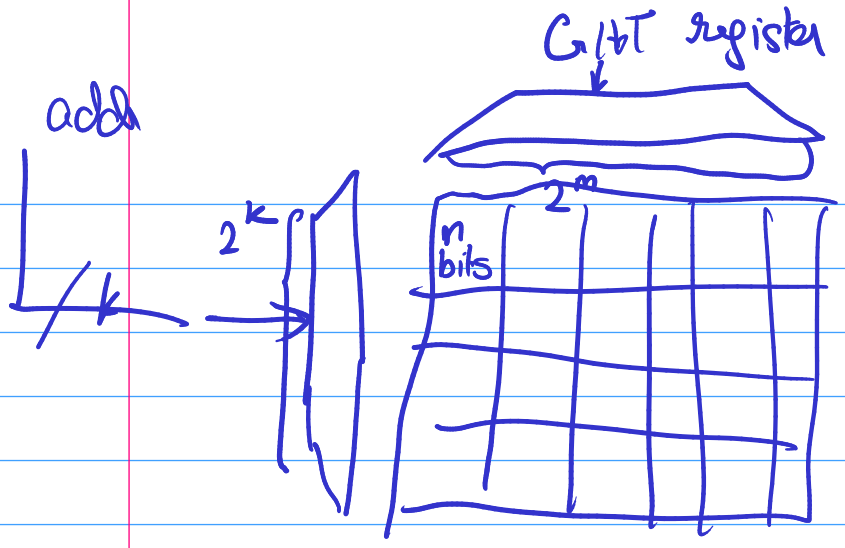
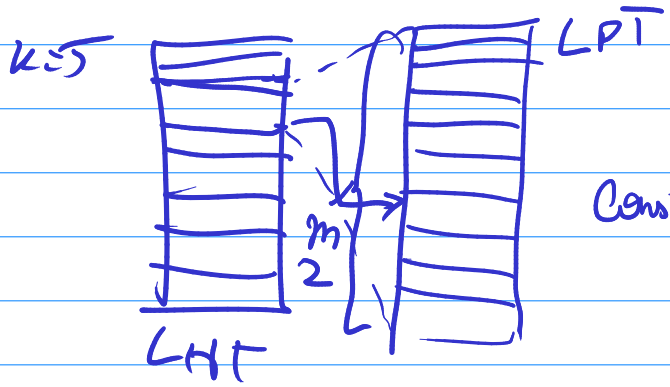
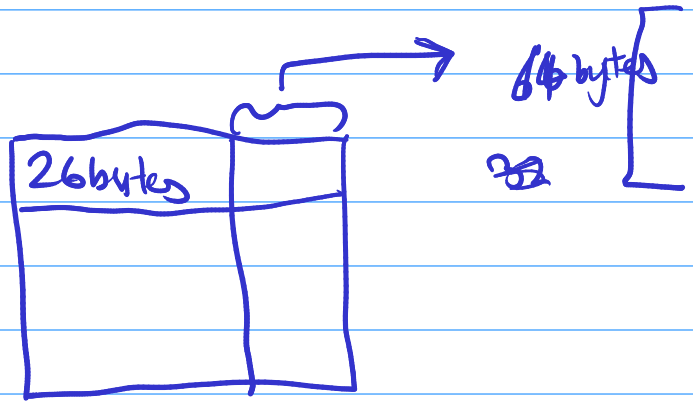


(m,n) branch predictor

Another way:



Const vector<const vector<const tuple>>

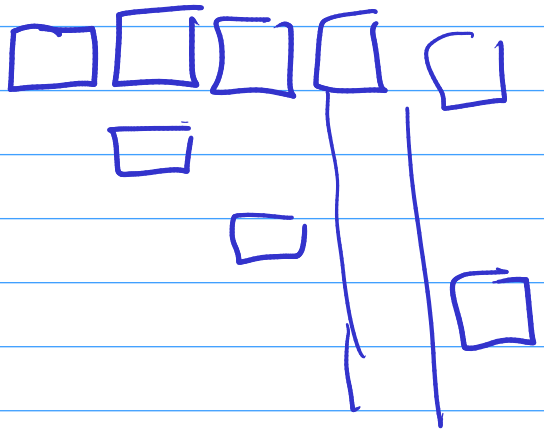


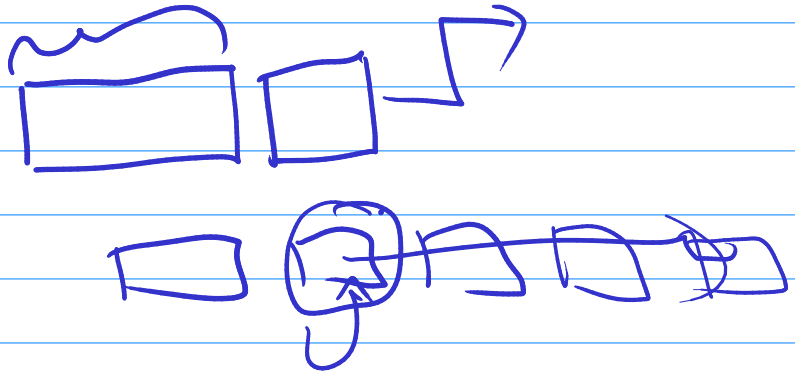
$$\frac{500ns}{100ns} = 5 inst$$

$$\frac{500000}{100749 \times 20} \approx$$

40% CPI = 1

40% : 5 (1.0 ns)



