CS 575 -- Spring Quarter 2023

Project #2

Simple OpenMP Experiment

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April 15 2023

*The running machine is flip.

1. The correct probability is approximately 26.85% since the probability will converge at 1000000 trials.

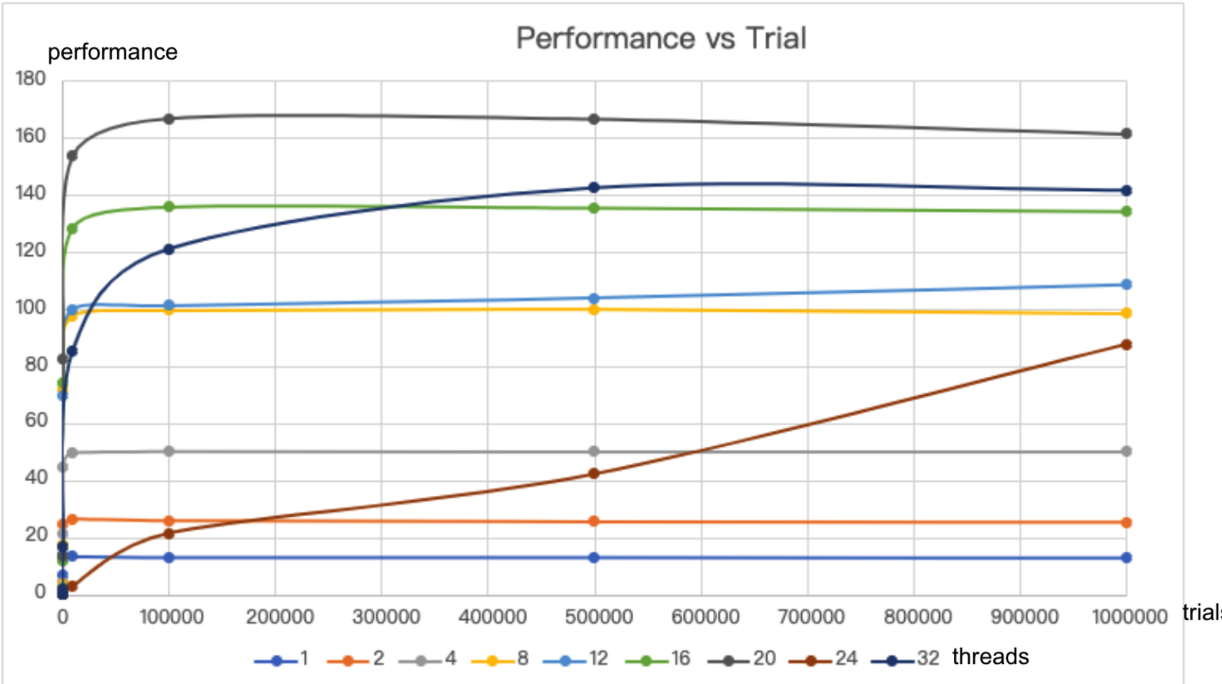
Thread	Trial	probability	Mega/Sec	Thread	Trial	probability	Mega/Sec	Thread	Trial	probability	Mega/Sec
1	1	0	1.25	8	1	0	0.33	20	1	100	0.23
1	10	50	6.85	8	10	20	3.34	20	10	30	1.85
1	100	29	12.4	8	100	21	17.11	20	100	28	13.49
1	1000	28	13.22	8	1000	25.4	72.04	20	1000	23.4	82.43
1	10000	26.66	13.19	8	10000	26.75	97.67	20	10000	26.99	153.54
1	100000	26.92	12.83	8	100000	26.77	99.51	20	100000	26.81	166.76
1	500000	26.83	12.79	8	500000	26.81	99.87	20	500000	26.85	166.54
1	1000000	26.85	12.76	8	1000000	26.82	98.41	20	1000000	26.8	161.34
2	1	0	0.54	12	1	0	0.28	24	1	100	0
2	10	10	4.06	12	10	30	2.39	24	10	30	0
2	100	22	16.57	12	100	35	13.78	24	100	31	0.06
2	1000	25.5	24.42	12	1000	26.9	69.79	24	1000	26.3	0.3
2	10000	26.35	26.33	12	10000	26.56	99.98	24	10000	26.69	2.95
2	100000	26.97	25.8	12	100000	26.67	101.16	24	100000	27.1	21.42
2	500000	26.88	25.42	12	500000	26.8	103.9	24	500000	26.86	42.16
2	1000000	26.86	25.22	12	1000000	26.82	108.53	24	1000000	26.88	87.59
4	1	0	0.48	16	1	0	0.16	32	1	0	0.02
4	10	20	4.11	16	10	0	1.62	32	10	60	0.2
4	100	26	20.98	16	100	25	12	32	100	31	1.77
4	1000	28	44.34	16	1000	27.6	74.22	32	1000	28.8	16.77
4	10000	27.35	49.48	16	10000	26.79	128.43	32	10000	26.98	85.48
4	100000	26.99	49.99	16	100000	26.77	135.74	32	100000	26.7	121.04
4	500000	26.84	49.93	16	500000	26.88	135.37	32	500000	26.88	142.55
4	1000000	26.9	49.95	16	1000000	26.86	134.13	32	1000000	26.81	141.63

