C-355 Credit HW # 1

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Q1 - Chris Kasper

A processor executes 5 classes of instructions, with the CPI for each class as given below:

Class CPI

A 1

B 2

C 2

D 3

E 5

A certain benchmark program contains these instruction classes in the ratio 5:4:3:2:1. A compiler optimization can change the ratio of the instructions to 4:3:2:2:1 while reducing the total number of instructions by 5%.

(i) What is the average CPI before and after the compiler optimization?

Average CPI = Σ(CPIi \* FreqI )

Before: Average CPI = (1\*5/15)+(2\*4/15)+(2\*3/15)+(3\*2/15)+(5\*1/15) => 2

After: Average CPI = (1\*4/12)+(2\*3/12)+(2\*2/12)+(3\*2/12)+(5\*1/12) => 2.08

(ii) By what percentage will the performance of the processor (as measured by executing the said benchmark program) go up by this optimization? (Assume the clock cycle time remains constant)

Execution TIme = #instructions \* Average CPI \* Clock Cycle Time

Execution TIme (before) = #instructions \* 2 \* Clock Cycle Time

Execution TIme (after) = (0.95\* #instructions) \* 2.08 \* Clock Cycle Time

Performance = 1 / Execution Time

P (after) / P (before) = Execution Time (before) / Execution Time (after)

= (#instructions \* 2 \* Clock Cycle Time) / ((0.95\* #instructions)\*

2.08 \* Clock Cycle Time)

= 2 / (0.95 \* 2.08) => 1.012

The performance of the processor went up 1.2%

Q2 - Chris Kasper

A program has a total of 10 million instructions. The instructions are divided into 3

classes . The CPI and the frequency of occurrence of each class is as given below

Class CPI Frequency

A 1 50%

B 3 30%

C 5 20%

What should be the minimum clock frequency to execute the program in no more

than 20 milliseconds?

Execution time = #instructions \* average CPI \* (1/Clock Rate)

20 \* 10-3 = 107 \* average CPI \* (1/Clock Rate)

Clock Rate = (107 \* average CPI) / (20 \* 10-3)

Average CPI = (1 \* 0.5) + (3 \* 0.3) + (5 \* 0.2) => 2.4

Clock Rate = (107 \* 2.4) / (20 \* 10-3) => 1.2 GHz

Q3 - Dallas Foglia

Which CPU + Compiler combination has the highest performance and which has the lowest performance? What is the ratio of the highest performance to the lowest performance?

CPU P1 + Compiler C1

Clock Rate = 1.6 GHz, No of instructions = 1.2 million, Average CPI = 2.4

CPU P2 + Compiler C2

Clock Rate = 1.8 GHz , No of instructions = 1.5 million , Average CPI = 2.2

CPU P3 + Compiler C3

Clock Rate = 1.15 GHz , No of instructions = 1 million , Average CPI = 2.0

Execution TIme = #instructions \* Average CPI / Clock Rate

P1+C1: Execution Time = 1.2 \* 106 instructions \* 2.4 CPI / 1.6 GHz = 0.00180 seconds

P2+C2: Execution Time = 1.5 \* 106 instructions \* 2.2 CPI / 1.8 GHz = 0.00183 seconds

P3+C3: Execution Time = 1.0 \* 106 instructions \* 2.0 CPI / 1.15 GHz = 0.001739 seconds

Performance = 1 / Execution Time

P1+C1: 1/0.0018 seconds = 555.56

P2+C2: 1/0.00183 seconds = 546.448 Lowest

P3+C3: 1/0.001739 seconds = 575.043 Highest

P3+C3 is 575.043 / 546.448 ≈ 1.05 times faster than P2+C2

Q4 - Dallas Foglia

A SPEC benchmark program has 1 billion total instructions. The reference time is 4 secs. The program consists of 4 classes of instructions A,B,C,D in the ratio 4:3:2:1. The CPI for the classes are 3, 2, 2, 1 respectively. The clock rate of the CPU under test is 2 GHz .

(i) What is the SPEC ratio?

Average CPI = ΣCPIi \* FreqI

Average CPI = (40 \* 3 + 30 \* 2 + 20 \* 2 + 10 \* 1)/100 = 2.3 CPI

Execution TIme = #instructions \* Average CPI / Clock Rate

Execution Time = 109 instructions \* 2.3 CPI / 2.0 GHz = 1.15 seconds

SPEC = Reference Time / Execution Time

SPEC = 4 seconds / 1.15 seconds = 3.48

(ii) What should be the clock rate to obtain a SPEC ratio of 5?

SPEC = Reference Time / Execution Time

Execution TIme = #instructions \* Average CPI / Clock Rate

Clock Rate = #instructions \* CPI \* SPEC / Reference Time

Clock Rate = 109 instructions \* 2.3 CPI \* 5 / 4 seconds = 2.875 GHz

(iii) What will be the SPEC ratio if a compiler optimization reduces the number of class A instructions by 20% and the number of class B instructions by 10% keeping the clock rate unchanged at 2 GHz?

Average CPI = ΣCPIi \* FreqI

Average CPI = (40 \* 3 \* 80% + 30 \* 2 \* 90% + 20 \* 2 + 10 \* 1)/100 = 2.0 CPI

Execution TIme = #instructions \* Average CPI / Clock Rate

Execution Time = 109 instructions \* 2.0 CPI / 2.0 GHz = 1.0 seconds

SPEC = Reference Time / Execution Time

SPEC = 4 seconds / 1.0 seconds = 4