Man in the Middle Attacks & DNS Spoofing

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Introduction

We have discussed in our previous courses how it is important to understand the concepts of designing before programming. Often, a proof of concept allows the programmer to quickly design and put together a prototype that can be used as a tangible deliverable. Because of its how quickly it is able to be developed, it could easily show if the idea is worthwhile to pursue or not, increasing productivity and wasting minimal time and efforts. Once it has been shown that the prototype is promising, we can transition to the next stage in development for optimization using C programming, for example.

In this assignment, we are applying the proof of concept practice by designing our own DNS Spoofing program. We shall be using Ruby as our language of choice to provide this “prototype” as our deliverable. The components of our program involves an ARP Poisoning thread that acts as the Man in the Middle, carrying out MITM attacks. In turn, the victim machine will ultimately think that our MITM machine is a legitimate switch, and will be sending DNS requests to our attacking machine. All the while, our attacking machine will be responsible for the communication exchange between the switch and DNS requests and replies.

Network Design & Pseudo Code

Names	IP Addresses
Man in the Middle	192.168.0.7
Legitimate User	192.168.0.8
Switch	192.168.0.100
DNS Server	*any arbitrary legitimate server*
Malicious Server	192.168.0.9

“Driver” - main.rb

```
#set some global variables
@interface = “em1”
@victim_ip = victim’s ip address
@victim_mac = victim’s mac address
@router_ip = router’s ip
@router_mac = router’s mac
@our_info = grab our attacking machine’s info through PacketFu
...
begin
    Create our arpSpoof object with arguments
    Create our dnsSpoof object with arguments

    Create arpSpoof thread
    Create dnsSpoof thread

    Join threads
    Catch “Ctrl+C” interrupt
    kill threads
    exit
end
```

ARP Spoof Class - “arpSpoof.rb”

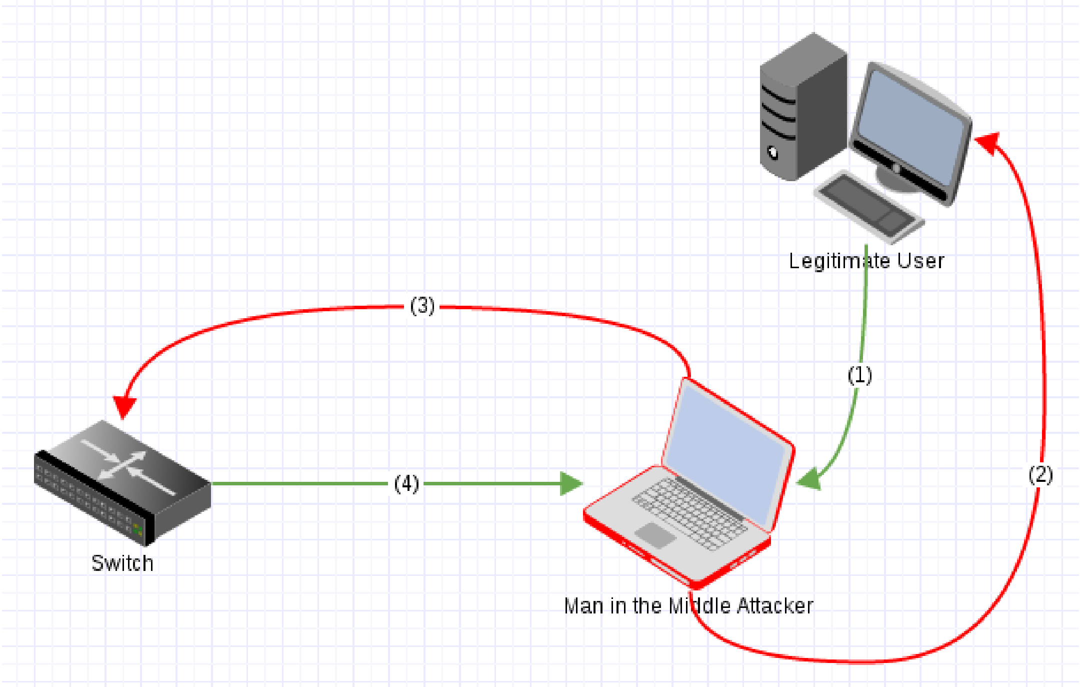
```
class ARPSpoof
    def init (...)
        create our ARP packet to victim machine
        create our ARP packet to router

        start arpSpoofing
    end
    def start
        `echo 1 > /proc/sys/net/ipv4/ip_forward`
        drop all ICMP redirects from the attacking machine using IPtables

        while caught == false do
            sleep 1
            send ARP packet to victim machine
            send ARP packet to router
        end
    end
    def stop
        stop sending ARP packets
        clear up IPtables
        exit 0
    end
end
```

