

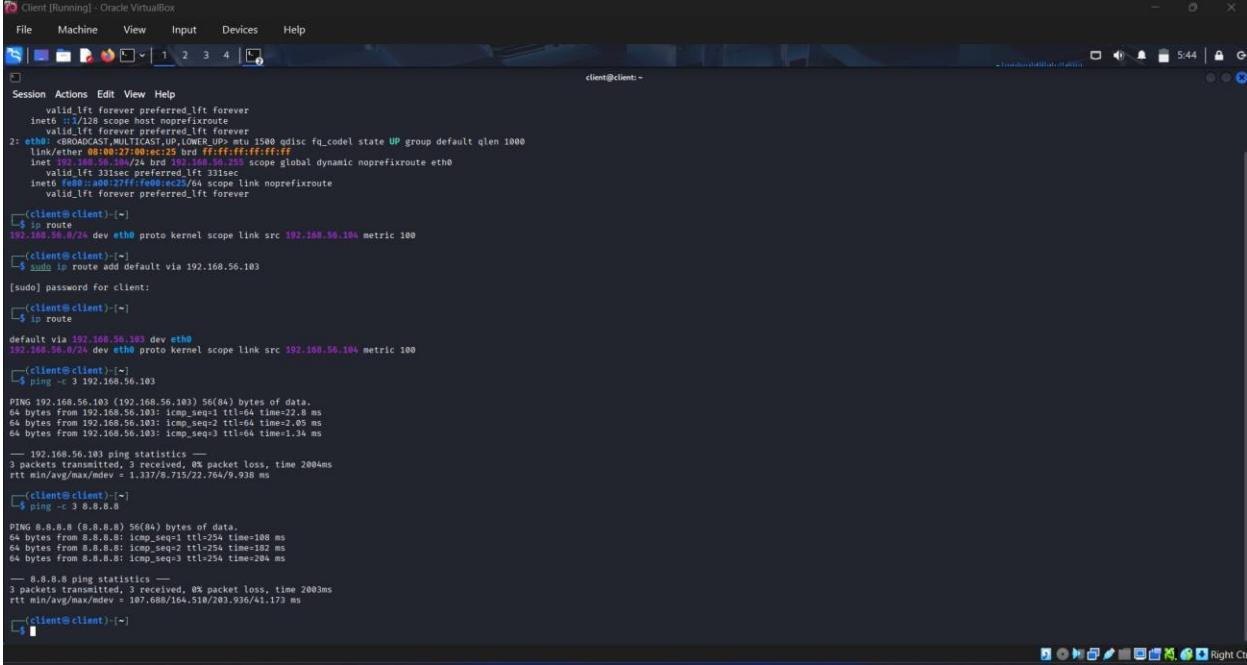
Proxy DNS Service Implementation on Internet Gateway

1. Introduction

In this assignment, we implemented a Proxy DNS service on a Kali Linux Internet Gateway. The goal was to provide DNS resolution for Client PCs using a secure upstream DNS server. We used:

- Unbound DNS server as the authoritative DNS for the local LAN (Client PCs).
- DNSCrypt-proxy as the upstream server to encrypt DNS queries between the gateway and public DNS servers.

This ensures that the client receives DNS responses while maintaining privacy and integrity of queries on the internet.



The screenshot shows a terminal window titled "Client [Running] - Oracle VirtualBox". The terminal displays a series of commands and their outputs:

```
client@client: ~
Session Actions Edit View Help
File Machine View Input Devices Help
client@client: ~
client@client: ~]$ ip link
1: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:29:fe:0e:c5 brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.103 brd 192.168.56.255 scope global dynamic noprefixroute eth0
        valid_lft 33sec preferred_lft 33sec
        inetb fe80::000c:29ff:fe0e:c5%eth0 brd ff:ff:ff:ff:ff:ff scope link noprefixroute
        valid_lft forever preferred_lft forever
(client@client): ~]$ ip route
default via 192.168.56.103 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
(client@client): ~]$ sudo ip route add default via 192.168.56.103
[sudo] password for client:
(client@client): ~]$ ip route
default via 192.168.56.103 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
(client@client): ~]$ ping -c 3 192.168.56.103
PING 192.168.56.103 (192.168.56.103) 56(84) bytes of data.
64 bytes from 192.168.56.103: icmp_seq=1 ttl=64 time=22.8 ms
64 bytes from 192.168.56.103: icmp_seq=2 ttl=64 time=2.05 ms
64 bytes from 192.168.56.103: icmp_seq=3 ttl=64 time=1.34 ms
--- 192.168.56.103 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 1.337/8.715/22.764/9.938 ms
(client@client): ~]$ ping -c 3 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=254 time=108 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=254 time=182 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=254 time=284 ms
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 107.688/104.510/203.936/41.173 ms
(client@client): ~]$
```

```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Se Firefox ESR Browse the WorldWideWeb
sysadmin@internet-gateway-dns: ~
$ sudo tcptrace -i eth0 icmp
[sudo] password for sysadmin:
tcptcpdump: verbose output suppressed, use -vvv... for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), snapshot length 262144 bytes
05:43:54.298223 IP 10.0.2.15 > dns.google: ICMP echo request, id 2, seq 1, length 64
05:43:54.298223 IP 10.0.2.15 > dns.google: ICMP echo reply, id 2, seq 1, length 64
05:43:55.289019 IP 10.0.2.15 > dns.google: ICMP echo request, id 4, seq 2, length 64
05:43:55.468977 IP dns.google > 10.0.2.15: ICMP echo reply, id 2, seq 2, length 64
05:43:56.299285 IP 10.0.2.15 > dns.google: ICMP echo request, id 2, seq 3, length 64
05:43:56.492822 IP dns.google > 10.0.2.15: ICMP echo reply, id 2, seq 3, length 64