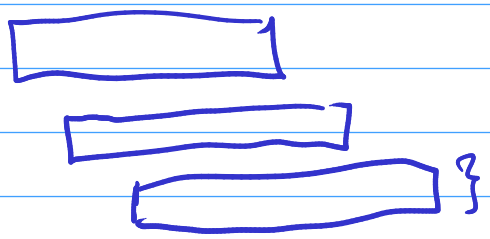


$(0.9 \times 0.1 \times 2)$ 0.09

$+(0.6 \times 0.1 \times 2)$ 18

$0.054 + 0.06$

0.228 cycles



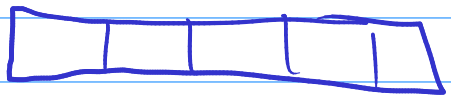
18% → 30%

(8% * 70% (60% × 62% + 40% × 1)

~~18%~~ ((42% × 62%) + 28% × 1)

if f_1 f_2 f_3 D Ex Mem1,2,3 WB

$32 \times 2^2 \times 2 = 256$



$16 \times 2^2 \times 2 = 128$

20% +

80%(66% × 0.5 + 34%)

1

2% 200

(1.5 mem / inst)

(30/1000 each misses)

1 + 0.02 × 200 × 1.5 = same

1 + 0.03 × 200

20 bits

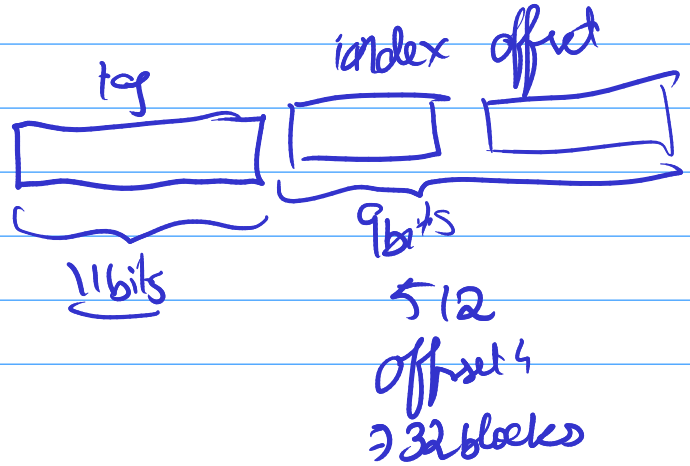
2(a) 11 bits 8

9 bits

index offset

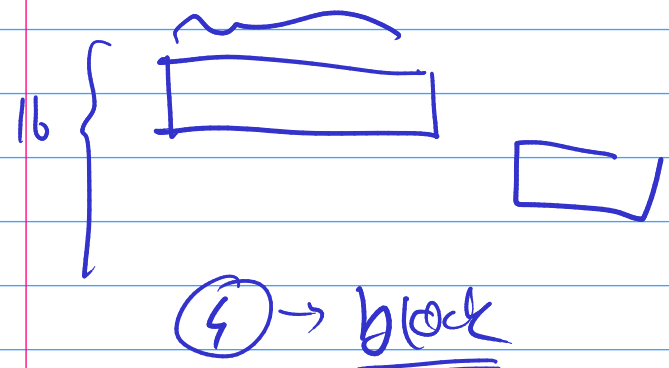
16 words

2(b)



2.4 clock cycles

2.4 clock cycles



(20% 100 60% x 4)

4 → block

0.12

12x4 = 48%

2.4 CC average access time

Found : 1 cloc

NF : 80 CC

2.4 = 1 + miss x 80

miss = 1.75

( ) + 1.75 x (6 + 2 x 80) = 100/165 x 24

z = Miss rate = 29.96

1 - z = 75%

A1:

4KB 16 bytes/line ⇒ $\frac{1}{4}$KB = 256B 8 bit index Line offset 3 bit w/offset

16MB ⇒ 24 bits 4 2 0 4 2 4 13 bit 11 bit offset

B D A : Line 42 } replace
B : Line 42 }

74C C Line 66 } Don't replace
740 D 66 }

0xB7496

B74 | 100100 | 10

offset

1011 0111 0100 1001 0110

100100

32 bytes Block size

VM: 64 bits PM: 48 bits Pg Size 8kB P.S. 4B word

TLB: 128 entries

Word addressable ⇒ 2^{11} addresses

2^{13} = 8kB

48 bits = $2^{48-13} = 2^{35}$ pages

64

128 x .

