Linux Firewall Exploration Lab

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Instruction: https://seedsecuritylabs.org/Labs_16.04/PDF/Firewall.pdf

Set up 2 VMs: - A: `10.0.2.15` - B: `10.0.2.4`.

Task 1

All commands run on the VM `10.0.2.15`, and modify Line 11 in its `/etc/default/ufw` with root privilege (e.g. `sudo vi`/`sudo gedit`/`sudo nano`+filename or whatever method you like) as:

```
DEFAULT_INPUT_POLICY="ACCEPT"
```

Or simply use the command:

```
sudo ufw default allow incoming
```

Ref to the manual and tutorial of `ufw`

At first, enable it:

```
sudo ufw enable
```

After configuration, reset it to the installed status and remove added rules:

```
sudo ufw reset
```

Prevent A from doing `telnet` to Machine B

```
sudo ufw deny out from 10.0.2.15 to 10.0.2.4 port 23
```

Prevent B from doing `telnet` to Machine A

```
sudo ufw deny in from 10.0.2.4 to 10.0.2.15 port 23
```

Prevent A from visiting an external web site

Use `ping` or `traceroute` to get one of the host IP address and block the corresponding `HTTP`/`HTTPS` connections:

```
sudo ufw deny out from 10.0.2.15 to host_ip port 80
sudo ufw deny out from 10.0.2.15 to host_ip port 443
```

Note: As this answer explains, It is impossible to stop the accessing to a domain.

Task 2

From the programming manual of `netfilter` module, I can implement a simplified firewall program as `packet_filter.c`

For each rule, a callback function is defined to filter packets meeting some specified conditions.

For example, the function for task 1.1 can be defined as `telnetFilter_1()`

```c
unsigned int telnetFilter_1(void *priv, struct sk_buff *skb,
                            const struct nf_hook_state *state)
// rule for task 1.1: Prevent A from doing `telnet` to Machine B
{
    struct iphdr *iph;
    struct tcphdr *tcph;

    iph = ip_hdr(skb);
    tcph = (void *)iph + iph->ihl * 4;

    if (iph->protocol == IPPROTO_TCP && tcph->dest == htons(23)
        && eq_daddr(iph, "10.0.2.4") && eq_saddr(iph,
        "10.0.2.15"))
    {
        printk(KERN_INFO "Dropping telnet from %pI4 packet to
            %pI4\n", &iph->saddr, &iph->daddr);
        return NF_DROP;
    }
    else
    {
        return NF_ACCEPT;
    }
}
```

Similarly, the `if` statement can be replaced by other rules to construct more filters.

The `if`condition in `telnetFilter_2()` for task 1.2:

```c
if (iph->protocol == IPPROTO_TCP && tcph->dest == htons(23) &&
    eq_daddr(iph, "10.0.2.15") && eq_saddr(iph, "10.0.2.4"))
```

Assume that we intend to block machine A from opening the website: http://notebook.xyli.me/. Before constructing the rule, we utilize Wireshark to get its 2 host IP address: `104.18.21.226` and `103.235.46.191`.

Based on the knowledge, the `if` condition in 'block_xyli_me' for task 1.3 should be:

```c
if ((tcph->dest == htons(80) || tcph->dest == htons(443))
&& (eq_daddr(iph, "104.18.21.226") ||
    eq_daddr(iph,"103.235.46.191"))
&& eq_saddr(iph, "10.0.2.15"))
```

To make it scalable for at least 5 filter rules, a `nf_hook_ops` array should be declared with a large size and `regist_num` is maintained to track the actual amount of filters used in the firewall:

```c
#define MAX_RULE_NUM 10

static struct nf_hook_ops FilterHookRule[MAX_RULE_NUM];
static int regist_num = 0;
```

