CS 161

HW 1

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1.

ISA	IPC	Clock
A	10	500 MHz
B	2	600 MHz

a. $MIPS = \frac{\text{Clock Rate}}{CPI \times 10^6}$

$CPI = \frac{\text{cycles}}{\text{instruction}} = \frac{1}{IPC}$

$IPC = \frac{1}{CPI}$

(A) $MIPS = \frac{\text{clock}}{\frac{1}{IPC} \times 10^6}$

$= \frac{500MHz}{\frac{1}{10} \times 10^6} = \frac{500 \times 10^6}{1 \times 10^5} = 5000$

b. (B) $MIPS = \frac{600MHz}{\frac{1}{2} \times 10^6} = \frac{600m \times 10^6}{0.5 \times 10^6} = 1200$

c. Unable to define, Because A and B are using different ISA instruction set, Even though we can have A and B's MIPS.

2.

Processor	CPI	clock Rate
P1	1.5	3.0 GHz
P2	1.0	2.5 GHz
P3	2.2	4.0 GHz

a. Calculate IPS.

$$IPS = \frac{\text{clock} \times 10^9}{CPI}$$

P1: $\frac{3.0 \times 10^9}{1.5} = 2 \times 10^9$

P2: $\frac{2.5 \times 10^9}{1.0} = 2.5 \times 10^9$

P3: $\frac{4.0 \times 10^9}{2.2} = 1.8 \times 10^9$

b. number of cycles | number of instructions (in 10 seconds)

P1: $3 \times 10^9 \times 10 = 3 \times 10^{10}$

P2: $2.5 \times 10^9 \times 10 = 2.5 \times 10^{10}$

P3: $4.0 \times 10^9 \times 10 = 4 \times 10^{10}$

P1: $2 \times 10^9 \times 10 = 2 \times 10^{10}$

P2: $2.5 \times 10^9 \times 10 = 2.5 \times 10^{10}$

P3: $1.8 \times 10^9 \times 10 = 1.8 \times 10^{10}$

c. $\text{execution time} = \frac{\text{Instruction count} \times CPI}{\text{clock Rate}}$

$\text{clock Rate} = \frac{\text{Instruction count} \times CPI\ (120\%)}{\text{execution time}\ (70\%)}$

$\frac{120\%}{70\%} = 1.714$

increase of 71.4% on clock Rate

3.

	CPI				
Processor	A	B	C	D	Clock Rate
P1	1	2	3	3	2.5GHz
P2	2	2	2	2	3.0 GHz

case 1

case 2.

Weighted average CPI

$$CPI = \frac{\text{clock Cycle}}{\text{Instruction Count}} = \sum_{i=1}^{n} \left(CPI_i \times \frac{\text{Instruction Count}_i}{\text{Instruction Count}} \right)$$

a. P1: $1 \times \frac{1}{10} + 2 \cdot \frac{2}{10} + 3 \cdot \frac{5}{10} + 3 \cdot \frac{2}{10}$

$= 0.1 + 0.4 + 1.5 + 0.6 = 2.6$

CPI (global)

P2: $2 \cdot \frac{1}{10} + 2 \cdot \frac{2}{10} + 2 \cdot \frac{5}{10} + 2 \cdot \frac{2}{10}$

$= 0.2 + 0.4 + 1 + 0.4 = 2.$

CPI (global)

b. clock Cycle = Instruction Count $\cdot$ CPI

P1: $1 \times 10^6 \cdot 2.6 = 2.6 \times 10^6$

P2: $1 \times 10^6 \cdot 2 = 2 \times 10^6$.

4.

Complier	instruction count	execution time
A	1×10^9	1.1s
B	1.2×10^9	1.5s.

a. $1ns = 1\times10^{-9}\cdot s$

$$\text{CPU time} = \text{Execution time} = \frac{\text{Instruction Count} \times \text{CPI}}{\text{clock rate}}$$

Execution time = Instruction count × CPI × clock cycle time

$$\text{(AVG) CPI} = \frac{\text{Execution time}}{\text{Instruction Count} \times \text{clock Cycle Time}}$$

$$A: \frac{1.1s}{1\times10^9 \cdot 1\times10^{-9}s} = 1.1 \qquad B: \frac{1.5s}{1.2\times10^9 \cdot 1\times10^{-9}s} = 1.25$$

b. Unknow variable: execution time..

