Sys Admin Documentation

Stéphane SIMON, Rémi JARDRET

05.12.2023

Table of Contents

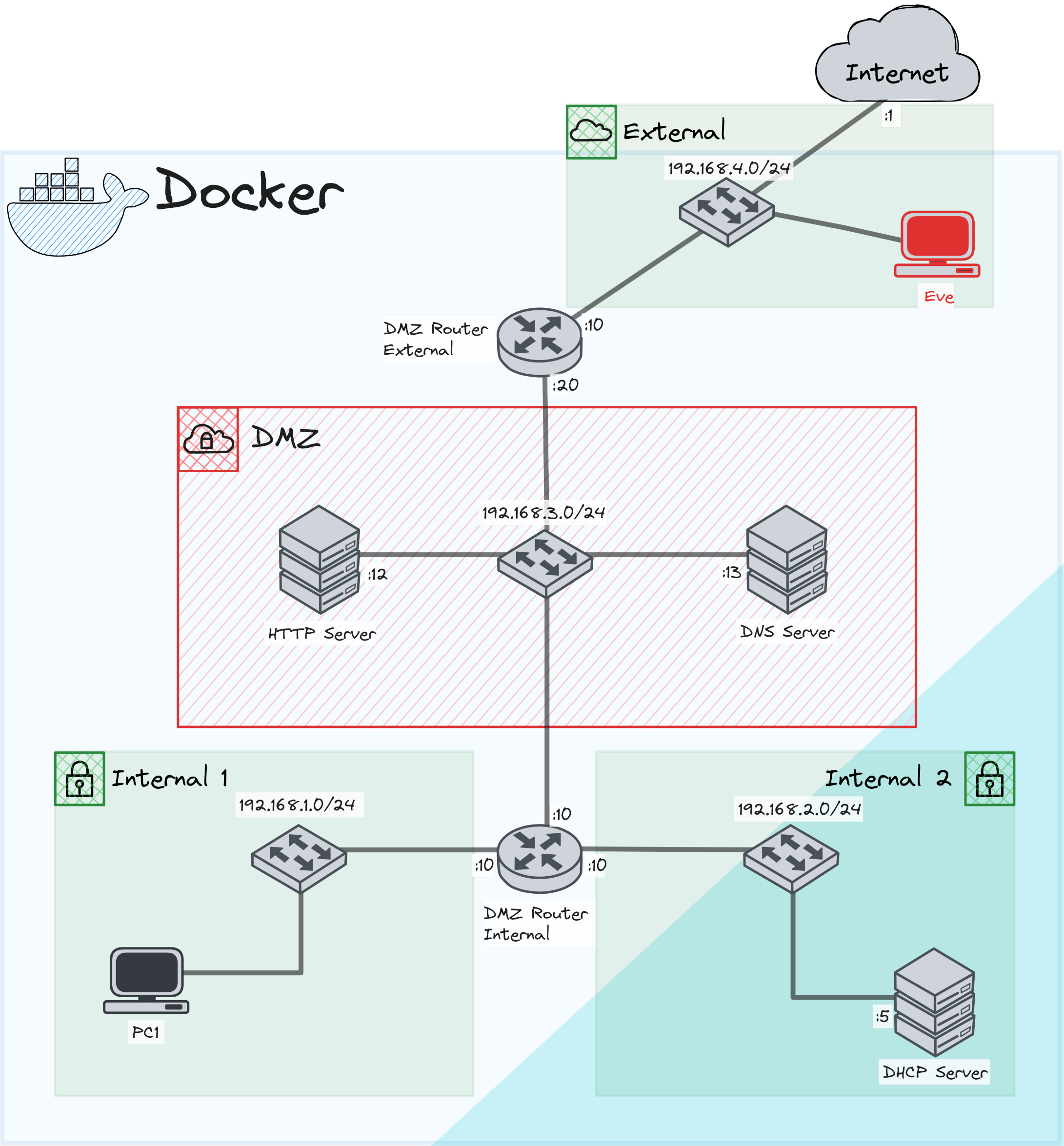
Introduction

This documentation aims to showcase the capabilities of our DockerSec environment by presenting different exercises involving tasks of system administration for beginners. All you need is access to a system with Docker installed and the `docker-compose.yml` file. Execute the command `docker compose up -d` and patiently wait for the setup to complete.

To open a terminal in a Docker container, use the command `docker exec -it <container-name> /bin/bash`. To list container names, execute `docker ps` and find them in the leftmost column under the `NAMES` heading.

Always refer to the provided diagram of the environment to gain a comprehensive understanding of the network configurations.

Diagram


Internet
:1
External
192.168.4.0/24
Docker
Eve
DMZ Router
External
:10
:20
DMZ
192.168.3.0/24
:12
:13
HTTP Server
DNS Server
Internal 1
192.168.1.0/24
:10
:10
:10
Internal 2
192.168.2.0/24
DMZ Router
Internal
PC1
:5
DHCP Server

Firewalls and Routing

For this project, we are using Ubuntu based routers with `iptables` for firewall and NAT, and `ip route` for routing. Because the container we provided have system capabilities to forward the ipv4 packets, they act like a router.