2. The Threads and Trials pivot table

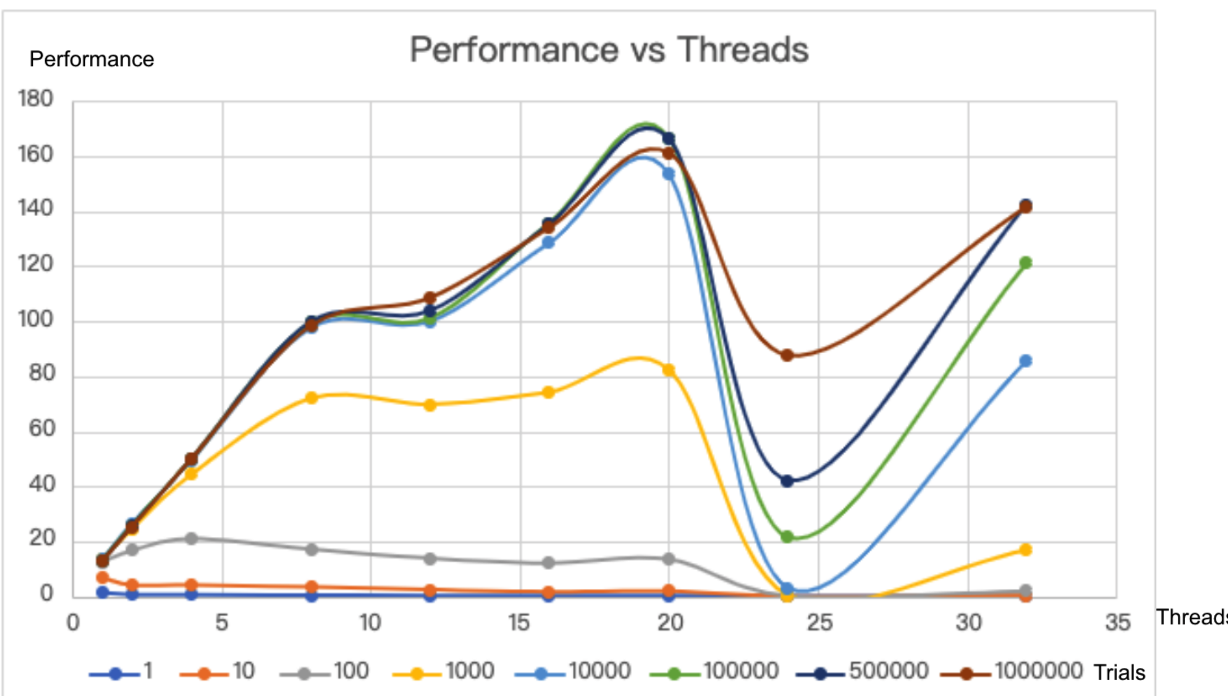
Thread\Trials	1	10	100	1000	10000	100000	500000	1000000
1	1.25	6.85	12.4	13.22	13.19	12.83	12.79	12.76
2	0.54	4.06	16.57	24.42	26.33	25.8	25.42	25.22
4	0.48	4.11	20.98	44.34	49.48	49.99	49.93	49.95
8	0.33	3.34	17.11	72.04	97.67	99.51	99.87	98.41
12	0.28	2.39	13.78	69.79	99.98	101.16	103.9	108.53
16	0.16	1.62	12	74.22	128.43	135.74	135.37	134.13
20	0.23	1.85	13.49	82.43	153.54	166.76	166.54	161.34
24	0	0	0.06	0.3	2.95	21.42	42.16	87.59
32	0.02	0.2	1.77	16.77	85.48	121.04	142.55	141.63

