Parallel Programming Exercise 4 - 12

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(If you and your team member contribute equally, you can use (co-first author), after each name.)

1 Problem and Proposed Approach

Problem

Calculate π.

Approach

Parallelly compute the different interval in Simpson's Rule.

2 Theoretical Analysis Model

We require all the processors to build a small interval, but all elements are independent. Thus, it will cost $\chi\ n/p$ per processor. After that, we just need to get the sum of the answer in each processor, we need to spend $\lambda \lceil log\ p \rceil$ on reduction.

Hence, the expected execution time of the parallel algorithm is approximately:

$$\chi\ n/p + \lambda \lceil log\ p \rceil \tag{1}$$

The time complexity:

$$O(n/p + log\ p) \tag{2}$$

We can further formalize the speedup related to processors by the isoefficiency relation:

$$\begin{cases} \sigma(n) = 0 \\ \phi(n) = \chi\ n \\ \kappa(n,p) = \lambda \lceil log\ p \rceil \\ \psi(n,p) \leq \frac{\sigma(n)+\phi(n)}{\sigma(n)+\phi(n)/p+\kappa(n,p)} \end{cases} \tag{3}$$

3 Performance Benchmark

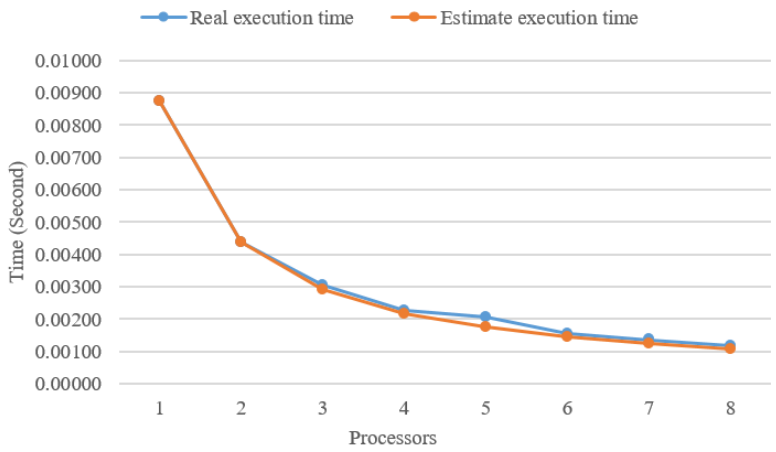
Use Equation 1 and the real execution time of one processor to get the value of χ. λ is approximately equal to 10^{-6} second. Then, use the same equation again to get all the estimation execution time.

I wrote a script to automatically submit the jobs with $p = [1, 8]$. For each job, I ran the main program for 20 times, and eliminate the smallest / largest 5 record. The value in the table is the average of the rest ten records.

Table 1: The execution time (in second)

Processors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Real execution time	0.00874	0.00440	0.00306	0.00227	0.00208	0.00157	0.00137	0.00118
Estimate execution time	0.00874	0.00437	0.00291	0.00218	0.00175	0.00146	0.00125	0.00109
Speedup	1.00000	1.98683	2.85102	3.85107	4.20810	5.56723	6.38510	7.41678
Karp-flatt metrics		0.00663	0.02613	0.01289	0.04705	0.01555	0.01605	0.01123

Figure 1: The performance of diagram.



4 Conclusion and Discussion

4.1 What is the speedup respect to the number of processors used?

The speedup is less than p since there exist some overhead while doing parallel programming.

4.2 How can you improve your program furthermore?

Consider some cache effects. Maybe we can use an array to increase the precision. (n is too small here, so the precision problem is not significant)

4.3 How do the communication and cache affect the performance of your program?

In this problem, the only part that requires communication is a reduction in an integer, so it does not affect our outcome too much.

4.4 How do the Karp-Flatt metrics and Iso-efficiency metrics reveal?

The Karp-Flatt metrics values fluctuate because the experiment uncertainty could lead to some small numeric error. The value is small because the sequential part is pretty small.