IPTables

Setting rules

`iptables` is powerful tool to manage firewall rules on a linux system, as it is only CLI, it is widely used on servers. The `iptables` have three main categories:

- INPUT
- FORWARD
- OUTPUT

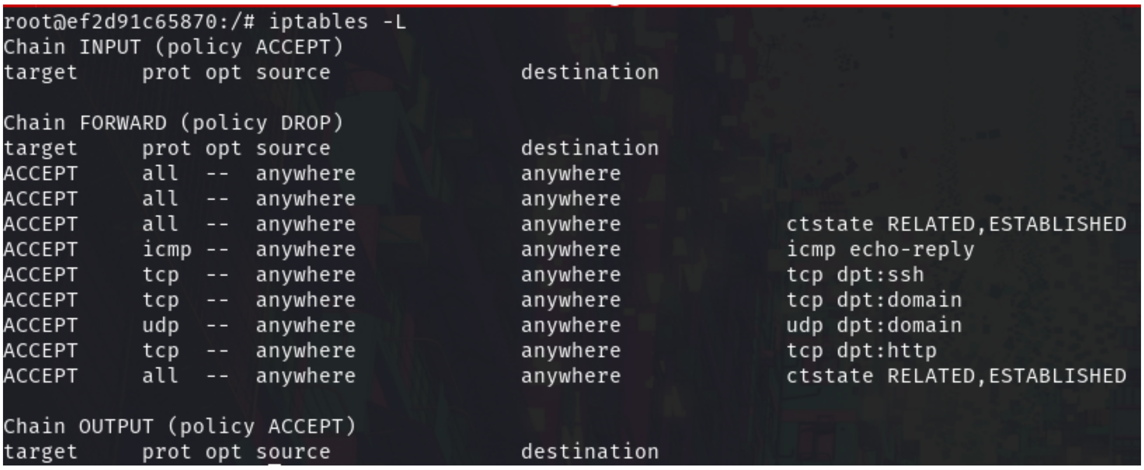
In this docker simulation, we use only FORWARD rules for firewall. Therefore, we will mainly set only such rules during the exercises, but the rules are almost identical between categories.

Questions

1. Connect to DMZ_Router_External and find a way to print the firewall rules. Optionnal: Print detailed firewall rules.
2. Show the NAT rules set in iptables
3. Create an INPUT rule to allow http service

Answers

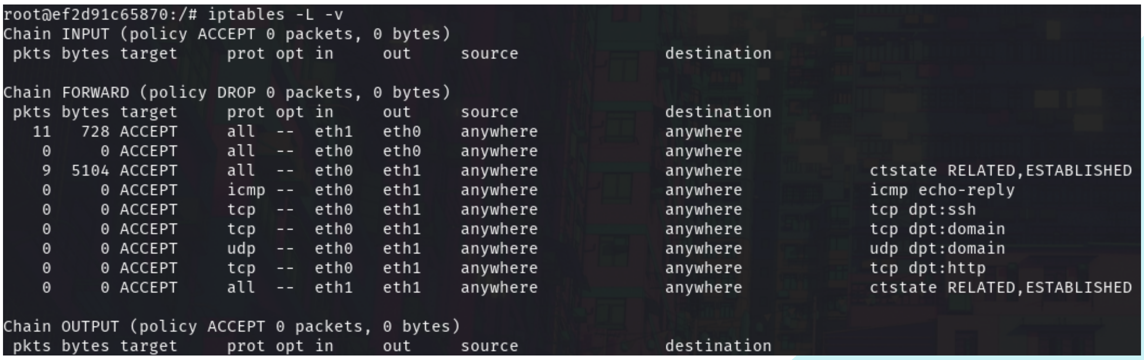
1. To show the firewall rules on the router, we can use the command `iptables -L`, and if we want detailed rules, we can upgrade the verbosity using `-v`:

   ```
   root@ef2d91c65870:/# iptables -L
   Chain INPUT (policy ACCEPT)
   target     prot opt source               destination

   Chain FORWARD (policy DROP)
   target     prot opt source               destination
   ACCEPT     all  --  anywhere             anywhere
   ACCEPT     all  --  anywhere             anywhere
   ACCEPT     all  --  anywhere             anywhere             ctstate RELATED,ESTABLISHED
   ACCEPT     icmp --  anywhere             anywhere             icmp echo-reply
   ACCEPT     tcp  --  anywhere             anywhere             tcp dpt:ssh
   ACCEPT     tcp  --  anywhere             anywhere             tcp dpt:domain
   ACCEPT     udp  --  anywhere             anywhere             udp dpt:domain
   ACCEPT     tcp  --  anywhere             anywhere             tcp dpt:http
   ACCEPT     all  --  anywhere             anywhere             ctstate RELATED,ESTABLISHED

   Chain OUTPUT (policy ACCEPT)
   target     prot opt source               destination
   ```

