CS 475

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Project 2

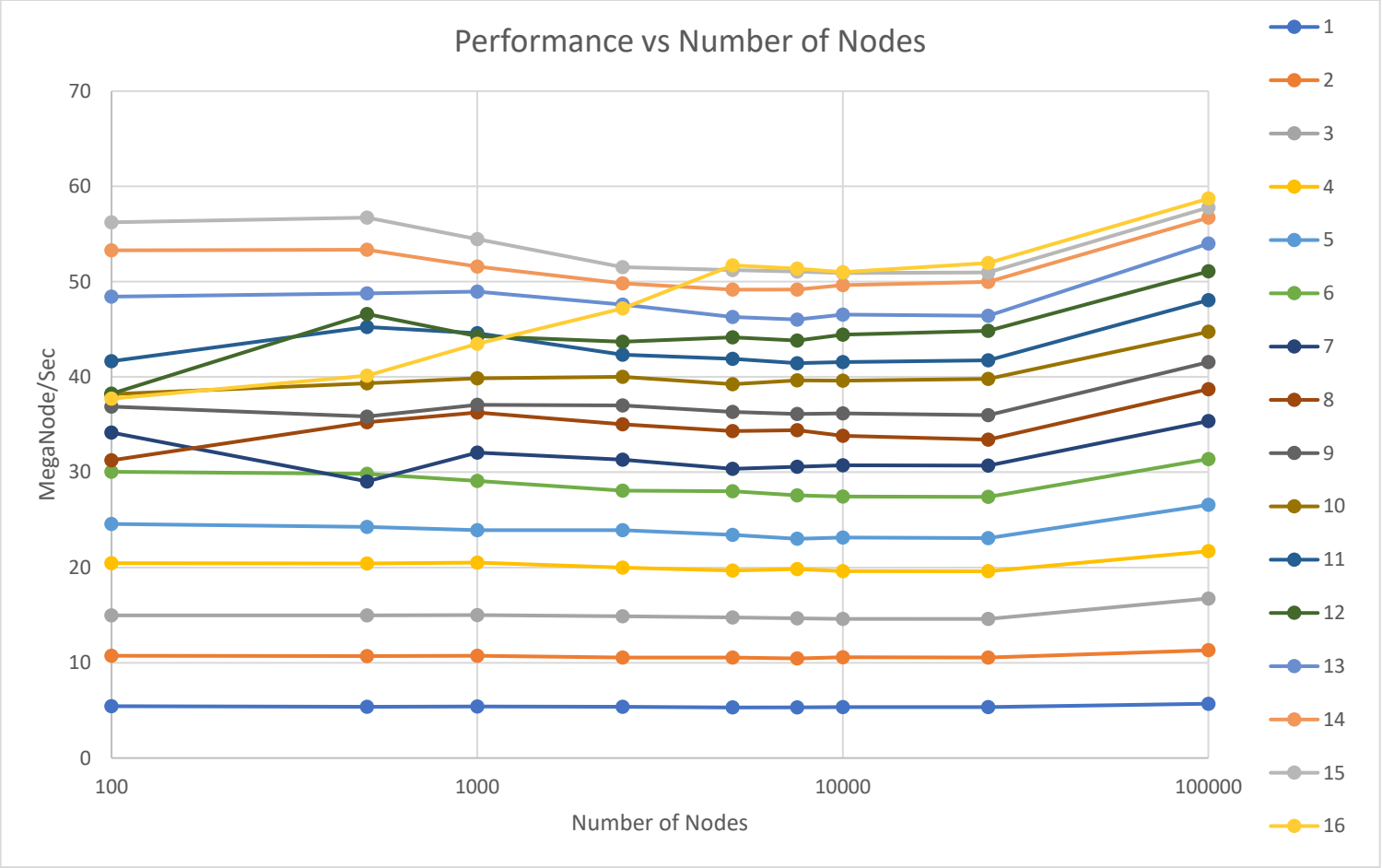
1. Tell what machine you ran this on.

   My computer running Intel I9 9900k @5.1GHz / 4.8~9GHz all core maxed out. ~30% background load while running tests.

