Assignment 07 (MPI Benchmarking 3D MPI Solver)

1. Intra-NUMA Scaling (1-18 ranks, 200×40×40 domain)

Results

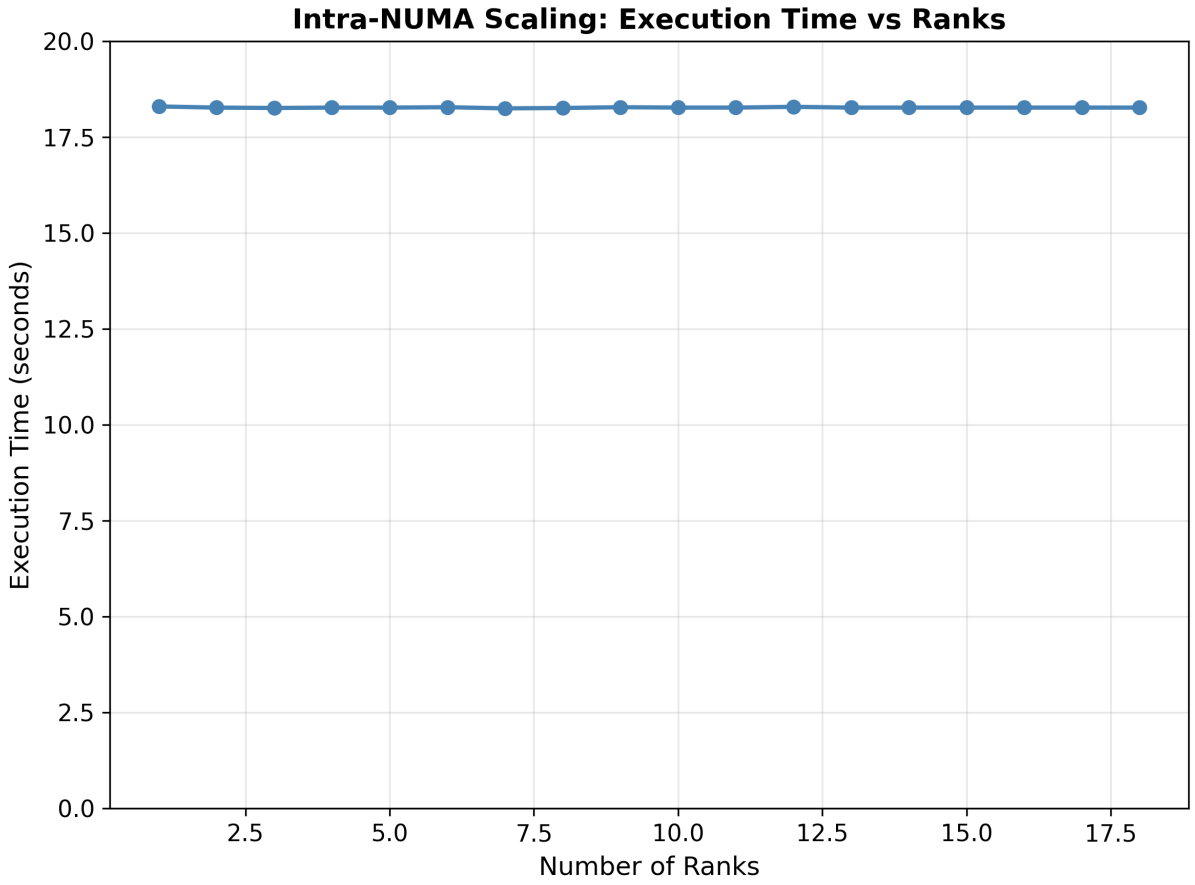

Figure 1: Intra-NUMA Scaling

- Execution time remains essentially constant across all rank counts:
- Mean: 18.272s
- Standard deviation: 0.011s

- Range: 18.25s to 18.30s

Analysis

- No speedup was observed, which indicates this configuration is memory-bound.

