IT-Security (ITS) B1

DIKU, E2024

Today’s agenda

Intrusion detection defined

Intrusion detection in theory

Intrusion detection in practice

Signature detection, anomaly detection, log analysis

Next time: Malware + Forensics

Intrusion Detection defined

Overall security goals

Prevent as much as possible with *best practices* such as secure coding, whitelisting, patching, secure configurations and more

Anticipate breaches and **build to contain** with defence in depth, segmentation, least privilege, etc.

Detect and **respond** when things go wrong

Learn and **repeat**

Intrusion Detection process / key activities

Intrusion Detection is the process of monitoring and analyzing system events, to identify and report such intrusions

Threat Assessment
How are we exposed (as a company, our business processes, and underlying IT)?

Visibility
What is the right level of insight we need in our systems and applications to detect intrusions?

Data Collection
How do we collect data to support our visibility needs?

Data Analysis
How do we analyse the data for signs of intrusions?

Incident Response
What do we do when we discover an attack?

Intrusions defined

What is an **intrusion**? Or, when does it go from being an **event** to something more.

An intrusion or incident is an event on a host or network that violates security policy, or is an imminent threat to put a system in an unauthorized state.

Not all **intrusion attempts** are successful, not all **intrusions** lead to **compromise.** The criticality of an intrusion/incident depends, on the stage in which it was discovered (anything non-targeted before Initial Access is borderline relevant), on the systems affected, the accounts compromised, the type of adversary, their motivation, and more.

Is this an incident?

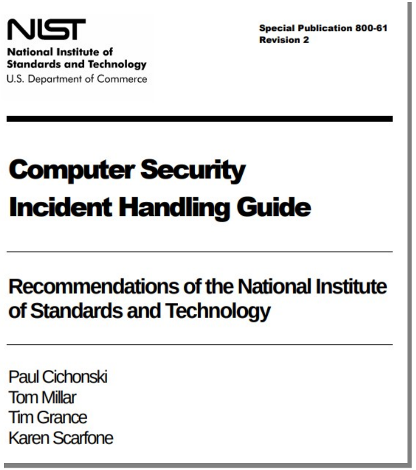
```
[**] IIS vti_inf access attempt [**]

10/10-22-10:17:13 63.209.91.31:4791 -> 84.2.3.13:80

TCP TTL:116 TOS:0x0 ID:6075 DF

***PA* Seq:0x1CB4699 Ack:0x2AE6F9 Win:0x217C
```

IDS alert

```
[Mon Oct 10 10:17:13 2022] [error] [client 63.209.91.31]

File does not exist: /usr/local/apache/htdocs/_vti_inf.html

[Mon Oct 10 10:17:14 2022] [error] [client 63.209.91.31]

File does not exist: /usr/local/apache/htdocs/_vti_bin/shtml.exe/_vti_rpc
```

Web server log

NIST Security Incident Handling process



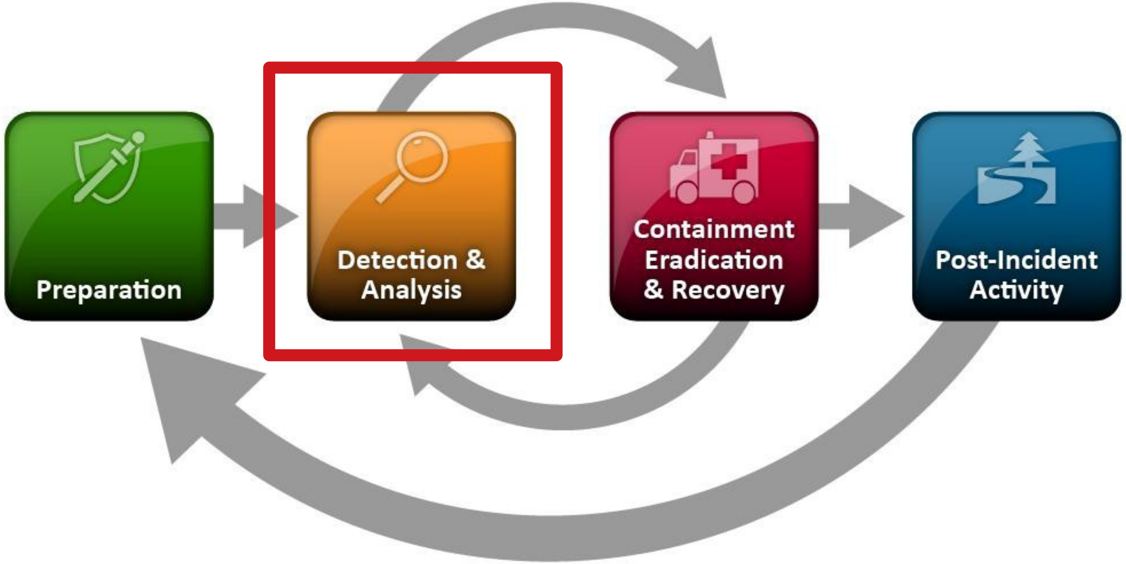
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Special Publication 800-61
Revision 2

Computer Security Incident Handling Guide

Recommendations of the National Institute of Standards and Technology

Paul Cichonski
Tom Millar
Tim Grance
Karen Scarfone



Intrusions by the numbers

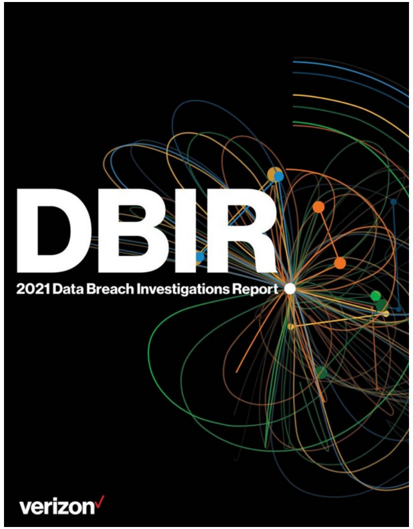
If or when?

“There are two kinds of companies.

There are those who've been hacked and those who don't know they've been hacked.”

Former FBI Director, James Comey

Overall trends in Intrusion Detection



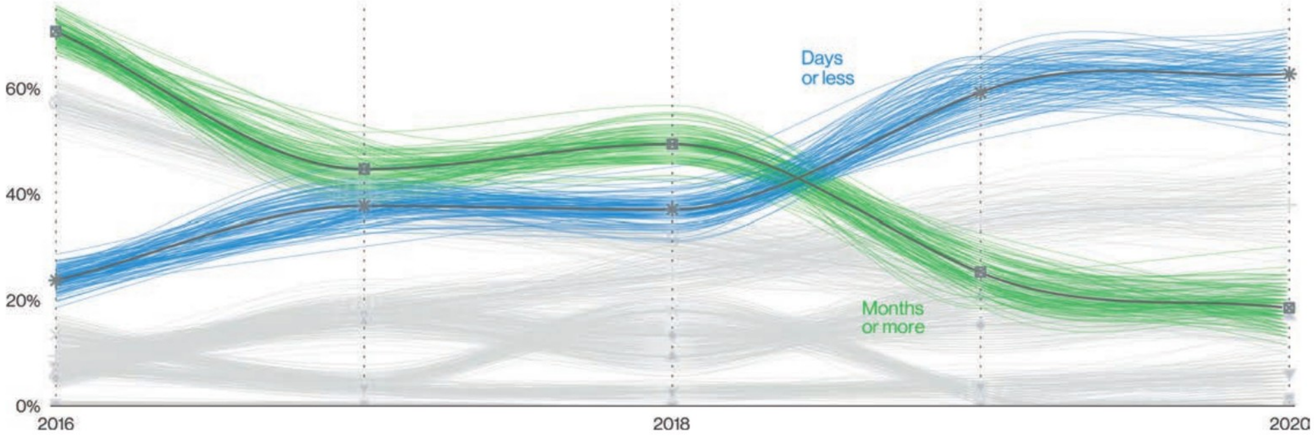
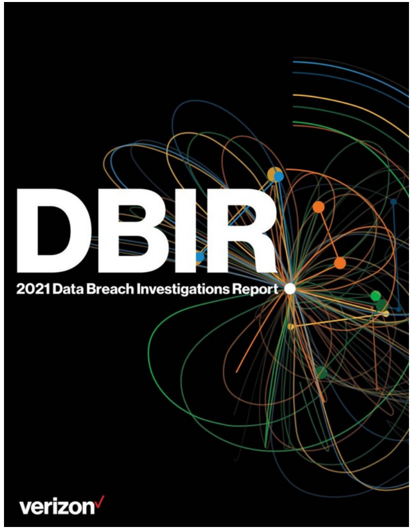