```



```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
/home/sysadmin Actions Ed Help
sysadmin@internet-gateway-dns: ~
$ ip route
default via 10.0.2.2 dev eth0
10.0.2.0/24 dev eth0 proto kernel scope link src 10.0.2.15
092.168.36.0/24 dev eth1 proto kernel scope link src 192.168.36.103 metric 100
[sudo] password for sysadmin:
$ sudo tcptrace -i eth1 icmp
[sudo] password for sysadmin:
tcptcpdump: verbose output suppressed, use -vvv... for full protocol decode
listening on eth1, link-type EN10MB (Ethernet), snapshot length 262144 bytes
05:43:54.289018 IP 192.168.36.104 > dns.google: ICMP echo request, id 2, seq 1, length 64
05:43:54.393761 IP dns.google > 192.168.36.104: ICMP echo reply, id 2, seq 1, length 64
05:43:55.288942 IP 192.168.36.104 > dns.google: ICMP echo request, id 2, seq 2, length 64
05:43:55.469065 IP dns.google > 192.168.36.104: ICMP echo reply, id 2, seq 2, length 64
05:43:56.298353 IP 192.168.36.104 > dns.google: ICMP echo request, id 2, seq 3, length 64
05:43:56.493977 IP dns.google > 192.168.36.104: ICMP echo reply, id 2, seq 3, length 64

```

2. System Architecture Gateway VM:

- eth0 → Internet-facing interface
- eth1 → LAN interface, connected to Client PC

Client VM: - Single interface connected to the LAN - Uses Gateway VM for DNS resolution and internet access

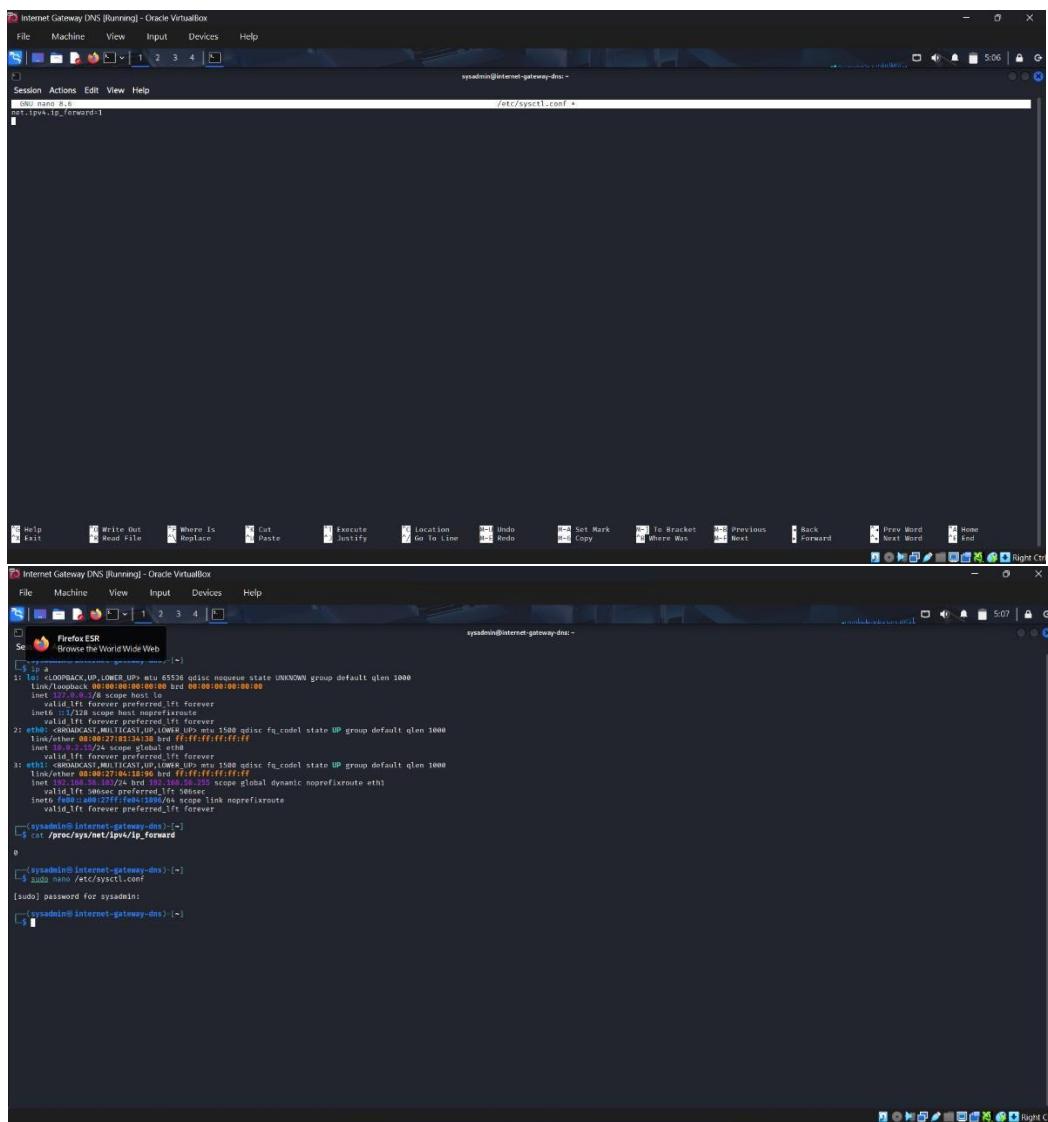
DNS Flow: Client PC → Gateway (Unbound) → DNSCrypt Proxy → Internet DNS