2^7

$\frac{2^{64} \times 4}{8 \times 2^{10}}$

$2^7 \times 2^{11} = 2^{18}$

#pages → $\frac{2^{64} \times 4}{2^{10} \times 8} = 2^{53}$

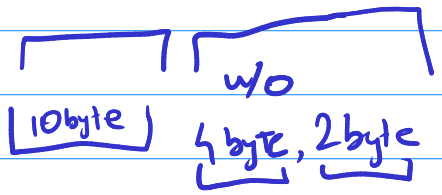
(extra cache, not in q.)

512 kB
4B word
64 B block size

8 way set associative
4 GB MEM

ABC39984

64 / 8 = 512 B



10011001 1000 0100

48569AC

01101001 1010 1100

3ns to access tag array value
4.2ns data array access
1.3ns hit/miss comparison

(∵ Tag search + Data access occur parallely)

Code Max(3 + 1.3, 4.2) + 1

Hit latency:

3 8 2 3 9 1 6 3 8 9 3 6 2 1 3

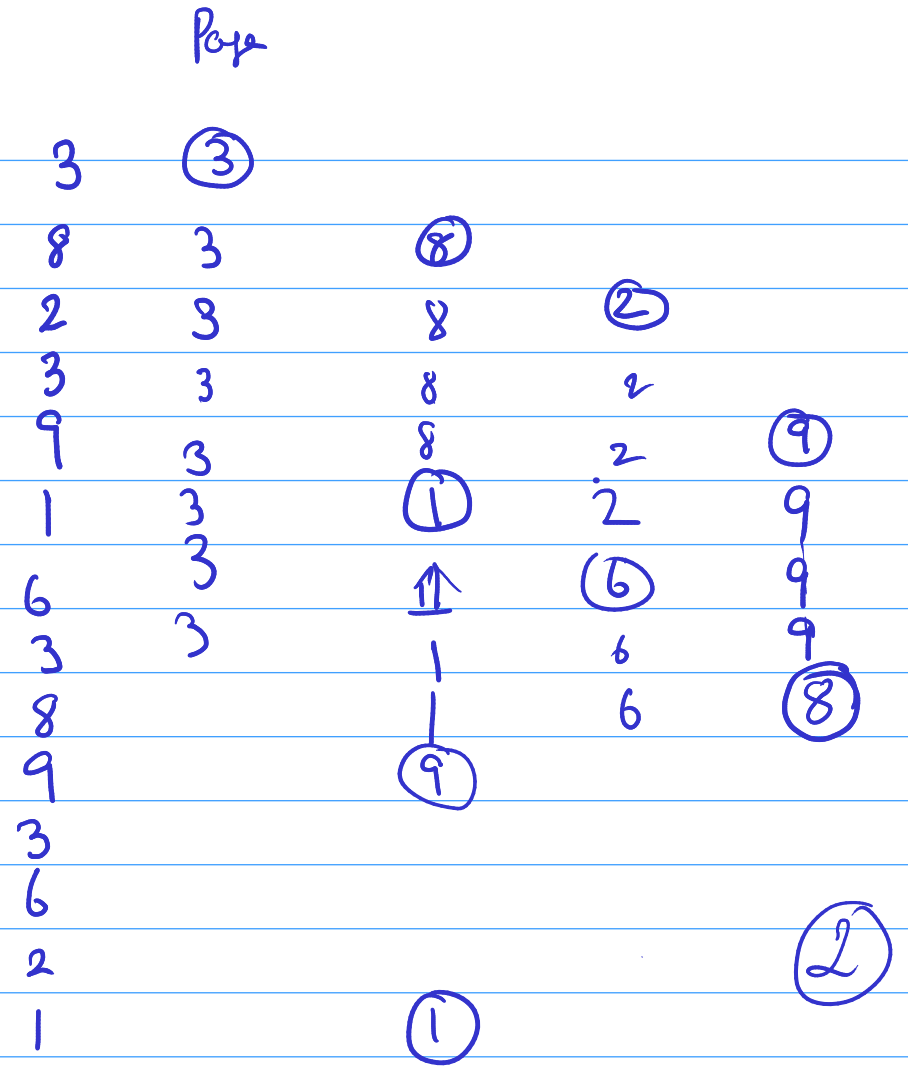
16 bits

16KB page size:

$\frac{2^{16}}{2^{14}} = 4$ pages in main memory

12 page fault FIFO

6
7
8
9
10
11
12



Two level paging TLB

~~no pg fault~~

20ns to search TLB

100ns phy mem 80% HR

EAT

$$EAT = HR\,(TLB + \text{Main mem}) + (1-HR)\,(\text{MM for level 1 page table} + \text{MM for level 2 page table} + \text{MM for data} + \text{TLB access to determine miss})$$

$$= 0.8\,(20+100) + 0.2\,(100+100\times 2+20)$$

$$= 160\text{ns}$$