

## 8. Multi-level page tables

PAGING: SMALLER TABLES**Homework**

This fun little homework tests if you understand how a multi-level page table works. And yes, there is some debate over the use of the term "fun" in the previous sentence. The program is called, perhaps unsurprisingly: `paging-multilevel-translate.py`; see the README for details.

From the README, we have:

Some basic assumptions:

- The page size is an unrealistically-small 32 bytes
- The virtual address space for the process in question (assume there is only one) is 1024 pages, or 32 KB
- Physical memory consists of 128 pages

Thus, a virtual address needs 15 bits (5 for the offset, 10 for the VPN). A physical address requires 12 bits (5 offset, 7 for the PFN).

The system assumes a multi-level page table. Thus, the upper five bits of a virtual address are used to index into a page directory; the page directory entry (PDE), if valid, points to a page of the page table. Each page table holds 32 page-table entries (PTEs). Each PTE, if valid, holds the desired translation (physical frame number, or PFN) of the virtual page in question.

The format of a PTE is thus:

VALID | PFN6 ... PFN0

and is thus 8 bits or 1 byte.

The format of a PDE is essentially identical:

VALID | PT6 ... PT0

For this question, assume the PDBR (page-directory base register) is 81. On the next two pages is the physical memory dump, where your answers will go.

- (a) CIRCLE which bytes are accessed during a load from virtual address 0x0e5e.
- (b) Put SQUARES around bytes accessed during a load from virtual address 0x012b

If you are curious, I am using `./paging-multilevel-translate.py -s 501 -n 5` to get the numbers for this question.

use `./paging-multilevel-translate.py -s 501 -n 5 -c`  
to get the answers.

page	0:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
page	1:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
page	2:	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	d8	7f	90	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	b8	7f	7f	7f	7f	
page	3:	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	a5	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	
page	4:	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	f8	7f	7f	fe	7f	7f	7f	7f	7f	
page	5:	0d	07	0b	17	08	06	1e	16	07	12	14	0f	0b	16	19	12	1d	1e	03	0f	11	1a	0b	1c	0d	05	03	0d	07	07	1a	15
page	6:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
page	7:	08	0b	0d	0d	15	16	10	19	18	0f	0e	18	18	19	03	06	0c	13	03	08	1a	00	07	02	17	18	08	09	18	12	0f	18
Page	8:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
page	9:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
page	10:	7f	7f	7f	be	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	7f	99	7f	7f	7f	7f	7f	7f	7f	d3	7f	7f	7f	7f	d	
page	11:	18	16	09	12	13	11	05	1c	1c	06	06	03	09	1e	09	00	08	06	15	08	00	07	1d	10	04	0f	08	04	18	16	08	0
page	12:	1c	0f	15	08	10	19	1c	0e	15	18	13	08	00	17	03	15	0b	14	0a	02	12	14	16	0b	1b	0f	01	0a	05	03	06	12
page	13:	0e	11	03	03	0d	10	1e	07	14	12	03	16	08	1c	05	1a	0b	0a	1c	11	12	14	14	14	13	09	12	14	01	04	15	0b
page	14:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
page	15:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
page	16:	03	10	18	0b	0b	06	14	0a	16	1d	16	0f	16	01	08	07	03	0f	04	13	1a	02	0b	12	1a	0d	13	0b	0e	17	0f	02
page	17:	09	12	18	0e	06	0d																										



