HPC Spring 2017 – Homework 2

Robert van Engelen

Due date: February 14, 2017

1. Consider a sequential algorithm A_s and parallel version A_P. The sequential time of A_s is $t_s = 18$ seconds and the total parallel execution time t_P of A_P for $P = 1, \ldots, 6$ was measured in seconds as follows:

$P =$	1	2	3	4	5	6
$t_P =$	24.00	13.50	10.00	8.25	7.20	6.50
$S_P =$						
$E_P =$						

   Determine the speedup S_P and efficiency E_P of the parallel algorithm compared to the sequential algorithm.

2. Consider a parallel algorithm A_P. The parallel execution time of the algorithm was measured in seconds for $P = 1, \ldots, 6$ as follows:

$P =$	1	2	3	4	5	6
$t_P =$	20.0	11.0	8.0	6.5	5.6	5.0
$S_P^1 =$						
$\alpha_P =$	n/a					

   For this example we determine the relative speedup S_P^1. With the relative speedup, determine α_P from Gustafson's law:

$$S_P^1 = P + (1 - P)\alpha$$

   Recall that α_P ($\alpha_P + \beta_P = 1$) measures the sequential part, but here we ignored the effect of the data size on execution time.

3. Assuming that the parallel algorithm of question #2 perfectly follows Amdahl's law

$$t_P = f\, t_s + (1-f)t_s/P$$

with fixed sequential part t_s, the Karp-Flatt metric determines f by rewriting Amdahl's law:

$$f = \frac{\frac{1}{S_P^1} - \frac{1}{P}}{1 - \frac{1}{P}}$$

Compute f and t_s for the algorithm of question #2.

4. The idealized formula for energy consumption by a processor core is

$$E = c\, t\, f\, V^2$$

where c is a CPU-dependent capacitance constant c, t is the total execution time of a task, f is the processor's clock frequency, and V is the supply voltage. If the voltage V is constant while f changes, then the energy is constant for the task since $t\, f$ is constant. Suppose the frequency and voltage are correlated

$$f = \alpha\, V$$

then $E \propto V^2$. Suppose our algorithm must complete in $t = 10$ seconds and needs a total of 10^{10} clock cycles to execute. What is the CPU energy consumption E for one task that completes in $t = 10$ seconds? What is the energy saving ratio E/E_2 when we run this perfectly parallelizable algorithm in two tasks on two CPU cores in parallel together consuming E_2 energy, assuming each task takes $t = 10$ seconds to complete?