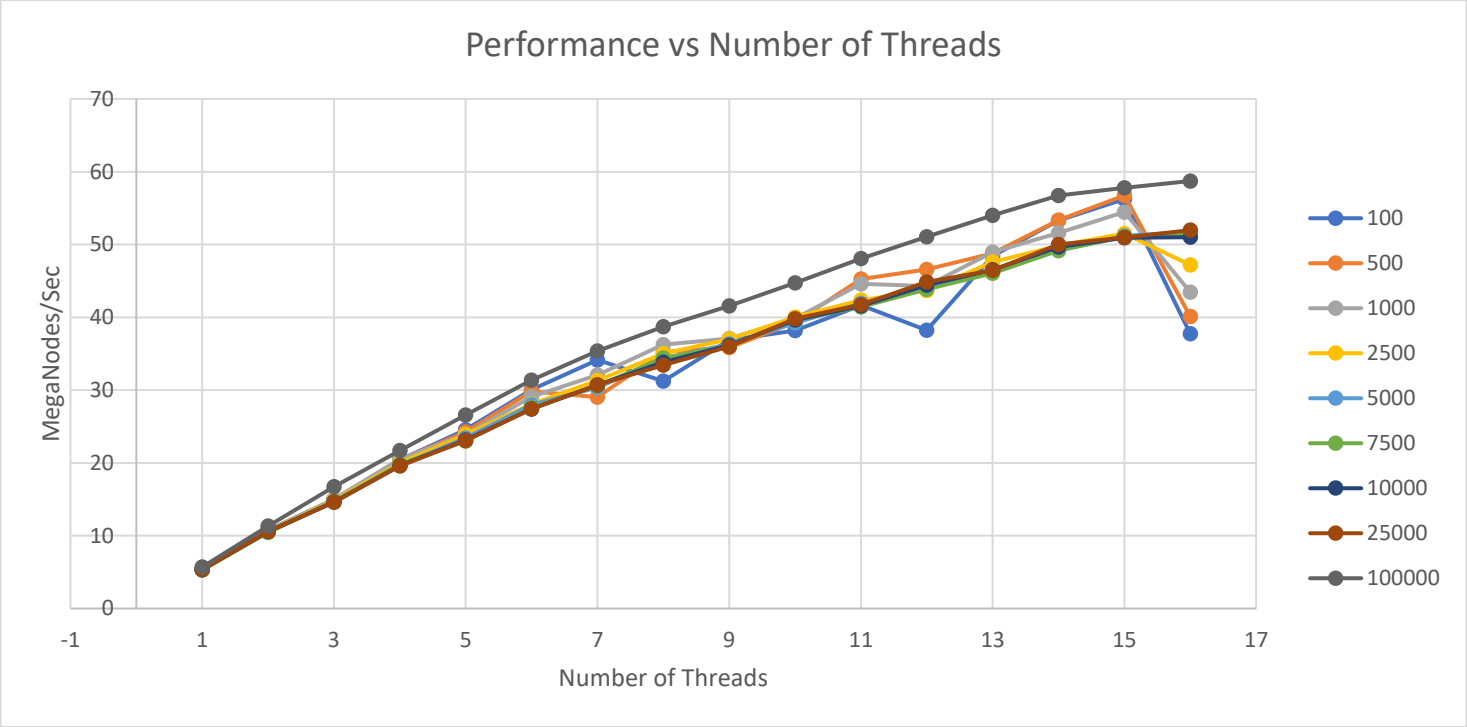
2. What do you think the actual volume is?

   Based off the calculations I would say that the actual volume is about 0.436. The volumes I got were all around 0.435xxx with the exception of 100,000 nodes; likely due to ULPs.

3. Show the performances you achieved in tables and two graphs showing:
   a. Performance as a function of NUMNODES with colored lines showing different NUMT values.



b. Performance as a function of NUMT with colored lines showing different NUMNODES values.

