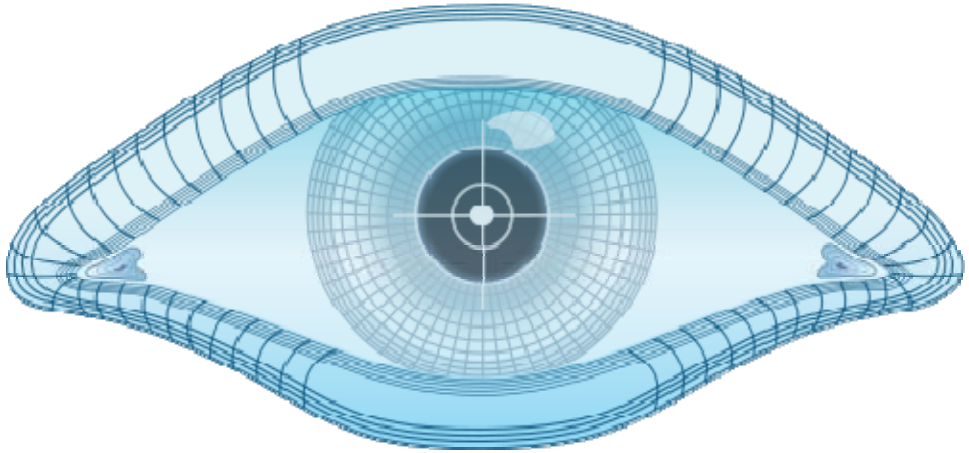
CSCE 629
Cyber Attack

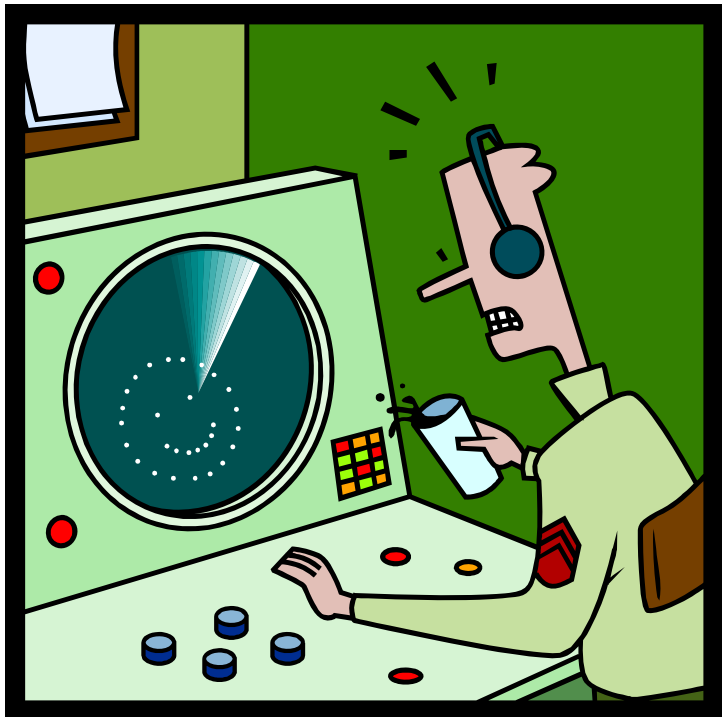
Scanning



Dr. Barry Mullins
AFIT/ENG
Bldg 642
Room 209
255-3636 x7979

define:Scanning

- Recon → searching for information about target
- Scanning → searching for
  - Systems / computers (IPs) and services / openings (ports)
- Together, they
  - Are a critical first step
  - Identify available avenues of entry / attack vectors



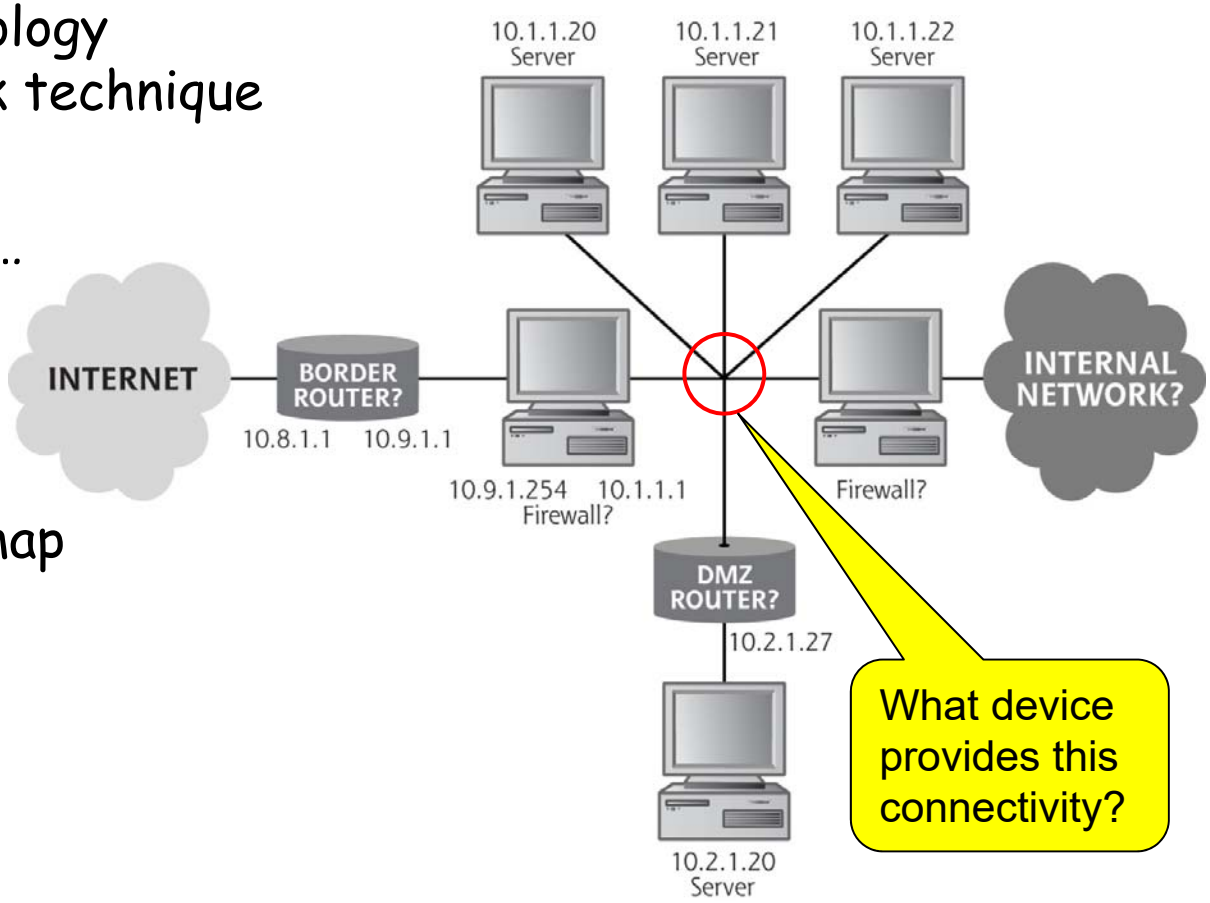
Computer and Network Hacker Exploits

- Step 1: Reconnaissance
- **Step 2: Scanning**
  - Network Mapping
  - Determining Open Ports Using Port Scanners
  - Vulnerability-Scanning Tools
  - Intrusion Detection System and Intrusion Prevention System Evasion
  - Shares
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

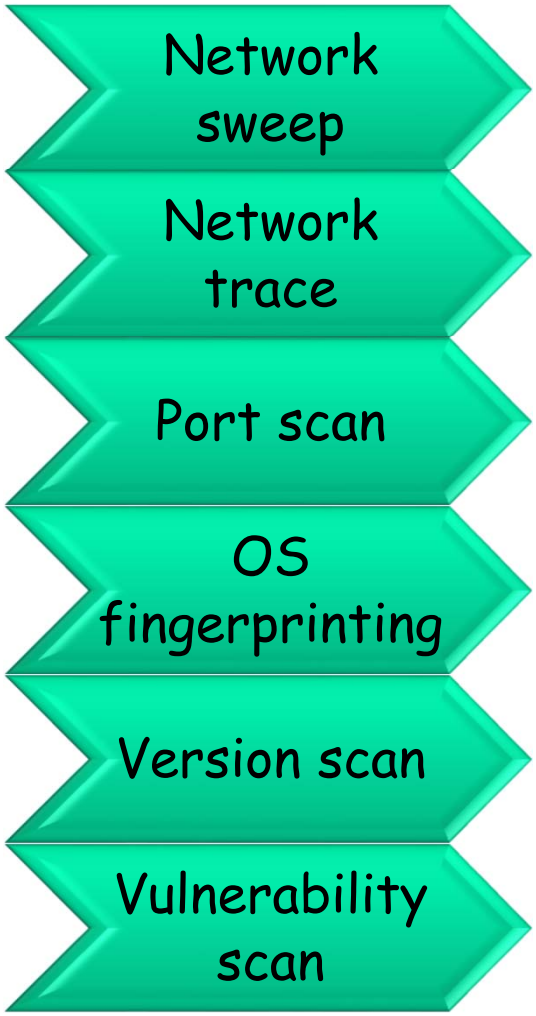
define:"Network Mapping"

- Probe systems to understand the Internet perimeter and topology (the layout of routers and hosts) of the target network
  - How is the target interfacing with the Internet?
  - Understanding topology helps decide attack technique
- Looking for addresses…

  … and how they are interconnected
- Goal is to generate a map of the network



Scanning Process



Is there a system at an IP?

How are the systems connected?

What ports are open / services provided?

What is the OS?

What version of SW is providing the service?

What vulnerabilities are known for these versions?

Network sweep

Network Mapping Using arp-scan

- Sends ARP request and listens for response

```
Vmware_3b:d4:e3     Broadcast           ARP         42 Who has 10.1.0.0? Tell 10.1.0.8
Vmware_3b:d4:e3     Broadcast           ARP         42 Who has 10.1.0.1? Tell 10.1.0.8
Dell_b2:c6:60       Vmware_3b:d4:e3     ARP         60 10.1.0.1 is at 00:23:ae:b2:c6:60
Vmware_3b:d4:e3     Broadcast           ARP         42 Who has 10.1.0.2? Tell 10.1.0.8
Adastra_6e:3b:8c    Vmware_3b:d4:e3     ARP         60 10.1.0.2 is at 00:20:0c:6e:3b:8c
Vmware_3b:d4:e3     Broadcast           ARP         42 Who has 10.1.0.3? Tell 10.1.0.8
```

```
root@kali:~# arp-scan --localnet
Interface: eth0, datalink type: EN10MB (Ethernet)
Starting arp-scan 1.9 with 2048 hosts (http://www.nta-monitor.
10.1.0.1        00:23:ae:b2:c6:60       Dell Inc.
10.1.0.2        00:20:0c:6e:3b:8c       ADASTRA SYSTEMS CORP.
10.1.0.3        48:0f:cf:50:38:bd       (Unknown)
10.1.0.4        2c:41:38:4f:3d:ce       Hewlett-Packard Company
10.1.0.5        48:0f:cf:50:38:cc       (Unknown)
                    <<snip>>
10.1.5.91       dc:4a:3e:70:27:89       (Unknown)
10.1.5.98       80:2a:a8:1d:b7:72       (Unknown)
10.1.5.99       08:00:27:a5:b4:f8       CADMUS COMPUTER SYSTEMS
10.1.5.102      48:0f:cf:50:19:7b       (Unknown)
10.1.6.25       08:00:27:dc:a6:21       CADMUS COMPUTER SYSTEMS

192 packets received by filter, 0 packets dropped by kernel
Ending arp-scan 1.9: 2048 hosts scanned in 9.129 seconds (224.34 hosts/sec). 192 responded
root@kali:~#
```

Effective beyond the subnet?
No. Why?

Network sweep

Network Mapping using Ping Sweeps

- Packet InterNet Groper (PING)
  - Sends an ICMP *echo request* (type 8, code 0)
  - Waits for an ICMP *echo reply* (type 0 , code 0)
- Also great for resolving an IP address from hostname

```
C:\Users\bmullins.CDN>ping fs-cdn-01

Pinging fs-cdn-01.CDN.LOCAL [10.1.2.7] with 32 bytes of data:
Reply from 10.1.2.7: bytes=32 time<1ms TTL=64
Reply from 10.1.2.7: bytes=32 time<1ms TTL=64
```

- Ping sweeps can be defeated by blocking incoming ICMP messages

Ping Sweeps With Scapy

sr() function sends layer 3 packets and receives answers

Send an IP packet containing an ICMP PING (default) payload

- `ans,unans=sr(IP(dst="10.1.0.1-254")/ICMP(),timeout=1)`

sr returns ans → list of couples (packet sent, answer)
unans → list of unanswered packets

Print the received packet's IP source address

- `ans.summary(lambda (s,r): r.sprintf("%IP.src% is alive") )`

lambda (s,r) is an anonymous function accepting sent (s) and received (r) packets

```
>>> ans.summary(lambda (s,r): r.sprintf("%IP.src% is alive") )
10.1.0.1 is alive
10.1.0.3 is alive
10.1.0.2 is alive
10.1.0.4 is alive
```

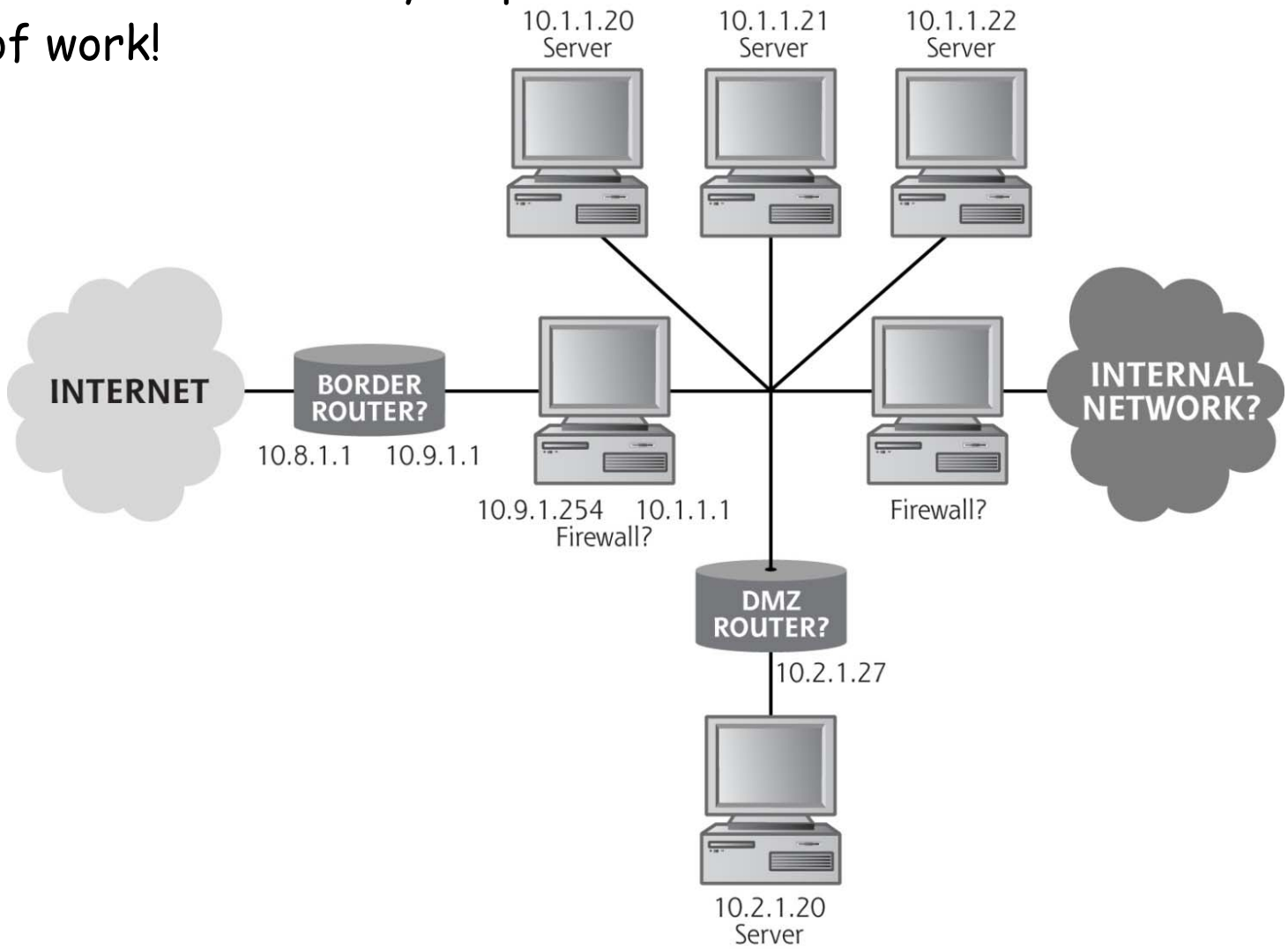
Network sweep

Network Mapping using TCP / UDP

- Send TCP SYN packet to a port commonly open (e.g., 80)
  - **ans,unans=sr(IP(dst="10.1.0.*")/TCP(dport=80,flags="S") ,timeout=1)**
  - **ans.summary(lambda (s,r): r.sprintf("%IP.src% is alive"))**
  - Target listening on that port → attacker receives SYN-ACK
    - There is a machine at that address
- Send a UDP packet to an unlikely port
  - **ans,unans=sr(IP(dst="10.1.1-7.1-10")/UDP(dport=0) ,timeout=1)**
  - **ans.summary(lambda (s,r): r.sprintf("%IP.src% is alive"))**
  - Target responds with ICMP port unreachable message
    - There is a machine at that address
- For both above,
  if I get ANY response, there is a machine at that address

Network Mapping using Traceroute

- Can use traceroute to manually map a network
  - A LOT of work!



Computer and Network Hacker Exploits

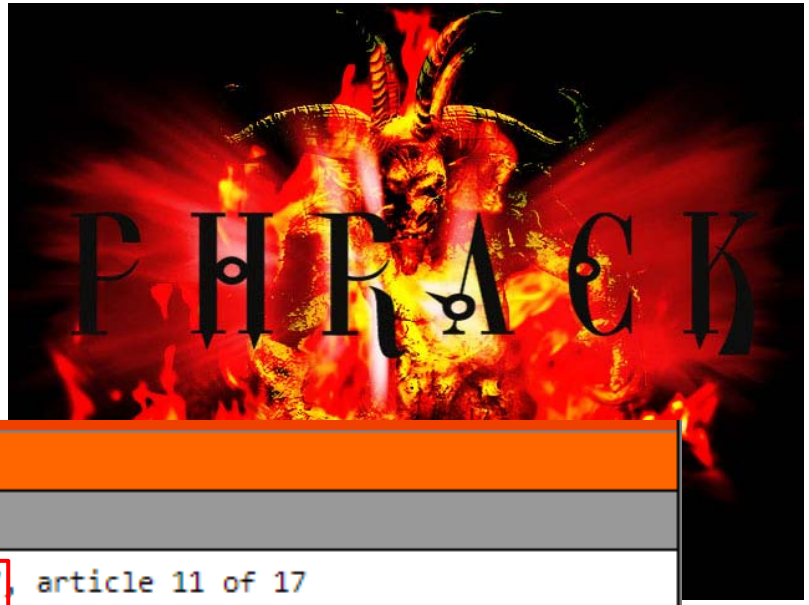
- Step 1: Reconnaissance
- **Step 2: Scanning**
  - Network Mapping
  - Determining Open Ports Using Port Scanners
  - Vulnerability-Scanning Tools
  - Intrusion Detection System and Intrusion Prevention System Evasion
  - Shares
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

Port Scanners

- Now we have
  - IP addresses of systems
  - Very basic understanding of the topology
- Still need
  - What ports (processes/services) are listening on these IPs?
    - Attacker can focus attack based on open ports
- Port scanners send packets to ports to determine what's listening
  - If a system responds,
    - that port is listening and
    - associated service is available

Nmap by Fyodor (Gordon Lyon)

- "Network exploration tool and security / port scanner"



