Cpt S 411 Assignment Cover Sheet

(To be turned in along with each homework and program project submission)

Assignment # 4

For individual assignments:

Student name (Last, First): Barik, Reet

For team projects:

List of all students (Last, First): Barik, Reet

List of collaborative personnel (excluding team participants):

I[1] certify that I have listed above all the sources that I consulted regarding this assignment, and that I have not received or given any assistance that is contrary to the letter or the spirit of the collaboration guidelines for this assignment. I also certify that I have not referred to online solutions that may be available on the web or sought the help of other students outside the class, in preparing my solution. I attest that the solution is my own and if evidence is found to the contrary, I understand that I will be subject to the academic dishonesty policy as outlined in the course syllabus.

Please print your names.

Assignment Project Participant(s): Barik, Reet

Today's Date: 14 November2020

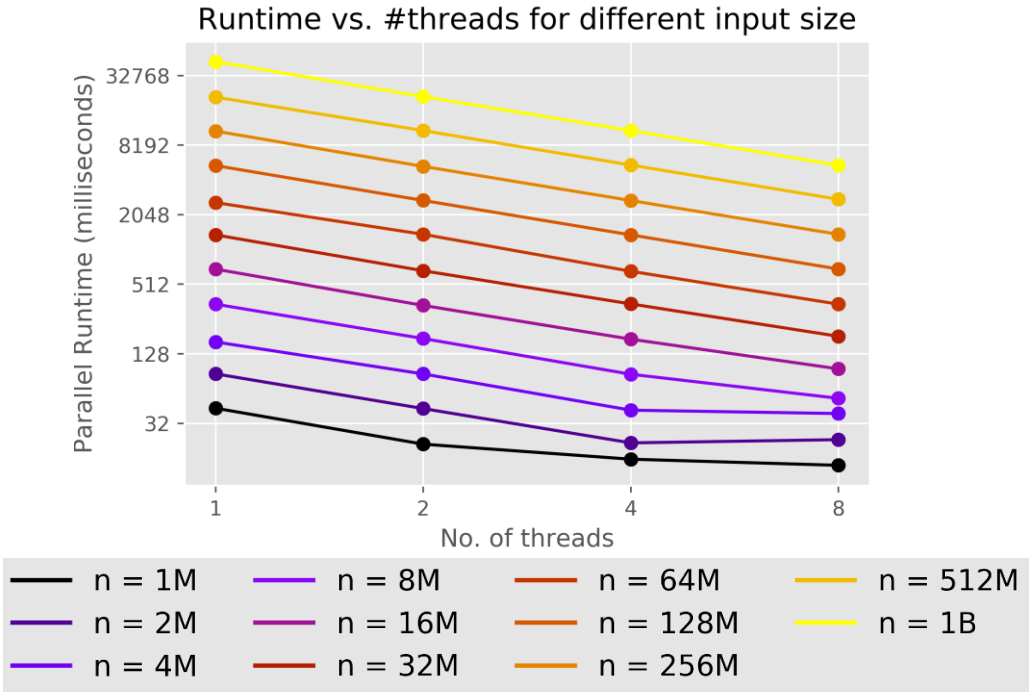
[1] If you worked as a team, then the word "I" includes yourself and your team members.

The following are the results:

1. Parallel runtime (in milliseconds)

Runtime (milliseconds)		p (#threads)			
		1	2	4	8
n (#darts)	1024	0.048655	0.113792	0.209289	5.216908
	2048	0.104942	0.141611	0.178337	6.592155
	4096	0.169088	0.203526	0.231241	6.693864
	8192	0.330263	0.277592	0.252343	6.851249
	16384	0.649469	0.443318	0.360426	6.610216
	32768	1.342312	0.795218	0.514275	5.292169
	65536	2.531864	1.446858	0.863167	5.839517
	131072	5.305713	2.667849	1.542709	6.316441
	262144	10.46994	5.434712	2.811204	7.819056
	524288	21.25847	10.69768	5.543952	10.02396
	1048576	43.2912	21.15394	15.6765	13.87357
	2097152	85.85916	42.97859	21.69611	23.14167
	4194304	162.0663	85.72666	41.62797	38.92202
	8388608	343.8892	173.5045	85.17043	52.73201
	16777216	691.84	335.7089	171.2879	94.79538
	33554432	1368.873	669.7561	345.855	181.4409
	67108864	2604.791	1384.575	662.8835	344.2196
	134217728	5446.499	2718.324	1368.711	693.0634
	268435456	10824.88	5358.83	2714.217	1383.697
	536870912	21291.42	10936.97	5503.293	2782.43
	1073741824	43130.95	21514.52	10910.38	5469.153

