Solutions for Exercise 1.5, 1.6, 1.8, 1.11, and 1.14

Disclaimer: The solution is just for your reference. They may contain some mistakes. DO TRY to solve the problems by yourself. Please also pay attentions to the course website for the updates.

1.5

a. performance of P1 (instructions/sec) = $3 \times 10^9/1.5 = 2 \times 10^9$

performance of P2 (instructions/sec) = $2.5 \times 10^9/1.0 = 2.5 \times 10^9$

performance of P3 (instructions/sec) = $4 \times 10^9/2.2 = 1.8 \times 10^9$

b. cycles(P1) = $10\times 3\times10^9 = 30\times10^9$s

cycles(P2) = $10 \times 2.5 \times10^9 = 25\times10^9$ s

cycles(P3) = $10 \times 4 \times10^9 = 40\times10^9$ s

c. No. instructions(P1) $=30\times10^9 /1.5 =20\times10^9$

No. instructions(P2) $=25\times10^9 /1=25\times10^9$

No. instructions(P3) $= 40\times10^9/2.2=18.18 \times 10^9$

$CPI_{new} = CPI_{old} \times 1.2$, then CPI(P1) = 1.8, CPI(P2)= 1.2, CPI(P3) =2.6

f =No. instr. × CPI/time, then

f(P1) = $20\times10^9\times1.8/7 = 5.14$ GHz

f(P2) = $25\times10^9\times 1.2/7 = 4.28$ GHz

f(P1) = $18.18\times10^9\times2.6/7 = 6.75$ GHz

1.6

a. Class A: 10^5 instr. Class B: 2×10^5 instr. Class C: 5×10^5 instr. Class D: 2×10^5 instr.

Time= No. instr. × CPI/clock rate

Total time P1 = $(10^5+ 2 \times10^5\times 2+ 5 \times10^5\times 3 + 2\times 10^5 \times 3)/(2.5 \times 10^9) =10.4\times 10^{-4}$ s

Total time P2 = $(10^5\times 2 +2 \times10^5 \times2+5 \times 10^5 \times 2 + 2 \times10^5 \times2)/(3\times10^9) = 6.66 \times10^{-4}$s

CPI(P1) = $10.4 \times 10^{-4} \times 2.5 \times 10^9/10^6 = 2.6$

CPI(P2) = $6.66 \times 10^{-4}\times 3 \times10^9/10^6= 2.0$

b. clock cycles(P1) = $10^5\times1+ 2 \times10^5\times 2 + 5 \times10^5 \times3 +2 \times10^5 \times3 =26 \times 10^5$

clock cycles(P2)= $10^5\times 2+ 2 \times10^5\times 2 + 5\times 10^5 \times 2 + 2\times 10^5\times 2 =20 \times 10^5$

1.8

1.8.1 C =2× DP/(V^2*F)

Pentium 4: C =3.2E–8F

Core i5 Ivy Bridge: C = 2.9E–8F

1.8.2 Pentium 4: 10/100= 10%. Ratio of static power to dynamic power = 1:9

Core i5 Ivy Bridge: 30/70= 42.9%. Ratio of static power to dynamic power = 3:4

1.8.3 $(S_{new} + D_{new})/(S_{old} + D_{old}) = 0.90$ … (1)

$D_{new}=C \times V_{new}$ ^2 × F …(2)

$S_{old} = V_{old} \times I$ …(3)

$S_{new} = V_{new} \times I$ …(4)

Therefore:

From (2), $V_{new} = [D_{new}/(C \times F)]^{1/2}$ …(5)

From (1), $D_{new} = 0.90 \times (S_{old} + D_{old}) - S_{new}$ …(6)

From (3)& (4), $S_{new} = V_{new} \times (S_{old}/V_{old})$ …(7)

For Pentium 4: $(S_{old} + D_{old} = 10+90=100, V_{old}=1.25)$

$S_{new} = V_{new} \times (S_{old}/V_{old}) = V_{new} \times (10/1.25) = V_{new} \times 8$

$D_{new} = 0.90 \times 100 - V_{new} \times 8 = 90 - V_{new} \times 8$

From (5), $V_{new} = [(90 - V_{new} \times 8)/(3.2E\text{-}8 \times 3.6E9)]^{1/2}$

V_{new} ~= 0.85 V

For Core i5:

$S_{new} = V_{new} \times (S_{old}/V_{old}) = V_{new} \times (30/0.9) = V_{new} \times 33.3$

$D_{new} = 0.90 \times 70 - V_{new} \times 33.3 = 63 - V_{new} \times 33.3$

$V_{new} = [(63 - V_{new} \times 33.3)/(2.9E\text{-}8 \times 3.4E9)]^{1/2}$

V_{new} ~= 0.64 V

11.1

1.11.1 CPI= clock rate × CPU time/instr. Count

clock rate = 1/cycle time = 3 GHz

CPI(bzip2) = $3\times 10^9 \times 750/(2389 \times 10^9)$= 0.94

1.11.2 SPEC ratio = ref. time/execution time

SPEC ratio(bzip2) =9650/750 =12.86

1.11.3. CPU time = No. instr. × CPI/clock rate

If CPI and clock rate do not change, the CPU time increase is equal to the increase in the of number of instructions, that is 10%.

