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OS Assignment 2 – Part 2

3.1

For this part, we need to define a TSS segment.
Firstly, I have added two zero segments to my kernel_entry.S. like this → .quad 0x0000000000000000.
These are the two entries for a TSS descripter which will be initialized in load_tss_segment() function in interrupts.h.

In boot.c:
I’m allocating two extra pages: 1 for rsp[0] stack and the other for tss.

In interrupts.h:
IN the init_tss_segment() function, I’ve initialized the tss_segment struct by assigning the required values – mainly the rsp stack address to rsp[0] and size of the structure to iopb_base.
The ist fields and other fields have been set to 0.

In the load_tss_segment() function, I’m passing the selector as 0x28 corresponding to the 5th entry in gdt. (8*5 = 40, which is 0x28)

I’m assigning the base as the tss address (same as the rsp[0] stack bottom address) and the limit as the size of the structure – 1.

This initializes and loads the tss segment in the code.

3.2

Firstly, I created the idt_descriptor structure as an array of size 256 and 16-byte aligned.

In kernel.c:
The x86_init() function is calling the init_idt_table() function which I’m using to initialize the idt descriptor structure by setting dpl as 0, p as 1, type as 14, ist as 0 and selector as 0x8.

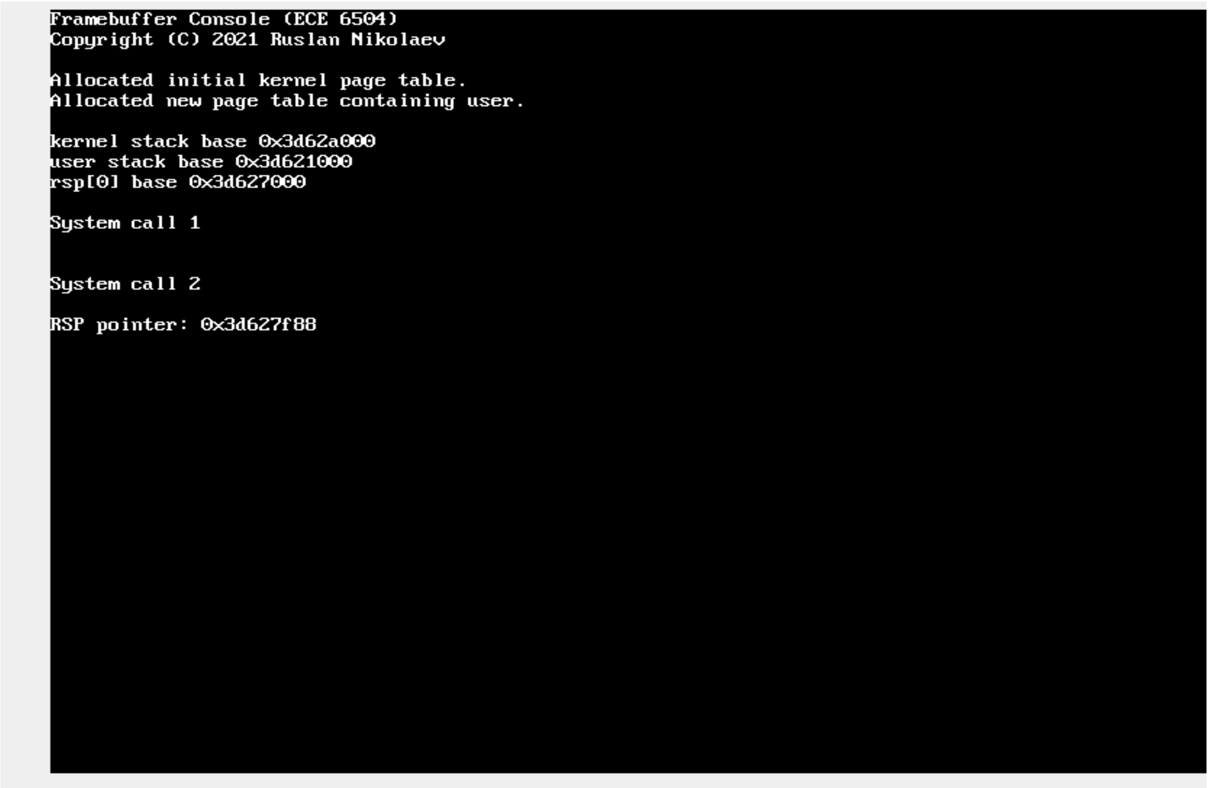
The offset values of the first 32 entries come from the default trap pointer address, and the rest are assigned 0.

