

## **CMPE283 - Assignment 4**

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**Q1.** For each member in your team, provide 1 paragraph detailing what parts of the lab that member implemented / researched. (You may skip this question if you are doing the lab by yourself).

This part is skipped. I did the assginment by myself

**Q2.** Include a sample of your print of exit ount output from dmesg from “with ept” and “without ept”

- Pre-condition: We need to use the Assignment 3 environment. I have the information about Assignment 1 in my linux github repository.
  - Check the version of the linux kernel by `uname -r` command. It should be the same as Assignment 3.
    - In my case, it was `5.4.0-rc+1`.
  - Delete the kvm-intel module by `rmmmod kvm-intel`
  - Insert the module with `ept=0`
    - `insmod /lib/modules/5.4.0-rc+1/kernel/arch/x86/kvm/kvm-intel.ko ept=0`
- With `ept=1` screenshots
  - `0x4fffffd` leaf for the total exit count for each exit type

```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 0
CPU 0:
  0x4fffffd 0x00: eax=0x0000290f ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x00: eax=0x0000290f ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 1
CPU 0:
  0x4fffffd 0x01: eax=0x00043433 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x01: eax=0x00043435 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 0
CPU 0:
  0x4fffffd 0x00: eax=0x00002910 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x00: eax=0x00002910 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 2
CPU 0:
  0x4fffffd 0x02: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x02: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 3
CPU 0:
  0x4fffffd 0x03: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x03: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 4
CPU 0:
  0x4fffffd 0x04: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x04: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 6
CPU 0:
  0x4fffffd 0x06: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x06: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 7
CPU 0:
  0x4fffffd 0x07: eax=0x00009156 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x07: eax=0x00009156 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 8
CPU 0:
  0x4fffffd 0x08: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x08: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 9
CPU 0:
  0x4fffffd 0x09: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
```

```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 10
CPU 0:
 0x4fffffd 0x0a: eax=0x0001c5a8 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0a: eax=0x0001c5a9 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 11
CPU 0:
 0x4fffffd 0x0b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 12
CPU 0:
 0x4fffffd 0x0c: eax=0x0005cc1d ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0c: eax=0x0005cc1f ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 13
CPU 0:
 0x4fffffd 0x0d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 14
CPU 0:
 0x4fffffd 0x0e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 15
CPU 0:
 0x4fffffd 0x0f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x0f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 16
CPU 0:
 0x4fffffd 0x10: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x10: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 17
CPU 0:
 0x4fffffd 0x11: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x11: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 18
CPU 0:
 0x4fffffd 0x12: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x12: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 19
CPU 0:
 0x4fffffd 0x13: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
 0x4fffffd 0x13: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 20
CPU 0:
 0x4fffffd 0x14: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
```



```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 32
CPU 0:
    0x4fffffd 0x20: eax=0x0011c197 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x20: eax=0x0011c19c ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 33
CPU 0:
    0x4fffffd 0x21: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x21: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 34
CPU 0:
    0x4fffffd 0x22: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x22: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 35
CPU 0:
    0x4fffffd 0x23: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x23: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 36
CPU 0:
    0x4fffffd 0x24: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x24: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 37
CPU 0:
    0x4fffffd 0x25: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x25: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 38
CPU 0:
    0x4fffffd 0x26: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x26: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 39
CPU 0:
    0x4fffffd 0x27: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x27: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 40
CPU 0:
    0x4fffffd 0x28: eax=0x00001e6b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x28: eax=0x00001e6b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 41
CPU 0:
    0x4fffffd 0x29: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x29: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 42
CPU 0:
    0x4fffffd 0x2a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x2a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
```

```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 43
CPU 0:
    0x4fffffd 0x2b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 44
CPU 0:
    0x4fffffd 0x2c: eax=0x0000000b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2c: eax=0x0000000b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 45
CPU 0:
    0x4fffffd 0x2d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 46
CPU 0:
    0x4fffffd 0x2e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 47
CPU 0:
    0x4fffffd 0x2f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 48
CPU 0:
    0x4fffffd 0x30: eax=0x0004eb1 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x30: eax=0x0004eb1 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 49
CPU 0:
    0x4fffffd 0x31: eax=0x00022376 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x31: eax=0x00022376 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 50
CPU 0:
    0x4fffffd 0x32: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x32: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 51
CPU 0:
    0x4fffffd 0x33: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x33: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 52
CPU 0:
    0x4fffffd 0x34: eax=0x00015d4b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x34: eax=0x00015d4b ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 53
CPU 0:
    0x4fffffd 0x35: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x35: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
```

