# HW#2 (CSC390)-SOLUTION

## 1.11

**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 = $700 \times 4 \times 10^9/(0.85 \times 2389 \times 10^9) = 1.37$

**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. = $960 \times 0.9 \times 4 \times 10^9/1.61 = 2146 \times 10^9$

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

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

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

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

## 1.13

**1.13.1** $T_{fp} = 70 \times 0.8 = 56$ s. $T_{new} = 56+85+55+40 = 236$ s. Reduction: 5.6%

**1.13.2** $T_{new} = 250 \times 0.8 = 200$ s, $T_{fp}+T_{l/s}+T_{branch} = 165$ s, $T_{int} = 35$ s. Reduction time INT: 58.8%

**1.13.3** $T_{new} = 250 \times 0.8 = 200$ s, $T_{fp}+T_{int}+T_{l/s} = 210$ s. NO

## 1.14

**1.14.1** 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/$2 \times 10^9$

clock cycles = $512 \times 10^6$; $T_{CPU} = 0.256$ s

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

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

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

$CPI_{improved\ l/s} = (256-198)/80 = 0.725$

**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/$2 \times 10^9$

$CPI_{int} = 0.6 \times 1 = 0.6$; $CPI_{fp} = 0.6 \times 1 = 0.6$; $CPI_{l/s} = 0.7 \times 4 = 2.8$; $CPI_{branch} = 0.7 \times 2 = 1.4$

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