Regist those hooks with functions above in functionsetUpFilter():

```c
int setUpFilter(void)
{
    int i;
    printk(KERN_INFO "Registering filters.\n");
    FilterHookRule[0] = (struct nf_hook_ops){.hook =
        telnetFilter_1, .hooknum = NF_INET_LOCAL_OUT, .pf =
        PF_INET, .priority = NF_IP_PRI_FIRST};
    FilterHookRule[1] = (struct nf_hook_ops){.hook =
        telnetFilter_2, .hooknum = NF_INET_LOCAL_IN, .pf =
        PF_INET, .priority = NF_IP_PRI_FIRST};
    FilterHookRule[2] = (struct nf_hook_ops){.hook =
        block_xyli_me, .hooknum = NF_INET_LOCAL_OUT, .pf =
        PF_INET, .priority = NF_IP_PRI_FIRST};

    // set the amount of filter rules
    regist_num = 3;

    for (i = 0; i < regist_num; i++)
        nf_register_hook(&FilterHookRule[i]);
    return 0;
}
```

When extending the module with more rules, just focus to fill out `hooknum` and `hook`(i.e. function definition) fields like this.

Note: `hooknum` field, namely hook type, is not consistent with the identifiers in the book. Please read their actual definition (alias `enum`) in `linux/netfilter.h`.

Define an unregist function as well and associate those functions in the module.

```c
void removeFilter(void)
{
    int i;
    printk(KERN_INFO "Filters are being removed.\n");
    //unregist hooks one by one
    for (i = 0; i < regist_num; i++)
        nf_unregister_hook(&FilterHookRule[i]);
    regist_num = 0;
}

module_init(setUpFilter);
module_exit(removeFilter);

MODULE_LICENSE("GPL");
```

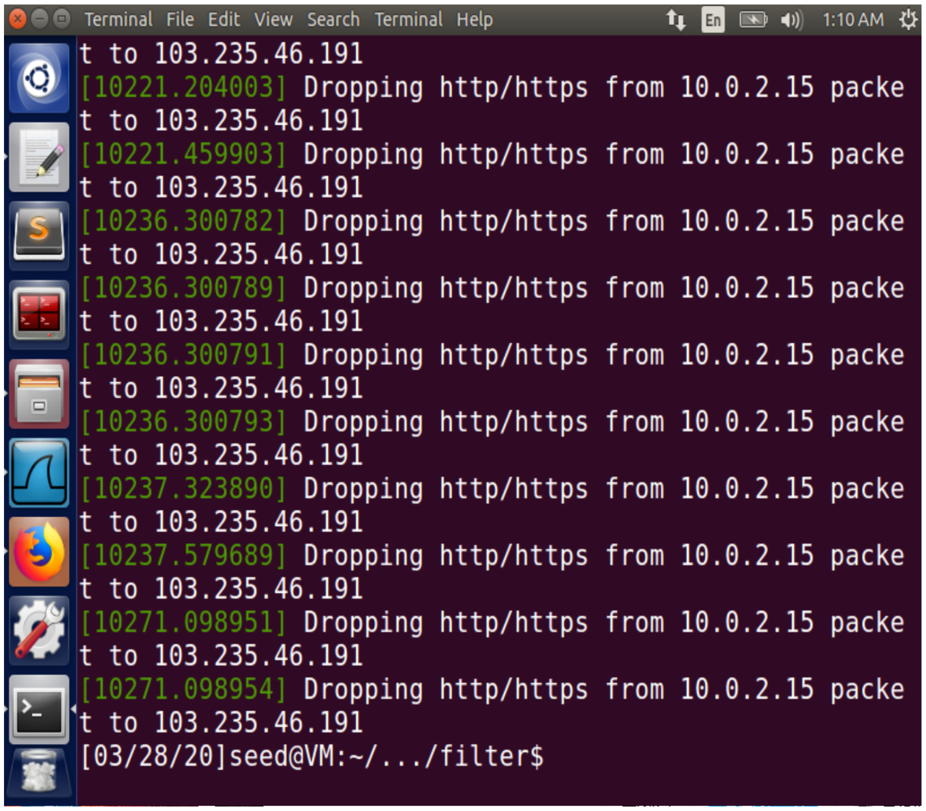
Finally, write a `makefile` and type `make` to compile:

```
obj-m += packet_filter.o
all:
    make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules

clean:
    make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
```

Install the output module `packet_filter.ko` into the kernel:

```
sudo insmod packet_filter.ko
```

Now, you can observe the firewall works, and log can be viewed with command `dmseg`:



```
t to 103.235.46.191
[10221.204003] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10221.459903] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10236.300782] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10236.300789] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10236.300791] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10236.300793] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10237.323890] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10237.579689] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10271.098951] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[10271.098954] Dropping http/https from 10.0.2.15 packe
t to 103.235.46.191
[03/28/20]seed@VM:~/.../filter$
```

Don't forget to uninstall the firewall after the lab:

```
sudo rmmod packet_filter
```

Task 3

Block all the outgoing traffic to external telnet servers.

