NTLM Relay Risk Is Coming

A New Exploit Technique Makes It Reborn

TyphoonCon

BCM Social Corp.

About us

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BCM Social Corp.

- Leader of Red Team at BCM Social Corp.
- Specializes in penetration testing and wireless security.
- A lecturer at the China Internet Security Conference (ISC) security training camp.
- Blackhat, Codeblue, Poc, Kcon, CanSecWest, etc. Conference speaker.

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Back2Zero

- Back2Zero/XDSEC Team.
- Independent Security Researcher.
- Currently focusing on web application security, cloud security, windows security.

TL;DR

- NTLM basic
- NTLM reflection attack history
- New technology to perform NTLM reflection attack
- A whole new perspective in SSRF
- Critical security issue in JAVA
- The new era in NTLM Reflection

Let’s Talk About NTLM

NTLM Authentication

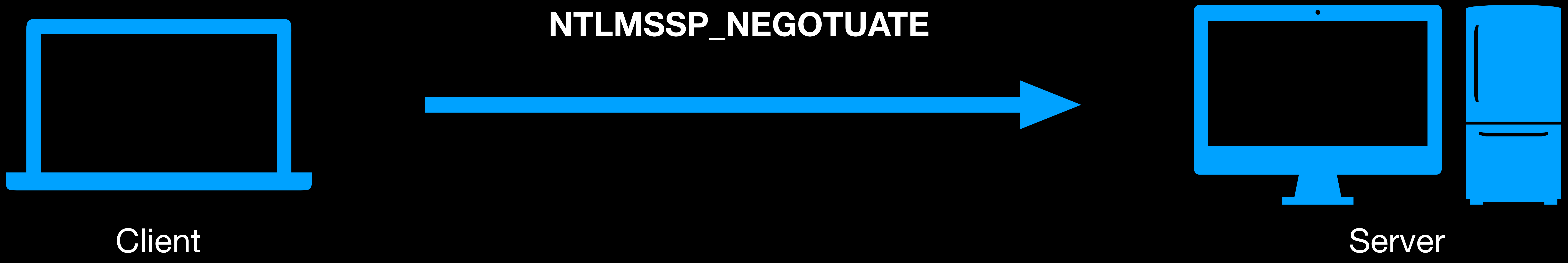
- NT LAN Manager: Suite of security protocols NTLM
- Network authentication for Remote Services
- Challenge-Response authentication mechanism

NTLM Authentication

- Supported by the NTLM Security Support Provider on Windows
- NTLMv1/ NTLMv2/ NTLM2 Session
- HTTP, SMB, LDAP, MSSQL, etc.

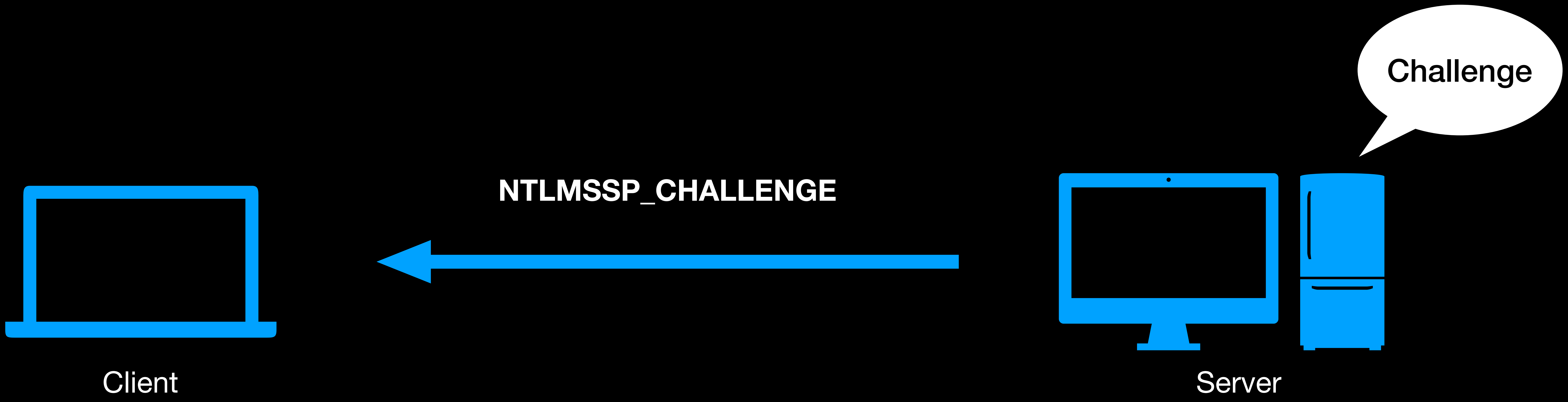
NTLM Type 1 Message

Client Request - NTLMSSP_NEGOTUATE



NTLM Type 2 Message

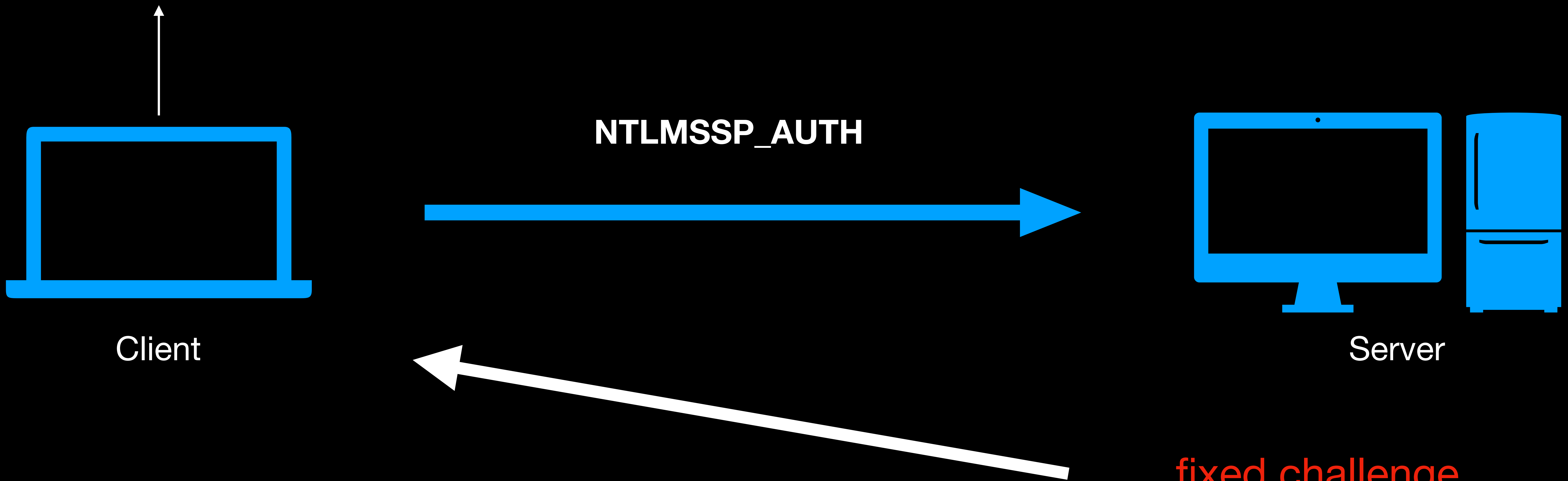
Server Response - NTLMSSP_CHALLENGE



NTLM Type 3 Message

Client Request - NTLMSSP_AUTH

Net-NTLM = f(Challenge, NTLM Hash)