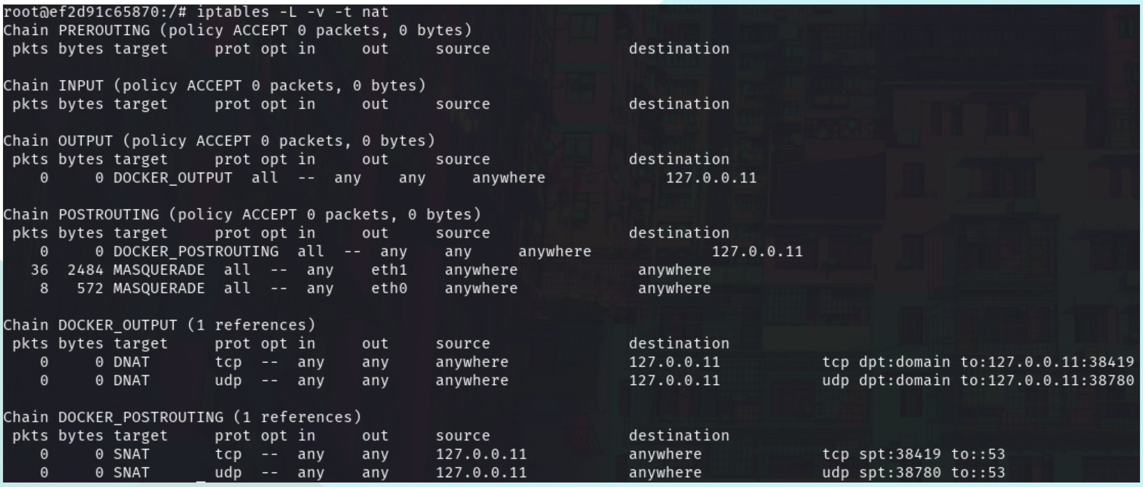
   

   ```
   root@ef2d91c65870:/# iptables -L -v
   Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination

   Chain FORWARD (policy DROP 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination
      11   728 ACCEPT     all  --  eth1   eth0    anywhere             anywhere
       0     0 ACCEPT     all  --  eth0   eth0    anywhere             anywhere
       9  5104 ACCEPT     all  --  eth0   eth1    anywhere             anywhere             ctstate RELATED,ESTABLISHED
       0     0 ACCEPT     icmp --  eth0   eth1    anywhere             anywhere             icmp echo-reply
       0     0 ACCEPT     tcp  --  eth0   eth1    anywhere             anywhere             tcp dpt:ssh
       0     0 ACCEPT     tcp  --  eth0   eth1    anywhere             anywhere             tcp dpt:domain
       0     0 ACCEPT     udp  --  eth0   eth1    anywhere             anywhere             udp dpt:domain
       0     0 ACCEPT     tcp  --  eth0   eth1    anywhere             anywhere             tcp dpt:http
       0     0 ACCEPT     all  --  eth1   eth1    anywhere             anywhere             ctstate RELATED,ESTABLISHED

   Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination
   ```

2. The NAT rules are not showed with previous command, you need to add the parameter `-t nat`. Which will print the nat rules like follow:

   ```
   root@ef2d91c65870:/# iptables -L -v -t nat
   Chain PREROUTING (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination

   Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination

   Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination
       0     0 DOCKER_OUTPUT  all  --  any    any     anywhere             127.0.0.11

   Chain POSTROUTING (policy ACCEPT 0 packets, 0 bytes)
    pkts bytes target     prot opt in     out     source               destination
       0     0 DOCKER_POSTROUTING  all  --  any    any     anywhere             127.0.0.11
      36  2484 MASQUERADE  all  --  any    eth1    anywhere             anywhere
       8   572 MASQUERADE  all  --  any    eth0    anywhere             anywhere

   Chain DOCKER_OUTPUT (1 references)
    pkts bytes target     prot opt in     out     source               destination
       0     0 DNAT       tcp  --  any    any     anywhere             127.0.0.11           tcp dpt:domain to:127.0.0.11:38419
       0     0 DNAT       udp  --  any    any     anywhere             127.0.0.11           udp dpt:domain to:127.0.0.11:38780

   Chain DOCKER_POSTROUTING (1 references)
    pkts bytes target     prot opt in     out     source               destination
       0     0 SNAT       tcp  --  any    any     127.0.0.11           anywhere             tcp spt:38419 to::53
       0     0 SNAT       udp  --  any    any     127.0.0.11           anywhere             udp spt:38780 to::53
   ```

   The `DOCKER_*` categories are specific to the setup environment, meaning you won't normally find it anywere else. We can see that POSTROUTING is set on the interfaces of the router, meaning we have NAT rules !

