CS 3710 Introduction to Cybersecurity
Term: Spring 2022

Lab Exercise 7 – Binary Analysis, Firewall, and Intrusion Detection

Due Date: April 15, 2022 11:59pm
Points Possible: 7
hz9xs

1. Overview

This lab exercise will provide some hands-on experience with binary analysis, firewall configuration, and intrusion detection.

2. Resources required

This exercise requires Kali Linux VM running in the Virginia Cyber Range.

3. Initial Setup

From your Virginia Cyber Range course, select the **Ubuntu with Snort and Other Tools** environment. Click "start" to start your environment and "join" to get to your Linux desktop login. This environment requires authentication. Log in using these credentials:

Username: **`student`**
Password: **`student`**

Once you are logged in, click the Terminal Emulator in the bottom menu to open the command line.

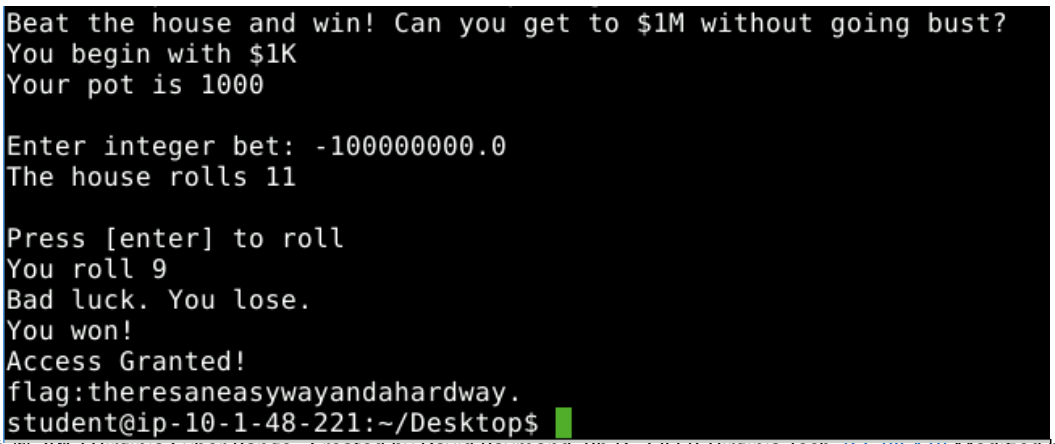
4. Tasks

Task 1: Binary Analysis

Run the file **game** and win the game. You can use the various static and dynamic tools and a little fuzzing to determine the best way to trick the game and win. The file is already located on the Desktop in Cyber Range but you may need to install the analysis tools you want to use. If you want to use your own system you can download the game file here:

bit.ly/3Cc5QEo

Provide a screenshot of what you entered to win the game. (.5 point)



I enter -100000000.0 to win the game.

Task 2: Firewall Configuration

[Note: be very careful with firewall rule configuration changes on your Cyber Range virtual machine. If you set the rules improperly you could break your network connection to the range VM. Fortunately, this can almost always be fixed by restarting your VM. If that happens, go to the Virginia Cyber Range page and select the "Stop Exercise" button for this lab, then restart the exercise and re-join.]

Use the following command to set the host-based firewall on your Linux system to a default policy that we have specified:

```
$ sudo /etc/default_firewall.sh
```

[When using ***sudo*** you may need to enter your student password: ***student***]

Linux host-based firewalls are configured using the **iptables** command. There is a pretty good (and short) tutorial at http://fideloper.com/iptables-tutorial. To review the firewall rules set by the default policy, use the following command (you may want to use the mouse to drag the terminal screen wider first to read the output more clearly with no linebreaks):

```
$ sudo iptables -L -n
```

Simple packet filtering firewalls usually have a default policy to DROP (deny) packets and only to accept traffic that meets specific criteria. When a packet arrives on a host, the firewall tries to match firewall rules starting with the first rule in the chain. The firewall will apply the first rule that matches and the default rule is applied last, so if there is a rule that "ACCEPTs" a packet before the default DROP, the packet will be accepted. In general, if a specific input or output IP address, port, or protocol is not specified, the rule applies to 'any' IP address, port, or protocol.

Review the default firewall configuration (**`$ sudo iptables –L –n`**) and answer questions 1 – 3.

