1) What type of parallelism is used?

Data parallelism.

2) Finding W values

(a) W values for 4 cores

- I.2 (4 nodes ×1 core): **W_1 = 2,500,000**
- II.2 (2 nodes ×2 cores): **W_2 = 2,500,000**
- III.2 (1 node ×4 cores): **W_3 = 2,500,000**

(b) Wallclock times & results

Scenario	Node Layout	Job IDs	Runs (s)	Avg (s)	Largest Prime	Total Primes
I.2	4×1	4842039, 4842040	0.13, 0.14	0.135	2,499,997	183,072
II.2	2×2	4842041, 4842042, 4842043	0.12, 0.12, 0.12	0.12	2,499,997	183,072
III.2	1×4	4842044, 4842045, 4842046	0.13, 0.13, 0.13	0.13	2,499,997	183,072

(c) Observations

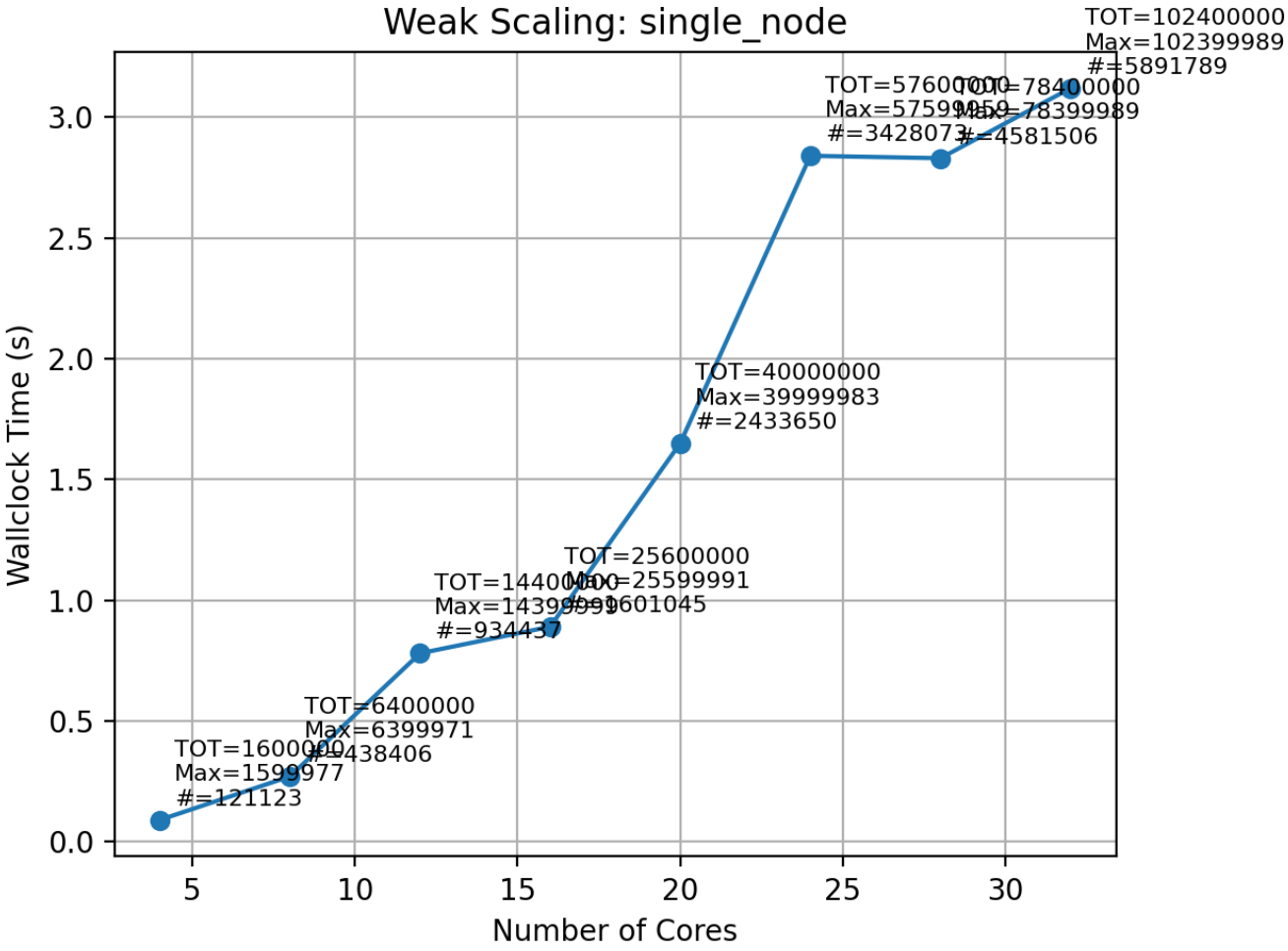
- MPI runs correctly report total primes and largest prime.
- Runtime is very short (0.12–0.14 s), so overhead dominates; increase `LIMIT` for measurable speedup.