page 65: 04 17 0a 12 11 00 16 17 1a 07 02 05 03 13 0b 1e 1c 03 1d 01 0d 19 00 09 0f 02 17 02 1a 0e 0c 1b  
page 66: 14 0f 1c 09 08 0b 12 0f 0f 0c 04 05 03 15 18 16 16 17 0b 03 13 1b 00 03 0e 1d 0d 0b 03 14 00 0e  
page 67: 7f 7f 7f c1 7f 7f 7f 7f 7f 7f ac 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 68: 13 1e 05 16 0b 13 11 0e 1e 12 10 1d 12 17 0c 05 0d 11 14 1d 14 15 1a 0b 15 19 17 16 10 15 09 09  
page 69: 0f 14 16 09 00 10 17 04 00 15 1b 1c 19 01 0b 07 0d 0a 02 03 1e 0a 0d 10 03 15 1d 11 03 0d 07 1e  
page 70: 00  
page 71: 7f  
page 72: 14 05 15 0e 16 18 17 0a 09 15 15 01 1a 13 00 1b 01 13 06 07 1c 0c 0b 1b 10 13 0c 12 1a 0c 01 0a  
page 73: 00  
page 74: 7f 7f 7f 91 7f 7f 7f 7f 7f 7f 7f 7f 7f b7 7f 7f 7f 7f 7f 8c 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 75: 7f 7f a8 7f  
page 76: 00  
page 77: 13 0e 18 06 05 1e 1e 09 07 08 17 17 17 0d 00 1c 1c 17 17 0a 1d 0e 17 16 14 07 17 11 10 16 11 09  
page 78: 01 12 16 04 1e 18 16 1c 08 0c 1e 0b 05 1a 03 1c 1b 1c 1d 17 02 04 00 1d 15 02 19 01 0a 16 19 02  
page 79: 05 1e 08 02 0c 17 07 16 10 15 00 1a 05 18 0d 14 05 19 0b 05 16 05 01 0b 19 1b 0d 19 1e 0b 15 13  
page 80: 7f  
page 81: b6 95 d9 83 db e3 c7 b5 ca 7f 7f a2 c3 7f cb eb f0 8a 7f aa e7 e1 a4 d0 82 7f 84 ad e0 fd 9c fb  
page 82: 00  
page 83: 04 05 0e 06 0e 17 14 0c 16 02 05 1c 0d 07 04 0f 17 06 04 03 16 03 03 05 05 12 0b 17 00 0e 12 06  
page 84: 00  
page 85: 00  
page 86: 00  
page 87: 19 0d 09 1a 0b 05 08 0f 13 1d 00 02 1b 06 1d 0b 15 15 1c 15 12 14 0e 0a 14 13 16 0d 1d 1d 0f 0d  
page 88: 1b 14 15 03 10 02 1c 03 17 00 1c 01 19 1a 0b 13 09 0e 04 05 15 19 1c 1c 01 09 18 04 1e 19 00 0f  
page 89: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f b0 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 90: 08 03 01 1b 1c 13 07 11 05 15 1d 1c 0e 08 0e 11 0f 01 19 1b 18 19 12 0f 08 00 04 12 09 03 0a 08  
page 91: 87 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f ea 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 92: 13 1e 0b 02 06 1a 1a 0b 16 1b 0a 08 1e 0b 1c 07 1d 01 0a 0d 01 19 1d 0c 15 08 09 14 0f 03 1e 1e  
page 93: 00  
page 94: 1b 04 0e 08 1a 1e 15 19 0e 16 19 1e 00 02 1e 0d 07 0f 18 1e 01 1b 0c 18 06 16 0a 07 13 0e 1d 13  
page 95: 0a 11 17 1b 04 0a 03 00 02 07 04 13 19 15 01 0d 08 1c 04 05 0c 01 1d 05 14 18 0e 13 16 1b 0e 04  
page 96: 7f 7f 7f 7f f2 7f  
page 97: 7f ed  
page 98: 00  
page 99: 7f c8 7f  
page 100: 00  
page 101: 00  
page 102: 10 05 00 10 0c 16 15 19 05 00 1c 13 0b 18 13 01 0f 03 1c 03 1c 0b 1e 10 1c 0a 0d 07 0d 06 0b 08  
page 103: 7f 7f 7f 9e 7f  
page 104: 00  
page 105: 00  
page 106: 09 12 01 10 11 04 0a 0e 1c 00 0c 06 14 02 1b 07 1a 04 13 0f 0f 05 08 1d 07 11 0f 11 07 0a 1b 01  
page 107: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f ba 7f 7f 7f 7f 7f ce 7f 7f 7f 7f 7f c4 7f 7f 7f 7f 7f 7f 7f af 7f  
page 108: 15 1e 16 1c 0e 02 16 1d 13 12 0f 00 19 17 1b 1e 05 0c 04 15 11 16 12 0c 13 11 01 0f 0d 1e 0a 1d  
page 109: 03 1d 1c 16 07 13 18 1a 0f 12 14 02 1e 0c 0c 05 18 03 15 0f 1e 1d 00 1b 00 12 0c 1b 0f 1e 0d 08  
page 110: 00  
page 111: 00  
page 112: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f ae 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 113: 00  
page 114: 07 1e 11 1b 03 18 16 08 1b 17 1e 16 1e 1b 18 05 0a 0e 18 12 1a 07 0a 14 15 0a 0f 03 00 0f 11 0c  
page 115: 00  
page 116: 00  
page 117: 00  
page 118: 0d 13 02 01 0f 06 17 13 0c 0f 15 03 18 19 06 04 17 14 18 1e 16 1c 06 0c 1b 16 13 0c 07 1a 01 1b  
page 119: 00  
page 120: 10 16 0c 1d 14 19 01 1d 05 09 0b 17 02 0d 1a 12 09 11 04 02 0d 07 11 03 05 15 18 04 19 17 15 11  
page 121: 13 03 1b 11 0e 10 0f 0c 19 0c 00 1e 19 06 06 02 18 12 0d 18 11 0c 01 11 1a 11 00 03 11 03 06 12  
page 122: 15 04 10 0e 16 17 0a 1e 11 0a 1e 09 19 04 1e 07 19 0e 09 00 0e 1d 1c 13 06 04 0c 1b 15 01 0c 16  
page 123: bd 7f 7f 7f 7f 7f 7f dc 7f 7f 7f 7f 7f 7f 7f e6 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f  
page 124: 17 0c 04 05 0b 0b 09 0e 10 0e 17 15 16 05 05 07 1e 0b 12 0f 1b 13 1d 01 0c 12 0f 11 17 13 12 0f  
page 125: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f cf 7f 7f 7f 85 7f 92 7f 7f 7f 7f 7f 7f 7f  
page 126: 0a 0b 14 0b 03 05 0f 06 13 18 02 0e 0d 03 07 02 13 1d 01 08 0b 0e 0d 0d 0e 06 01 0c 1b 0d 13 19  
page 127: 0c 0c 02 03 0d 0f 03 18 0a 08 0c 04 09 02 11 0b 04 0c 0a 1d 02 18 11 1d 0f 1b 1e 06 00 0b 06 10