James Guerrera-Sapone - A20365203
Robert Judka - A20348051

myMemory System Call Manual (MAN) Page

NAME

myMemory – display current physical memory usage in terms of pages allocated

SYNOPSIS

```
#include "user.h"

int myMemory();
```

DESCRIPTION

myMemory() traverses the *page table directory* and each *page table* to count the pages based on their flagged bits.

There are three key flag bits to account for:

- *present bit*: checks if page is accessible by process
  - page tables shared between kernel and user process
- *user bit*: checks if page is accessible by user
- *writable bit*: checks if process can write to page

RETURN VALUE

Zero is always returned regardless of the state of system call.

ERRORS

Any error that occurs while traversing the paging structure will result in a thrown exception (most likely indicating an error elsewhere in the system).

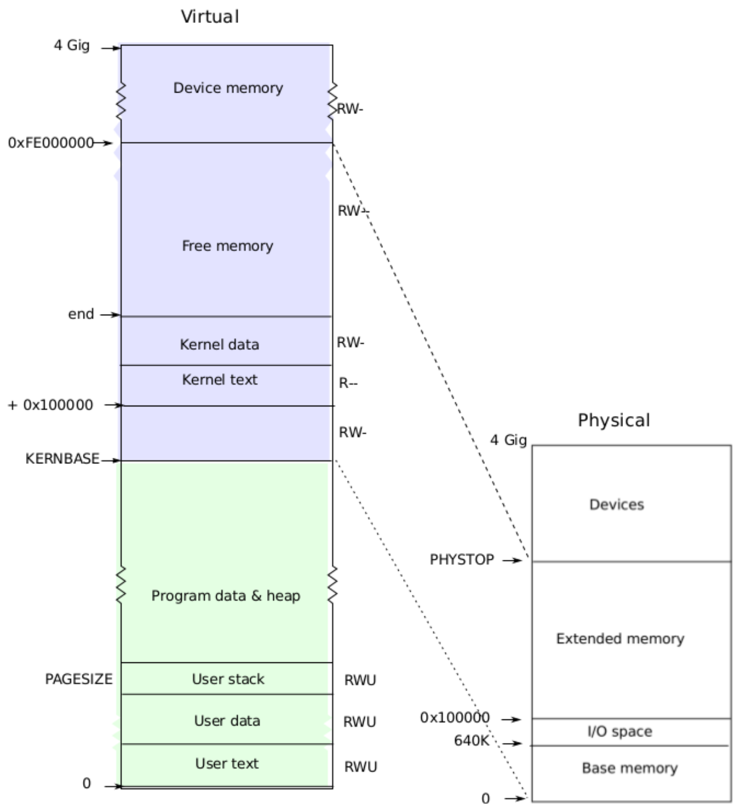
NOTES

Based on the implementation of the paging mechanism in xv6, the pages allocated Is not always an accurate representation of the memory usage of a process.

Because the page table is shared between the kernel and the user process, pages that appear to be *present* to a process are not always actually readily usable by the user process. Thus, the system call displays the memory information in relation to the kernel and user space.

myMemory System Call Implementation

xv6 memory details



xv6 includes various techniques when defining the page table of a user process. First, the user process shares the page table with the kernel which maintains mappings for the user space and the kernel space (as pictured above). xv6 has a fixed-size stack (of size one) and an inaccessible stack-guard page used to prevent the stack from going beyond its one page. The xv6 data/text page(s) are also readable and writable by the user process and kernel, which count towards a process's overall allocated pages.

With the implementation used in this system call, there was no need to make any changes to the xv6 memory management code. Also, there is no separate *accessible bit* as xv6 uses the *present* and *user bits* for that purpose.

The code for determining the allocated memory and displaying the information is described below.

xv6/proc.c

```
void
myMemory(void)
{
  struct proc *p = myproc();
  pde_t *pgdir;
```

myproc() returns a pointer to a process's *proc* structure which contains the attributes for the process. The *proc* structure has an attribute *pgdir* which will be used for finding a process's page table.

```
  int kernel_p = 0;
  int kernel_w = 0;
  int user_p = 0;
  int user_w = 0;
```

Before dealing with the page table structures, the memory descriptor counters get initialized. Each counter is described as follows:

- *kernel_p* counts the number of pages allocated to the kernel
- *kernel_w* counts the pages writable by the kernel
- *user_p* counts the number of pages allocated to the user
- *user_w* counts the pages writable by the user

The reason for splitting up all these counts is to be able to display a more fine-grained summary of the allocated memory. Because a user process shares its page table with the kernel, we felt it was important to differentiate between the two.

```
  int i, j;
  for(i = 0; i < NPDENTRIES; i++){
    if(p->pgdir[i] & PTE_P){
      pgdir = (pte_t*)P2V(PTE_ADDR(p->pgdir[i]));
```

Working under the assumption that the address space is contiguous (as described in the xv6 documentation), we can iterate through the entire *p->pgdir* array and check for any page table directories that have the *present bit* set. For any page table directory that is present, we can perform an address translation to get the virtual address.
Here, we can assume the predetermined number of page directory entries (1024) as the maximum iterations to perform.

```
        for(j = 0; j < NPTENTRIES; j++){
          if(pgdir[j] & PTE_P){ // kernel
            kernel_p++;
```

After getting the virtual address to the page table, and working under the same assumption as above, we can iterate through the computed *pgdir* array and check for any page table entries that have the *present bit* set. For any page table entry that is present, we increment the kernel's allocated page counter (because the page table is shared, any present page, regardless of the other bits, is considered allocated to the kernel).

Same as above, we can assume the predetermined number of page table entries (1024) as the maximum iterations to perform.

```
            if(pgdir[j] & PTE_U){ // user
              user_p++;
              if(pgdir[j] & PTE_W) // user writeable
                user_w++;
            }
```

If the page is present in the page table, the next flag to check is the *user bit* which marks a page as specific to a user process. For any page allocated for the user process, we increment the user's allocated page counter and check the *write bit* to see if a page is writable by the user. If the *write bit* is set, we increment the user's writable page counter.

```
            if(pgdir[j] & PTE_W) // kernel writeable
              kernel_w++;
```

We then check the *write bit* for every present page and increment the kernel's writable page counter for any page that has the *write bit* set.

```
  cprintf("----------- MyMemory -----------\n");
  cprintf("| ========== kernel ==========\n");
  cprintf("|  allocated pages: %d\n", kernel_p);
  cprintf("|  writable pages: %d\n", kernel_w);
  cprintf("|\n");
  cprintf("| =========== user ===========\n");
  cprintf("|  allocated pages: %d\n", user_p);
  cprintf("|  writable pages: %d\n", user_w);
  cprintf("-------------------------------\n");
```

After each page table directory and page table entry have been traversed, the memory information is displayed using the count values computed while traversing the tables. As mentioned earlier, the reason for displaying both kernel and user counts is because both entities share the same table so to get a clearer idea of the memory allocated, knowing values for both would be beneficial.