Title : The Art of Scanning

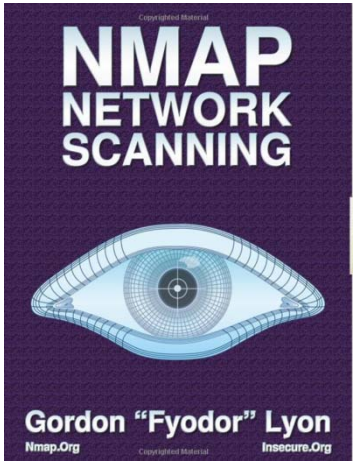
Author : Fyodor

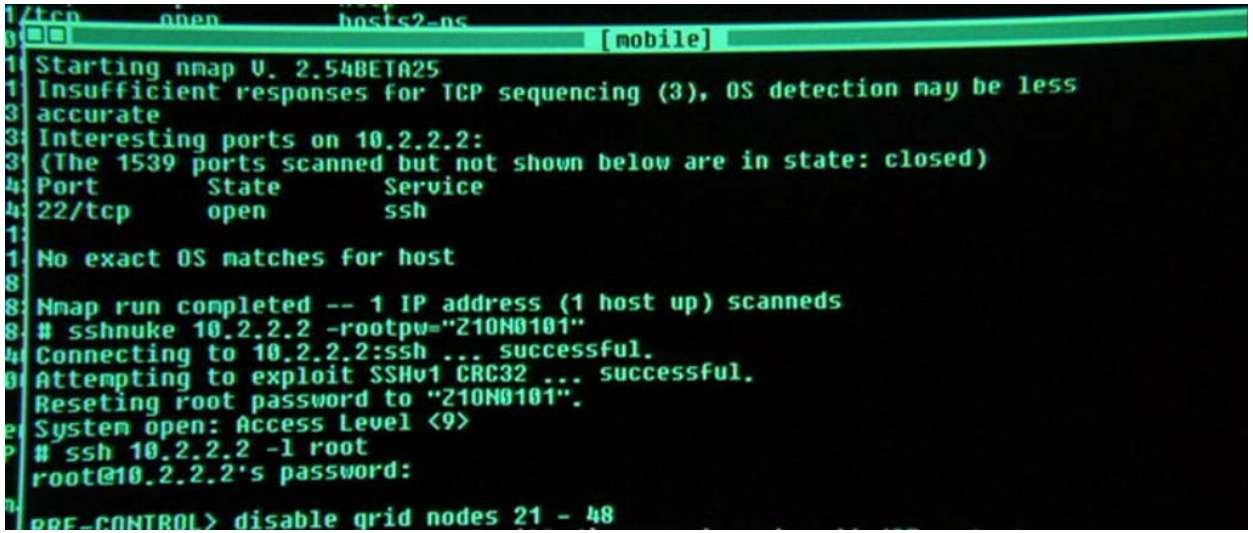
```
---[  Phrack Magazine   Volume 7, Issue 51 September 01, 1997, article 11 of 17


-------------------------[  The Art of Port Scanning


--------[  Fyodor <fyodor@dhp.com>


[ Abstract ]

This paper details many of the techniques used to determine what ports (or
similar protocol abstraction) of a host are listening for connections.  These
ports represent potential communication channels.  Mapping their existence
facilitates the exchange of information with the host, and thus it is quite
useful for anyone wishing to explore their networked environment, including
hackers.  Despite what you have heard from the media, the Internet is NOT
all about TCP port 80.  Anyone who relies exclusively on the WWW for
information gathering is likely to gain the same level of proficiency as your
average AOLer, who does the same.  This paper is also meant to serve as an
introduction to and ancillary documentation for a coding project I have been
working on.  It is a full featured, robust port scanner which (I hope) solves
some of the problems I have encountered when dealing with other scanners and
when working to scan massive networks.  The tool, nmap, supports the following:
```

Nmap by Fyodor

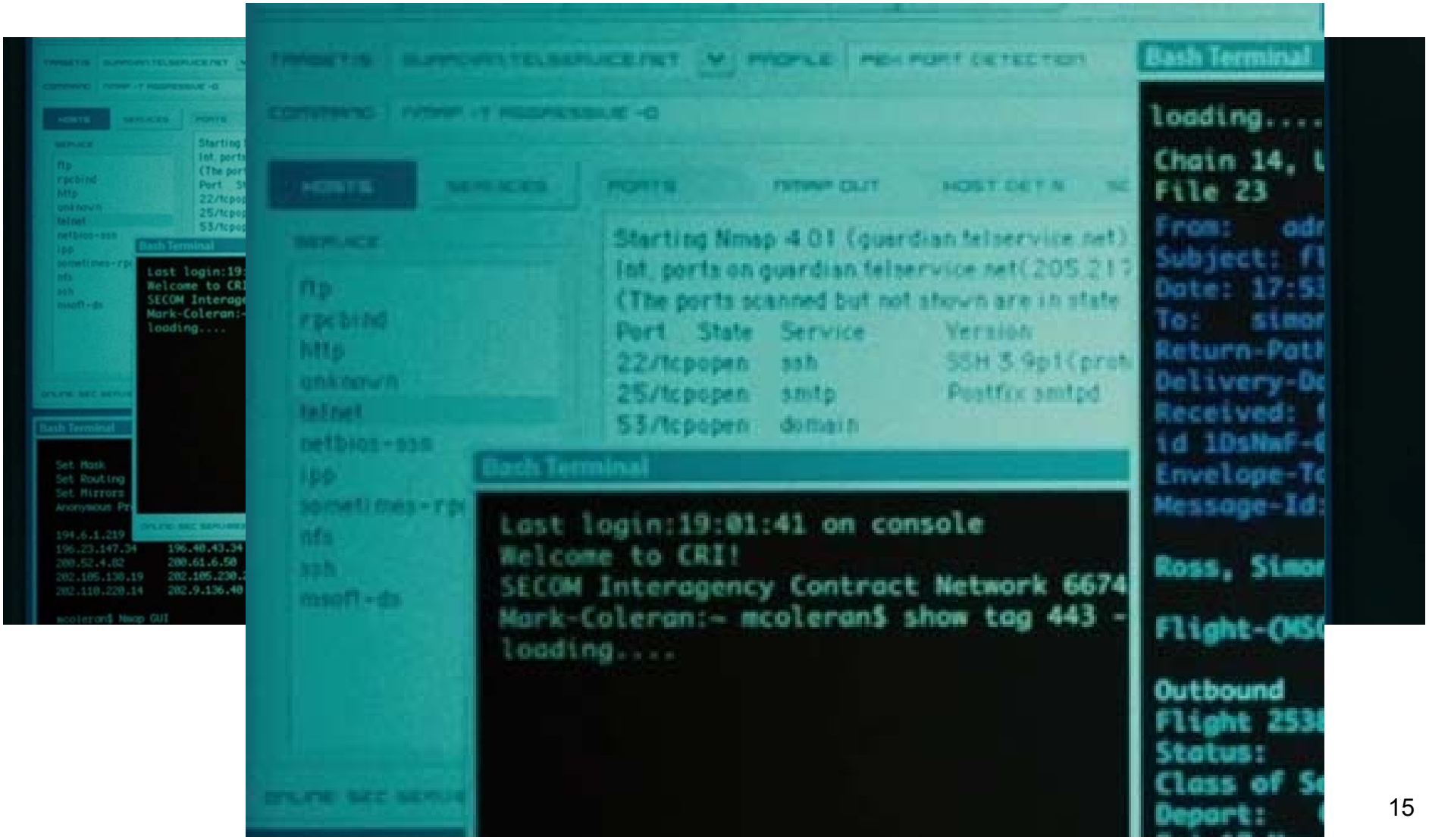
- GUI version available (Zenmap) in Unix or Windows
  - Basically generates command line from GUI inputs
- nmap.org
- Featured in The Matrix Reloaded

nmap.org/book/toc.html





Nmap in *The Bourne Ultimatum*



Nmap in Ocean's 8

Nmap

I know you're what you're thinking…

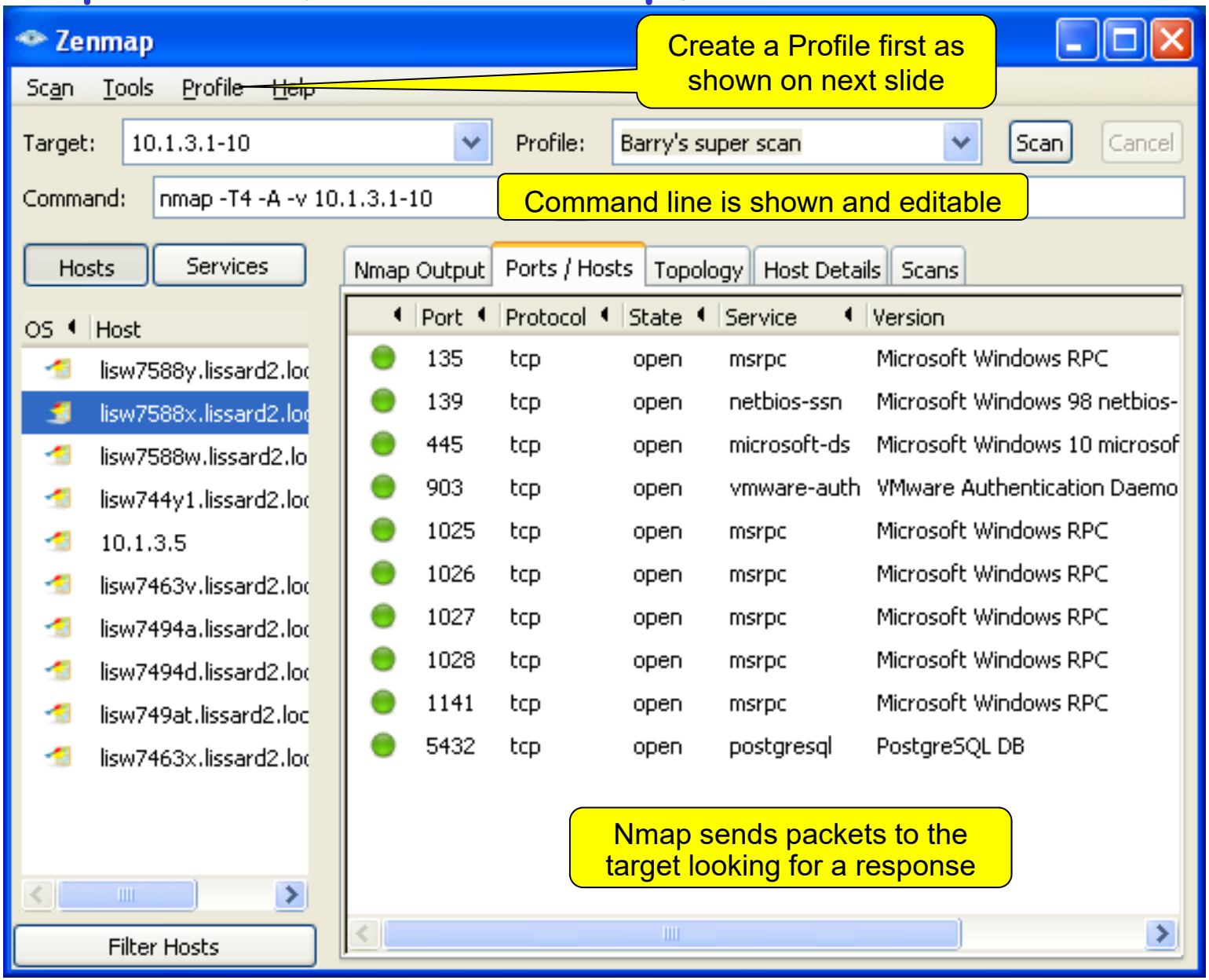
This movie stuff is a fantasy world. Why should I care about nmap?

President George W. Bush visited the NSA headquarters at Fort Meade in January 2006

nmap [Scan Type ...] [Options] {target specification }

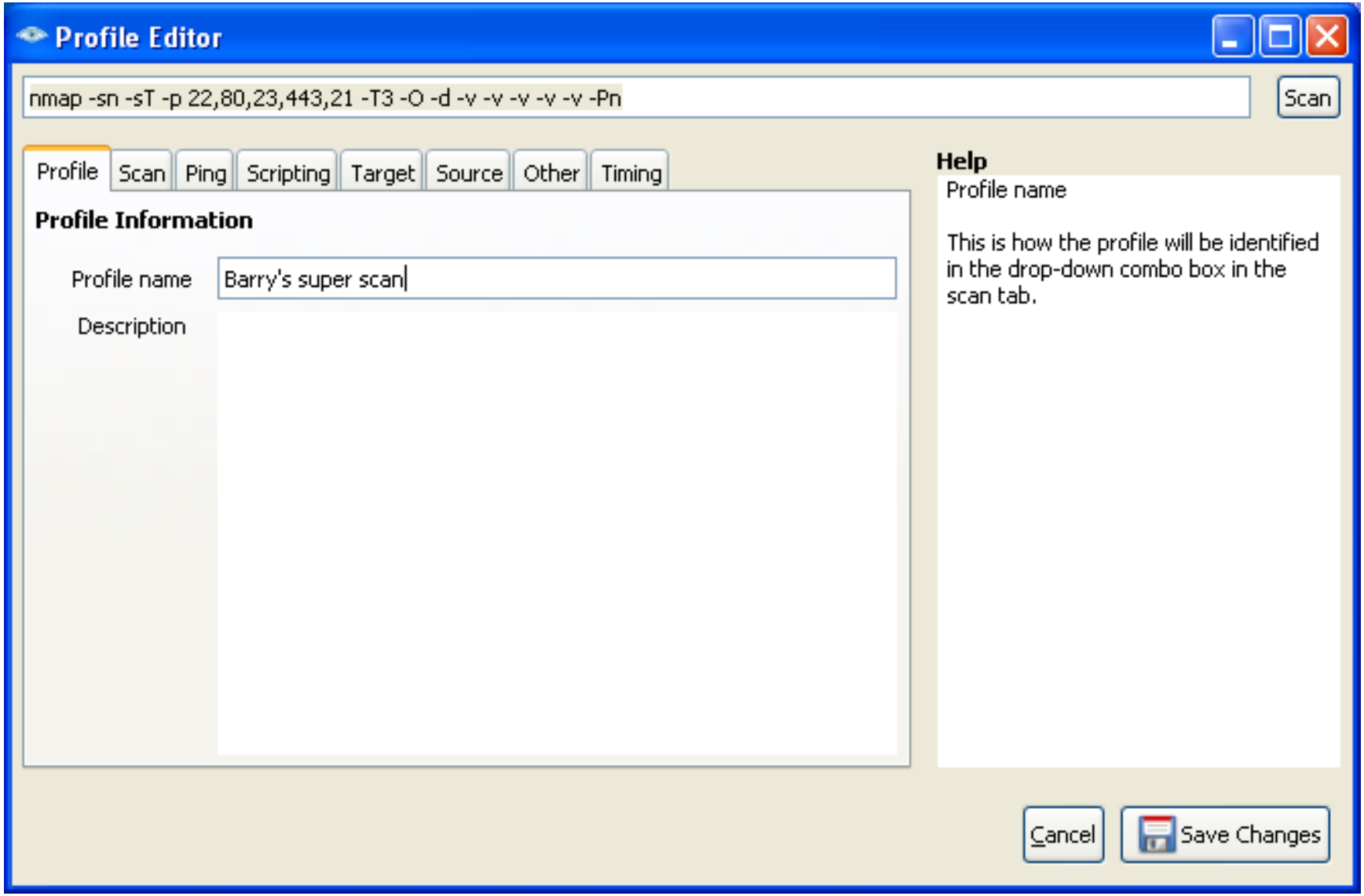
Nmap GUI (aka Zenmap)

Built into Kali or install in Windows (nmap.org/download.html)



nmap [Scan Type ...] [Options] {target specification }

Nmap GUI (aka Zenmap)



Nmap - Scan Types

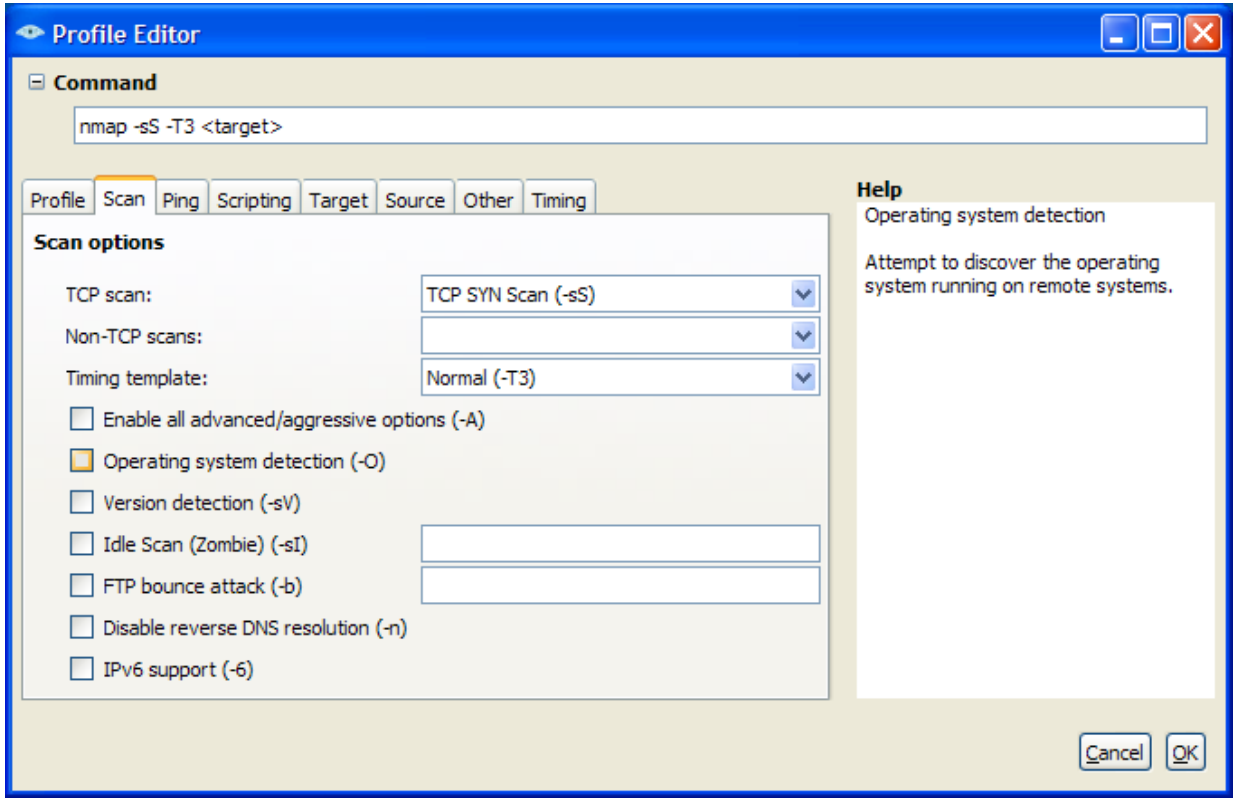
- TCP Connect scan
  - Completes three-way handshake
  - Not stealthy
- TCP SYN scan ("half-open" scans)
  - Only send initial SYN
  - Receive SYN-ACK → Port is open
  - Stealthier than connect scan
    - Still can ID the attacker using IP addr of SYN pkt
  - Faster than connect scan
- TCP FIN scan
  - Send FIN to ports
  - Receive RESET → closed
  - Receive nothing → probably open
  - Stealthier than connect scan

www.counterhack.net

Nmap - Scan Types

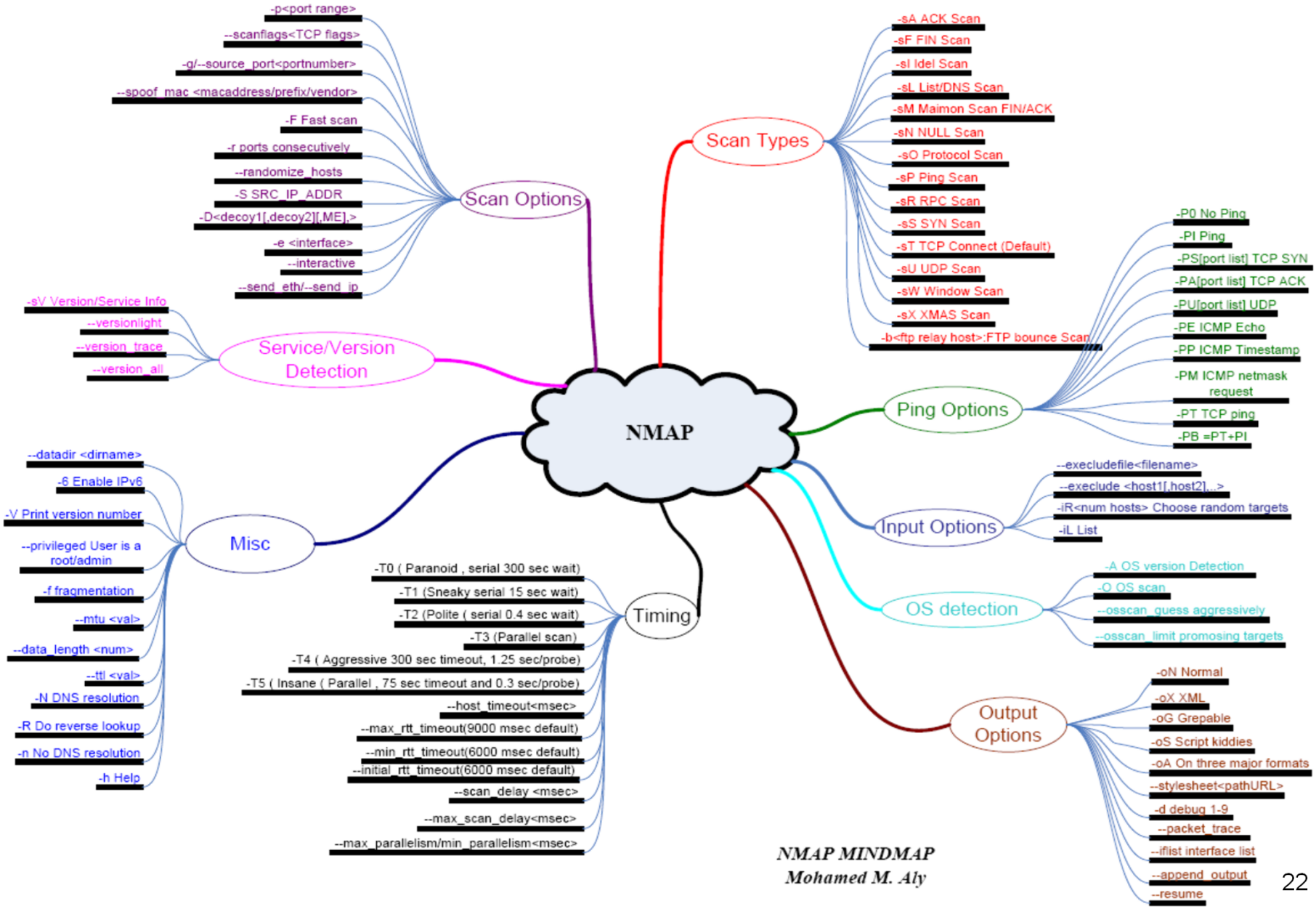
- TCP Xmas tree scan → Send a packet with all control bits set
- TCP null scan → Send a packet with no control bits set
  - Receive RESET → closed
  - Receive nothing → probably open

