

# CPUID EMULATION IN KVM

## ASSIGNMENT 2

### VIRTUAL TECHNOLOGIES

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# 1 PROJECT SCOPE

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This assignment is designed to demonstrate modifying CPU Identification (CPUID) processor instruction behavior inside the KVM hypervisor. This instruction is used by system utilities and operating systems for capturing detailed information about the CPU.

## 1.1 GITHUB REPO

<https://github.com/tlavette/cmpe283assignment-2.git>

# 2 PREREQUISITE:

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Prerequisites: Working completion of Assignment #1

# 3 TERMS AND DEFINITIONS

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CPUID leaf node	The most significant or highest EAX command parameter of the EAX set
KVM	Kernel Based Virtual Machine
Kernel	An architecture standpoint it stands in between the Applications and CPU, Memory and Devices and is the main interface between the physical hardware and the processes running on it.
Kernel module	Code that can be loaded and unloaded to the Kernel
lsmod	Displays loaded modules
rmmod	Command used to remove running modules
modprobe	Program used to add and remove modules from the Linux Kernel
RDTSC	Read time Stamp Counter measures the number of CPU cycles since its reset.
CPU	Central Processing Unit
module	Are extensions used to create and manage various components of virtual machines such as networking, storage, and networking.
SSH	Secure Shell
GCP	Google Cloud Platform

## 4 IMPLEMENTATION

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### 4.1 DYNAMIC TEAMWORK – TEAM CONTRIBUTION

The following was the overall effort dynamic placed in the completion of this assignment. We met and collaborated on the strategy and each one of us had point lead for the bulleted items, however, we spent much time collaborating via Zoom in peer configuration and code triage. We also spent time engaging in knowledge transfer as each item had slightly different requirements and needs for ultimate completion.

Tonja Jean

- Confirmed the VM module and kernel were successfully running.
- Perform collaborative review of the requirements to determine the resources needed to complete.
- Created Nested VM
- Installed build essentials and cupid package nested VM.
- Perform code update of CPUID leaf node %eax=0x4FFFFFFF
- Worked on modifying the cpuid.c and vmx.c programs for calculating the total count of all exits when eax=0x4FFFFFFF
- Created and compiled test program to ensure the code worked as expected.
- Performed test and debug collaboration.
- Collected and compiled documentation.
- Performed final code refactoring and compilation.

Puja Kumari

- Confirmed the VM module and kernel were successfully running.
- Perform collaborative review of the requirements to determine the resources needed to complete.
- Installed the nested Ubuntu VM inside the outer VM.
- As part of nested VM installation, installed other packages like Virt-Manger, and downloaded OS ISO images.
- Performed code update CPUID leaf node %eax=0x4FFFFFFE
- Worked on modifying the cupid.c and vmx.c programs for calculating CPU cycles for processing all exits when eax=0x4FFFFFFE
- Created and compiled test program to ensure the code worked as expected.
- Performed test and debug collaboration.
- Performed final code refactoring and compilation.
- Collected and compiled documentation.

## 4.2 ENVIRONMENT SET UP

The steps used in completing this lab is as follows. The user will need to consider the libraries and components needed may vary by CPU type, Server OS, memory etc. Please note it is required to use an Intel CPU Platform that supports nested environments. For this lab we used the following:

### 4.2.1 Server Type

Google Cloud Platform VM Server Machine Type: n1-standard-8 CPU Platform: Intel Haswell Architecture: x86/64 Boot Disk: debian-11-bullseye-v20231115 200G

### 4.2.2 Environment Setup – As completed in assignment 1 and included here for context.

Cloned the GitHub repository-

```
$git clone https://github.com/torvalds/linux.git
```

```
Enter root mode – $sudo bash
```

### 4.2.3 Install the build essentials.

```
$ apt-get install build-essential kernel-package fakeroot  
libncurses5-dev libssl-dev ccache bison flex libelf-dev
```

### 4.2.4 Confirm KVM is not already loaded, remove actively loaded, and perform add the kernel modules.

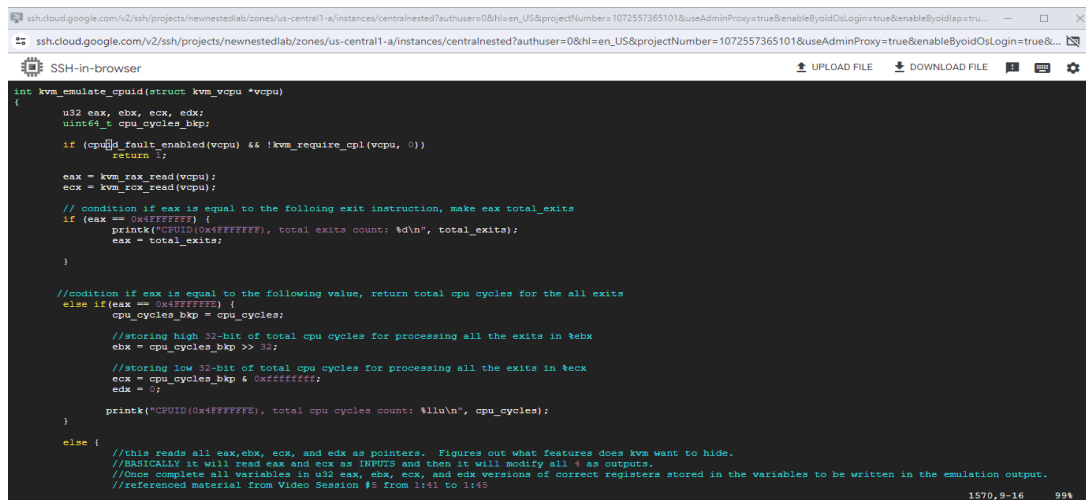
```
lsmod | grep kvm  
lsmod | grep kvm_intel  
Remove KVM modules actively loaded.  
rmmod kvm_intel and rmmod kvm  
modprobe kvm  
mod probe kvm_intel
```