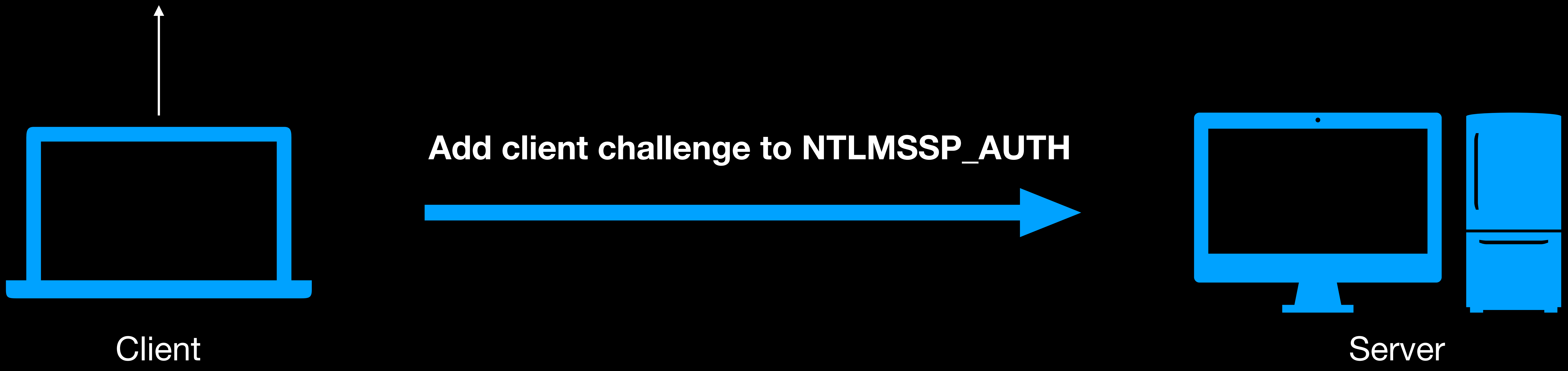


fixed challenge

NTLMv2 Type 3 Message

Difference in NTLMv2 and NTLMv1

Net-NTLM = f(Challenge, NTLM Hash, Client Challenge)



SMB -> SMB Reflection Attack

NTLM Reflection

SMB Reflection - SMB->SMB

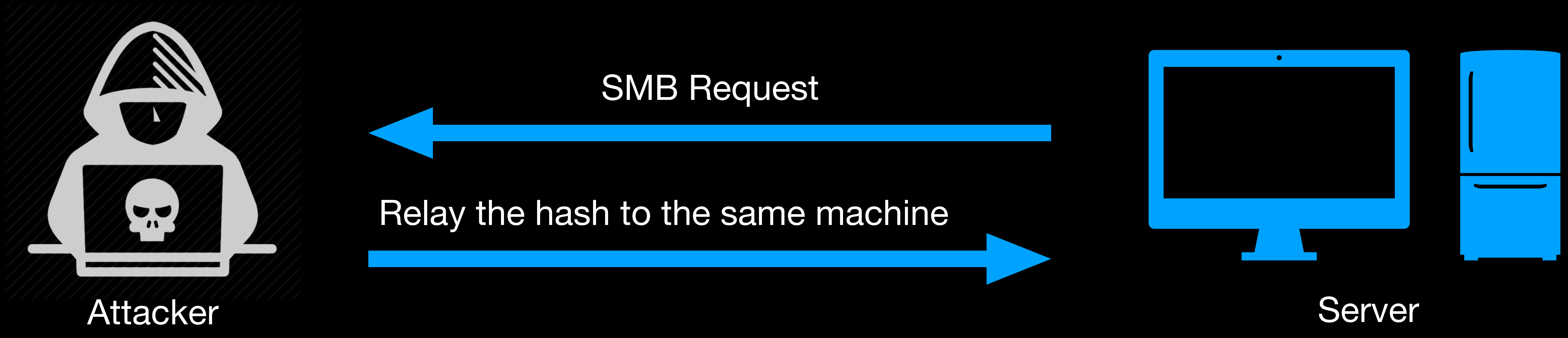
Steps to reproduce:

Visiting an attacker's Web site with file:// in HTLM.

The browser will authenticate to attacker automatically.

(There are many ways to get an SMB request)

Relaying the Net-NTLM HASH to the same machine (SMB Reflection)



NTLM Reflection

SMB Reflection - MS08-068

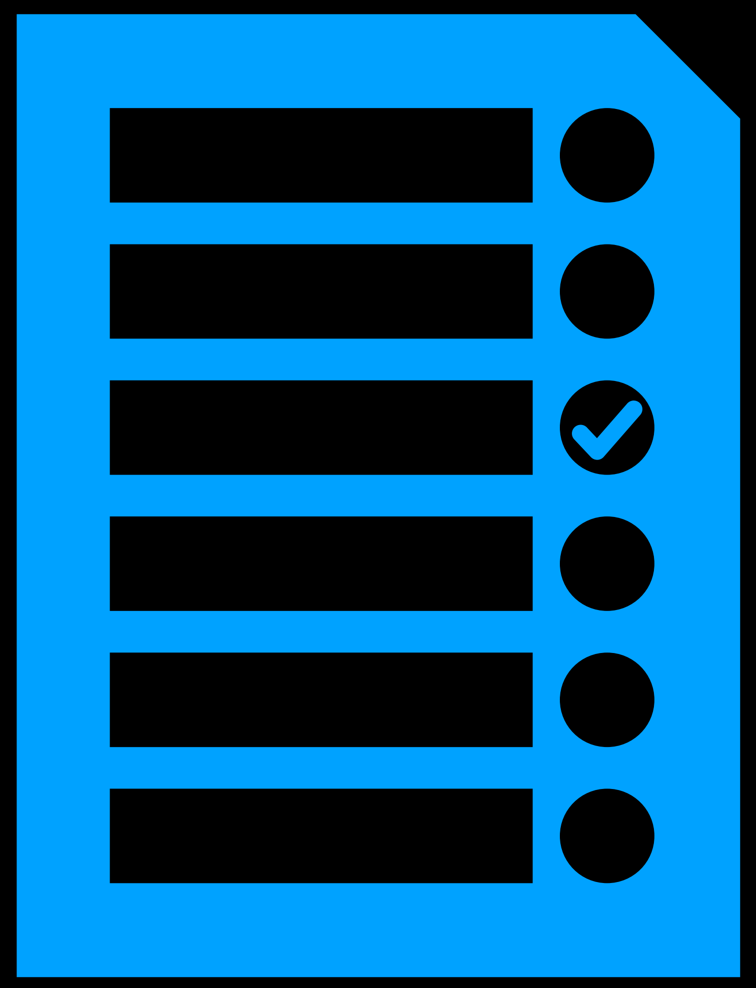
Microsoft issued a partial fix (MS08-068)

Stop relaying back to itself finally.

Can not stop Attacker from

Relaying the Net-NTLM Hash to another machine or

Perform Cross-Protocol Reflection attack.