Figure 39. Discovery over time in breaches

Overall trends in Intrusion Detection



DBIR

2021 Data Breach Investigations Report

verizon

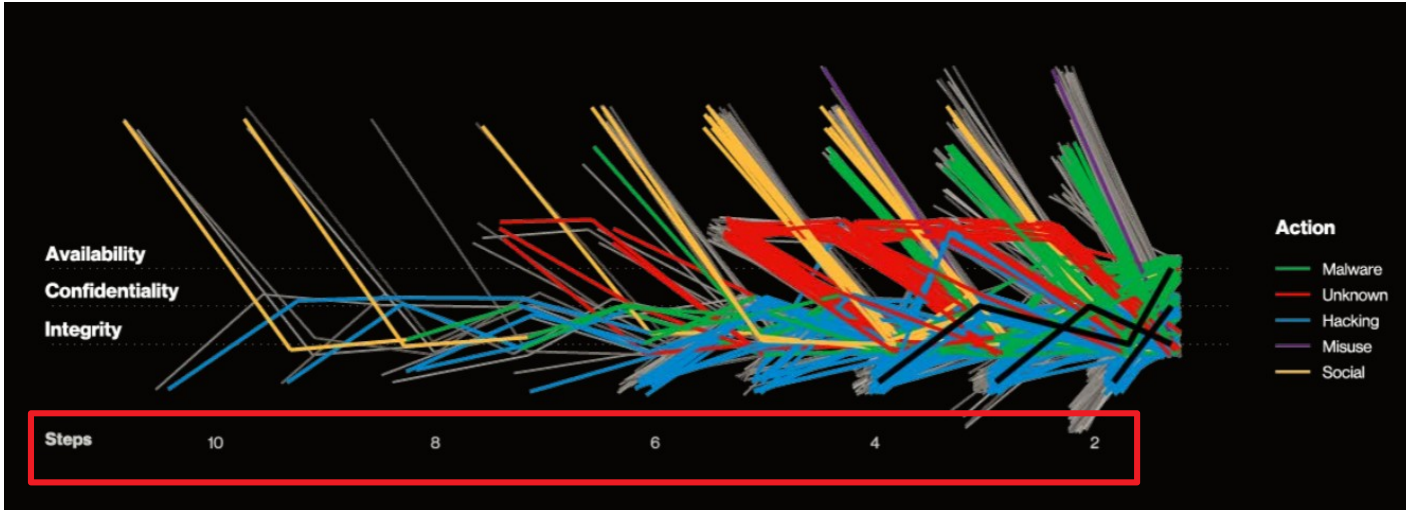
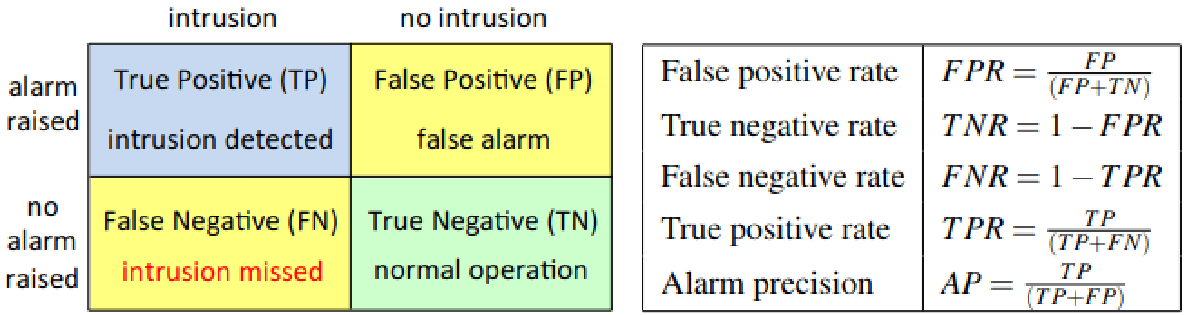


Figure 81. System Intrusion incident paths (n=251)

Intrusion Detection in Theory

True/false positive/negative

We have **events**, **sensors**, **HIDS** and **NIDS**: the **intrusion detection problem** is to determine whether an event is from a distribution of events of intruder behavior, or from a legitimate user distribution.

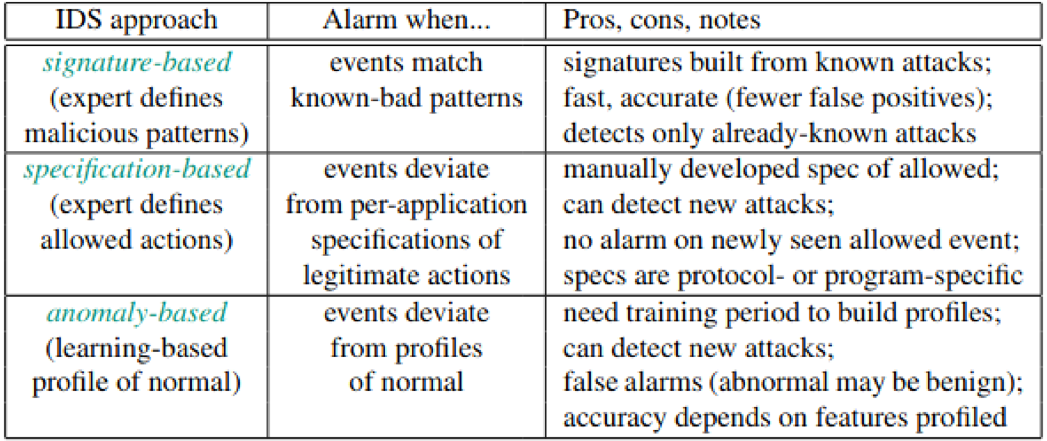


	intrusion	no intrusion
alarm raised	True Positive (TP) intrusion detected	False Positive (FP) false alarm
no alarm raised	False Negative (FN) intrusion missed	True Negative (TN) normal operation

False positive rate	$FPR = \frac{FP}{(FP+TN)}$
True negative rate	$TNR = 1 - FPR$
False negative rate	$FNR = 1 - TPR$
True positive rate	$TPR = \frac{TP}{(TP+FN)}$
Alarm precision	$AP = \frac{TP}{(TP+FP)}$

Figure 11.1: IDS event outcomes (left) and metrics (right). FP and FN (yellow) are the classification errors. TPR is also called the *detection rate*.

Intrusion detection: approaches



IDS approach	Alarm when...	Pros, cons, notes
signature-based (expert defines malicious patterns)	events match known-bad patterns	signatures built from known attacks; fast, accurate (fewer false positives); detects only already-known attacks
specification-based (expert defines allowed actions)	events deviate from per-application specifications of legitimate actions	manually developed spec of allowed; can detect new attacks; no alarm on newly seen allowed event; specs are protocol- or program-specific
anomaly-based (learning-based profile of normal)	events deviate from profiles of normal	need training period to build profiles; can detect new attacks; false alarms (abnormal may be benign); accuracy depends on features profiled

Table 11.1: IDS methodologies. Signature-based approaches use expert-built patterns (manual denylists). Specification approaches use expert-built specs (manual allowlists). Anomaly approaches define "normal" behavior from training data (empirical allowlists).

Intrusion Detection in Practice

Nmap

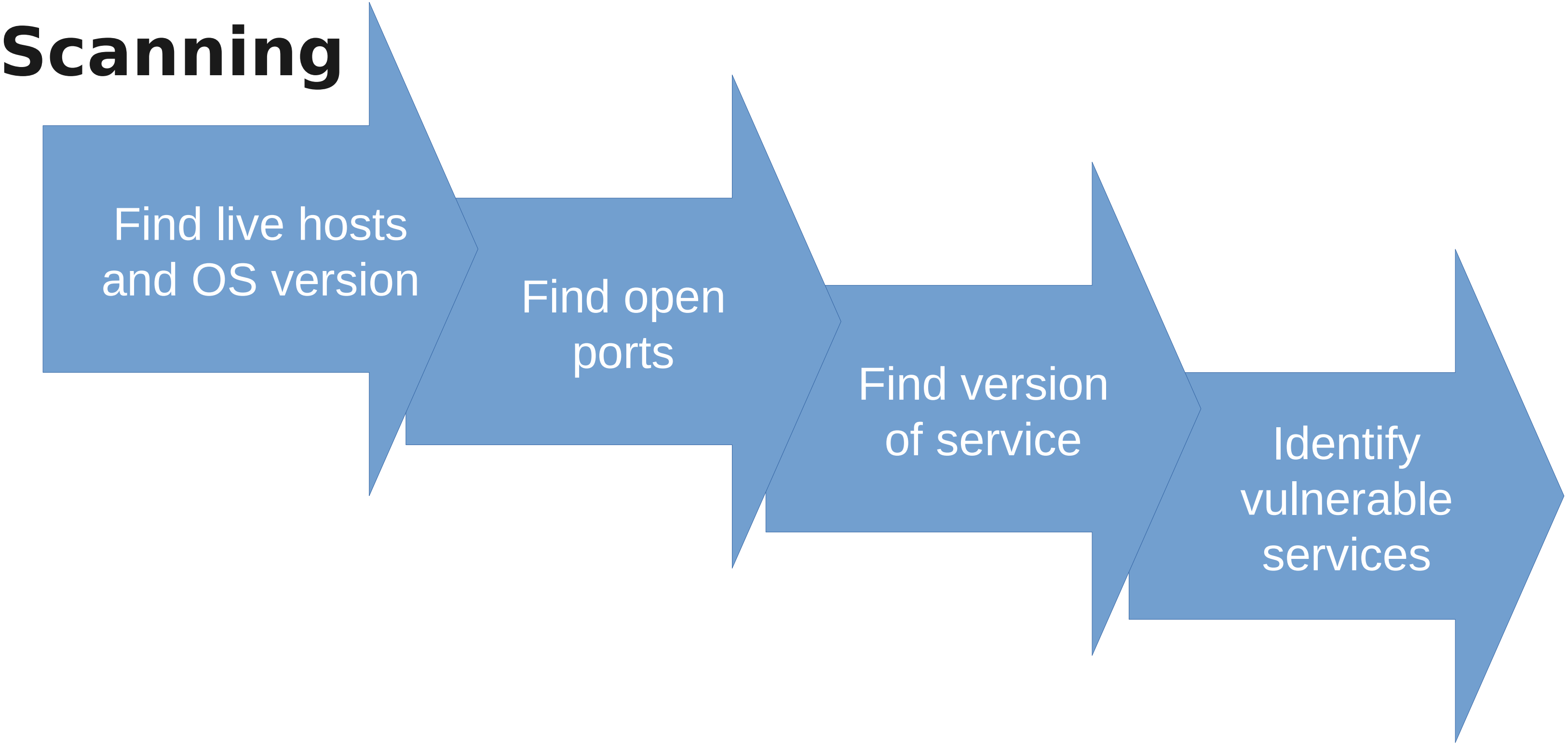
Snort

Bro/Zeek

Scanning

```
nmap
-sS (TCP SYN)
-sT (TCP connect)

nmap 127.0.0.1
nmap –sT 127.0.0.1
nmap –sT –O 127.0.0.1
nmap –sV –p 80,443 127.0.0.1
nmap –sV –script=vulnscan 127.0.0.1
```

