Computer Architecture and Programming Languages
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Homework 8 - MIPS Instruction Set Architecture/Performance

Problem 8.1

Solution:

a) $25 \div 32$ is equal to 0.78125

$0.78125 \times 2 = 1.5625$
$0.5625 \times 2 = 1.125$
$0.125 \times 2 = 0.25$
$0.25 \times 2 = 0.5$
$0.5 \times 2 = 1.0$

0.78125 is now equal to: 0.11001
We must shift the decimal point and write it in scientific notation, which results in the following: 1.1001×2^{-1}

Therefore, we can gather the following information:
1. Sign bit (1 bit): 0 (because it is a positive number)
2. Exponent (8 bits): 127 - 1 = 126 $\rightarrow$ 01111110_2
3. Mantissa (23 bits): The rest of the decimal number $\rightarrow$ 10010000000000000000000

	Sign	Exponent	Mantissa
	0	01111110	10010000000000000000000

b) 27.351562

$27 \div 2 = 13 + 1$	$0.351562 \times 2 = 0.7031125$
$13 \div 2 = 6 + 1$	$0.7031125 \times 2 = 1.40625$
$6 \div 2 = 3 + 0$	$0.40625 \times 2 = 0.8125$
$3 \div 2 = 1 + 1$	$0.8125 \times 2 = 1.625$
$1 \div 2 = 0 + 1$	$0.625 \times 2 = 1.25$
.	$0.25 \times 2 = 0.5$
.	$0.5 \times 2 = 1.0$
.	$0.0 \times 2 = 0.0$

27.351562 is now equal to: 11011.0101101
We must shift the decimal point, expressing it in scientific notation: 1.10110101101 $\times$ 2^4

Therefore, we can gather the following information:
1. Sign bit (1 bit): 0 (because it is a positive number)
2. Exponent (8 bits): 127 + 4 = 131 $\rightarrow$ 10000011_2
3. Mantissa (23 bits): The rest of the numbers after the decimal point $\rightarrow$ 1011010110...

	Sign	Exponent	Mantissa
	0	10000011	10110101100000000000000

Problem 8.2

Solution:

a. True

b. False

c. False

d. False

e. False

Problem 8.3
Solution:

a. 000000 10000 10101 01011 00000 100000
Since the first 6 bits are all 0's, this doesn't show us what kind of instruction it is, which is why we have to look at the function code and 100000 represents add. Therefore, we have the following MIPS code, according to the rs, rt, and rd values:

add $t3, $s0, $s5

Problem 8.4
Solution:

a. 26 bits

b. What can be done to still be able to jump "anywhere" is simply to jump twice, one to the address and the next one to the relative address.

Problem 8.5
Solution:
In order to find which computer will finish rendering first, we need to calculate the average CPI for both computers. We do this by multiplying the CPI with the frequency and adding it all up:

C1: $(1 \times 0.6) + (2 \times 0.1) + (3 \times 0.1) + (4 \times 0.1) + (3 \times 0.1) = 1.8$

C2: $(2 \times 0.6) + (2 \times 0.1) + (2 \times 0.1) + (4 \times 0.1) + (4 \times 0.1) = 2.4$

We then need to calculate the CPU time for each computer, which is an equation given from the lecture:

CPU for P1: $\frac{13 \times 1.8}{4} = 5.85 \rightarrow$ where 4 is the clock rate for P1

CPU for P2: $\frac{14 \times 2.4}{6} = 5.6 \rightarrow$ where 6 is the clock rate for P2

Therefore, P2 is faster than P1 by the factor of CPU of P1 divided by CPU of P2, which is: $\frac{5.85}{5.6}$

Problem 8.6
Solution:
Since class A occurs twice as often, we must multiply that by 2, add the rest of the classes and divide it by 6 to get the average CPI:

C1: $\frac{(1 \times 2)+3+3+4+2}{6} = \frac{7}{3}$

C2: $\frac{(2 \times 2)+3+2+3+3}{6} = \frac{5}{2}$

To calculate which is faster, one must multiply we fraction between the clock rate and CPI, as shown below:

$\frac{P2clockrate}{P1clockrate} \times \frac{C1}{C2}$

$= \frac{6}{4} \times \frac{7/3}{5/2}$

$= \frac{6}{4} \times \frac{14}{15}$

$= \frac{84}{60}$

$= \frac{7}{5}$