I’m initializing the idt_pointer by setting the size of the idt table -1 and base as the address of the idt table.

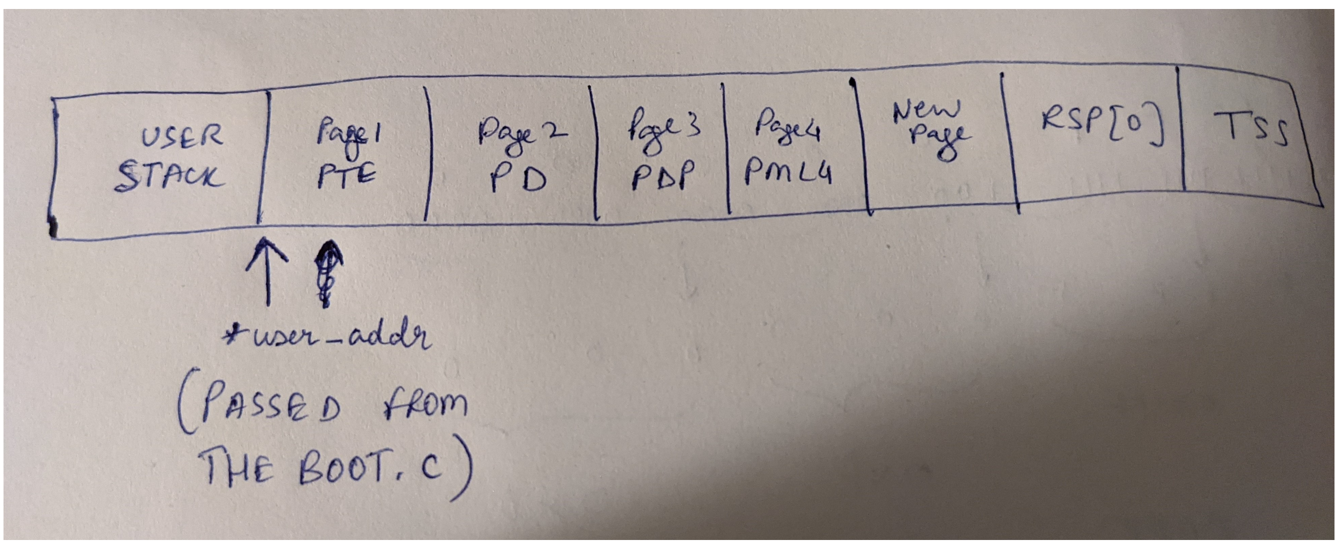
In kernel_entry.S, I’m assigning two pointers to point to the default and page fault handler respectively.

In kernel_asm.S,
under default_trap, I’m calling the default_handler() function and passing the rsp value as an argument using the rdi register.

The default_handler is defined in kernel.c and it prints out the rsp pointer value. I try to access a non-existent address, which triggers the default handler. As we can see in the screenshot below, the rsp value is bigger than the rsp[0] stack base address and lesser than +0x1000, which means the stack is occupied.



Reference:
Picture of my user_addr buffer which might help in getting a clearer picture of the pointer arithmetic I have done in pagefault_handler to access the pte and pml4 addresses from the rsp[0] stack address.



3.3

Here we allocate the 15th IDT entry which executes page faults to a different handler called the page fault handler.

In boot.c,
I allocate 1 extra page to set up the last entry in my User PTE to handle the page fault.

In kernel.c,
While defining the initial user PTE I set up the last entry (511 entry) with address 0 and present 0, but with write as 1 and user bit as 1 (basically, 0x6).

I've already set up the page fault pointer in kernel_entry.S to point to my kernel handler function.

