ITP 30002-02 Operating System, Spring 2020

Homework 1

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1. Introduction

The mousehole can be summarized into two functions. The first function is blocking the file opening. With the received uid and file name from Jerry, the mousehole prevents a certain user from opening the file. The second function is to protect the process kill. Mousehole protects to kill process executed by uid which is provided by jerry before the kill system call routine is executed.

User interface (UI) part of mousehole is jerry. Jerry provides to user more fancy and safe command-line interface to use mousehole's functions. To implement this communication between jerry and mousehole, it constructs a communication through the proc filesystem.

2. Approach

In this section, I will describe details on the mousehole and jerry.

2.1. Jerry Command-line Interface (CLI)

Jerry provides five commands: -bf, -uf, -pk, -uk, and -status. If given command-line is not valid format, jerry prints its usage. Also, if given command-line has some error, jerry prints error message. For example: jerry -bf ubuntu hello.txt.

-bf stands for block file open. This command takes two arguments which are username and file name. -pk stands for protect killing process. This command takes only one argument which is username. Jerry converts username to uid using getpwnam() function. Because with username, jerry can get passwd struct which has its uid. -uf and -uk indicate -bf command and -pk command cancel, respectively. -status command shows mousehole's current status. -uf, -uk and -status have no additional arguments.

2.2. Communication through Proc Filesystem

Jerry and mousehole are establish the communication using proc filesystem. When mousehole initiates, it creates mousehole file into /proc directory and register its own callback functions like proc_read. In jerry, if the command is -status, Mousehole provides its status through reading /proc/mousehole, so jerry reads /proc/mousehole

2.3. Blocking file opening

If the sys_open routine that was originally in the system call table at __NR_open is replaced with a mousehole's sys_open function, the mousehole can be listened to for all sys_open system calls. If the mousehole's sys_open does not call an original sys_open, the file is not opened.

In hooked sys_open, mousehole tokenizes the file path received when the system call is called using strsep with '/' delimiter. Mousehole uses the strstr function to compare whether the string received from Jerry exists as a substring of the last string of strsep. If the return value of strstr is not null, mousehole compares uid. Using current → cred → uid, mousehole compares the uid of the user who requested this system call and the uid received from Jerry. If it is the same, it means mousehole have to block this system call, -EACCES is returned. Otherwise, original sys_open is called.

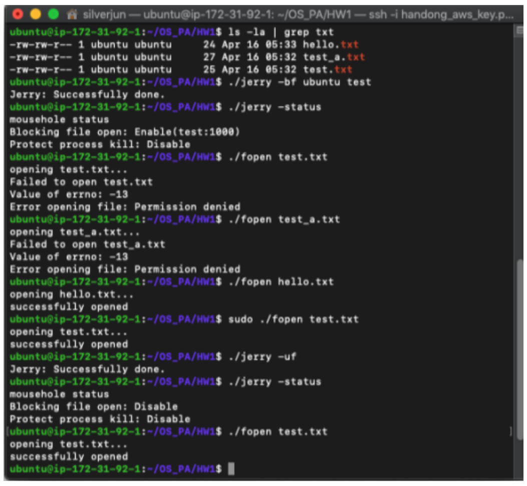
2.4. Protect process killing

Protecting process kills is similar to preventing file opening. As the original sys_open was in __NR_open in the system call table, sys_kill is at __NR_kill in system call table. Mousehole replaces it with own sys_kill. Then, like sys_open, mousehole can listen for all process kill system calls. Mousehole needs to compare the uid received from Jerry with the uid that creator of the process being killed. To find the process, which is candidate of killing, use for_each_process to search all currently open processes and compare pid. The process is implemented as a task_struct, which has a cred among its members and a uid in cred. Mousehole compares this uid with the uid received from Jerry. If it is equal, it returns -EACCES. Otherwise, original sys_kill is called.

3. Evaluation

I will describe the requirements that must be satisfied to ensure that they are implemented properly.

In the function one, only the user given by Jerry should not be able to open the file. To show this, I give a user through Jerry and try to open the file as a user and a root user respectively. Also, I try to open another file which is not contain jerry provided file name with a user. Later, I undo the file open prevention command through jerry and tries. To proof successfully file opening or failing, I made a simple file open program with open() function. If the file descriptor (fd) returned by open() is negative value, it prints fd and error string. In my experiments, It shows that the user which is provided to mousehole cannot open the file. In contrast, root user can open the file.