3. Implementation Steps

Step 1: Network Setup Gateway VM:

```
sudo sysctl -w net.ipv4.ip_forward=1  
echo "net.ipv4.ip_forward = 1" | sudo tee -a /etc/sysctl.conf  
sudo sysctl -p
```

```
sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE  
sudo iptables -A FORWARD -i eth1 -o eth0 -j ACCEPT  
sudo iptables -A FORWARD -i eth0 -o eth1 -m state --state RELATED,ESTABLISHED -j ACCEPT
```




```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns: ~
$ ip route
default via 10.0.2.2 dev eth0
10.0.2.0/24 dev eth0 proto kernel scope link src 10.0.2.15
192.168.56.0/24 dev eth1 proto kernel scope link src 192.168.56.103 metric 100
$ sudo tcptrace -i eth1 icmp
(sudo) password for sysadmin:
tcpdump: verbose output suppressed, use -v[el] for full protocol decode
listening on eth1, link-type EN10MB (Ethernet), snapshot length 262144 bytes

```



```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns: ~
$ systemctl status dnscrypt-proxy
dnscrypt-proxy.service - dnscrypt-client proxy
   Active: active (running) since Thu 2026-01-08 04:52:42 EST; 5min ago
     Invocation: /usr/lib/systemd/system/dnscrypt-proxy.service; preset: disabled
   TriggeredBy: https://github.com/DSCrypt/dnscrypt-proxy/wiki
   Docs: https://github.com/DSCrypt/dnscrypt-proxy/wiki
 Main PID: 83786 (dnscrypt-proxy)
   Memory: 8.6M (peak: 11.4M)
      CPU: 1.89%+
   CGroup: /system.slice/dnscrypt-proxy.service
           └─ 83786 /usr/bin/dnscrypt-proxy -c /etc/dnscrypt-proxy/dnscrypt-proxy.conf

Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [WARNING] Systemd sockets are untested and unsupported - use at your own risk
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] Wiring systemd TCP socket #0, dnscrypt-proxy_socket, 127.0.2.1:153
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] Wiring systemd UDP socket #1, dnscrypt-proxy_socket, 127.0.2.1:153
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] Firewall workaround initialized
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] Firefox workaround initialized
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] Hot reload is disabled
Jan 08 04:52:42 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:42] [NOTICE] https://github.com/DSCrypt/dnscrypt-proxy: https://raw.githubusercontent.com/DSCrypt/dnscrypt-proxy/main/config /dns-query?dn=www.cloudflare.com&query=AAAAAAAAMAAAACAAEAAACKQAAAAMAMFAJAMABBBMhbvcJfyz-zN-Wgrth22": net/http: request canceled while
Jan 08 04:52:52 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:52:52] [NOTICE] dnscrypt-proxy is waiting for at least one server to be reachable
Jan 08 04:57:39 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:57:39] [NOTICE] [cloudflare] OK (Dom - RTT: 240ms
Jan 08 04:57:39 internet-gateway-dns dnscrypt-proxy[83786]: [2026-01-08 04:57:39] [NOTICE] Server with the lowest initial latency: cloudflare (RTT: 240ms)
$ time 8-24/23 (Thu) [1]

```

```

[sudo] password for yadmin:
tcpdump: verbose output suppressed, use -vvv... for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), snapshot length 262144 bytes

```

```

yadmin@internet-gateway-dns:~$ nano /etc/unbound/unbound.conf
server:
  interface: 0.0.0.0
  port: 53
  access-control: 192.168.56.0/24 allow
  do-udp: yes
  do-tcp: yes
forward-zone:
  name: "."
  forward-addr: 127.0.2.1953

