計算機結構 Exercise 01

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1.5 a. $Instructions\ per\ second = \frac{Clock\ Rate}{CPI}$

P1 $\frac{3\times10^9}{1.5} = 2\times10^9\ (instructions\ per\ second)$

P2 $\frac{2.5\times10^9}{1.0} = 2.5\times10^9\ (instructions\ per\ second)$

P3 $\frac{4.0\times10^9}{2.2} = 1.82\times10^9\ (instructions\ per\ second)$

Therefore, **P2** has the highest performance expressed in instructions per second.

b. $number\ of\ cycles = Clock\ Rate \times CPU\ Time$

$number\ of\ instructions = \frac{Clock\ Rate\times CPU\ Time}{CPI}$

P1

- $number\ of\ cycles = (3\times10^9)\times 10 = 3\times10^{10}$
- $number\ of\ instructions = \frac{(3\times10^9)\times10}{1.5} = 2\times10^{10}$

P2

- $number\ of\ cycles = (2.5\times10^9)\times 10 = 2.5\times10^{10}$
- $number\ of\ instructions = \frac{(2.5\times10^9)\times10}{1.0} = 2.5\times10^{10}$

P3

- $number\ of\ cycles = (4.0\times10^9)\times 10 = 4.0\times10^{10}$
- $number\ of\ instructions = \frac{(4.0\times10^9)\times10}{2.2} = 1.82\times10^{10}$

c. $CPU\ Time = \frac{Instruction\ Count\times CPI}{Clock\ Rate}$

When instruction count is fixed, $CPU\ Time \propto \frac{CPI}{Clock\ Rate}$ If CPI increases by 20%, and we want CPU time to reduce by 30%, clock rate should become $\frac{1.2}{0.7} = 1.714$ times. That is to say, clock rate should increase by 71.4%.

1.8.1 $Dynamic\ Power\ Consumption = Capacitive\ load \times Voltage^2 \times Frequency$

Prescott $Capacitive\ load = \frac{90}{1.25^2\times(\frac{1}{2}\times3.6\times10^9)} = 3.2\times10^{-8}\ (F)$

Ivy Bridge $Capacitive\ load = \frac{40}{0.9^2\times(\frac{1}{2}\times3.4\times10^9)} = 2.905\times10^{-8}\ (F)$

1.8.2 Prescott

- $Percentage$ $\frac{10}{10+90}\times 100\% = 10\%$
- $Ratio$ $\frac{10}{90} = 0.1111$

Ivy Bridge

- *Percentage* $\frac{30}{30+40} \times 100\% = 42.86\%$
- *Ratio* $\frac{30}{40} = 0.75$

1.8.3 $Static\ Power\ Consumption = V \times I_{leakage}$
Prescott
$I_{leakage} = \frac{10}{1.25} = 8$
To maintain the same leakage current and reduce the total dissipated power by 10%, the new equation becomes
$(10 + 90) \times 90\% = V \times 8 + 3.2 \times 10^{-8} \times V^2 \times (\frac{1}{2} \times 3.6 \times 10^9)$
Solve the equation to get $V = 1.1825, -1.3214$. Therefore, the voltage should be reduced to $1.1825V$.
Ivy Bridge $I_{leakage} = \frac{30}{0.9} = 33.33$
To maintain the same leakage current and reduce the total dissipated power by 10%, the new equation becomes
$(30 + 40) \times 90\% = V \times 33.33 + 2.905 \times 10^{-8} \times V^2 \times (\frac{1}{2} \times 3.4 \times 10^9)$
Solve the equation to get $V = 0.8413, -1.5163$. Therefore, the voltage should be reduced to $0.8413V$.

1.12.1 $CPU\ Time = \frac{Instruction\ Count \times CPI}{Clock\ Rate}$
P1 $\frac{(5.0\times10^9)\times0.9}{4\times10^9} = 1.125\ (s)$
P2 $\frac{(1.0\times10^9)\times0.75}{3\times10^9} = 0.25\ (s)$

P1 has a larger clock rate, but its performance is worse than **P2**.

1.12.2 $\frac{(1.0\times10^9)\times0.9}{4\times10^9} = \frac{Instruction\ Count\times0.75}{3\times10^9}$, $Instruction\ Count = 0.9 \times 10^9$

P2 can execute 0.9×10^9 instructions in the same time that **P1** needs to execute 1.0×10^9 instructions.

1.12.3 $MIPS = \frac{Clock\ Rate}{CPI\times10^6}$
P1 $\frac{4\times10^9}{0.9\times10^6} = 4444.44\ (MIPS)$
P2 $\frac{3\times10^9}{0.75\times10^6} = 4000\ (MIPS)$

P1 has a larger MIPS, but its performance is worse than **P2**.

1.12.4 $MFLOPS = \frac{No.FP\ operations}{execution\ time\times10^6}$
P1 $\frac{5.0\times10^9\times40\%}{1.125\times10^6} = 1777.78\ (MFLOPS)$
P2 $\frac{1.0\times10^9\times40\%}{0.25\times10^6} = 1600\ (MFLOPS)$

1.15 $per\ processor\ execution\ time = \frac{100}{processor\ num} + 4$
$speedup = \frac{100}{\frac{100}{processor\ num}+4}$
$ideal\ speedup = \frac{100}{\frac{100}{processor\ num}} = processor\ num$

2 processors

- $per\ processor\ execution\ time = \frac{100}{2} + 4 = 54$
- $speedup = \frac{100}{54} = 1.85$
- $ratio = \frac{1.85}{2} = 0.9260$

4 processors

- $per\ processor\ execution\ time = \frac{100}{4} + 4 = 29$
- $speedup = \frac{100}{29} = 3.45$
- $ratio = \frac{3.45}{4} = 0.8621$

8 processors

- $per\ processor\ execution\ time = \frac{100}{8} + 4 = 16.5$
- $speedup = \frac{100}{16.5} = 6.06$
- $ratio = \frac{6.06}{8} = 0.7576$

16 processors

- $per\ processor\ execution\ time = \frac{100}{16} + 4 = 10.25$
- $speedup = \frac{100}{10.25} = 9.76$
- $ratio = \frac{9.76}{16} = 0.6098$

32 processors

- $per\ processor\ execution\ time = \frac{100}{32} + 4 = 7.13$
- $speedup = \frac{100}{7.13} = 14.04$
- $ratio = \frac{14.04}{32} = 0.4386$

64 processors

- $per\ processor\ execution\ time = \frac{100}{64} + 4 = 5.56$
- $speedup = \frac{100}{5.56} = 17.98$
- $ratio = \frac{17.98}{64} = 0.2809$

128 processors

- $per\ processor\ execution\ time = \frac{100}{128} + 4 = 4.78$
- $speedup = \frac{100}{4.78} = 20.92$
- $ratio = \frac{20.92}{128} = 0.1634$