Active Challenge Table

HTTP -> SMB Reflection Attack

Cross-Protocol Reflection

NTLM Reflection

Hot Potato - HTTP->SMB Reflection

Combined 3 vulnerabilities to perform Privilege Escalation

1. NetBIOS Name Service Spoofing
2. Web Proxy Auto-Discovery (WAPD) MITM Attack
3. HTTP->SMB Reflection Attack

NTLM Reflection

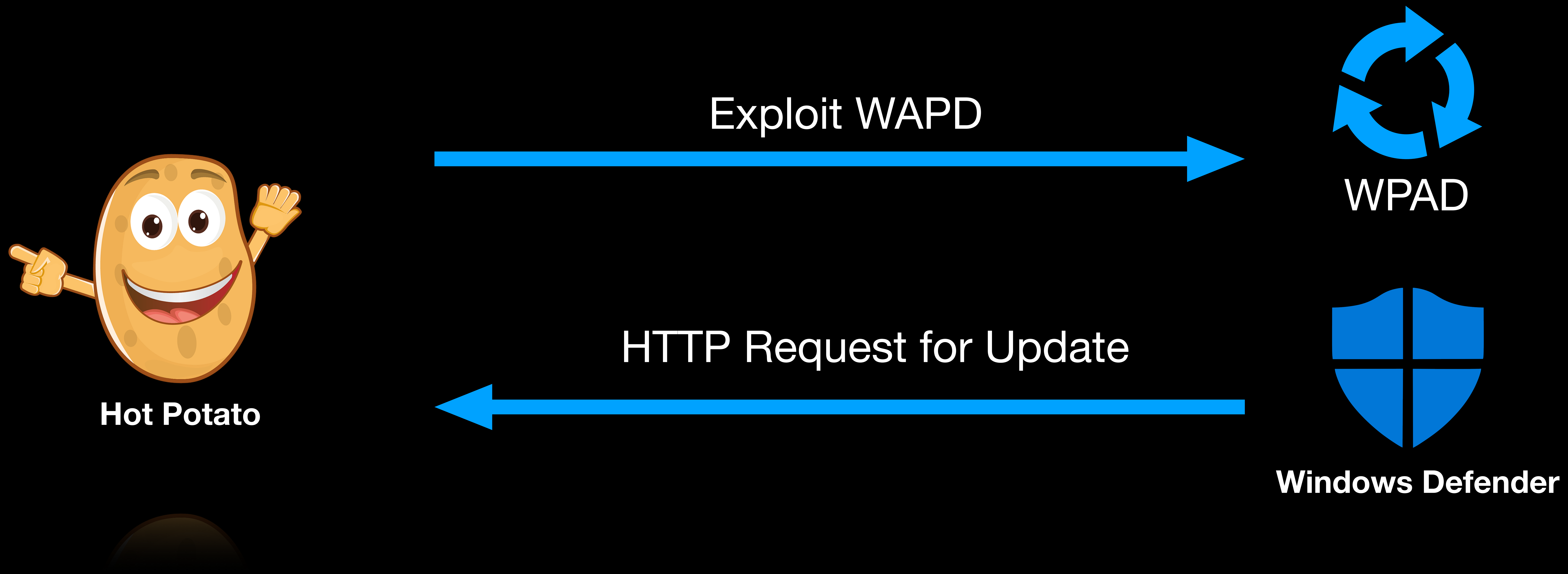
Hot Potato - HTTP->SMB Reflection

6 Steps To Reproduce (Windows 7)

1. Start NBNS Spoofing to hijack WAPD
2. Start a Web Server on localhost:80
3. Redirect Windows Defender Update request to http//localhost/GETHASHxxx
4. Send 401 Response to Windows Defender Update
5. Windows Defender Update will authenticate to us with SYSTEM account automatically.
6. Send the Net-NTLM Hash to Samba Service

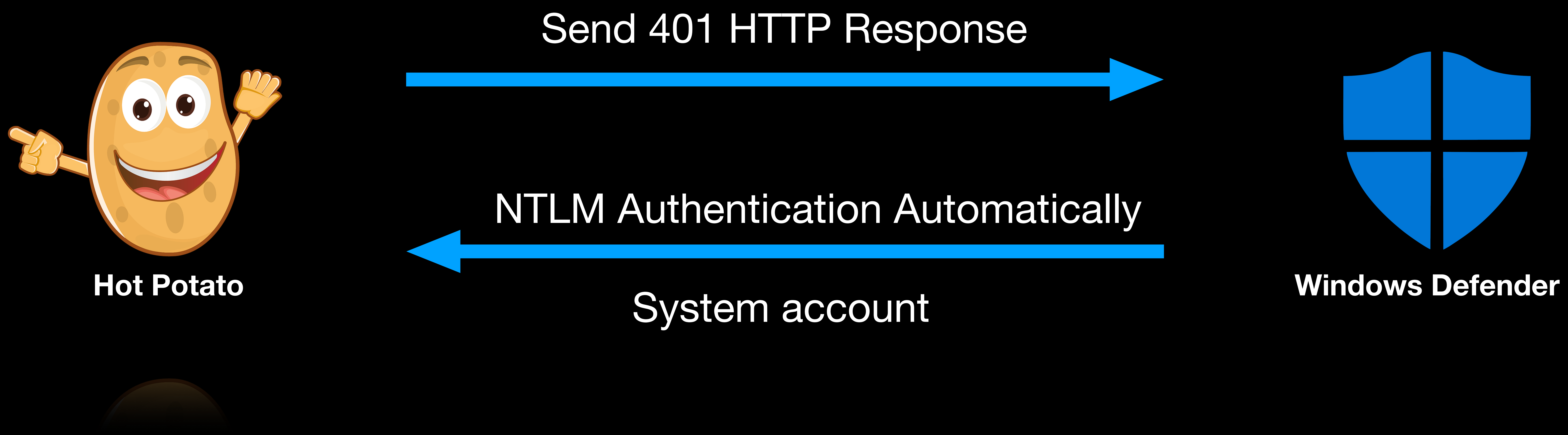
NTLM Reflection

Hot Potato - HTTP->SMB Reflection



NTLM Reflection

Hot Potato - HTTP->SMB Reflection



Send 401 HTTP Response

NTLM Authentication Automatically

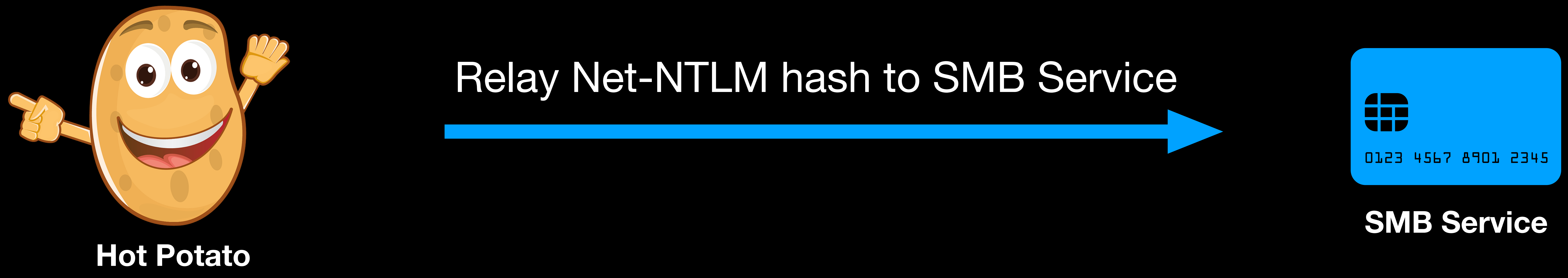
System account

Hot Potato

Windows Defender

NTLM Reflection

Hot Potato - HTTP->SMB Reflection



Hot Potato

Relay Net-NTLM hash to SMB Service

SMB Service

NTLM Reflection

Hot Potato - HTTP->SMB Reflection

MS16-075

Fix local HTTP->SMB Reflection

MS16-077

WPAD Name Resolution will not use NetBIOS (CVE-2016-3213)

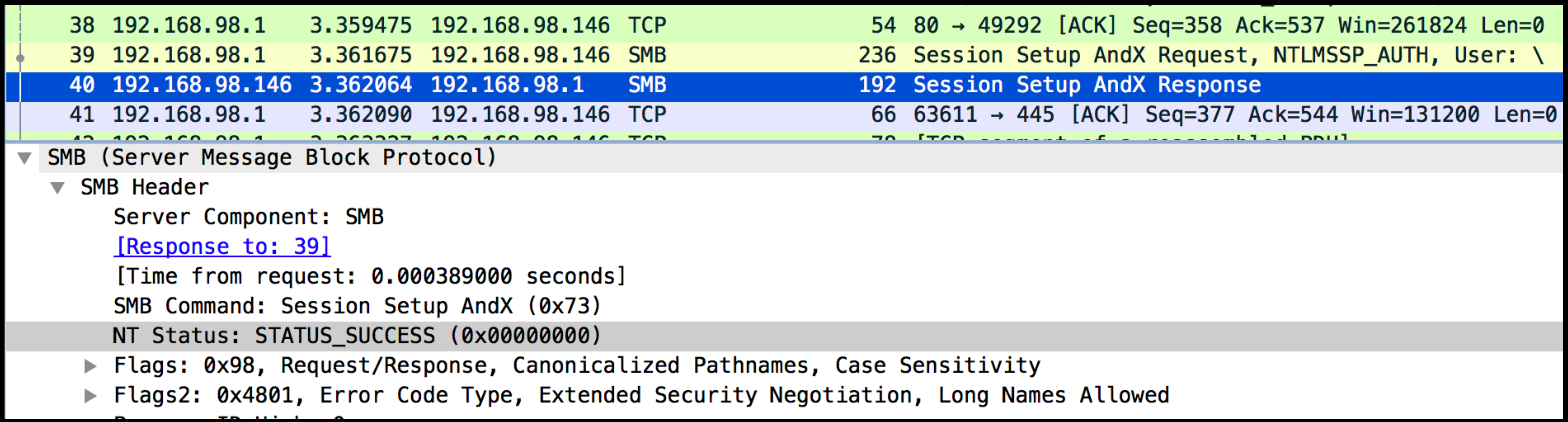
Does not send credential when requesting the PAC file(CVE-2016-3236)

