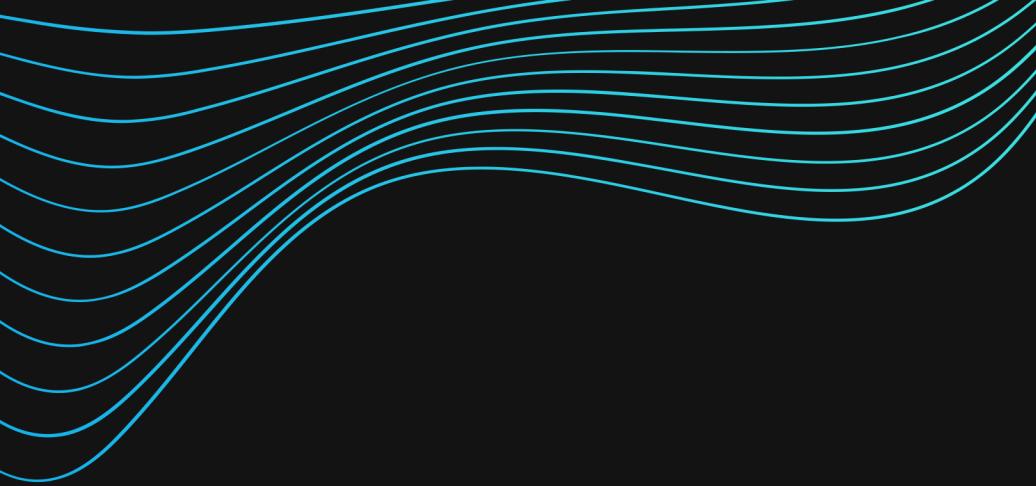


$N \times N$

Multiplication Table

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Agenda

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- THE GOAL
 - EXAMPLES
 - LOAD BALANCING
 - PARALLEL ALGORITHM
 - DEMO VIDEO
 - BENCHMARKING
 - LIVE DEMO

The Goal

Find an efficient implementation using a parallel algorithm to compute the product of an $N \times N$ valued multiplication table and count the number of distinct products that occur

OBSERVATIONS

Table is symmetric

- Look at upper triangle above diagonal line to reduce redundancy and increase efficiency

1	2	3
2	4	6
3	6	9

Example 1

5 X 5 MULTIPLICATION TABLE

$$M(5) = 14$$

	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

Example 2

10 X 10 MULTIPLICATION TABLE

$$M(10) = 42$$

Load Balancing

WHAT IS IT?

Load balancing is a method that distributes network traffic equally across a pool of resources.



Distributing the Workload

Minimum number of products per processor:

$$15/4 = 3 \text{ Remainder } 3$$

Processor 0 (Red) : 4 elements

Processor 1 (Blue) : 4 elements

Processor 2 (Orange) : 4 elements

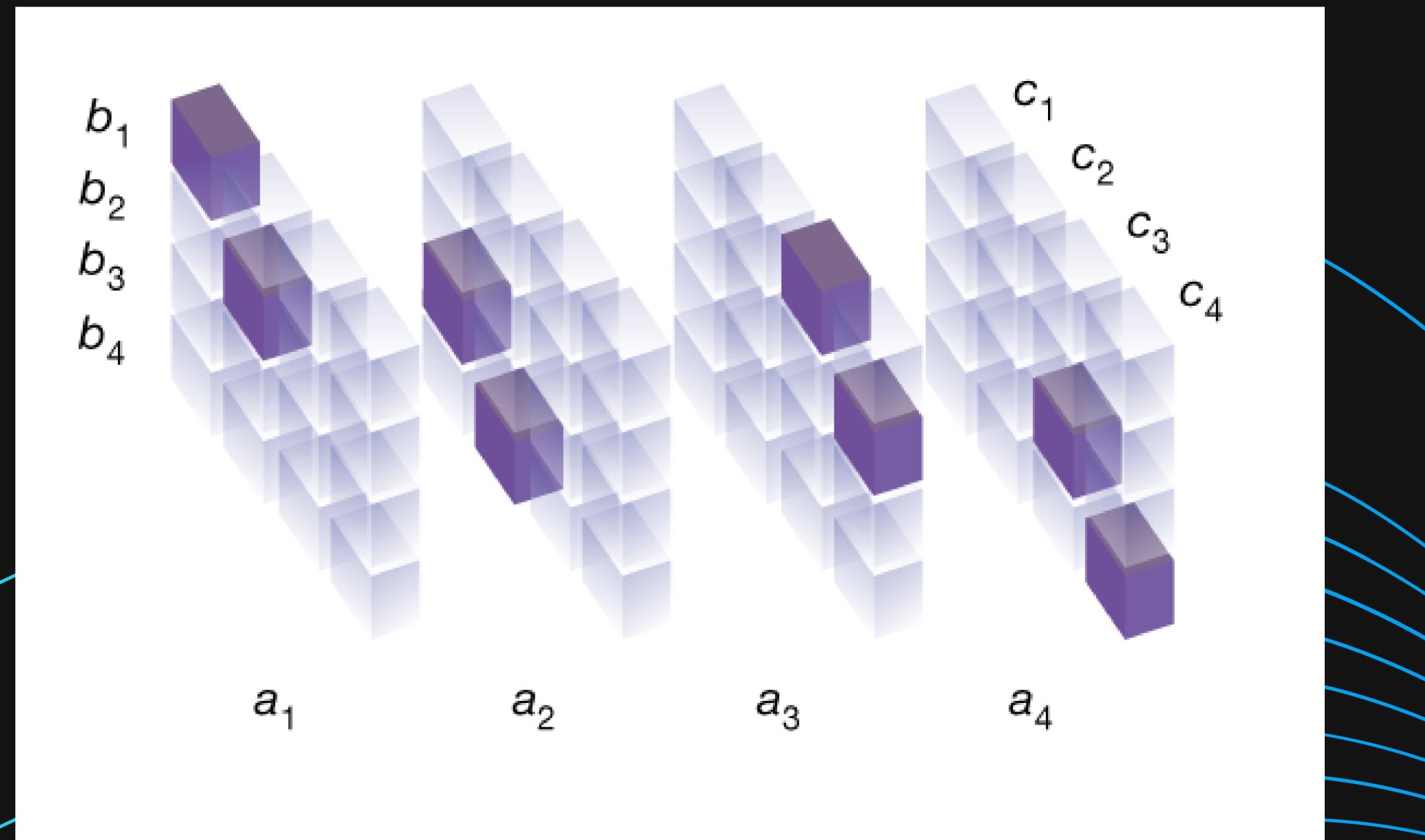
Processor 3 (Purple) : 3 elements

	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

LOAD BALANCING ALGORITHM

Parallel Algorithm

- Initialisation
- Preprocessing
- Local Computation
- Parallel Compilation

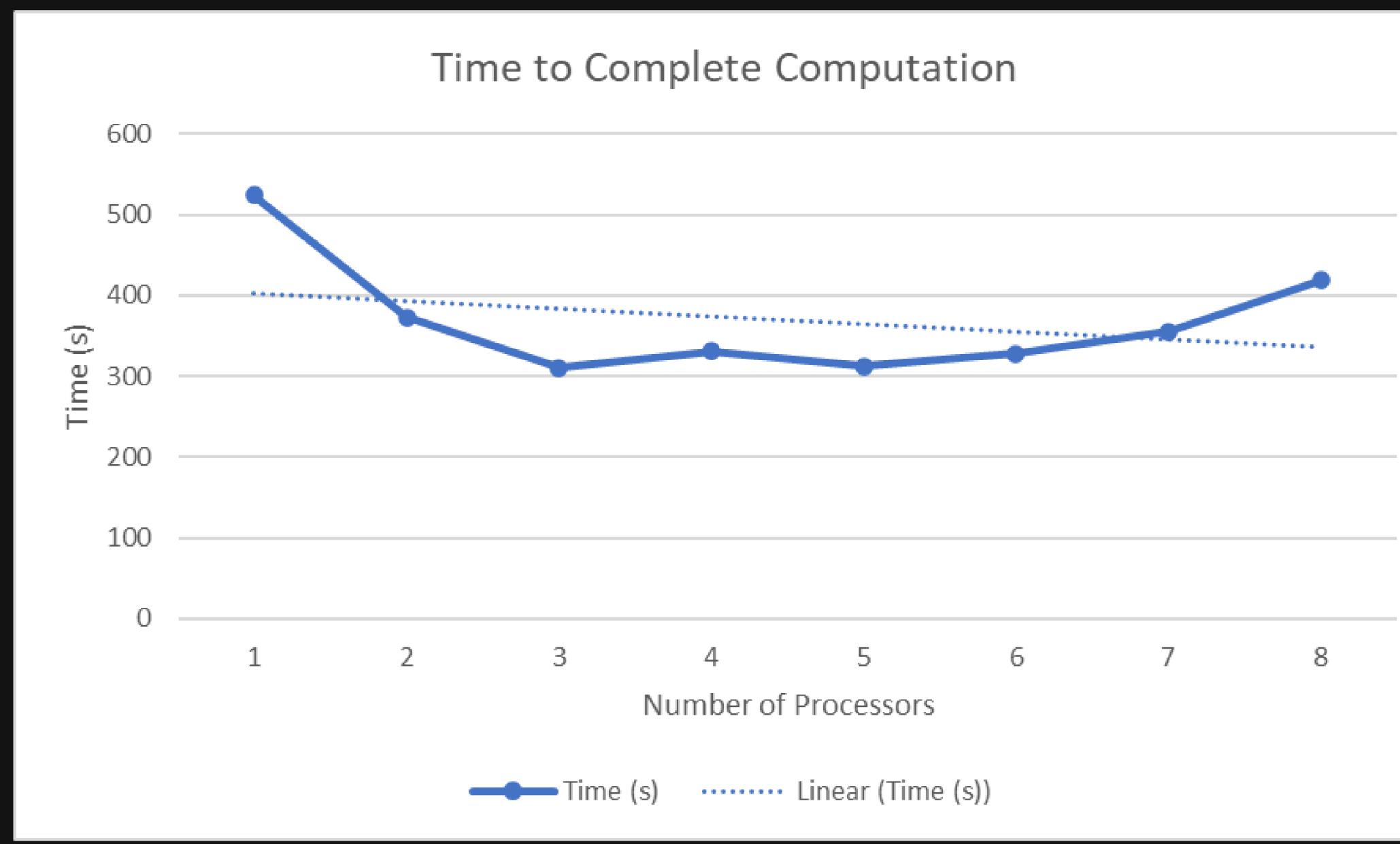


Demo

```
Command Prompt - ssh -Y id  +  × - o ×

lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp/PBM$ cd ..
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ ls
bash.sh main Modified-main2.c output_261760.txt output_261765.txt output_262048.txt output_262586.txt
code main.c Modified-main.c output_261761.txt output_261885.txt output_262062.txt output_262587.txt
code.c main-M2 output_261757.txt output_261763.txt output_262046.txt output_262064.txt PBM
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ mkdir old
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ cp bash3.sh ../PBM/
cp: cannot create regular file '../PBM/': Not a directory
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ cp bash3.sh ../PBM
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ ls
bash3.sh old PBM
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ cd PBM/
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp/PBM$ ls
bash1.sh bash5.sh bash8.sh old-output output_262937.txt output_262942.txt
bash2.sh bash6.sh code output_262935.txt output_262940.txt output_262943.txt
bash4.sh bash7.sh code.c output_262936.txt output_262941.txt output_262944.txt
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp/PBM$ ls
bash1.sh bash4.sh bash7.sh code.c output_262936.txt output_262941.txt output_262944.txt
bash2.sh bash5.sh bash8.sh old-output output_262937.txt output_262942.txt
bash3.sh bash6.sh code output_262935.txt output_262940.txt output_262943.txt
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp/PBM$ cd ..
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ ls
bash3.sh old PBM
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ mpicc -o code code.c -lm
-bash: mpicc: command not found
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ module load gcc/12.2.0 openmpi/4.1.4
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ mpicc -o code code.c -lm
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ ls
bash3.sh code code.c old PBM
lcl_uotwlus2340@teach01:/scratch/l/lcl_uotwlus/lcl_uotwlus2340/tp$ |
```