- This is due to the Problem size being too small.
- All ranks compete for shared NUMA memory bandwidth.
- Small domains for each process increase communication-to-computation ratio
- This leads to Memory access dominating over computation time.

2. Inter-NUMA Scaling (18-72 ranks, 300×150×150 domain)

Results

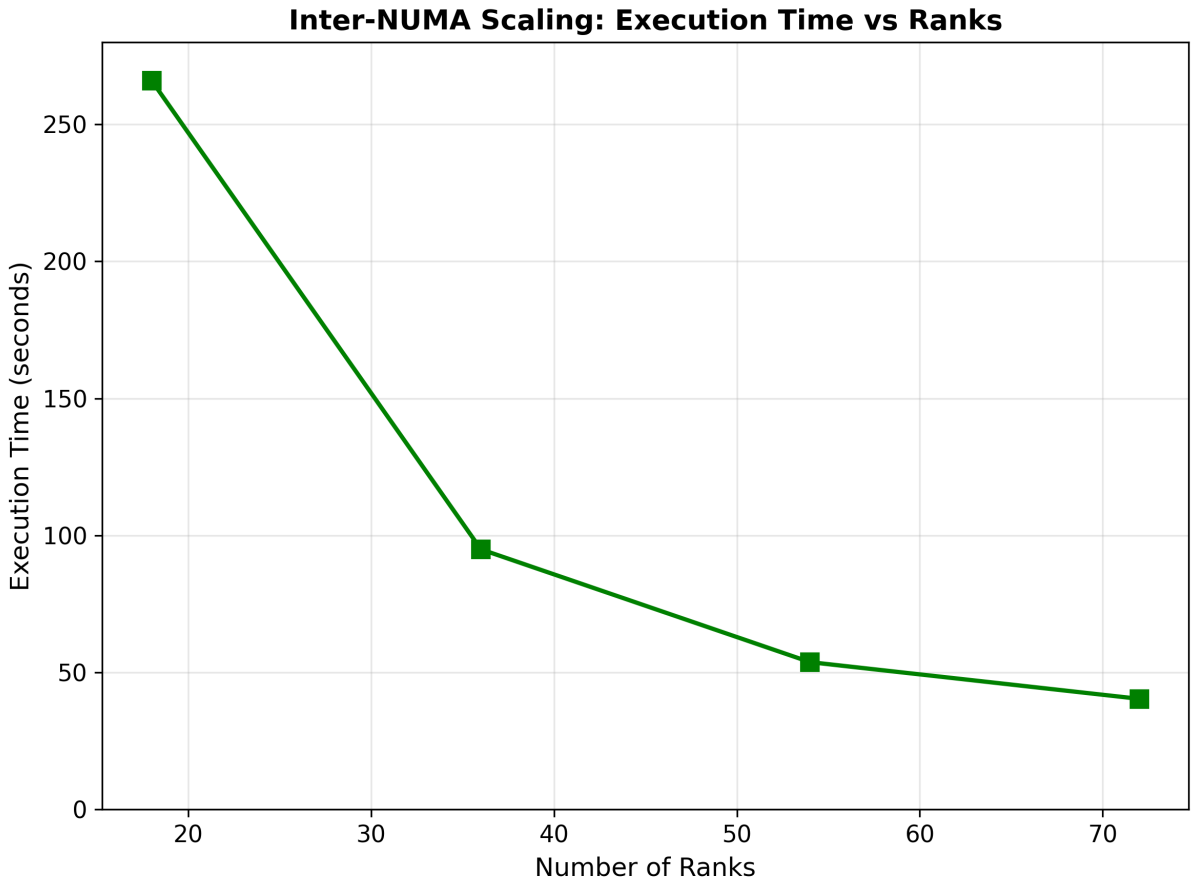

Figure 2: Timing Inter-NUMA Scaling

Ranks	Time (s)	Speedup
18	265.93	1.00×
36	94.93	2.80×

Ranks	Time (s)	Speedup
54	53.75	4.95×