```

Step 2: DNS Service Setup on Gateway Install Unbound and DNSCrypt-proxy:

`sudo apt update && sudo apt install unbound dnscrypt-proxy -y`

Unbound Configuration (`/etc/unbound/unbound.conf`):

server:

```

interface: 0.0.0.0
port: 53
access-control: 192.168.56.0/24 allow
do-udp: yes
do-tcp: yes
do-not-query-localhost: no
username: "root"

```

forward-zone:

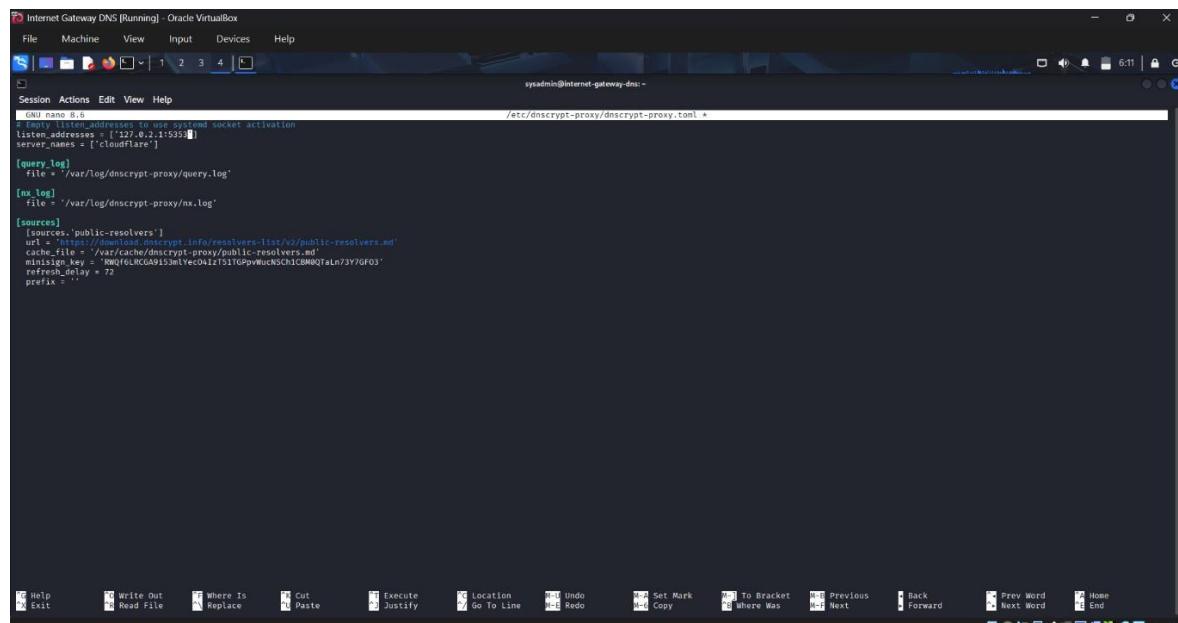
```
name: "."
forward-addr: 127.0.2.1@5353
```

DNSCrypt Proxy Configuration (/etc/dnscrypt-proxy/dnscrypt-proxy.toml): - Listening port: 5353 on 127.0.2.1 - Use public resolvers (Cloudflare, Quad9)

