



School of Computer Science
COMP-3300 Operating Systems Fundamentals
Course project

Individual assignment. Copying the work of others is prohibited for this assignment.

Deadline: March 29, 2021

Objective: The aim of this project is to help students understand the main concepts of memory management (Chapter 8) and virtual memory (Chapter 9). Students will obtain hands on experience in programming such a system along with its features.

Designing a Virtual Memory Manager

The project consists of writing a program that translates logical to physical addresses for a virtual address space of $2^{16} = 65,536$ bytes. Your program will read from a file containing logical addresses and, using a page table, will translate each logical address to its corresponding physical address and output the value of the byte stored at the translated physical address. The goal behind this project is to simulate the steps involved in translating logical to physical addresses. Make sure your program uses fast operations like left/right shift operators

Specifics

Your program will read a file containing several 32-bit integer numbers that represent logical addresses. However, you need only be concerned with 16-bit addresses, so you must mask the rightmost 16 bits of each logical address. These 16 bits are divided into:

- (1) an 8-bit page number, and
- (2) an 8-bit page offset.

Hence, the addresses are structured as shown in the figure below:



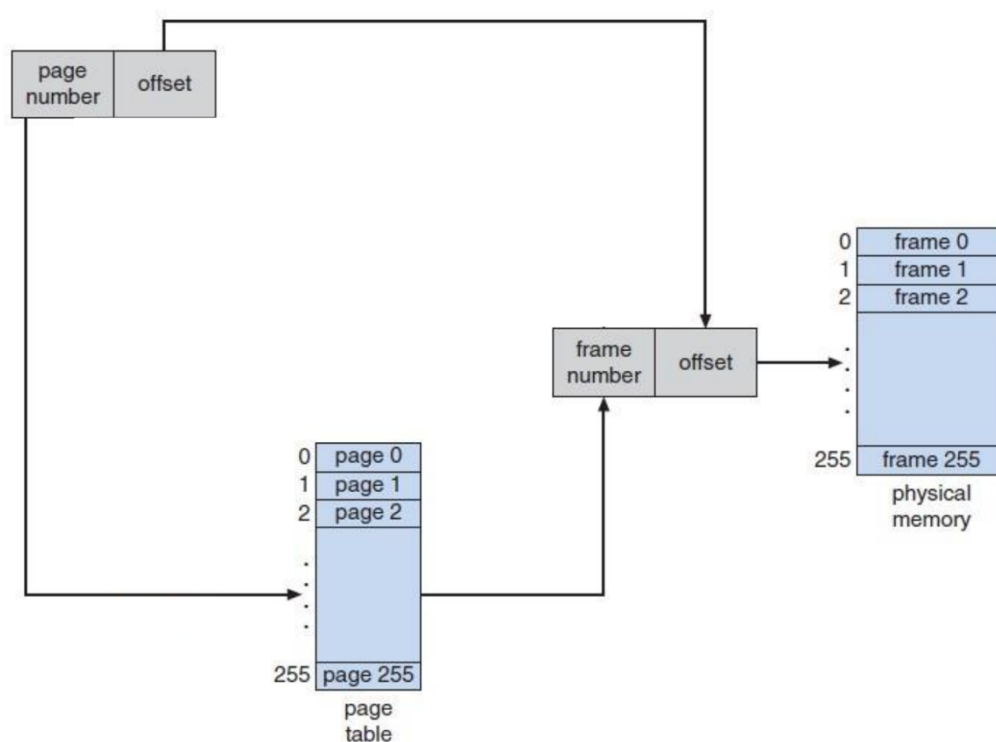
Other specifics include the following:

- 2^8 entries in the page table
- Page size of 2^8 bytes
- Frame size of 2^8 bytes
- 256 frames
- Physical memory of 65,536 bytes (256 frames x 256-byte frame size)

Additionally, your program need only be concerned with reading logical addresses and translating them to their corresponding physical addresses. You do not need to support writing to the logical address space.

Address Translation

Your program will translate logical to physical addresses using a page table as outlined in Section 8.5 of the textbook (the Paging section). First, the page number is extracted from the logical address, and the frame number is obtained from the page table or a page fault occurs (check the valid-invalid bit). A visual representation of the address-translation process appears in the figure below:



Handling Page Faults

Your program will implement demand paging as described in Section 9.2 of the textbook (the Demand Paging section). The backing store is represented by the file `BACKING_STORE.bin`, a binary file of size 65,536 bytes. When a page fault occurs, you will read in a 256-byte page from the file `BACKING_STORE` and store it in an available page frame in physical memory. For example, if a logical address with page number 15 resulted in a page fault, your program would read in page 15 from `BACKING_STORE` (remember that pages begin at 0 and are 256 bytes in

size) and store it in a page frame in physical memory. Once this frame is stored (and the page table is updated), subsequent accesses to page 15 will be resolved by the page table.

You will need to treat BACKING_STORE.bin as a random-access file so that you can randomly seek to certain positions of the file for reading. We suggest using the standard C library functions for performing I/O, including fopen(), fread(), fseek(), and fclose().

The size of physical memory is the same as the size of the virtual address space --65,536 bytes-- so you do not need to be concerned about page replacements during a page fault.

Test file

We provide the file addresses.txt, which contains integer values representing logical addresses ranging from 0 to 65535 (the size of the virtual address space). Your program will open this file, read each logical address and translate it to its corresponding physical address, and output the value of the signed byte at the physical address.

How to Begin

First, write a simple program that extracts the page number and offset (based on the first figure above) from the following integer numbers:

1, 256, 32768, 32769, 128, 65534, 33153

Perhaps the easiest way to do this is by using the operators for bit-masking and bit-shifting. Once you can correctly establish the page number and offset from an integer number, you are ready to begin.

How to Run Your Program

Your program should run as follows:

```
./a.out addresses.txt
```

Your program will read in the file addresses.txt, which contains 1,000 logical addresses ranging from 0 to 65535. Your program is to translate each logical address to a physical address and determine the contents of the signed byte stored at the correct physical address. (Recall that in C, the char data type occupies a byte of storage, so we suggest using char values.)

Your program should output the following values:

1. The logical address being translated (the integer value being read from addresses.txt).
2. The corresponding physical address (what your program translates the logical address to).
3. The signed byte value stored at the translated physical address.

We also provide the file correct.txt, which contains the correct output values for the file addresses.txt. You should use this file to determine if your program is correctly translating logical to physical addresses.