72	40.36	6.59×

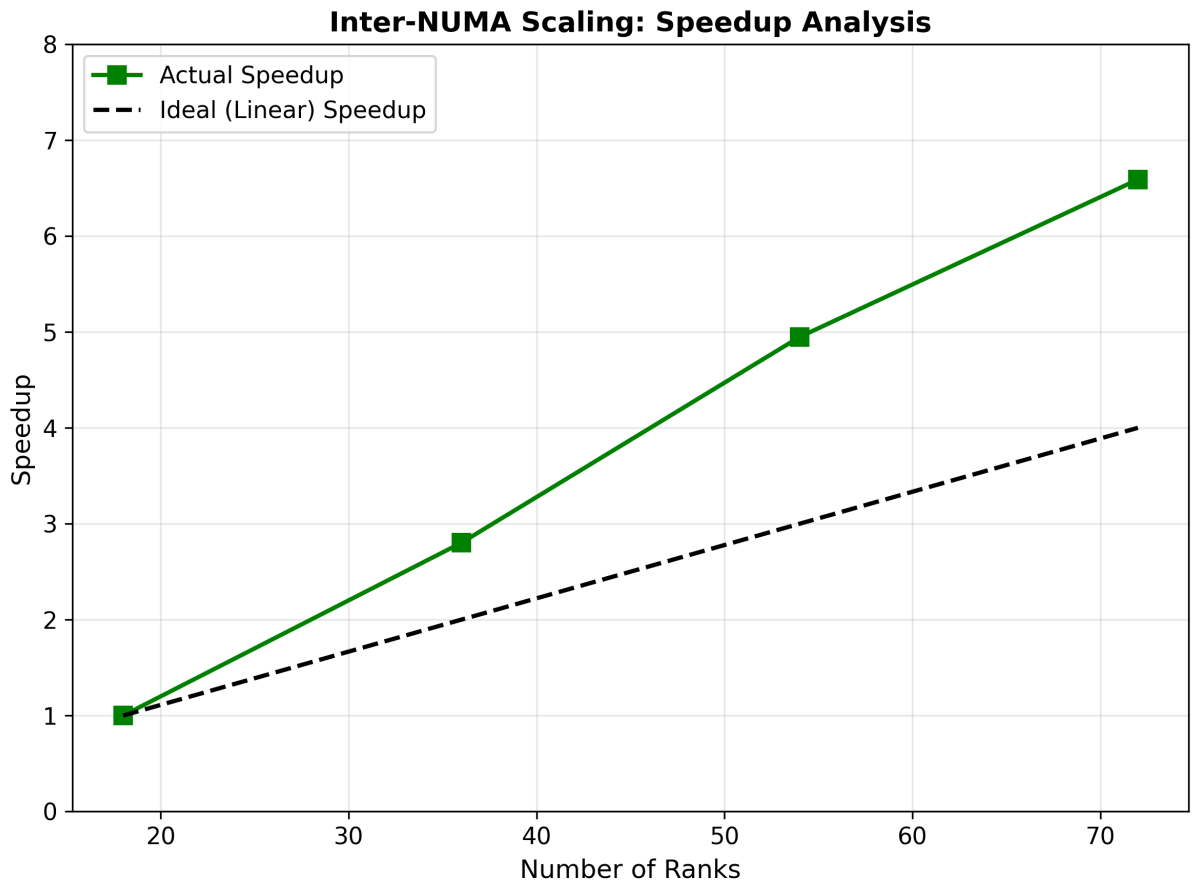

Figure 3: Speedup Inter-NUMA Scaling

Analysis

- The plot show the Super-linear scaling with peak efficiency up to 164.9%.
- Larger problems (6.75M cells, ~93.8K cells/rank) provides in this configuration sufficient work.
- The workload fits better into cache and therefore reduces memory latency.
- Application now exhibits compute-bound behavior.
- Communication overhead is now reduced compared to the intranode numa case.