Step 3: Start and Enable Services

```
sudo systemctl restart unbound
sudo systemctl enable unbound
```

```
sudo systemctl start dnscrypt-proxy
sudo systemctl enable dnscrypt-proxy
```



```
[Internet Gateway DNS [Running] - Oracle VirtualBox]
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns: ~
[dnscrypt-proxy.toml]
listen_addresses = ["127.0.2.1:5353"]
server_names = ["cloudflare"]
[query_log]
file = '/var/log/dnscrypt-proxy/query.log'
[nx_log]
file = '/var/log/dnscrypt-proxy/nx.log'
[sources]
[public-resolvers]
cache_file = '/var/cache/dnscrypt-proxy/public-resolvers.md'
minisig_key = 'RWDf6LRCGA9i53mlyec04izT51TGpvWucNSch1CBM0QfaLn73Y7Gf03'
refresh_delay = 72
prefix = ''
```

```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns:~>

sudo lsof -i :53
udp  UNCONN  0      127.0.2.1:5353  0.0.0.0:*  users:(("dnscrypt-proxy",pid=127745,fd=7))
udp  UNCONN  0      127.0.2.1:53  0.0.0.0:*  users:(("dnscrypt-proxy",pid=127745,fd=10),("systemd",pid=1,fd=92))
tcp   LISTEN  0      4096   127.0.2.1:538  0.0.0.0:*  users:(("dnscrypt-proxy",pid=127745,fd=9))
tcp   LISTEN  0      4096   127.0.2.1:53  0.0.0.0:*  users:(("dnscrypt-proxy",pid=127745,fd=11))

COMMAND PID USER FD  TYPE DEVICE SIZE/OFF NODE NAME
systemd  1 root  92u IPv4 268883  0t0  TCP 127.0.2.1:domain (LISTEN)
systemd  1 root  93u IPv4 268883  0t0  UDP 127.0.2.1:domain
dnscrypt- 127745 dnscrypt-proxy 18u IPv4 268885  0t0  UDP 127.0.2.1:domain (LISTEN)
dnscrypt- 127745 dnscrypt-proxy 18u IPv4 268885  0t0  UDP 127.0.2.1:domain

[sudo@internet-gateway-dns]:~]
$ sudo systemctl stop dnscrypt-proxy.socket
[sudo@internet-gateway-dns]:~]
$ sudo systemctl disable dnscrypt-proxy.socket
[sudo@internet-gateway-dns]:~]
$ sudo systemctl mask dnscrypt-proxy.socket
Created symlink '/etc/systemd/system/dnscrypt-proxy.socket' → '/dev/null'.

[sudo@internet-gateway-dns]:~]
$ sudo ss -lntpu | grep ':53'

[sudo@internet-gateway-dns]:~]
$ sudo systemctl restart unbound
[sudo@internet-gateway-dns]:~]

unbound-service - Unbound DNS server
  loaded: loaded: /etc/systemd/system/unbound.service; disabled; preset: disabled)
  Drop-In: /etc/systemd/system/unbound.service.d
    override.conf
  Active: active (running) since Thu 2026-01-08 06:44:07 EST; 66ms ago
  Invocation: fce2008edcced1ae7404519395520
  Docs: man:unbound(8)
  Main PID: 140264 (unbound)
  Tasks: 1 (pid: 140264)
  Memory: 0.2M (peak: 0.4M)
  CPU: 144ms
  CGroup: /system.slice/unbound.service
          └─140264 /usr/sbin/unbound -d -p

Jan 08 06:44:07 internet-gateway-dns systemd[1]: Starting unbound.service - Unbound DNS server...
Jan 08 06:44:07 internet-gateway-dns unbound[140264]: [140264@0] warning: no mem for snbuf 4194304 was not granted. Got 425984. To fix: start with root permissions(linux) or sysctl bigger net.core.wmem_m_use system value).
Jan 08 06:44:07 internet-gateway-dns [140264@0]: notices: init module 0: validator
Jan 08 06:44:07 internet-gateway-dns [140264@0]: notices: init module 1: iterator
Jan 08 06:44:07 internet-gateway-dns [140264@0]: Started unbound-service - Unbound DNS server.
Jan 08 06:44:07 internet-gateway-dns [140264@0]: info: start of service (unbound 1.24.2).
Hint: Some lines were ellipsized, use -l to show in full.

[sudo@internet-gateway-dns]:~]
$ 

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns:~>

/home/sysadmin
Session Actions Edit View Help
[sudo@internet-gateway-dns]:~]
$ sudo systemctl unmask dnscrypt-proxy.socket
[sudo@internet-gateway-dns]:~]
$ sudo password for sysadmin:
[sudo@internet-gateway-dns]:~]
$ sudo systemctl enable dnscrypt-proxy.socket
[sudo@internet-gateway-dns]:~]
$ sudo systemctl start dnscrypt-proxy.socket
Created symlink '/etc/systemd/system/sockets.target.wants/dnscrypt-proxy.socket' → '/usr/lib/systemd/system/dnscrypt-proxy.socket'.
Job failed. See "journalctl -ve" for details.

[sudo@internet-gateway-dns]:~]
$ sudo lsof -i :53
[sudo@internet-gateway-dns]:~]
$ sudo lsof -i :5353
tcp  UNCONN  0      0.0.0.1:5353  0.0.0.0:*  users:(["unbound",pid=142796,fd=3])
tcp  LISTEN  0      256     0.0.0.0:53  0.0.0.0:*  users:(["unbound",pid=142796,fd=4])

COMMAND PID USER FD  TYPE DEVICE SIZE/OFF NODE NAME
unbound 142796 root 3u  IPv4 303133  0t0  UDP :domain
unbound 142796 root 4u  IPv4 303134  0t0  TCP :domain (LISTEN)

[sudo@internet-gateway-dns]:~]
$ sudo systemctl stop unbound

[sudo@internet-gateway-dns]:~]
$ sudo nano /etc/dnscrypt-proxy/dnscrypt-proxy.toml

[sudo@internet-gateway-dns]:~]
$ sudo systemctl start dnscrypt-proxy
[sudo@internet-gateway-dns]:~]
$ sudo systemctl enable dnscrypt-proxy

[sudo@internet-gateway-dns]:~]
$ ss -lntpu | grep ':5353'

[sudo@internet-gateway-dns]:~]
$ 

[sudo@internet-gateway-dns]:~]