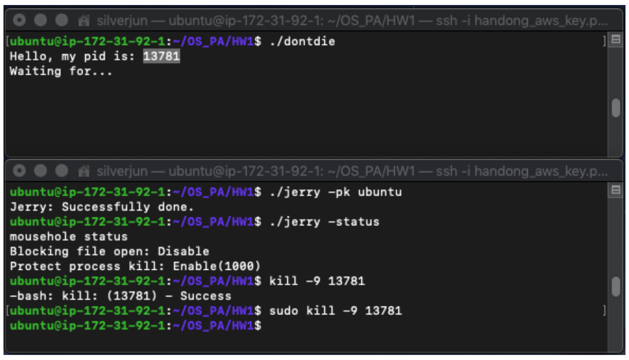


silverjun — ubuntu@ip-172-31-92-1: ~/OS_PA/HW1 — ssh -i handong_aws_key.p...

```
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ls -la | grep txt
-rw-rw-r-- 1 ubuntu ubuntu     24 Apr 16 05:33 hello.txt
-rw-rw-r-- 1 ubuntu ubuntu     27 Apr 16 05:32 test_a.txt
-rw-rw-r-- 1 ubuntu ubuntu     25 Apr 16 05:32 test.txt
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -bf ubuntu test
Jerry: Successfully done.
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -status
mousehole status
Blocking file open: Enable(test:1000)
Protect process kill: Disable
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./fopen test.txt
opening test.txt...
Failed to open test.txt
Value of errno: -13
Error opening file: Permission denied
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./fopen test_a.txt
opening test_a.txt...
Failed to open test_a.txt
Value of errno: -13
Error opening file: Permission denied
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./fopen hello.txt
opening hello.txt...
successfully opened
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ sudo ./fopen test.txt
opening test.txt...
successfully opened
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -uf
Jerry: Successfully done.
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -status
mousehole status
Blocking file open: Disable
Protect process kill: Disable
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./fopen test.txt
opening test.txt...
successfully opened
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ 
```

Figure 1. The function one experiment with test.txt, test_a.txt hello.txt.

In the function two, in order to check if the second function has been properly implemented, the process created by the user passed through Jerry must be prevented from being killed. To show this, after running a simple blocking program written by C, we will give a command through Jerry and check whether the process is killed with the privileges of various users.



silverjun — ubuntu@ip-172-31-92-1: ~/OS_PA/HW1 — ssh -i handong_aws_key.p...
silverjun — ubuntu@ip-172-31-92-1: ~/OS_PA/HW1 — ssh -i handong_aws_key.p...

```
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./dontdie
Hello, my pid is: 13781
Waiting for...
```

```
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -pk ubuntu
Jerry: Successfully done.
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ ./jerry -status
mousehole status
Blocking file open: Disable
Protect process kill: Enable(1000)
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ kill -9 13781
-bash: kill: (13781) - Success
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$ sudo kill -9 13781
ubuntu@ip-172-31-92-1:~/OS_PA/HW1$
```

Figure 2. The function two experiment with dontdie process.

In my second experiment, I successfully showed it is working very well.

4. Discussion

In this discussion section, I will describe that I noticed information and some future works.

4.1. About Error Throwing

As you can see in Figure 2, kill said that is successfully killed. But it did not kill at all. In my mousehole code, I simply return -EACCES value. But it really not working. I searched about kernel module error throwing mechanism but I can't find another method. Many people said that returning negative value is automatically set errno by OS. I need to figure out this problem in future.

4.2. Process Blocking Product for Kids

In iOS, Apple showed a "screen time" feature that forces a process to shut down when it's on. Like this, many parents need process management program for kids to manage usage of digital devices. I think this kind of program made by this kernel module. After this homework, I want to make my own process management program to save my time.

4.3. About Rootkit

At the first homework describing video, professor said that this homework is making kind of rootkit. After making mousehole, I really have a question, how to make rootkit? I googled and found nice site describing about rootkit. Like hook sys_open system call, rootkit hooks setreuid system call and change privilege to root. So I can run with root user. It is amazing!

5. Conclusion

Mousehole can be summarize by two protection functions: file open by specific user and being killed process which creator is specific user. In this homework, I really enjoyed and had some funs to explorer linux kernel site, forums and stack overflow.

Demo: https://youtu.be/P2aP4WJnnek

Drive: https://drive.google.com/file/d/155oqILtNL1KX5e0Qoil-47jSv7TgJa_N/view?usp=sharing