DNS Spoof Class - “dnsSpoof.rb”

```
class DNSSpoof
    def init (...)
        set some variables
        start capturing
    end

    def capturing
        set filter: “udp and port 53 and src “ + victim’s ip
        set capturing module from PacketFu

        check each packet coming in using filter
        if the packet is UDP, parse it
            if packet is DNS Query, grab it
                parse domain name
                send domain name and packet to send_request
            end
        end
    end

    def send_request(packet, domain name)
```

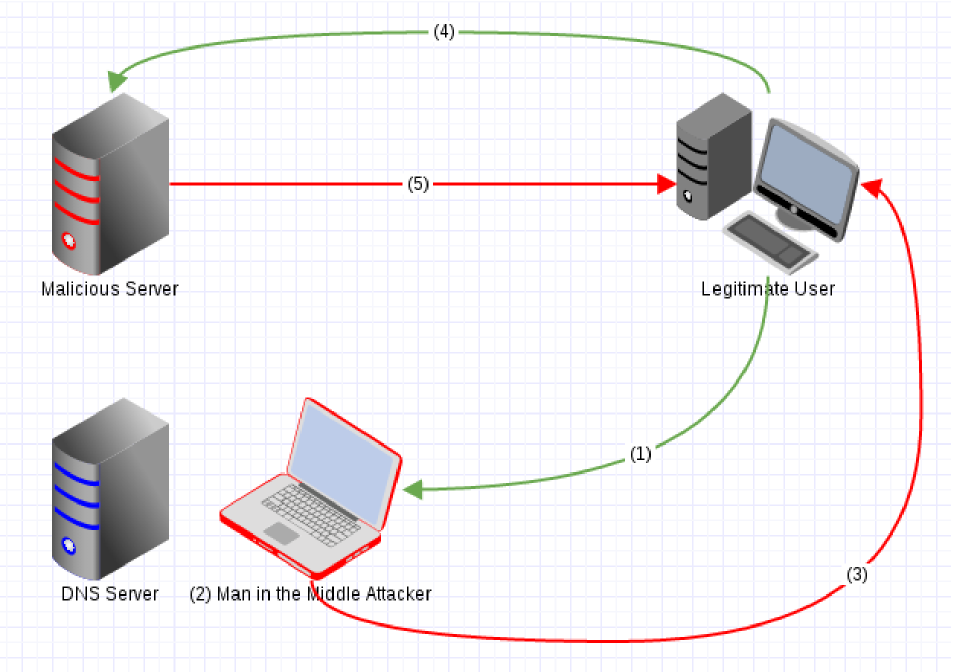
```
        set some UDP variables
        populate payload with DNS Response flags
        populate payload with domain name
        populate payload with more DNS Response flags
        populate payload with Spoof'd IP (in hex)
        recalculate UDP packet size
        send udp packet to victim
    end
end
```

ARP Poisoning Diagram



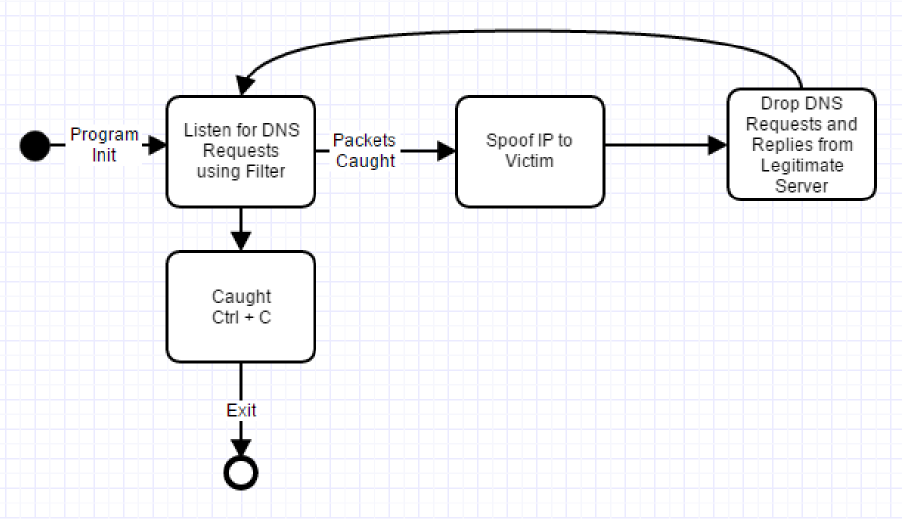
1. The Legitimate User sends an ARP request to the Switch.
2. The Man in the Middle intercepts this ARP request, and responds back to the Legitimate User, masquerading as the Switch.
3. Simultaneously, the Man in the Middle sends a fabricated ARP request to the Switch, masquerading as the Legitimate user.
4. The Switch sends back the ARP reply to the Man in the Middle, thinking that it is the Legitimate user. At this point, the Man in the Middle attacker relays the reply back to the Legitimate user but prepares the reply to look like the Switch.