```

```

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns: ~

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl daemon-reexec
sudo systemctl daemon-reload

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl start dnscrypt-proxy
sudo systemctl enable dnscrypt-proxy

Created symlink '/etc/systemd/system/sockets.target.wants/dnscrypt-proxy.socket' to '/usr/lib/systemd/system/dnscrypt-proxy.socket'.

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl status dnscrypt-proxy --no-pager

dnscrypt-proxy.service - DNSCrypt client proxy
   Loaded: loaded (/etc/systemd/system/dnscrypt-proxy.service; enabled; preset: disabled)
   Drop-In: /etc/systemd/system/dnscrypt-proxy.service.d
             └─dnscrypt-proxy.conf
     Active: active (running) since Thu 2026-01-08 12:03:34 EST; 23s ago
   Invocation-Id: 16268f463b7842a592dfcfc9178484d
   Triggers-By: dnscrypt-proxy.socket
   Docs: https://github.com/DNSCrypt/dnscrypt-proxy/wiki
   Main PID: 207530 (dnscrypt-proxy)
      Tasks: 8 (limit: 2208)
        Memory: 1.0M (peak: 8.0M)
         CPU: 162ms
      CGroup: /system.slice/dnscrypt-proxy.service
              └─207530 /usr/sbin/dnscrypt-proxy -c /etc/dnscrypt-proxy/dnscrypt-proxy.toml

Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [NOTICE] Now listening to 127.0.2.1:1533 [TCP]
Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [WARNING] Systemd sockets are untested and unsupported - use at your own risk
Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [NOTICE] Wiring system TCP socket #0, dnscrypt-proxy.socket, 127.0.2.1:153
Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [NOTICE] Source [public-resolvers] loaded
Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [NOTICE] Firewall workaround initialized
Jan 08 12:03:34 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:34] [NOTICE] relayed DNS queries via 127.0.2.1:1533 [NOTICE] [Cloudflare (Cloudflare)] - rtt: 237ms
Jan 08 12:03:35 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:35] [NOTICE] Server with the lowest initial latency: cloudflare (rtt: 237ms)
Jan 08 12:03:35 internet-gateway-dns dnscrypt-proxy[207530]: [2026-01-08 12:03:35] [NOTICE] dnscrypt-proxy is ready - live servers: 1

[sysadmin@internet-gateway-dns: ~]
$ sudo ss -ltnp | grep :5353
udp  UNCONN  0      0      127.0.2.1:5353    0.0.0.0.* users:(("dnscrypt-proxy",pid=29730,fd=10),("systemd",pid=29730,fd=10))
tcp  UNCONN  0      0      127.0.2.1:53      0.0.0.0.* users:(("dnscrypt-proxy",pid=29730,fd=10),("systemd",pid=29730,fd=10))
tcp  LISTEN  4096   127.0.2.1:5353    0.0.0.0.* users:(("dnscrypt-proxy",pid=29730,fd=9),("systemd",pid=1,fd=255))

[sysadmin@internet-gateway-dns: ~]

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
sysadmin@internet-gateway-dns: ~

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl start dnscrypt-proxy
sudo systemctl enable dnscrypt-proxy

Failed to start dnscrypt-proxy.service: Unit dnscrypt-proxy.socket is masked.
Unit /etc/systemd/system/dnscrypt-proxy.socket is masked, ignoring.

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl unmask dnscrypt-proxy.socket
sudo systemctl unmask dnscrypt-proxy.service

Removed '/etc/systemd/system/dnscrypt-proxy.socket'.

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl stop dnscrypt-proxy.service dnscrypt-proxy.socket

[sysadmin@internet-gateway-dns: ~]
$ sudo nano /usr/lib/systemd/system/dnscrypt-proxy.service

[sysadmin@internet-gateway-dns: ~]
$ sudo nano /usr/lib/systemd/system/dnscrypt-proxy.service

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl daemon-reexec
sudo systemctl daemon-reload
sudo systemctl reset-failed dnscrypt-proxy

[sysadmin@internet-gateway-dns: ~]
$ sudo systemctl start dnscrypt-proxy
sudo systemctl enable dnscrypt-proxy

[sysadmin@internet-gateway-dns: ~]
$ sudo ss -ltnp | grep 5353
udp  UNCONN  0      0      127.0.2.1:5353    0.0.0.0.* users:(("dnscrypt-proxy",pid=316284,fd=5))
tcp  LISTEN  4096   127.0.2.1:5353    0.0.0.0.* users:(("dnscrypt-proxy",pid=316284,fd=5))

[sysadmin@internet-gateway-dns: ~]
$ sudo ss -ltnp | grep :53
tcp  UNCONN  0      0      127.0.2.1:53      0.0.0.0.* users:(("dnscrypt-proxy",pid=316284,fd=5))

[sysadmin@internet-gateway-dns: ~]