In kernel_asm.S,
under pagefault_trap, I'm calling the pagefault_handler() function.
This handler which is defined in kernel.c, accesses the pte[511] entry and puts the address as the newly retrieved address of the page (lazy load page) from boot.c and sets present as 1.

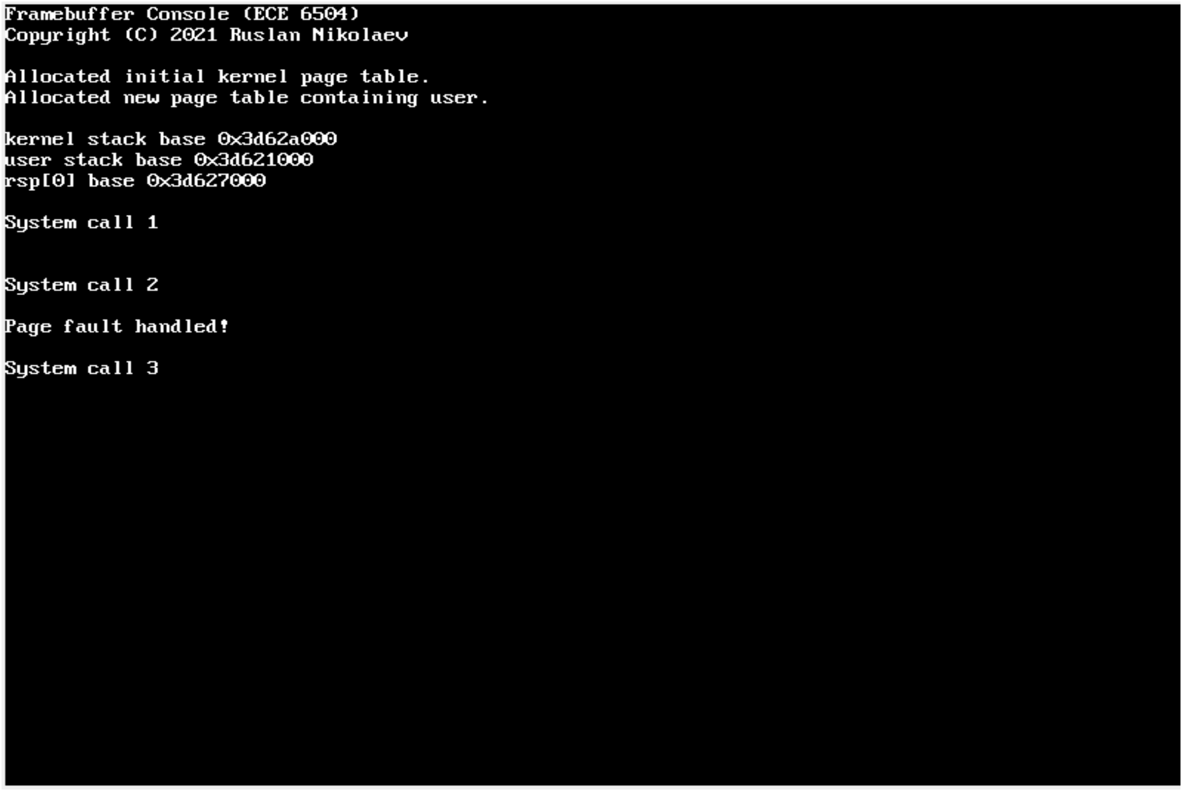
Then, I reload the cr3 register.

So, now when I try to access the non-existent address, my page fault handler gets executed and that address is not non-existent anymore.
I'm printing "page fault handled!" message as the last statement in my handler function.

This statement gets executed in my code right after I reload CR3, which goes to show that my page table has been correctly set up. I verify that the last entry in my page table contains the address of the lazy load page.

I've kept rsp_base_addr as the global variable which contains the rsp[0] base address, and I'm calculating pte and pml4 values based on that, since they are from the same buffer.

Then I'm executing a system call which prints the message "System call 3!" which shows the program is still alive.


Framebuffer Console (ECE 6504)
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Allocated initial kernel page table.
Allocated new page table containing user.
kernel stack base 0x3d62a000
user stack base 0x3d621000
rsp[0] base 0x3d627000
System call 1
System call 2
Page fault handled!
System call 3