New technology to perform NTLM reflection attack

NTLM Reflection

A Journey to bypass MS16-075

Unpatched



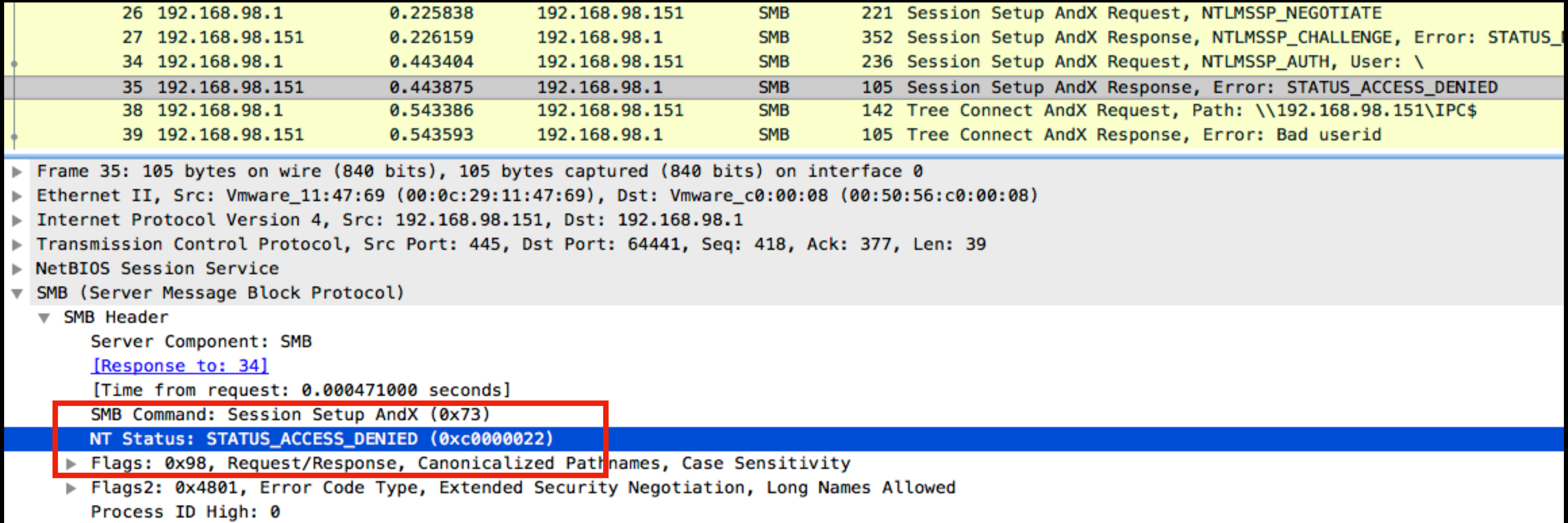
```
38  192.168.98.1    3.359475  192.168.98.146  TCP    54  80 → 49292 [ACK] Seq=358 Ack=537 Win=261824 Len=0
39  192.168.98.1    3.361675  192.168.98.146  SMB   236  Session Setup AndX Request, NTLMSSP_AUTH, User: \
40  192.168.98.146  3.362064  192.168.98.1    SMB   192  Session Setup AndX Response
41  192.168.98.1    3.362090  192.168.98.146  TCP    66  63611 → 445 [ACK] Seq=377 Ack=544 Win=131200 Len=0
```

```
▼ SMB (Server Message Block Protocol)
  ▼ SMB Header
      Server Component: SMB
      [Response to: 39]
      [Time from request: 0.000389000 seconds]
      SMB Command: Session Setup AndX (0x73)
      NT Status: STATUS_SUCCESS (0x00000000)
    ▶ Flags: 0x98, Request/Response, Canonicalized Pathnames, Case Sensitivity
    ▶ Flags2: 0x4801, Error Code Type, Extended Security Negotiation, Long Names Allowed
```

NTLM Reflection

A Journey to bypass MS16-075

Patched



```
26  192.168.98.1     0.225838   192.168.98.151   SMB   221  Session Setup AndX Request, NTLMSSP_NEGOTIATE
27  192.168.98.151   0.226159   192.168.98.1     SMB   352  Session Setup AndX Response, NTLMSSP_CHALLENGE, Error: STATUS_
34  192.168.98.1     0.443404   192.168.98.151   SMB   236  Session Setup AndX Request, NTLMSSP_AUTH, User: \
35  192.168.98.151   0.443875   192.168.98.1     SMB   105  Session Setup AndX Response, Error: STATUS_ACCESS_DENIED
38  192.168.98.1     0.543386   192.168.98.151   SMB   142  Tree Connect AndX Request, Path: \\192.168.98.151\IPC$
39  192.168.98.151   0.543593   192.168.98.1     SMB   105  Tree Connect AndX Response, Error: Bad userid
```

```
▶ Frame 35: 105 bytes on wire (840 bits), 105 bytes captured (840 bits) on interface 0
▶ Ethernet II, Src: Vmware_11:47:69 (00:0c:29:11:47:69), Dst: Vmware_c0:00:08 (00:50:56:c0:00:08)
▶ Internet Protocol Version 4, Src: 192.168.98.151, Dst: 192.168.98.1
▶ Transmission Control Protocol, Src Port: 445, Dst Port: 64441, Seq: 418, Ack: 377, Len: 39
▶ NetBIOS Session Service
▼ SMB (Server Message Block Protocol)
  ▼ SMB Header
      Server Component: SMB
      [Response to: 34]
      [Time from request: 0.000471000 seconds]
      SMB Command: Session Setup AndX (0x73)
      NT Status: STATUS_ACCESS_DENIED (0xc0000022)
    ▶ Flags: 0x98, Request/Response, Canonicalized Pathnames, Case Sensitivity
    ▶ Flags2: 0x4801, Error Code Type, Extended Security Negotiation, Long Names Allowed
      Process ID High: 0
```

NTLM Reflection

A Journey to bypass MS16-075

Flags in Type 2 Message

Contained in a bitfield within the header

Most of these will make more sense late

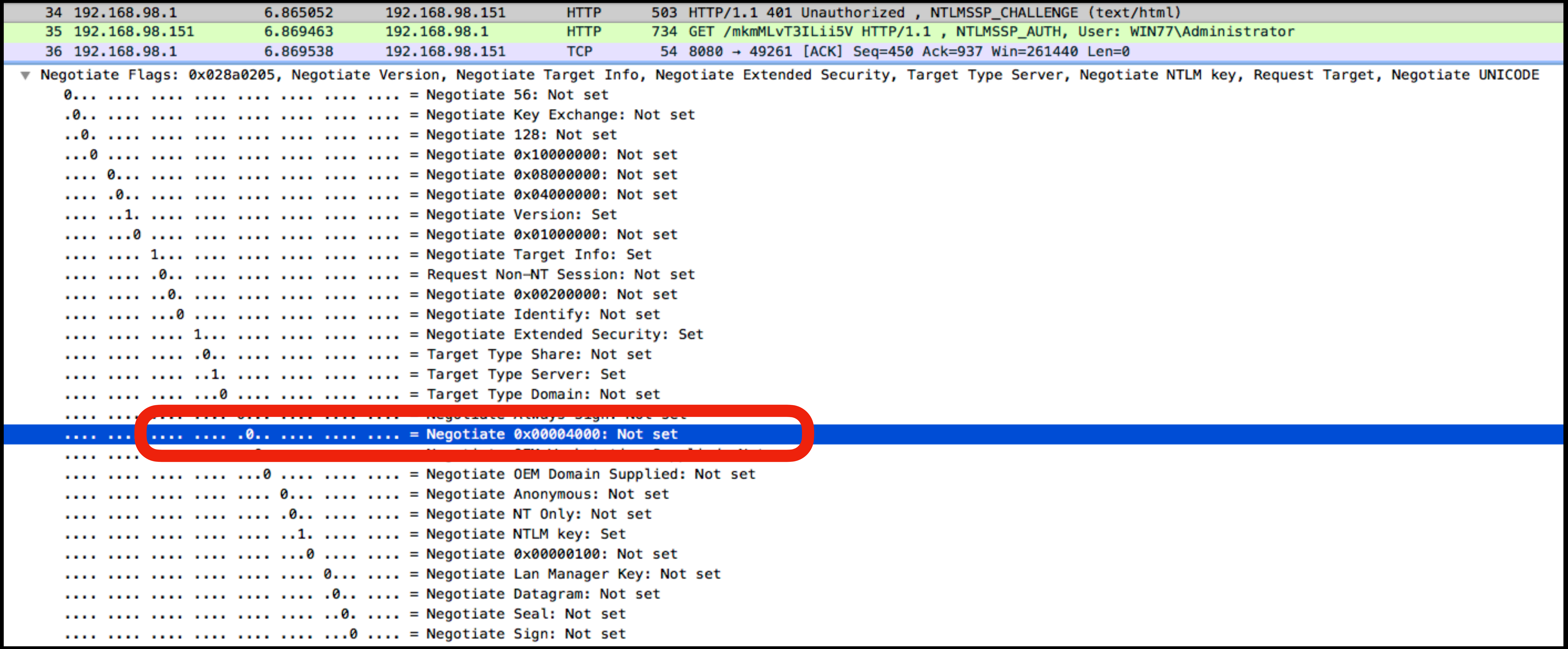
Description	Content
Signature	Null-terminated ASCII "NTLMSSP"
Message Type	long (0x02000000)
Target Name	the name of the authentication target
Flags	long
Challenge	8 bytes information about the authentication target
Context	8 bytes
Target Information	security buffer
Version	8 bytes

Fuzzing NTLM Message Flags

NTLM Reflection

A Journey to bypass MS16-075

Get a different Type 3 Message!