```

Step 4: Client Configuration

dig google.com @192.168.56.103
ping 8.8.8.8

```
Client [Running] - Oracle VirtualBox
File Machine View Input Devices Help
client@client: ~
Session Actions Edit View Help
[client@client] (~)
$ ip link
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 brd 127.255.255.255 scope host loopback
        valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host noprefixroute
            valid_lft forever preferred_lft forever
2: eth0 <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:27:ff:fe:00 brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.103/24 brd 192.168.56.255 scope global dynamic noprefixroute eth0
        valid_lft 33sec preferred_lft 33sec
        inet6 fe80::a00c:27ff:fe00:c25/64 scope link noprefixroute
            valid_lft forever preferred_lft forever
[client@client] (~)
$ ip route
192.168.56.8/24 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
[client@client] (~)
$ sudo ip route add default via 192.168.56.103
[sudo] password for client:
[client@client] (~)
$ ip route
default via 192.168.56.103 dev eth0
192.168.56.8/24 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
[client@client] (~)
$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=64 time=22.8 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=64 time=2.05 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=64 time=1.34 ms
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 1.337/8.715/22.764/9.938 ms
[client@client] (~)
$
```

```
Client [Running] - Oracle VirtualBox
File Machine View Input Devices Help
client@client: ~
Session Actions Edit View Help
[client@client] (~)
$ 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 brd 127.255.255.255 scope host loopback
        valid_lft forever preferred_lft forever
        inet6 ::1/128 scope host noprefixroute
            valid_lft forever preferred_lft forever
2: eth0 <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 00:0c:27:ff:fe:00 brd ff:ff:ff:ff:ff:ff
    inet 192.168.56.103/24 brd 192.168.56.255 scope global dynamic noprefixroute eth0
        valid_lft 33sec preferred_lft 33sec
        inet6 fe80::a00c:27ff:fe00:c25/64 scope link noprefixroute
            valid_lft forever preferred_lft forever
[client@client] (~)
$ ip route
192.168.56.8/24 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
[client@client] (~)
$ sudo ip route add default via 192.168.56.103
[sudo] password for client:
[client@client] (~)
$ ip route
default via 192.168.56.103 dev eth0
192.168.56.8/24 dev eth0 proto kernel scope link src 192.168.56.104 metric 100
[client@client] (~)
$ ping -c 3 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=64 time=22.8 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=64 time=2.05 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=64 time=1.34 ms
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 1.337/8.715/22.764/9.938 ms
[client@client] (~)
$
```

```

Client [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
(client@client) ~-
$ sudo nano /etc/resolv.conf
[sudo] password for client:
(client@client) ~-
$ dig google.com @192.168.56.103
ping 8.8.8.8

<>> DIG 9.8.11-+b1-Debian <>> google.com @192.168.56.103
;; global options: +cmd
;; Got answer:
;; flags: qr rd ra; opcode: QUERY, status: NOERROR, id: 48579
;; Flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
;; OPT PREFERENCE: 0, Flags: udp: 1232
;; QUESTION SECTION:
google.com. IN A
;; ANSWER SECTION:
google.com. 300 IN A 142.251.221.174
;; Query time: 372 msec
;; SERVER: 192.168.56.103#53 (192.168.56.103) (UDP)
;; WHEN: Thu Jan 08 12:14:07 EST 2026
;; MSG SIZE rcvd: 55
ping: connect: Network is unreachable
(client@client) ~-
$ 

Client [Running] - Oracle VirtualBox
File Machine View Input Devices Help
Session Actions Edit View Help
google.com. 300 IN A 142.251.221.174
client@client: ~-
$ ping 8.8.8.8
ping: connect: Network is unreachable
(client@client) ~-
$ sudo ip route add default via 192.168.56.103
(client@client) ~-
$ ping 8.8.8.8
ping: connect: Network is unreachable
$ dig google.com
;; Tests internet connectivity
;; Tests DNS resolution via gateway
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=0 ttl=254 time=79.6 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=254 time=78.8 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=254 time=78.8 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=254 time=77.2 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=254 time=75.3 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=254 time=76.5 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=254 time=80.7 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=254 time=81.5 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=254 time=87.7 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=254 time=86.2 ms
64 bytes from 8.8.8.8: icmp_seq=10 ttl=254 time=86.2 ms
64 bytes from 8.8.8.8: icmp_seq=11 ttl=254 time=78.7 ms
64 bytes from 8.8.8.8: icmp_seq=12 ttl=254 time=648 ms
64 bytes from 8.8.8.8: icmp_seq=13 ttl=254 time=84.4 ms
64 bytes from 8.8.8.8: icmp_seq=14 ttl=254 time=84.4 ms
64 bytes from 8.8.8.8: icmp_seq=15 ttl=254 time=81.2 ms
64 bytes from 8.8.8.8: icmp_seq=16 ttl=254 time=76.3 ms
64 bytes from 8.8.8.8: icmp_seq=17 ttl=254 time=80.8 ms
64 bytes from 8.8.8.8: icmp_seq=18 ttl=254 time=80.2 ms
64 bytes from 8.8.8.8: icmp_seq=19 ttl=254 time=82.7 ms
64 bytes from 8.8.8.8: icmp_seq=20 ttl=254 time=75.6 ms
64 bytes from 8.8.8.8: icmp_seq=21 ttl=254 time=75.6 ms
64 bytes from 8.8.8.8: icmp_seq=22 ttl=254 time=244 ms
64 bytes from 8.8.8.8: icmp_seq=23 ttl=254 time=95.1 ms
64 bytes from 8.8.8.8: icmp_seq=24 ttl=254 time=102.5 ms
64 bytes from 8.8.8.8: icmp_seq=25 ttl=254 time=71.2 ms
64 bytes from 8.8.8.8: icmp_seq=26 ttl=254 time=74.1 ms
64 bytes from 8.8.8.8: icmp_seq=27 ttl=254 time=74.1 ms
64 bytes from 8.8.8.8: icmp_seq=28 ttl=254 time=71.6 ms
64 bytes from 8.8.8.8: icmp_seq=29 ttl=254 time=198 ms
64 bytes from 8.8.8.8: icmp_seq=30 ttl=254 time=91.7 ms
64 bytes from 8.8.8.8: icmp_seq=31 ttl=254 time=91.7 ms
2
ssh: suspended ping 8.8.8.8

