TP - Introduction to Parallel Computing

ING2 – GSI/MI – Architecture et Programmation Parallèle

Academic year 2023–2024

Performance metrics

1 When executing a given program, computer A runs 100 MIPS against 5 MIPS for computer B. On the other hand, computer A takes 60 seconds to run the program, while computer B requires 45. How is this possible? □

2 A program running on a given system requires 1000,000 cycles. If the system has an CPI of 40, how many instructions have been executed to run the program? □

3 What is the IPC of a program that runs 35000 instructions and requires 17000 cycles? □

4 A program contains 200 000 instructions of which 40% are floating operations (having an CPI of 10), and the remainder are other instructions (having an CPI of 2). What will be the execution time of the program knowing that the cycle time is 10^{-6} seconds? □

Amdahl's Law

5 Consider a computer which spends 90% of its time to manage a particular type of calculation when it runs a given program. Its manufacturer makes a change that improves its performance on that type of calculation by multiplying it by 10.

a) If the program initially took 100 seconds to complete, how long will it take after the change?

b) What is the acceleration from the old to the new system?

c) What fraction of its execution time does the new system take to perform the type of calculation that has been improved?

□

6 Which improvement reduces the execution time the most: an improvement that it is used 20% of the time which multiplies the performance by two when it is used, or an improvement used 70% of the time which multiplies the performance by 1.3 when it is used? □

7 A computer architect designs the memory system for a processor's next generation. If in its current version, the processor spends 40% of its time processing memory references, how much does the architect have to accelerate the memory system to propose a general acceleration of 1.2? What would it be for a general acceleration of 1.6? □

Purchase of laboratory machines

Your lab has just bought new machines with 4 cores and you are asked to optimize your software that, for now, is only sequential. Two applications must run on these machines at the same time, but their resource requirements are different. The first application requires 60% of the resources and the second one 40%.

8 Assuming that the first application is parallelisable to 80%, what gain would you get if this application was run alone on the system? □

9 Assuming that the second application is parallelisable to 90%, what gain would you get if this application was run on the system alone? □

10 Assuming always that the first application is parallelizable to 80%, what global gain of the system would you get if this application was parallelized, but not the second application (running both at the same time)? □

11 What overall gain would you get if both applications were parallelized and executed at the same time (still with a parallelization of 80% for the first one and 90% for the second one)? What would be the efficiency? □

12 Repeat the calculations of the 4 previous exercises, this time considering a system with 12 cores and then with 24 cores. What do you conclude about the increase in the number of cores? □

13 A machine with 4 cores costs 1000 EUR, a machine with 12 cores costs 2500 EUR and a machine with 24 cores costs 6000 EUR. Considering these prices and the previous speedups obtained, what would you advise the purchasing manager? □

Choose the number of processors

14 You have a program that takes 1000 units of time to execute. After some analysis, you consider that 70% of its code is parallelisable. Considering the Amdahl's law, what is the maximum speedup possible? □

15 Each time a core is added, the system loses some time for additional thread management. You estimate this loss at 5 units of time per core. Draw a curve representing the evolution of execution time as a function of the number of cores (use powers of 4 for the cores). What is the optimal value of the number of cores to use? □

16 On the same graph, add the curve corresponding to the sequential code. From how many cores will the parallel application become slower than the sequential version? □

Gustafson's law

17 Consider a computer program that processes files from disk. A part of that program may scan the directory of the disk and create a list of files internally in memory. After that, another part of the program passes each file to a separate thread for processing. The part that scans the directory and creates the file list cannot be sped up on a parallel computer, but the part that processes the files can.
Let the total execution time on the parallel system be $T = 1$ second for 10 processors. We decide to assign 4 additional processors to our system. By how much must the workload vary if we want to keep the execution time constant? By how much does the speedup vary? Consider that the part of the program that scans the directory and creates the file list amounts for 5% of the total execution workload. □