- Discussed later
  - "Idle" Scanning
  - Version Scanning



nmap [Scan Type ...] [Options] {target specification }

Nmap – Options Galore



Nmap Command Line Examples
nmap [Scan Type ...] [Options] {target specification }

```
root@kali:~/Desktop# nmap fs-cdn-01
Starting Nmap 7.70 ( https://nmap.org ) at 2019-01-07 14:41 EST
Nmap scan report for fs-cdn-01 (10.1.2.7)
Host is up (0.015s latency).
Not shown: 990 closed ports
PORT     STATE SERVICE
80/tcp   open  http
111/tcp  open  rpcbind
139/tcp  open  netbios-ssn
443/tcp  open  https
445/tcp  open  microsoft-ds
548/tcp  open  afp
2049/tcp open  nfs
3261/tcp open  winshadow
5000/tcp open  upnp
5001/tcp open  commplex-link
MAC Address: 00:11:32:32:6F:61 (Synology Incorporated)

Nmap done: 1 IP address (1 host up) scanned in 5.51 seconds
root@kali:~/Desktop#
```

Run a default TCP connect scan against target

Any host running logging software will easily detect this type of scan

Nmap Command Line Examples

OS fingerprinting

nmap [Scan Type ...] [Options] {target specification }

nmap -A -Pn -p 1-65535 -oN <filename> <ip address>

- Use TCP connect scan (default)
- -A → Performs OS fingerprinting, version scan, script scan, and traceroute
- -Pn → nmap will not ping the machine before scanning it
  - Useful if target blocks ICMP pings. Without this option, if the remote machine does not respond to pings, nmap will report that the machine is down and not scan.
- -p 1-65535 → ports to scan -p- → Shorthand for scan all ports
  - If time permits, scan all 65,535 ports (1-65535)
  - Single port: 80 (nmap -A -p 80)
  - List of ports: 135,137-139,445 (nmap -A -p 135,137-139,445)
- -oN <filename> → Sends scan output to a file. Depending on number of machines, sending scan output to a text file is recommended.
- <ip address> → Scan single IP address or range of IP addresses
  - Single: nmap -A -p 1-65535 10.1.1.1
  - Range: nmap -A -p 1-65535 10.1.1.1-254
  - Range: nmap -A -p 1-65535 fs-cdn-01/24
  - List: nmap -A -p 1-65535 10.1.1.2,4,8,16,32,64,128

Nmap Command Line Examples

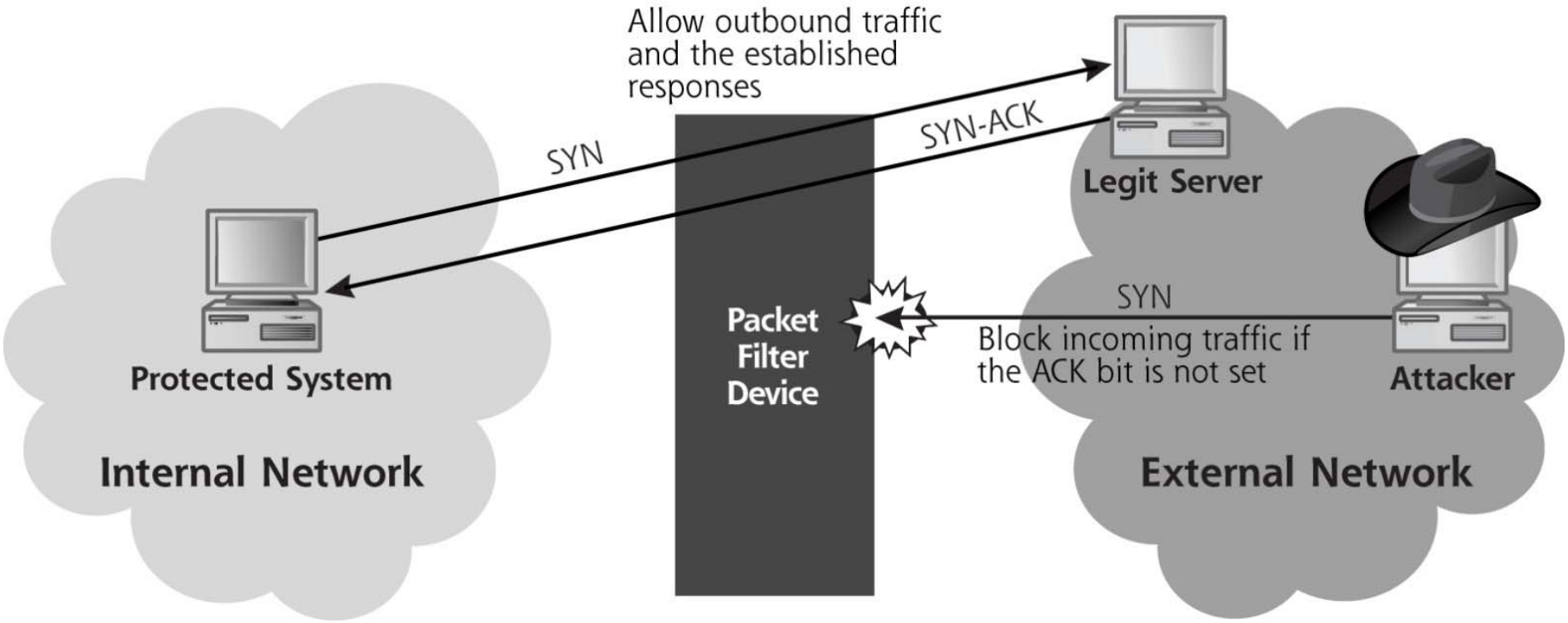
- **`nmap -sV -p- 198.116.0-255.1-127`**
  - -sV → version / service information
    - If any port is found open, version detection is used to determine what application is running
  - -p- → Scan all ports
  - Target IPs → first half of each of the 255 possible subnets in the 198.116. address space
- **`nmap -v -iR 100000 -Pn -p 80`**
  - -v → enables verbose mode
  - -iR 100000 → Asks nmap to choose 100,000 IPs at random
  - -p 80 → scan hosts for web servers (port 80)
  - -Pn → no ping
- **`nmap -p 80 --open 192.168.1.0/24`**
  - --open → only display IPs with port 80 open

Firewalls – Review

- Packet Filtering
  - Inspects each packet individually
  - Packets allowed through based on this single packet
- Stateful packet filtering
  - Remembers previous packets and tries to correlate new packets with previous traffic in order to make filtering decision
    - ACK packet will be allowed only if destined for an IP/port number used by an earlier SYN sent out of the network
- Proxy firewalls (application layer)
  - First, sender makes a connection to the proxy
  - Then, proxy makes a separate connection to destination
  - Packet header information is modified

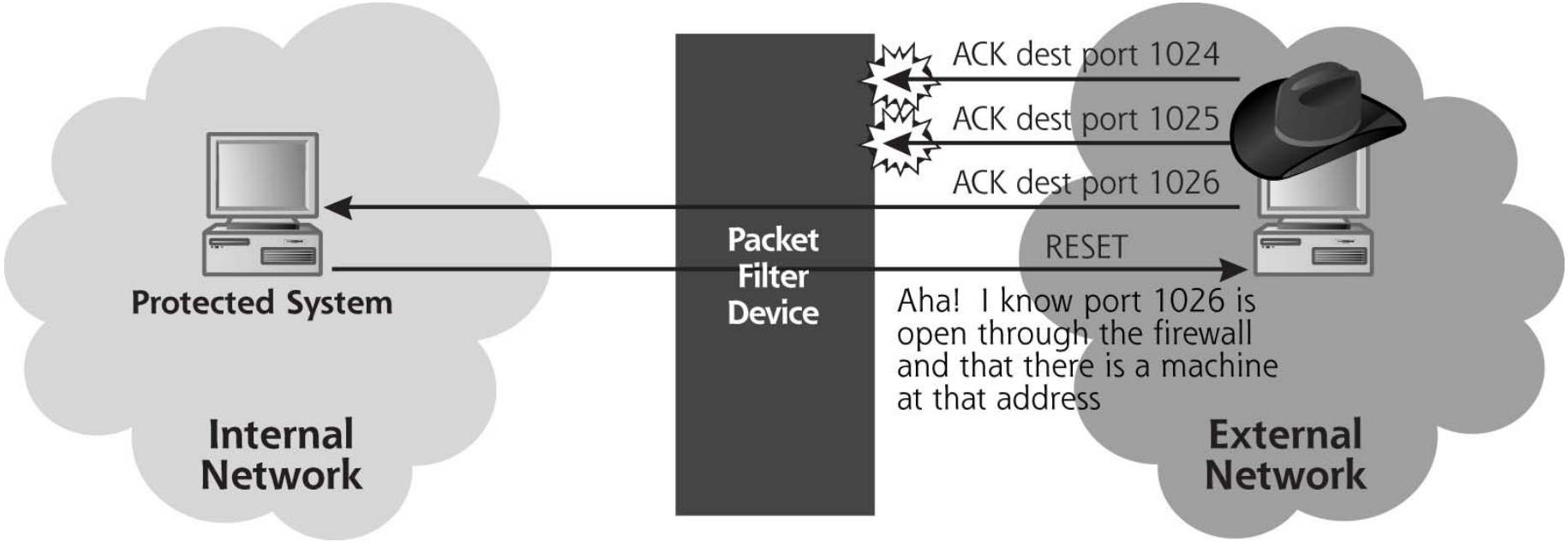
Firewalls – Review

- Suppose firewall allows outgoing connections, but blocks incoming
  - Allow outgoing SYNs
  - Allow incoming connections (packets) only if ACK bit is set
  - Blocks connection attempts from the outside



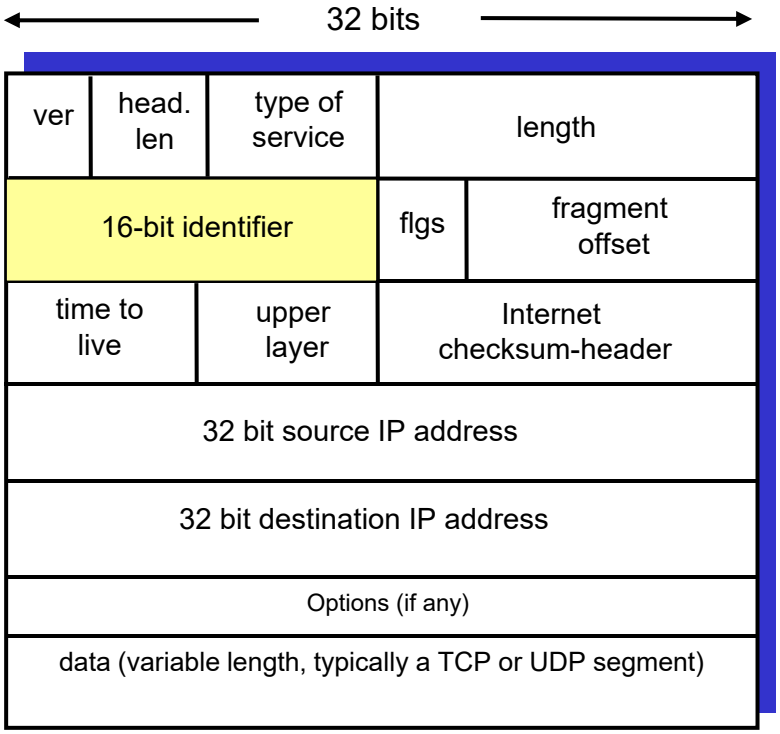
Nmap - ACK Scanning

- ACK Scan → used to map out firewall rule sets
  - Will firewall allow outbound connections on port 1026?

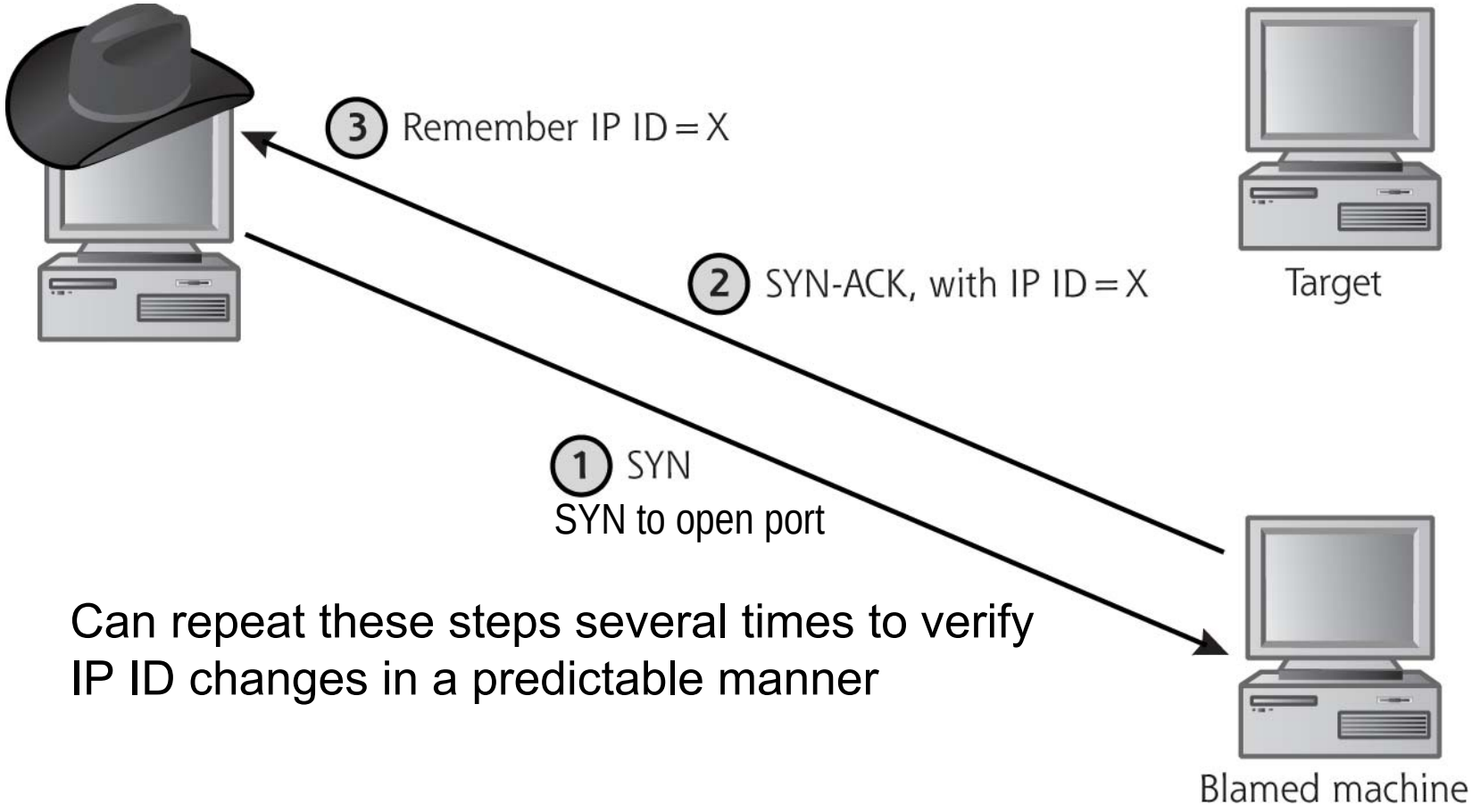


Idle Scans in Nmap – First Step: Pick a "Blamed Machine"

- Find a machine that is relatively idle
  - Machine that generates very few packets
- Could be any system that attacker can send packets to and receive packets from
  - Web server
  - Client connected to cable modem
- Must have a predictable IP ID field
  - IP ID used to group all fragments together for packet reassembly
  - Each packet assigned an IP ID value incremented by one



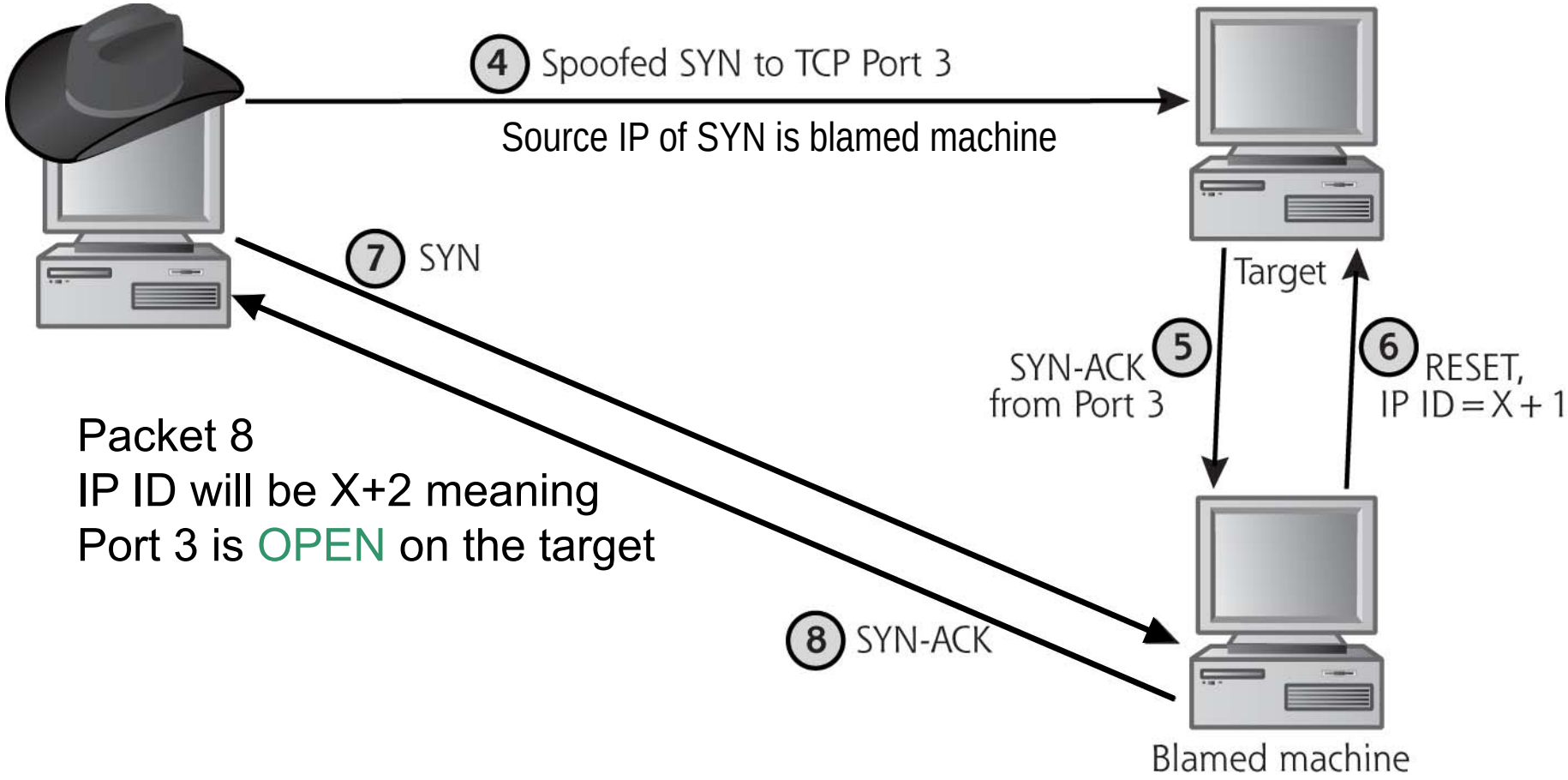
Idle Scans in Nmap – Prep For Attack



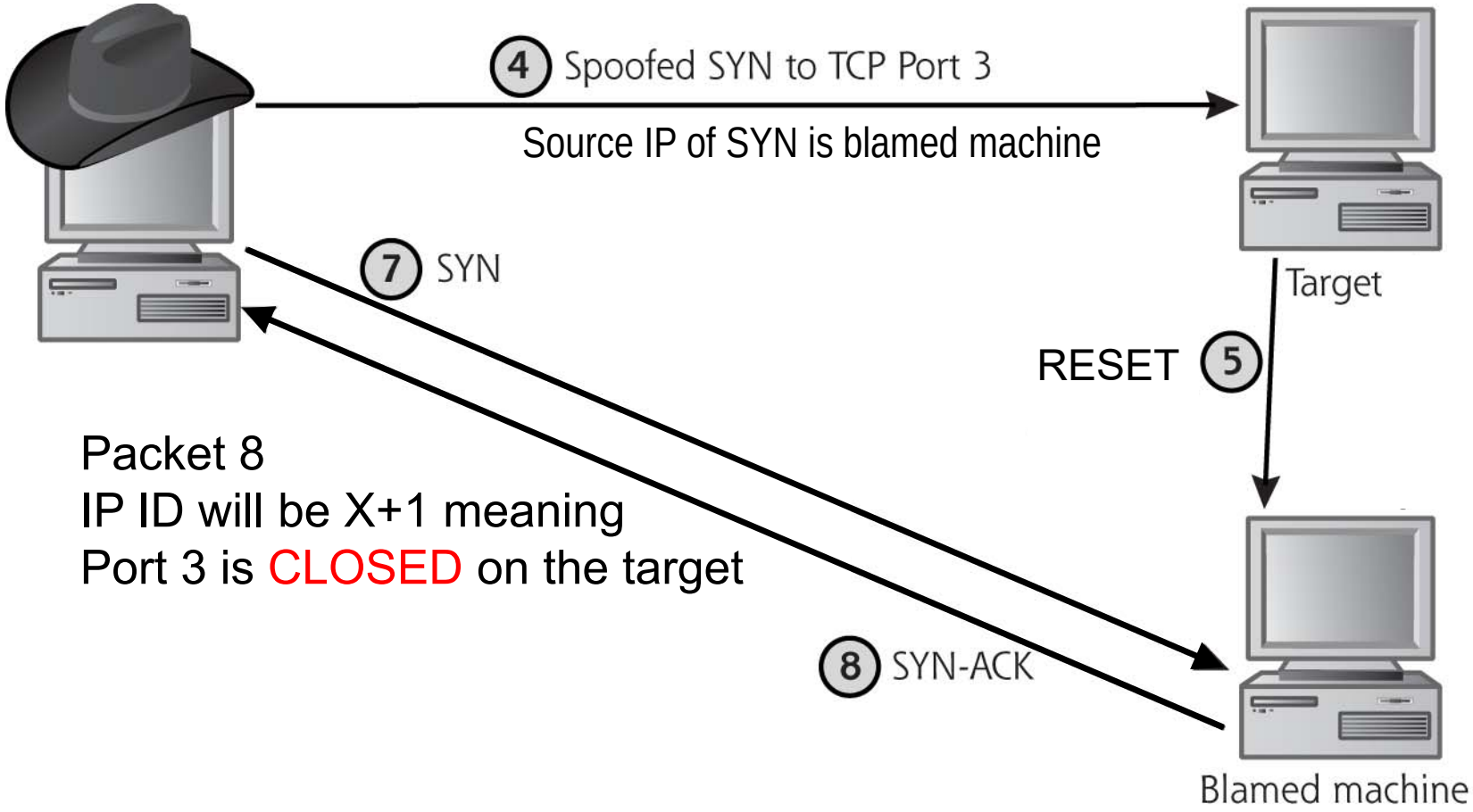
Can repeat these steps several times to verify IP ID changes in a predictable manner