```

4. Verification and Testing Gateway:

dig google.com @127.0.0.1

Output shows valid IP, e.g., 142.251.221.174

Client:

```
dig google.com @192.168.56.103  
ping 8.8.8.8
```

- DNS resolution: Success
 - Internet access: Success

```
Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help

sysadmin@internet-gateway-dns: ~
Session Actions Edit View Help
$ sudo unbound -l <input> | grep :53
unbound: UNCONN 0 0 127.0.2.1:5353 0.0.0.0:* users:(("dnsproxy",pid=316284,fd=5))
tcp LISTEN 0 4096 127.0.2.1:5353 0.0.0.0:* users:(("dnsproxy",pid=316284,fd=6))

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo ss -lntu | grep :53
unbound: UNCONN 0 0 127.0.2.1:5353 0.0.0.0:* users:(("dnsproxy",pid=316284,fd=5))
tcp LISTEN 0 4096 127.0.2.1:5353 0.0.0.0:* users:(("dnsproxy",pid=316284,fd=6))

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo nano /etc/unbound/unbound.conf

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo unbound-checkconf
unbound-checkconf: no errors in /etc/unbound/unbound.conf

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo systemctl restart unbound
$ sudo systemctl enable unbound

Synchronizing state of unbound.service with SysV service script with /usr/lib/systemd/systemd-sysv-install.
Executing: /usr/lib/systemd/systemd-sysv-install enable unbound

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ dig google.com @127.0.0.1

; <>> DIG 9.20.11-4+bl-Debian <>> google.com @127.0.0.1
;; Global options: +cmd
;; Got answer:
;; ->HEADER<- opcode: QUERY, status: NOERROR, id: 60987
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
;
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: udp: 1232
;; QUESTION SECTION:
;google.com. IN A
;
;; ANSWER SECTION:
google.com. 126 IN A 142.251.221.174
;
;; Query time: 264 msec
;; SERVER: 127.0.0.1#53(127.0.0.1) (UDP)
;; WHEN: Thu Jan 08 12:41:50 EST 2026
;; MSG SIZE rcvd: 55

[sudo] password for sysadmin@internet-gateway-dns: ~[~]

Internet Gateway DNS [Running] - Oracle VirtualBox
File Machine View Input Devices Help

sysadmin@internet-gateway-dns: ~
Session Actions Edit View Help
$ sudo systemctl restart unbound
$ sudo systemctl enable unbound

Synchronizing state of unbound.service with SysV service script with /usr/lib/systemd/systemd-sysv-install.
Executing: /usr/lib/systemd/systemd-sysv-install enable unbound

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ dig google.com @127.0.0.1

; <>> DIG 9.20.11-4+bl-Debian <>> google.com @127.0.0.1
;; Global options: +cmd
;; Got answer:
;; ->HEADER<- opcode: QUERY, status: NOERROR, id: 60987
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
;
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: udp: 1232
;; QUESTION SECTION:
;google.com. IN A
;
;; ANSWER SECTION:
google.com. 126 IN A 142.251.221.174
;
;; Query time: 264 msec
;; SERVER: 127.0.0.1#53(127.0.0.1) (UDP)
;; WHEN: Thu Jan 08 12:41:50 EST 2026
;; MSG SIZE rcvd: 55

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo sysctl -w net.ipv4.ip_forward=1 | sudo tee -a /etc/sysctl.conf
$ sudo sysctl -p

net.ipv4.ip_forward = 1
net.ipv4.ip_forward = 1
net.ipv4.ip_forward = 1
net.ipv4.ip_forward = 1

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
$ sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
$ sudo iptables -A FORWARD -i eth1 -o eth0 -j ACCEPT
$ sudo iptables -A FORWARD -i eth0 -o eth1 --state RELATED,ESTABLISHED -j ACCEPT

[sudo] password for sysadmin@internet-gateway-dns: ~[~]
```

5. Conclusion

- Proxy DNS service successfully implemented using Unbound and DNSCrypt-proxy.
- Client PCs can resolve DNS securely through the gateway.
- NAT and IP forwarding ensure full internet access while protecting DNS traffic.