## 4.3 UPDATE KERNEL CODE FILES

### 4.3.1 Update kvm hypervisor files: cupid.c and vmx.c files

**cpuid.c**

Modified `kvm_emulate_cpuid` code for CPUID exit handling.



```

int kvm_emulate_cpuid(struct kvm_vcpu *vcpu)
{
    u32 eax, ebx, ecx, edx;
    uint64_t cpu_cycles_bkp;

    if (cpu_id_fault_enabled(vcpu) && !kvm_require_cpi(vcpu, 0))
        return 1;

    eax = kvm_rax_read(vcpu);
    ecx = kvm_rcx_read(vcpu);

    // condition if eax is equal to the following exit instruction, make eax total_exits
    if (eax == 0x4FFFFFFF) {
        printk("CPUID(0x4FFFFFFF), total exits count: %d\n", total_exits);
        eax = total_exits;
    }

    //condition if eax is equal to the following value, return total cpu cycles for the all exits
    else if (eax == 0x4FFFFFFE) {
        cpu_cycles_bkp = cpu_cycles;

        //storing high 32-bit of total cpu cycles for processing all the exits in tebx
        ebx = cpu_cycles_bkp >> 32;

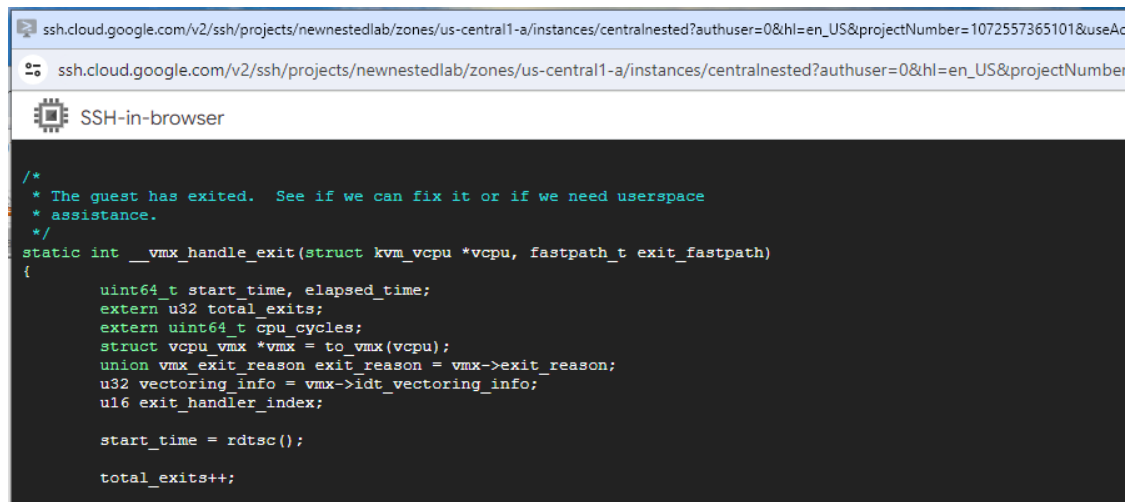
        //storing low 32-bit of total cpu cycles for processing all the exits in tebx
        ecx = cpu_cycles_bkp & 0xFFFFFFFF;
        edx = 0;

        printk("CPUID(0x4FFFFFFE), total cpu cycles count: %llu\n", cpu_cycles);
    }
    else {
        //this reads all eax, ebx, ecx, and edx as pointers. Figures out what features does kvm want to hide.
        //BASICALLY it will read eax and ecx as INPUTS and then it will modify all 4 as outputs.
        //Once complete all variables in u32 eax, ebx, ecx, and edx versions of correct registers stored in the variables to be written in the emulation output.
        //referenced material from Video Session #5 from 1:41 to 1:45
    }
}