Scanning



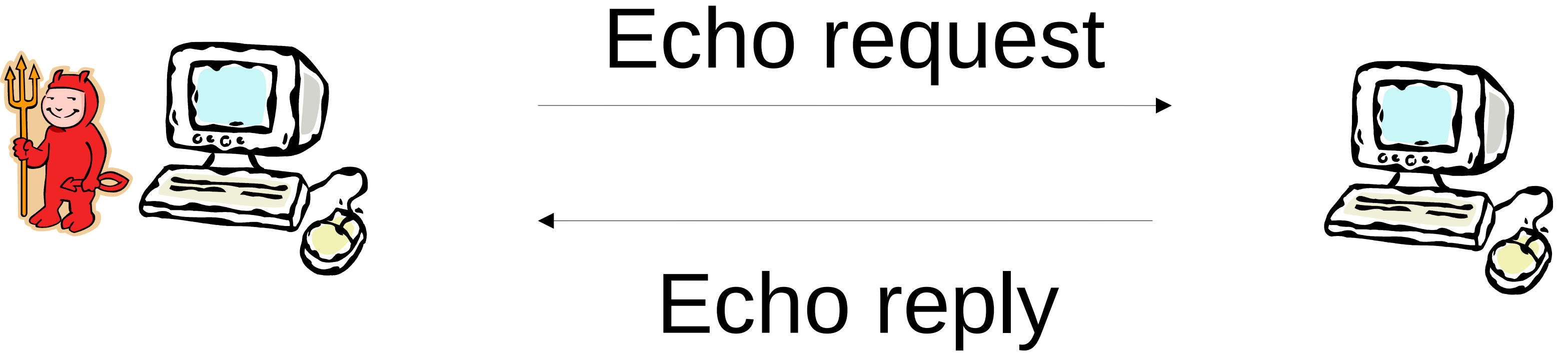
Find live hosts and OS version

Find open ports

Find version of service

Identify vulnerable services

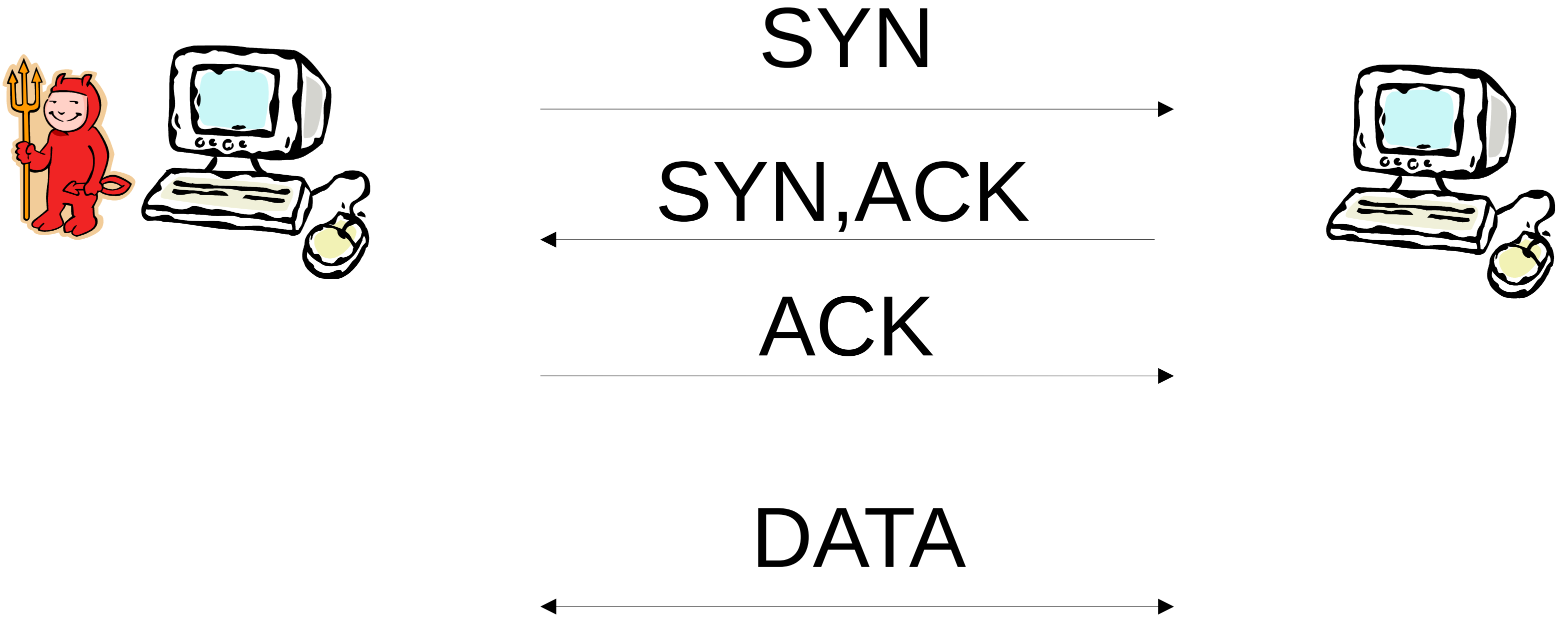
Scanning



Echo request

Echo reply

Port scanning



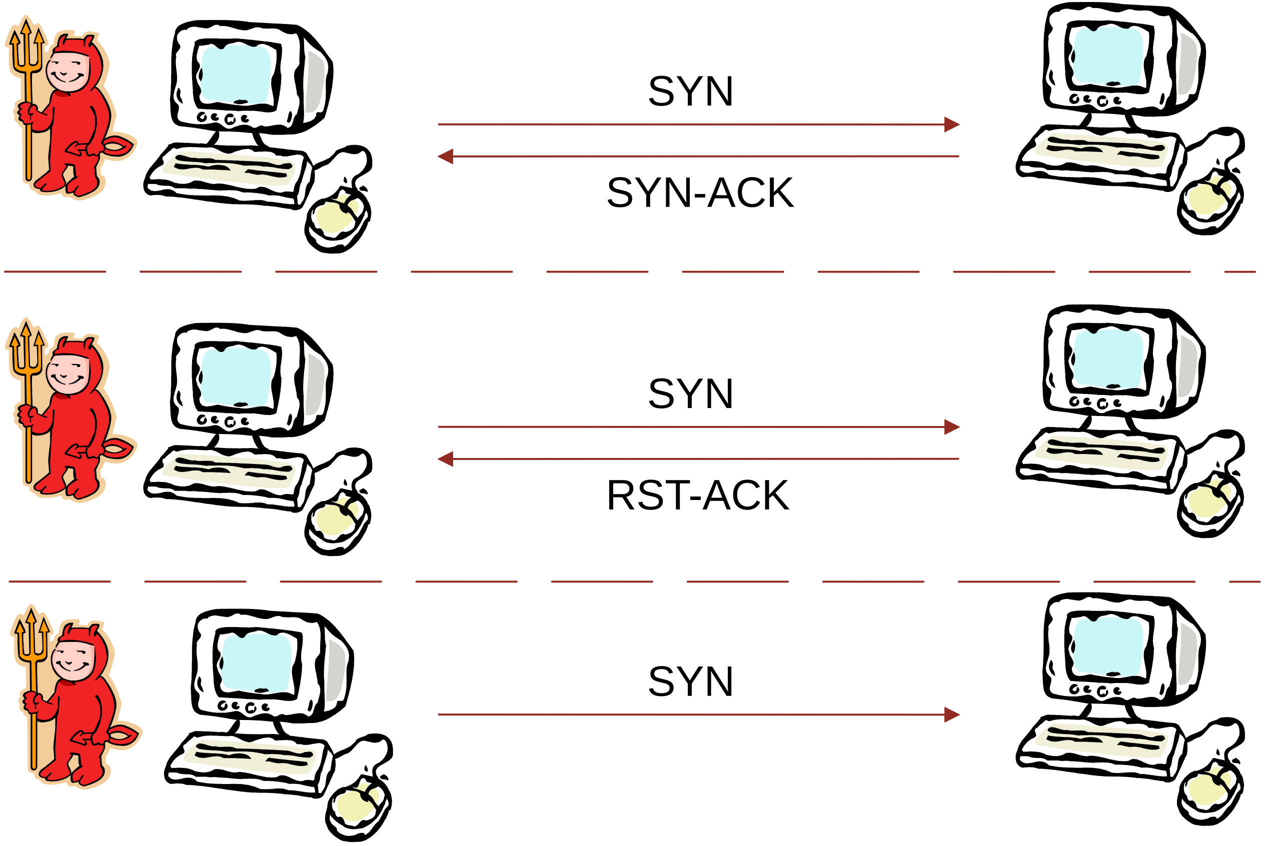
SYN

SYN,ACK

ACK

DATA

TCP



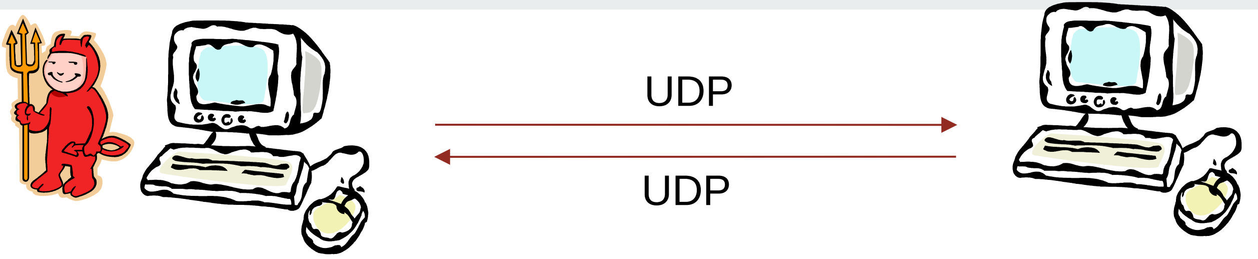
Port open!