IP ID Scanning (aka Idle Scan)

Open Port

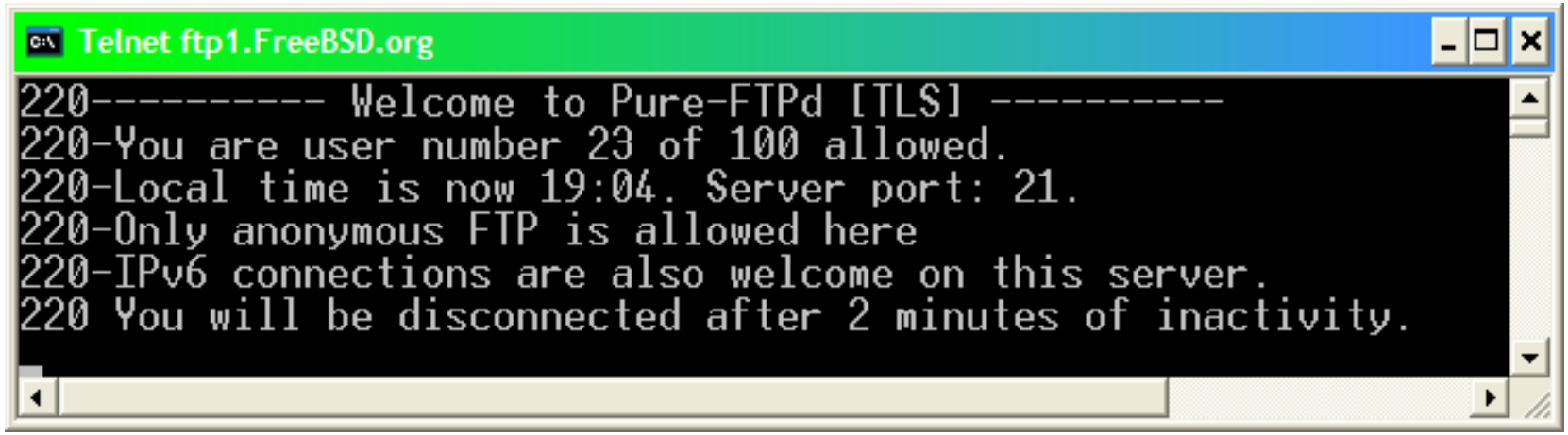


IP ID Scanning (aka Idle Scan)
Closed Port



Version Scanning

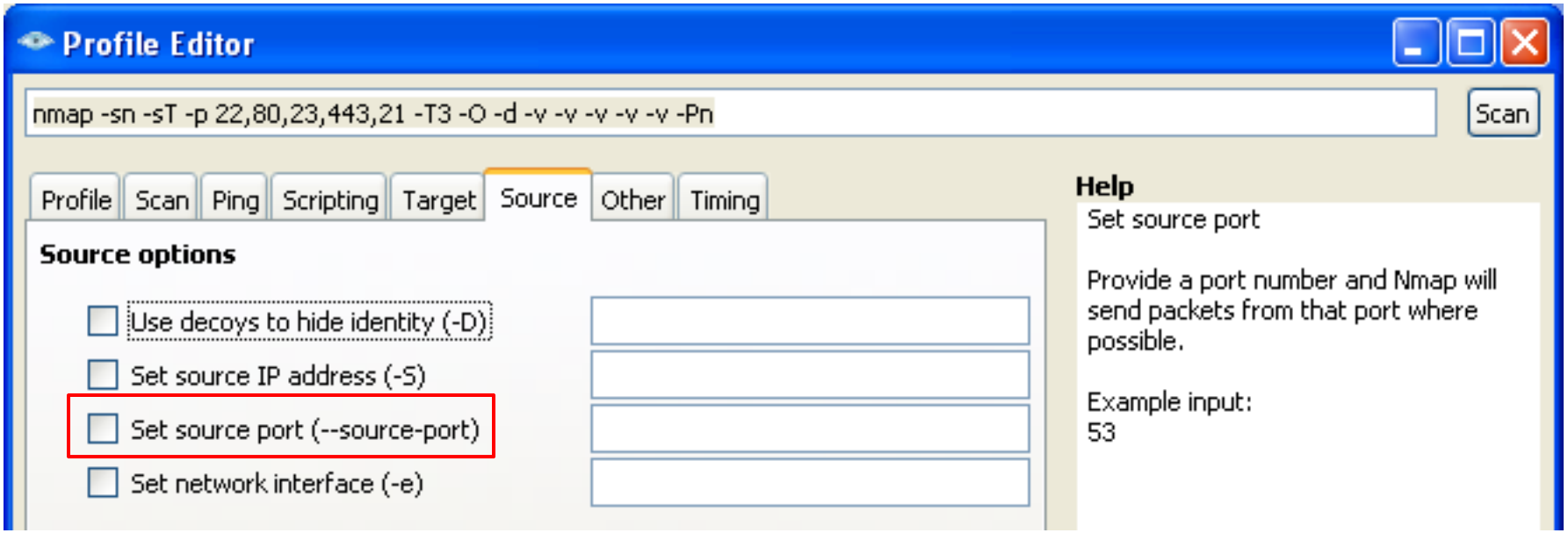
- Detects what service and software version is running on a port
  - Will find all services even if the service is listening on an unconventional port
    - I can place a web server on port 12345
- Nmap compares banner information presented after a three-way handshake to its internal database



- If no banner returned, nmap probes more to elicit some response

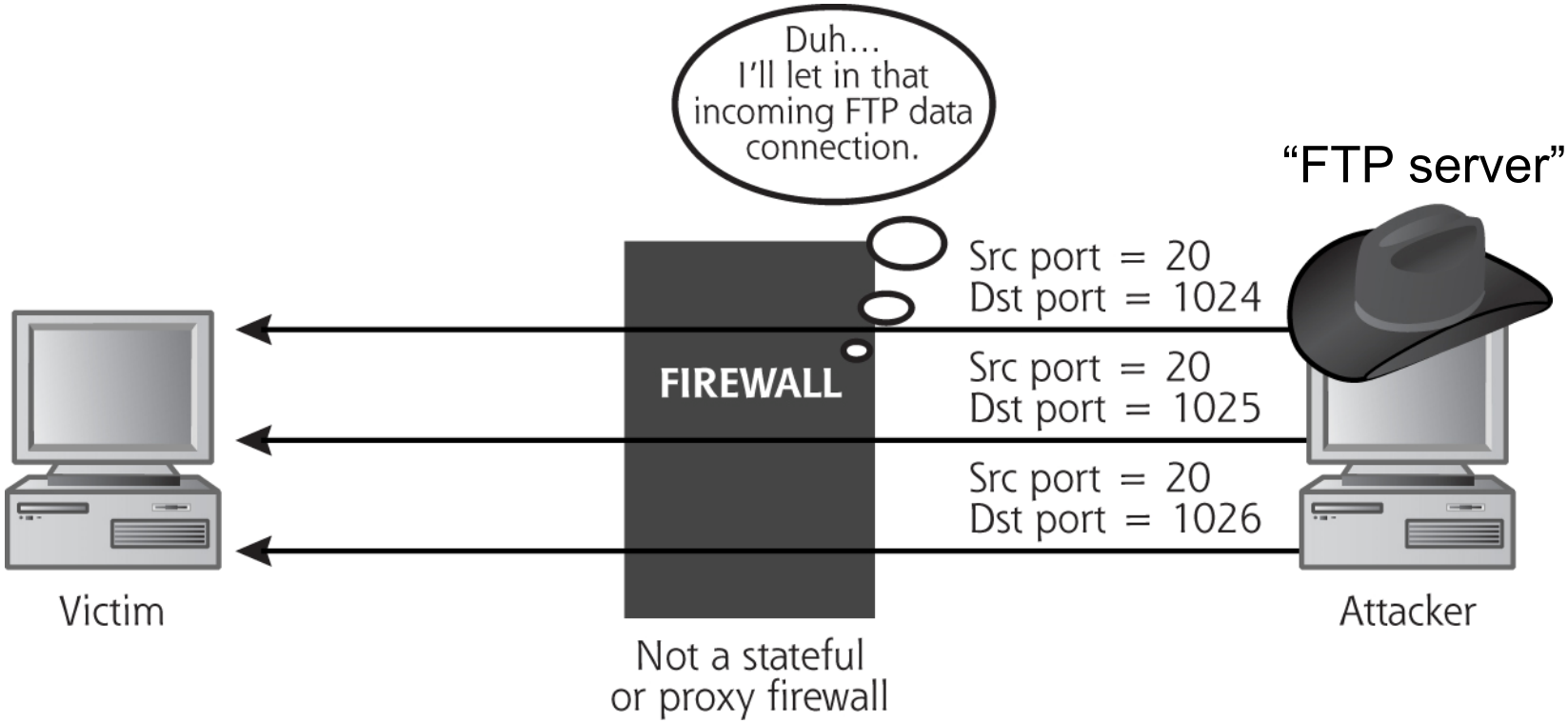
Setting Source Ports

- You want your scanning traffic to blend in with other network traffic
- Use common port numbers as the source
  - TCP port 25 – appears to be SMTP email traffic
  - UDP port 53 – appears to be a DNS response
  - TCP port 80 - appears to be a web server response



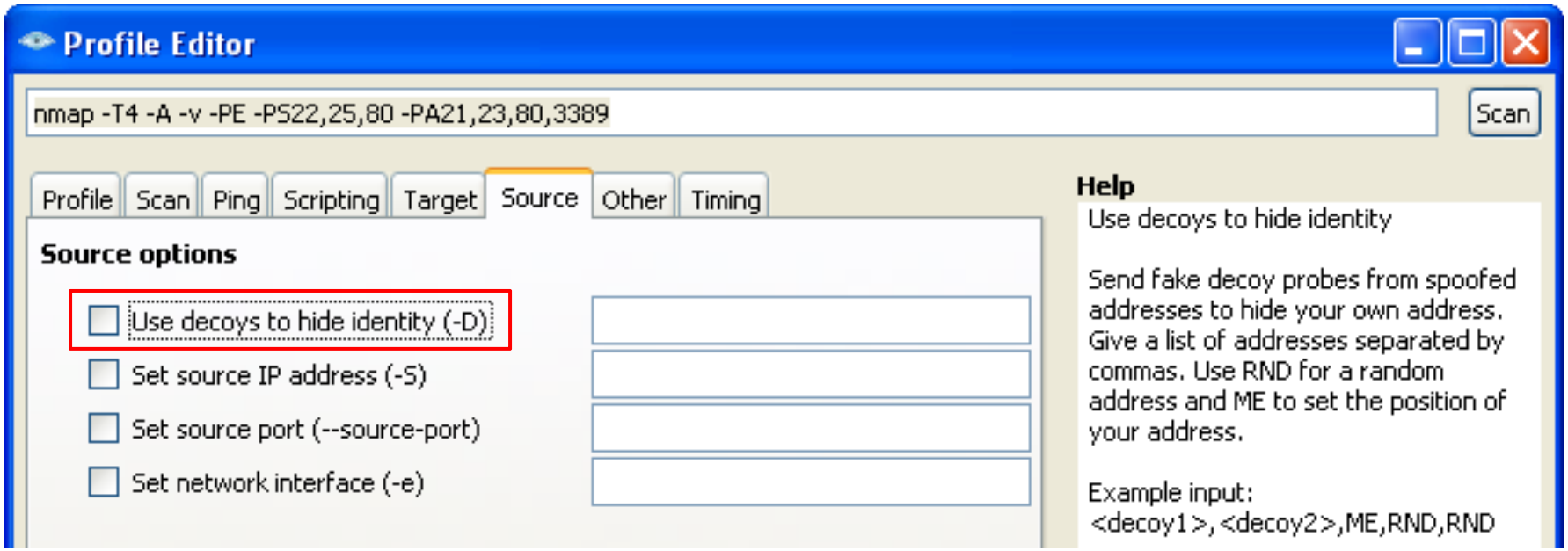
Use FTP as a Source Port

- Remember FTP uses two connections
  - FTP control connection - TCP port 21
  - FTP data connection - TCP port 20 (on FTP server - Active)
  - Port 20 very useful as source port
- Stateful packet filter or proxy firewall will catch this



Nmap Decoys (-D option)

- Nmap can send multiple copies of its scans using spoofed (decoy) IP addresses
- Target must sift through bogus IPs
- <decoy1>,<decoy2>,ME,RND,RND
- RND = random address and ME=attacker



Timing Options (-T)

- Paranoid (-T0) → serial; 300 sec between probes
- Sneaky (-T1) → serial; 15 sec between probes
- Polite (-T2) → serial; 0.4 sec between probes

Stealthy. Less likely to be noticed

- Normal (-T3) (Default)
  - parallel
  - send as quickly as possible
- Aggressive (-T4)
  - parallel
  - send as quickly as possible
  - only spend 300 sec on one host then move to next
  - wait no more than 1.25 sec for response
- Insane (-T5)
  - parallel
  - send as quickly as possible
  - only spend 75 sec on one host then move to next
  - wait no more than 0.3 sec for response

Likely to miss traffic

Nmap Active OS Fingerprinting

- Attempts to identify target OS by sending various packet types and monitoring the response
- Each OS responds to "non-standard" inputs in different ways
  - RFCs don't describe how to handle every packet permutation
- Nmap uses these tests to determine the platform:
  - SYN packet to open port
  - ACK packet to open port
  - NULL packet to open port
  - SYN | FIN | URG | PSH packet to open port
  - SYN packet to closed port
  - ACK packet to closed port
  - FIN | PSH | URG packet to closed port
  - UDP packet to closed port
  - TCP initial sequence number prediction

OS fingerprinting

Scanning More Than Once

- You may have to run nmap more than once with different settings to achieve your goal

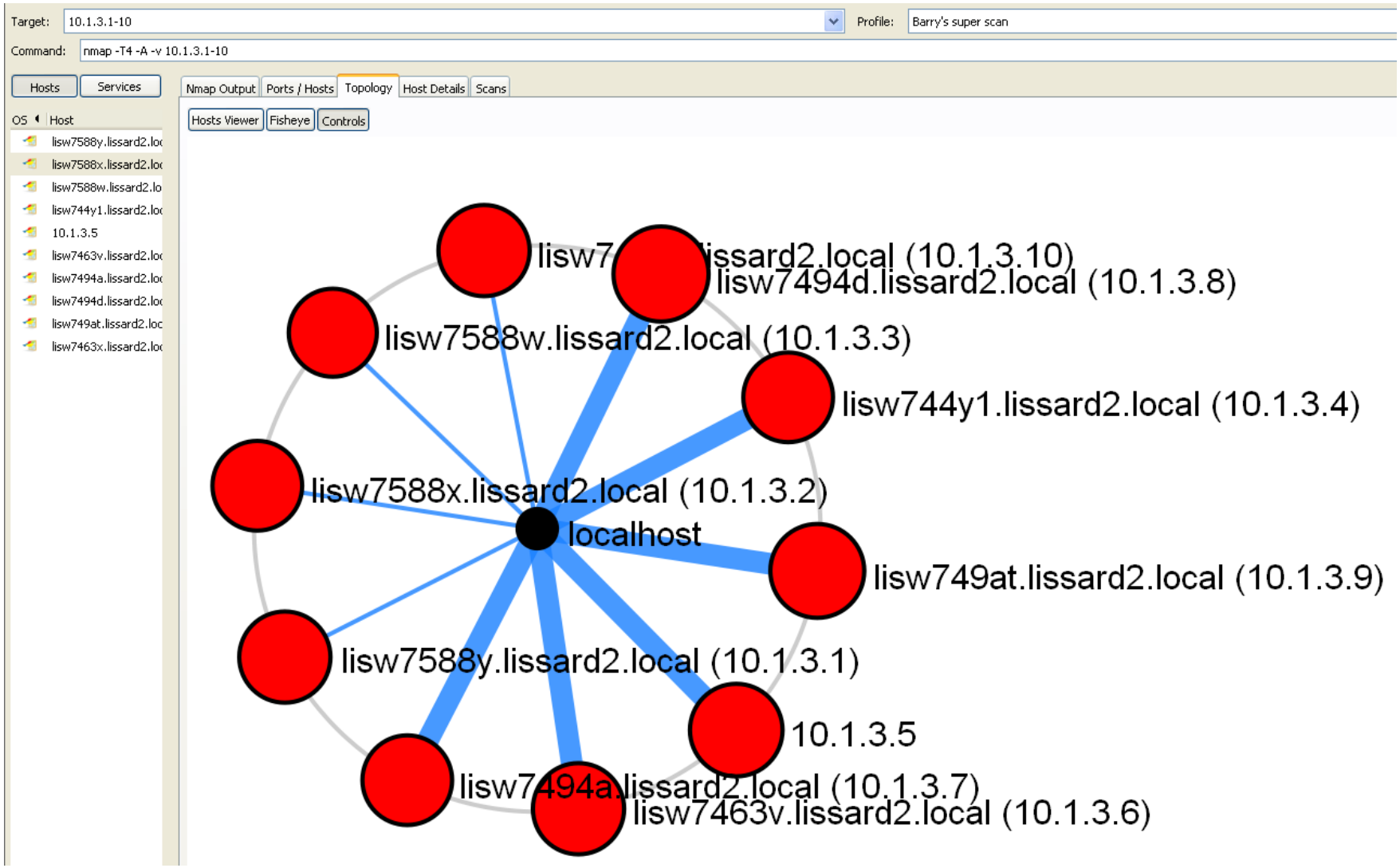
Scenario: What is the host name of a machine listening on port 8888

- First find the IP address
  - **`nmap –p 8888 --open 10.1.1.0/24`**
    - Assume there was a hit on 10.1.1.88
- Now find the host name
  - **`nmap –-script nbstat 10.1.1.88`**
  - **`nmap –A 10.1.1.88`**

- If you try to scan and fingerprint using one nmap command, it will likely not give you the host name since it is only scanning port 8888

Nmap GUI - Topology Tab

Announced at DEFCON 2008



Some ports are filtered

Passive OS Fingerprinting

- Covered on pages 446-448, but I discuss it here
- How do operating systems populate various fields?
  - Initial sequence number
  - Initial TTL
  - IP ID
- Technique can identify the operating system on machines whose communications you can observe
  - machines that connect to your box (SYN mode)
  - machines you connect to (SYN+ACK mode)
  - machines you **cannot** connect to (RST mode)

POF3 – Totally Passive!