DNS Spoofing Diagram

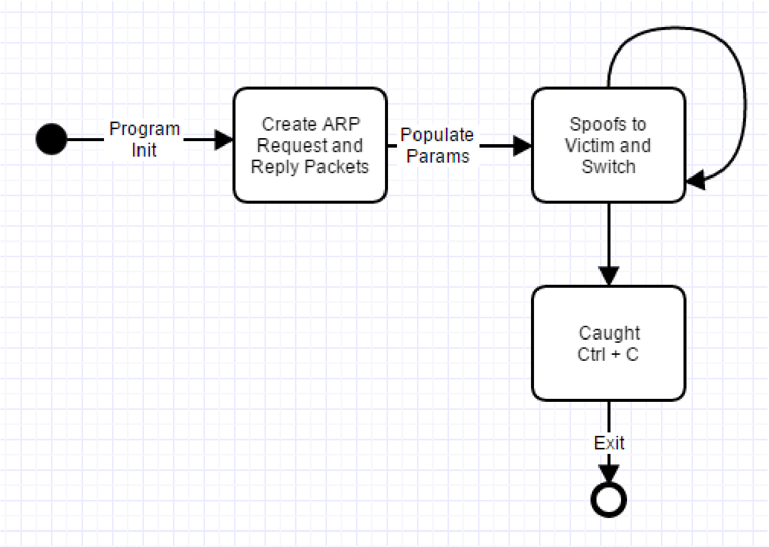


1. The Legitimate user wishes to visit a web page and sends a DNS query
2. The Man in the Middle intercepts this DNS query and fabricates its own DNS response. *The DNS Query does not even reach the legitimate DNS Server!*
3. The Man in the Middle then crafts its own values and sends back the DNS Response, with the destination pointing to the Malicious Server.
4. The Legitimate user, thinking that the DNS response is authentic, visits the Malicious Server.
5. The Malicious server responds by providing its web pages to the Legitimate user.

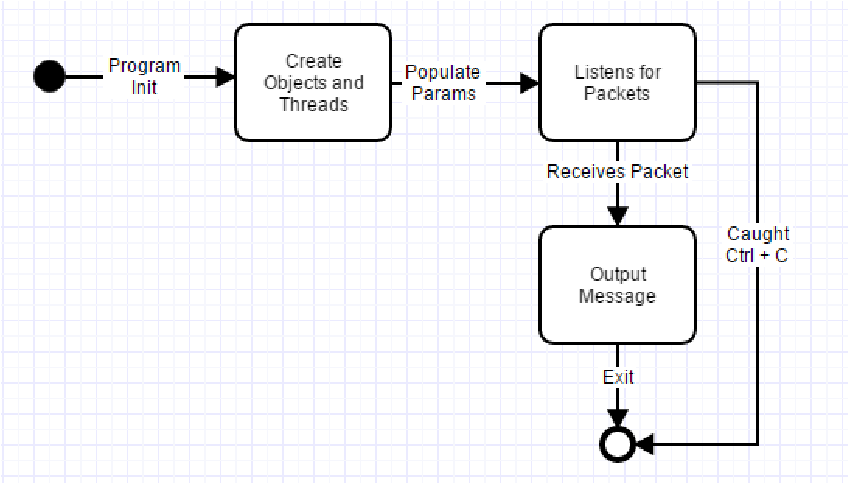
dnsSpoof.rb State Chart Diagram


Program Init
Listen for DNS Requests using Filter
Packets Caught
Spoof IP to Victim
Drop DNS Requests and Replies from Legitimate Server
Caught Ctrl + C
Exit

arpSpoof.rb State Chart Diagram


Program Init
Create ARP Request and Reply Packets
Populate Params
Spoofs to Victim and Switch
Caught Ctrl + C
Exit

main.rb State Chart Diagram



Tools & Equipment Used

Hardware

- 8GB RAM
- Victim Machine
- Intel i5 Quad Core
- Man in the Middle
- 500GB HDD
- Switch

Software

- Fedora Linux 20 64-bit
- Terminal
- Ruby Programming
- PacketFu Library
- Wireshark
- IPtables

