154B Discussion 8

March 4th, 2022

Goals

- VM Quiz
- Assignment 5
  - Some basics of running gem5 and the stats

VM Quiz

Question5 Flat translation table [0x1234; 0x5678; 0x9abc; 0xdef0]
0 1 2 3

64kiB page size

Physical Address [PFN | page-offset]

Virtual Address [VPN | page-offset]

Size of the Virtual address space?
$2^{(\#\text{bits of virtual address})}$

64 KiB page size → 16 bits for page-offset

2^{16} bytes

VA

0x1|465c
VPN page-offset

→

PA

0x5678|465c
PFN page-offset

VM Quiz

Question 8

Memory latency: 100 cycles

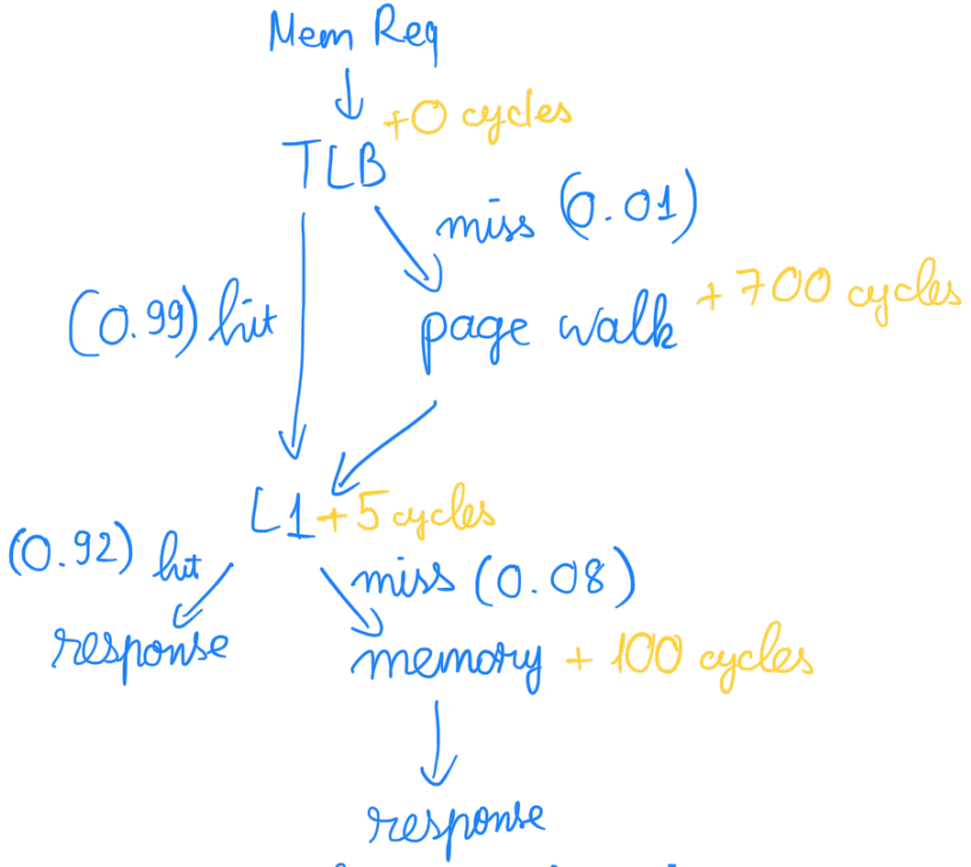
Avg. page walk time: 700 cycles

TLB latency: 0 cycles

TLB hit rate: 99%

L1 hit rate: 92%

L1 hit time: 5 cycles



$AMAT = AMAT_{TLB} + AMAT_{cache}$

$= TLB\_miss\_rate \times page\_walk\_time + L1\_hit\_time + L1\_miss\_rate \times mem\_latency$

$= (1 - 0.99) \times 700 + 5 + (1 - 0.92) \times 100 = \ldots$

VM Quiz

Question 6

- base page size: 16 kiB
- PTE: 32 bits
- 4 levels of page tables.

page table size: 16 kiB → 2^{14} bytes

$$\#\text{ entries} = \frac{\text{page table size}}{\text{PTE size}} = \frac{2^{14}}{2^2} = 2^{12}$$

$$\#\text{ index bits} = \log_2(\#\text{ entries}) = 12$$

vaddr space $= 2^{48} \times 2^{14} = 2^{62}$ bytes $= 2^{22}$ TiB

PTE → page table entry

PAddr: [PFN | page-offset]