Set up another VM C: `10.0.2.5`.

On machine A:

```
sudo ufw deny out from 10.0.2.15 to any port 23
sudo ufw enable
```

Block all the outgoing traffic to `www.facebook.com`

~~It's difficult because the domain has many dynamic IP addresses as hosts. For example, `ping` it at different time:~~

```
$ping www.facebook.com
```

```
PING star-mini.c10r.facebook.com (157.240.2.35) 56(84) bytes of
    data.
64 bytes from edge-star-mini-shv-01-ort2.facebook.com
    (157.240.2.35): icmp_seq=1 ttl=52 time=18.7 ms
```

```
$ ping www.facebook.com
PING star-mini.c10r.facebook.com (157.240.18.35) 56(84) bytes of
    data.
64 bytes from edge-star-mini-shv-02-ort2.facebook.com
    (157.240.18.35): icmp_seq=1 ttl=52 time=19.3 ms
```

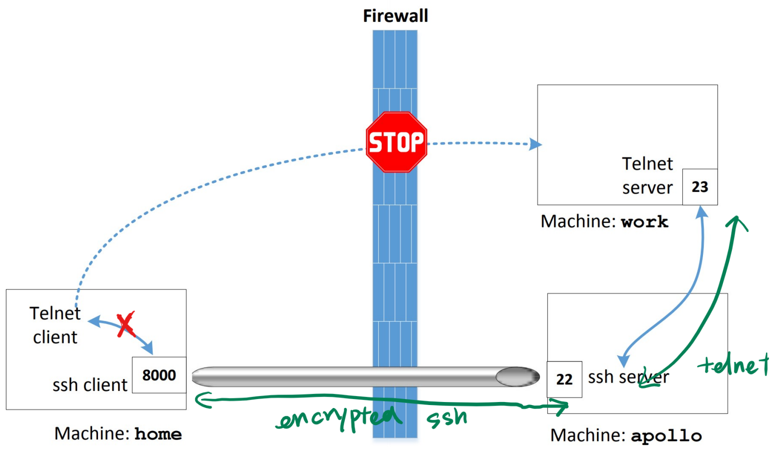
To ensure the blocking, you can use the subnet instead of a specified IP address:

```
sudo ufw deny out from 10.0.2.15 to 157.240.2.35/16
```

Task 3.a: Telnet to Machine B through the firewall

Note: The solution given by the instruction may not work. Perhaps because `telnet` usally fails on ports other than a few certain ports (see https://aplawrence.com/DirkHart/telnet2023.html and https://superuser.com/questions/790782/using-telnet-port-number)

Here is a simple alternative method:

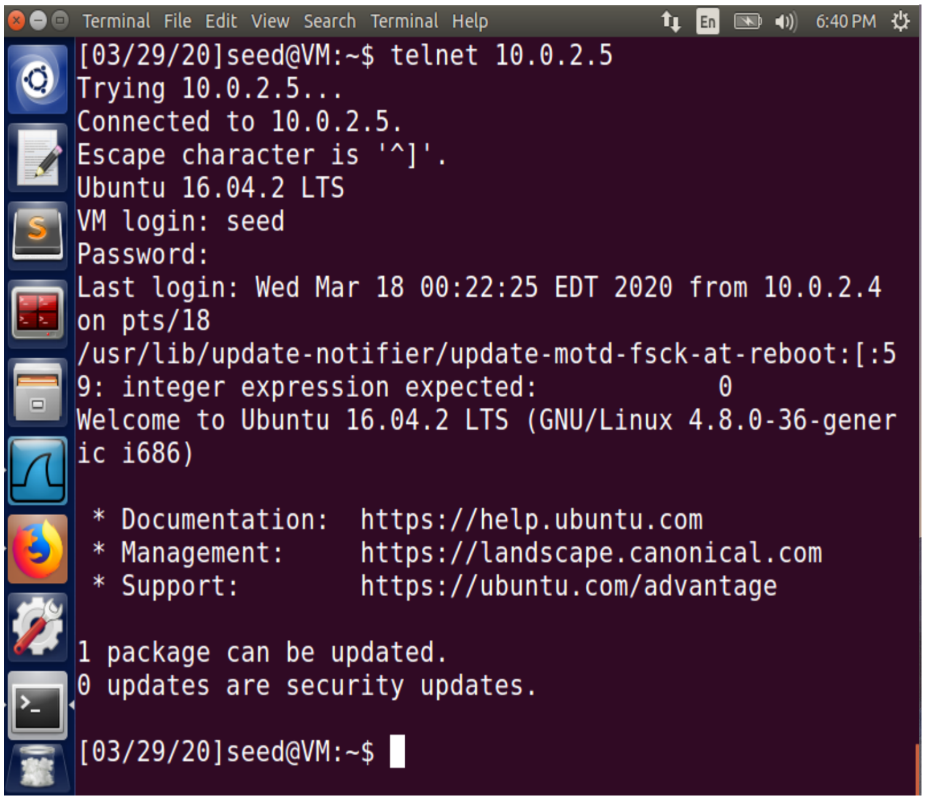


Don't do any extra port mappings. use the most naive way to `ssh` machine B

```
ssh seed@10.0.2.4
```

type the password and directly `telnet` machine C

```
telnet 10.0.2.5
```



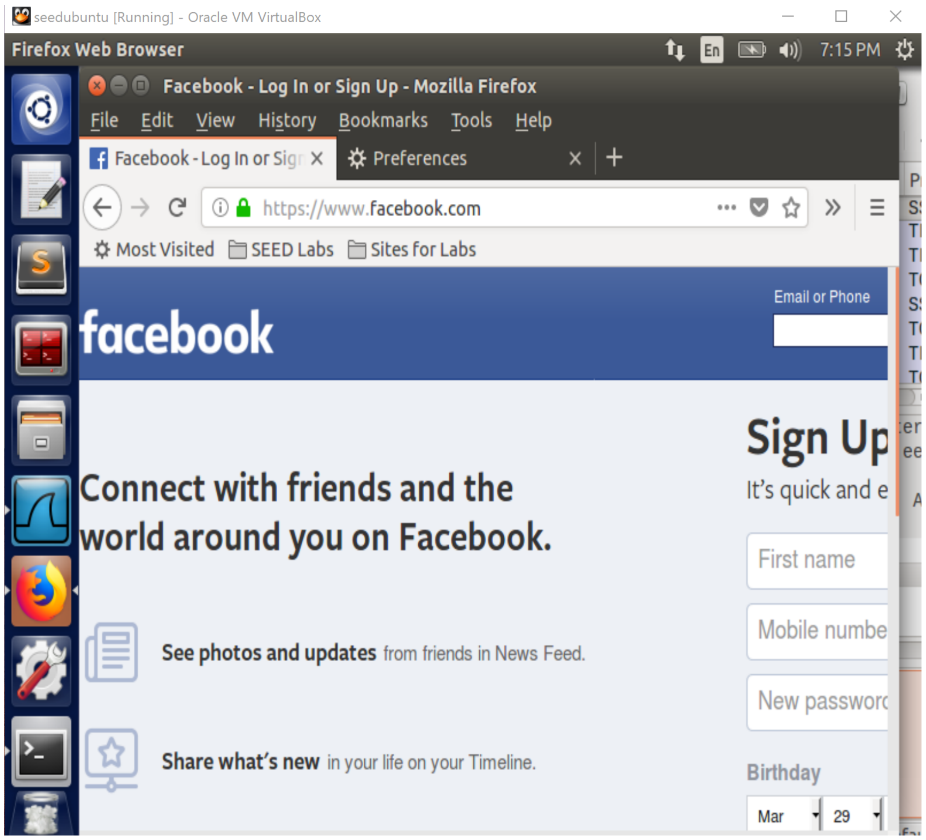
```
[03/29/20]seed@VM:~$ telnet 10.0.2.5
Trying 10.0.2.5...
Connected to 10.0.2.5.
Escape character is '^]'.
Ubuntu 16.04.2 LTS
VM login: seed
Password:
Last login: Wed Mar 18 00:22:25 EDT 2020 from 10.0.2.4
on pts/18
/usr/lib/update-notifier/update-motd-fsck-at-reboot:[:5
9: integer expression expected:            0
Welcome to Ubuntu 16.04.2 LTS (GNU/Linux 4.8.0-36-gener
ic i686)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

1 package can be updated.
0 updates are security updates.

[03/29/20]seed@VM:~$ 
```