- With `ept=0` (without `ept`) screenshots
    - `0x4fffffff` leaf for the total exit count for each exit type

```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 0
CPU 0:
    0x4fffffd 0x00: eax=0x0012e0fe ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x00: eax=0x0012e0ff ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 1
CPU 0:
    0x4fffffd 0x01: eax=0x00026a84 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x01: eax=0x00026a88 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 2
CPU 0:
    0x4fffffd 0x02: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x02: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 3
CPU 0:
    0x4fffffd 0x03: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x03: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 4
CPU 0:
    0x4fffffd 0x04: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x04: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 5
CPU 0:
    0x4fffffd 0x05: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x05: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 6
CPU 0:
    0x4fffffd 0x06: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x06: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 7
CPU 0:
    0x4fffffd 0x07: eax=0x00004942 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x07: eax=0x00004945 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 8
CPU 0:
    0x4fffffd 0x08: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x08: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 9
CPU 0:
    0x4fffffd 0x09: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x09: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 10
CPU 0:
    0x4fffffd 0x0a: eax=0x0000429f ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x0a: eax=0x000042a0 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
```



```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 22
CPU 0:
  0x4fffffd 0x16: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x16: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 23
CPU 0:
  0x4fffffd 0x17: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x17: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 24
CPU 0:
  0x4fffffd 0x18: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x18: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 25
CPU 0:
  0x4fffffd 0x19: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x19: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 26
CPU 0:
  0x4fffffd 0x1a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 27
CPU 0:
  0x4fffffd 0x1b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 28
CPU 0:
  0x4fffffd 0x1c: eax=0x00b0503c ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1c: eax=0x00b05377 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 29
CPU 0:
  0x4fffffd 0x1d: eax=0x00000002 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1d: eax=0x00000002 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 30
CPU 0:
  0x4fffffd 0x1e: eax=0x0002982c ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1e: eax=0x0002982c ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 31
CPU 0:
  0x4fffffd 0x1f: eax=0x000001d1 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x1f: eax=0x000001d1 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 32
CPU 0:
  0x4fffffd 0x20: eax=0x000330d6 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
  0x4fffffd 0x20: eax=0x000330db ebx=0x00000000 ecx=0x00000000 edx=0x00000000
```

```
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 33
CPU 0:
    0x4fffffd 0x21: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x21: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 34
CPU 0:
    0x4fffffd 0x22: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x22: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 35
CPU 0:
    0x4fffffd 0x23: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x23: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 36
CPU 0:
    0x4fffffd 0x24: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x24: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 37
CPU 0:
    0x4fffffd 0x25: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x25: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 38
CPU 0:
    0x4fffffd 0x26: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x26: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 39
CPU 0:
    0x4fffffd 0x27: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x27: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 40
CPU 0:
    0x4fffffd 0x28: eax=0x000007cd ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x28: eax=0x000007cd ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 41
CPU 0:
    0x4fffffd 0x29: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x29: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 42
CPU 0:
    0x4fffffd 0x2a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
CPU 1:
    0x4fffffd 0x2a: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xfffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 43
CPU 0:
    0x4fffffd 0x2b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x2b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
```



```

song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 55
CPU 0:
    0x4fffffd 0x37: eax=0x00000003 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x37: eax=0x00000003 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 56
CPU 0:
    0x4fffffd 0x38: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x38: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 57
CPU 0:
    0x4fffffd 0x39: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x39: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 58
CPU 0:
    0x4fffffd 0x3a: eax=0x00027b48 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3a: eax=0x00027b48 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 59
CPU 0:
    0x4fffffd 0x3b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3b: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 60
CPU 0:
    0x4fffffd 0x3c: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3c: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 61
CPU 0:
    0x4fffffd 0x3d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3d: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 62
CPU 0:
    0x4fffffd 0x3e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3e: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 63
CPU 0:
    0x4fffffd 0x3f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x3f: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 64
CPU 0:
    0x4fffffd 0x40: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x40: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 65
CPU 0:
    0x4fffffd 0x41: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xffffffff
CPU 1:
    0x4fffffd 0x41: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0xffffffff
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 66
CPU 0:
    0x4fffffd 0x42: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x42: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 67
CPU 0:
    0x4fffffd 0x43: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x43: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0x4fffffd -s 68
CPU 0:
    0x4fffffd 0x44: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffd 0x44: eax=0x00000000 ebx=0x00000000 ecx=0x00000000 edx=0x00000000

```

\* 0xffffffff leaf for the total exit counts

```

song-virt@songvirt-Standard-PC-i440FX-PIIX-1996:~$ cpuid -l 0xffffffff
CPU 0:
    0x4fffffff 0x00: eax=0x00f29f00 ebx=0x00000000 ecx=0x00000000 edx=0x00000000
CPU 1:
    0x4fffffff 0x00: eax=0x00f29f6a ebx=0x00000000 ecx=0x00000000 edx=0x00000000

```

**Q3.** What did you learn from the count of exits? Was the count what you expected? If not, why not?

The result showed me the difference of the total exit counts and the total exit count for each exit type in the two different memory address translation technologies; Shadow Paging and Nested Paging.

The count of exits with nested paging or `ept=1` is smaller than ones with shadow paging or `ept=0`.

The result was the same as I expected because for generally speaking, shadow paging includes the page fault and TLB flushes whereas nested paging does not. Thus, I expected there would be more exits in shadow paging. Also, as we can check from the results, exits related to EPT are only enabled in nested paging. For example, exit 48 and 49, EPT violation and EPT misconfiguration, are only detected in nested paging.

**Q4.** What changed between the two runs (ept vs no-ept)?

When I ran with `ept=1`, nested paging enabled, and it generates exit counts less than shadow paging. As the question 3, EPT related exit reasons are only detectable in nested paging.

With `ept=0` or without `ept`, shadow paging enabled, and it generates more exit counts. The reason is that shadow paging includes page fault and TLB flushes whereas nested paging does not.