Testing & Documentation

Test Cases

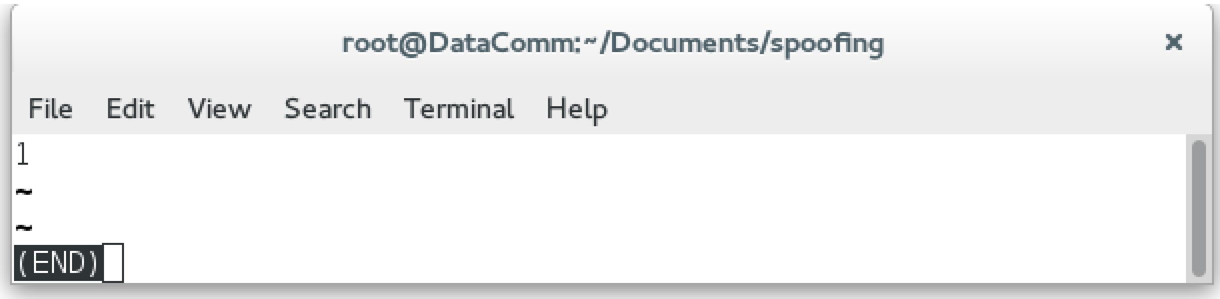
Case #	Test Case	Tools Used	Expected Outcome	Results
1	arpSpoof enables ip forwarding	less /proc/sys/net/ipv4/	ip_forwarding = 1	PASSED. See results for details.
2	arpSpoof is able to create IPtable rules	iptables -L -n -v -x	Four distinct IPtable rules should exist	PASSED. See results for details.
3	arpSpoof is able to poison victim machine	terminal, arp	Victim machine will show two identical MAC addresses that belong to our attacking machine	PASSED. See results for details.
4	dnsSpoof is able to filter packets using the filter specified	terminal	Terminal output shows our filter	PASSED. See results for details.
5	dnsSpoof is able to spoof to intended website	terminal	Terminal will output intended spoof IP	PASSED. See results for details.
6	dnsSpoof is able to parse DNS requests when victim machine uses web browser	terminal	Terminal will output DNS requests	PASSED. See results for details.
7	Victim machine will be redirected to spoofed website	Web Browser, Wireshark	Wireshark will display filtered packets that have the DNS response with our spoofed IP; Web Browser will redirect to intended website	PASSED. See results for details.
8	Ctrl + C kills both threads	ps aux | grep main.rb, ps aux | grep arpSpoof.rb, ps aux | grep dnsSpoof.rb	All threads get killed and program exits	PASSED. See results for details.
9	Ctrl + C resets ip forwarding	less /proc/sys/net/ipv4/	ip_forwarding = 0	PASSED. See results for details.
10	Ctrl + C resets iptables firewall rules	iptables -L -n -v -x	All tables should have accept policy	PASSED. See results for details.

Test Results

arpSpoof enables ip forwarding

When initializing our program, we require IP forwarding to be enabled on Linux systems. Below, we confirm that our program does just that by running the following command to see that the file is inserted with a “1” to enable IP forwarding:

Command: `less /proc/sys/net/ipv4/ip_forward`

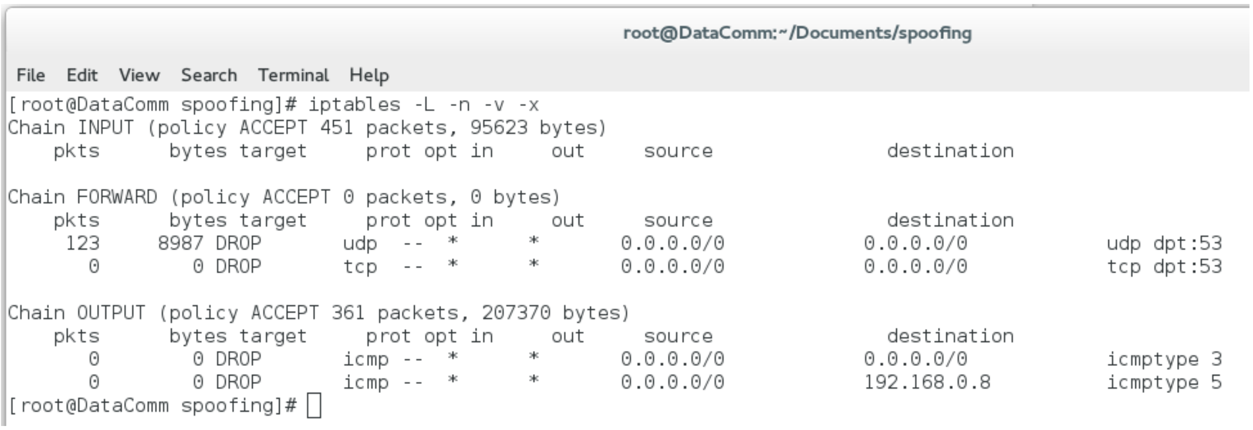

root@DataComm:~/Documents/spoofing
File Edit View Search Terminal Help

```
1
~
~
(END)
```

arpSpoof is able to create iptables rules

Our code executes four lines of iptables configurations. Here we run the following command to display our current firewall settings.

