INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Class Test 1 Solutions

Date: 06-02-23 **Timing:** 3 pm - 4:30 pm **Place:** NR223 **Total Marks =** 30
Subject No : CS60003 **HIGH PERFORMANCE COMPUTER ARCHITECTURE**
Department/Centre/School : Computer Science and Engineering
Answer all questions. In case of reasonable doubt, make assumptions and state them upfront. Marks will be deducted for claims without proper reasoning. Write your answers (with all analysis, justification, calculation etc) within the allotted time.

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1. **[5]**

Given overall speedup $S = 3$ and speedup enhanced $S_e = 4$, due to 4 cores. We know

$$Overall\ Speedup = \frac{Old\ execution\ time}{New\ execution\ time} \tag{1}$$

Using Amdahl's law, the above can be rewritten as

$$S = \frac{1}{(1 - f + \frac{f}{S_e})}$$

where f is the fraction of the program that needs to be distributed across the cores to achieve required speedup.

Substituting given values of S and S_e in above equation, we have

$$\begin{aligned} 3 &= \frac{1}{(1 - f + \frac{f}{4})} \\ 1 - f + \frac{f}{4} &= \frac{1}{3} \\ f - \frac{f}{4} &= 1 - \frac{1}{3} \\ f(1 - \frac{1}{4}) &= \frac{2}{3} \\ \frac{3}{4} * f &= \frac{2}{3} \\ f &= \frac{2}{3} * \frac{4}{3} \\ f &= \frac{8}{9} \\ f &= 0.889 \end{aligned}$$

Thus 88.9% of program execution needs to be distributed across all 4 cores to achieve an overall speedup of 3.

2. **[10]**

To determine which enhancement to make, we need to calculate the current weighted CPI and then compare it with the weighted CPI for each potential enhancement. The weighted CPI is calculated as follows:

Weighted CPI = (% of instruction type x CPI of instruction type)

For the current processor, the weighted CPI is:

(0.39 x 5) + (0.12 x 5) + (0.28 x 3) + (0.06 x 6) + (0.02 x 15) + (0.10 x 4) + (0.03 x 4) = 4.57

For enhancement a, the new weighted CPI would be:

(0.39 x 5) + (0.12 x 5) + (0.28 x 3) + (0.06 x 6) + (0.02 x 15) + (0.10 x 2) + (0.03 x 4) = 4.37

For enhancement b, the new weighted CPI would be:

(0.39 x 5) + (0.12 x 5) + (0.28 x 3) + (0.06 x 3) + (0.02 x 15) + (0.10 x 4) + (0.03 x 4) = 4.39

For enhancement c, the new weighted CPI would be:

(0.39 x 5) + (0.12 x 5) + (0.28 x 3) + (0.06 x 6) + (0.02 x 7) + (0.10 x 4) + (0.03 x 4) = 4.41

For enhancement d, the new weighted CPI would be:

(0.39 x 5) + (0.12 x 5) + (0.28 x 2) + (0.06 x 6) + (0.02 x 15) + (0.10 x 4) + (0.03 x 4) = 4.29

Therefore, enhancement d would be the best choice since it results in the lowest weighted CPI.

3. **[5]**

Assuming load instruction in both versions to be *lw r3 r0* 100:-

For Version 1, data dependencies are as follows:

1. WAW between I1 and I2 because of r3.
2. WAW between I2 and I3 because of r3.
3. WAR between I2 and I4 because of r5.

For Version 2, data dependencies are as follows:

1. WAW between I1 and I2 because of r3.
2. WAW between I2 and I4 because of r3.
3. WAR between I2 and I3 because of r5.

There are no RAW dependencies.

Assuming load instruction in both versions to be *lw r0 r3* 100:-

For Version 1, data dependencies are as follows:

1. WAR between I1 and I2 because of r3.
2. WAW between I2 and I3 because of r3.
3. WAR between I2 and I4 because of r5.
4. RAW between I1 and I4 because of r0.

For Version 2, data dependencies are as follows:

1. WAR between I1 and I2 because of r3.
2. WAW between I2 and I4 because of r3.
3. WAR between I2 and I3 because of r5.
4. RAW between I1 and I3 because of r0.

4. **[10]**

The values below in red denote the number of mispredictions.

a. How many branch instructions are executed for a single run of the program?

B1: 31 B2: 90 B3: 60 B4: 30

b. How many branches are predicted correctly if we predict Always-Not-Taken?

B1: 30 B2: 60 B3: 00 B4: 00

B1: 01 B2: 30 B3: 60 B4: 30

c. How many branches are predicted correctly if we use local last time 1-bit predictor?

B1: 30 B2: 31 B3: 59 B4: 29

B1: 01 B2: 59 B3: 01 B4: 01
