Dong Hu

HOMEWORK 2

Problem 1.6

Because the instruction counts are the same, we use IC to represent it.

$$
\begin{aligned}
T_{P1} &= \frac{(0.1\times1+0.2\times2+0.5\times3+0.2\times3)\times IC}{2.5}\\
&= \frac{2.6IC}{2.5}\\
&= 1.04\times IC
\end{aligned}
$$

$$
\begin{aligned}
T_{P2} &= \frac{(0.1\times2+0.2\times2+0.5\times2+0.2\times2)\times IC}{3}\\
&= \frac{2IC}{3}\\
&= 0.67\times IC < 1.04\times IC = T_{P1}
\end{aligned}
$$

Thus P2 is <u>Faster</u>

(1) $Global\ CPI_{P1} = \frac{CPU\ time\times clock\ rate}{Instruction\ count}$
$= \frac{1.04\times10^{-3}\times2.5\times10^{9}}{10^{6}}$
$=2.6$

$Global\ CPI_{P2} = \frac{CPU\ time\times clock\ rate}{Instruction\ count}$
$= \frac{0.67\times10^{-3}\times3\times10^{9}}{10^{6}}$
$=2.01$

(2) $\#of\ clock\ cycles_{P1} = Global\ CPI_{P1}\times Instruction\ count$
$=2.6\times10^{6}$
$\#of\ clock\ cycles_{P2} = Global\ CPI_{P2}\times Instruction\ count$
$=2.01\times10^{6}$

Problem 1.9

(1) $$\begin{aligned} CPU\ time_{P1} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{2.56E9\times1+1.28E9\times12+2.56E8\times5}{2E9} \\ &= 9.6 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P2} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times1}{0.7\times2}+\frac{1.28E9\times12}{0.7\times2}+2.56E8\times5}{2E9} \\ &= 7.02 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P4} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times1}{0.7\times4}+\frac{1.28E9\times12}{0.7\times4}+2.56E8\times5}{2E9} \\ &= 3.86 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P8} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times1}{0.7\times8}+\frac{1.28E9\times12}{0.7\times8}+2.56E8\times5}{2E9} \\ &= 2.25 \text{ sec} \end{aligned}$$

2 Processors speedup $= \frac{9.6\ sec}{7.02\ sec} = 1.37\ times$

4 Processors speedup $= \frac{9.6\ sec}{3.86\ sec} = 2.49\ times$

8 Processors speedup $= \frac{9.6\ sec}{2.25\ sec} = 4.27\ times$

(2) $$\begin{aligned} CPU\ time_{P1} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{2.56E9\times2+1.28E9\times12+2.56E8\times5}{2E9} \\ &= 10.88 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P2} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times2}{0.7\times2}+\frac{1.28E9\times12}{0.7\times2}+2.56E8\times5}{2E9} \\ &= 7.95 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P4} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times2}{0.7\times4}+\frac{1.28E9\times12}{0.7\times4}+2.56E8\times5}{2E9} \\ &= 4.30 \text{ sec} \end{aligned}$$

$$\begin{aligned} CPU\ time_{P8} &= \frac{clock\ cycle}{clockrate} \\ &= \frac{\frac{2.56E9\times2}{0.7\times8}+\frac{1.28E9\times12}{0.7\times8}+2.56E8\times5}{2E9} \\ &= 2.47 \text{ sec} \end{aligned}$$

(3) 4 Processors CPU time = 3.86 sec (from 1.9.1)
let the CPI for load/store be x.
Then we have $\frac{2.56E9\times2+1.28E9\times x+2.56E8\times5}{2E9} = 3.86$

$$0.64x = 1.94$$
$$x = 3.03$$

Hence the reduced CPI is 3.03/12 = 0.25 = 25%

Problem 1.13

(1) INT = 250-70-85-40 = 55

FP New = 70×(1-0.2) = 56

Total New = 56+85+55+40 = 236 sec

Reduced Time = 250-236 = 14 sec

Reduced Rate = $\frac{14\ sec}{250\ sec} \times 100\% = 5.6\%$

(2) Total New = 250×(1-0.2) = 200

INT New = 200-70-85-40 = 5

Reduced Rate = $\frac{5}{55} \times 100\% = 90.9\%$

(3) New Total = 250×(1-0.2) = 200

New Total-Old Total = 250 - 200 = 50 > 40

Hence we cannot reduce total time by just reducing the branch instructions.

Problem 1.14

(1) Each processor clock rate is 2GHz
Execution time $= \sum \frac{Clockcycles}{Clockrate}$
Clock cycles $= CPI_{FP} \times IC_{FP} + CPI_{INT} \times IC_{INT} + CPI_{L/S} \times IC_{L/S} + CPI_{branch} \times IC_{branch}$
$=(50 \times 10^4 \times 1) + (110 \times 10^4 \times 1) + (80 \times 10^4 \times 4) + (16 \times 10^4 \times 2)$
$=5.12 \times 10^8$e
For Floating point instructions:
Execution time $= \frac{5.12^8}{2\times10^9} = 0.256sec$
For 16 processors:
Execution time $= \frac{5.12^8}{2\times10^9} = 0.256sec$
Half the number of clock cycles to improve the CPI of FP instructions:
$\frac{Clockcycles}{2} = CPI_{FPimproved} \times IC_{FP} + CPI_{INT} \times IC_{INT} + CPI_{L/S} \times IC_{L/S} + CPI_{branch} \times IC_{branch}$
$CPI_{FPimproved} = \frac{\frac{Clockcycles}{2} - CPI_{INT} \times IC_{INT} + CPI_{L/S} \times IC_{L/S} + CPI_{branche} \times IC_{branch}}{IC_{FP}}$
$= \frac{\frac{5.12\times10^8}{2} - (110\times10^4\times1) + (80\times10^4\times4) + (16\times10^4\times2)}{50\times10^6}$
$=-4.12 < 0$
Thus we cannot improve CPI of Floating Point two times faster since the result is negative.

(2) Half the number of clock cycles to improve the CPI of LS instructions:
$\frac{Clockcycles}{2} = CPI_{FP} \times IC_{FP} + CPI_{INT} \times IC_{INT} + CPI_{L/Simproved} \times IC_{L/S} + CPI_{branch} \times IC_{branch}$
$CPI_{L/Simproved} = \frac{\frac{Clockcycles}{2} - CPI_{FP} \times IC_{FP} + CPI_{INT} \times IC_{INT} + CPI_{branch} \times IC_{branch}}{IC_{L/S}}$
$= \frac{\frac{5.12\times10^8}{2} - (50\times10^4\times1) + (110\times10^4\times1) + (16\times10^4\times2)}{80\times10^4}$
$=0.8 > 0$
Thus in order to improve the program by two times, we need to improve CPI_{LS} by $\frac{4}{0.8} = 5$ times.

(3) Reduce 40% on Floating point: $CPI_{FP} = 1 - 1 \times 0.4 = 0.6$
Reduce 40% on INT: $CPI_{INT} = 1 - 1 \times 0.4 = 0.6$
Reduce 30% on Load/Store: $CPI_{L/S} = 4 - 4 \times 0.3 = 2.8$
Reduce 30% on Branch: $CPI_{branch} = 2 - 2 \times 0.3 = 1.4$
Initial Execution time$=\frac{342.4\times10^6}{2\times10^9} = 0.1712$ *sec*
Thus, improving execution time of program $=\frac{0.256sec}{0.171sec} = 1.497$ *times*