

CS586: Distributed Computing

TA: Eleftherios Kosmas

Tutorial 1

Exercise 1

1. Suppose a computer program has a method M that cannot be parallelized, and this method accounts for 40% of the programs execution time. What is the limit for the overall speedup that can be achieved by running the program on an n-processor multiprocessor machine?
2. You have a choice between buying one uni-processor that executes $5 \cdot 10^{15}$ instructions per second, or a ten-processor multiprocessor where each processor executes 10^{15} instructions per second. Using Amdahls Law, explain how you would decide which to buy for a particular application.

Solution:

1. We use Amdahl's law (where $1 - P = 0.4$ and $P = 0.6$) to find the maximum speedup when n goes to infinity, as follows:

$$S = \frac{1}{1 - P + \frac{P}{N}} = \frac{1}{0.4 + \frac{0.6}{N}} \Rightarrow \lim_{n \rightarrow \infty} S = \frac{1}{0.4} = 2.5$$

2. Let f be the frequency of a single processor of the ten-processor machine, i.e., f is the number of instruction executed by this processor per second. We know that $f = 10^{15}$. Given that we have 10 processors of frequency f , the maximum number of instructions per second executed by them are:

$f' = S \cdot f$, where S is the speedup of the ten-processor machine for an arbitrary application, over a one-processor machine with frequency f .

By Amdahl's law, $S = \frac{1}{1 - P + \frac{P}{N}}$, where $N = 10$ and P is the portion of the application that can be parallelized.

$$\text{So, } f' = S \cdot f = \frac{1}{1 - P + \frac{P}{10}} \cdot 10^{15}.$$

We will choose to use the ten-processor machine if $f' > 5 \cdot 10^{15}$, i.e., if the application runs faster in the ten-processor machine.

$$f' > 5 \cdot 10^{15} \Leftrightarrow \frac{1}{1 - P + \frac{P}{10}} \cdot 10^{15} > 5 \cdot 10^{15} \Leftrightarrow 1 > 5 \cdot \left(1 - P + \frac{P}{10}\right) \Leftrightarrow 0.2 > 1 - \frac{9P}{10} \Leftrightarrow \frac{9P}{10} > 0.8 \Leftrightarrow$$

$$P > \frac{8}{9} \Leftrightarrow P > 88.88\%$$

Thus, only if we have an application that can be parallelized by at least 88.88%, we should use the ten processor machine.