Thread #9 Program Excution Time : 57ms
Thread #0 Program Excution Time : 81ms
Thread #3 Program Excution Time : 66ms
Thread #4 Program Excution Time : 78ms
Thread #5 Program Excution Time : 49ms
Thread #12 Program Excution Time : 53ms
Thread #13 Program Excution Time : 67ms
Thread #11 Program Excution Time : 64ms
Thread #6 Program Excution Time : 52ms
Thread #2 Program Excution Time : 78ms
Thread #7 Program Excution Time : 46ms
Thread #8 Program Excution Time : 57ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]:14 , [Time]: 152 ms

Process finished with exit code 0

```
Thread #1 Program Excution Time : 72ms
Thread #15 Program Excution Time : 75ms
Thread #10 Program Excution Time : 66ms
Thread #9 Program Excution Time : 105ms
Thread #14 Program Excution Time : 56ms
Thread #0 Program Excution Time : 42ms
Thread #4 Program Excution Time : 55ms
Thread #11 Program Excution Time : 52ms
Thread #13 Program Excution Time : 59ms
Thread #12 Program Excution Time : 58ms
Thread #3 Program Excution Time : 62ms
Thread #5 Program Excution Time : 57ms
Thread #7 Program Excution Time : 62ms
Thread #8 Program Excution Time : 44ms
Thread #6 Program Excution Time : 76ms
Thread #2 Program Excution Time : 65ms
Matrix[500][500]
```

Matrix Sum = 125231132

[thread_no]:16 , [Time]: 150 ms

Process finished with exit code 0

```
Thread #6 Program Excution Time : 82ms
Thread #24 Program Excution Time : 79ms
Thread #30 Program Excution Time : 80ms
Thread #7 Program Excution Time : 66ms
Thread #1 Program Excution Time : 84ms
Thread #5 Program Excution Time : 83ms
Thread #15 Program Excution Time : 42ms
Thread #13 Program Excution Time : 93ms
Thread #23 Program Excution Time : 82ms
Thread #29 Program Excution Time : 123ms
Thread #28 Program Excution Time : 83ms
Thread #14 Program Excution Time : 126ms
Thread #4 Program Excution Time : 66ms
Thread #0 Program Excution Time : 84ms
Thread #20 Program Excution Time : 36ms
Thread #19 Program Excution Time : 117ms
Thread #2 Program Excution Time : 77ms
Thread #25 Program Excution Time : 113ms
Thread #22 Program Excution Time : 66ms
Thread #9 Program Excution Time : 107ms
```

```
Thread #3 Program Excution Time : 87ms
Thread #16 Program Excution Time : 150ms
Thread #21 Program Excution Time : 12ms
Thread #31 Program Excution Time : 88ms
Thread #26 Program Excution Time : 69ms
Thread #17 Program Excution Time : 147ms
Thread #8 Program Excution Time : 83ms
Thread #10 Program Excution Time : 105ms
Thread #18 Program Excution Time : 122ms
Thread #12 Program Excution Time : 94ms
Thread #11 Program Excution Time : 74ms
Thread #27 Program Excution Time : 66ms
Matrix[500][500]
```

```
Matrix Sum = 125231132
```

```
[thread_no]:32 , [Time]: 253 ms
```

```
Process finished with exit code 0
```