3. The charts

Performance vs Trial



Performance vs Threads



4. The parallel fraction

Thread 1 performance is 12.76.

- Parallel Fraction with 2 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_2}{P_1} = 25.22/12.76 = 1.976$$

  $$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{2}{1})(1 - \frac{1}{1.976}) = 0.988$$

- Parallel Fraction with 4 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_4}{P_1} = 49.95/12.76 = 3.914$$

  $$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{4}{3})(1 - \frac{1}{3.914}) = 0.993$$

- Parallel Fraction with 8 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_8}{P_1} = 98..41/12.76 = 7.712$$

  $$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{8}{7})(1 - \frac{1}{7.712}) = 0.995$$

- Parallel Fraction with 12 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_{12}}{P_1} = 108.53/12.76 = 8.505$$

  $$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{12}{11})(1 - \frac{1}{8.505}) = 0.962$$

- Parallel Fraction with 16 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_{16}}{P_1} = 134.13/12.76 = 10.511$$

  $$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{16}{15})(1 - \frac{1}{10.511}) = 0.965$$

- Parallel Fraction with 20 threads and 1000000 trials

  $$Speedup = \frac{T_1}{T_n} = \frac{P_{20}}{P_1} = 161.34/12.76 = 12.644$$

$$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{20}{19})(1 - \frac{1}{12.644}) = 0.969$$

- Parallel Fraction with 24 threads and 1000000 trials

$$Speedup = \frac{T_1}{T_n} = \frac{P_{24}}{P_1} = 87.59/12.76 = 6.864$$

$$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{24}{23})(1 - \frac{1}{6.864}) = 0.891$$

- Parallel Fraction with 32 threads and 1000000 trials

$$Speedup = \frac{T_1}{T_n} = \frac{P_{32}}{P_1} = 141.63/12.76 = 11.099$$

$$F_p = (\frac{n}{n-1})(1 - \frac{1}{Speedup}) = (\frac{32}{31})(1 - \frac{1}{11.099}) = 0.939$$

5. Commentary of the graph

In the Performance vs Trial graph, we can see that when the number of trials increases to over 100,000, the performance stabilizes at a certain value. These results fit Amdahl's Law. As the number of threads increases, the performance also increases. However, something different happens when the number of threads exceeds 20. This is probably due to only 12 hardware cpus on flip. The performance may drop during increasing threads number over 12.

In the Performance vs Threads graph, the peak performance was achieved with 20 threads. The performance was the greatest at this point. When we increased the number of threads to 24, the performance dropped. However, when we increased the number of threads to 32, the performance rose again. When the thread numbers exceed the hardware cpu numbers, the operating system will have to switch between threads, leading to increased overhead and potentially slowing down the program. The synchronization will be affected by shared memory as well when the threads number increases.