3. Internode Scaling (72-288 ranks, 600×200×200 domain)

Results

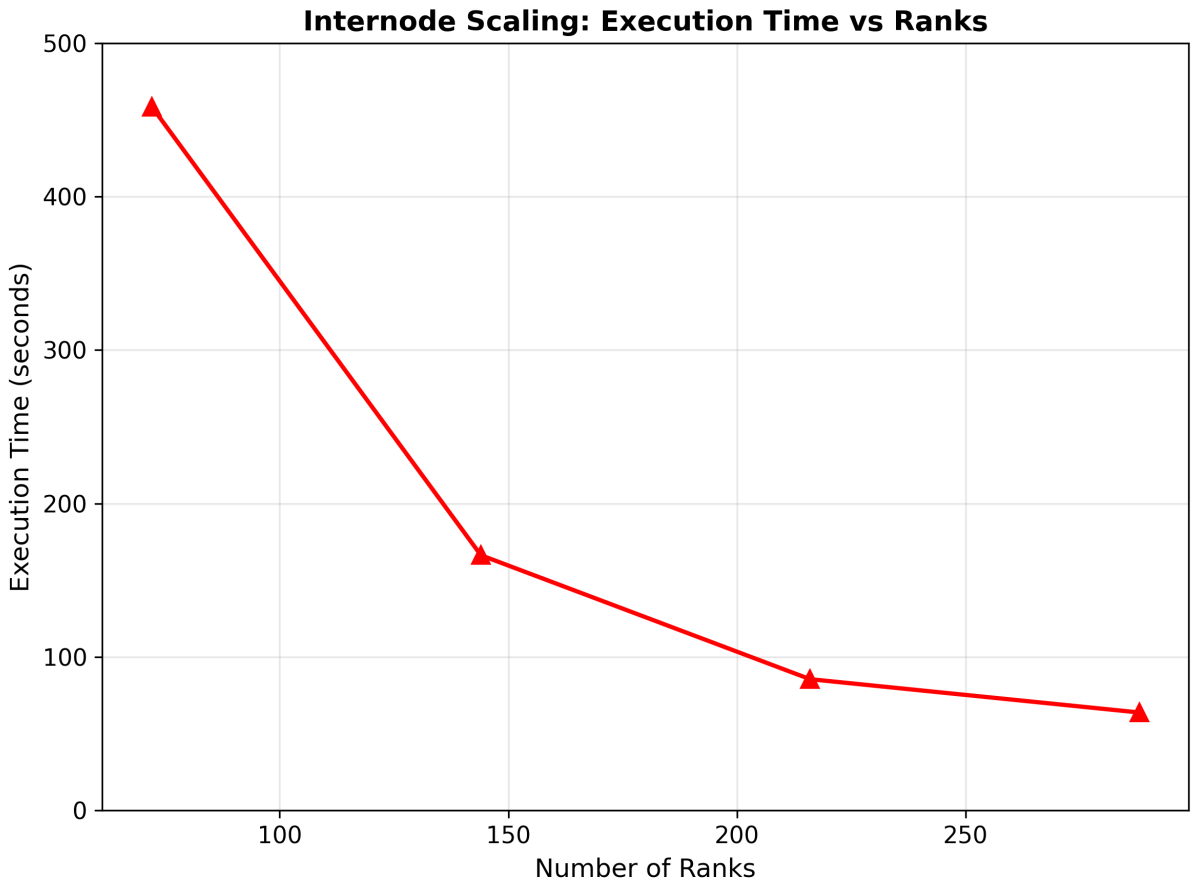

Figure 4: Timing Internode Scaling

Ranks	Nodes	Time (s)	Speedup
72	1	458.71	1.00×
144	2	166.34	2.76×
216	3	85.53	5.36×
288	4	63.83	7.19×