- Passive sniffer and database for determining system type
  - Does not generate traffic
- Determines the type of system that generated the packet based solely on sniffed packets
- Can also detect or measure
  - firewall presence
  - NAT use
  - the distance to the remote system and its uptime
  - target's network hookup (DSL, OC3, avian carriers) and ISP
- lcamtuf.coredump.cx/p0f3/

Determining Firewall Filter Rules - Firewalking

- Allows an attacker to determine which packets are allowed through a packet filtering device

- Firewalk is based on ideas originally used in traceroute
  - Works with both TCP or UDP since TTL is in the IP header
  - Works with firewalls or routers
  - Does not work with proxies since the TTL is reset by proxy

Determining Firewall Filter Rules - Firewalking

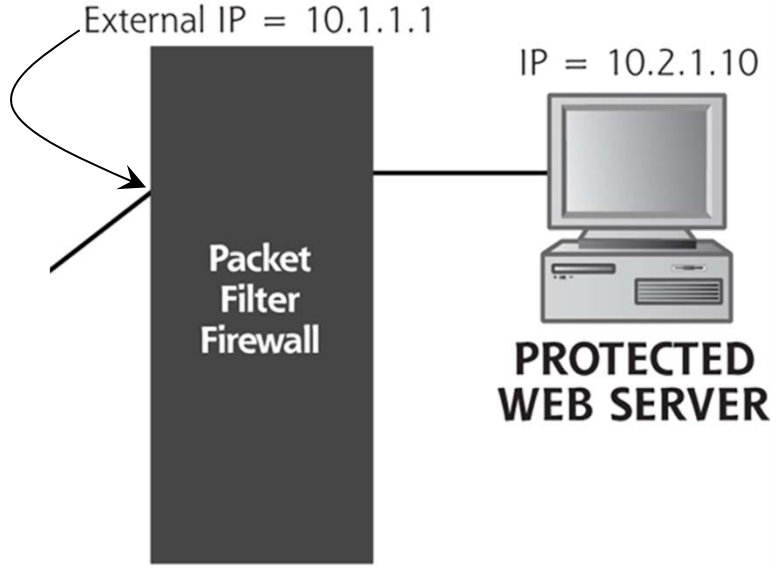
- Different than nmap ACK scan
  - Firewalking tells us that the firewall allows new connections from outside to inside (SYN bit set)
  - Nmap ACK scan tells us which ports allow established connections from inside to outside (ACK bit set)

- Nmap has a firewalking script → --script=firewalk
- packetfactory.openwall.net/projects/firewalk/
  - Kali: **`apt-get install firewalk`**
- Tutorial → https://www.hackingloops.com/firewalk/

Firewalk Operation

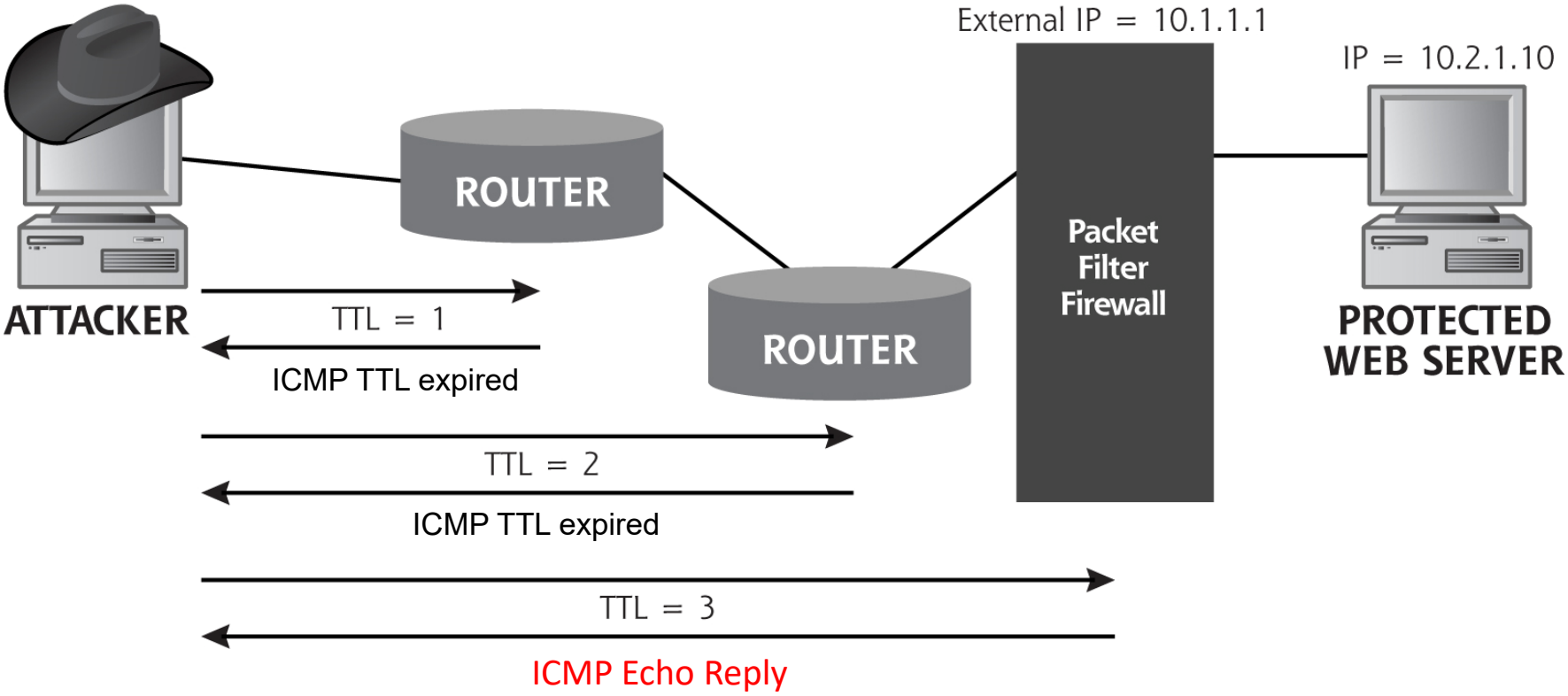
- Requires 2 IP addresses:
  - Network hop just before filtering takes place
    - Typically external address of packet-filtering device (e.g., 10.1.1.1)
  - Destination machine on the other side of packet-filtering device (e.g., 10.2.1.10)

- Operates in two phases:
  - Network Discovery
  - Scanning



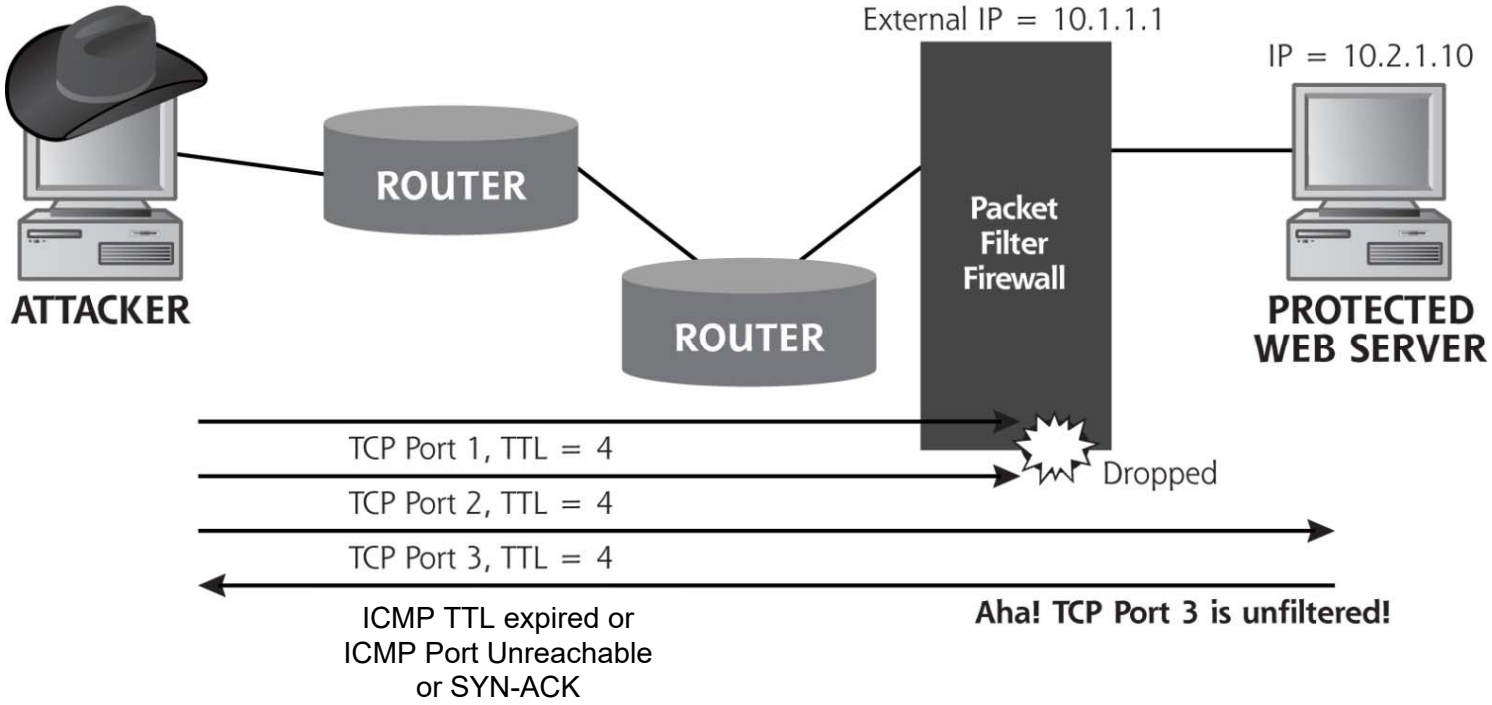
Firewalk Network Discovery Phase

- Essentially does a traceroute to determine how many network hops (e.g., 3 hops) are between tool and firewall



Firewalk Scanning Phase

- Send packet with TTL = hop_count + 1 (e.g., 4) and start timer
- If filter allows traffic, it forwards packet to next hop where it could generate an ICMP TTL Expired message, an ICMP Port Unreachable message, or SYN-ACK
  - In all cases we know the port is not filtered
- If timer expires and no response means the port is filtered



Let's Step Back For A Moment… What Do We Know So Far?

What the attacker knows	Tools used to get the information
List of addresses of live hosts on the network	Arp-scan, Ping, Scapy
General network topology	Traceroute, Nmap
List of open ports on live hosts	Nmap port scan
List of services and versions running on the target ports	Nmap version scan
Operating systems on live hosts	Nmap (active) and P0f3 (passive) operating system fingerprinting
List of ports open through packet filters on target network	Firewalk

Computer and Network Hacker Exploits

- Step 1: Reconnaissance
- **Step 2: Scanning**
  - Network Mapping
  - Determining Open Ports Using Port Scanners
  - Vulnerability-Scanning Tools
  - Intrusion Detection System and Intrusion Prevention System Evasion
  - Shares
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

Vulnerability scan

Vulnerability Scanning Tools

- Automated tool to find target vulnerabilities
  - We exploit these vulnerabilities to gain access
- Tool maintains list of known vulnerabilities
- Common vulnerabilities include
  - Configuration / Implementation errors
  - Default configurations
    - Default accounts and passwords
  - Well-known security vulnerabilities
    - List grows longer each day
- Tool connects to target and sees if vulnerability is present
  - Checking for less secure, version of software (e.g., SSH server)

Vulnerability Disclosures

- Bugtraq (www.securityfocus.com)
  - Discussions about vulnerabilities, vendor security-related announcements, methods of exploitation, and how to fix them

BugTraq

Back to list | Post reply

SQL Injection in LightNEasy Dec 30 2010 09:47AM
advisory htbridge ch

Vulnerability ID: HTB22750
Reference: http://www.htbridge.ch/advisory/sql_injection_in_lightneasy.html
Product: LightNEasy
Vendor: Fernando Baptista (http://www.lightneasy.org/)
Vulnerable Version: 3.2.2
Vendor Notification: 15 December 2010
Vulnerability Type: SQL Injection
Status: Not Fixed, Vendor Alerted, Awaiting Vendor Response
Risk level: High
Credit: High-Tech Bridge SA - Ethical Hacking & Penetration Testing (http://www.htbridge.ch/)

Vulnerability Details:
The vulnerability exists due to failure in the "/LightNEasy.php" script to properly sanitize user-supplied input in "handle" variable.
Attacker can alter queries to the application SQL database, execute arbitrary queries to the database, compromise the application, access or modify sensitive data, or exploit various vulnerabilities in the underlying SQL database.

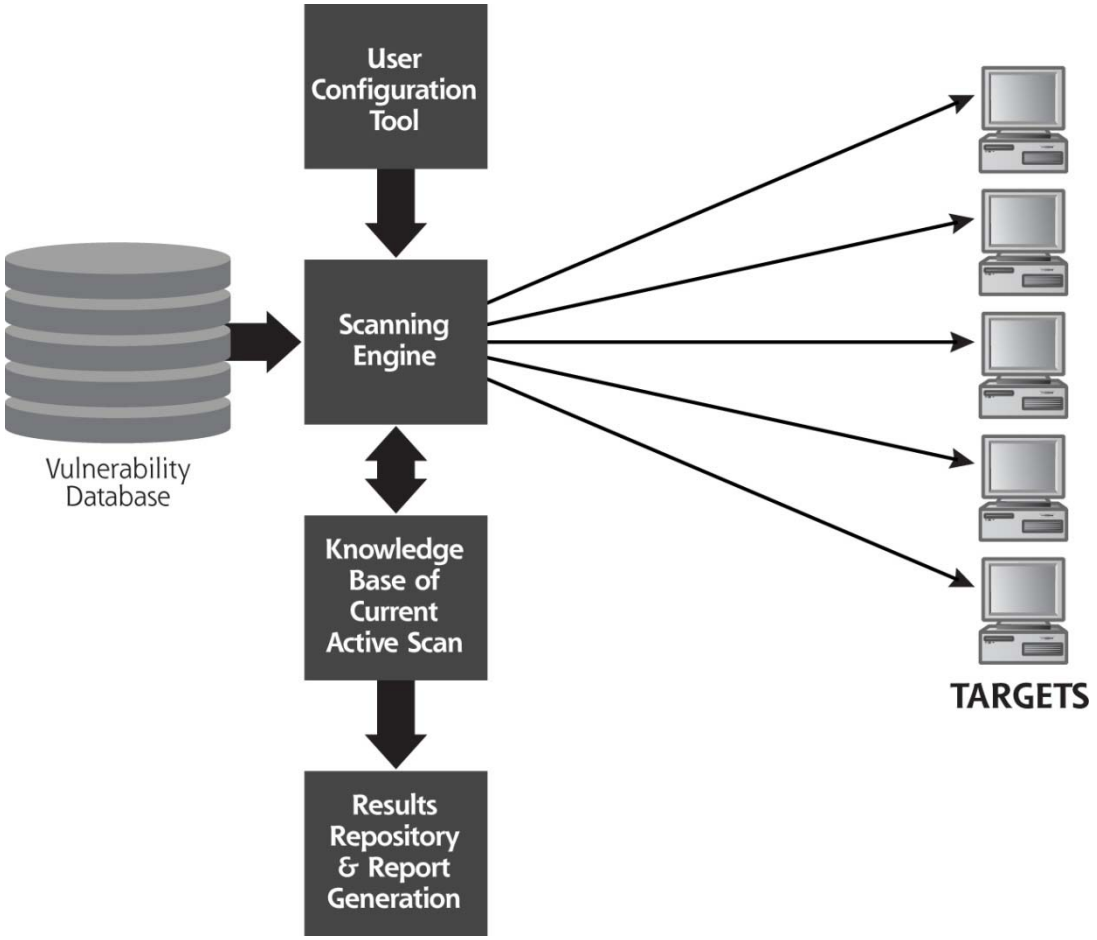
The following PoC is available:

```
<form action="http://[host]/LightNEasy.php?do=login" method="post" name="main" >
<input type="hidden" name="handle" value='123"SQL_CODE_HERE'/>
<input type="hidden" name="password" value="1"/>
<input type="hidden" name="do" value="login"/>
<input type="submit" value="submit" name="submit" />
</form>
```

[reply]

A Generic Vulnerability Scanner

- User config tool
  - Select targets and which vulns to check
- Vulnerability database
  - List of vulns and how to check for them
- Scanning engine
  - Creates and sends packets to targets
- Knowledge base of current active scan
  - Short term memory
- Results repository & report generation
  - Lists vulns on targets and recommends COA



Vulnerability Scanning Tools

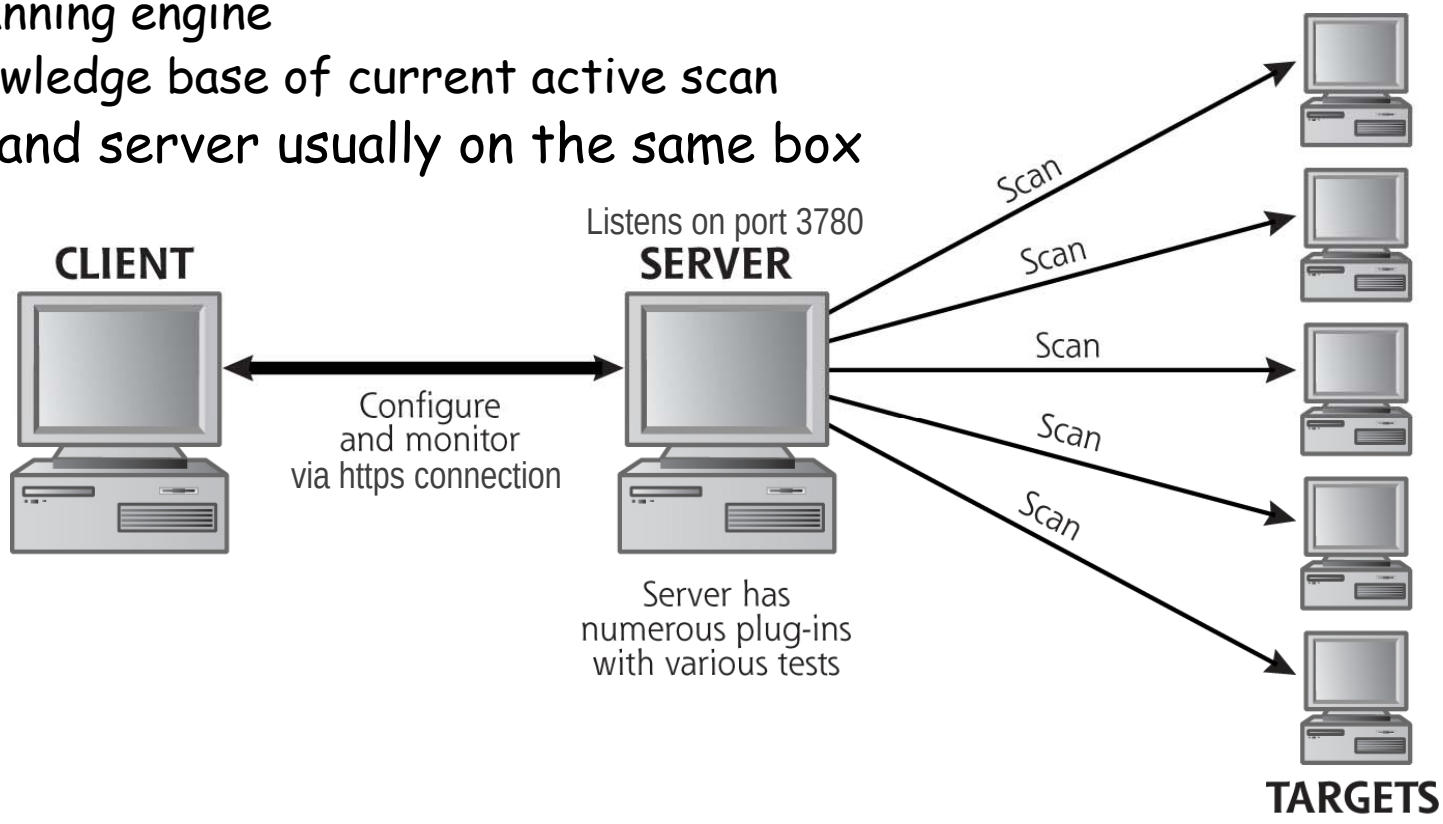
- Nexpose – "Free"
  - https://www.rapid7.com/products/nexpose/

- Nessus – "Free"
  - www.tenable.com/products/nessus

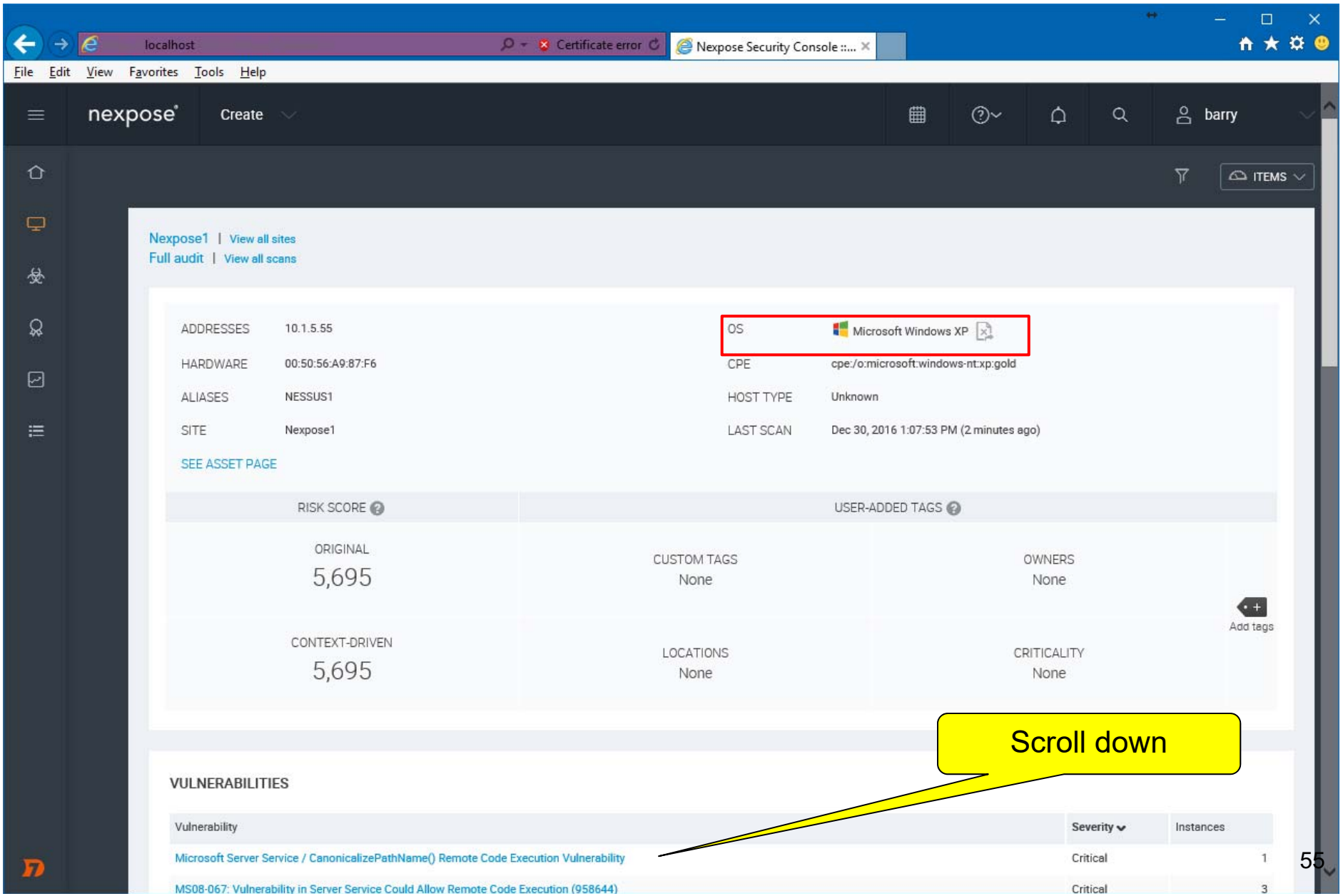
- Numerous commercial scanners available
- Many commercial services offer subscription-based services

