CS202 Computer organization HW1

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1 Problem 1

1. For each processor, in instructions per second (ins/sec), $performance = \frac{1}{execution\ time} = \frac{clock\ rate}{CPI}$, we have

$$performance_{P1} = \frac{3.0\ GHz}{1.5\ cyc/ins} = 2.00 \times 10^9\ ins/sec$$
$$performance_{P2} = \frac{2.5\ GHz}{1.0\ cyc/ins} = 2.50 \times 10^9\ ins/sec$$
$$performance_{P3} = \frac{4.0\ GHz}{2.2\ cyc/ins} = 1.82 \times 10^9\ ins/sec$$

   it follows that processor P2 has the highest performance.

2. In 10 seconds, we have
   Number of instructions (NI): $NI = performance\ (in\ instructions\ per\ second) \times time$

$$NI_{P1} = 2.00 \times 10^9\ ins/sec \times 10\ sec = 2.00 \times 10^{10}\ ins$$
$$NI_{P2} = 2.50 \times 10^9\ ins/sec \times 10\ sec = 2.50 \times 10^{10}\ ins$$
$$NI_{P3} = 1.82 \times 10^9\ ins/sec \times 10\ sec = 1.82 \times 10^{10}\ ins$$

   Number of cycles (NC): $NC = CPI \times NI$

$$NC_{P1} = 1.5\ cyc/ins \times 20.0 \times 10^9\ ins = 3.00 \times 10^{10}\ cyc$$
$$NC_{P2} = 1.0\ cyc/ins \times 25.0 \times 10^9\ ins = 2.50 \times 10^{10}\ cyc$$
$$NC_{P3} = 2.2\ cyc/ins \times 18.2 \times 10^9\ ins = 4.00 \times 10^{10}\ cyc$$

3. Since $execution\ time = \frac{IC \times CPI}{clock\ rate}$, when execution time is reduced by 30% but CPI is increased by 20%, then we have

$$clock\ rate_{P1} = 3.0\ GHz \times \frac{12}{7} = 5.14\ GHz$$
$$clock\ rate_{P2} = 2.5\ GHz \times \frac{12}{7} = 4.28\ GHz$$
$$clock\ rate_{P3} = 4.0\ GHz \times \frac{12}{7} = 6.86\ GHz$$

2 Problem 2

Since $CPU\ time = \frac{IC \times CPI}{clock\ rate}$, we have

$$CPU\ time_{P1} = \frac{1.0 \times 10^6\ ins \times (1 \times 10\% + 2 \times 20\% + 3 \times 50\% + 3 \times 20\%)}{1.5\ GHz} = 1.73$$
$$CPU\ time_{P2} = \frac{1.0 \times 10^6\ ins \times (2 \times 10\% + 2 \times 20\% + 2 \times 50\% + 2 \times 20\%)}{3.0\ GHz} = 0.67$$

So P2 is faster.

1.

$$global\ CPI_{P1} = 1 \times 10\% + 2 \times 20\% + 3 \times 50\% + 3 \times 20\% = 2.6$$
$$global\ CPI_{P2} = 2 \times 10\% + 2 \times 20\% + 2 \times 50\% + 2 \times 20\% = 2.0$$

2.

$$clock\ cycle_{P1} = 1.0 \times 10^6 ins \times global\ CPI_{P1} = 2.6 \times 10^6 cyc$$
$$clock\ cycle_{P2} = 1.0 \times 10^6 ins \times global\ CPI_{P2} = 2.0 \times 10^6 cyc$$

3 Problem 3

1.

$$aveCPI_A = \frac{execution\ time}{IC \times Tc} = \frac{1.1\ s}{1.0 \times 10^9 \times 1\ ns} = 1.10$$
$$aveCPI_B = \frac{execution\ time}{IC \times Tc} = \frac{1.5\ s}{1.2 \times 10^9 \times 1\ ns} = 1.25$$

2. Since $clock\ rate = \frac{IC \times CPI}{execution\ time}$, then we have

$$\frac{clock\ rate_A}{clock\ rate_B} = \frac{IC_A \times aveCPI_A}{IC_B \times aveCPI_B} = \frac{1.0 \times 10^9 \times 1.10}{1.2 \times 10^9 \times 1.25} = 0.73$$

3. Since $clock\ rate = \frac{IC \times CPI}{execution\ time}$, then we have
versus A

$$\frac{clock\ rate_{new}}{clock\ rate_A} = \frac{6.0 \times 10^8 \times 1.1}{1.0 \times 10^9 \times 1.10} = 0.60$$

versus B

$$\frac{clock\ rate_{new}}{clock\ rate_B} = \frac{6.0 \times 10^8 \times 1.1}{1.2 \times 10^9 \times 1.25} = 0.44$$

4 Problem 4

1. From $P = \frac{1}{2}CV^2f$, we have $C = \frac{2P}{V^2f}$, then

$$C_{Pentium\ 4\ Prescott} = \frac{2 \times 90\ W}{(1.25\ V)^2 \times 3.6\ GHz} = 3.2 \times 10^{-8}\ F$$
$$C_{Core\ i5\ Ivy\ Bridge} = \frac{2 \times 40\ W}{(0.9\ V)^2 \times 3.4\ GHz} = 2.9 \times 10^{-8}\ F$$

2. Suppose the percentage of the total dissipated power by static power and ratio of static power to dynamic power are denoted by PD and R.
Total dissipated power by static power

$$PD_{Pentium\ 4\ Prescott} = \frac{10\ W}{10\ W + 90\ W} \times 100\% = 10.00\%$$
$$PD_{Core\ i5\ Ivy\ Bridge} = \frac{30\ W}{30\ W + 40\ W} \times 100\% = 42.86\%$$

Ratio of static power to dynamic power

$$R_{Pentium\ 4\ Prescott} = \frac{10\ W}{90\ W} = \frac{1}{9}$$
$$R_{Core\ i5\ Ivy\ Bridge} = \frac{30\ W}{40\ W} = \frac{3}{4}$$

3. Since $P = VI$, when P is reduced by 10% and I remains, V should be reduced by 10%, i.e., V should be reduced by 0.125V for A and 0.09V for B.