$$\text{clock cycle time} = \frac{\text{Execution time}}{\text{Instruction Count} \cdot \text{CPI}} =$$

$$\frac{A}{B}: \frac{\frac{\text{Execution time}A}{\text{Instruction count}A \cdot \text{CPI}A}}{\frac{\text{Execution time}B}{\text{Instruction count}B \cdot \text{CPI}B}} = \frac{\text{Execution time}A}{\text{Execution time}B} \cdot \frac{\text{Instruction count}B \cdot \text{CPI}B}{\text{Instruction count}A \cdot \text{CPI}A}$$

result is unknown due to unkown execution time

$$= \frac{\text{Execution time}A}{\text{Execution time}B} \cdot \frac{1.2\times10^9 \cdot 1.25}{1\times10^9 \cdot 1.1}$$

$$= 1.36\ \frac{\text{Execution time}A}{\text{Execution time}A}$$

c. instruction count · CPI $= 6\times10^8 \cdot 1.1 = 6.6\times10^8$

$$\frac{\text{new complier}}{A} = \frac{6.6\times10^8}{11\times10^8} = 0.6 \qquad \frac{1}{0.6} = 1.67 \text{ performace increase } 0.67$$

$$\frac{\text{new complier}}{B} = \frac{6.6\times10^8}{12\times10^8 \cdot 1.25} = 0.44 \qquad \frac{1}{0.44} = 2.27 \text{ increase } 1.27.$$

5.

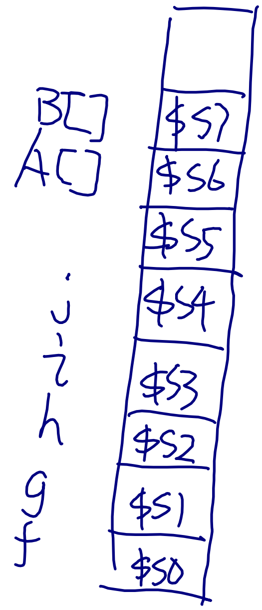
$$\text{Speed up}_{total} = \frac{1}{\left(1-\text{Fraction}_{\text{enhanced}1}-\text{Fraction}_{\text{enhanced}2}\right)+\frac{\text{Fraction enhanced}1}{\text{Speedup enhanced}1}+\frac{\text{Fraction enhanced}2}{\text{Speedup enhanced}2}}$$

$$= \frac{1}{(1-0.3\cdot 0.8-0.3\cdot 0.2\cdot 0.5)+\frac{0.3\cdot 0.8}{4}+\frac{0.3\cdot 0.2\cdot 0.5}{2}}$$

$$= \frac{1}{0.805} = 1.24$$

6、

```
  sll  $t0, $s0, 2       # $t0 = f·4
  add  $t0, $s6, $t0     # $t0 = &A[f]
  sll  $t1, $s1, 2       # $t1 = g·4
  add  $t1, $s7, $t1     # $t1 = &B[g] ☆
  lw   $s0, 0($t0)       # f = A[f]
  addi $t2, $t0, 4       # $t2 = &A[f+1]
  lw   $t0, 0($t2)       # $t0 = A[f+1]
  add  $t0, $t0, $s0     # $t0 = A[f+1]+A[f]
  sw   $t0, 0($t1)       # B[g] = A[f+1]+A[f]
```



f = A[f];

f = A[f+1] + A[f]

B[g] = f

7. B[8] = A[i] + A[j] ;

```
sll  $t0, $s3, 2      # $t0 = i·4
add  $t0, $t0, $s6    # $t0 = &A[i]
lw   $t0, 0($t0)      # $t0 = A[i]
sll  $t1, $s4, 2      # $t1 = j·4
add  $t1, $t1, $s6    # $t1 = &A[j]
lw   $t1, 0($t1)      # $t1 = A[j]
add  $t2, $t0, $t1    # $t2 = A[i] + A[j]
sw   $t2, 32($s7)     # B[8] = A[i]+A[j]
```

32 = 4×8

B[]	$s7
A[]	$s6
j	$s4
i	$s3
h	$s2
g	$s1
f	$s0

8、

```
addi  $t0, $s6, 4      # $t0 = &A[1]
add   $t1, $s6, $0     # $t1 = &A[0]
sw    $t1, 0($t0)      # A[0] = A[1]
lw    $t0, 0($t0)      # $t0 = A[0]
add   $s0, $t1, $t0.   # f = A[0] + A[1]
```

$A[1] = A[0];$

$f = A[0] + A[1]$

9. t0 has 0x0010 1000

```
slt   $t2, $0, $t0      #
bne   $t2, $0, ELSE.    #
j DONE
ELSE:
      addi  $t2, $t2, 2  #

DONE:
```

① Compare $0 and $t0:

if $0 < $t0

$t2 = 1; ✓ ⇒ next ②

else

$t2 = 0;

② Not equal

if($t2 != $0)

{ ELSE;} ✓ ⇒ next ③

③ Adding 2 to $t2.

$t2 + 2 = 3.

$t2 = 3.