Nexpose Architecture

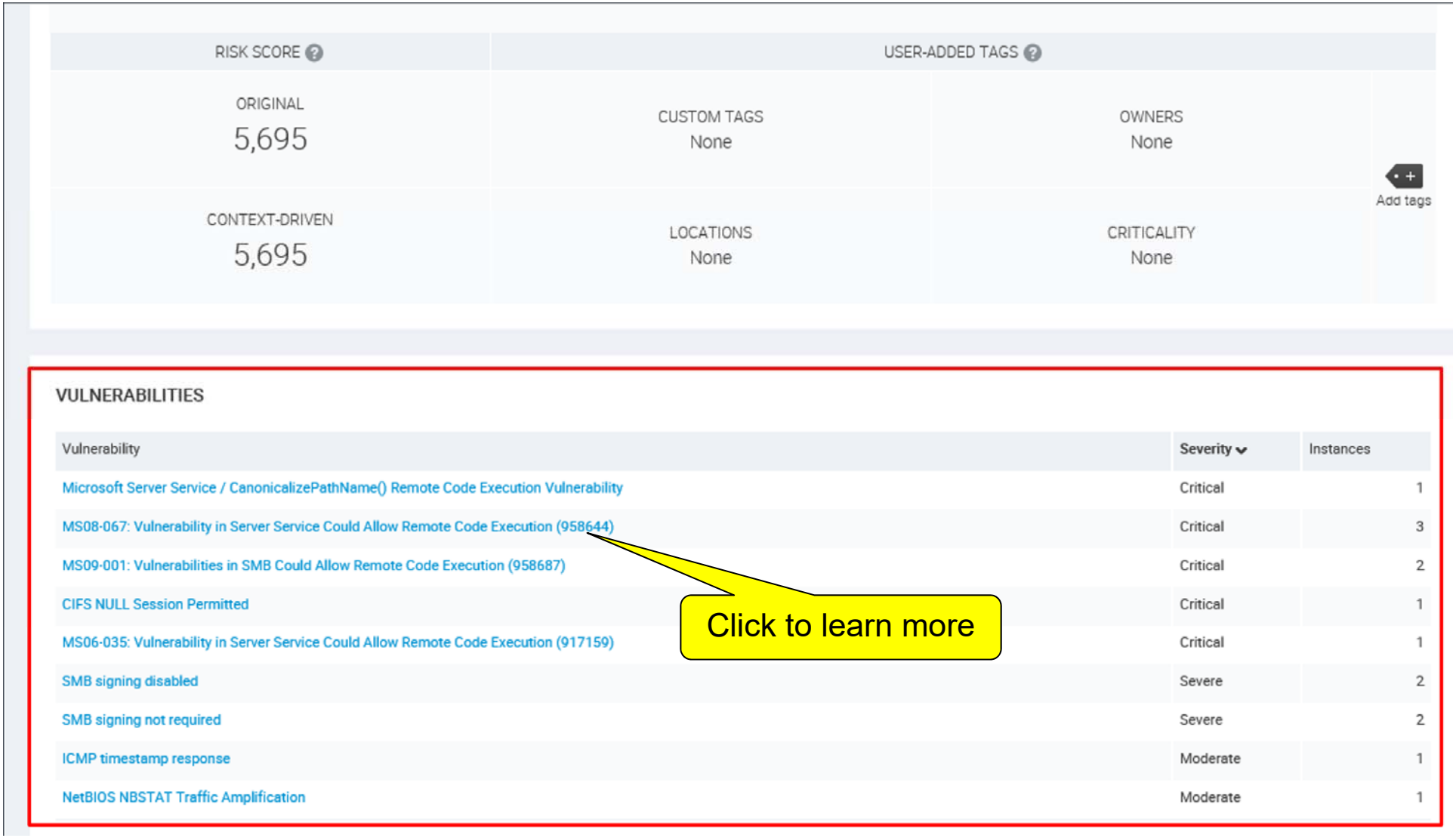
- Client
  - User configuration tool
  - Results repository & report generation
- Server
  - Vulnerability database
  - Scanning engine
  - Knowledge base of current active scan
- Client and server usually on the same box



NexposeTarget Results



Vulnerabilities



Vulnerability Information

VULNERABILITY INFORMATION

OVERVIEW

Title	Severity	Vulnerability ID	CVSS	Published	Modified
MS08-067: Vulnerability in Server Service Could Allow Remote Code Execution (958644)	Critical (10)	windows-hotfix-ms08-067	10 (AV:N/AC:L/Au:N/C:C/I:C/A:C)	Oct 23, 2008	Feb 13, 2015

DESCRIPTION

This security update resolves a privately reported vulnerability in the Server service. The vulnerability could allow remote code execution if an affected system received a specially crafted RPC request. On Microsoft Windows 2000, Windows XP, and Windows Server 2003 systems, an attacker could exploit this vulnerability without authentication to run arbitrary code. It is possible that this vulnerability could be used in the crafting of a wormable exploit. Firewall best practices and standard default firewall configurations can help protect network resources from attacks that originate outside the enterprise perimeter.

Computer and Network Hacker Exploits

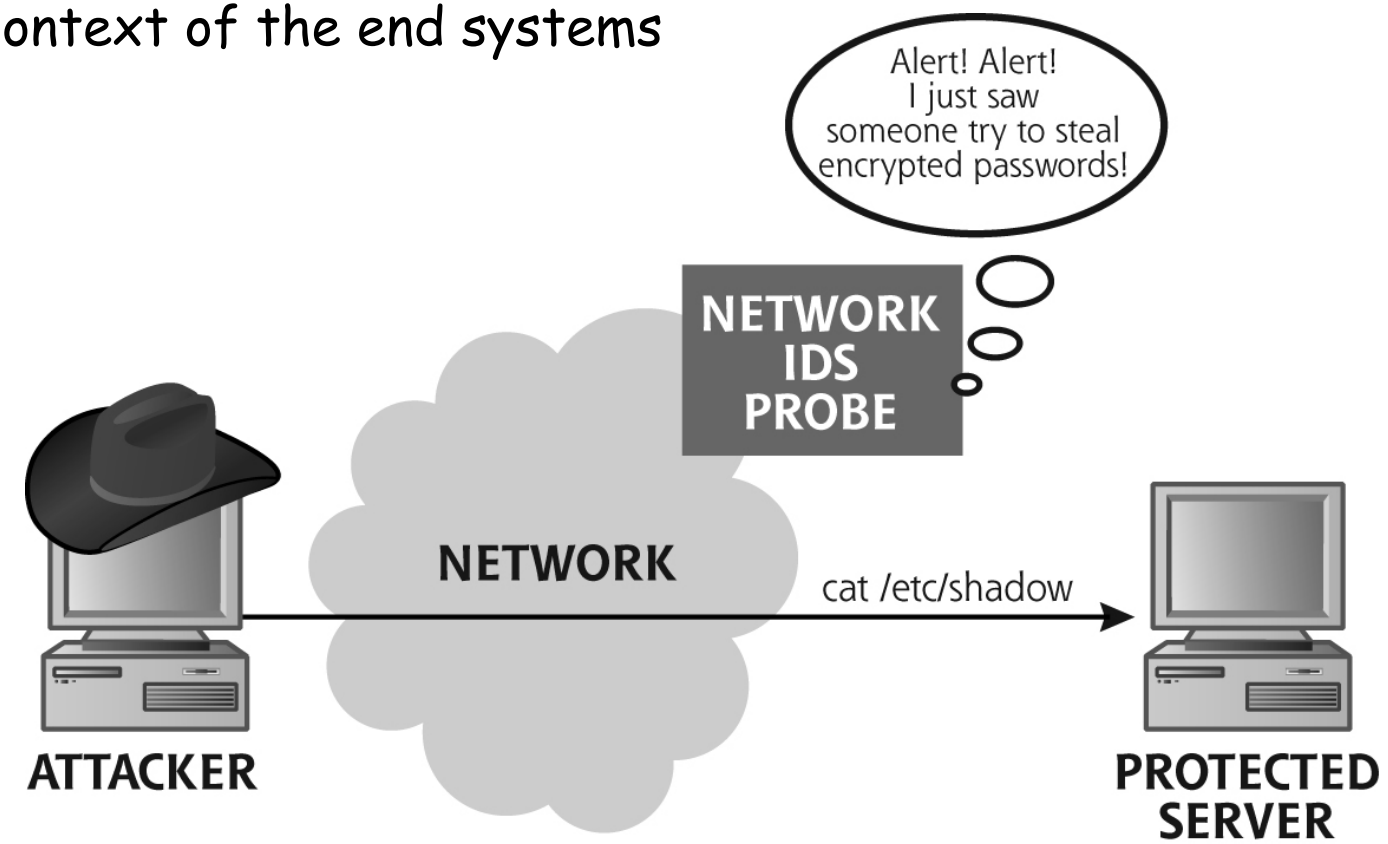
- Step 1: Reconnaissance
- **Step 2: Scanning**
  - Network Mapping
  - Determining Open Ports Using Port Scanners
  - Vulnerability-Scanning Tools
  - Intrusion Detection System and Intrusion Prevention System Evasion
  - Shares
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

IDS and IPS Evasion

- Intrusion Detection System / Intrusion Prevention System
  - Attempt to thwart attacks by matching packet and traffic signatures against traffic it sees
  - Must sort through a mountain of traffic to fingerprint attack
- Scanning tools generate a tremendous amount of packets
  - A diligent sysadmin may notice
  - IDS / IPS will most likely raise an alert
- Your mission, if you choose to accept it, is to evade IDS and IPS

How Does Signature Matching Work?

- Monitor traffic looking for specific sequences of bytes
  - Alert raised if it sees "**`cat /etc/shadow`**" in traffic
- How can the attacker slip things past a network IDS?
  - Exploit the fact that the IDS does not maintain complete context of the end systems



Evade IDS / IPS Systems at the Network Level

- Change how your traffic appears to these systems
- Alter packet structure or syntax

- Manually fragment the message into smaller packets
  - Send each packet out of order with large delays between each
  - Long delay = IDS needs long-term (lots) memory
    - Snort Frag3 times out after 60 seconds
- "Attack at noon" becomes

"noon" …

"at"…

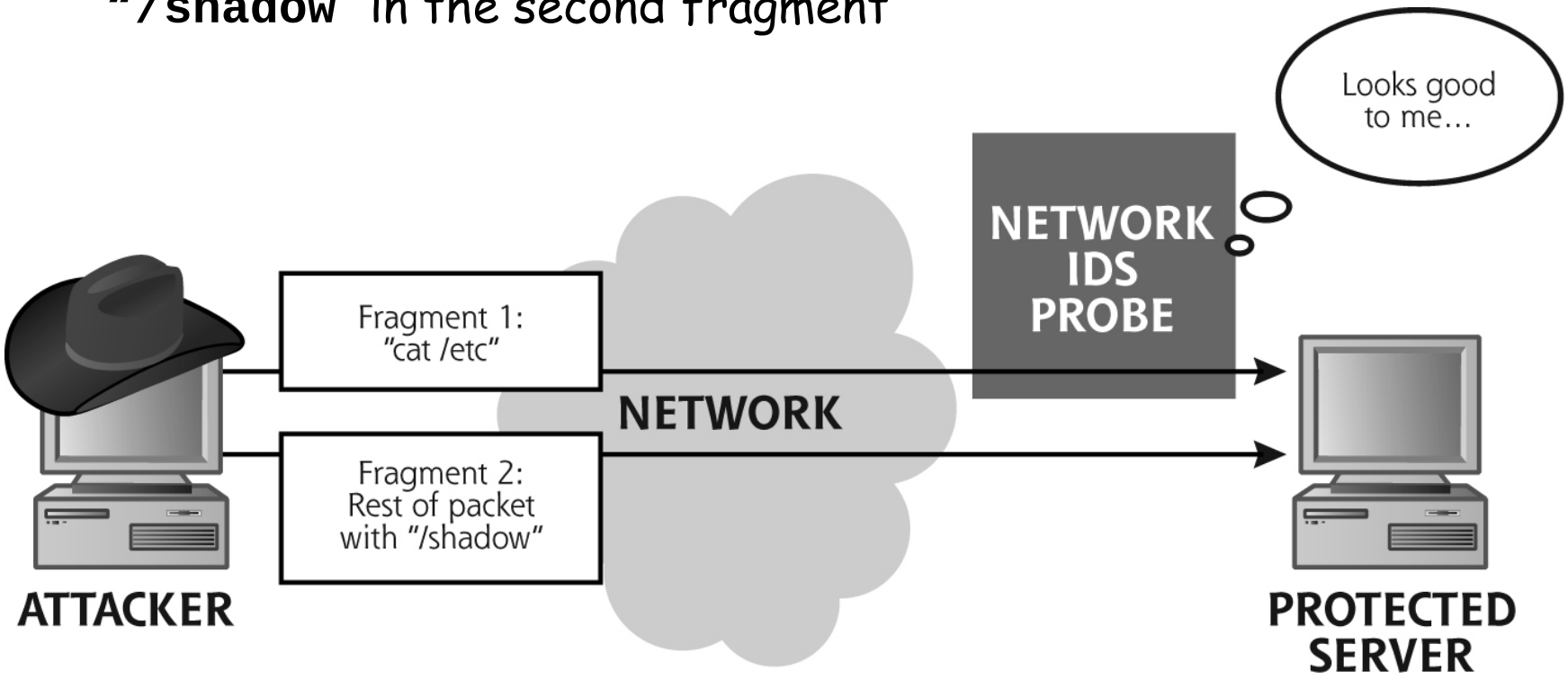
"Attack"

Evade IDS / IPS Systems at the Network Level

- Older IDS/IPS systems could not handle fragmentation
- Seems easy for the IDS/IPS to reconstruct the message since fragment offsets are included in the packets, however…
- What if we
  - fragment packets in unexpected ways
    - Not all OSs reconstruct specially-crafted fragments the same
  - also flood the IDS/IPS with bogus fragments filling up frag memory

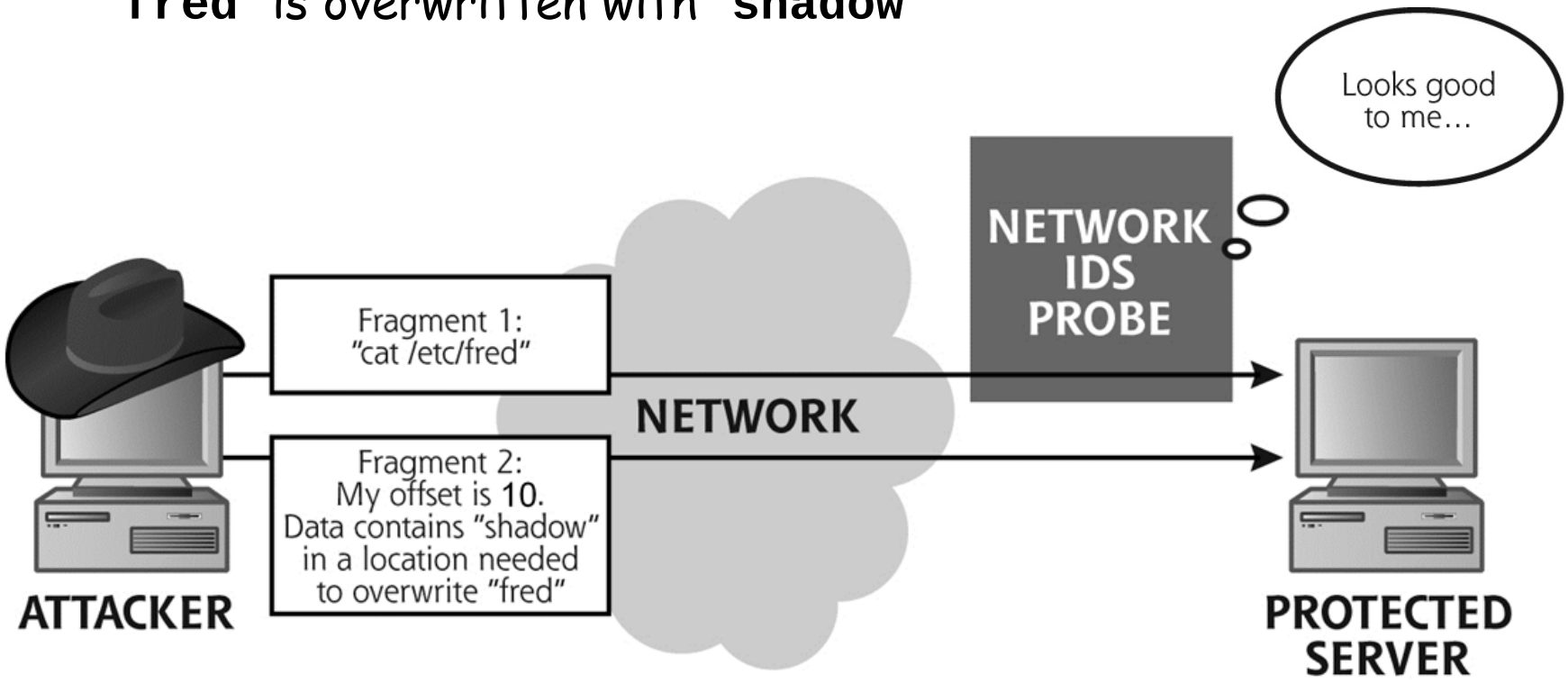
Tiny Fragment Attack

- Create multiple, small fragments such that no one fragment triggers the IDS
  - Send "**`cat /etc`**" in the first fragment and the remainder "**`/shadow`**" in the second fragment



Fragment Overlap Attack

- First fragment "**`cat /etc/fred`**" is fine
- Second fragment provides an incorrect (too small) frag offset
  - When the packet is reconstructed at the protected server, "**`fred`**" is overwritten with "**shadow**"



How are Fragments Reassembled?

- Various operating systems reassemble packets differently
  - Earliest fragment not allowed to be overlapped
  - Fragment with lowest offset will overwrite others, regardless of when it arrives
  - Complete overlap or partial overlap are handled differently

- IDS might not know which method end systems (hosts) use
  - Could ask IDS to reassemble using all methods
  - Cisco Secure IDS has one setting to choose whether it reassembles for Windows, Solaris, Cisco IOS, or Linux/BSD
  - Snort with Frag2 preprocessor always reassembles for Linux machines
  - Snort with Frag3 preprocessor includes multiple frag reassembly buffers running in parallel

IP Fragment Attack Tools

- Nmap has a limited packet frag option → tiny fragment attack

- FragRoute intercepts, modifies, and rewrites egress traffic
  - FragRoute does not route
    - It must reside on the same machine as the attack tool
  - Built into Kali (tools.kali.org/information-gathering/fragroute)

Evade at the Application Level

Recall how a web server uses CGI scripts:

```
POST http://www.briancasey.org/artifacts/astro/moon.cgi HTTP/1.1
Content-Length: 25
Host: www.briancasey.org
<<snip>>
<crlf>
year=2007&month=11&day=30
```

25 characters

Many CGI Scripts Have Vulnerabilities

- Since scripts run on servers, attacker could take control of server
- CGI programs usually have same level of privileges as web server

- Attacker can escape out of the web server process and send data directly to command line for execution

- Cool! How do I find a vulnerable website?