```

**vmx.c**

Modified `vmx.c` code `vmx_handle_exit` to increment the total number of exits.



```

/*
 * The guest has exited. See if we can fix it or if we need userspace
 * assistance.
 */
static int __vmx_handle_exit(struct kvm_vcpu *vcpu, fastpath_t exit_fastpath)
{
    uint64_t start_time, elapsed_time;
    extern u32 total_exits;
    extern uint64_t Cpu_cycles;
    struct vcpu_vmx *vmx = to_vmx(vcpu);
    union vmx_exit_reason exit_reason = vmx->exit_reason;
    u32 vectoring_info = vmx->idt_vectoring_info;
    u16 exit_handler_index;

    start_time = rdtsc();

    total_exits++;
}

```

`sudo make modules -j 8 modules`

Initial run errors found. These were corrected in the `vmx.c` file and the job reran.

```

tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ cd arch/x86/kvm/
tonja_jean@centralnested:~/linux/arch/x86/kvm$ cd vmx
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ vi vmx.c
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ cd ../../
tonja_jean@centralnested:~/linux/arch/x86$ cd ..
tonja_jean@centralnested:~/linux/arch$ cd ..
tonja_jean@centralnested:~/linux$ sudo make -j 8 modules
mkdir -p /home/tonja_jean/linux/tools/objtool && make O=/home/tonja_jean/linux subdir=tools/objtool --no-print-directory -C objtool
INSTALL libsubcmd headers
CALL scripts/checksyscalls.sh
CC [M] arch/x86/kvm/vmx/vmx.o
LD [M] arch/x86/kvm/kvm-intel.o
MODPOST Module.symvers
ERROR: modpost: "total_exits" [arch/x86/kvm/kvm.ko] undefined!
ERROR: modpost: "cpu_cycles" [arch/x86/kvm/kvm.ko] undefined!
make[2]: *** [scripts/Makefile.modpost:145: Module.symvers] Error 1
make[1]: *** [/home/tonja_jean/linux/Makefile:1863: modpost] Error 2
make: *** [Makefile:234: _sub-make] Error 2
tonja_jean@centralnested:~/linux$ cd arch/x86/kvm
tonja_jean@centralnested:~/linux/arch/x86/kvm$ cd vmx
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ vi vmx.c
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ cd ../../
tonja_jean@centralnested:~/linux/arch/x86$ cd ../../
tonja_jean@centralnested:~/linux$ sudo make -j 8 modules
mkdir -p /home/tonja_jean/linux/tools/objtool && make O=/home/tonja_jean/linux subdir=tools/objtool --no-print-directory -C objtool
INSTALL libsubcmd headers
CALL scripts/checksyscalls.sh
CC [M] arch/x86/kvm/vmx/vmx.o
LD [M] arch/x86/kvm/kvm-intel.o
MODPOST Module.symvers
LD [M] arch/x86/crypto/poly1305-x86_64.ko
CC [M] arch/x86/kvm/kvm.mod.o
CC [M] arch/x86/kvm/kvm-intel.mod.o
LD [M] arch/x86/kvm/kvm-amd.ko
LD [M] crypto/asymmetric_keys/pkcs8_key_parser.ko
LD [M] lib/raid6/raid6_pq.ko
LD [M] drivers/scsi/scsi_mod.ko
LD [M] arch/x86/kvm/kvm.ko
LD [M] arch/x86/kvm/kvm-intel.ko
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ make INSTALL_MOD_STRIP=1 modules_install && make install

```

```
make INSTALL_MOD_STRIP=1 && make install
```

Collaboration Session:

## 4.4 CREATE L2 VM AND TEST CPUID ASSIGNMENT

### 4.4.1 Create Nested L2 VM

```

sudo apt-get install virt-manager
sudo apt-get install libvirt-bin libvirt-doc
sudo apt-get install qemu-system
sudo virt-manager

```

## Installing Virt-Manager

```

tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ sudo apt-get install qemu-kvm libvirt-daemon-system libvirt-clients bridge-utils
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Note, selecting 'qemu-system-x86' instead of 'qemu-kvm'
libvirt-clients is already the newest version (7.0.0-3+deb11u2).
libvirt-clients set to manually installed.
libvirt-daemon-system is already the newest version (7.0.0-3+deb11u2).
libvirt-daemon-system set to manually installed.
qemu-system-x86 is already the newest version (1:5.2+dfsg-11+deb11u3).
The following NEW packages will be installed:
  bridge-utils
0 upgraded, 1 newly installed, 0 to remove and 5 not upgraded.
Need to get 37.9 kB of archives.
After this operation, 124 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 https://deb.debian.org/debian bullseye/main amd64 bridge-utils amd64 1.7-1 [37.9 kB]
Fetched 37.9 kB in 0s (138 kB/s)
Selecting previously unselected package bridge-utils.
(Reading database ... 104349 files and directories currently installed.)
Preparing to unpack .../bridge-utils_1.7-1_amd64.deb ...
Unpacking bridge-utils (1.7-1) ...
Setting up bridge-utils (1.7-1) ...
Processing triggers for man-db (2.9.4-2) ...
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ sudo kvm-ok
INFO: /dev/kvm exists
KVM acceleration can be used