1.11.4 CPU time(before) = No. instr. × CPI/clock rate

CPU time(after) =1.1 × No. instr. × 1.05× CPI/clock rate

CPU time(after)/CPU time(before) = 1.1 × 1.05 =1.155. Thus, CPU time is increased by 15.5%.

1.11.5 SPECratio=reference time/CPU time

SPECratio(after)/SPECratio(before) = CPU time(before)/CPU time(after) = 1/1.1555 = 0.86. The SPECratio is decreased by 14%.

1.11.6 CPI = (CPU time × clock rate)/No. instr.

CPI = 700 × 4 ×10^9/(0.85× 2389 × 10^9) = 1.37

1.11.7 Clock rate ratio= 4 GHz/3 GHz = 1.33

CPI @ 4 GHz = 1.37, CPI @ 3 GHz = 0.94, ratio = 1.45

They are different because, although the number of instructions has been reduced by 15%, the CPU time has been reduced by a lower percentage.

1.11.8 700/750 =0.933. CPU time reduction: 6.7%

1.11.9 No. instr.=CPU time × clock rate/CPI

No. instr. =960 × 0.9 ×4× 10^9/1.61 = 2146 × 10^9

1.11.10 Clock rate =No. instr. × CPI/CPU time.

Clock $rate_{new}$ = No. instr. × CPI/0.9 × CPU time = 1/0.9 clock $rate_{old}$ = 3.33 GHz

1.11.11 Clock rate= No. instr. × CPI/CPU time.

Clock $rate_{new}$ = No. instr. × 0.85× CPI/0.80 CPU time = 0.85/0.80, clock $rate_{old}$ =3.18 GHz

1.14.1 Clock cycles = CPI_{fp} × No. FP instr. + CPI_{int} × No. INT instr. + $CPI_{l/s}$ × No. L/S instr. + CPI_{branch} × No. branch instr.

T_{CPU} = clock cycles/clock rate = clock cycles/2 × 10^9

clock cycles = 512 × 10^6; T_{CPU} = 0.256 s

To have the number of clock cycles by improving the CPI of FP instructions:

$CPI_{improved\ fp}$ × No. FP instr. + CPI_{int} × No. INT instr. + $CPI_{l/s}$ × No. L/S instr. + CPI_{branch} × No. branch instr. = clock cycles/2

$CPI_{improved\ fp}$ = (clock cycles/2 - (CPI_{int} × No. INT instr. + $CPI_{l/s}$ × No. L/S instr. + CPI_{branch} × No. branch instr.)) / No. FP instr.

$CPI_{improved\ fp}$ = (256-462)/50 <0==> not possible

1.14.2 Using the clock cycle data from a.

To have the number of clock cycles improving the CPI of L/S instructions:

$CPI_{fp} \times$ No. FP instr. + $CPI_{int} \times$ No. INT instr. + $CPI_{improved\ l/s} \times$ No. L/S instr. + $CPI_{branch} \times$ No. branch instr. = clock cycles/2

$CPI_{improved\ l/s}$ = (clock cycles/2 - ($CPI_{fp} \times$ No. FP instr. + $CPI_{int} \times$ No. INT instr. + $CPI_{branch} \times$ No. branch instr.)) / No. L/S instr.

=(256×10^6 – (50×10^6+110×10^6+32×10^6))/ 80×10^6

$CPI_{improved\ l/s}$ = (256-192)/80 = 0.8

1.14.3 Clock cycles = $CPI_{fp} \times$ No. FP instr. + $CPI_{int} \times$ No. INT instr. + $CPI_{l/s} \times$ No. L/S instr. + $CPI_{branch} \times$ No. branch instr.

T_{CPU} = clock cycles/clock rate = clock cycles/2 × 10^9

$CPI_{int} = 0.6 \times 1 = 0.6$; $CPI_{fp} = 0.6 \times 1 = 0.6$; $CPI_{l/s} = 0.7 \times 4 = 2.8$;

$CPI_{branch} = 0.7 \times 2 = 1.4$

T_{CPU} (before improv.) = 0.256 s; T_{CPU} (after improv.)= 0.171 s