1. **What is the default policy on the INPUT, FORWARD, and OUTPUT chains in the default firewall configuration and what does this mean for each? (.5 point)**

Default policy on the INPUT is DROP, default policy on the FORWARD is ACCEPT, and default policy on the OUTPUT is ACCEPT, which means that any packet in INPUT that does not match any rules will not be accepted, but any packet in FORWARD and OUTPUT that does not match any rules will be accepted.

2. **What specific firewall rules are in place on the INPUT chain? Specify protocols and ports for which packets are allowed by the rules provided, and under what conditions those packets are allowed. (Hint: there are 5 rules) (.5 point)**

```
Chain INPUT (policy DROP)
target     prot opt source               destination
ACCEPT     icmp --  0.0.0.0/0            0.0.0.0/0
ACCEPT     udp  --  0.0.0.0/0            0.0.0.0/0
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:22 state N
EW,ESTABLISHED
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:3389 state
 NEW,ESTABLISHED
ACCEPT     all  --  0.0.0.0/0            0.0.0.0/0
```

There are 5 rules:
1. Accept packets from ICMP protocol
2. Accepts packets from UDP protocol
3. Accepts packets from TCP protocol with port 22 that has NEW or ESTABLISHED connection state
4. Accepts packets from TCP protocol with port 3389 that has NEW or ESTABLISHED connection state
5. Accepts all packets

3. **You notice a big problem with the firewall rules on the INPUT chain. What is it? (.5 point)**

The fifth rule accepts all packets despite whether it's dangerous or not, so the default DROP rule will be useless if we apply the fifth rule. We should remove the fifth rule so that packets that we do not want or is dangerous will be dropped by default.

4. **What firewall rules are in place on the OUTPUT chain? Specify protocols and ports for which packets are allowed by the rules provided, and under what conditions those packets are allowed. (.5 point)**

```
Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:22 state E
STABLISHED
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:3389 state
 ESTABLISHED
ACCEPT     all  --  0.0.0.0/0            0.0.0.0/0
```

There are 3 rules:
1. Accept packets from TCP protocol with port 22 that has ESTABLISHED connection state
2. Accept packets from TCP protocol with port 3389 that has ESTABLISHED connection state
3. Accept all packets

We will use two shell scripts to modify the firewall configuration. A script called '/etc/extingui.sh' will clear all firewall rules and set the default policy on the INPUT, OUTPUT, and FORWARD chains to ALLOW all traffic in and out of your server. Execute this script as follows.

```
$ sudo /etc/extingui.sh
```

Perform the following command again to see that the firewall rules are cleared:

```
$ sudo iptables -L -n
```

Once the firewall rules are cleared, you will modify the script '/home/student/lab2/firewall.sh' to add firewall configuration commands. This file is not a blank file, it already has a firewall rules template in it. Use the text editor of your choice to edit this script (one option is “mousepad”.)

```
$ mousepad /home/student/lab2/firewall.sh
```

Iptables commands are of the following form:

```
iptables [command-type] [pattern-match options] -j [action]
```

Where `[command-type]` specifies whether the rule will be added or deleted on a specified chain, `[pattern-match-options]` specifies the port, interface, address, etc. to match, and `[action]` specifies what action to take if the packet matches the pattern (DROP, REJECT, ACCEPT, LOG).

In our simple packet filtering firewall, all of our rules will be added to the INPUT or OUTPUT chains and our actions will either be ACCEPT or DROP; so in this exercise, all of your rules will be of the form:

```
iptables -A INPUT  [pattern-match options]  -j [ACCEPT or DROP]
```

Pattern match options that you will use include:

-s	source IP address or address range (can use CIDR addressing)
-d	destination IP address or address range
-p	transport layer protocol (tcp, udp, or icmp)
-m	match a specific property (such as ‘state’)
--dport	destination port number (must be used with a protocol specified by the -p option)
--sport	source port number (must be used with a protocol specified by the -p option)
--state	connection state (NEW, ESTABLISHED, etc.)

An example rule using the above options is here:

```
# Allow inbound packets to TCP port 20 from subnet 192.168.1.0/24
iptables -A INPUT -s 192.168.1.0/24 -p tcp --dport 20 -j ACCEPT
```

Add rules to your /home/student/lab2/firewall.sh script that will allow outbound connection attempts on port 80 and the return traffic. Be very specific with your rules and include state, don’t just allow all.