```

```

tonja_jean@centralnested:~/linux$ uname -a
Linux centralnested 6.7.0-rc3+ #6 SMP PREEMPT_DYNAMIC Sun Dec 17 02:46:03 UTC 2023 x86_64 GNU/Linux
tonja_jean@centralnested:~/linux$ sudo adduser 'puja' libvirt
adduser: The user 'puja' does not exist.
tonja_jean@centralnested:~/linux$ sudo getent group | grep libvirt
libvirt:x:116:
libvirt-qemu:x:64055:libvirt-qemu
tonja_jean@centralnested:~/linux$ sudo adduser 'libvirt-qemu:x:64055:libvirt-qemu' libvirt
adduser: The user 'libvirt-qemu:x:64055:libvirt-qemu' does not exist.
tonja_jean@centralnested:~/linux$ sudo getent group | grep kvm
kvm:x:110:
tonja_jean@centralnested:~/linux$ sudo adduser libvirt-qemu:x:64055:libvirt-qemu libvirt
adduser: The user 'libvirt-qemu:x:64055:libvirt-qemu' does not exist.
tonja_jean@centralnested:~/linux$ users
tonja_jean tonja_jean
tonja_jean@centralnested:~/linux$ sudo adduser 'tonja_jean' libvirt
Adding user 'tonja_jean' to group 'libvirt' ...
Adding user tonja_jean to group libvirt
Done.
tonja_jean@centralnested:~/linux$ sudo getent group | grep libvirt
libvirt:x:116:tonja_jean
libvirt-qemu:x:64055:libvirt-qemu
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ sudo adduser 'tonja_jean' kvm
Adding user 'tonja_jean' to group 'kvm' ...
Adding user tonja_jean to group kvm
Done.
tonja_jean@centralnested:~/linux$ sudo getent group | grep kvm
kvm:x:110:tonja_jean

```



## Virt-manager running successfully on the VM

```
tonja_jean@centralnested:~/linux$ sudo virsh list --all
Id      Name      State
-----
tonja_jean@centralnested:~/linux$ sudo systemctl status libvirt
● libvirtd.service - Virtualization daemon
   Loaded: loaded (/lib/systemd/system/libvirtd.service; enabled; vendor preset: enabled)
   Active: active (running) since Sun 2023-12-17 19:31:23 UTC; 6min ago
   TriggeredBy: ● libvirtd.socket
                 ● libvirtd-admin.socket
                 ● libvirtd-ro.socket
   Docs: man:libvirtd(8)
          https://libvirt.org
   Main PID: 1081 (libvirtd)
    Tasks: 19 (limit: 32768)
   Memory: 31.9M
     CPU: 223ms
   CGroup: /system.slice/libvirtd.service
           └─1081 /usr/sbin/libvirtd

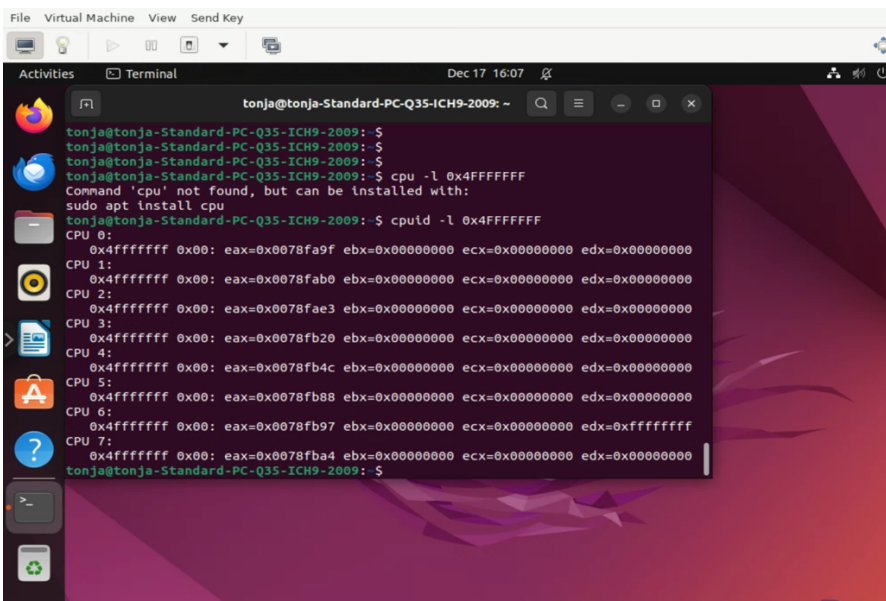
Dec 17 19:31:21 centralnested systemd[1]: Starting Virtualization daemon...
Dec 17 19:31:23 centralnested systemd[1]: Started Virtualization daemon.
tonja_jean@centralnested:~/linux$
```

#### 4.4.2 Installed GEMO compatible Ubuntu OS on the inner VM using Chrome Remote Desktop

#### 4.5 PERFORM CPUID CONFIRMATION TEST - RESULTS

Run cupid command from inside the inner VM to test the functionality and checked the dmesg log in the outer VM to verify the exit responses.

