**Assignment-2**

1. **Assumptions:**

* The inputs are such that the average is always an integer as the div operation used will always give value in terms of integer.
* The size of the array has been directly stored in the variable value ($t8) as 100.
* The given array is pre-filled with the values.

**MIPS Code**

**main:**

**addi $t0, $0, 200** # putting the base address of the array in $t0

**lw $t1, 0($t0)** # Highest value of the array = $t1= array[0]

**lw $t2, 0($t0)** #Lowest value of the array = $t2 = array[0]

**addi $t3,$0,0** #Highest value Index = $t3 =0

**addi $t4,$0,0** # Lowest value Index = $t4 =0

**addi $t6,$0,0** #$t6=sum=0

**addi $t7,$0,0** #$t7=index=0

**addi $t8,$0,100** #t8= value=100

**while:**

**beq $t7,$t8,average**

**lw $s2,0($t0)** #load the value in $s2

**slt $s1,$t1,$s2**  # if $t1 less than $s2 then $s1 will become 1

**bne $s1,$0, Highest**  #if the value of $s1 not equals 0 then move to Highest

**slt $s1,$s2,$t1** # if $s2 less than $t1 then $s1 will become 1

**bne $s1,$0, Lowest**  #if the value of $s1 not equals 0 then move to Lowest

**addi $t7,$t7,1** #index+=1

**addi $t0,$t0,4**  #incrementing the index value of the pointer

**add $t6,$t6,$s2** #increment sum

**j while**

**Highest:**

**add $t1,$0,$s2** # Highest = array[0]

**add $t3,$0,$t7**  #Highest Index= current index

**addi $t7,$t7,1** #index+=1

**add $t6,$t6,$s2** #increment sum

**addi $t0,$t0,4**  #incrementing index value of the pointer

**j while**

**Lowest:**

**add $t2,$0,$s2**  # Lowest = array[0]

**add $t4,$0,$t7**  #LowestInd= current index

**addi $t7,$t7,1**  #index+=1

**add $t6,$t6,$s2** #increment sum

**addi $t0,$t0,4** #incrementing the index value

**j while**

**average:**

**div $t6,$t6,100** #Dividing by 100

**jr $ra**

1. **Throughput = (Total number of instructions/Time taken to complete the instructions)**

**Total time = (CPI)\*(Instruction Count)/(Clock Rate)**

Therefore,

Instruction Count of Program A = (Total time) \* (Clock Rate)/(CPI) = 6\*(10^9)/6 = **10^9**

Instruction Count of Program B = (Total time) \* (Clock Rate)/(CPI) = 5\*(10^9)/5 = **10^9**

Total Instruction count = Instruction count of Program A + Instruction count of Program B

= **2\*(10^9)**

Total time taken to complete the instruction count = maximum of (time taken by A, time taken by B) {This is because the processes are being done in different cores and therefore parallel operation} = **6 seconds**

**Thus, Throughput = (Total number of instructions/Time taken to complete the instructions) = 2\*(10^9)/6 = 10^9/3 = 3.33\*10^8 Instructions per second**

1. **Total time taken = (CPI\* Instruction count)/ (Clock Rate)**

Given Instruction count of processor X for program A = 10\*(10^9)

Given Clock Rate of processor X for program A = 2\*(10^9) Hz

Given avg. CPI of processor X for program A = 3

Total time taken by processor X = 10\*(10^9)\*3/(2\*(10^9) = **15 seconds**

Given CPI of processor Y for program A = 7\*(10^9)

Given Clock Rate of processor Y for program A = 4\*(10^9) Hz

Given avg. CPI of processor Y for program A = 5

Total time taken by processor Y = 7\*(10^9)\*5/(4\*(10^9) = **8.75 seconds**

**Speed up of Program A on processor Y over the processor X = total time taken by processor X/ total time taken by processor Y = (15/8.75) = 1.71428**

**Therefore, Processor Y is 1.71428 times faster than Processor X for program A**

1. **Total time taken = (CPI\* Instruction count)/ (Clock Rate)**

Given Instruction count for program A = 9\*(10^9)

Given Clock Rate for program A = 1\*(10^9) Hz

Given avg. CPI for program A = 1.5

Total time taken by program A on the processor = 9\*(10^9)\*1.5/(1\*(10^9) = **13.5 seconds**

Total time taken by program A on the newly designed processor = total time taken by program A on the previous processor/4 = 13.5/4 = **3.375 seconds**

**Assuming that the ISA remains the same and thus the Instruction count for the program remains the same on the new processor design**

Thus, 3.375 seconds = (CPI of program A on new design\* Instruction count)/(Clock rate of the new processor)

Thus the CPI of the program for the new processor = (3.375\* clock rate of the new processor)/ Instruction count = 3.375\*(2\*10^9)/(9\*10^9) = **0.75**

**Therefore, the CPI of the program on the new processor design is 0.75 counts per instructions**

1. **Here to solve the question I have assumed that the dynamic power constitutes 60% and thus the static power constitutes 40% of the total power. This has been taken according to what has been mentioned in the book**

Dynamic power is given by the formula = **0.5\*C(V^2)\*f**

Here C represents the Capacitance, V represents the voltage and f represents the frequency

Static power is given by the formula = VI

Given total power = 80W

Therefore, according to the assumption, Static power will be 0.4\*80 = 32W

Dynamic Power will be 0.6\*80 =48W

1. Now if the frequency gets increased to 5GHz then the Dynamic Power will become 5/2 times the current dynamic power as the dynamic power is directly proportional to the frequency. Since the earlier frequency was 2 GHz thus the new value will be 5/2 times the current value as it has increased to 5 GHz thus the value of the dynamic power is: 48\*2.5 W = **120 W**
2. Now the operating value of the voltage drops to 2V.

Static power = VI = 32\*(2/5) = **12.8W**

Dynamic power = 0.5\*C(V^2)\*f = (48\*(2/5)^2) = **7.84W**

Overall power consumption = static power + dynamic power = 12.8W +7.84W = 20.64W

**Fraction of static power in the total power = static power/total power = (12.8/20.64) = 0.6201**