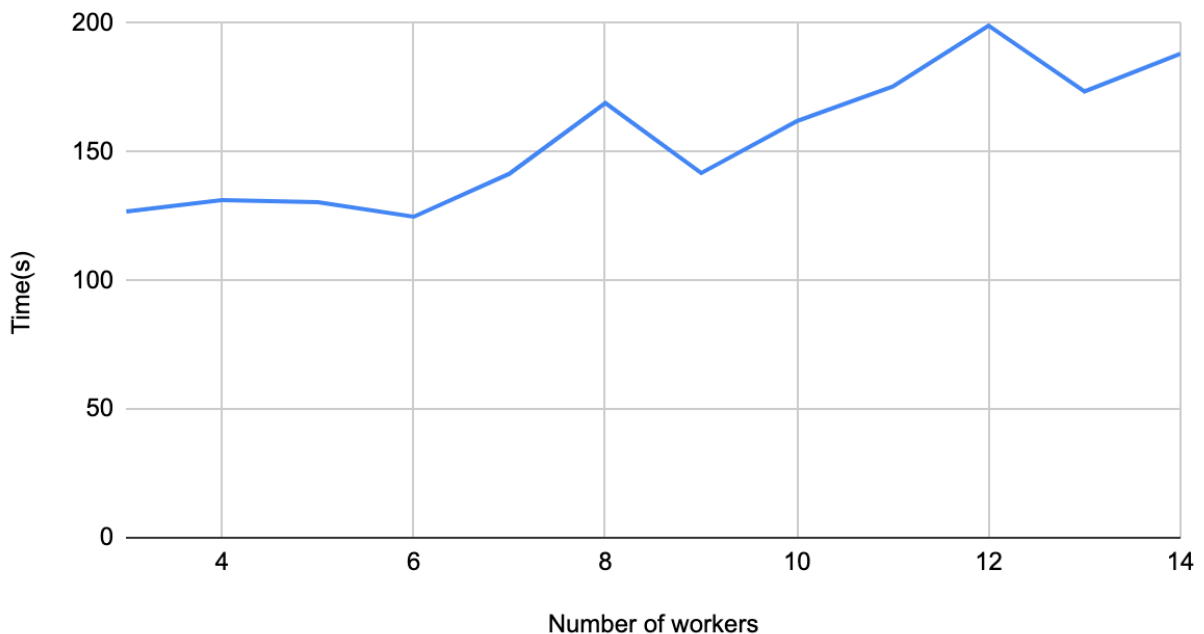


A1: Vary the number of workers using T3 and plot a line graph (number of workers on the x-axis and time taken on the y-axis) for Q3

Time(s) vs. Number of workers



A2: Record the time taken for Q4 for all techniques (T1, T2, and T3) with the following resources:

For question 4, for three techniques, the runtime is as follows:

- Multi-threading - 10 threads - 57.4 seconds
- Multi-processing - 4 processes - 189.3 seconds
- MPI - 4 workers - 103.7seconds

The above statistics are collected from machine with processor 2.3 GHz 8-Core Intel Core i9 and memory 32 GB 2667 MHz DDR4.

From the results, the muti-threading with 10 threads is the most efficient for processing data in Q4. Multi-processing with 4 processes is less efficient. The MPI with 4 workers is in between. Compare between multi-processing and multi-threading, the runtime improves by 69.7%. From multi-processing to MPI, the runtime improves by 45.2%. The runtime improvement from MPI to multi-threading is 45.3%.