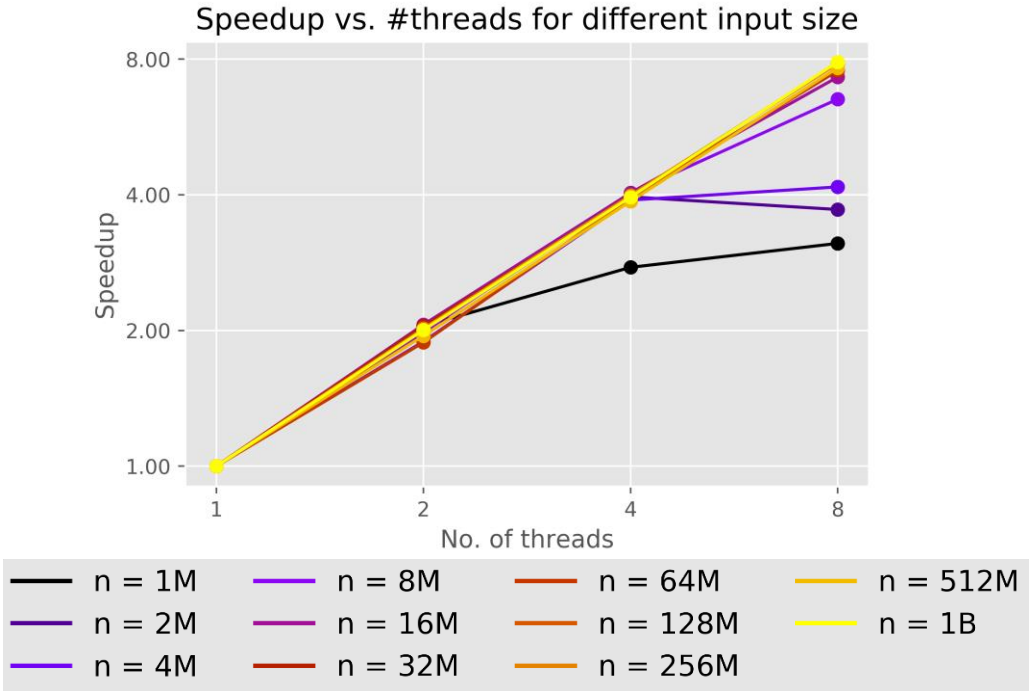
Only the results for n ≥ 1M is shown in the plot below:



