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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 page 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-multiferel-traslate. py -s JOI -n J-c to get the answers.

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page page 7f page 7f a5 7f page 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 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 Page page page 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 0b 1c Of 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 page 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 1b 02 0a 0c 07 01 0e 13 06 0b 19 12 13 06 03 07 0a 02 0e 1b 1e 08 14 1a 02 12 page 18: 05 0a 13 15 15 07 05 0b 1d 00 19 0b 00 0a 16 16 0e 02 0f 06 1e 18 06 17 0b 1b 13 1b 00 1a 11 1b page 19: 11 1e 02 00 0f 0f 1e 03 02 19 11 15 17 05 1d 00 06 08 0e 09 16 02 07 04 02 07 0f 19 10 00 12 1b page page 7f 9b 7f 22: 05 01 08 0f 19 08 1d 16 1e 05 1c 0b 05 1d 16 1b 15 18 0d 11 05 0a 01 0e 1a 03 0b 0a 09 09 1e 09 page page 23: 00 18 06 0b 12 02 02 0d 03 0a 12 0d 09 14 1e 19 14 1c 15 0e 04 06 07 18 1a 06 0b 02 17 0d 09 1a page 24: Oc 1e 0a 15 Of Oc 13 06 08 07 08 06 1d 14 0e 14 02 00 1a 14 16 0b 1d 07 15 19 11 08 04 03 08 Of 25: 1a 0b 0c 08 0e 0a 16 17 1a 0f 18 13 11 1e 1a 16 03 01 06 0c 0b 12 11 12 1e 09 0d 14 11 1b 10 06 page page 09 09 1b 19 1d 01 07 0d 10 05 05 1c 0f 05 09 09 14 07 02 05 07 18 08 1d 06 04 12 04 19 17 11 03 page page 29: 14 12 08 1b 14 1d 04 05 15 06 00 09 15 14 1d 0b 1b 16 07 08 1b 0c 15 00 1d 08 1e 19 06 05 05 0a 30: 0a 0b 16 0a 1d 0e 0b 00 17 06 0e 14 0e 1d 0c 0b 03 00 03 11 03 0f 04 18 01 18 1c 1d 0e 19 05 1d page 31: 0a 0d 11 09 0d 10 1c 11 03 13 13 08 0b 09 03 07 18 0c 0a 01 18 1d 0c 11 1d 18 04 0b 18 09 10 07 page 32: 0c 07 1b 07 14 06 0c 07 07 17 10 03 15 13 11 05 0b 0d 11 08 1c 07 11 0b 01 10 1b 11 0a 18 02 03 page 16 00 12 1a 0a 09 1b 1e 06 10 02 13 00 09 09 11 03 1d 1b 1c 0c 0c 19 11 0f 1e 0a 0f 11 17 page page 7f 7f c2 7f 8b 7f page 7f 7f 7f 7f 7f 7f a1 7f 37: 1a 1a 02 1a 07 1d 15 0b 0f 13 0f 11 19 02 0b 1d 15 0e 00 18 0a 0f 07 05 1d 08 19 03 18 16 13 0e page 38: 1c 12 0d 18 02 0e 1a 13 13 03 19 06 1d 09 10 10 08 09 15 10 14 0e 17 0a 0f 11 09 1e 0f 1c 10 0f page page 39: 17 07 06 09 19 14 09 08 11 0f 08 09 07 09 02 19 19 17 17 1a 0f 10 08 0d 0c 18 11 04 08 10 0a 18 40: 10 09 13 04 0e 06 0e 0e 14 09 09 11 11 0d 0b 01 0d 17 17 08 17 0f 16 02 04 0d 12 10 0e 0d 0f 11 page page page 43: 05 0e 1b 12 1e 05 00 17 08 12 00 09 04 09 12 19 14 12 07 04 15 1b 18 09 0a 08 06 1c 1d 1b 01 05 page 44: 19 10 0b 05 0c 15 12 1a 03 08 01 1c 00 12 0c 00 0e 15 13 01 0c 0f 00 00 09 08 10 01 04 12 0b 16 page page 7f 7f 7f 7f 7f 46: 13 Of 0e 17 17 07 09 1e 14 1c 10 09 1c 16 13 1e 19 Of 07 1b 1d 1a 0c 04 09 00 1d 0d 16 08 18 17 page 47: 13 00 1e 04 13 09 19 1a 0c 12 00 12 03 13 11 08 15 10 1d 14 0a 1d 08 00 05 19 1d 04 09 19 14 1a page 48: 0a 0e 0a 18 00 12 00 19 11 10 0b 0e 1e 1e 1d 0b 14 12 19 04 1e 0f 1e 14 1e 12 0e 1d 16 10 0e 1c page 49: 1b 0a 09 16 0f 10 14 10 1e 17 10 04 05 1c 0f 14 10 17 1b 0f 15 18 12 1c 18 08 1a 1c 1d 1c 0d 09 page 50: 1b 05 01 0f 11 0c 04 19 0c 1e 09 0f 1e 0a 0b 09 19 00 1d 0e 0f 1b 13 06 1c 1e 1e 09 09 06 04 02 page page page page 55: 10 12 04 10 04 0a 0f 02 1e 13 1d 1c 1e 18 09 0c 1b 0f 07 1a 0b 05 15 1a 14 0e 0d 0a 0a 1d 12 04 page 56: 0d 02 1c 07 0d 10 12 14 0a 0c 19 04 12 16 0d 15 1b 13 03 07 18 14 10 0e 1b 05 0d 0d 09 02 1d 1a 1d 1d 08 18 1d 19 14 16 16 19 0d 00 1a 04 06 13 00 01 0e 02 00 01 06 10 1b 04 16 11 04 15 08 0b page 58: 1b 13 1c 16 1c 14 04 1d 11 0f 08 01 12 04 13 00 00 1b 11 0e 17 19 09 1d 08 09 0c 0d 13 09 page page 59: 14 11 08 09 02 1e 09 0f 00 04 09 0d 13 01 09 1d 17 0f 01 01 19 14 0d 1b 09 15 0c 0e 0b 17 03 02 page page 61: 15 1a 1a 12 0b 10 1b 03 05 19 07 1b 0c 11 12 02 05 1d 15 0d 15 11 1d 1d 08 0e 11 1d 12 02 09 0e 62: Of 05 08 0d 0b 14 16 07 0d 1d 13 10 0e 1b 13 03 12 13 06 05 09 0d 0e 0e 14 1e 16 05 02 09 14 10 page page

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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 66: 14 Of 1c 09 08 0b 12 Of Of Oc 04 05 03 15 18 16 16 17 0b 03 13 1b 00 03 0e 1d 0d 0b 03 14 00 0e 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 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 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 page page 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 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 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 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 page 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 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 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 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 page 7f 7f 7f 7f 7f 7f ed page 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 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 108: 15 le 16 lc 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 114: 07 le 11 1b 03 18 16 08 1b 17 le 16 1e 1b 18 05 0a 0e 18 12 1a 07 0a 14 15 0a 0f 03 00 0f 11 0c 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 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 07 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 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 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