Test 1: Tested functionality for %eax=04FFFFFF –



Verified in dmesg log

```
[ 44.103331] process 'subagents/fluent-bit/bin/fluent-bit' started with e
[ 199.844759] CPUID(0x4FFFFFFF), total exit count: 749902
[ 199.850608] CPUID(0x4FFFFFFF), total exit count: 749926
[ 199.856433] CPUID(0x4FFFFFFF), total exit count: 749944
[ 199.863432] CPUID(0x4FFFFFFF), total exit count: 749988
[ 199.871914] CPUID(0x4FFFFFFF), total exit count: 750062
[ 199.878367] CPUID(0x4FFFFFFF), total exit count: 750148
[ 199.884875] CPUID(0x4FFFFFFF), total exit count: 750185
[ 199.893459] CPUID(0x4FFFFFFF), total exit count: 750231
tonja_jean@centralnested:~/linux$
```

Test 2: Tested functionality for %eax=04FFFFFFE –

```
tonja@tonja-Standard-PC-Q35-ICH9-2009:~$ cpuid -l 0x4FFFFFFE
CPU 0:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c670c edx=0x00000000
CPU 1:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6756 edx=0x00000000
CPU 2:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6838 edx=0x00000000
CPU 3:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6884 edx=0x00000000
CPU 4:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6941 edx=0x00000000
CPU 5:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c69e4 edx=0x00000000
CPU 6:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6a32 edx=0x00000000
CPU 7:
 0x4ffffffe 0x00: eax=0x4ffffffe ebx=0x00000000 ecx=0x0e5c6aec edx=0x00000000
tonja@tonja-Standard-PC-Q35-ICH9-2009:~$
```

Verified in dmesg log –

```
[ 199.893459] CPUID(0x4FFFFFFF), total exit count: 750231
[ 271.582526] CPUID(0x4FFFFFFFE), total cpu cycles count: 33918081
[ 271.589183] CPUID(0x4FFFFFFFE), total cpu cycles count: 33918295
[ 271.596647] CPUID(0x4FFFFFFFE), total cpu cycles count: 33918984
[ 271.604074] CPUID(0x4FFFFFFFE), total cpu cycles count: 33919531
[ 271.611919] CPUID(0x4FFFFFFFE), total cpu cycles count: 33919885
[ 271.619217] CPUID(0x4FFFFFFFE), total cpu cycles count: 33920949
[ 271.626573] CPUID(0x4FFFFFFFE), total cpu cycles count: 33921678
[ 271.634132] CPUID(0x4FFFFFFFE), total cpu cycles count: 33922007
tonja_jean@centralnested:~/linux$
```

