

- #1 Structural Hazard
- #2 Pipelining
- #3 Pipeline Data Hazard
- #4 Temporal Locality
- #5 Control

#6

$$\frac{2227}{8192} = 0.27, \text{tag} = 0 \quad \text{TLB} = \text{miss}, \text{Page Table: valid bit} = 1, \text{page num} = 5$$

$$\frac{4669}{8192} = 0.57, \text{tag} = 0 \quad \text{TLB} = \text{hit}$$

$$\frac{13916}{8192} = 1.69, \text{tag} = 1 \quad \text{TLB} = \text{miss}, \text{Page Table: valid bit} = 0, \text{page \#} = 24, \text{page fault}$$

$$\frac{12108}{8192} = 1.54, \text{tag} = 1 \quad \text{TLB} = \text{hit}$$

$$\frac{49225}{8192} = 6.01, \text{tag} = 6 \quad \text{TLB} = \text{miss}, \text{Page Table: valid bit} = 0, \text{page \#} = 48, \text{page fault}$$

$$\frac{39587}{8192} = 4.22, \text{tag} = 4 \quad \text{TLB} = \text{miss}, \text{Page Table: valid bit} = 1, \text{page \#} = 9$$

$$\frac{48870}{8192} = 5.96, \text{tag} = 5 \quad \text{TLB} = \text{miss}, \text{Page Table: valid bit} = 1, \text{page \#} = 11$$

Page Table

Valid	Page #
1	5
1	24
0	Disk
1	6
1	9
1	11
1	48
1	4
0	Disk
0	Disk
1	3
1	12

TLB

Valid	Tag	Page #	LRU
1	4	9	1
1	5	11	0
1	1	24	3
1	6	48	2

#8 2 word blocks = 36 bit offset
 8 blocks = 3 bit index

because all of the given numbers fit inside 5 bits, the tag field is always zero

one-way set associative (direct-mapped)

Decimal	Binary	offset	index	tag	Hit/miss
21	10101	101	010	0	M
24	11000	000	011	0	M
21	10101	101	010	0	H
18	10010	010	010	0	H
15	01111	111	001	0	M
3	00011	011	000	0	M
15	01111	111	001	0	H
15	01111	111	001	0	H
14	01110	110	001	0	H

4-misses

two-way set associative

Dec	Binary	offset	index	tag	Hit/miss
21	10101	101	10	0	M
24	11000	000	11	0	M
21	10101	101	10	0	H
18	10010	010	10	0	H
15	01111	111	01	0	M
3	00011	011	00	0	M
15	01111	111	01	0	H
15	01111	111	01	0	H
14	01110	110	01	0	H

4-misses

$\frac{2 \text{ blocks}}{2 \text{ way}} = 4 \text{ sets} = 2^2$ 2 bits index (tag = 0 st)

#2 continued

four-way set associative

$$\frac{8 \text{ blocks}}{4 \text{ way}} = 2 \text{ sets} = 2^1 \text{ 1 bit index} \quad \text{tag} = 1 \text{ bit}$$

Dec	Binary	offset	index	tag	Hit/miss
21	10101	101	0	1	M
24	11000	000	1	1	M
21	10101	101	0	1	H
18	10010	010	0	1	H
15	01111	111	1	0	M
3	00011	011	0	0	M
15	01111	111	1	0	H
15	01111	111	1	0	H
14	01110	110	1	0	H

4-misses

2-way set associative

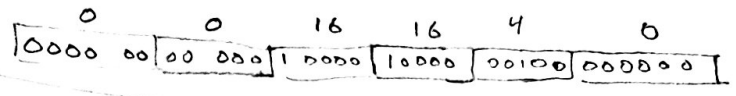
$$\frac{8 \text{ blocks}}{8 \text{ way}} = 1 \text{ set} = 2^0 \text{ 0 bit index} \quad \text{tag} = 2 \text{ real 6 bits}$$