3. To create an INPUT to allow http service, you need to run the following:

```
    iptables -A INPUT -p tcp --dport 80 -j ACCEPT
```

Explanation of the options used:

- -A INPUT: Appends a rule to the INPUT chain.
- -p tcp: Specifies the protocol as TCP.
- --dport 80: Specifies the destination port as 80 (HTTP).
- -j ACCEPT: Specifies the target action as ACCEPT. You can use the command from question 1 to see if the rule is set !

Setting a stateful firewall

If you check again the output of iptables -L, you might notice that some rules have a ctstate writen. This meaning that the firewall will be applying a stateful rule using conntrack. Connection tracking is the main difference between what we call a stateless firewall and a stateful firewall.

With a stateless firewall, when a connection is esthablished, the firewall will check its source and destination, go through the firewall rules and then allow the connection. But with a stateful firewall, the firewall will keep track of the connection state and therefore detect if it is a new connection attempt or a part of an established one.

The stateful firewall is more secured and has better performance, therefore it is recommended to use it ! With iptables, it is very simple to set a stateful rule, we just need to add the parameter --cstate <flag>. Usually, we use the flags ESTABLISHED, NEW or RELATED.

Let's change the http rule we had set before, to do so, we need to first delete the input rule we made:

```
iptables -D INPUT 1
```

Then, we add the flags ESTABLISHED and NEW, which will allow us to create new connection but also to track the established ones:

```
    iptables -A INPUT -p tcp --dport 80 -m conntrack --ctstate NEW,
       ESTABLISHED -j ACCEPT
```

Save rules

All the rules we have set since now are not persistent, meaning that if the machine restart, it will be lost. Therefore, they many ways to save them and restore them, but we will detail one.

1. Save the rules in a file using `iptables-save > /etc/iptables/rules.v4`
2. Set a cron task at reboot that will run the following `iptables-restore < /etc/iptables/rules.v4`

Therefore, using `iptables-save` and `iptables-restore`, you can backup and restore your configuration. If you make a mistake of configuration or you are doing some testing, this is very useful in order to avoid service disruptions.

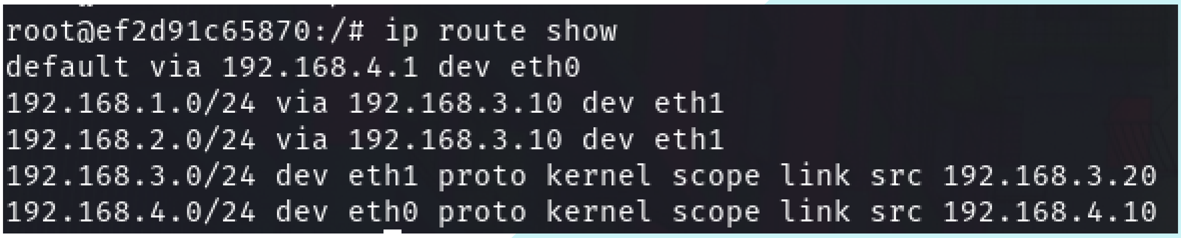
IP routes

In order to some routing on ubuntu system, we decided to use `ip route`. This set of command is helpful to set route path to subnets, the default gateway, get stats from a route path and so on.

First of all, we will show the `ip route` set on the DMZ_Router_External, let's connect to it and run the following:

```
ip route show
```

Here is the result:



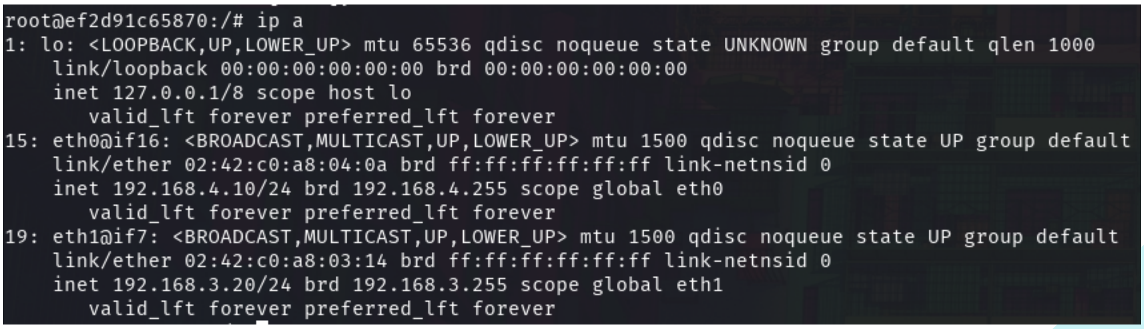
```
root@ef2d91c65870:/# ip route show
default via 192.168.4.1 dev eth0
192.168.1.0/24 via 192.168.3.10 dev eth1
192.168.2.0/24 via 192.168.3.10 dev eth1
192.168.3.0/24 dev eth1 proto kernel scope link src 192.168.3.20
192.168.4.0/24 dev eth0 proto kernel scope link src 192.168.4.10
```