Task 3.b: Connect to Facebook using SSH Tunnel

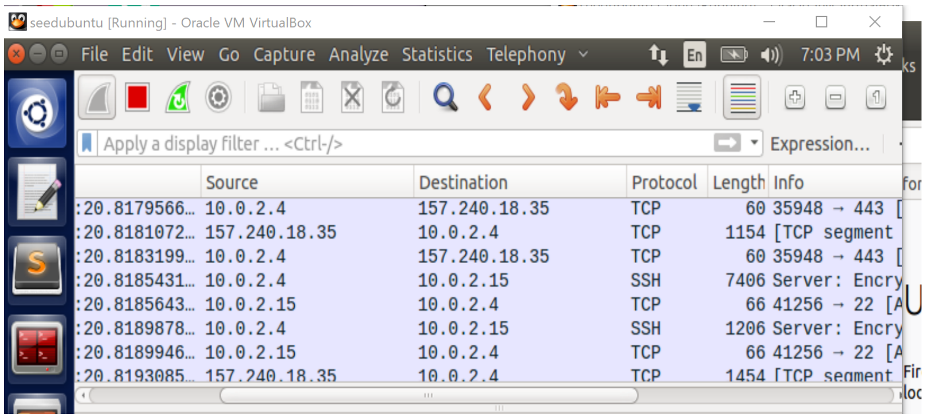
```
ssh -D 500 -C seed@10.0.2.4
```

Then configure on Firefox, change the network proxy as manual proxy mode with SOCKS host: `127.0.0.1:9000`

1. Now, I can open `www.facebook.com`


seedubuntu [Running] - Oracle VM VirtualBox
Firefox Web Browser
7:15 PM
Facebook - Log In or Sign Up - Mozilla Firefox
File Edit View History Bookmarks Tools Help
Facebook - Log In or Sign
Preferences
https://www.facebook.com
Most Visited
SEED Labs
Sites for Labs
facebook
Email or Phone
Sign Up
It's quick and e
Connect with friends and the world around you on Facebook.
See photos and updates from friends in News Feed.
Share what's new in your life on your Timeline.
First name
Mobile numbe
New passworc
Birthday
Mar
29

2. When the ssh connection is broken, clean the history data in the brower, the website `www.facebook.com` cannot be accessed any more.
3. re-connect to machine B with `ssh` command above, the website `www.facebook.com` can be opened now.
4. And using Wireshark, it shows that the actual HTTP packet is communicated between the external host of `facebook` and machine B, then our local machine A communicate with machine B by `SSH` to request the date from `facebook`:



seedubuntu [Running] - Oracle VM VirtualBox
File Edit View Go Capture Analyze Statistics Telephony
7:03 PM
Apply a display filter ... <Ctrl-/>
Expression...

```
               Source          Destination     Protocol Length Info
:20.8179566…  10.0.2.4        157.240.18.35   TCP        60 35948 → 443 [
:20.8181072…  157.240.18.35   10.0.2.4        TCP      1154 [TCP segment
:20.8183199…  10.0.2.4        157.240.18.35   TCP        60 35948 → 443 [
:20.8185431…  10.0.2.4        10.0.2.15       SSH      7406 Server: Encry
:20.8185643…  10.0.2.15       10.0.2.4        TCP        66 41256 → 22 [A
:20.8189878…  10.0.2.4        10.0.2.15       SSH      1206 Server: Encry
:20.8189946…  10.0.2.15       10.0.2.4        TCP        66 41256 → 22 [A
:20.8193085…  157.240.18.35   10.0.2.4        TCP      1454 [TCP segment
```