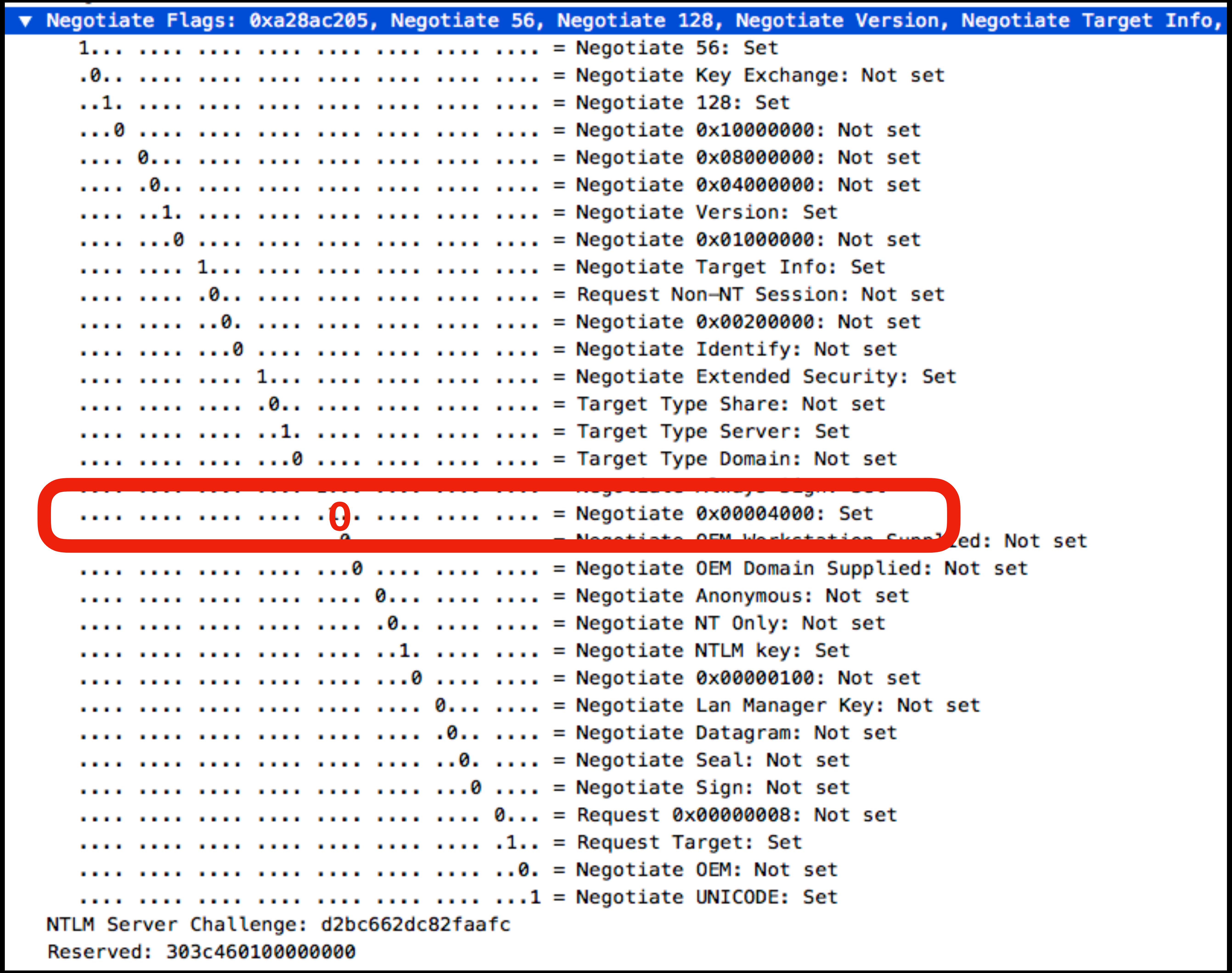
```
34 192.168.98.1      6.865052    192.168.98.151    HTTP     503 HTTP/1.1 401 Unauthorized , NTLMSSP_CHALLENGE (text/html)
35 192.168.98.151    6.869463    192.168.98.1      HTTP     734 GET /mkmMLvT3ILii5V HTTP/1.1 , NTLMSSP_AUTH, User: WIN77\Administrator
36 192.168.98.1      6.869538    192.168.98.151    TCP       54 8080 → 49261 [ACK] Seq=450 Ack=937 Win=261440 Len=0
▼ Negotiate Flags: 0x028a0205, Negotiate Version, Negotiate Target Info, Negotiate Extended Security, Target Type Server, Negotiate NTLM key, Request Target, Negotiate UNICODE
    0... .... .... .... .... .... .... .... = Negotiate 56: Not set
    .0.. .... .... .... .... .... .... .... = Negotiate Key Exchange: Not set
    ..0. .... .... .... .... .... .... .... = Negotiate 128: Not set
    ...0 .... .... .... .... .... .... .... = Negotiate 0x10000000: Not set
    .... 0... .... .... .... .... .... .... = Negotiate 0x08000000: Not set
    .... .0.. .... .... .... .... .... .... = Negotiate 0x04000000: Not set
    .... ..1. .... .... .... .... .... .... = Negotiate Version: Set
    .... ...0 .... .... .... .... .... .... = Negotiate 0x01000000: Not set
    .... .... 1... .... .... .... .... .... = Negotiate Target Info: Set
    .... .... .0.. .... .... .... .... .... = Request Non-NT Session: Not set
    .... .... ..0. .... .... .... .... .... = Negotiate 0x00200000: Not set
    .... .... ...0 .... .... .... .... .... = Negotiate Identify: Not set
    .... .... .... 1... .... .... .... .... = Negotiate Extended Security: Set
    .... .... .... .0.. .... .... .... .... = Target Type Share: Not set
    .... .... .... ..1. .... .... .... .... = Target Type Server: Set
    .... .... .... ...0 .... .... .... .... = Target Type Domain: Not set
    .... .... .... .... 0... .... .... .... = Negotiate Always Sign: Not set
    .... .... .... .... .0.. .... .... .... = Negotiate 0x00004000: Not set
    .... .... .... .... ..0. .... .... .... = Negotiate OEM Workstation Supplied: Not set
    .... .... .... .... ...0 .... .... .... = Negotiate OEM Domain Supplied: Not set
    .... .... .... .... .... 0... .... .... = Negotiate Anonymous: Not set
    .... .... .... .... .... .0.. .... .... = Negotiate NT Only: Not set
    .... .... .... .... .... ..1. .... .... = Negotiate NTLM key: Set
    .... .... .... .... .... ...0 .... .... = Negotiate 0x00000100: Not set
    .... .... .... .... .... .... 0... .... = Negotiate Lan Manager Key: Not set
    .... .... .... .... .... .... .0.. .... = Negotiate Datagram: Not set
    .... .... .... .... .... .... ..0. .... = Negotiate Seal: Not set
    .... .... .... .... .... .... ...0 .... = Negotiate Sign: Not set
```

NTLM Reflection

A Journey to bypass MS16-075

Negotiate Local Call:

The server sets this flag to inform the client that the server and client are on the same machine



```
▼ Negotiate Flags: 0xa28ac205, Negotiate 56, Negotiate 128, Negotiate Version, Negotiate Target Info,
    1... .... .... .... .... .... .... .... = Negotiate 56: Set
    .0.. .... .... .... .... .... .... .... = Negotiate Key Exchange: Not set
    ..1. .... .... .... .... .... .... .... = Negotiate 128: Set
    ...0 .... .... .... .... .... .... .... = Negotiate 0x10000000: Not set
    .... 0... .... .... .... .... .... .... = Negotiate 0x08000000: Not set
    .... .0.. .... .... .... .... .... .... = Negotiate 0x04000000: Not set
    .... ..1. .... .... .... .... .... .... = Negotiate Version: Set
    .... ...0 .... .... .... .... .... .... = Negotiate 0x01000000: Not set
    .... .... 1... .... .... .... .... .... = Negotiate Target Info: Set
    .... .... .0.. .... .... .... .... .... = Request Non-NT Session: Not set
    .... .... ..0. .... .... .... .... .... = Negotiate 0x00200000: Not set
    .... .... ...0 .... .... .... .... .... = Negotiate Identify: Not set
    .... .... .... 1... .... .... .... .... = Negotiate Extended Security: Set
    .... .... .... .0.. .... .... .... .... = Target Type Share: Not set
    .... .... .... ..1. .... .... .... .... = Target Type Server: Set
    .... .... .... ...0 .... .... .... .... = Target Type Domain: Not set
    .... .... .... .... 1... .... .... .... = Negotiate Always Sign: Set
    .... .... .... .... .0.. .... .... .... = Negotiate 0x00004000: Set
    .... .... .... .... ..0. .... .... .... = Negotiate OEM Workstation Supplied: Not set
    .... .... .... .... ...0 .... .... .... = Negotiate OEM Domain Supplied: Not set
    .... .... .... .... .... 0... .... .... = Negotiate Anonymous: Not set
    .... .... .... .... .... .0.. .... .... = Negotiate NT Only: Not set
    .... .... .... .... .... ..1. .... .... = Negotiate NTLM key: Set
    .... .... .... .... .... ...0 .... .... = Negotiate 0x00000100: Not set
    .... .... .... .... .... .... 0... .... = Negotiate Lan Manager Key: Not set
    .... .... .... .... .... .... .0.. .... = Negotiate Datagram: Not set
    .... .... .... .... .... .... ..0. .... = Negotiate Seal: Not set
    .... .... .... .... .... .... ...0 .... = Negotiate Sign: Not set
    .... .... .... .... .... .... .... 0... = Request 0x00000008: Not set
    .... .... .... .... .... .... .... .1.. = Request Target: Set
    .... .... .... .... .... .... .... ..0. = Negotiate OEM: Not set
    .... .... .... .... .... .... .... ...1 = Negotiate UNICODE: Set
  NTLM Server Challenge: d2bc662dc82faafc
  Reserved: 303c460100000000
```

NTLM Reflection

CVE-2019-1040

VIDEO DEMO

NTLM Reflection

A Journey to bypass MS16-075

Now we bypass Microsoft patch successfully!

Rebirth Hot Potato

HTTP->SMB NTLM Reflection&WAPD Attack

NTLM Reflection

Potato Rebirth - Bypass MS16-075

- **MS16-075**
  - Fix local HTTP->SMB Relay
  - Windows Defender Update Client will send a Net-NTLM hash that can’t be exploited

NTLM Reflection

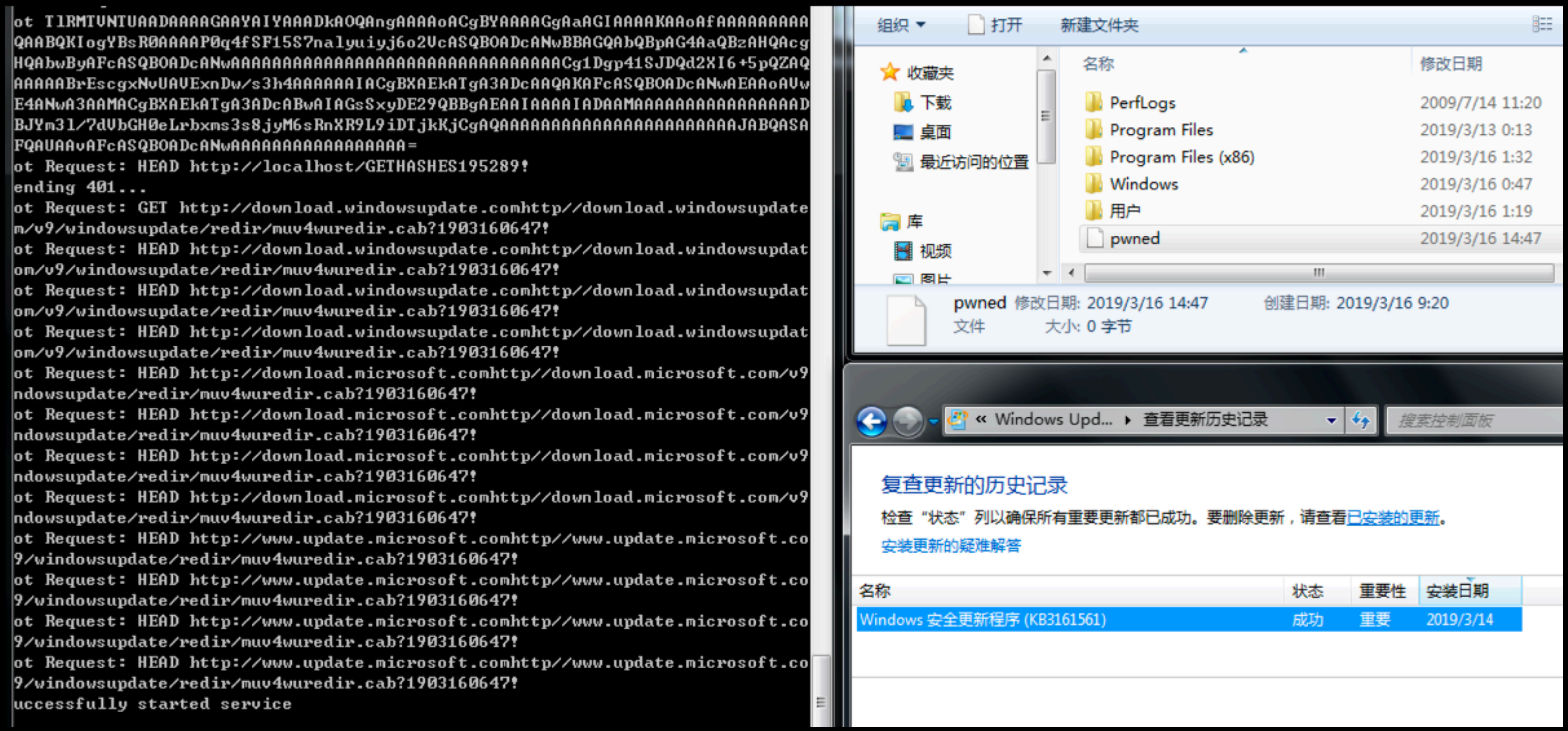
Potato Rebirth - Bypass MS16-075

http://go.microsoft.com/fwlink/?LinkID=121721

NTLM Reflection

Potato Rebirth

MS16-075 Patched



```
ot TlRMTVNTUAADAAAAGAAYAIYAAADkAOQAngAAAAoACgBYAAAAGgAaAGIAAAAKAAoAfAAAAAAAAA
QAABQKIogYBsR0AAAAP0q4fSF15S7nalyuiyj6o2VcASQBOADcANwBBAGQAbQBpAG4AaQBzAHQAcg
HQAbwByAFcASQBOADcANwAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAACg1Dgp41SJDQd2XI6+5pQZAQ
AAAAABrEscgxNvUAVExnDw/s3h4AAAAAAIACgBXAEkATgA3ADcAAQAKAFcASQBOADcANwAEAAoAVw
E4ANwA3AAMACgBXAEkATgA3ADcABwAIAGsSxyDE29QBBgAEAAIAAAAIADAAMAAAAAAAAAAAAAAAAD
BJYm3l/7dVbGH0eLrbxms3s8jyM6sRnXR9L9iDTjkKjCgAQAAAAAAAAAAAAAAAAAAAAAAAJABQASA
FQAUAAvAFcASQBOADcANwAAAAAAAAAAAAAAAAA=
ot Request: HEAD http://localhost/GETHASHES195289!
ending 401...
ot Request: GET http://download.windowsupdate.comhttp//download.windowsupdate
m/v9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.windowsupdate.comhttp//download.windowsupdat
om/v9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.windowsupdate.comhttp//download.windowsupdat
om/v9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.windowsupdate.comhttp//download.windowsupdat
om/v9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.microsoft.comhttp//download.microsoft.com/v9
ndowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.microsoft.comhttp//download.microsoft.com/v9
ndowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.microsoft.comhttp//download.microsoft.com/v9
ndowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://download.microsoft.comhttp//download.microsoft.com/v9
ndowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://www.update.microsoft.comhttp//www.update.microsoft.co
9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://www.update.microsoft.comhttp//www.update.microsoft.co
9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://www.update.microsoft.comhttp//www.update.microsoft.co
9/windowsupdate/redir/muv4wuredir.cab?1903160647!
ot Request: HEAD http://www.update.microsoft.comhttp//www.update.microsoft.co
9/windowsupdate/redir/muv4wuredir.cab?1903160647!
uccessfully started service
```