Port closed!

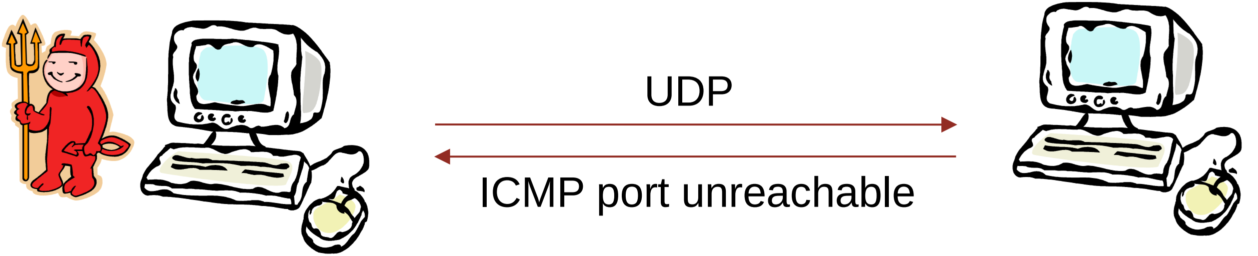
Blocked by firewall?

UDP

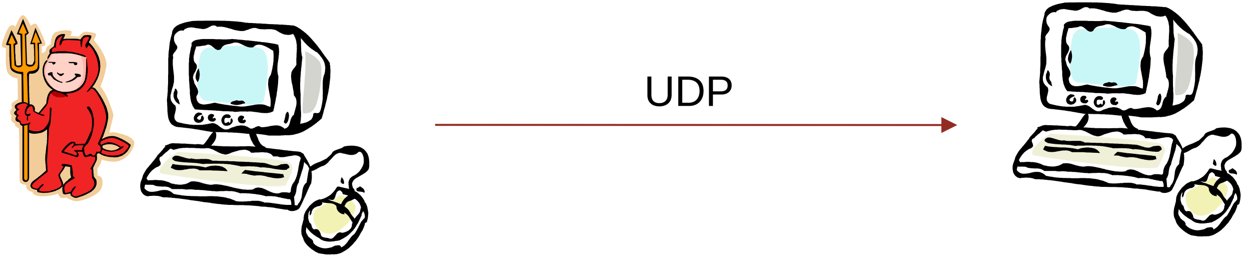
Port open!



Port closed (blocked by firewall?)!



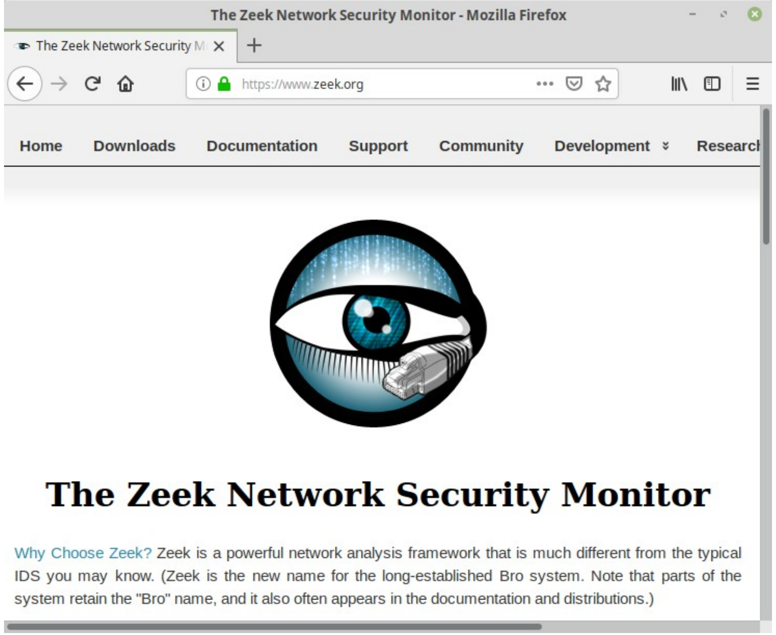
Port closed or blocked by firewall or port open but expecting specific data?



Snort

```
# Snort rule to detect the packet used to exploit a vulnerability in CVS.

alert tcp $EXTERNAL_NET any -> 130.225.254.12 2401 (msg:"CVS server
heap overflow attempt"; flow:to_server,established; content:"|45 6e 74 72 79
20 43 43 43 43 43 43 43 43 43 2f 43 43|"; offset:0; depth:20; dsize: >512;
threshold: type limit, track by_dst, count 1, seconds 60 ; sid:1000000; rev:1;
classtype:attempted-admin;)
```

Example: Files sent over the network



The Zeek Network Security Monitor

Why Choose Zeek? Zeek is a powerful network analysis framework that is much different from the typical IDS you may know. (Zeek is the new name for the long-established Bro system. Note that parts of the system retain the "Bro" name, and it also often appears in the documentation and distributions.)

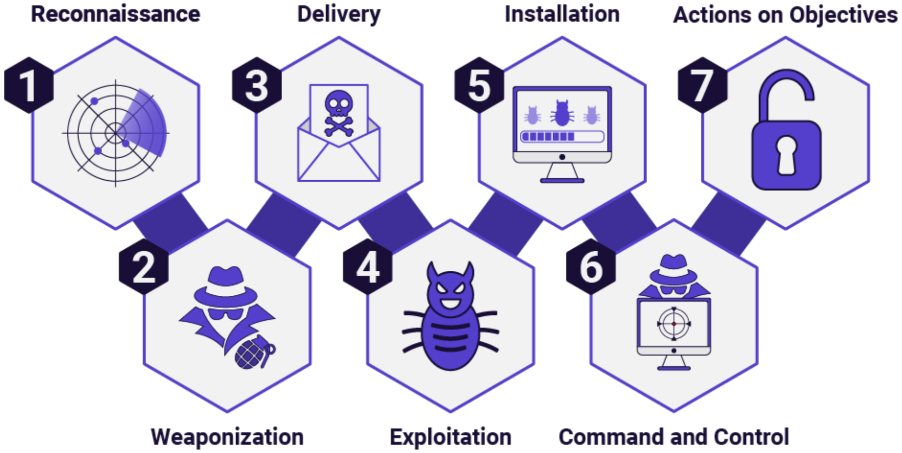
Intrusion Detection in Even More Practice

Where should we focus?

Visibility

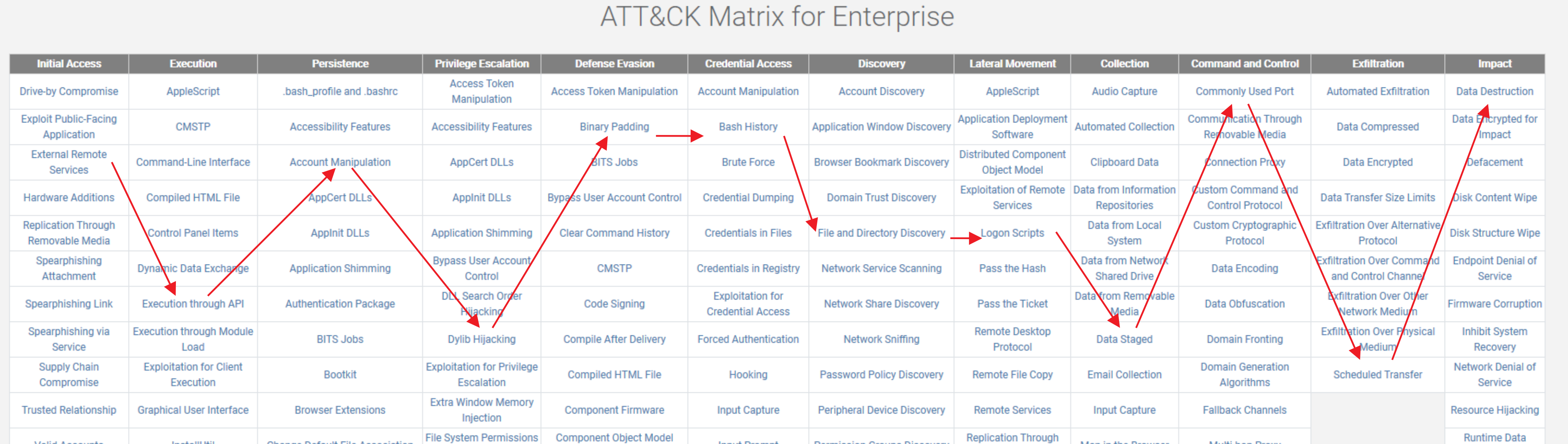
Q: What is the right level of insight we need in our systems and applications to detect intrusions?