Questions

1. What is the default gateway on the router ?
2. Which interface is used to access the subnet `192.168.3.0/24` ?
3. Find a way to show the ip address of the machine

Answers

1. The default gateway is written on the first line as `default via 192.168.4.1 dev eth0`. Which means that `192.168.4.1` is the default gateway address of the router and is located on interface `eth0`.
2. Reading the output of `ip route show`, we can see that the interface responsible of `192.168.3.0/24` is `eth1`. We can see for other subnets that the path is specified `via`, which means it will get to an IP address to reach the requested subnet!
3. In order to show the ip address of the machine, you can simply run `ip a`

   ```
   root@ef2d91c65870:/# ip a
   1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
       link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
       inet 127.0.0.1/8 scope host lo
          valid_lft forever preferred_lft forever
   15: eth0@if16: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default
       link/ether 02:42:c0:a8:04:0a brd ff:ff:ff:ff:ff:ff link-netnsid 0
       inet 192.168.4.10/24 brd 192.168.4.255 scope global eth0
          valid_lft forever preferred_lft forever
   19: eth1@if7: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default
       link/ether 02:42:c0:a8:03:14 brd ff:ff:ff:ff:ff:ff link-netnsid 0
       inet 192.168.3.20/24 brd 192.168.3.255 scope global eth1
          valid_lft forever preferred_lft forever
   ```

   You can read the ip address on `inet` for each interface ! You can even read the MAC address on `link/ether`.

Troubleshooting

IP routes are not parameters that you will set a lot. Usually you set them once at the initial setup and that's it, you might update them if you changed your router config but it is rare. Also, on sophisticated routers, you don't even need to go on each machines to set the ip routes because they will provide them. On our setup, we had to set them as we are in a docker environment.

The gateway will be set either manually, either by the DHCP server, therefore mistakes can happen. If you notice issues in terms of connections, you can try to ping networks using `ping <ip>`. But also using ip routes, you can see if the route is cached or not, using `ip route get <ip>`. This command is similar to `traceroute <ip>`.

Let's try the previous commands on the DMZ_Router_External.

One issue can be a missing route to a network, to add them, you can run `ip route add [destination] via [gatewayIP]`. And to delete them `ip route del [destination] via [gatewayIP]`. If you wanna change the default gateway, simply run `ip route add default via [gateway]`.

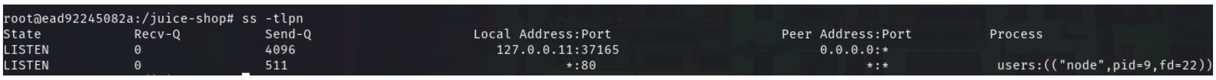
Services

In this docker simulation, we are a running three main services: web server, a domain name server and a DHCP server.

HTTP

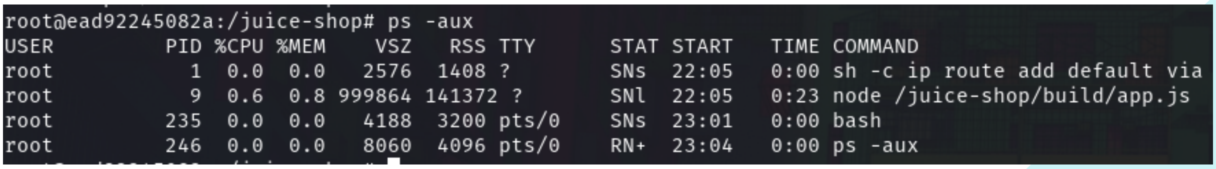
This server is hosting an HTTP server running a javascript website using NodeJS. Therefore, we can see the service running using different commands.

At first, we see if the port 80 is currently used using `ss -tlpn`:



```
root@ead92245082a:/juice-shop# ss -tlpn
State          Recv-Q          Send-Q                         Local Address:Port                    Peer Address:Port          Process
LISTEN         0               4096                              127.0.0.11:37165                        0.0.0.0:*
LISTEN         0               511                                        *:80                               *:*              users:(("node",pid=9,fd=22))
```

We can read a state LISTEN on the port `*:80` , we can even read the Process ID of node. Speaking of process, we can check if the process is running fine using `ps -aux`:



```
root@ead92245082a:/juice-shop# ps -aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  0.0  0.0   2576  1408 ?        SNs  22:05   0:00 sh -c ip route add default via
root           9  0.6  0.8 999864 141372 ?       SNl  22:05   0:23 node /juice-shop/build/app.js
root         235  0.0  0.0   4188  3200 pts/0    SNs  23:01   0:00 bash
root         246  0.0  0.0   8060  4096 pts/0    RN+  23:04   0:00 ps -aux
```

Therefore we can see which command was used to start the website ! And also, we can use `kill <pid>` to stop the service from running. But as we can read the command, we can simply restart it.