Define: Web Server Scanners

- Automated program that searches for known script vulnerabilities in web servers and web apps
  - Search for "default" example scripts left on system during install
  - Search for specific scripts that are known to be vulnerable
- Typically called Web Application Security Scanners

- There are many Web scanners out there
  - w3af → Web Application Attack and Audit Framework
  - Nikto

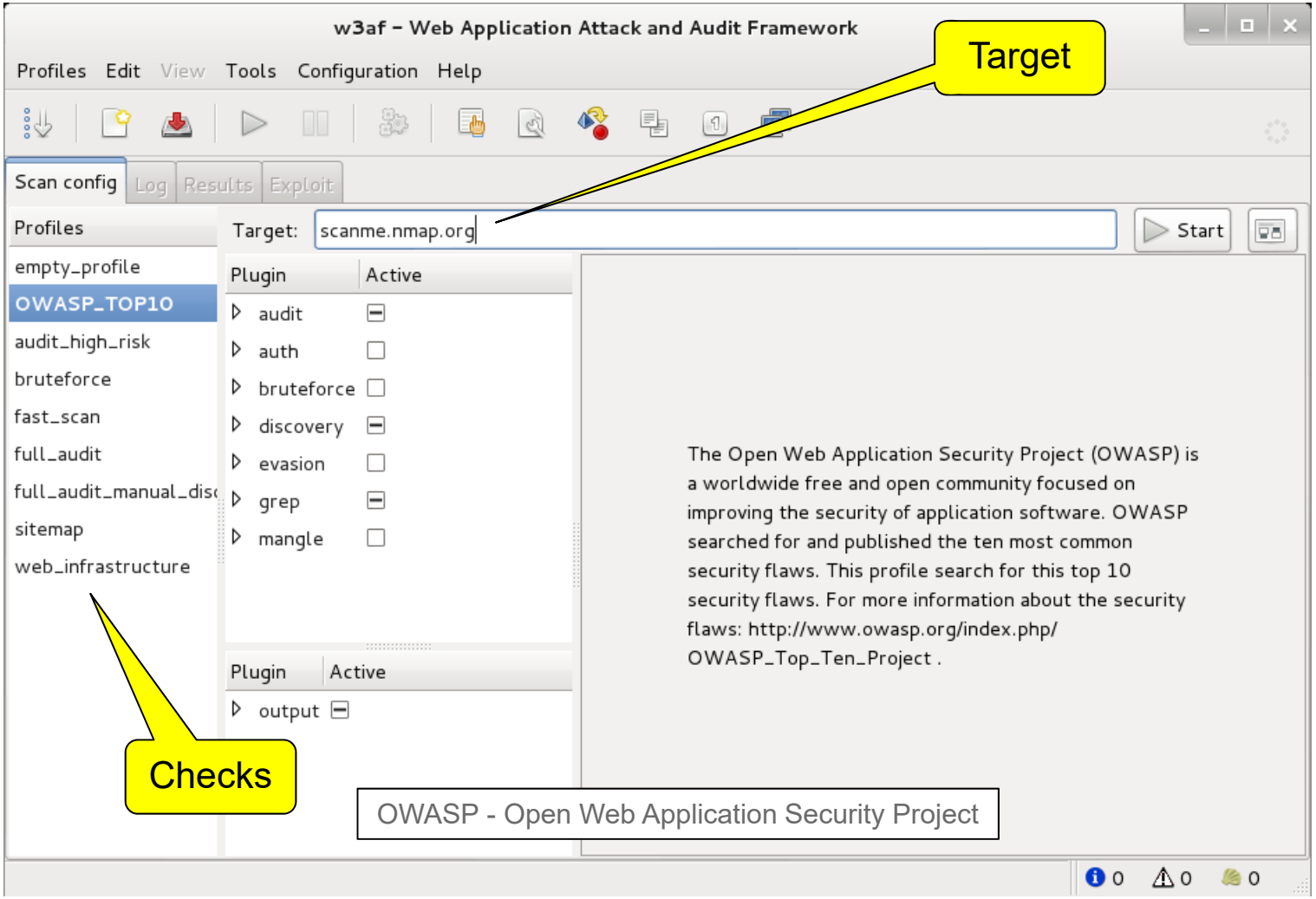
w3af Configure

Application

w3af

Web Application Attack and Audit Framework

- Find and exploit web application vulnerabilities
- w3af.org Works best in Linux – Removed from Kali-rolling



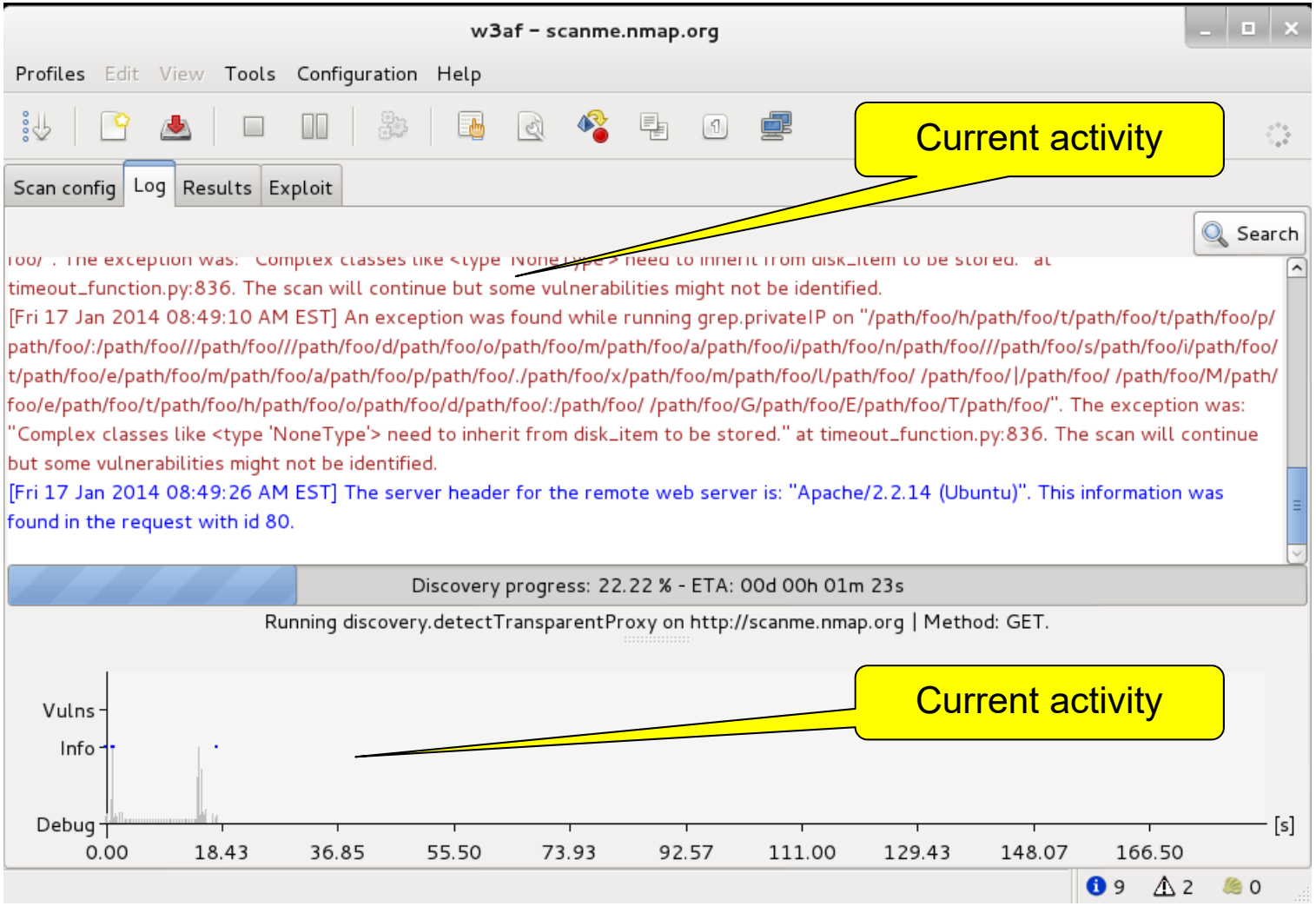
w3af Running

Application

w3af

Web Application Attack and Audit Framework

- Watch current activity in Log tab and timeline (bottom)

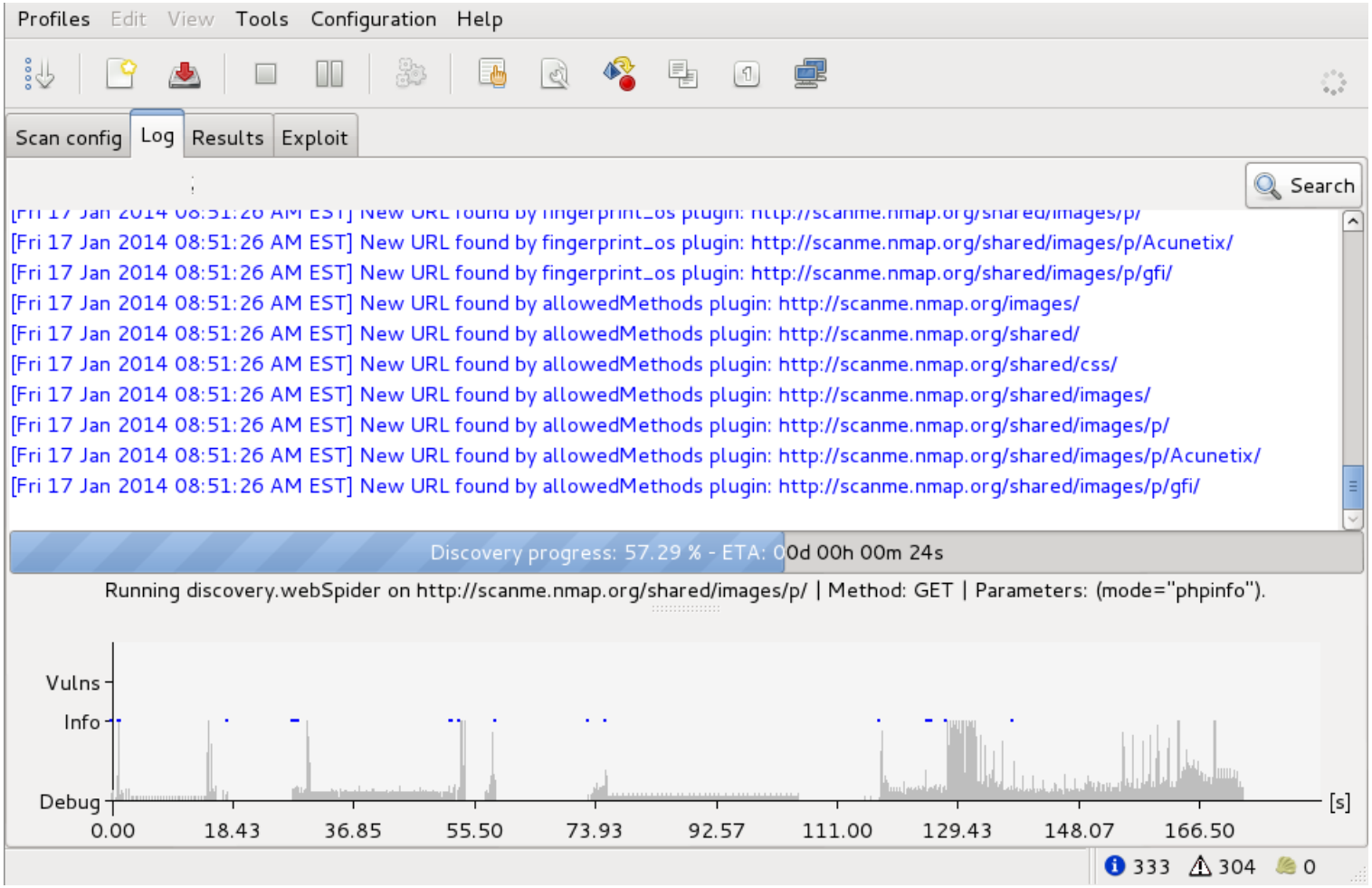


w3af Timeline Symbols

Application

w3af
Web Application Attack and Audit Framework

- Grey bar → quantity of debug messages
- Blue dot → information messages
- Vertical red bar → quantity of vulnerabilities found there

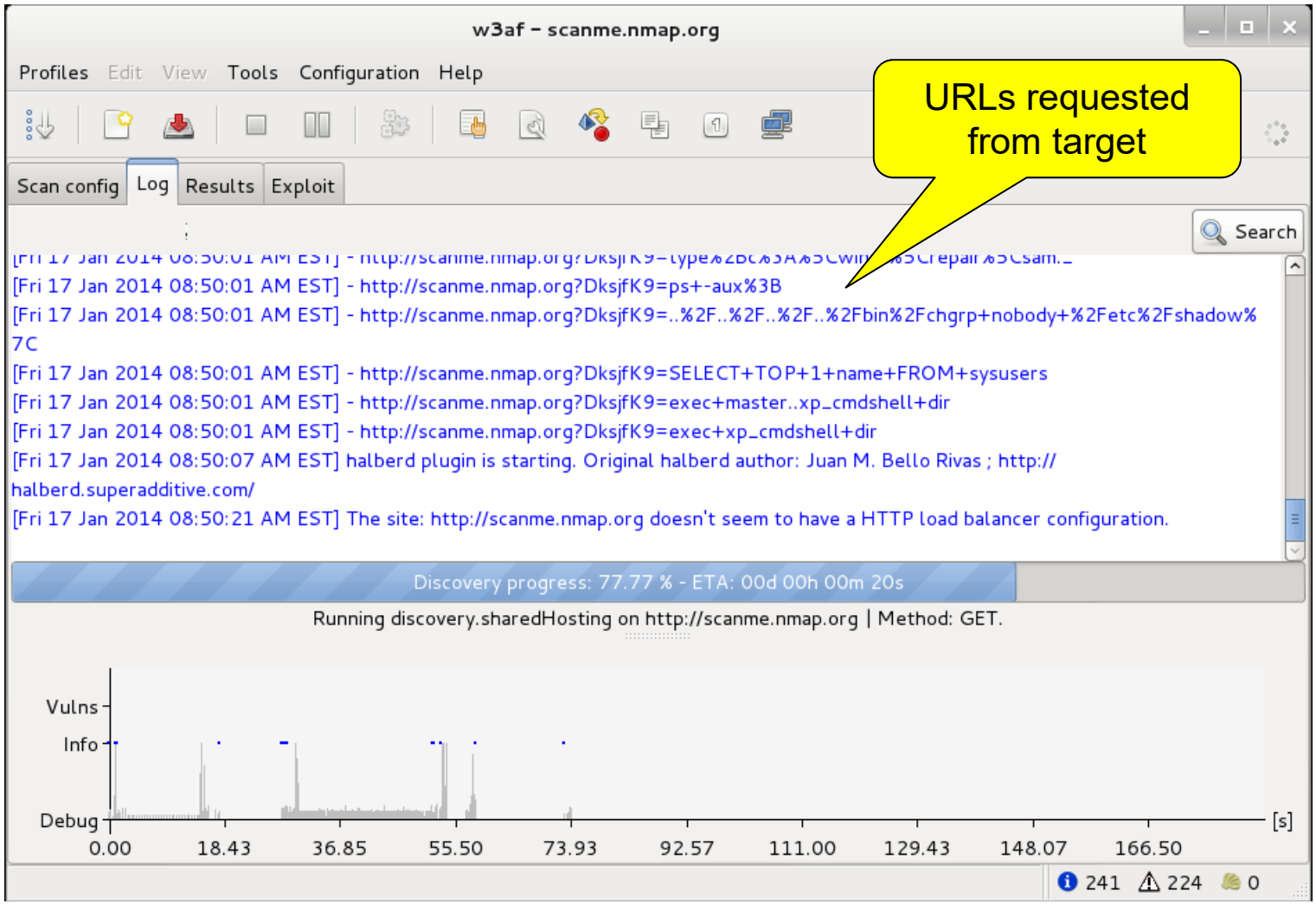


w3af Example Scan

Application

w3af

Web Application Attack and Audit Framework

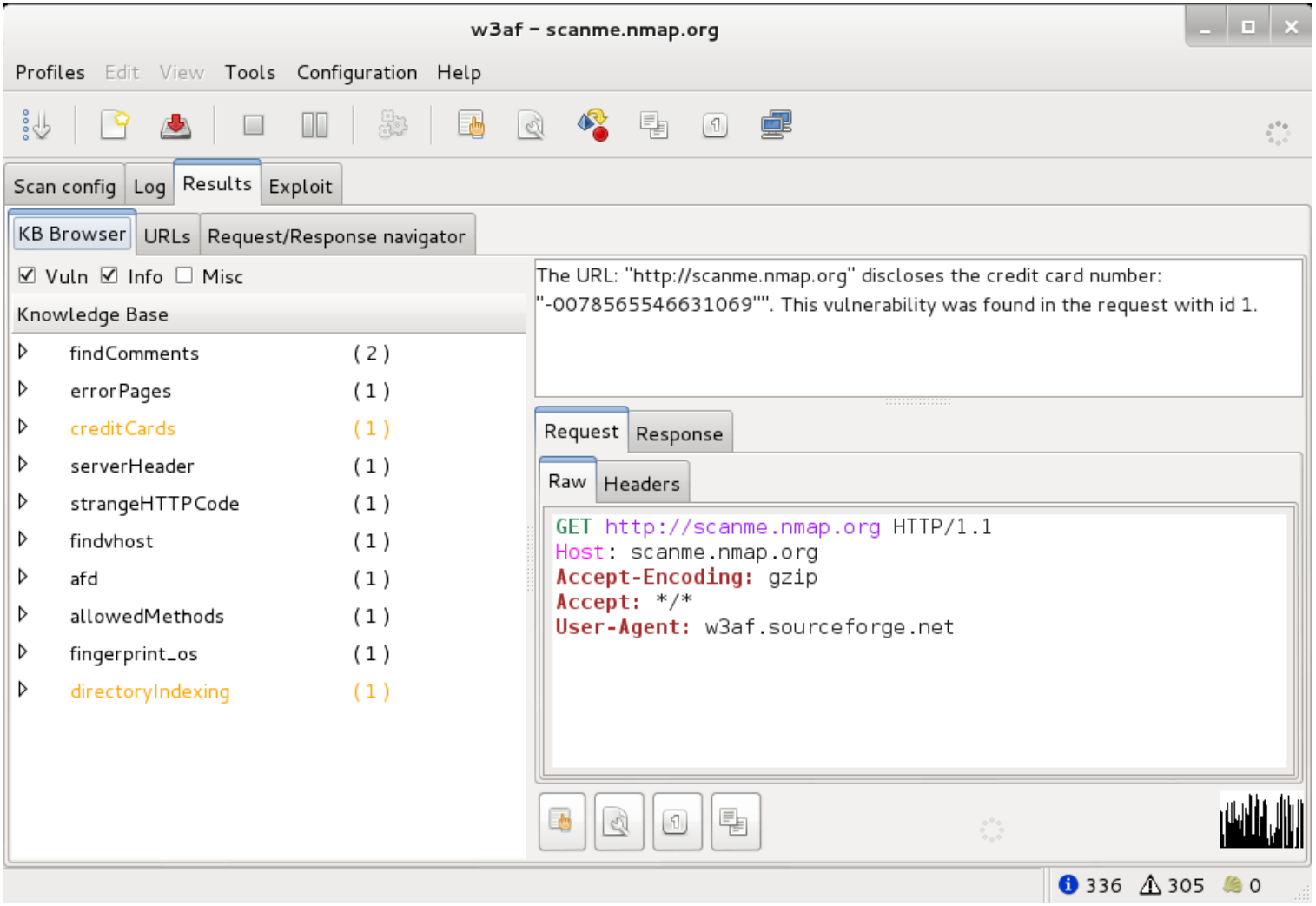


w3af Results

Application

w3af

Web Application Attack and Audit Framework



Nikto - Web Server Scanner

- Designed to find various default and insecure files, configurations and programs on many web servers
- Scans for over 6,700 potentially dangerous files / CGIs
- Checks for
  - outdated versions of servers
  - Server configuration items such as
    - the presence of multiple index files
    - HTTP server options
  - Attempts to identify installed web servers and software
- Automatically searches for CGI directories
- Uses robots.txt to focus searches
- www.cirt.net/Nikto2

Nikto IDS Evasion Techniques

- **`nikto -host http://scanme.nmap.org -evasion 1`**

Evasion techniques on next slides

- Techniques based on paper by Rain Forest Puppy
  - www.ussrback.com/docs/papers/IDS/whiskerids.html
- Nikto changes the request format in subtle, yet still fully functional, ways
- Let's look at the request to the vulnerable script called broken.cgi
  - **`GET /cgi-bin/broken.cgi HTTP/1.0`**

Nikto IDS Evasion Techniques

GET /cgi-bin/broken.cgi HTTP/1.0

1. URL Encoding – use hex equivalents of characters
   - GET /%63%67%69%2d%62%69%6e/broken.cgi HTTP/1.0
   - Try it: www.%61%6d%61%7a%6f%6e.com

"cgi-bin" in ASCII

2. Directory self-reference - /./
   - /./ → change to the current directory → no real action
   - GET /./cgi-bin/./././broken.cgi HTTP/1.0

3. Premature URL ending – place URI in header
   - GET / HTTP/1.0\r\nHEADER: /../../cgi-bin/broken.cgi HTTP/1.0\r\n
   - Which equates to:
     - GET /HTTP/1.0\r\n
     - HEADER: ../../cgi-bin/broken.cgi HTTP/1.0\r\n
   - IDS may stop scanning after "HTTP/1.0"

Nikto IDS Evasion Techniques

`GET /cgi-bin/broken.cgi HTTP/1.0`

4. Prepend long random string
   - GET /bunchofjunktomaketheURLlonger/../cgi-bin/broken.cgi HTTP/1.0
   - Everything before /../ is ignored
   - Scanner may only look at first 1,000 characters

5. Fake Parameter
   - GET /index.htm?param=/../cgi-bin/broken.cgi HTTP/1.0
   - Scanner may stop looking after"?"

Use alternate space (instead of space (0x20))

6. TAB → GET<tab>/cgi-bin/broken.cgi<tab>HTTP/1.0

A. Carriage return (0x0d)

B. Vertical tab (0x0b)

Nikto IDS Evasion Techniques

`GET /cgi-bin/broken.cgi HTTP/1.0`

7. Change the case of the URL
   - GET /CGI-BIN/broken.cgi HTTP/1.0
   - Windows systems are case insensitive
   - Will be allowed through a Linux IDS and execute on a Windows web app

