Computer Architecture

Fall, 2024

Week 2

2024.09.09

組別：___________ 簽名：____

[group12]

1. Fill the table below. (Put a X by the item that you think doesn't affect the below performance factors)

	Instruction Count	CPI	Clock Rate
Program			
Compiler			
Instruction Set			
Organization			
Technology			

Ans:

	Instruction Count	CPI	Clock Rate
Program			X
Compiler			X

Instruction Set			
Organization	X		
Technology	X	X	

[group1]

2. Consider two different implementations of the same ISA. The instructions can be divided into four classes(A, B, C, D) according to their CPI. Both implementations have the same clock rate. Implementation 1's CPIs of each class is A: 1, B: 2, C: 3, D: 4. Implementation 2's CPIs of each class is A: 2, B: 2, C: 2, D: 2. Given a program whose instructions are divided into classes as follows: 40% of A, 30% of B, 20% of C, 10% of D. Which implementation has better performance?

Ans:

Since both implementations have the same clock rate, better performance means lower instruction count, so we only need to calculate their average CPI.

Implementation 1's average CPI = 1*0.4+2*0.3+3*0.2+4*0.1 = 2

Implementation 2's average CPI = 2*0.4+2*0.3+2*0.2+2*0.1 = 2

So both implementations have the same performance.

[group8]

3. Given computer A, B using the same ISA. Computer A: Cycle time = 400ps, CPI = 1.0. Computer B: Cycle time = 800ps, CPI = 1.3. Which one is faster, and how much faster than the other one? If the computer A and B use different ISA, should we need to compare the CPU Time?

Ans:

$$\underline{CPU\ time_A = CPU\ clock\ cycles_A \times\ Clock\ cycle\ time_A}$$

$$\underline{CPU\ time_A = Instructions\ Count \times CPI_A \times\ Clock\ cycle\ time_A}$$

$$\underline{CPU\ time_A = I \times 1.0 \times\ 400\ ps}$$

$$\underline{CPU\ time_A = I \times 400\ ps}$$

$$\underline{CPU\ time_B = CPU\ clock\ cycles_B \times\ Clock\ cycle\ time_B}$$

$$\underline{CPU\ time_B = Instructions\ Count \times CPI_B \times\ Clock\ cycle\ time_B}$$

$$\underline{CPU\ time_B = I \times 1.3 \times\ 800\ ps}$$

$$\underline{CPU\ time_B = I \times 1040\ ps}$$

To calculate the amount faster:

$$\frac{CPU\ time_B}{CPU\ time_A} = \frac{I \times 1040\ ps}{I \times 400\ ps} = 2.6$$