Once you have edited and saved the firewall.sh file, apply at the command line as follows:

```
$ sudo /home/student/lab2/firewall.sh
```

Perform the following command again to see that the firewall rules are cleared:

```
$ sudo iptables -L -n
```

5. **List the rule(s) that you added to the firewall.sh to allow outbound HTTP requests (port 80) and responses. (1 point)**

iptables -A INPUT -p tcp --sport 80 -j ACCEPT
iptables -A OUTPUT -p tcp --dport 80 -j ACCEPT

Task 2: Intrusion Detection

Your Virginia Cyber Range virtual machine has Snort software installed for intrusion detection. Instead of observing traffic from a network interface, we will use Snort to process packet capture files (.pcap files) from previously captured traffic.

Here is a great Snort reference from the Snort creator: https://paginas.fe.up.pt/~mgi98020/pgr/writing_snort_rules.htm

Before we run Snort against captured packets, we'll take a look at some snort rules (signatures) in the /etc/snort/rules directory. To do this, open a terminal window and change to the appropriate directory as follows.

```
$ cd /etc/snort/rules
$ ls                    ← this will list all the rule files
```

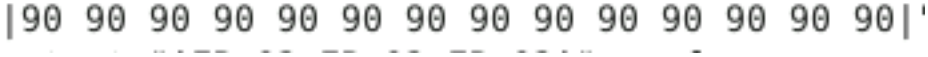
Examine the file **`shellcode.rules`** using the text editor of your choice (your Linux VM includes *vi* and *nano*, as well as a GUI text editor called *mousepad* as shown in the command below. You could also use the *cat* or *more* command).

```
$ mousepad shellcode.rules &
```

Each rule has a unique Snort ID number (sid), which is included in the signature. In *shellcode.rules*, find **sid:648** amongst the rules in that file and answer the following questions.

1. **What is the specific signature (content) that sid:648 tries to match? (.5 point)**

The specific content is "90 90 90 90 90 90 90 90 90 90 90 90 90 90"



2. **What action is Snort supposed to take if the signature contained in sid:648 is matched? (.5 point)**

The Snort will generate an alert "SHELLCODE x86 NOOP", and then log the packet.

Change directories to **/home/student/lab2** and run **snort** against the packet capture file called **theft.pcap** in that directory as shown here.

```
$ sudo snort –c /etc/snort/snort.conf –r theft.pcap
```

[When using ***sudo*** you may need to enter your student password: ***student***]

You will see Snort processing on your screen, let it complete and return on the command prompt $.

When Snort finishes processing, open a web browser on your Cyber Range virtual machine (on the menu bar at the bottom of the screen) It will automatically open the following URL: http://localhost/base.

BASE is the Basic Analysis and Security Engine, which is installed on your virtual machine along with Snort. It allows you to view Snort alerts in a nice graphical format. Log in to BASE using the username: **john** and the password: **secret3**. The homepage should show the results of the scan we just processed using Snort, with a little over 27,000 Total Number of Alerts. [If you aren't seeing "Total Number of Alerts: 27081, It takes a few minutes for the back-end alert processing to complete, so you might have to refresh the page a few times.] NOTE: If you run the command with theft.pcap more than once you will have double or triple the alerts, **so only run it once**.

Review the alerts (you might have to do some filtering) and answer the following questions.

3. **An attacker was trying to steal a specific, and very sensitive, file from the target system. What file was she after? (Hint: Click on the Total Number of Alerts, then click on Unique Alerts to filter the information) (.5 point)**

The attacker is trying to steal the file "/etc/passwd" which contains the password of the user.

4. **What is the technique that the attacker was trying to use to steal the file? (1 point)**

The attacker was trying to use directory traversal to steal the file.

5. **What is the source IP address of the attacker that is trying to steal the file from the system? (1 point)**

The IP address of the attacker is 92.60.73.14.

By submitting this assignment you are digitally signing the honor code, "I pledge that I have neither given nor received help on this assignment".

END OF EXERCISE

References

- iptables man page: https://linux.die.net/man/8/iptables
- iptables tutorial: https://fideloper.com/iptables-tutorial
- Snort: https://www.snort.org/
- Writing Snort Rules: https://paginas.fe.up.pt/~mgi98020/pgr/writing_snort_rules.htm
- BASE: https://lwn.net/Articles/112548/