

HW5

4.31

4.31.1

- 同type要等execution unit空才可以進去

cycle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
li x12, 0	IF	ID	EX	ME	WB																					
jal ENT	IF	ID	...	EX	ME	WB																				
bne x12,x13,TOP		IF	...	ID	EX	ME	WB																			
slli x5, x12, 3		IF	...	ID	...	EX	ME	WB																		
add x6, x10, x15				IF	...	ID	EX	ME	WB																	
ld x7, 0(x6)				IF	...	ID	...	EX	ME	WB																
ld x29, 8(x6)						IF	...	ID	EX	ME	WB															
sub x30, x7, x29						IF	...	ID	...	...	EX	ME	WB													
add x31, x11, x5							IF	...	...	ID	EX	ME	WB													
sd x30, 0(x31)							IF	...	...	ID	...	EX	ME	WB												
addi x12, x12, 2											IF	...	ID	EX	ME	WB										
bne x12, x13, TOP											IF	...	ID	...	EX	ME	WB									
slli x5, x12, 3												IF	...	ID	EX	ME	WB									
add x6, x10, x15												IF	...	ID	...	EX	ME	WB								
ld x7, 0(x6)													IF	...	ID	EX	ME	WB								
ld x29, 8(x6)														IF	...	ID	...	EX	ME	WB						
sub x30, x7, x29															IF	...	ID	...	EX	ME	WB					
add x31, x11, x5															IF	...	ID	...	...	EX	ME	WB				
sd x30, 0(x31)																	IF	...	...	ID	EX	ME	WB			
addi x12, x12, 2																	IF	...	...	ID	...	EX	ME	WB		
bne x12, x13, TOP																				IF	...	ID	EX	ME	WB	

4.31.2

- 1-issue needs additional stall between **ld x29, 8(x6)** and **sub x30, x7, x29**
 - 10 cycles per iteration when loop iteration is large
- 2-issue needs 21-2+1 to run 2 iterations
 - 10 cycles per iteration when loop iteration is large
- speedup ≈ 1

4.31.3

- example:

```
    beqz x13, DONE
    li x12, 0
    jal ENT
TOP:
    slli x5, x12, 3
    add x6, x10, x5
    ld x7, 0(x6)
    ld x29, 8(x6)
    addi x12, x12, 2
    sub x30, x7, x29
    add x31, x11, x5
    sd x30, 0(x31)
ENT:
    bne x12, x13, TOP
DONE:
```

4.31.4

- example

```
    beqz x13, DONE
    li x12, 0
TOP:
    slli x5, x12, 3
    add x6, x10, x5
    ld x7, 0(x6)
    add x31, x11, x5
    ld x29, 8(x6)
    addi x12, x12, 2
    sub x30, x7, x29
    sd x30, 0(x31)
    bne x12, x13, TOP
DONE:
```

4.31.5

cycle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
beqz x13, DONE li x12, 0	IF IF	ID ID	EX ...	ME EX	WB ME	WB																	
slli x5, x12, 3 add x6, x10, x5		IF IF	...	ID ID	EX ...	ME EX	WB ME	WB															
ld x7, 0(x6) add x31, x11, x5				IF IF	...	ID ID	EX EX	ME ME	WB WB														
ld x29, 8(x6) addi x12, x12, 2						IF IF	ID ID	EX EX	ME ME	WB WB													
sub x30, x7, x29 sd x30, 0(x31)							IF IF	ID ID	...	EX ...	ME EX	WB ME	WB										
bne x12, x13, TOP slli x5, x12, 3								IF IF	...	...	ID ID	EX ...	ME EX	WB ME	WB								
add x6, x10, x5 ld x29, 8(x6)											IF IF	...	ID ID	EX ...	ME EX	WB ME	WB						
addi x12, x12, 2 sub x30, x7, x29													IF IF	...	ID ID	EX ...	ME EX	WB ME	WB				
sd x30, 0(x31) bne x12, x13, TOP															IF IF	...	ID ID	EX ...	ME EX	WB ME	WB		
slli x5, x12, 3 add x6, x10, x5																	IF IF	...	ID ID	EX ...	ME EX	WB ME	WB

4.31.6

- 4.31.3, 9 cycles per iteration
- 4.31.4, $(16-2+1)/2=7.5$ cycles per iteration
- speedup = $9/7.5 \approx 1.19$

4.31.7

- example

```

beqz x13, DONE
li x12, 0
TOP:
    slli x5, x12, 3
    add x6, x10, x5
    add x31, x11, x5
    ld x7, 0(x6)
    ld x29, 8(x6)
    ld x5, 16(x6)
    ld x15, 24(x6)
    addi x12, x12, 4
    sub x30, x7, x29
    sub x14, x5, x15
    sd x30, 0(x31)
    sd x14, 16(x31)
    bne x12, x13, TOP
DONE:

```

4.31.8

- example

```
    beqz x13, DONE li x12, 0
    addi x6, x10, 0
TOP:
    ld x7, 0(x6)
    add x31, x11, x5
    ld x29, 8(x6)
    addi x12, x12, 4
    ld x16, 16(x6)
    slli x5, x12, 3
    ld x15, 24(x6)
    sub x30, x7, x29
    sd x30, 0(x31)
    sub x14, x16, x15
    sd x14, 16(x31)
    add x6, x10, x5
    bne x12,x13,TOP
DONE:
```

4.31.9

cycle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
beqz x13, DONE li x12, 0	IF IF	ID ID	EX ...	ME EX	WB ME	WB																	
addi x6, x10, 0 ld x7, 0(x6)		IF IF	...	ID ID	EX ...	ME EX	WB ME	WB															
add x31, x11, x5 ld x29, 8(x6)				IF IF	...	ID ID	EX EX	ME ME	WB WB														
addi x12, x12, 4 ld x16, 16(x6)						IF IF	ID ID	EX EX	ME ME	WB WB													
slli x5, x12, 3 ld x15, 24(x6)							IF IF	ID ID	EX EX	ME ME	WB WB												
sub x30, x7, x29 sd x30, 0(x31)								IF IF	ID ID	EX ...	ME EX	WB ME	WB										
sub x14, x16, x15 sd x14, 16(x31)									IF IF	...	ID ID	EX EX	ME ME	WB WB									
add x6, x10, x5 bne x12, x13, TOP											IF IF	ID ID	EX EX	ME ME	WB WB								
ld x7, 0(x6) add x31, x11, x5												IF IF	ID ID	EX EX	ME ME	WB WB							
ld x29, 8(x6) addi x12, x12, 4													IF IF	ID ID	EX EX	ME ME	WB WB						
ld x16, 16(x6) slli x5, x12, 3														IF IF	ID ID	EX EX	ME ME	WB WB					
ld x15, 24(x6) sub x30, x7, x29															IF IF	ID ID	EX EX	ME ME	WB WB				
sd x30, 0(x31) sub x14, x16, x15																IF IF	ID ID	EX ...	ME EX	WB ME	WB		
sd x14, 16(x31) add x6, x10, x5																	IF IF	...	ID ID	EX EX	ME ME	WB WB	
bne x12, x13, TOP ld x7, 0(x6)																			IF IF	ID ID	EX EX	ME ME	WB WB

- 4.31.7, 13 cycles every two iterations, 6.5 cycles per iteration
- 4.31.8, $(18-4+1)/2=7.5$ cycles every two iteration2, 3.75 cycles per iteration
- speedup = $6.5/3.75 \approx 1.73$

4.31.10

- no improvement in this case because there are no stalls due to structural hazards

5.5

5.5.1

- 1 word: 4bytes
- $2^5 \text{ bytes} / 4 \text{ bytes} = 2^3 \text{ words} = 8 \text{ words}$

5.5.2

- $2^5 = 32 \text{ blocks}$

5.5.3

- data storage bits: $2^{10} \text{ bytes} = 8192 \text{ bits}$
- bits required for implementation: 54 tag bits and 1 valid bit for each block plus 8192 bits
 - $8192 + (54 + 1) * 32 = 9952 \text{ bits}$
- ratio: $9952/8192 \approx 1.2148$

5.5.4

address	tag	index	offset	hit or miss	bytes replaced
0x00	0x0	0x00	0x00	miss	
0x04	0x0	0x00	0x04	hit	
0x10	0x0	0x00	0x10	hit	
0x84	0x0	0x04	0x04	miss	
0xe8	0x0	0x07	0x08	miss	
0xa0	0x0	0x05	0x00	miss	
0x400	0x1	0x00	0x00	miss	0x00-0x1f
0x1e	0x0	0x00	0x1e	miss	0x400-0x41f
0x8c	0x0	0x04	0x0c	hit	
0xc1c	0x3	0x00	0x1c	miss	0x00-0x1f
0xb4	0x0	0x05	0x14	hit	
0x884	0x2	0x04	0x4	miss	0x80-0x9f

5.5.5

- $4/12 \approx 33\%$

5.5.6

1. $\langle 0x0, 0x3, \text{Mem}[0xc00]-\text{Mem}[0xc1f] \rangle$
2. $\langle 0x4, 0x2, \text{Mem}[0x880]-\text{Mem}[0x89f] \rangle$
3. $\langle 0x5, 0x0, \text{Mem}[0x0a0]-\text{Mem}[0x0bf] \rangle$
4. $\langle 0x7, 0x0, \text{Mem}[0x0e0]-\text{Mem}[0x0ff] \rangle$