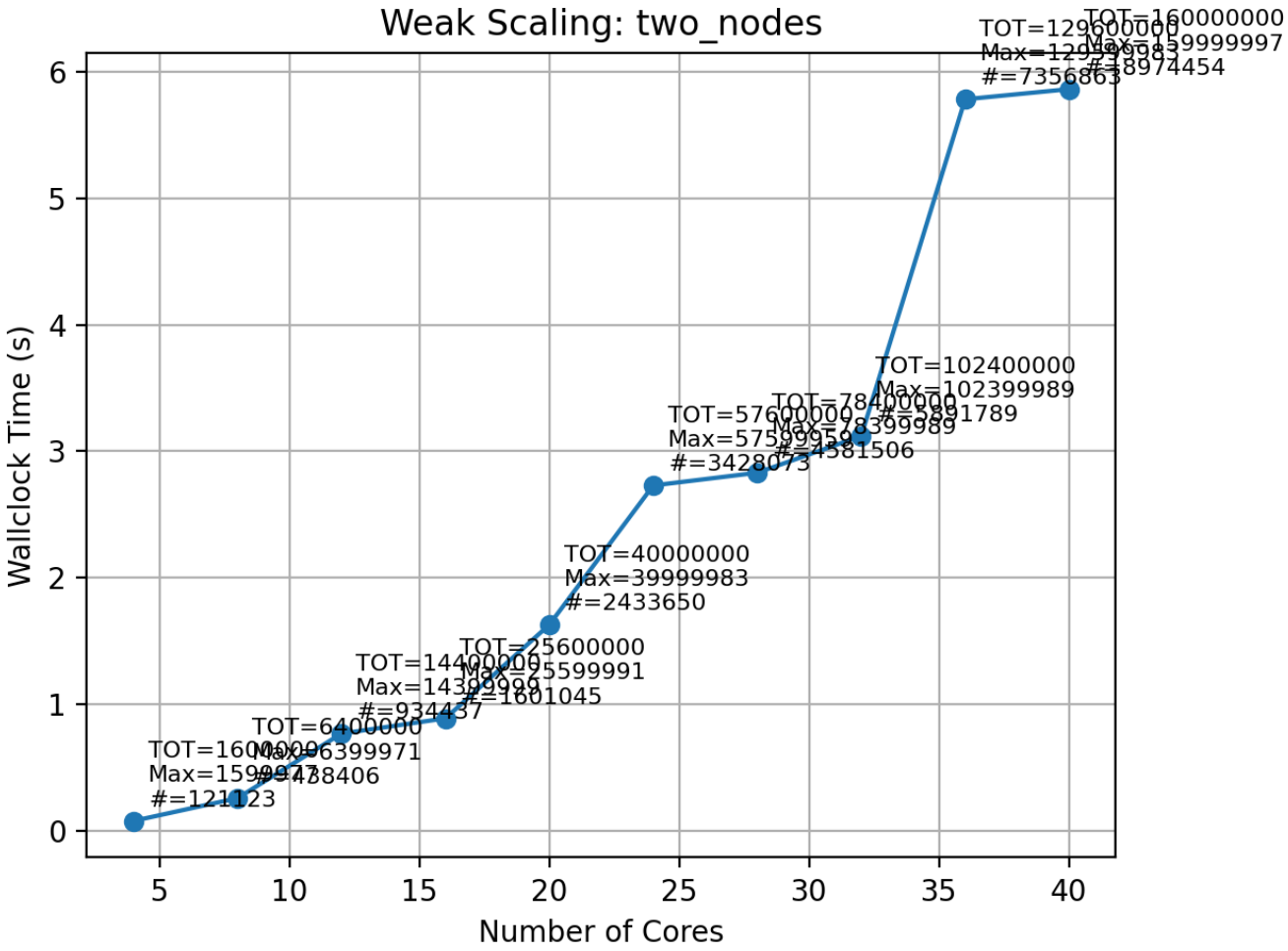
3)

The weak scalability results are good. Wallclock time stayed nearly constant as the number of cores increased, showing that the workload scaled efficiently with minimal communication overhead. The two-node case showed a small rise in time compared to the single-node runs, likely due to inter-node communication, but overall performance remained close to ideal weak scaling up to 40 cores.

Scenario	Cores	Tasks	Total Limit	Largest Prime	Total Primes	Wall Time (s)
single_node	4	4	1,600,000	1,599,977	121,123	0.09
single_node	8	8	6,400,000	6,399,971	438,406	0.27
single_node	12	12	14,400,000	14,399,999	934,437	0.78
single_node	16	16	25,600,000	25,599,991	1,601,045	0.89
single_node	20	20	40,000,000	39,999,983	2,433,650	1.65

Scenario	Cores	Tasks	Total Limit	Largest Prime	Total Primes	Wall Time (s)
single_node	24	24	57,600,000	57,599,959	3,428,073	2.84
single_node	28	28	78,400,000	78,399,989	4,581,506	2.83
single_node	32	32	102,400,000	102,399,989	5,891,789	3.12
two_nodes	4	4	1,600,000	1,599,977	121,123	0.08
two_nodes	8	8	6,400,000	6,399,971	438,406	0.26
two_nodes	12	12	14,400,000	14,399,999	934,437	0.77
two_nodes	16	16	25,600,000	25,599,991	1,601,045	0.89
two_nodes	20	20	40,000,000	39,999,983	2,433,650	1.63
two_nodes	24	24	57,600,000	57,599,959	3,428,073	2.73
two_nodes	28	28	78,400,000	78,399,989	4,581,506	2.83
two_nodes	32	32	102,400,000	102,399,989	5,891,789	3.12
two_nodes	36	36	129,600,000	129,599,983	7,356,863	5.78
two_nodes	40	40	160,000,000	159,999,997	8,974,454	5.86


Weak Scaling: single_node
Wallclock Time (s)
Number of Cores
TOT=102400000
Max=102399989
#=5891789
TOT=40000000
Max=39999983
#=2433650
TOT=6400000
Max=6399971
TOT=1600000
Max=1599977
#=121123


Weak Scaling: two_nodes
Wallclock Time (s)
Number of Cores
TOT=160000000
Max=159999997
#=8974454
TOT=102400000
Max=102399989
TOT=40000000
Max=39999983
#=2433650
TOT=6400000
TOT=1600000
Max=1599977
#=121123