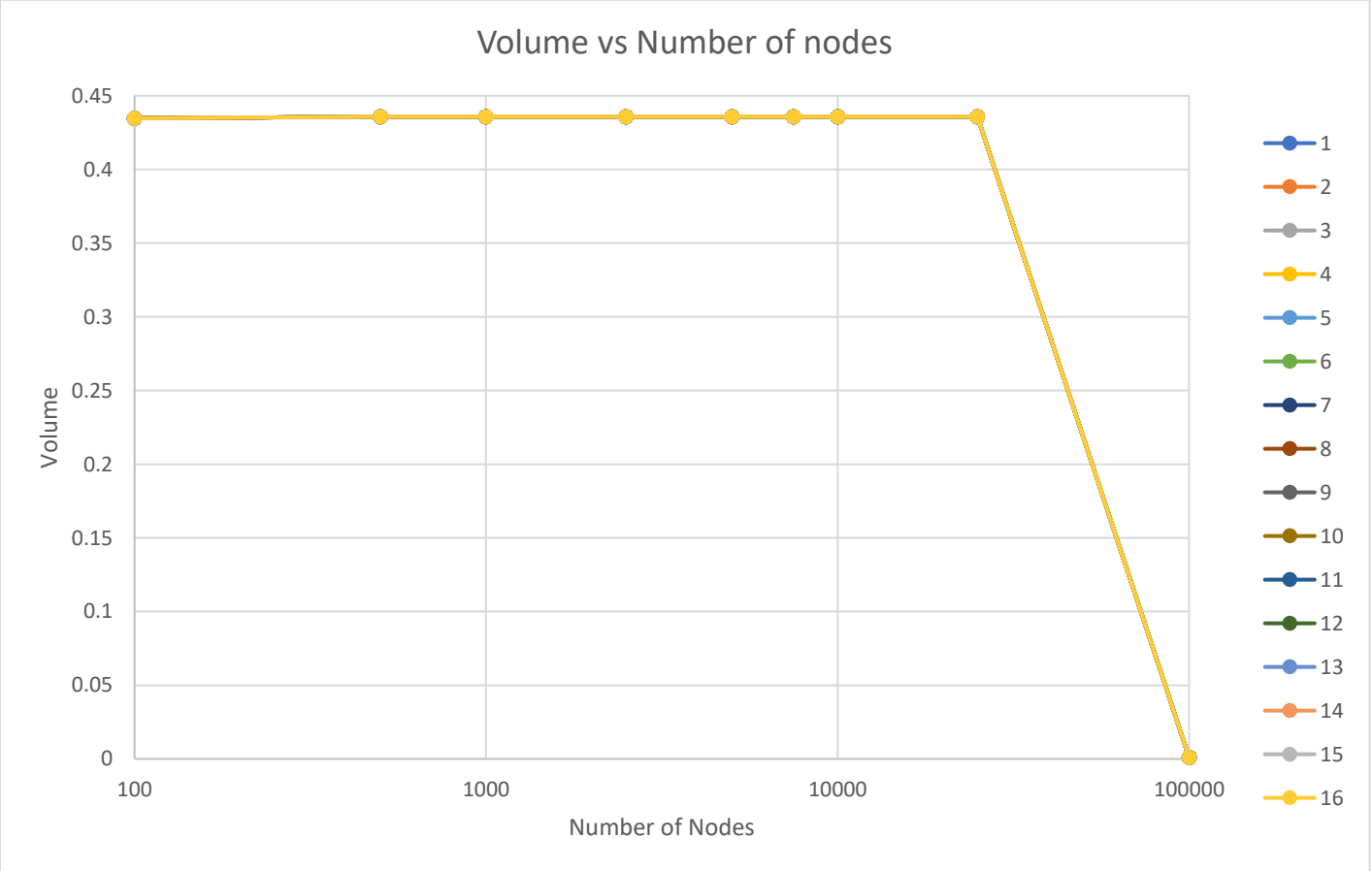


Performance (MegaNodes/Sec) as Threads vs # nodes

	100	500	1000	2500	5000	7500	10000	25000	100000
1	5.438034	5.394279	5.403244	5.371156	5.305436	5.306353	5.347644	5.333066	5.698177
2	10.73192	10.68911	10.72431	10.56292	10.54962	10.45275	10.56879	10.56319	11.31031
3	14.97006	14.97975	15.01269	14.88039	14.75201	14.65993	14.60499	14.60044	16.75017
4	20.43736	20.43168	20.50037	19.99499	19.6761	19.82783	19.63161	19.6035	21.70812
5	24.57606	24.25654	23.91166	23.91219	23.4092	23.00971	23.13649	23.07017	26.5736
6	30.04808	29.82795	29.09946	28.07441	27.99735	27.57296	27.43363	27.41089	31.38373
7	34.15301	29.03702	32.06218	31.3221	30.34842	30.56793	30.72748	30.70173	35.36149
8	31.25	35.23211	36.26684	35.02988	34.32733	34.40307	33.82459	33.42844	38.71822
9	36.87316	35.84898	37.06436	37.00723	36.31963	36.11192	36.16385	35.98676	41.55093
10	38.1971	39.32487	39.86128	40.01721	39.2243	39.64813	39.61789	39.79267	44.73378
11	41.64931	45.23986	44.59985	42.33743	41.89708	41.44701	41.56397	41.73904	48.0719
12	38.24092	46.59745	44.29169	43.69554	44.16395	43.83052	44.42908	44.84232	51.07685
13	48.42615	48.77287	48.95266	47.59011	46.30871	46.02718	46.55138	46.42656	53.9944
14	53.3049	53.35382	51.58096	49.81429	49.16336	49.17934	49.64478	49.99028	56.71394
15	56.24297	56.73437	54.46564	51.51207	51.20081	51.07115	50.90562	50.95568	57.78553
16	37.72162	40.13614	43.46711	47.19485	51.72625	51.3822	51.0061	51.96852	58.72207

Volume as Threads vs # nodes

	100	500	1000	2500	5000	7500	10000	25000	100000
1	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
2	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
3	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
4	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
5	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
6	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
7	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
8	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
9	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
10	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
11	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
12	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
13	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
14	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
15	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004
16	0.434729	0.435714	0.435761	0.435778	0.435781	0.435782	0.435782	0.435782	0.001004



4. What patterns are you seeing in the speeds?