8. Use Windows directory separator (backslash → \)
   - GET /cgi-bin\broken.cgi HTTP/1.0
   - Will be allowed through a Linux IDS and execute on a Windows web app

- NULL method
  - GET%00 /cgi-bin/broken.cgi HTTP/1.0
  - If IDS uses C-library strings, everything after the null (%00) is ignored since the null char is used to indicate end of string

Yet More Nikto IDS Evasion Modes

GET /cgi-bin/broken.cgi HTTP/1.0

- Session splicing – send separate TCP segments in same connection
  - "G"
  - "ET"
  - " /cgi-"
  - "bin"
  - "/broken.cgi HTTP/1.0"
  - This is essentially transport-level IDS evasion

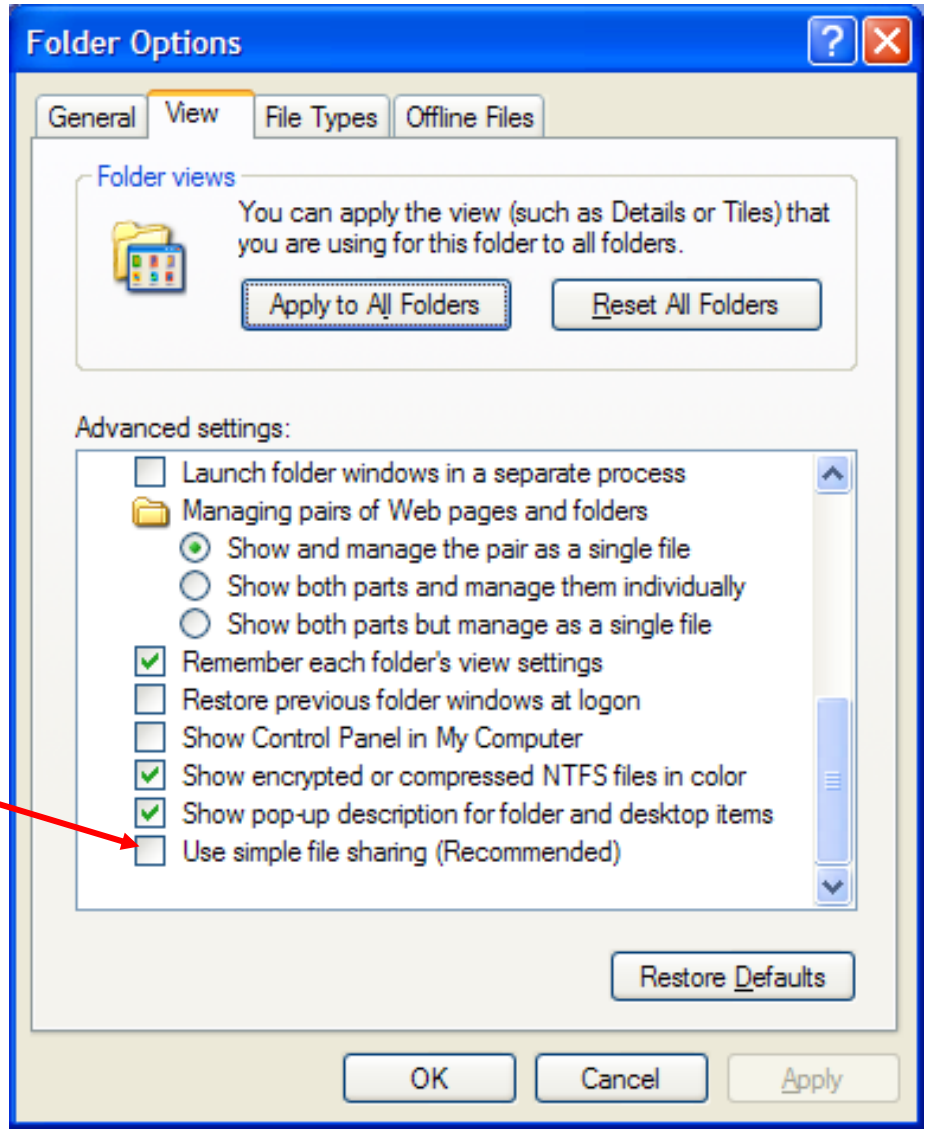
- Attacker can also craft hundreds of different combinations of these techniques
  - **nikto -host http://scanme.nmap.org -evasion 126**
  - Run evasions 1, 2, and 6
  - This exacerbates the IDS's job

Computer and Network Hacker Exploits

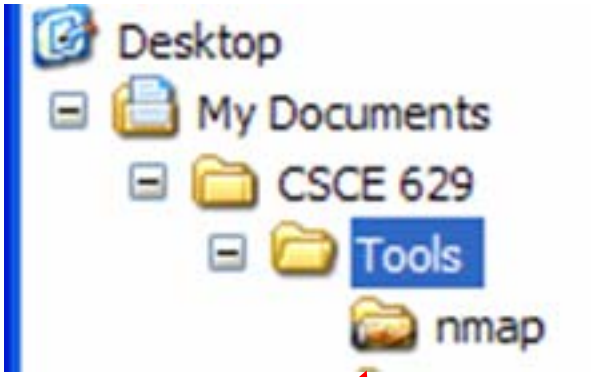
- Step 1: Reconnaissance
- **Step 2: Scanning**
  - Network Mapping
  - Determining Open Ports Using Port Scanners
  - Vulnerability-Scanning Tools
  - Intrusion Detection System and Intrusion Prevention System Evasion
  - Shares
- Step 3: Gaining Access
  - Application and Operating System Attacks
  - Network Attacks
  - Denial of Service Attacks
- Step 4: Maintaining Access
- Step 5: Covering Tracks and Hiding

Windows LAN Scans

- Requires LAN (insider) access
- Windows machines have unique "features" built in by Microsoft to "enhance the user's experience"
- Microsoft has always supported file and printer sharing



Windows Network Shares



- Windows allows users to create shares
- Shares can be files, directories, and drives
  - Win XP: "Hand" denotes the item is shared
  - Vista, Win7, …: Icon is gone

- To enable sharing, Microsoft developed NetBIOS
  - Network Basic Input/Output System
  - Allows computer communication over a LAN
  - Since NetBIOS is not routable over the Internet and everyone on the LAN is presumed trustworthy, Microsoft did not concern itself a great deal with security…

    … then LANs got increasingly complex

    So, Microsoft created NetBIOS over TCP/IP (NetBT)

Server Message Block (SMB)

- Client-server application-layer network protocol that provides sharing
- SMB can run on TCP port 139 (NetBIOS over TCP)
- Windows: SMB can run directly on top of TCP via TCP port 445
  - Preferred method

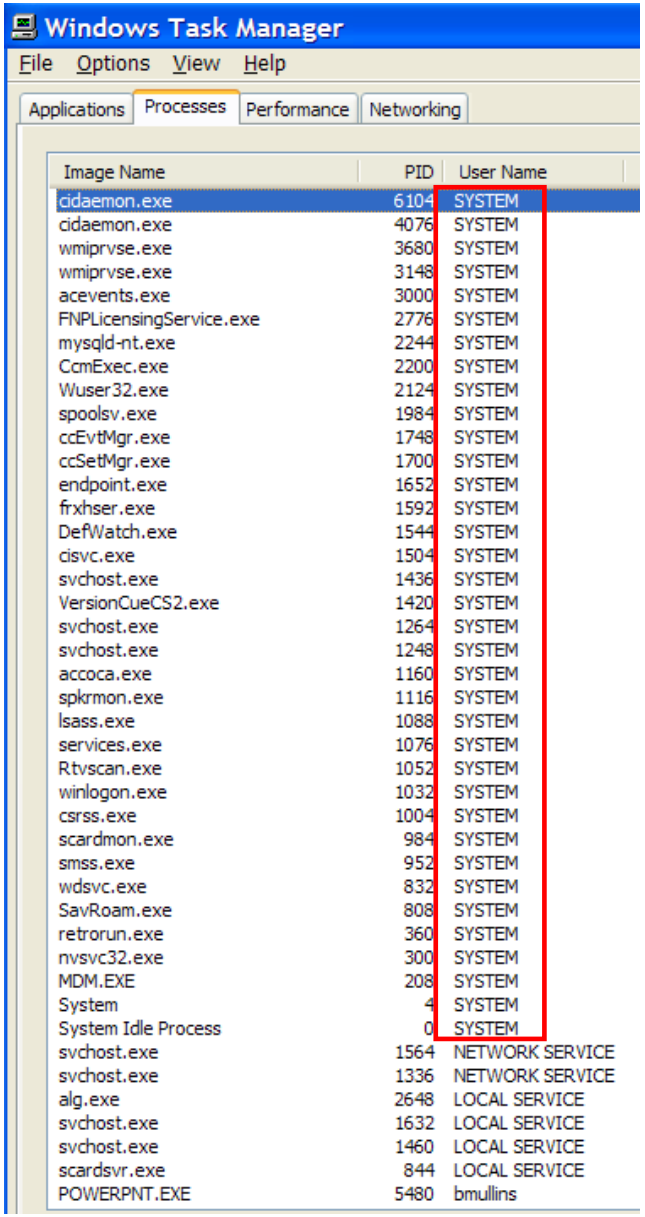
<table>
<tr><th>OSI</th><th>TCP/IP</th><th>Port 139</th><th>Port 445</th></tr>
<tr><td>Application</td><td rowspan="3">Application (e.g., HTTP)</td><td rowspan="2">SMB</td><td rowspan="3">SMB</td></tr>
<tr><td>Presentation</td></tr>
<tr><td>Session (error recovery)</td><td>NetBIOS</td></tr>
<tr><td>Transport</td><td>TCP/UDP</td><td>TCP/UDP</td><td>TCP/UDP</td></tr>
<tr><td>Network</td><td>IP</td><td>IP</td><td>IP</td></tr>
<tr><td>Link</td><td>Ethernet</td><td>Ethernet</td><td>Ethernet</td></tr>
</table>

Server Message Block (SMB)

- SMB protocol is implemented on Unix systems using Samba
- CIFS (Common Internet File System) was SMB as it existed in Windows 2000

Windows Network Shares

- Many local services run as SYSTEM
  - SYSTEM has virtually unlimited privileges
- SYSTEM sometimes needs to access information on other machines
  - Available shares, usernames, etc.
  - It can't log on to the other systems using UserID/password
    - It has no password
- SYSTEM uses Null sessions via NetBT
  - Unauthenticated connection
    - Undefined (null) username and domain / Empty password string



Net Commands

- Used to update, fix, or view network settings

```
C:\Users\bmullins.CDN>net
The syntax of this command is:

NET
    [ ACCOUNTS | COMPUTER | CONFIG | CONTINUE | FILE | GROUP | HELP |
      HELPMSG | LOCALGROUP | PAUSE | SESSION | SHARE | START |
      STATISTICS | STOP | TIME | USE | USER | VIEW ]

C:\Users\bmullins.CDN>
```

- On the next slide, I view my computer's network settings

Hidden shares are indicated by a $ (e.g. C$)

Hidden

Visible

```
C:\Users\bmullins.CDN>net share

Share name   Resource                        Remark

-------------------------------------------------------------------------------
C$           C:\                             Default share
G$           G:\                             Default share
IPC$                                         Remote IPC
S$           S:\                             Default share
ADMIN$       C:\WINDOWS                      Remote Admin
My Music     G:\My Documents\My Music
The command completed successfully.
```

To see the contents of a hidden share, you must use an administrator's account on the target

```
C:\Users\bmullins.CDN>net user

User accounts for \\DESKTOP-9GUNCEU

-------------------------------------------------------------------------------
___VMware_Conv_SA___     barry-local              DefaultAccount
fatcat                   ghost
The command completed successfully.


C:\Users\bmullins.CDN>net accounts
Force user logoff how long after time expires?:       0
Minimum password age (days):                          0
Maximum password age (days):                          60
Minimum password length:                              14
Length of password history maintained:                None
Lockout threshold:                                    Never
Lockout duration (minutes):                           Never
Lockout observation window (minutes):                 60
Computer role:                                        WORKSTATION
The command completed successfully.
```

Net View

Client/server network

Peer-to-peer Windows computer network

- Scan the LAN for other computers in domains or workgroups

net view [*ComputerName*] [/domain[:*DomainName*]]

Domain or workgroup

```
C:\Users\Administrator>net view /domain:lissard2
Server Name                     Remark

-------------------------------------------------------------------------------
\\AS-LISSARD2-02                AS-LISSARD2-02
\\BS-LISSARD2-01                Disk Station
\\DC-LISSARD2-01                DC-LISSARD2-01
\\DC-LISSARD2-02
\\DESKTOP-2GC8FPE
\\DESKTOP-9GUNCEU
\\DS-LISSARD2-01
\\FS-LISSARD2-01
\\JONNYLACEYPC
\\JPWINDOWS8                    JPWindows8
\\LISW10797V
\\LISW744PA
\\LISW744PC
\\LISW744XY
```

Displaying SMB Shares

- Display available (not hidden) shares on another computer
  - **net view [*ComputerName*]**

```
C:\Users\user.WIN-AJACIDD48FR>net view \\10.1.2.7
Shared resources at \\10.1.2.7


Share name    Type  Used as  Comment

-------------------------------------------------------------------------------
Ace_Faculty   Disk
Admin         Disk           Admin Use Only
ghost         Disk           ghost folder
ISO           Disk           ISO files
Mullins       Disk
music         Disk           System default shared folder
NetBackup     Disk           System default shared folder
PCE           Disk           PCE
PCE Share     Disk           PCE Share Folder
```

Displaying SMB Shares

- Displays SMB shares on remote computer
  - **smbmap -d domain -H x.x.x.x**
- May have to provide a set of credentials if share is restricted
  - **smbmap -u user -p password -d domain -H x.x.x.x**

```
root@kali:~/Desktop# smbmap -d cdn-0l -H 10.1.2.7
[+] Finding open SMB ports....
[+] Guest SMB session established on 10.1.2.7...
[+] IP: 10.1.2.7:445    Name: 10.1.2.7
        Disk                                                    Permissions
        ----                                                    -----------
        Ace_Faculty                                             NO ACCESS
        Admin                                                   NO ACCESS
        ghost                                                   NO ACCESS
```

- smbclient works too
  - **smbclient -L 10.1.2.7 -U user -W domain**

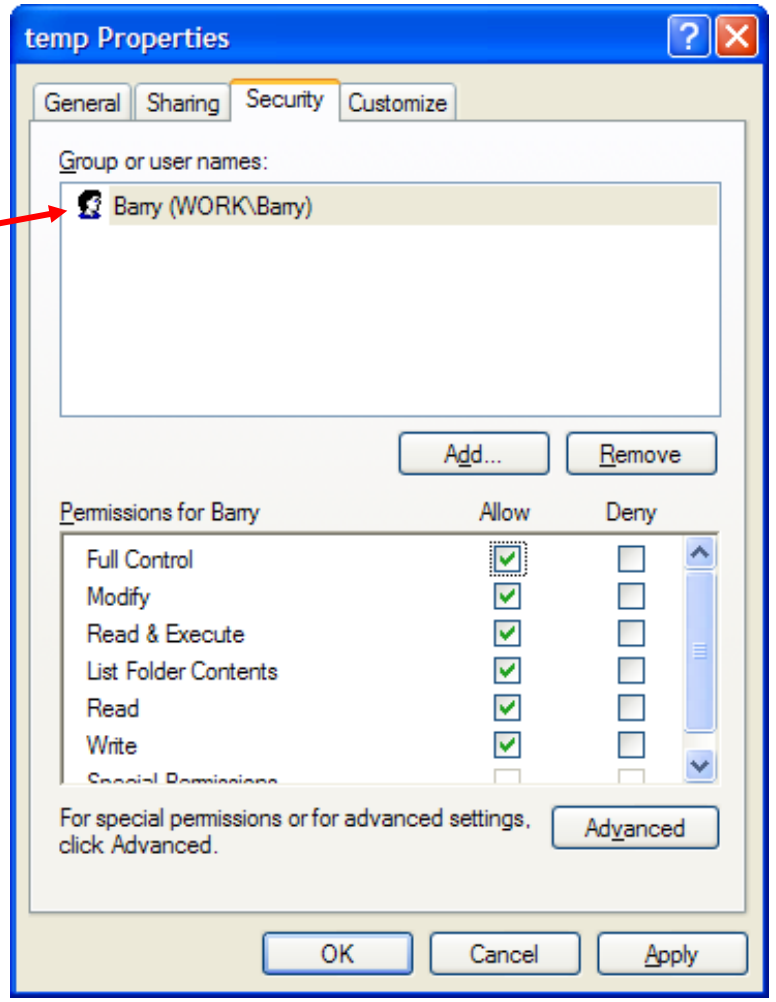
Displaying Domain Users

- **net user /domain**

```
C:\Users\bmullins.CDN>net user /domain
The request will be processed at a domain controller for domain CDN.LOCAL.


User accounts for \\DC-CDN-01.CDN.LOCAL

-------------------------------------------------------------------------------
aaragon                  aduchane                 alin
aroberts                 atroya                   bburfeind
bfroberg                 bheitmeyer               bjeffries
blambert                 blaw                     bmullins
bnolan                   bvoetberg                cbramlette
ccady                    ccunningham              cpeters
crodriguez               crondeau                 csolberg
```

Restricted-Access Share

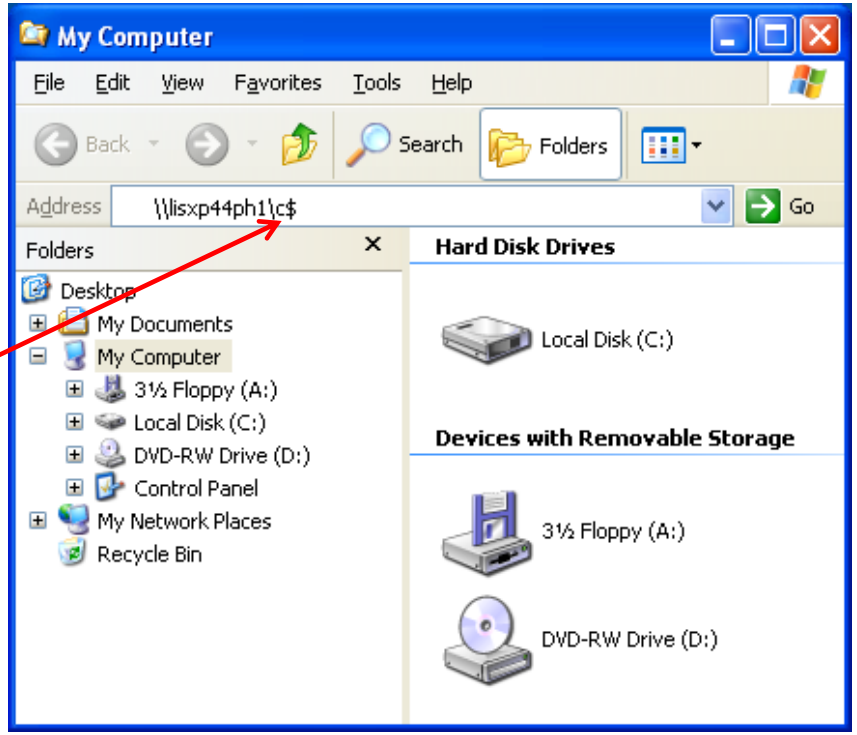
- A user can restrict access to files/folders to self
  - Not even an administrator or SYSTEM can access
  - You can see it but not access the contents
- Do not change file permissions to access the files/folders!
- If this happens, you must connect as each user on the target until you find the owner



Mapping Drives (1)

- Once you know some users and their passwords, you can map their share to a local drive and search it:
  - `> net use g: \\10.1.2.122\c$` a hidden share
  - `> net use g: \\10.1.2.122\my music` a visible share
    - After "The password or user name is invalid for \\..."
      - You will be asked for a username and a password
      - Unless you already gave the username and password

  - Could also use Windows explorer and enter credentials when asked
    - Need admin creds here since it is a hidden share



Mapping Drives (2)

```
C:\Users\bmullins.CDN>net share

Share name   Resource                        Remark

-------------------------------------------------------------------------------
C$           C:\                             Default share
G$           G:\                             Default share
IPC$                                         Remote IPC
S$           S:\                             Default share
ADMIN$       C:\WINDOWS                      Remote Admin
My Music     G:\My Documents\My Music
The command completed successfully.
```

Could insert password here

- Map to remote share
  - **`net use g: \\10.1.2.122\My Music /u:<target>\jsmith`**
    - Asks for jsmith password if not provided
    - Must use **`/u:<target>\jsmith`** since user account is on local (target) machine (*e.g.*, **`/u:lisxp41b1\jsmith`** or **`/u:10.1.1.6\jsmith`**)
- Share is now effectively a hard drive on your machine
- Move to share → **`g:`**
- Search for flags (on *g:*)
  - **`dir /s/a g:\flag*.txt`** or just **`dir /s/a flag*.txt`**
  - /a = all; useful for finding hidden files
  - /s = Displays files in specified directory and all subdirectories
  - Will only search files in My Music folder and below
    - G:\My Documents\My Music

Not searched

Mapping Drives (3)

- Did you find a flag file?
- If not, disconnect the drive
  - **`net use g: /d`**
- … and repeat

Password included this time

```
net use g: \\10.1.2.122\My Music socialengr /u:<target>kmitnick
g:
dir /s/a flag*.txt
```

- Log in as each user you know (**`/u:<username>`**) and have the password
- Remember to disconnect when done
  - **`net use g: /d`**

Example of Mapping Drives and Search