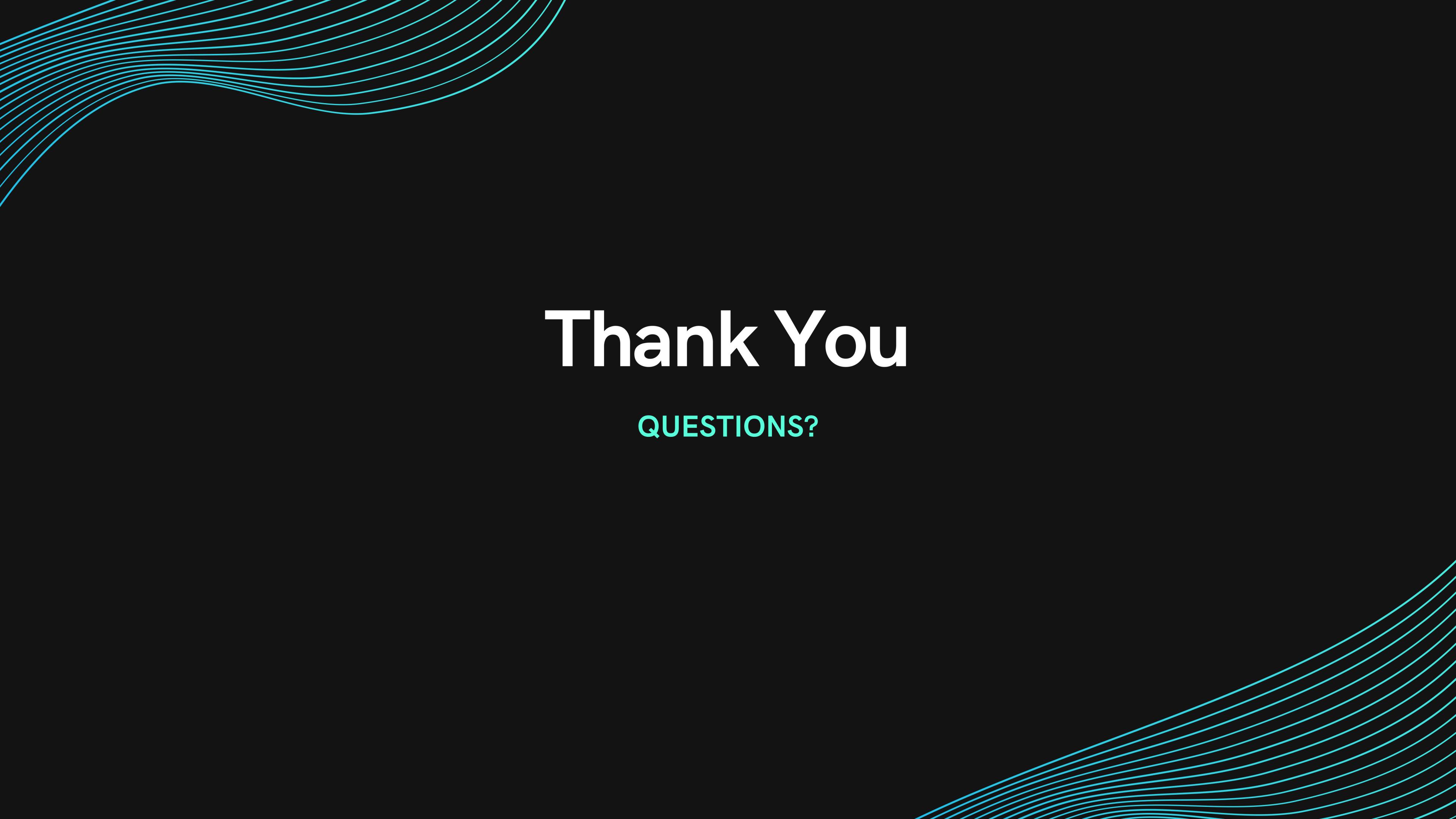
Benchmarking



Number Of Processors	Time (s)
1	523.590
2	372.581
3	310.017
4	330.432
5	312.006
6	327.596
7	355.099
8	418.330



Live Demo



Thank You

QUESTIONS?