名称	修改日期
PerfLogs	2009/7/14 11:20
Program Files	2019/3/13 0:13
Program Files (x86)	2019/3/16 1:32
Windows	2019/3/16 0:47
用户	2019/3/16 1:19
pwned	2019/3/16 14:47

pwned 修改日期: 2019/3/16 14:47 创建日期: 2019/3/16 9:20
文件 大小: 0 字节

复查更新的历史记录

检查“状态”列以确保所有重要更新都已成功。要删除更新，请查看已安装的更新。

安装更新的疑难解答

名称	状态	重要性	安装日期
Windows 安全更新程序 (KB3161561)	成功	重要	2019/3/14

NTLM Reflection

Potato Rebirth - MS16-077

MS16-077:

WPAD Name Resolution will not use NetBIOS (CVE-2016-3213)

Does not send credential when requesting the PAC file(CVE-2016-3236)

WAPD MITM Attack is Dead!

NTLM Reflection

Potato Rebirth - MS16-077

Compromising IPv4 networks via IPv6

using mitm6 to abuses the default IPv6 configuration in Windows network to spoof DNS replies by acting as a malicious DNS server and redirect traffic to an attacker-specified endpoint.

WAPD MITM Attack Rebirth!

NTLM Reflection

Potato Rebirth - MS16-077

Combined 3 vulnerabilities to perform Privilege Escalation

1. Compromising IPv4 networks via IPv6 to hijack WAPD

2. Use go.microsoft.com to get an authentication

3. Change flag in NTLM Type 2 Message to bypass MS16-075

Hot Potato Rebirth!

Incidentally

Man-in-the-middle Attack are required before most NTLM attacks

- Poison DNS
- Spoof NetBIOS/LLMNR
- ARP attack
- Exploit the WPAD
- etc

We always relay to SMB.

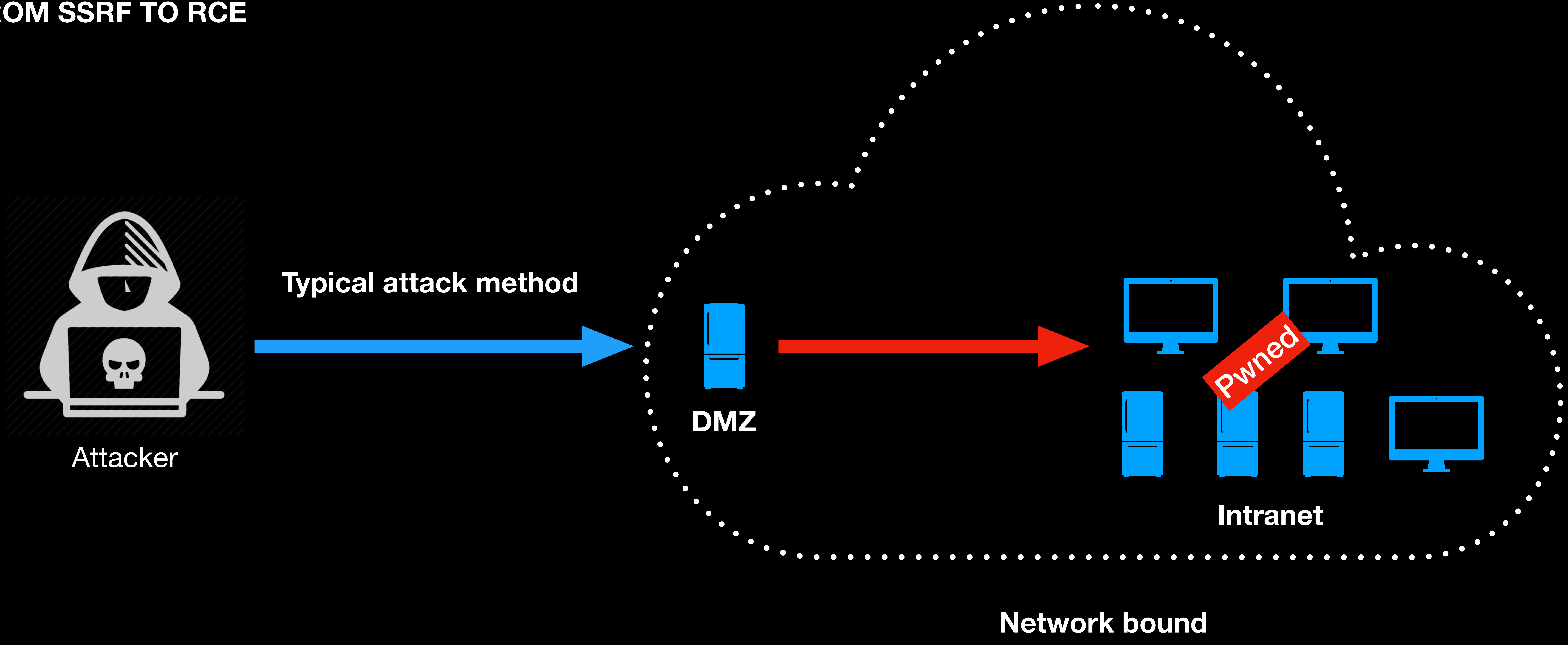
We need to wait and wait.