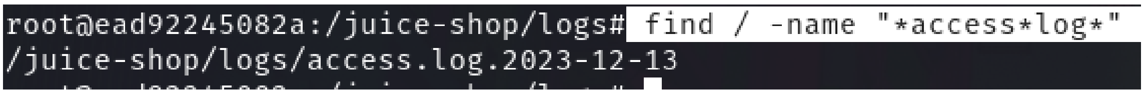
If you want a more interactive way to show the process, you can run `top` command.

Question

1. Can you find the logs related to the access of the website ?

Answers

1. In order to find the logs, we can run an `ls` command in the folder `/juice-shop` and notice a folder called `logs` containing the requested logs. But what if we wanted to find them located in another folder ? We can run a `find / -name "*access*log*"` in order to find them !



```
root@ead92245082a:/juice-shop/logs# find / -name "*access*log*"
/juice-shop/logs/access.log.2023-12-13
```

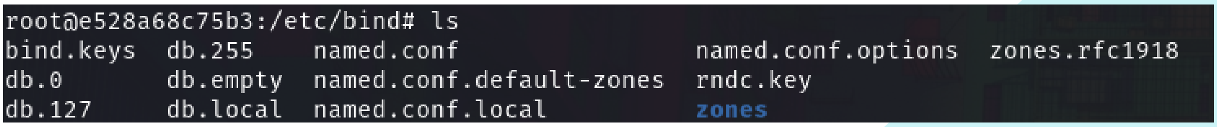
DNS

As you can see on the diagram of the project, we have a DNS server inside the DMZ. Therefore, we will use its configuration files in order to understand how it is set!

Bind9

To have a DNS server, we need a service and to do so, we use Bind9, also called "named". Using the `ps -aux` or `top` commands, you can see it running !

The DNS configuration files will be stored in `/etc/bind/` :

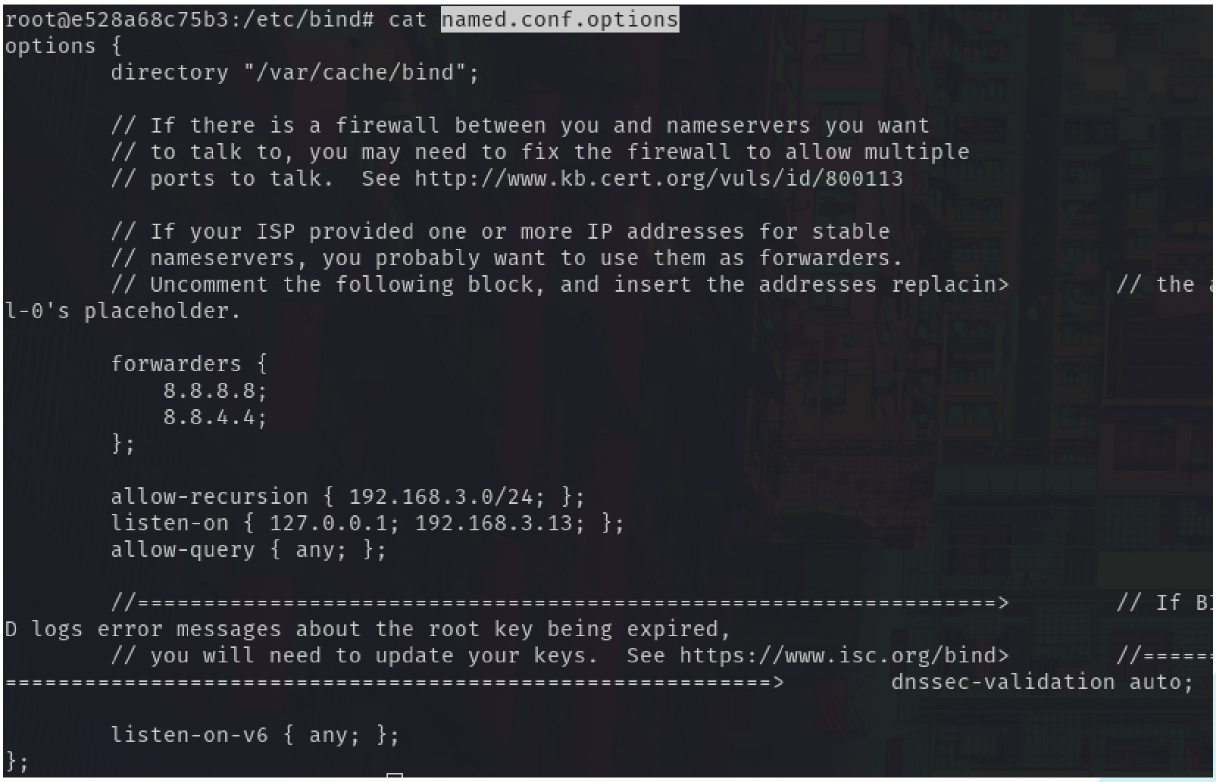


```
root@e528a68c75b3:/etc/bind# ls
bind.keys  db.255    named.conf                  named.conf.options  zones.rfc1918
db.0       db.empty  named.conf.default-zones    rndc.key
db.127     db.local  named.conf.local            zones
```