Command: iptables -L -n -v -x

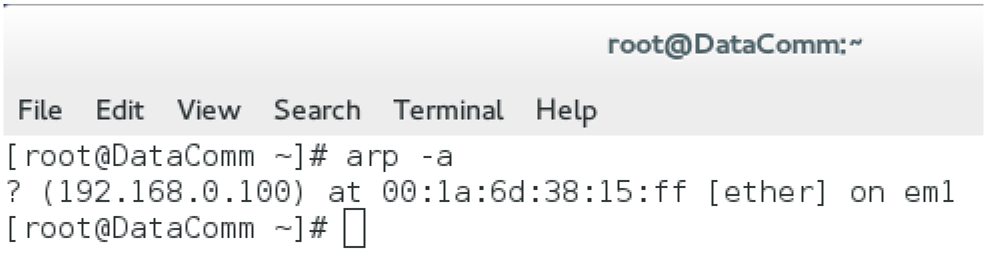

root@DataComm:~/Documents/spoofing
File Edit View Search Terminal Help

```
[root@DataComm spoofing]# iptables -L -n -v -x
Chain INPUT (policy ACCEPT 451 packets, 95623 bytes)
    pkts      bytes target     prot opt in     out     source               destination

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
    pkts      bytes target     prot opt in     out     source               destination
     123     8987 DROP       udp  --  *      *       0.0.0.0/0            0.0.0.0/0            udp dpt:53
       0        0 DROP       tcp  --  *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:53

Chain OUTPUT (policy ACCEPT 361 packets, 207370 bytes)
    pkts      bytes target     prot opt in     out     source               destination
       0        0 DROP       icmp --  *      *       0.0.0.0/0            0.0.0.0/0            icmptype 3
       0        0 DROP       icmp --  *      *       0.0.0.0/0            192.168.0.8          icmptype 5
[root@DataComm spoofing]#
```

arpSpoof is able to poison victim machine

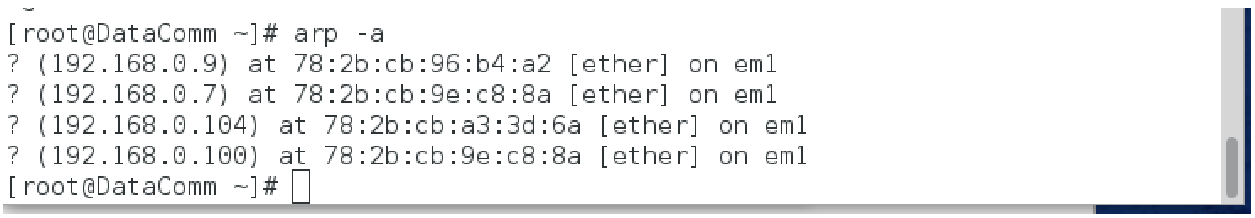
In the following screenshot, we show what the ARP table looks like on our victim machine. Note that this is our legitimate router MAC address.

Before:



```
[root@DataComm ~]# arp -a
? (192.168.0.100) at 00:1a:6d:38:15:ff [ether] on em1
[root@DataComm ~]#
```

After Spoofing:

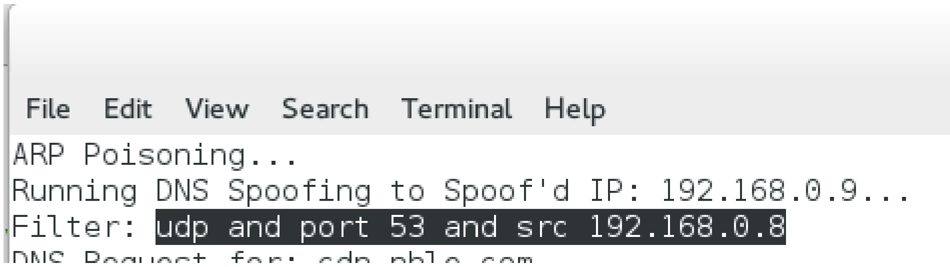


```
[root@DataComm ~]# arp -a
? (192.168.0.9) at 78:2b:cb:96:b4:a2 [ether] on em1
? (192.168.0.7) at 78:2b:cb:9e:c8:8a [ether] on em1
? (192.168.0.104) at 78:2b:cb:a3:3d:6a [ether] on em1
? (192.168.0.100) at 78:2b:cb:9e:c8:8a [ether] on em1
[root@DataComm ~]#
```

After we started the program to ARP poison our victim machine, we can clearly see that MAC addresses of 192.168.0.7 and 192.168.0.100 are the same. This is a sure signature of being ARP poisoned.

dnsSpoof is able to filter packets using the filter specified

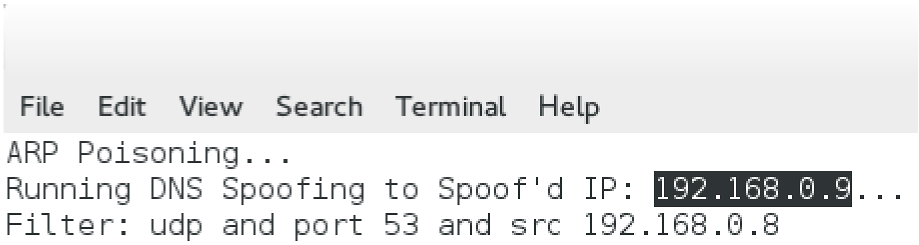
The below screenshot displays the filtering of packet captures and uses TCPdump-like notations for its filtering. Note that it is filtering packets originating from our victim IP address.



```
ARP Poisoning...
Running DNS Spoofing to Spoof'd IP: 192.168.0.9...
Filter: udp and port 53 and src 192.168.0.8
DNS Request for: cdn.pblo.com
```