## 4.6 DEBUGGING

### Errors with kvm\_emulate\_cpuid

```
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ cd ../../
tonja_jean@centralnested:~/linux/arch/x86$ cd ..
tonja_jean@centralnested:~/linux$ sudo make -j 8 modules
mkdir -p /home/tonja_jean/linux/tools/objtool && make O=/home/tonja_jean/linux subdir=tools/objtool --no-print-directory -C objtool
INSTALL libsubcmd headers
CALL scripts/checksyscalls.sh
CC [M] arch/x86/kvm/vmx/vmx.o
LD [M] arch/x86/kvm/vmx-intel.o
MODPOST Module.symvers
ERROR: modpost: "total_exits" [arch/x86/kvm/vmx.ko] undefined!
ERROR: modpost: "cpu_cycles" [arch/x86/kvm/vmx.ko] undefined!
make[2]: *** [scripts/Makefile.modpost:145: Module.symvers] Error 1
make[1]: *** [/home/tonja_jean/linux/Makefile:1863: modpost] Error 2
make: *** [Makefile:234: _sub-make] Error 2
tonja_jean@centralnested:~/linux$ cd arch/x86/kvm
tonja_jean@centralnested:~/linux/arch/x86/kvm$ cd vmx
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ vi vmx.c
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$
tonja_jean@centralnested:~/linux/arch/x86/kvm/vmx$ cd ../../
tonja_jean@centralnested:~/linux/arch/x86$ cd ../../
tonja_jean@centralnested:~/linux$ sudo make -j 8 modules
mkdir -p /home/tonja_jean/linux/tools/objtool && make O=/home/tonja_jean/linux subdir=tools/objtool --no-print-directory -C objtool
INSTALL libsubcmd headers
CALL scripts/checksyscalls.sh
CC [M] arch/x86/kvm/vmx/vmx.o
LD [M] arch/x86/kvm/vmx-intel.o
MODPOST Module.symvers
CC [M] arch/x86/crypto/poly1305-x86_64.ko
CC [M] arch/x86/kvm/vmx/mod.o
CC [M] arch/x86/kvm/vmx-intel.mod.o
LD [M] arch/x86/kvm/vmx-vmx.ko
LD [M] crypto/asymmetric_keys/pkcs8_key_parser.ko
LD [M] lib/raid6/raid6_pq.ko
LD [M] drivers/scsi/scsi_mod.ko
LD [M] arch/x86/kvm/vmx.ko
LD [M] arch/x86/kvm/vmx-intel.ko
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$
tonja_jean@centralnested:~/linux$ make INSTALL_MOD_STRIP=1 modules_install && make install
```

```
ssh.cloud.google.com/v2/ssh/projects/newnestedlab/zones/us-central1-a/instances/centralnested?authuser=0&hl=en_US&projectNumber=107255736...
ssh.cloud.google.com/v2/ssh/projects/newnestedlab/zones/us-central1-a/instances/centralnested?authuser=0&hl=en_US&projectNumber=1...
SSH-in-browser
UPLOAD FILE
DOWNLOAD FILE
INSTALL /lib/modules/6.7.0-rc34/kernel/net/rds/rds.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/rds/rds.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/rds/rds_rdma.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/rds/rds_rdma.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/rds/rds_tcp.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/rds/rds_tcp.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/tipc/tipc.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/tipc/tipc.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/tipc/tipc_diag.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/tipc/tipc_diag.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/smc/smc.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/smc/smc.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/smc/smc_diag.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/smc/smc_diag.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/dns_resolver/dns_resolver.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/dns_resolver/dns_resolver.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/ceph/libceph.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/ceph/libceph.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/psample/psample.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/psample/psample.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/life/life.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/life/life.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/openvswitch/openvswitch.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/openvswitch/openvswitch.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-vxlan.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-vxlan.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-geneve.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-geneve.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-gre.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/openvswitch/vport-gre.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock_diag.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock_diag.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_transport.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_transport.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_virtio_transport.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_virtio_transport.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_virtio_transport_common.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vmci_virtio_transport_common.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/hv_sock.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/hv_sock.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock_loopback.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/vmw_vsock/vsock_loopback.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/net/nah/nah.ko
STRIP /lib/modules/6.7.0-rc34/kernel/net/nah/nah.ko
INSTALL /lib/modules/6.7.0-rc34/kernel/virt/lib/irqbypass.ko
STRIP /lib/modules/6.7.0-rc34/kernel/virt/lib/irqbypass.ko
DEPMOD /lib/modules/6.7.0-rc34/
depmod: ERROR: Cycle detected: kvm -> kvm_intel -> kvm
depmod: ERROR: Found 2 modules with dependency cycles!
make[2]: *** [scripts/Makefile.modpost:145: Module.symvers] Error 1
make[1]: *** [/home/tonja_jean/linux/Makefile:1819: modules_install] Error 2
make: *** [Makefile:234: _sub-make] Error 2
tonja_jean@centralnested:~/linux$
```

## Building modules

## First run errors:

```

arch/x86/kvm/cpuid.c: In function 'kvm_emulate_cpuid':
arch/x86/kvm/cpuid.c:1576:3: error: the address of 'edx' will always evaluate as 'true' [-Werror=address]
1576 |   kvm_cpuid(vcpu, &eax, &eax, &ebx, &ecx, &edx, false);
      |   ^~~~~~
arch/x86/kvm/cpuid.c:1576:3: error: too many arguments to function 'kvm_cpuid'
arch/x86/kvm/cpuid.c:1509:6: note: declared here
1509 |   bool kvm_cpuid(struct kvm_vcpu *vcpu, u32 *eax, u32 *ebx,
      |   ^~~~~~
cc1: all warnings being treated as errors
make[4]: *** [scripts/Makefile.build:243: arch/x86/kvm/cpuid.o] Error 1
make[3]: *** [scripts/Makefile.build:480: arch/x86/kvm] Error 2
make[2]: *** [scripts/Makefile.build:480: arch/x86] Error 2
make[1]: *** [/home/tonja_jean/linux/Makefile:1911: .] Error 2
make: *** [Makefile:234: __sub-make] Error 2
tonja_jean@centralnested:~/linux$