A: Study how hackers actually hack: The **Cyber Kill Chain**:



MITRE ATT&CK

The Cyber Kill Chain is a good resource, but somewhat high-level. **MITRE ATT&CK** to the rescue:



ATT&CK Matrix for Enterprise

Initial Access	Execution	Persistence	Privilege Escalation	Defense Evasion	Credential Access	Discovery	Lateral Movement	Collection	Command and Control	Exfiltration	Impact
Drive-by Compromise	AppleScript	.bash_profile and .bashrc	Access Token Manipulation	Access Token Manipulation	Account Manipulation	Account Discovery	AppleScript	Audio Capture	Commonly Used Port	Automated Exfiltration	Data Destruction
Exploit Public-Facing Application	CMSTP	Accessibility Features	Accessibility Features	Binary Padding	Bash History	Application Window Discovery	Application Deployment Software	Automated Collection	Communication Through Removable Media	Data Compressed	Data Encrypted for Impact
External Remote Services	Command-Line Interface	Account Manipulation	AppCert DLLs	BITS Jobs	Brute Force	Browser Bookmark Discovery	Distributed Component Object Model	Clipboard Data	Connection Proxy	Data Encrypted	Defacement
Hardware Additions	Compiled HTML File	AppCert DLLs	AppInit DLLs	Bypass User Account Control	Credential Dumping	Domain Trust Discovery	Exploitation of Remote Services	Data from Information Repositories	Custom Command and Control Protocol	Data Transfer Size Limits	Disk Content Wipe
Replication Through Removable Media	Control Panel Items	AppInit DLLs	Application Shimming	Clear Command History	Credentials in Files	File and Directory Discovery	Logon Scripts	Data from Local System	Custom Cryptographic Protocol	Exfiltration Over Alternative Protocol	Disk Structure Wipe
Spearphishing Attachment	Dynamic Data Exchange	Application Shimming	Bypass User Account Control	CMSTP	Credentials in Registry	Network Service Scanning	Pass the Hash	Data from Network Shared Drive	Data Encoding	Exfiltration Over Command and Control Channel	Endpoint Denial of Service
Spearphishing Link	Execution through API	Authentication Package	DLL Search Order Hijacking	Code Signing	Exploitation for Credential Access	Network Share Discovery	Pass the Ticket	Data from Removable Media	Data Obfuscation	Exfiltration Over Other Network Medium	Firmware Corruption
Spearphishing via Service	Execution through Module Load	BITS Jobs	Dylib Hijacking	Compile After Delivery	Forced Authentication	Network Sniffing	Remote Desktop Protocol	Data Staged	Domain Fronting	Exfiltration Over Physical Medium	Inhibit System Recovery
Supply Chain Compromise	Exploitation for Client Execution	Bootkit	Exploitation for Privilege Escalation	Compiled HTML File	Hooking	Password Policy Discovery	Remote File Copy	Email Collection	Domain Generation Algorithms	Scheduled Transfer	Network Denial of Service
Trusted Relationship	Graphical User Interface	Browser Extensions	Extra Window Memory Injection	Component Firmware	Input Capture	Peripheral Device Discovery	Remote Services	Input Capture	Fallback Channels		Resource Hijacking
Valid Accounts	InstallUtil	Change Default File Association	File System Permissions	Component Object Model	Input Prompt	Permission Groups Discovery	Replication Through	Man in the Browser	Multi-hop Proxy		Runtime Data

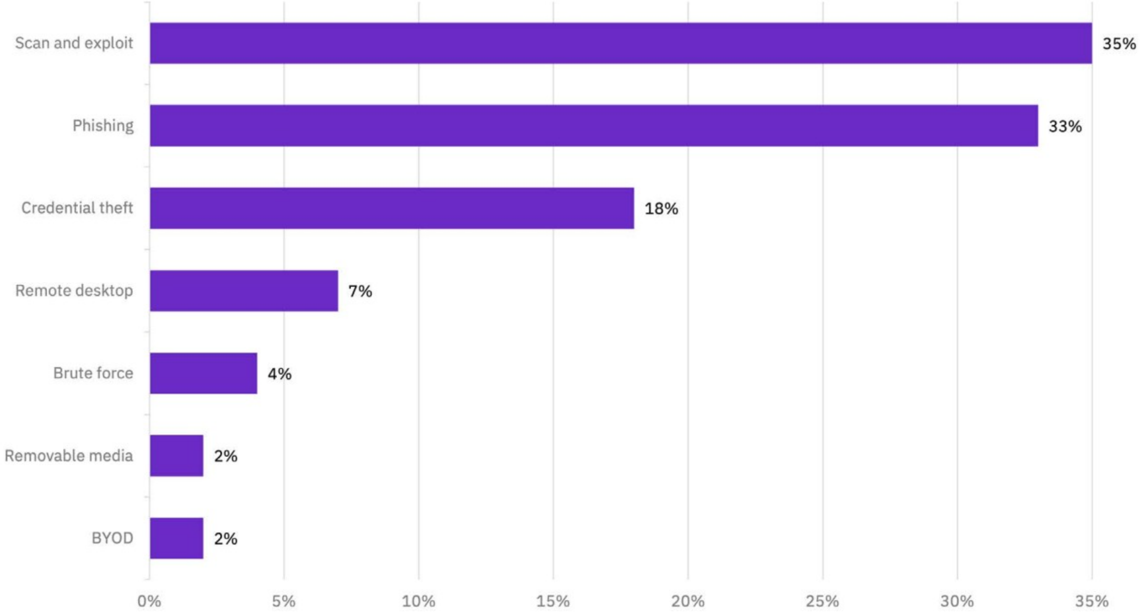
Which ATT&CK Techniques to focus on?

All?

Or, **some**? And if so, then **which**?

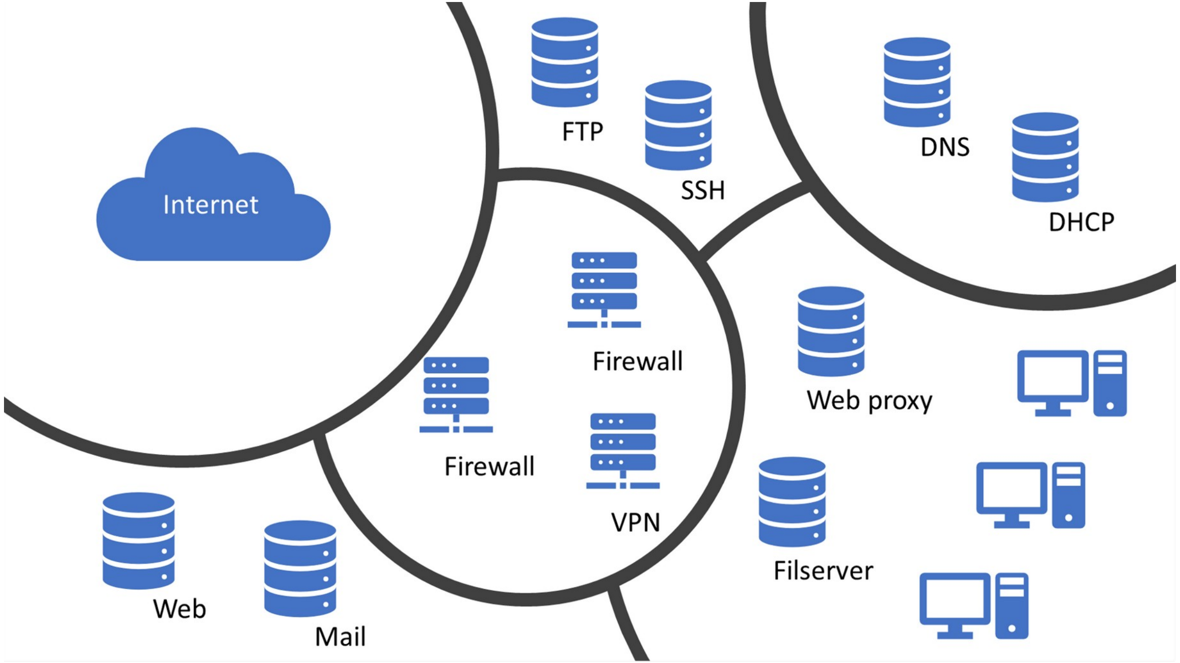
Look at the evidence, i.e. **tecniques observed in the wild** - either by ourself or reported in freely available information aka **(open source) threat intelligence**.

For example, in their 2021 X-Force Threat Intelligence Index, IBM notes their observations on the Initial Access tactic:

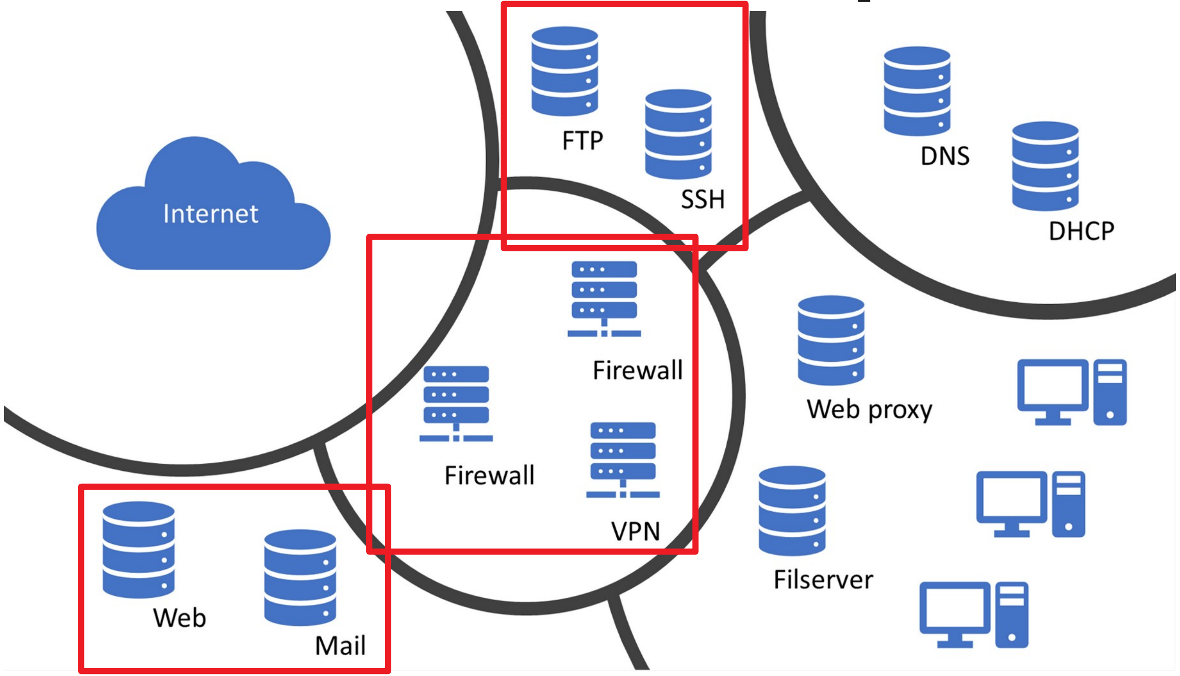


Visibility

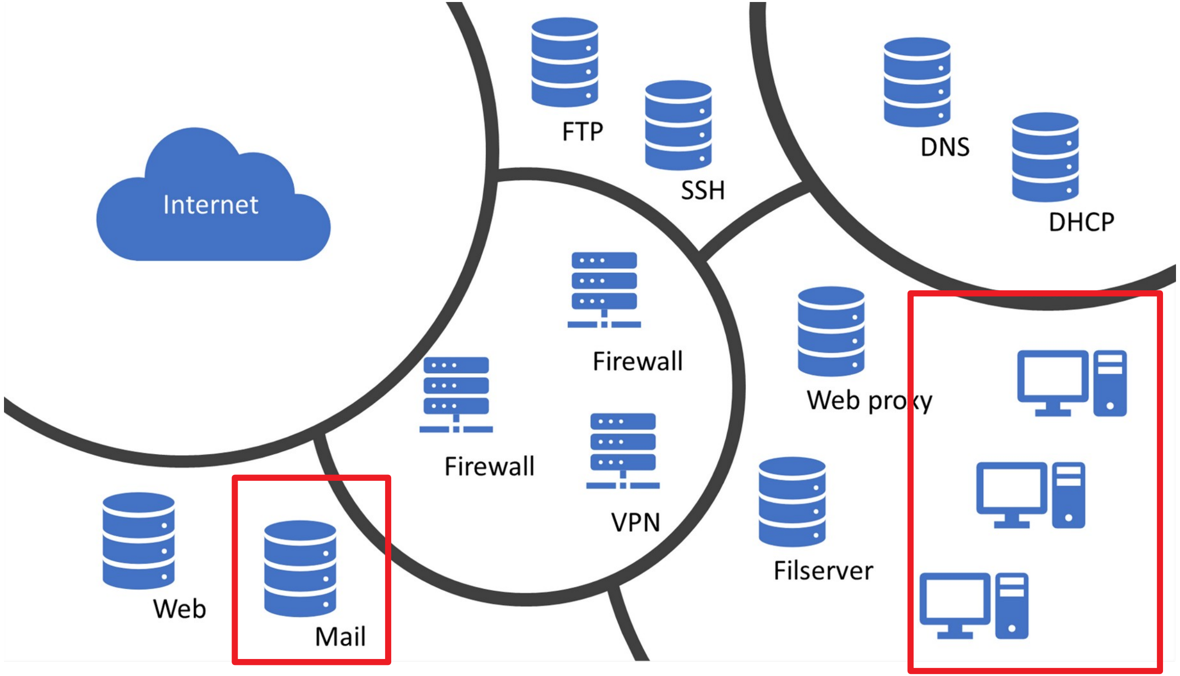
Possible data sources, include:



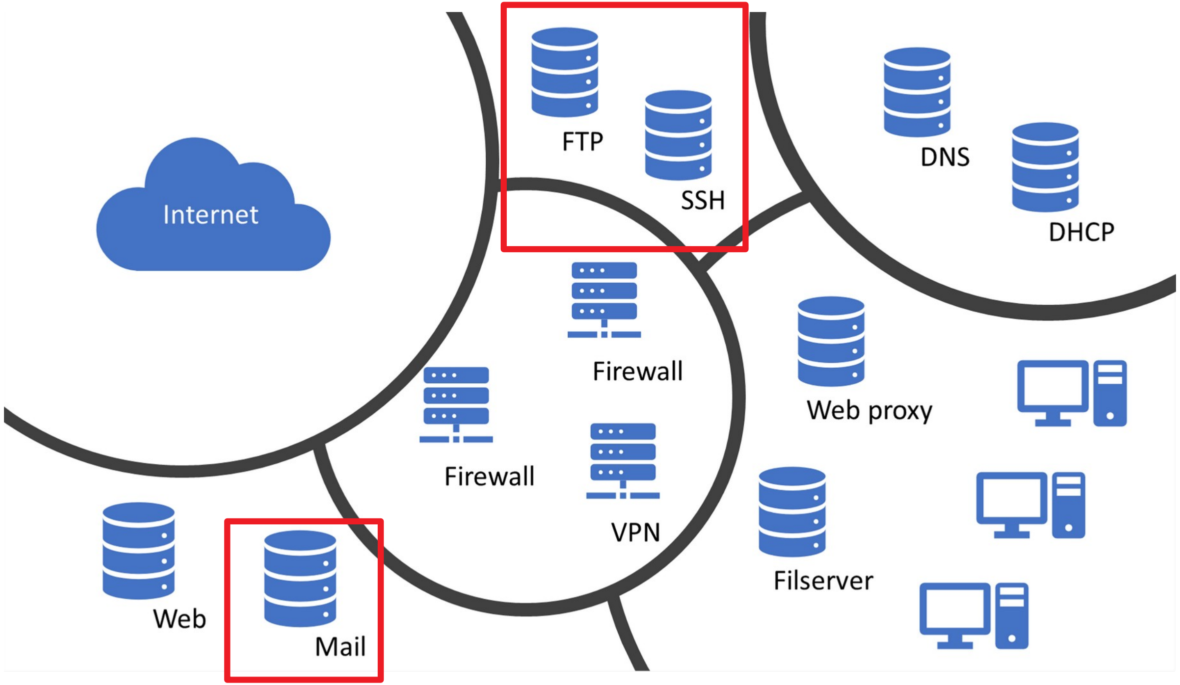
Initial Access: Scan and exploit



Initial Access: Phishing



Initial Access: Credential theft



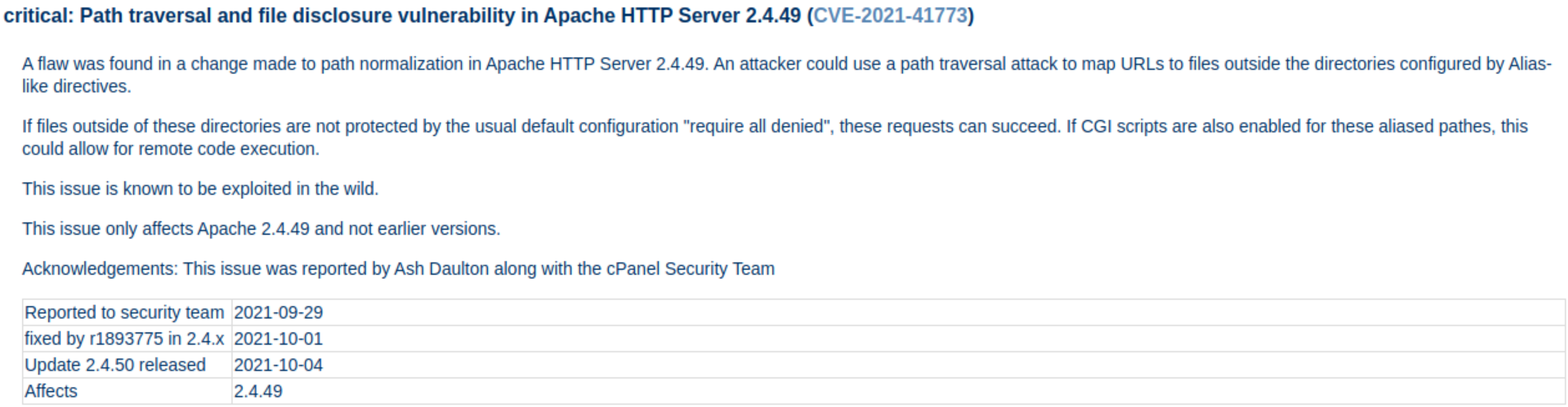
Example mail server log

```
2022-10-10T11:29:49.0000000Z,user@company.com,UserLoggedIn,[Details]      🇩🇰
2022-10-10T11:31:34.0000000Z,user@company.com,UserLoggedIn,[Details]      🇳🇬
2022-10-10T11:31:42.0000000Z,user@company.com,FilePreviewed,[Details]
2022-10-10T11:31:45.0000000Z,user@company.com,UserLoggedIn,[Details]
2022-10-10T11:31:47.0000000Z,user@company.com,UserLoggedIn,[Details]
2022-10-10T11:32:44.0000000Z,user@company.com,UserLoggedIn,[Details]
2022-10-10T11:32:54.0000000Z,user@company.com,UserLoggedIn,[Details]
2022-10-10T11:42:30.0000000Z,user@company.com,Set-Mailbox,[Details]
2022-10-10T11:49:33.0000000Z,user@company.com,New-InboxRule,[Details]
2022-10-10T11:55:24.0000000Z,user@company.com,UserLoggedIn,[Details]
```

Example web server log

```
[Oct 1 12:47:57 2022] 87.118.116.103:46928 [200]: /pressroom.php
[Oct 1 12:47:57 2022] 87.118.116.103:46930 [404]: /favicon.ico - No such file or directory
[Oct 1 12:47:57 2022] Notice:  Undefined index: tag in /tmp/php/pressroom.php on line 17
[Oct 1 12:48:05 2022] 87.118.116.103:46932 [200]: /pressroom.php?tag=news
[Oct 1 12:48:14 2022] 87.118.116.103:46934 [200]: /pressroom.php?tag=events
[Oct 1 12:48:14 2022] 87.118.116.103:46936 [200]: /pressroom.php?tag=research
[Oct 1 12:48:18 2022] 87.118.116.103:46938 [200]: /pressroom.php?tag=foo
[Oct 1 12:48:18 2022] Notice:  Non-existent tag requested: foo
[Oct 1 12:48:55 2022] 87.118.116.103:46946 [200]: /pressroom.php?tag=error.log
[Oct 1 12:49:10 2022] 87.118.116.103:46950 [200]: /pressroom.php?tag=../../etc/passwd
```

CVE-2021-41773 Apache path traversal



critical: Path traversal and file disclosure vulnerability in Apache HTTP Server 2.4.49 (CVE-2021-41773)

A flaw was found in a change made to path normalization in Apache HTTP Server 2.4.49. An attacker could use a path traversal attack to map URLs to files outside the directories configured by Alias-like directives.