dnsSpoof is able to spoof to intended website

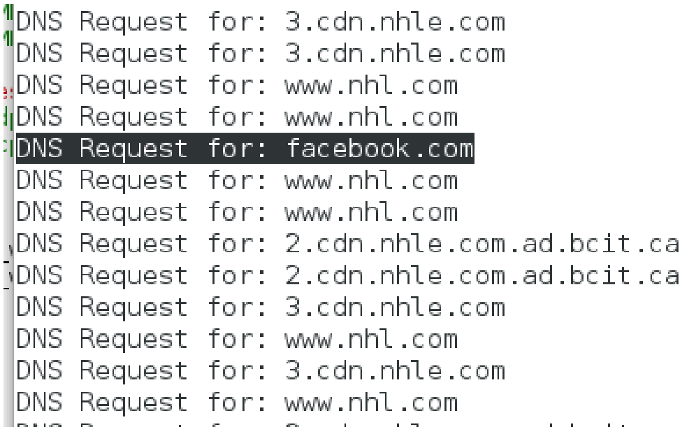
The following screenshot displays that our DNS Spoofer will be redirecting all DNS replies with spoofed IP of 192.168.0.9...



```
ARP Poisoning...
Running DNS Spoofing to Spoof'd IP: 192.168.0.9...
Filter: udp and port 53 and src 192.168.0.8
```

dnsSpoof is able to parse DNS requests when victim machine uses web browser

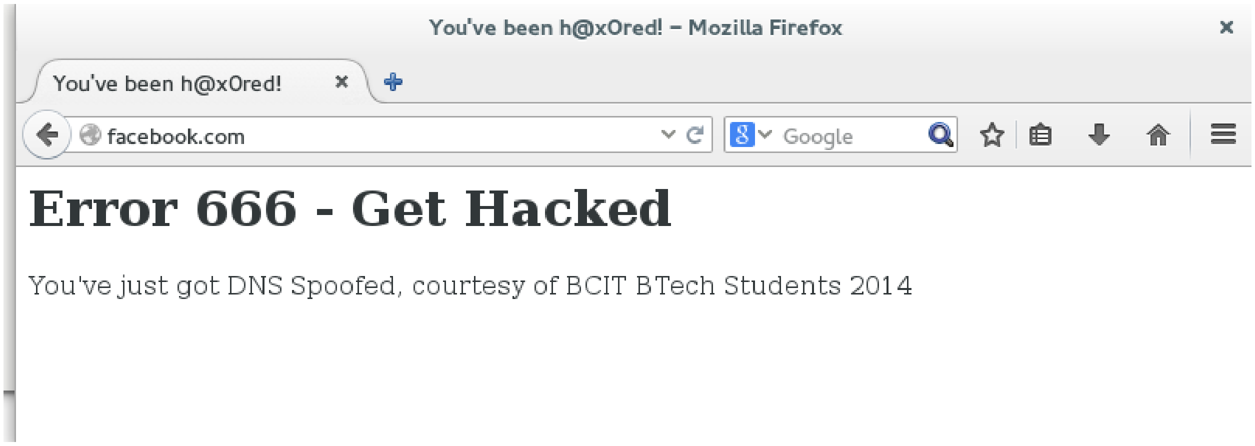
When our victim opens a browser and visits a popular website such as Facebook, we can confirm that our DNS Spoofer is filtering and capturing packets based on our victim's activity.



```
DNS Request for: 3.cdn.nhle.com
DNS Request for: 3.cdn.nhle.com
DNS Request for: www.nhl.com
DNS Request for: www.nhl.com
DNS Request for: facebook.com
DNS Request for: www.nhl.com
DNS Request for: www.nhl.com
DNS Request for: 2.cdn.nhle.com.ad.bcit.ca
DNS Request for: 2.cdn.nhle.com.ad.bcit.ca
DNS Request for: 3.cdn.nhle.com
DNS Request for: www.nhl.com
DNS Request for: 3.cdn.nhle.com
DNS Request for: www.nhl.com
```

Victim machine will be redirected to spoofed website

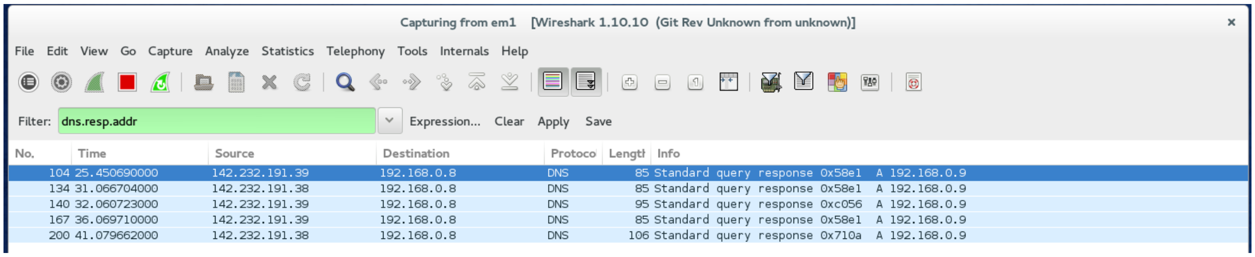
Below is what the victim sees when he or she visits our spoofed website.



