Shakti Singh Rathore
Prof. Gomez
HW 1
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Q 1.5

a. Performance = (clock Rate)/CPI instructions per second
For P1, performance = 3*10^9/1.5 = 2*10^9 instructions per second
For P2, performance = 2.5*10^9/1.0 = 2.5*10^9 instructions per second
For P3, performance = 4.0*10^9/2.2 = 1.81*10^9 instructions per second
Since, Performance = 1/Execution Time
So, processor with less time performs better. So, processor P3 has the highest performance expressed in instructions per second.

b. Program in 10s, find cycles and No. of instructions
cycles = Time * clock rate
Instruction Count(No of Instructions) = cycles/CPI
For P1, cycles = 10 * 3*10^9 = 30 *10^9
No of instructions = 30*10^9/1.5 = 20 * 10^9
For P2, cycles = 10 * 2.5*10^9 = 25*10^9
No of instructions =25*10^9/1.0 = 25* 10^9
For P1, cycles = 10 * 4.0*10^9 = 40*10^9
No of instructions =40*10^9/2.2 = 18.18* 10^9

c. Old Execution Time = 10s
Now, time decreased by 30% => New Time = 7s
CPI increased by 20% => New CPI = 1.2*CPI
Clock Rate = (Instruction Count* CPI)/ Time
We already know No of instructions, so just need to plug in new CPI and new time to get new clock rate.
For P1, clock rate = (20*10^9 * 1.2 * 1.5)/7 = 5.14 GHz
For P2, clock rate = (25*10^9 * 1.2 * 1.0)/7 = 4.28 GHz
For P3, clock rate = (18.18*10^9 * 1.2 * 2.2)/7 = 6.85 GHz

Q 1.6

There are 4 different classes(A,B,C,D) based on CPI.
Instruction Count = 10^6
CPU Time = (sum of products of instruction count and CPI of different class)/clock rate
For P1, CPU Time =(0.1 * 1* 10^6 + 0.2* 2*10^6 + 0.5*3* 10^6+ 0.2*3* 10^6)/2.5 * 10^9
= 2.6 * 10^-3/2.5 = 1.04 milliseconds (because 1ms = 10^-3 s)

For P2, CPU Time =(0.1 * 2* 10^6 + 0.2* 2*10^6 + 0.5*2* 10^6+ 0.2*2* 10^6)/3 * 10^9
= 2* 10^-3/3 = 0.67 milliseconds (because 1ms = 10^-3 s)

Since, CPU Time for P2 is less, so P2 is faster.

a. Global CPI -
CPI = CPU Time * Clock Rate / Instruction Count
For P1, Global CPI = 1.04 * 10^-3 * 2.5 * 10^9/10^6 = 2.6
For P2, Global CPI = 0.67 * 10^-3 * 3 * 10^9/10^6 = 2.01

b. Clock Cycles -
For P1, clock cycle = Global CPI * Instruction Count
= 2.6 * 10^6 = 26 * 10^5
For P2, clock cycle = Global CPI * Instruction Count
= 2.01 * 10^6 = 20.1* 10^5

Q 1.7

a. Calculating CPI, CPU Time = Instruction Count * CPI * clock cycles time
CPI = CPU Time/I.C. *cycles
For compiler A, CPI = 1.1/(10^9 * 1 * 10^-9) = 1.1
For compiler B, CPI = 1.5/(1.2 *10^9 * 1 * 10^-9) = 1.25
Thus, average CPI for A is 1.1 and for B is 1.25

b. Execution time is same but running on different processors.
Execution Time = Instruction Count * CPI * clock cycle
For A, Execution Time = 1 * 10^9 * 1.1 *clock cycle of A
For B, Execution Time = 1.2 * 10^9 * 1.25 *clock cycle of B
Both Execution Time are equal, so equate both times,
1 * 10^9 * 1.1 *clock cycle of A = 1.2 * 10^9 * 1.25 *clock cycle of B
clock cycle of A = 1.36 * clock cycle of B.
So, the clock of the processor running compiler A's code is 1.36 times faster than the clock of the processor running compiler B's code.