In this folder we need to focus on three files at the moment:

- `named.conf.options`
- `named.conf.local`
- `/zones/juice-shop.local`

Each file ending on `.local` is a zone file, which will be detailed in the next part ! Let's read the content of `named.conf.options` using `cat`:



```
root@e528a68c75b3:/etc/bind# cat named.conf.options
options {
        directory "/var/cache/bind";

        // If there is a firewall between you and nameservers you want
        // to talk to, you may need to fix the firewall to allow multiple
        // ports to talk.  See http://www.kb.cert.org/vuls/id/800113

        // If your ISP provided one or more IP addresses for stable
        // nameservers, you probably want to use them as forwarders.
        // Uncomment the following block, and insert the addresses replacin>        // the a
l-0's placeholder.

        forwarders {
            8.8.8.8;
            8.8.4.4;
        };

        allow-recursion { 192.168.3.0/24; };
        listen-on { 127.0.0.1; 192.168.3.13; };
        allow-query { any; };

        //=================================================================>        // If BI
D logs error messages about the root key being expired,
        // you will need to update your keys.  See https://www.isc.org/bind>        //=====
==========================================================>        dnssec-validation auto;

        listen-on-v6 { any; };
};
```

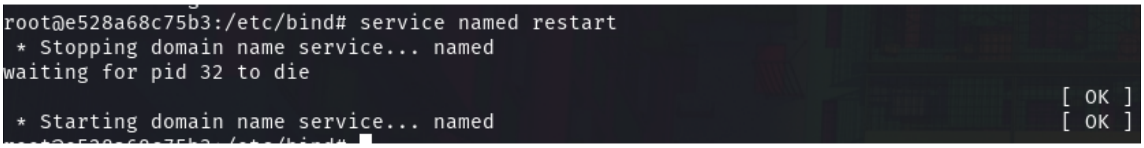
Here, we can read the options currently set for the DNS server we are running. One of the most important option is `forwarders` because it allows the DNS server to query another DNS server if the request domain isn't known.

Questions

1. Find who's forwarder is `8.8.8.8`
2. Find another famous forwarder and set it. How can you restart the service for the setting to apply ?

Answers

1. `8.8.8.8` is the DNS of google !
2. Another famous is DNS is `1.1.1.1`. After editing the file using `vim`, you can restart the service using `service named restart`:

   ```
   root@e528a68c75b3:/etc/bind# service named restart
    * Stopping domain name service... named
   waiting for pid 32 to die
                                                                [ OK ]
    * Starting domain name service... named                     [ OK ]
   root@e528a68c75b3:/etc/bind#
   ```

   As you can read `[ OK ]`, it means the service restarted properly and you didn't made any mistake on the forwarder change !

Zones

In the context of DNS, a zone refers to a portion of the domain namespace for which a particular DNS server is responsible. Each zone contains information about the domain names within that space and their associated resource records.

Let's explore the contents of the `named.conf.local` file to understand how zones are configured. Use the `cat` command to view the file:

```
cat /etc/bind/named.conf.local
```

This file typically includes statements for defining zone configurations:

```
zone "juiceshop.local" {
    type master;
    file "/etc/bind/zones/juiceshop.local";
};
```

This snippet indicates that there is a zone named "juiceshop.local," and the associated information is stored in the file `/etc/bind/zones/juiceshop.local`. The `type master;` statement signifies that this DNS server is authoritative for the zone.

Now, let's examine the contents of a sample zone file, such as `/etc/bind/zones/juiceshop.local`. You can use the `cat` command to display the file:

```
cat /etc/bind/zones/juice-shop.local
```

A zone file typically includes various resource records (RRs) that provide information about the domain. Common types of RRs include:

- **SOA (Start of Authority):** Provides authoritative information about the domain and the zone.
- **NS (Name Server):** Specifies authoritative DNS servers for the domain.

- **A (Address):** Maps a domain to an IPv4 address.
- **AAAA (IPv6 Address):** Maps a domain to an IPv6 address.
- **CNAME (Canonical Name):** Creates an alias for a domain.
- **MX (Mail Exchange):** Specifies mail servers for the domain.