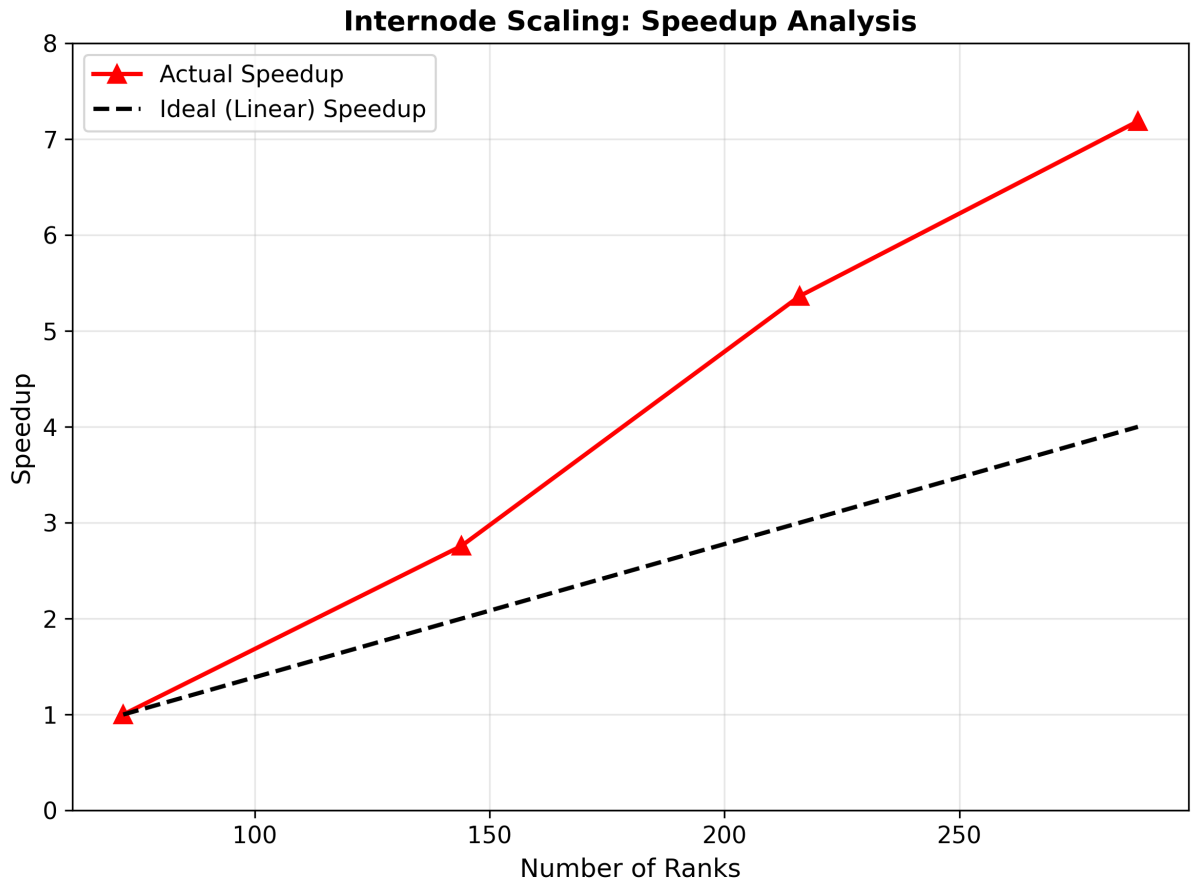

Figure 5: Speedup Internode Scaling

Analysis

- Here we can observer even stronger super-linear scaling with peak efficiency of up to almost 180%.
- Even large problem (24M cells, ~83.3K cells/rank) has an optimizes cache utilization.
- Each of the four nodes can provide independent memory subsystem.
- Shows a good balance between local domain size and parallelism.
- This clearly exhibits a strongly compute-bound
- Network communication overhead appears to be negligible.