Dec	Binary	offset	index	tag	H/M
21	10101	101	N/A	10	M
24	11000	000	1	11	M
21	10101	101	1	10	H
18	10010	010	1	10	H
15	01111	111	1	01	M
3	00011	011	1	00	M
15	01111	111	1	01	H
15	01111	111	1	01	H
14	01110	110	1	01	H

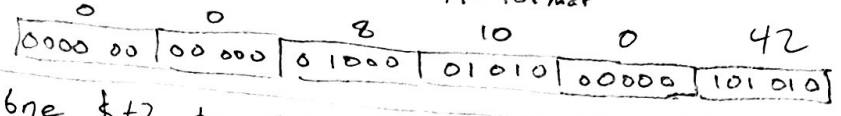
4-misses

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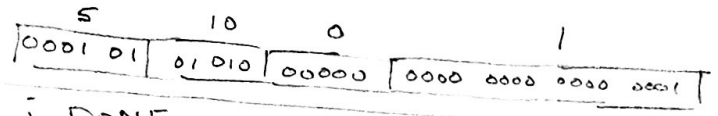
#9 sll \$t0, \$s0, 4 - R-format



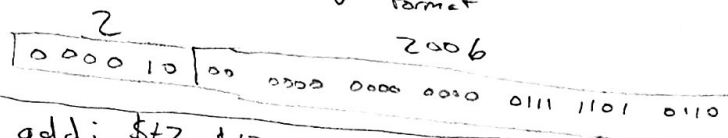
sllt \$t2, \$0, \$t0 - R-format



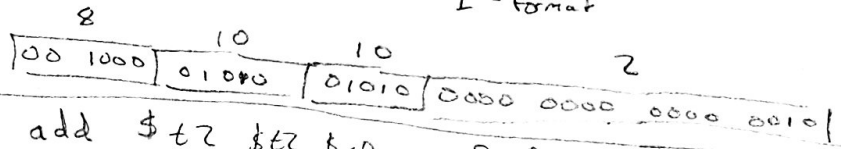
bne \$t2, \$0, ELSE - I-format



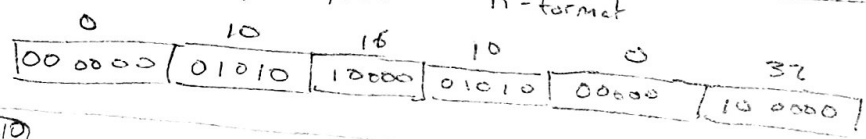
j DONE - J-format



addi \$t2, \$t2, 2 - I-format



add \$t2, \$t2, \$s0 - R-format



#10 263.3
+m

half-precision 010111 00000 111 01

single 01000 0111 0000 0111 0100 1100 1100 110

double 0100 0000 0111 0000 0111 0100 1100 1100 1100 1100 1100 1100 1100 1100 1101

#12 3 GHz = 3×10^9 cycles/sec

$$P1 = 3 \times 10^9 \frac{\text{cycles}}{\text{sec}} \cdot \frac{1 \text{ instruction}}{2.5 \text{ cycles}} = 1.2 \times 10^9 \text{ instructions/sec}$$

$$P2 = 3 \times 10^9 \frac{\text{cycles}}{\text{sec}} \cdot \frac{1 \text{ instruction}}{1 \text{ cycle}} = 3 \times 10^9 \text{ instructions/sec}$$

P2 has better performance

$$P1 = 3 \times 10^9 \frac{\text{cycles}}{\text{sec}} \cdot 30 \text{ sec} = 9 \times 10^{10} \text{ cycles}$$

$$1.2 \times 10^9 \frac{\text{inst}}{\text{sec}} \cdot 30 \text{ sec} = 3.6 \times 10^9 \text{ instructions}$$

$$P2 = 3 \times 10^9 \frac{\text{cycles}}{\text{sec}} \cdot 30 \text{ sec} = 9 \times 10^{10} \text{ cycles}$$

$$3 \times 10^9 \frac{\text{inst}}{\text{sec}} \cdot 30 \text{ sec} = 9 \times 10^{10} \text{ instructions}$$