```

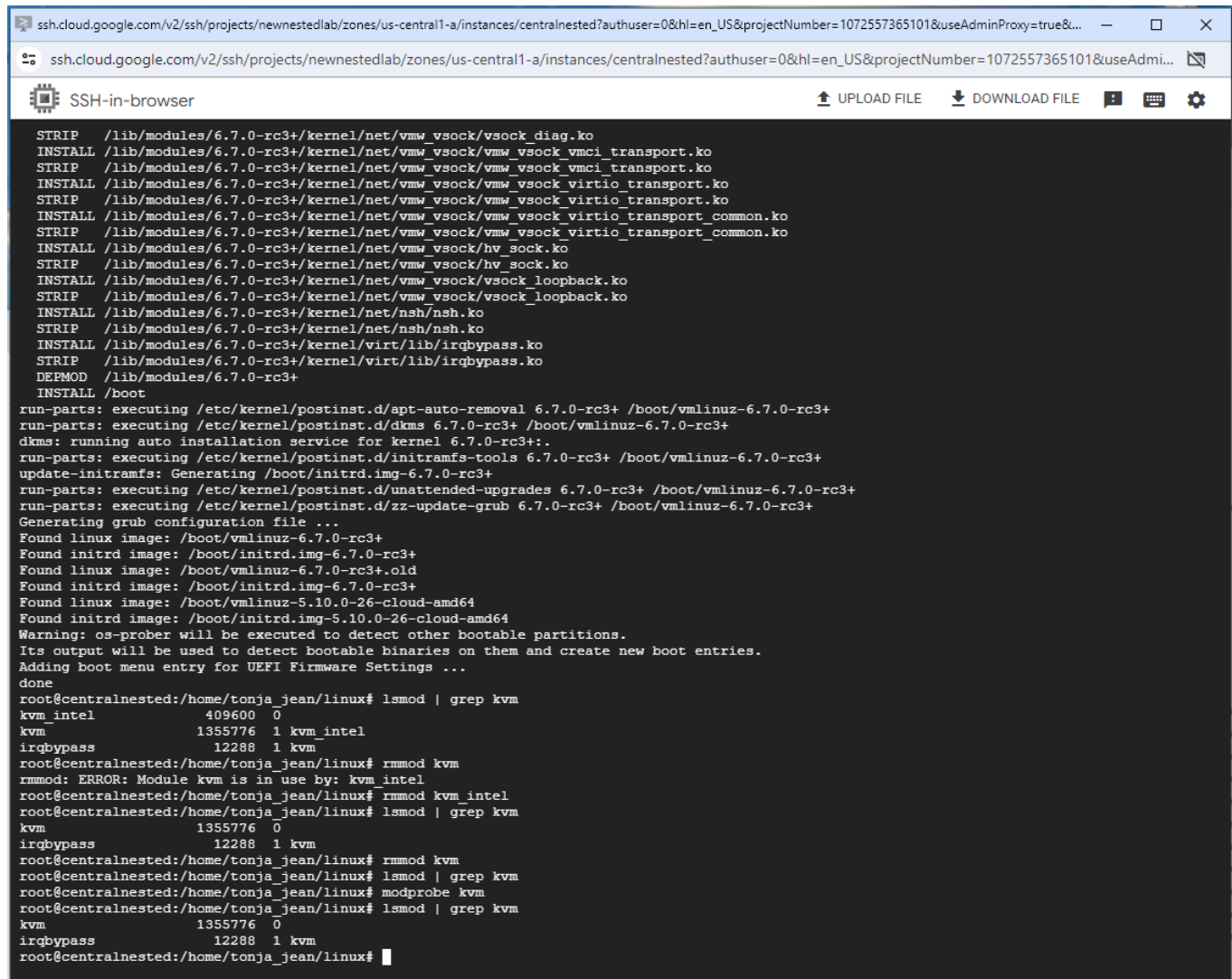
Corrected the errors in the code cpuid.c and reran followed with  
 Check for kvm already loaded, clear, and load.

```

lsmod | grep kvm
lsmod | grep kvm_intel
rmmod kvm
modprobe kvm
lsmod | grep kvm

```

Resolved – cleared loaded kvm and reloaded



```

ssh.cloud.google.com/v2/ssh/projects/newnestedlab/zones/us-central1-a/instances/centralnested?authuser=0&hl=en_US&projectNumber=1072557365101&useAdminProxy=true&...
ssh.cloud.google.com/v2/ssh/projects/newnestedlab/zones/us-central1-a/instances/centralnested?authuser=0&hl=en_US&projectNumber=1072557365101&useAdmi...
SSH-in-browser
UPLOAD FILE
DOWNLOAD FILE

STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vsock_diag.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_vmci_transport.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_vmci_transport.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_virtio_transport.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_virtio_transport.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_virtio_transport_common.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vmw_vsock_virtio_transport_common.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/hv_sock.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/hv_sock.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vsock_loopback.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/vmw_vsock/vsock_loopback.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/net/nsh/nsh.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/net/nsh/nsh.ko
INSTALL /lib/modules/6.7.0-rc3+/kernel/virt/lib/irqbypass.ko
STRIP /lib/modules/6.7.0-rc3+/kernel/virt/lib/irqbypass.ko
DEPMOD /lib/modules/6.7.0-rc3+
INSTALL /boot
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 6.7.0-rc3+ /boot/vmlinuz-6.7.0-rc3+
run-parts: executing /etc/kernel/postinst.d/dkms 6.7.0-rc3+ /boot/vmlinuz-6.7.0-rc3+
dkms: running auto installation service for kernel 6.7.0-rc3+:.
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 6.7.0-rc3+ /boot/vmlinuz-6.7.0-rc3+
update-initramfs: Generating /boot/initrd.img-6.7.0-rc3+
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 6.7.0-rc3+ /boot/vmlinuz-6.7.0-rc3+
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 6.7.0-rc3+ /boot/vmlinuz-6.7.0-rc3+
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-6.7.0-rc3+
Found initrd image: /boot/initrd.img-6.7.0-rc3+
Found linux image: /boot/vmlinuz-6.7.0-rc3+.old
Found initrd image: /boot/initrd.img-6.7.0-rc3+
Found linux image: /boot/vmlinuz-5.10.0-26-cloud-amd64
Found initrd image: /boot/initrd.img-5.10.0-26-cloud-amd64
Warning: os-prober will be executed to detect other bootable partitions.
Its output will be used to detect bootable binaries on them and create new boot entries.
Adding boot menu entry for UEFI Firmware Settings ...
done
root@centralnested:/home/tonja_jean/linux# lsmod | grep kvm
kvm_intel          409600      0
kvm                1355776     1 kvm_intel
irqbypass         12288       1 kvm
root@centralnested:/home/tonja_jean/linux# rmmod kvm
rmmod: ERROR: Module kvm is in use by: kvm_intel
root@centralnested:/home/tonja_jean/linux# rmmod kvm_intel
root@centralnested:/home/tonja_jean/linux# lsmod | grep kvm
kvm                1355776     0
irqbypass         12288       1 kvm
root@centralnested:/home/tonja_jean/linux# rmmod kvm
root@centralnested:/home/tonja_jean/linux# lsmod | grep kvm
root@centralnested:/home/tonja_jean/linux# modprobe kvm
root@centralnested:/home/tonja_jean/linux# lsmod | grep kvm
kvm                1355776     0
irqbypass         12288       1 kvm
root@centralnested:/home/tonja_jean/linux#

