Computer Organization

Chapter 1

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1. (18%) A complier designer is trying to decide between two code sequences for a particular computer. The hardware designers have supplied the following facts:

	CPI for this instruction class		
	A	B	C
CPI	1	2	3

For a particular high-level-language statement, the compiler writer is considering two code sequences that require the following instruction counts:

Code sequence	Instruction counts for instruction class		
	A	B	C
1	2	1	2
2	4	1	1

(a) Which code sequence executes the most instructions?
(b) Which will be faster?
(c) What is the CPI for each sequence?

Ans:

(a) 2+1+2=5, 4+1+1=6
Code sequence 2 executes the most instructions.

(b) 2*1+1*2+2*3=10, 4*1+1*2+1*3=9
Code sequence 2 is faster.

(c) CPI for sequence 1 = 10/5=2
CPI for sequence 2 = 9/6=1.5

2. (24%) Consider two different implementations of the same instruction set architecture. There are four classes of instructions, A, B, C, and D. The clock rate and CPI of each implementation are given in the following table.

	Clock rate	CPI Class A	CPI Class B	CPI Class C	CPI Class D
P1	2 GHz	2	1	3	4
P2	2.5 GHz	1	2	1	1

(a) Given a program with 10^6 instructions divided into classes as follows: 20% class A, 10% class B, 40% class C and 30% class D, which implementation is faster?
(b) What is the global CPI for each implementation?
(c) Find the clock cycles required in both cases.

The following table shows the number of instructions for a grogram.

Arith	Store	Load	Branch	Total
300	50	150	100	600

(d) Assuming that arith instructions take 1 cycle, load and store 5 cycles and branch 3 cycles, what is the execution time of the program in a 2 GHz processor?
(e) Find the CPI for the program.
(f) If the number of load instructions can be reduced by one-half, what is the speed-up and the CPI?

Ans:

(a)

P2;

Total time P1=10^6 *(0.2*2+0.1*1+0.4*3+0.3*4) /(2*10^9)=14.5* 10^{-4};

Total time P2=10^6 *(0.2*1+0.1*2+0.4*1+0.3*1) /(2.5*10^9)=4.4 * 10^{-4}

(b)

CPI (P1)=2.9;

CPI (P2)=1.1;

(c) clock cycles (P1)=2.9 x 10^6; clock cycles (P2)= 1.1x10^6

(d) 800 ns

(e) CPI=2.67 0.5+0.42+1.25+0.5=2.67

(f) Time=612.5 ns; Speed-up=1.31; CPI=2.33

3. (8%) The performance of a 100MHz microprocessor P is measured by executing 10^7 instructions of Benchmark code, which is found to take 0.25s. What are the values of CPI and MIPS for this performance experiment?

Ans:

CPI = (100*10^6 *0.25)/ 10^7 = 2.5

MIPS =10^7 / (0.25*10^6) = 40

4. (10%) You are going to enhance a computer, and there are two possible improvements: either make multiply instructions run four times faster than before, or make memory access instructions tun two times faster than before. You repeatedly run a program that takes 100 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks.

Calculate the speedup:

(a) Speedup if we improve only multiplication

(b) Speedup if we only improve memory access

(c) Speedup if both improvements are made

Ans:

(a) speedup = 1/(0.2/4 + 0.8) = 1.18

(b) speedup = 1/(0.5/2 + 0.5) = 1.33

(c) speedup = 1/(0.2/4 + 0.5/2 + 0.3) = 1.67

5. (20%) Suppose we have an application running on a shared-memory multiprocessor. With one processor, the application runs for 30 minutes.

(a) Suppose the processor clock rate is 2GHz. The average CPI (assuming that all references hit in the cache) on single processor is 0.5. How many instructions are executed in the application?

(b) Suppose we want to reduce the run time of the application to 5 minutes with 8 processor. Let's optimistically assume that parallelization adds zero overhead to the application, i.e. no extra instructions, no extra cache misses, no communications,etc. What fraction of the application must be executed in parallel?

Ans:

(a) 30 * 60 seconds = IC * 0.5 * 0.5ns

IC = 7200 * 10^9 (7200 billion)

(b)

30/5 = 1/ ((1-F) + F/8) F = 20/21 = 0.952

6. (10%)Instruction count, CPI, and clock rate are three key factors to measure performance.What performance factor(s) above may be affected by using different Instruction Set Architectures?

Ans: Instruction count, CPI, and clock rate

7. (10%) Consider the following performance measurements for a program:

Measurement	Computer A	Computer B	Computer C
Instruction count	12 billion	12 billion	10 billion
Clock Rate	4 GHz	3GHz	2.8 GHz
Cycle Per Instruction	2	1.5	1.4

(a) which is computer is faster?
(b) which computer has higher MIPS rating?

Ans:
(a) Computer C

Execution Time for Computer A = 6
Execution Time for Computer B = 6
Execution Time for Computer C = 5

(b) The MIPS rates for all computers are the same

MIPS for Computer A = 2000
MIPS for Computer B = 2000
MIPS for Computer C= 2000