VAddr: [VPN | page-offset]

page size (in bytes) $= 2^{\#\text{bits of page-offset}}$

$2^{14} =$

→ # page-offset-bits = 14

L1: 1 table mapping to 2^{12} tables at L2

L2: 2^{12} tables, each maps to 2^{12} tables at L3

L3: 2^{24} tables, each maps to 2^{12} tables at L4

L4: 2^{36} tables, each has 2^{12} PFNs

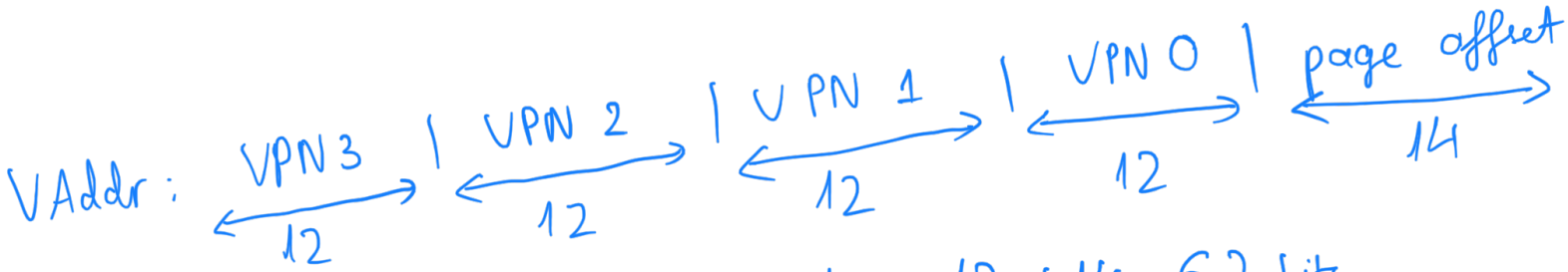
→ 2^{48} PFNs in total ($2^{36} \times 2^{12}$)

or, 2^{48} VPNs, each maps to a range of VAddr of size $2^{\#\text{bits of page-offset}}$ bytes

VM Quiz

Question 6 (cont.)

OR, size of VAddr space = $2^{\#\text{ bits of VAddr}}$



bits of VAddr = 12 + 12 + 12 + 12 + 14 = 62 bits

VM Quiz

SATP: 0x6c52 7400 (PAddr of root page table)

Effective address: 0x02533898

Question 9

2^{16} bytes → 16 bits for page_offset

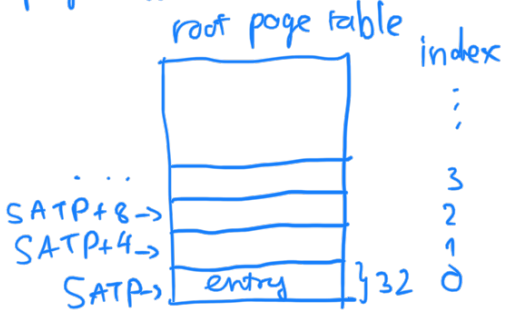
Page size: 64kiB

PAddr: 32 bits

VAddr: 26 bits

2-level page table

All PTEs are 32 bits



PAddr: [PFN (16) | page_offset (16)]

VAddr: [VPN1 (5) | VPN0 (5) | page_offset (16)]

Physical Address	4 bytes of data
0x6c52 7400	0x352c 7f53
0x6c52 7448 →	0x746d 3520
0x746d 356C	0x0000 1524

PAddr of the entry of L1 page table

↳ SATP + entry_size × VPN1

0x6c527400 + 4×18

hexadecimal decimal

= 0x6c527448

mem[0x6c527448] = 0x746d3520

PAddr of the table of L2

Effective Addr:

0x0253 | 3898

VPN page_offset

0x0253

0000 00 | 10 0101 | 0011

VPN1 VPN0

VPN1 = 18

VPN2 = 19

index of 1st level

index of 2nd level

VM Quiz

Physical Address	4 bytes of data
0x6c527400	0x352c7f53
0x6c527448	0x746d3520
0x746d356C	0x00001524
0x15243898	...

the page table at L2

mem[0x6c527448] = 0x746d3520
PAddr of the table at L2

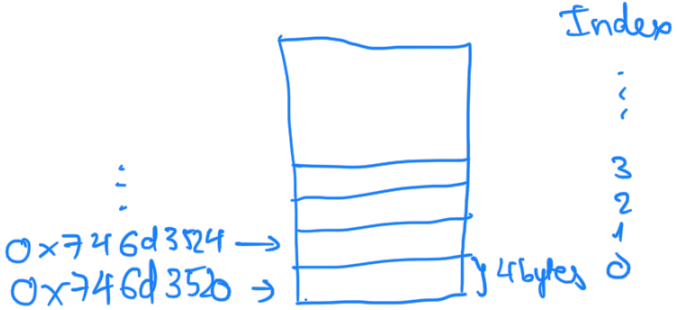
0x746d3520 + entry size x VPN
4 x 19
= 0x746d356c

ignore | PFN

mem[0x746d356c] = 0x00001524

Recall that for this problem, PFN is 16 bits long

PAddr = [PFN | page-offset] = 0x15243898
PFN | page-offset



So, the VAddr 0x02533898 is translated to PAddr 0x15243898.
So, mem[0x15243898] contains the answer.

VM Quiz