Here’s the zone file of juiceshop:

```
$TTL 1D
@       IN      SOA     ns1.juiceshop.local. admin.juiceshop.local. (
                2023111601 ; Serial
                3H ; Refresh
                15 ; Retry
                1w ; Expire
                3h ; Negative Cache TTL
);

@       IN      NS      ns1.juiceshop.local.
@       IN      A       192.168.3.12
www     IN      A       192.168.3.12
ns1     IN      A       192.168.3.13
```

Question

1. Create a zone for `example.com` and use `traceroute example.com` to show the proper configuration.

Answer

1. To create zone for example.com, you first need to create a zone file :

   ```
   nano /etc/bind/zones/example.com
   ```

   Then you will edit the file as follow:

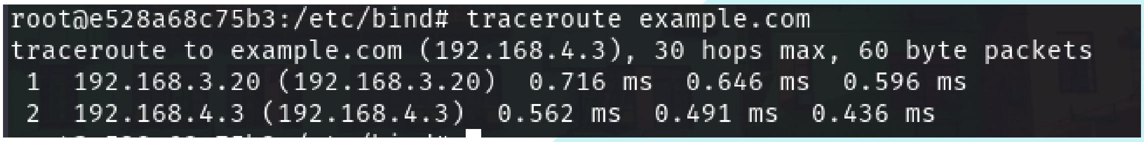
   ```
   $TTL 1D
   @       IN      SOA     ns1.example.com. admin.example.com. (
                   2023111601 ; Serial
                   3H ; Refresh
                   15 ; Retry
                   1w ; Expire
                   3h ; Negative Cache TTL
   );

   @       IN      NS      ns1.example.com.
   @       IN      A       192.168.4.3
   www     IN      A       192.168.4.3
   ns1     IN      A       192.168.4.3
   ```

   Saving and exiting the file, you will now add the zone entry into `/etc/bind/named.conf.local`

   ```
   zone "example.com" {
       type master;
       file "/etc/bind/zones/example.com";
   };
   ```

   Now you just have to restart the service using `service named restart` and check the output of `traceroute example.com`:

   ```
   root@e528a68c75b3:/etc/bind# traceroute example.com
   traceroute to example.com (192.168.4.3), 30 hops max, 60 byte packets
    1  192.168.3.20 (192.168.3.20)  0.716 ms  0.646 ms  0.596 ms
    2  192.168.4.3 (192.168.4.3)  0.562 ms  0.491 ms  0.436 ms
   ```

   The IP is the one we have set into the DNS configuration, therefore it is now working !

DHCP

If you pay attention to the diagram, you might see that the DHCP server is not located into the DMZ, because it should not be accessible from the outside ! Therefore, we have less strict firewall rules when accessing PC1 from DHCP server.

The DHCP server will be using package called `isc-dhcp-server`, which we will be the DHCP service ! It has two main files:

- /etc/dhcp/dhcpd.conf
- /etc/default/isc-dhcp-server

Let's start with /etc/default/isc-dhcp-server, check its content using cat command.

```
INTERFACESv4="eth0"
INTERFACESv6=""
```

You might notice a lot of comments and only one parameter set. This parameter specify which interface the DHCP server should listen for DHCP requests of new devices!

Now, let's check /etc/dhcp/dhcpd.conf with cat command:

```
# option definitions common to all supported network
subnet 192.168.2.0 netmask 255.255.255.0 {
}
subnet 192.168.1.0 netmask 255.255.255.0 {
    range 192.168.1.2 192.168.1.20;
    option routers 192.168.1.10;
    option domain-name-servers 192.168.3.13;
    option domain-name "dockersec.com";
    option broadcast-address 192.168.1.255;
    default-lease-time 600;
    max-lease-time 7200;
}
```

Once again, you might notice plenty of comments, but let's focus on this part. As you can see we have two subnets with a netmask. From the different options on 192.168.1.0, we can read the following:

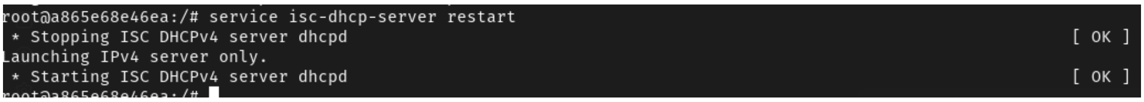
- range 192.168.1.2 192.168.1.20; –> this is the IP range we will give to the devices connecting to this subnet.
- option routers 192.168.1.10; –> that will define the default gateway of the device.
- option domain-name-servers 192.168.3.13; & option domain-name " dockersec.com"; –> these are responsible of the DNS configuration and will specify the DNS server IP and name !
- option broadcast-address 192.168.1.255; –> we need to know which ip to use for broadcasts.
- default-lease-time 600; & max-lease-time 7200; –> this will define in seconds how long a DHCP lease will be set for, so how long our device will have the IP set.

Questions

1. How can you extend the IP range from 19 IPs to 40 ?
2. How to restart the service ?

Answers

1. To extend the IP range, you need to change the ligne `range 192.168.1.2 192.168.1.20;` to `range 192.168.1.2 192.168.1.41;` for example.
2. You need to run `service isc-dhcp-server restart`:



```
root@a865e68e46ea:/# service isc-dhcp-server restart
 * Stopping ISC DHCPv4 server dhcpd                                                                    [ OK ]
Launching IPv4 server only.
 * Starting ISC DHCPv4 server dhcpd                                                                    [ OK ]
root@a865e68e46ea:/#
```