   One of the patterns that I see is that the number of nodes does not seem to affect the performance all that much. The only time the number of nodes affects the performance is when the core to node ratio is high. This pattern can also be seen in the performance vs number of threads graph as in the higher thread count, the low node count significantly reduces performance.

   There is also a decrease in speedup gained from adding more threads that seems to take place around 7 threads.

5. Why do you think it is behaving this way?

   The first pattern, static performance while increasing nodes, that was noticed would be due to the CPU's clock speed limits. This is excluding the higher thread count where overhead would be an issue, which is another pattern. The larger thread count having poor performance on low node count would be due to the overhead in setting up more threads. The CPU is fast enough to do all of the calculations on the lower number of nodes in a short amount of time so setting up more cores and having only one thread able to write to volume at a time is shown to significantly reduce performance on low node counts.

   The decrease in speedup from adding more threads could be due to the threads all writing to the same buffer. This would cause more threads to be waiting than calculating, where the sequential portion of the code starts causing noticeable speedup decrease. I would assume this would be less of an issue if there were more calculations or instructions in between writing time so that there is a lower chance of threads trying to write at the same time. Another issue that could cause some slowdown with higher cores is that my CPU was hitting a power limit. The higher node counts would make the threads that were being used to go to 100% utilization and eventually it will thermal throttle. This causes some issues since the CPU will be running slower once it thermal throttles, giving inaccurate data for the higher thread counts after the CPU decides to thermal throttle.

6. What is the Parallel Fraction for this application, using the Inverse Amdahl equation?

   I am calculating using 100,000 nodes and a speed up from 1 to 16 cores. I am using 100,000 nodes because the data contains the least amount of "noise" (overhead, ect. Will be less of an issue).

   $S = \frac{58.722\ Mn/S}{5.698\ Mn/S} = 10.3057$

   $F_p = \frac{16}{15}\left(1 - \frac{1}{10.3057}\right)$

   $F_p = 0.963164 \approx 96.3\%$

7. Given that Parallel Fraction, what is the maximum speed-up you could *ever* get?

   Max Speedup = $\frac{1}{1-0.963} \approx 27.15$