If files outside of these directories are not protected by the usual default configuration "require all denied", these requests can succeed. If CGI scripts are also enabled for these aliased pathes, this could allow for remote code execution.

This issue is known to be exploited in the wild.

This issue only affects Apache 2.4.49 and not earlier versions.

Acknowledgements: This issue was reported by Ash Daulton along with the cPanel Security Team

Reported to security team	2021-09-29
fixed by r1893775 in 2.4.x	2021-10-01
Update 2.4.50 released	2021-10-04
Affects	2.4.49

```
$hostname/cgi-bin/.%2e/%2e%2e/%2e%2e/etc/passwd
```

Example DNS log

```
30-09-2022 01:29:55 UDP Rcv 10.232.65.43    Q (3)www(7)gstatic(3)com(0)
30-09-2022 01:29:55 UDP Snd 10.232.65.43  R Q (3)www(7)gstatic(3)com(0)
30-09-2022 01:29:55 UDP Rcv 10.201.120.30   Q (5)login(4)live(3)com(0)
30-09-2022 01:29:55 UDP Snd 10.201.120.30 R Q (5)login(4)live(3)com(0)
30-09-2022 01:29:55 UDP Rcv 10.230.20.106   Q (2)gg(6)google(3)com(0)
30-09-2022 01:29:55 UDP Snd 10.230.20.106 R Q (2)gg(6)google(3)com(0)
30-09-2022 01:29:55 UDP Rcv 10.201.100.45   Q (4)pool(3)ntp(3)org(0)
30-09-2022 01:29:55 UDP Snd 10.201.100.45 R Q (4)pool(3)ntp(3)org(0)
30-09-2022 01:29:55 UDP Rcv 10.201.100.65   Q (5)yahoo(3)com(0)
30-09-2022 01:29:55 UDP Snd 10.201.100.65 R Q (5)yahoo(3)com(0)
```

Example DHCP log

```
10,2022/09/09,08:30:01,Assign,10.201.22.101,WS10012A,8c164566564e
10,2022/09/09,08:33:12,Assign,10.201.22.108,WS10022A,8c1645665a4b,
10,2022/09/09,08:33:55,Assign,10.201.22.109,WS10052A,8c164566779e,
10,2022/09/09,08:34:01,Assign,10.201.22.110,WS10044A,8c164566464c,
11,2022/09/09,08:34:32,Renew,10.201.22.122,VM10081A,005056c00001,
10,2022/09/09,08:34:34,Assign,10.201.22.130,WS10012A,8c16456651aa
11,2022/09/09,08:35:45,Renew,10.201.22.133,VM10110A,005056cee001,
10,2022/09/09,08:35:53,Assign,10.201.22.134,WS10072A,8c16456ab1a4b,
12,2022/09/09,08:37:01,Release,10.201.22.110,WS10048A,8c16456694c,
10,2022/09/09,08:37:10,Assign,10.201.22.110,WS10097A,8c164561239e,
```

Example firewall log

```
Mar  1 11:28:47 Built inbound UDP id 4253 from 192.38.84.35/7179 to 130.226.237.14/53
Mar  1 11:28:47 Teardown TCP id 4198 duration 0:00:00 bytes 7194 TCP FINs from in
Mar  1 11:28:47 Deny TCP from 10.150.96.249/54735 to 130.226.237.153/4433 flags RST ACK
Mar  1 11:28:47 Built inbound UDP id 4254 from 192.38.84.42/61918 to 130.226.237.14/53
Mar  1 11:28:47 Built inbound UDP id 4257 from 10.202.55.102/64651 to 130.226.237.14/53
Mar  1 11:28:47 Built outbound UDP id 4259 from 130.226.142.7/53 to 130.226.237.14/20238
Mar  1 11:28:47 Built inbound UDP id 4258 from 10.202.55.21/53921 to 130.226.237.14/53
Mar  1 11:28:47 Built outbound UDP id 4255 from 130.226.237.173/53 to 130.226.237.14/27800
Mar  1 11:28:47 Teardown TCP id 4210 duration 0:00:00 bytes 0 TCP FINs
Mar  1 11:28:47 Built inbound id 4260 TCP from 10.209.100.121/62921 to 130.226.237.153/4433
```

Example firewall log

```
Jun 4 14:23:01 src=192.168.30.143 dst=46.30.215.95 tcp spt=42449 dpt=80 len=60 syn [Details]
Jun 4 14:23:01 src=46.30.215.95 dst=192.168.30.143 tcp spt=80 dpt=42449 len=60 ack syn [Details]
Jun 4 14:23:01 src=192.168.30.143 dst=46.30.215.95 tcp spt=42449 dpt=80 len=52 ack [Details]
Jun 4 14:23:01 src=192.168.30.143 dst=46.30.215.95 tcp spt=42449 dpt=80 len=39 ack psh [Details]
Jun 4 14:23:01 src=46.30.215.95 dst=192.168.30.143 tcp spt=80 dpt=42449 len=52 ack [Details]
Jun 4 14:23:01 src=46.30.215.95 dst=192.168.30.143 tcp spt=80 dpt=42449 len=67 ack psh [Details]
Jun 4 14:23:01 src=192.168.30.143 dst=46.30.215.95 tcp spt=42449 dpt=80 len=52 ack [Details]
Jun 4 14:23:01 src=46.30.215.95 dst=192.168.30.143 tcp spt=80 dpt=42449 len=64 ack psh [Details]
Jun 4 14:23:01 src=192.168.30.143 dst=46.30.215.95 tcp spt=42449 dpt=80 len=52 ack [Details]
Jun 4 14:23:01 src=46.30.215.95 dst=192.168.30.143 tcp spt=80 dpt=42449 len=52 ack fin [Details]
```

Example Windows server Security Log

```
Information 10-06-2021 05:00:00 Microsoft Windows security auditing. 4624 Logon
Information 10-06-2021 05:00:00 Microsoft Windows security auditing. 4648 Logon
Information 10-06-2021 04:55:29 Microsoft Windows security auditing. 4625 Logon
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4624 Logon
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4648 Logon
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4673 Sensitive Privilege Use
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4624 Logon
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4648 Logon
Information 10-06-2021 04:55:27 Microsoft Windows security auditing. 4673 Sensitive Privilege Use
Information 10-06-2021 04:55:10 Microsoft Windows security auditing. 4673 Sensitive Privilege Use
```

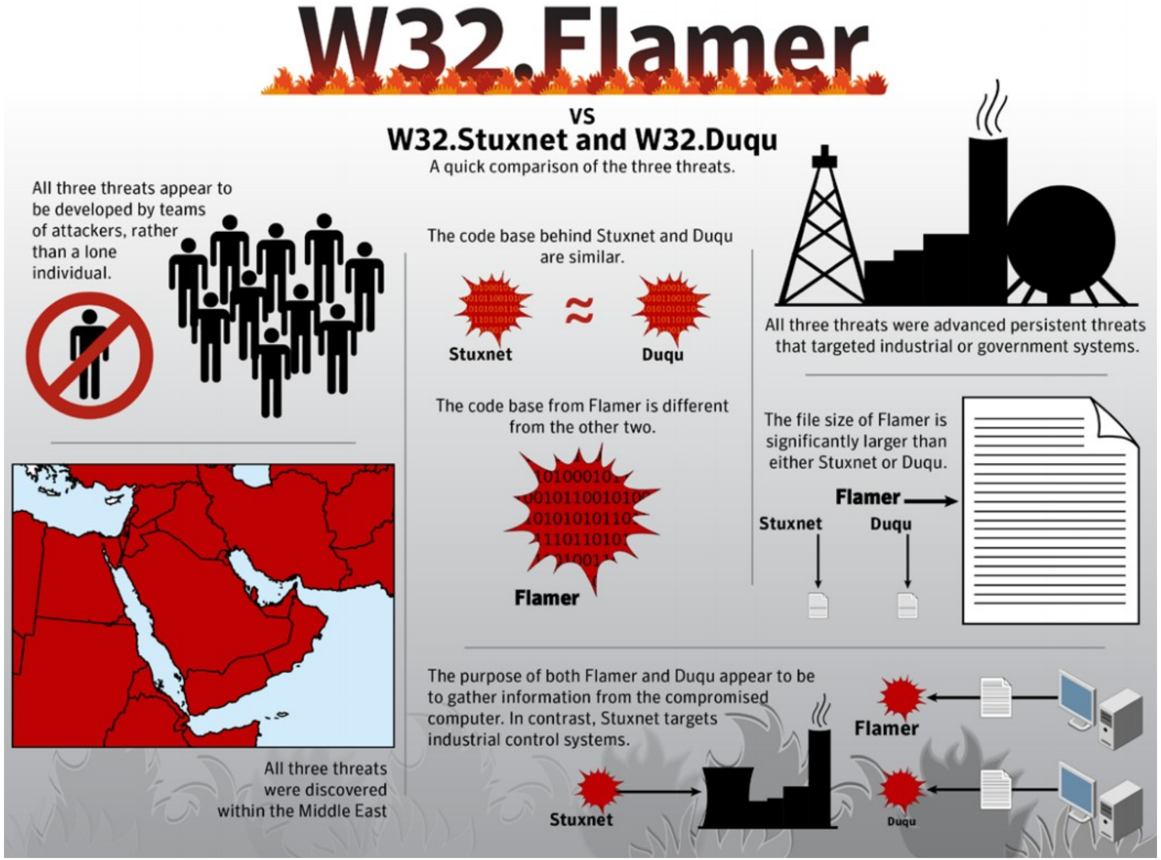
Indicators of compromise in Intrusion Detection

Indicators of compromise (IOCs)

Technical characteristics that identify a known threat, attacker methodology, or other evidence of compromise, e.g.:

- C2 domains
- IPs used in attack
- Special GET requests
- Malware file system locations
- Malware hashes
- Memory artifacts

Duqu IOCs



W32.Flamer

VS

W32.Stuxnet and W32.Duqu

A quick comparison of the three threats.