Error 666 - Get Hacked

You've just got DNS Spoofed, courtesy of BCIT BTech Students 2014

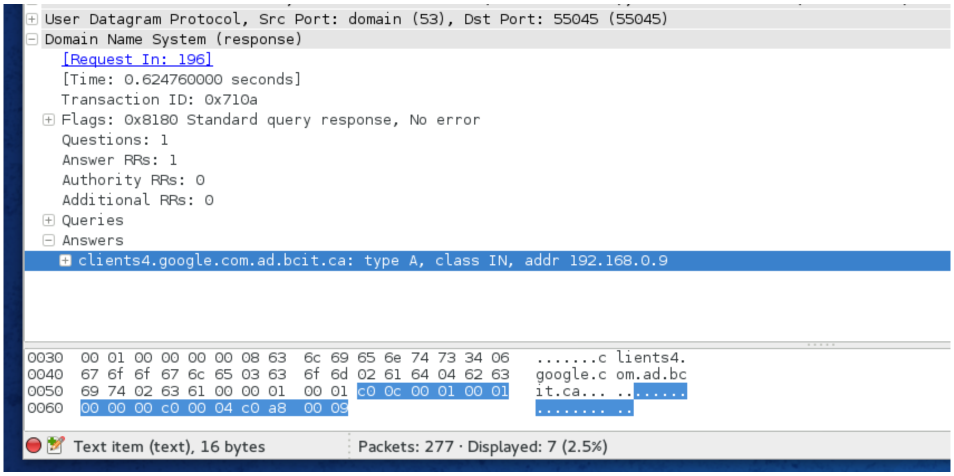
The following are Wireshark captures of the DNS replies to our victim machine. Note how the domain name remains the same but the IP address is our spoofed IP.



Filter: dns.resp.addr

No.	Time	Source	Destination	Protoco	Lengtl	Info
104	25.450690000	142.232.191.39	192.168.0.8	DNS	85	Standard query response 0x58e1 A 192.168.0.9
134	31.066704000	142.232.191.38	192.168.0.8	DNS	85	Standard query response 0x58e1 A 192.168.0.9
140	32.060723000	142.232.191.39	192.168.0.8	DNS	95	Standard query response 0xc056 A 192.168.0.9
167	36.069710000	142.232.191.39	192.168.0.8	DNS	85	Standard query response 0x58e1 A 192.168.0.9
200	41.079662000	142.232.191.38	192.168.0.8	DNS	106	Standard query response 0x710a A 192.168.0.9

In further detail of a sample packet, we see that all captured packets that are DNS requests are being intercepted and crafted to send our victim to our spoofed address.

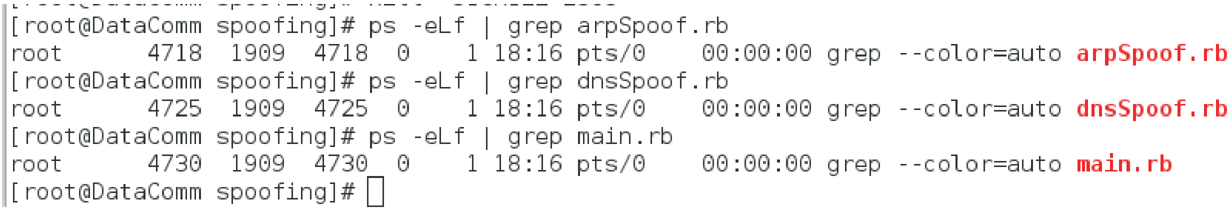


```
⊞ User Datagram Protocol, Src Port: domain (53), Dst Port: 55045 (55045)
⊟ Domain Name System (response)
    [Request In: 196]
    [Time: 0.624760000 seconds]
    Transaction ID: 0x710a
  ⊞ Flags: 0x8180 Standard query response, No error
    Questions: 1
    Answer RRs: 1
    Authority RRs: 0
    Additional RRs: 0
  ⊞ Queries
  ⊟ Answers
    ⊞ clients4.google.com.ad.bcit.ca: type A, class IN, addr 192.168.0.9

0030  00 01 00 00 00 00 08 63  6c 69 65 6e 74 73 34 06   .......c lients4.
0040  67 6f 6f 67 6c 65 03 63  6f 6d 02 61 64 04 62 63   google.c om.ad.bc
0050  69 74 02 63 61 00 00 01  00 01 c0 0c 00 01 00 01   it.ca... ........
0060  00 00 00 c0 00 04 c0 a8  00 09                     ........ ..
```

Text item (text), 16 bytes
Packets: 277 · Displayed: 7 (2.5%)