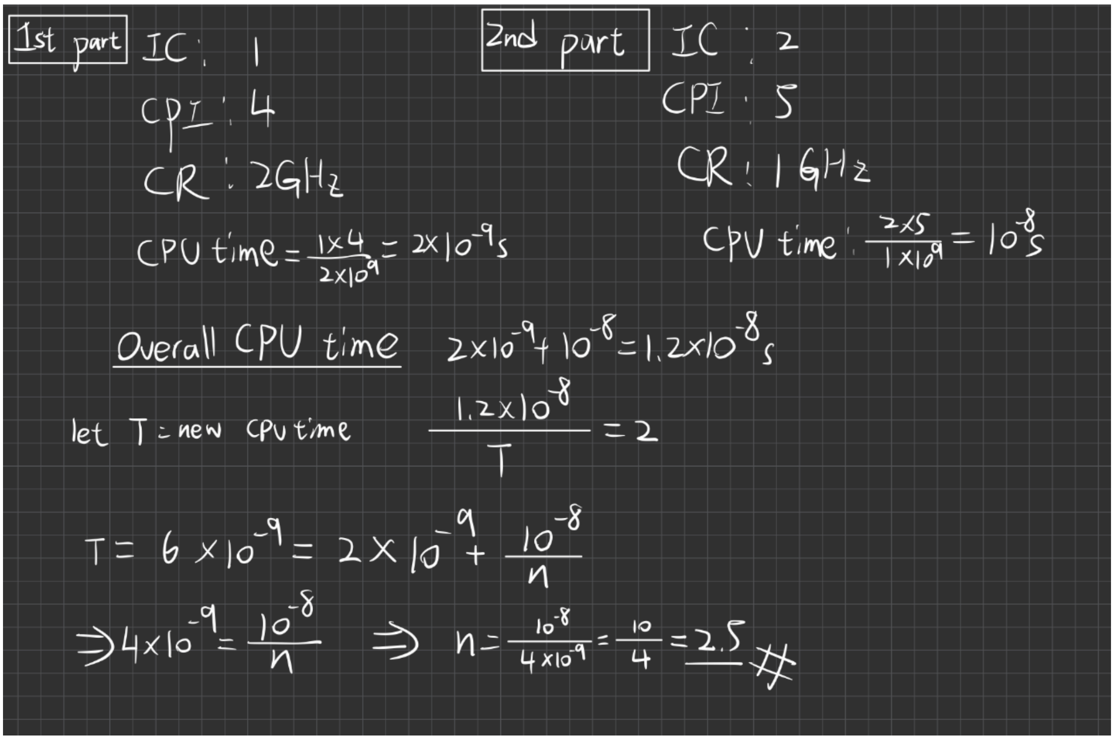
A: A is 2.6 times faster than B

B: Different ISA will take different instruction counts for the same task, so it's inappropriate to compare these two computers by using different ISA.

[group11]

4. A program consists of two different sets of instructions. The instruction count of the first part is 1, with a CPI of 4 and a clock rate of 2 GHz. The instruction count of the second part is 2, with a CPI of 5 and a clock rate of 1 GHz. If you want to optimize the second part so that the overall program efficiency doubles, by how many times does the second part need to be optimized?

Ans:



[group10]

5. Consider two different programs running on the same processor. Program X consists of 30% floating-point instructions (CPI = 4) and 70% integer instructions (CPI = 2). Program Y consists of 60% floating-point instructions and 40% integer instructions. The processor's clock speed is 3 GHz, and each program executes 500 million instructions. Calculate the CPU time for both programs and determine which one is faster, and by how much?

Ans: Program X Average CPI : 0.3*4+0.7*2=2.6
Program Y Average CPI : 0.6*4+0.4*2=3.2
CPU time for Program X : (2.6*500*10^6) / (3*10^9) = 0.43 (sec) … faster
CPU time for Program Y : (3.2*500*10^6) / (3*10^9) = 0.53 (sec)
CPU time_Y/CPU time_X=0.53/0.43=1.23…by this much

[group14]

6. (a) 假設一台處理器有兩個優化方案可供選擇：

- 優化方案 A 可讓 50%的程式碼加速 4 倍
- 優化方案 B 可讓 25%的程式碼加速 10 倍

請問應該選擇哪個方案以達到更高的總體加速效果？

(b) 此處理器在製造時，假設一個 wafer 成本 20 元，可切成 10 個 dies，切一個 wafer costs 10 元，每個 die 可創造 4 元的收入，請問 yield 要多少才不會虧錢？

Ans: (a) A.

S(A) = 1 / ((1-0.5)+(0.5/4)) = 1.6

S(B) = 1 / ((1-0.25)+(0.25/10)) = 1.29.

S(A) > S(B). So the Ans is A.

(b) Yield*10*4=20+10，Yield=¾=75%

[group4]

7. 根據 Amdahl's Law, 假設今天一個改良方式可以影響到四分之三的執行時間，若希望總效能翻倍,請問改良部分至少要優化為幾倍?

Ans: 3

[group9]

8. (a) Explain Amdahl's law and describe how it guides the process of system performance improvement.

   (b) Explain power wall. How else can we improve performance?

Ans: (a) $T_{improved} = \frac{T_{affected}}{improvemen\ t\ factor} + T_{unaffected}$

Amdahl's Law 主要用於效能提升的分析和衡量，定律指出，當你試圖通過提升系統中某些部分的性能來提高整體性能時，實際能達到的效果取決於那部分在整個系統中所占的比例。系統中目標被加速的部分佔比越大，性能提升的潛力就越大，即使你將某部分的性能提升無限倍，但如果無法加速的部分很大，整體性能的提升也非常有限。這個定律指導了系統性能改進的過程，表明應優先優化那些對整體性能影響最大的部分。

(b)

Power Wall 是指隨著處理器性能的提升，功耗和散熱問題成為了主要的瓶頸。電壓降到極限後，隨著 CPU clock 頻率提升，功耗呈現正比增長，這導致了散熱問題變得更加嚴重，進而限制了處理器頻率的進一步提升。簡單提高時鐘頻率已不再是提升性能的有效途徑，因為更高的頻率會帶來更高的功耗和更嚴重的散熱需求。

其他方法有使用多核處理器或用多顆 CPU，通過並行處理提升性能；使用專用硬件如圖形處理器（GPU）提高特定任務的處理效率；記憶體層次結構改進，使用 cache 等方式減少訪問記憶體的次數，提高抓取 data 傳輸效率。