```

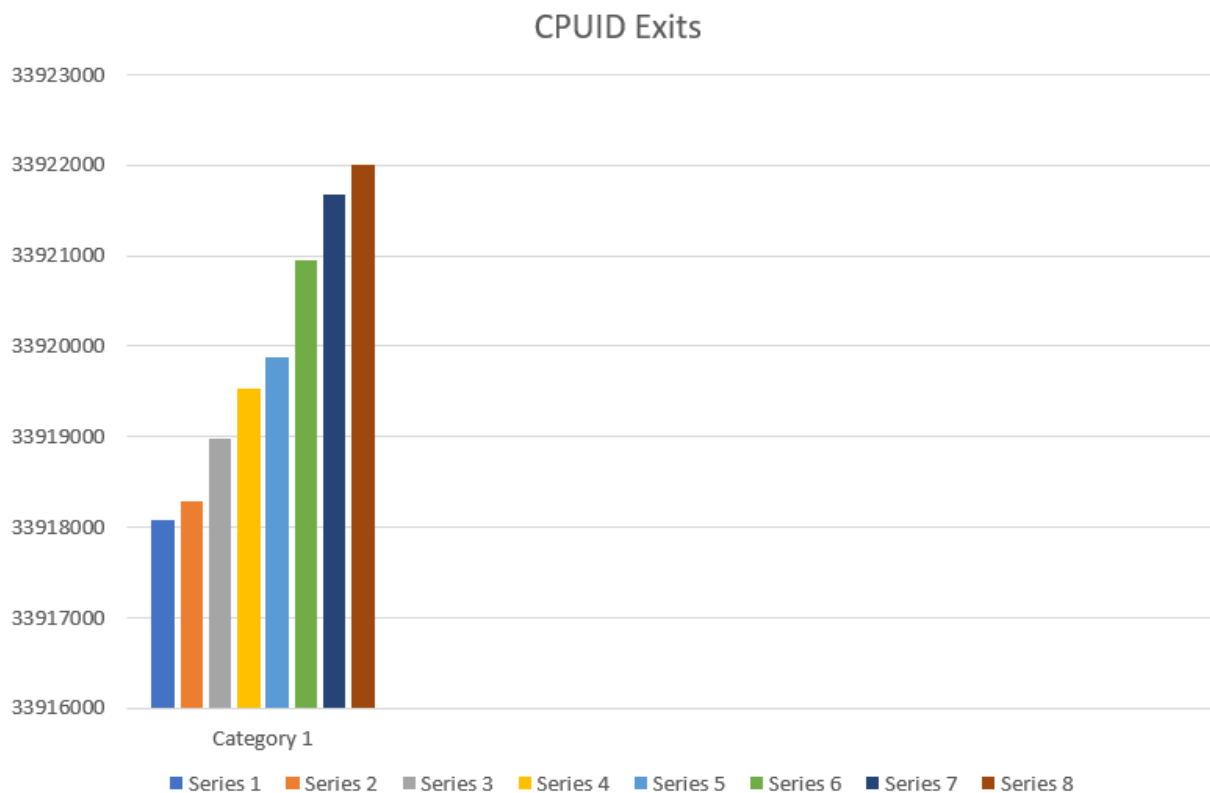
## 5 SUMMARY AND QUESTIONS

1. Team Members: Described in Section 4.1

Puja Kimari

Tonja Jean

2. Detailed Steps: Sections 4.2 – 4.5
3. The frequency of exists appears to gradually increase without major spikes in the trend.



During this boot, a full boot cycle appeared to handle 271,359,410 exits.

Of the exit types defined in the SDM, which are the most frequent? Least?

Most Frequent Exit:

- Exit number 48 - EPT Violation

- Exit number 1- External Interrupt

Least Frequent Exit :

- Exit number 54 - WBINVD
- Exit number 55 - XSETBV