Ctrl + C kills threads

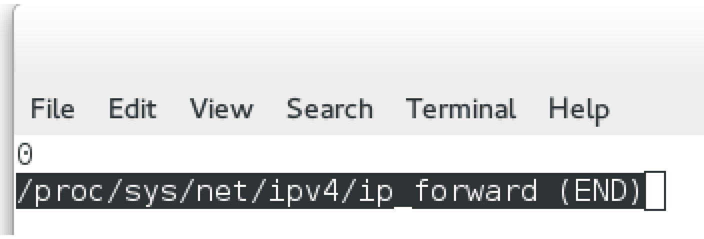
Once we enter Control + C on our attacking machine, we should see no signs of any lingering processes or threads related to our program.



```
[root@DataComm spoofing]# ps -eLf | grep arpSpoof.rb
root      4718  1909  4718  0    1 18:16 pts/0    00:00:00 grep --color=auto arpSpoof.rb
[root@DataComm spoofing]# ps -eLf | grep dnsSpoof.rb
root      4725  1909  4725  0    1 18:16 pts/0    00:00:00 grep --color=auto dnsSpoof.rb
[root@DataComm spoofing]# ps -eLf | grep main.rb
root      4730  1909  4730  0    1 18:16 pts/0    00:00:00 grep --color=auto main.rb
[root@DataComm spoofing]# 
```

Ctrl + C resets ip forwarding

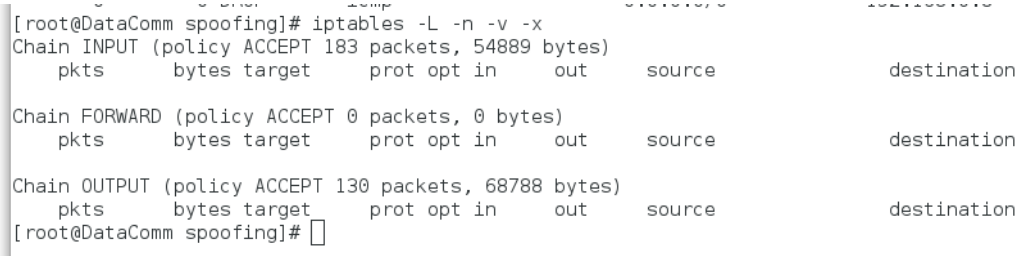
IP forwarding is reverted back to its default settings of “0”.



```
0
/proc/sys/net/ipv4/ip_forward (END)
```

Ctrl + C resets iptables firewall rules

Firewall rules are reverted back to their default values. There are no special rules specified in the below screenshot.



```
[root@DataComm spoofing]# iptables -L -n -v -x
Chain INPUT (policy ACCEPT 183 packets, 54889 bytes)
    pkts      bytes target     prot opt in     out     source               destination

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

Chain OUTPUT (policy ACCEPT 130 packets, 68788 bytes)
    pkts      bytes target     prot opt in     out     source               destination
[root@DataComm spoofing]# 
```

Limitations of Proof of Concept

Since we are using the Ruby language as a proof of concept for our DNS Spoofing, we ran into a problem where actual legitimate DNS replies came back faster than our attacking machine was able to even send its crafted packet. Also, once we applied firewall rules to delimit any forwarding of legitimate DNS replies, we saw that it took abnormally long to resolve a website name, even though we supplied the victim machine with a legitimate looking DNS reply packet. This is a serious drawback of using Ruby programming in this case. Suspecting victims will eventually grow tired, wearied and will definitely notice this strange lagging behavior of their once-fast machine if we used our program to DNS Spoof them. This violates practice of being covert and legitimate. However, while the drawbacks are visible, a proof of concept is still tangible in the sense that it can demonstrate simple weaknesses without having to provide rich and fully functional code.

Conclusion

In more verbose programming languages like C, packet crafting such as we have done in this assignment may require code two or three times as much compared to the code in Ruby. However, because of the nature of C, it allows programmers to have much more control over their programming, rather than relying on automated features or libraries that may or may not execute code as intended. But sometimes spending all that effort in C may not surmount to a feasible project or program. In which case, time and effort is wasted. By quickly conjuring up a proof of concept as we have here, we can determine if the idea is worth pursuing without having to overextend.

A note on DNS spoofing, we can easily see how man in the middle attacks can exploit a network. Without preventive measures in place, a rogue employee with the know-how of the network infrastructure of the business organization, can easily take advantage of the other technologically-illiterate employees to providing or doing activities that can leverage the attacker.

Therefore, it is imperative that security is implemented on networks to check for DNS spoofing. Some solutions involve adding randomness to the queries, others include DNS request and reply checking. Whatever the case may be, DNS spoofing can be damaging to personal users and business organizations if left undetected.

References

Queenan, L. (2012, October 29). Ruby DNS Spoofing using Packetfu. Retrieved November 1, 2014, from http://crushbeercrushcode.org/2012/10/ruby-dns-spoofing-using-packetfu/

Appendices

Appendix I - Files on Disk

Files located on-disk are the following:

- Man in the Middle Attacks & DNS Spoofing (.pdf)

- Ruby Code (directory)
  - main.rb
  - arpSpoof.rb
  - dnsSpoof.rb

- README.txt