c. For new compiler, instruction count = 6 * 10^8
average CPI = 1.1
CPU time = Instruction count * CPI * clock cycles time
= 6 * 10^8 * 1.1 * 1 * 10^-9 (because 1ns = 10^-9 s)
= 0.66 seconds
Speed up compared to compiler A = Execution Time of A/ 0.66 = 1.1/0.66 = 1.66
Speed up compared to compiler B = Execution Time of B/ 0.66 = 1.5/0.66 = 2.27

Q 1.8

a. Two processor - Pentium 4 Prescott and i5 Ivy Bridge
Power = Capacitance Load * Voltage^2 * clock rate
Capacitance Load = Power / *Voltage^2 * clock rate)
For Pentium 4 processor, Capacitance Load = 90/(1.25^2 * 3.6 * 10^9)
= 16 * 10^-9
For i5 processor, Capacitance Load = 40/(0.9^2 * 3.4 * 10^9)
= 14.5* 10^-9

b. For Pentium 4 processor, total power dissipated = static power + dynamic power
= 10+90=100W
% of static power of the total power dissipated = 10/100 * 100= 10%
So, the percentage of the total dissipated power comprised by static power = 10%
Ratio of static power to dynamic power = 10/90
is 1:9

For i5 processor, total power dissipated = static power + dynamic power
= 30+40=70W
% of static power of the total power dissipated = 30/70 * 100= 42.85%
So, the percentage of the total dissipated power comprised by static power = 42.85%
Ratio of static power to dynamic power = 30/40
is 3:4

c. Power reduced by 10%.
We know, Power = Voltage * current. Since current is same. So
New Power/ New Voltage = Old Power/ Old Voltage
(100 -10)/New Voltage = 100/ Old Voltage
New Voltage/ Old Voltage =90/100 = 0.9
So, the New Voltage should be 0.9 times the old voltage.

Q 1.11

a. SPEC CPU running on an AMD Barcelona.
Instruction count = 2.389 * 10^12, Execution Time = 750s, and reference time = 9650s
clock cycle = 0.333 ns => clock rate = 1/0.333 = 3 GHz
CPI = Execution Time * Clock Rate/ No of Instructions
= 750 * 3 * 10^9/2.389 * 10^12 = 0.94

b. SPEC ratio = Reference Time/Execution Time = 9650/750 = 12.86

c. CPU Time = CPI * Instruction Count/ Clock rate.
Since CPI and clock rate are same. CPU Time increases exactly equal to the increase in the Instruction Count. So, instruction count increases by 10% so CPU Time increases by 10%.

d. Before increase, CPU Time before = CPI * No of instructions/ Clock rate
After increase, new CPI = 1.05 CPI and new No of instructions = 1.1 No of instructions before. So New CPU Time = 1.05 CPI * 1.1 No of instructions/ clock rate
New CPU Time/ CPU Time before = 1.05 * 1.1/1 = 1.155
This means CPU Time increases by 15%.

e. SPEC ratio previous/ SPEC ratio new = CPU Time before/ CPU Time now
= 1/1.155 (because increased by 15%)
= 0.86
So, SPEC ratio decreased by 14%.

f. New CPI = ? where clock rate = 4 GHz, Instruction count is reduced by 15%, execution time is 700s, and SPEC ratio is 13.7.

New instruction count = previous - 15% reduction

= 2.389 * 10^12 - 2.389 * 10^12 *0.15 = 2.03 * 10^12

CPU Time = CPI * Instruction count/ clock rate

700 = CPI * 2.03 * 10^12/4 * 10^9

CPI = 1.37

g. Since, CPU Time = CPI * Instruction Count/Clock rate. If we keep Instruction count and CPU time constant, then CPI and clock rate are directly proportional to each other.So if there is an increment in CPI then there is an increment in clock rate too. But CPI depends on other things like Instruction count and CPU Time so their changes will be dissimilar.

h. Initial CPU time = 750s

Final CPU time = 700s

% Reduction =((750-700)/750)*100 = 6.66%