

CSCI 3150 Introduction to Operating Systems

Basic Assignment Four: Virtual Memory

Deadline: 23:59, April 14, 2024

Total Marks: 100

Suppose the page size is 8 bytes, the first-level page table has 4 entries and the second-level page table has 8 entries. You need to answer the following questions:

1. Calculation (20 marks)

- What is the size of the virtual address space? $4 \times 8 \times 8 = 256 \text{ bytes}$
- How many bits does a virtual address have? $256 = 2^8 \therefore 8 \text{ bits}$
- How many bits should be reserved for the first-level page table index, the second-level page table index and the offset respectively?
 1st-level 2 bits
 2nd-level 3 bits
 offset 3 bits

2. Address Translation (50 marks)

For the virtual address space defined by the two-level page tables as shown in Figure 1, given the following virtual addresses: 51, 72, 172, 200.

- Which virtual addresses are mapped? $\text{floor}(51/64) = 0$ $\text{floor}(72/64) = 1$ $\text{floor}(172/64) = 2$
- If a virtual address is mapped, what is its corresponding physical address?

Page Directory		PT@PFN=10		PT@PFN=11	
0	10	0		16	0
1		1	2	17	0
2	11	2		18	
3		3	6	19	
		4		20	
		5		21	8
		6	5	22	4
		7	3	23	7

$44 \% 8 = 4$
 $PA = 8 \times 8 + 4 = 68$

Figure 1. The two-level page mapping table. The numbers in entries are physical page frame numbers. Entries in gray color are not mapped.

3. Page Mapping Setup (30 marks)

A program has three segments that should be loaded and mapped:

- Code segment** is loaded at physical memory range [0, 24) and should be mapped to virtual memory range [16, 40)
- Data segment**: PA [32, 64) and should be mapped to VA [64, 96)
- Stack segment**: PA [64, 80) and should be mapped to VA [240, 256)

You should fill the **physical page frame numbers** in the following page tables in Figure 2 to set up the

$51 \% 64 = 51$
 $\text{floor}(51/8) = 6$
 $172 \% 64 = 44$
 $\text{floor}(44/8) = 5$
 $51 \% 8 = 3$
 $PA = 5 \times 8 + 3 = 43$
 $44 \% 8 = 4$
 $PA = 8 \times 8 + 4 = 68$
 $172_d = 10101100_b$
 $\therefore VPN1 = 10_b = 2_d$
 $VPN2 = 101_b = 5_d$
 $\text{offset} = 100 = 4_d$
 $PA = 8 \times 8 + 4 = 68$

page mapping. If some entries in the page tables are not used, you can just leave them empty.

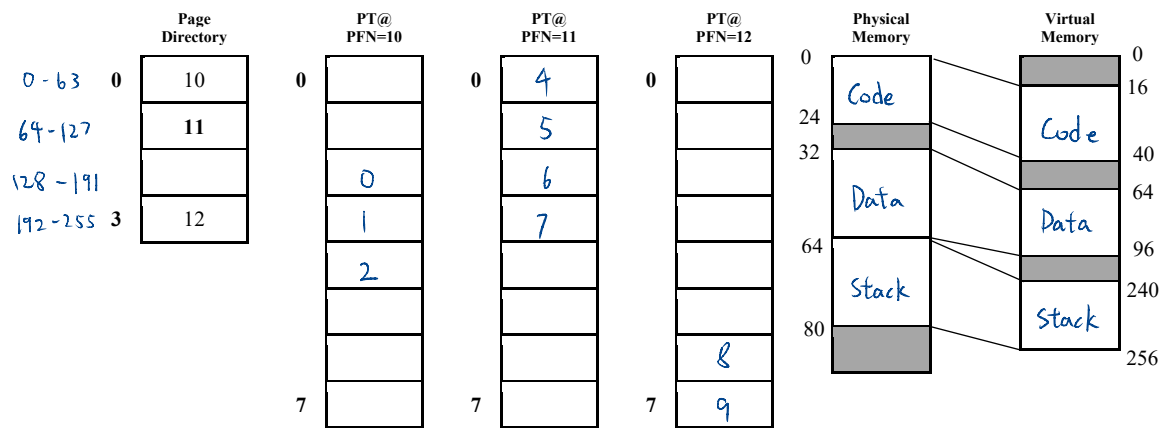


Figure 2. Page tables and address mapping

Note: the page directory has been set up. You only need to attach the three filled page tables **PT@PFN=10**, **PT@PFN=11** and **PT@PFN=12** in your answer

Submission:

In this Assignment, you need to fill all the blanks in the scheduling result table.

You only need to submit one pdf file that contains your answer, and name the file as “SID-Assign4.pdf”.

TA CHEN Xiangao is in charge of this assignment, if you have any questions about this assignment, you can enquiry with this email: xachen23@cse.cuhk.edu.hk