2. Speedup

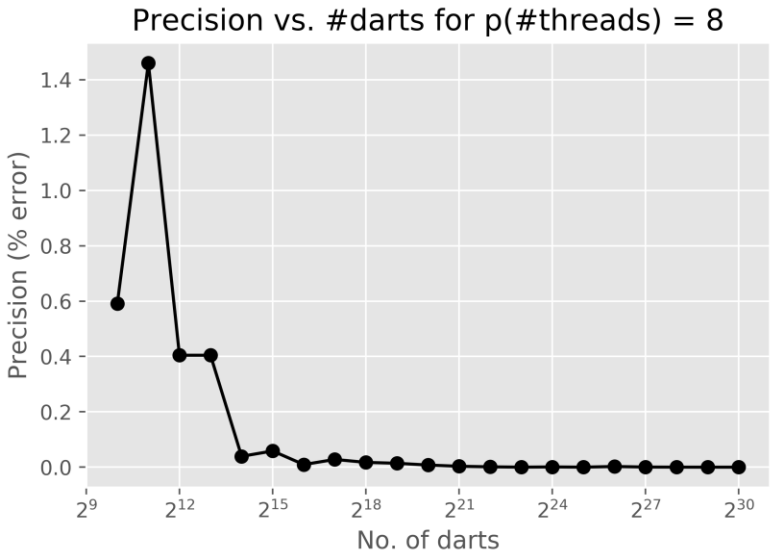
Speedup		p (#threads)			
		1	2	4	8
n (#darts)	1024	1	0.427578	0.232478	0.009326
	2048	1	0.741058	0.588448	0.015919
	4096	1	0.830793	0.73122	0.02526
	8192	1	1.189742	1.308786	0.048205
	16384	1	1.465018	1.801948	0.098252
	32768	1	1.68798	2.610105	0.253641
	65536	1	1.749905	2.933226	0.433574
	131072	1	1.988761	3.439218	0.839985
	262144	1	1.926494	3.724362	1.339029
	524288	1	1.987203	3.834533	2.120765
	1048576	1	2.046484	2.761535	3.120408
	2097152	1	1.997719	3.957353	3.710154
	4194304	1	1.890501	3.893208	4.163872
	8388608	1	1.982019	4.03766	6.52145
	16777216	1	2.060833	4.039048	7.298246
	33554432	1	2.043838	3.957939	7.544456
	67108864	1	1.881293	3.929485	7.567236
	134217728	1	2.003624	3.979291	7.858588
	268435456	1	2.020009	3.988215	7.823162
	536870912	1	1.946738	3.868851	7.652094
	1073741824	1	2.004737	3.953202	7.88622

Only the results for n ≥ 1M is shown in the plot below:



3. Precision (obtained by keeping p = 8 and increasing n)

Precision			
n (#darts)	Estimated Pi	Runtime (ms)	Precision (% error)
1024	3.16015625000000000000	5.216908	0.590898
2048	3.09570312500000000000	6.592155	1.460709
4096	3.15429687500000000000	6.693864	0.404388
8192	3.15429687500000000000	6.851249	0.404388
16384	3.14282226562500000000	6.610216	0.03914
32768	3.14343261718750000000	5.292169	0.058568
65536	3.14129638671875000000	5.839517	0.00943
131072	3.14071655273437500000	6.316441	0.027887
262144	3.14213562011718750000	7.819056	0.017283
524288	3.14115142822265625000	10.023963	0.014045
1048576	3.14135360717773437500	13.873571	0.007609
2097152	3.14148902893066406250	23.14167	0.003298
4194304	3.14155387878417968750	38.922021	0.001234
8388608	3.14158964157104492188	52.732014	0.000096
16777216	3.14156413078308105469	94.795384	0.000908
33554432	3.14159476757049560547	181.440915	0.000067
67108864	3.14166873693466186523	344.219589	0.002422
134217728	3.14157760143280029297	693.063367	0.000479
268435456	3.14158788323402404785	1383.696541	0.000152
536870912	3.14159233868122100830	2782.430253	0.00001
1073741824	3.14159403368830680847	5469.153019	0.000044



As we can see, ignoring the smaller values of 'n' ($\leq 2^{12}$), there is a general decrease in the percentage error in estimating the value of Pi. The ground truth value of Pi used (accurate up to 20 decimal places) is as follows: 3.14159265358979323846.

Observations:

1. Significant decrease in runtime and consequent increase in Speedup is observed for $n \geq 1M$. Mixed results for smaller values of n shows that parallelization is an overkill for those cases and might result in net slowdown.
2. The decrease in runtime and increase in speedup becomes more and more linear as one increases n. For example, for $1M \leq n \leq 8M$, the speedup is clearly sub-linear whereas it is very close to linear for $n = 1B$.
3. As is expected, we observe a general trend of the percentage error in estimating Pi decreasing as one increases the number of darts thrown (ignoring the smaller values where $n \leq 2^{12}$).