All three threats appear to be developed by teams of attackers, rather than a lone individual.

All three threats were discovered within the Middle East

The code base behind Stuxnet and Duqu are similar.

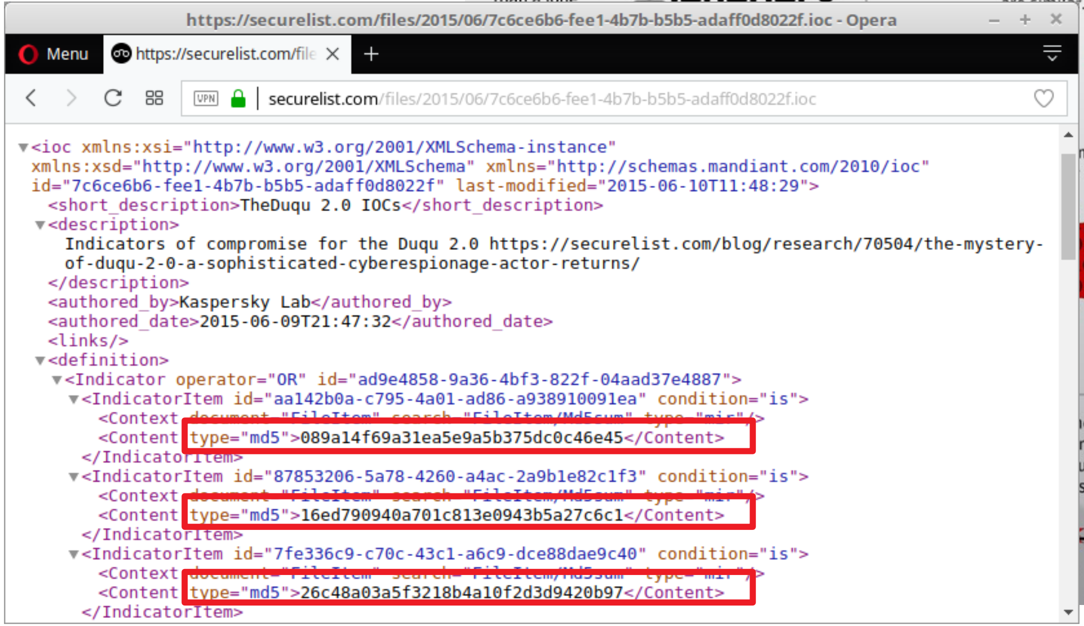
The code base from Flamer is different from the other two.

All three threats were advanced persistent threats that targeted industrial or government systems.

The file size of Flamer is significantly larger than either Stuxnet or Duqu.

The purpose of both Flamer and Duqu appear to be to gather information from the compromised computer. In contrast, Stuxnet targets industrial control systems.

Duqu IOCs



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Menu
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securelist.com/files/2015/06/7c6ce6b6-fee1-4b7b-b5b5-adaff0d8022f.ioc
VPN

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 ▼<description>
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   </description>
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   <links/>
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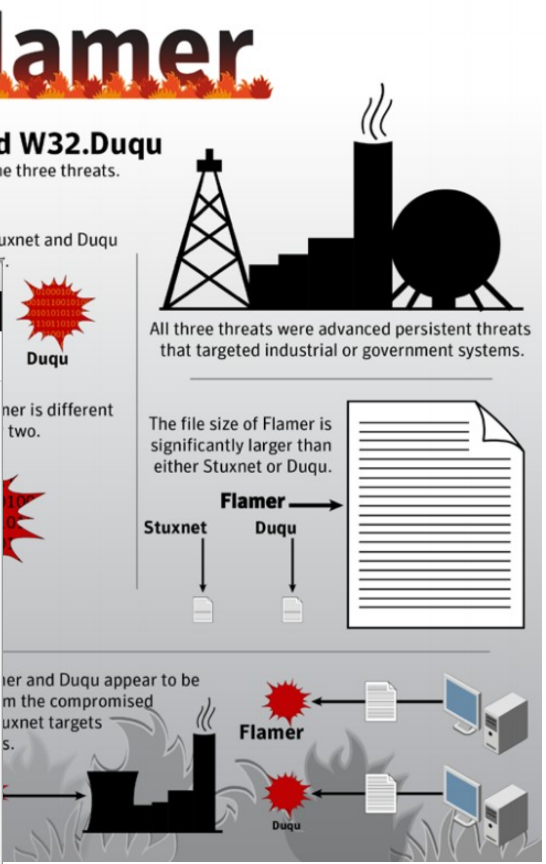

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Duqu
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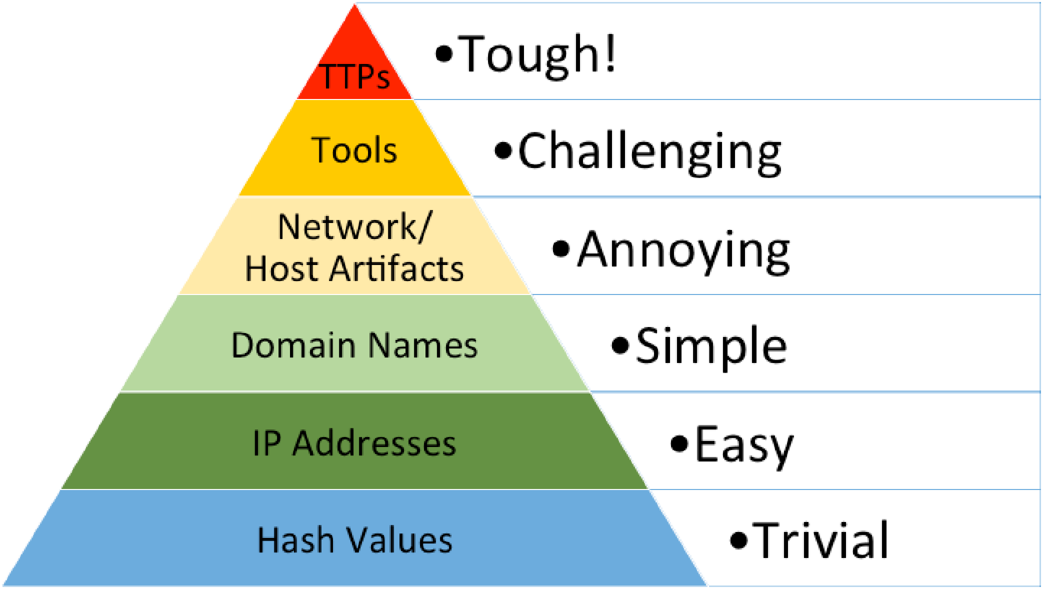
Flamer
Duqu

IOCs and “The Pyramid of Pain”



TTPs
- Tough!

Tools
- Challenging

Network/
Host Artifacts
- Annoying

Domain Names
- Simple

IP Addresses
- Easy

Hash Values
- Trivial

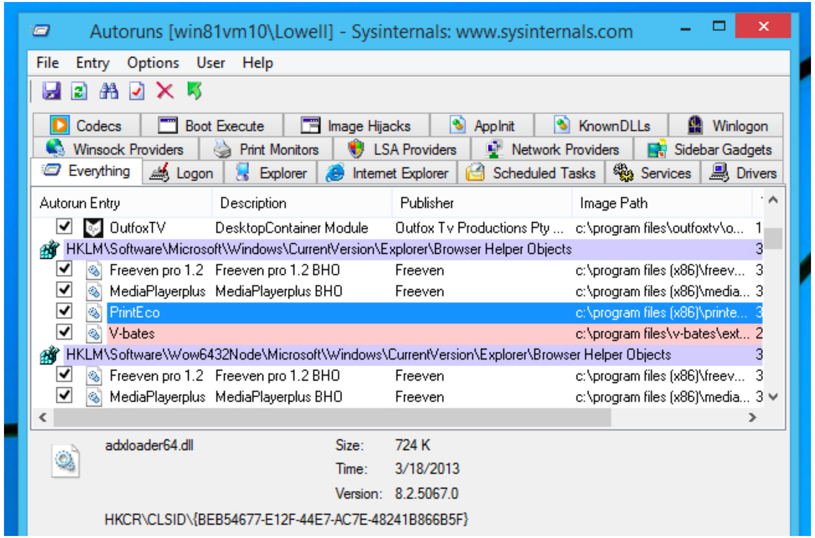
IOC (hash) strategy

```
Collect IOC file hashes
For each host in my network:
    Calculate file hashes
    Match against IOC list
Problems:
    What if attacker updates the malware?
    What if we get a match = IOC fidelity
```

Refined approach

Same as before but in stead of all files, calculate only for executables that **autostart**

Plus: Look for new entries or hosts with entries unlike most, i.e. **anomalies** instead of IOCs only



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☑ Freeven pro 1.2	Freeven pro 1.2 BHO	Freeven	c:\program files (x86)\freev...	3
☑ MediaPlayerplus	MediaPlayerplus BHO	Freeven	c:\program files (x86)\media...	3
☑ PrintEco			c:\program files (x86)\printe...	3
☑ V-bates			c:\program files\v-bates\ext...	2
HKLM\Software\Wow6432Node\Microsoft\Windows\CurrentVersion\Explorer\Browser Helper Objects				3
☑ Freeven pro 1.2	Freeven pro 1.2 BHO	Freeven	c:\program files (x86)\freev...	3
☑ MediaPlayerplus	MediaPlayerplus BHO	Freeven	c:\program files (x86)\media...	3

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Time: 3/18/2013
Version: 8.2.5067.0

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