A Whole New perspective In SSRF

Ignore Many SSRF defense&Directly lead to RCE Via once exploit

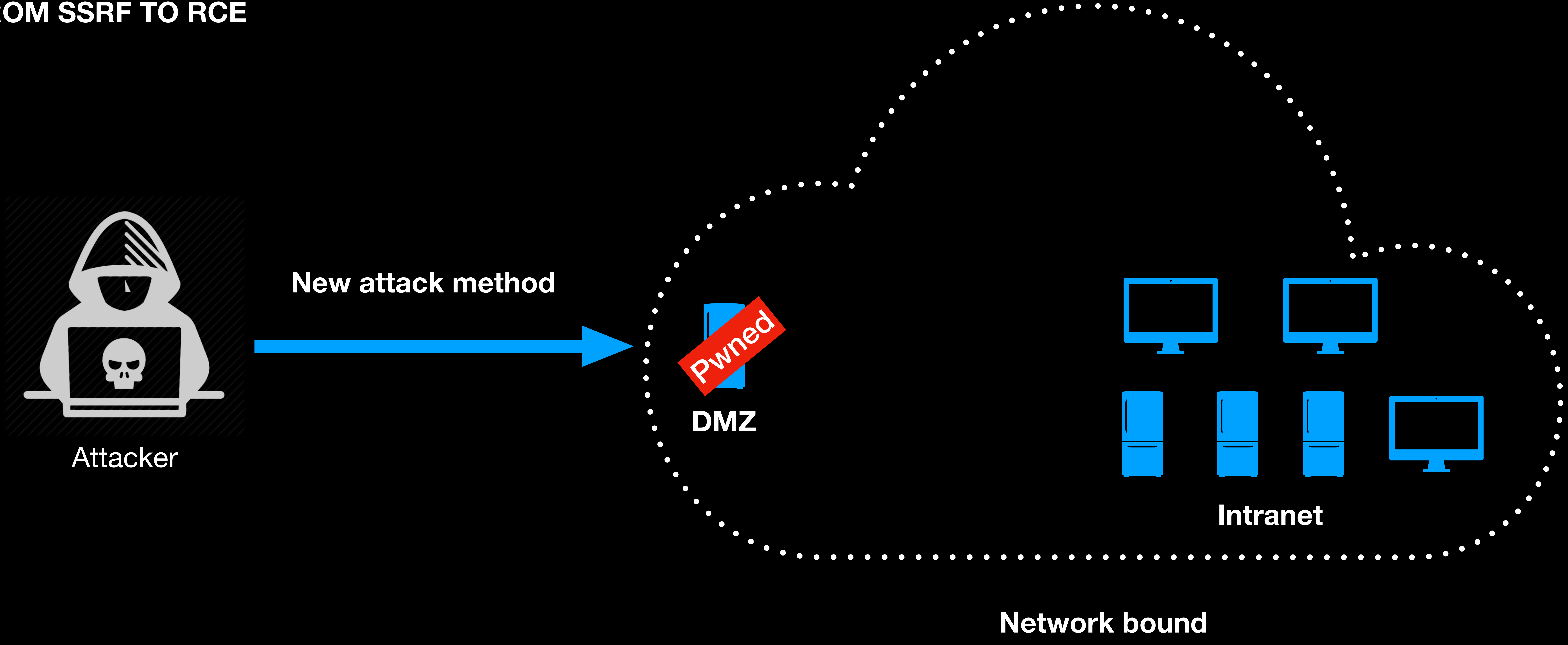
New perspective In SSRF

FROM SSRF TO RCE



New perspective In SSRF

FROM SSRF TO RCE



New perspective In SSRF

FROM SSRF TO RCE

Attack Network Connector

- Completely ignore most of the SSRF defense solutions.
- Once exploiting can directly lead to the impact of RCE.
- Increasing the risk of many SSRF vulnerabilities which have been considered in low impact.

Critical Security Issue in JAVA

Critical Security Issue

FROM SSRF TO RCE

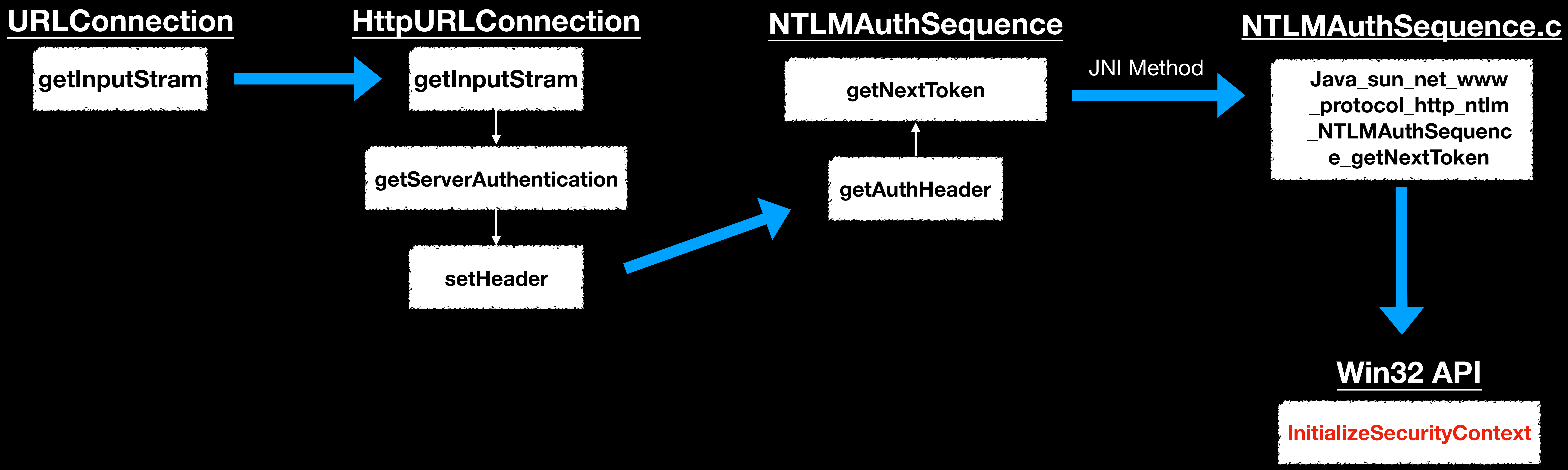
URLConnection

The superclass of all classes that represent a communications link between the application and a URL.

The most of JAVA function use URLConnection to send HTTP request.

Critical Security Issue

FROM SSRF TO RCE



Critical Security Issue

FROM SSRF TO RCE

The default behavior of Java will not judge the validity of the URL, but always return true.

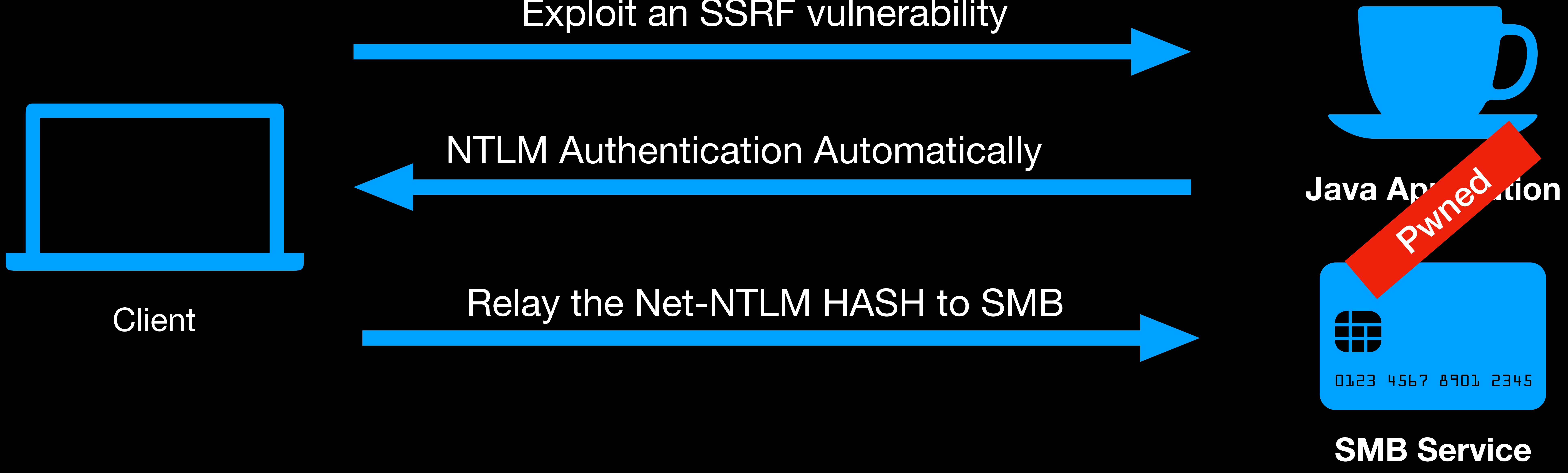
```
static class DefaultNTLMAuthenticationCallback extends NTLMAuthenticationCallback{

        DefaultNTLMAuthenticationCallback() {

         public boolean isTrustedSite(URL var1) {
                     return true;
          }
}
```

Critical Security Issue

FROM SSRF TO RCE



Client

Exploit an SSRF vulnerability

NTLM Authentication Automatically

Relay the Net-NTLM HASH to SMB

Java Application

Pwned

SMB Service

NTLM Reflection

FROM SSRF TO RCE

Affects all JDK versions!

NTLM Reflection

FROM SSRF TO RCE

An SSRF vulnerability is required, is that all?

The new era in NTLM Reflection

NTLM Reflection

New era in NTLM Reflection

NTLM Authenticate Automatically

Security issue in Java basic Class, that means most of JAVA application is affected.

Influence Expansion

Not just SSRF, anything which will send an HTTP request to us is affected. Over other vulnerabilities, such as XXE, Deserialization, etc.

Java Deserialization

NTLM Reflection

New era in NTLM Reflection

Deserialization Attack (Affects most of Java application)

Chris Frohoff and Gabriel Lawrence presented their research into Java object deserialization vulnerabilities ultimately resulting in what can be readily described as the biggest wave of RCE bugs in Java history.

After two years later, Moritz Bechler releases a tool to achieve code execution during the unmarshalling process in 2017.

How to fixed?

Add a blacklist to mitigate Java Deserialization Attack.

NTLM Reflection

New era in NTLM Reflection

Bypass all Java Deserialization Blacklist

Just need to find a gadget that will send an HTTP request to us.

Affected Software

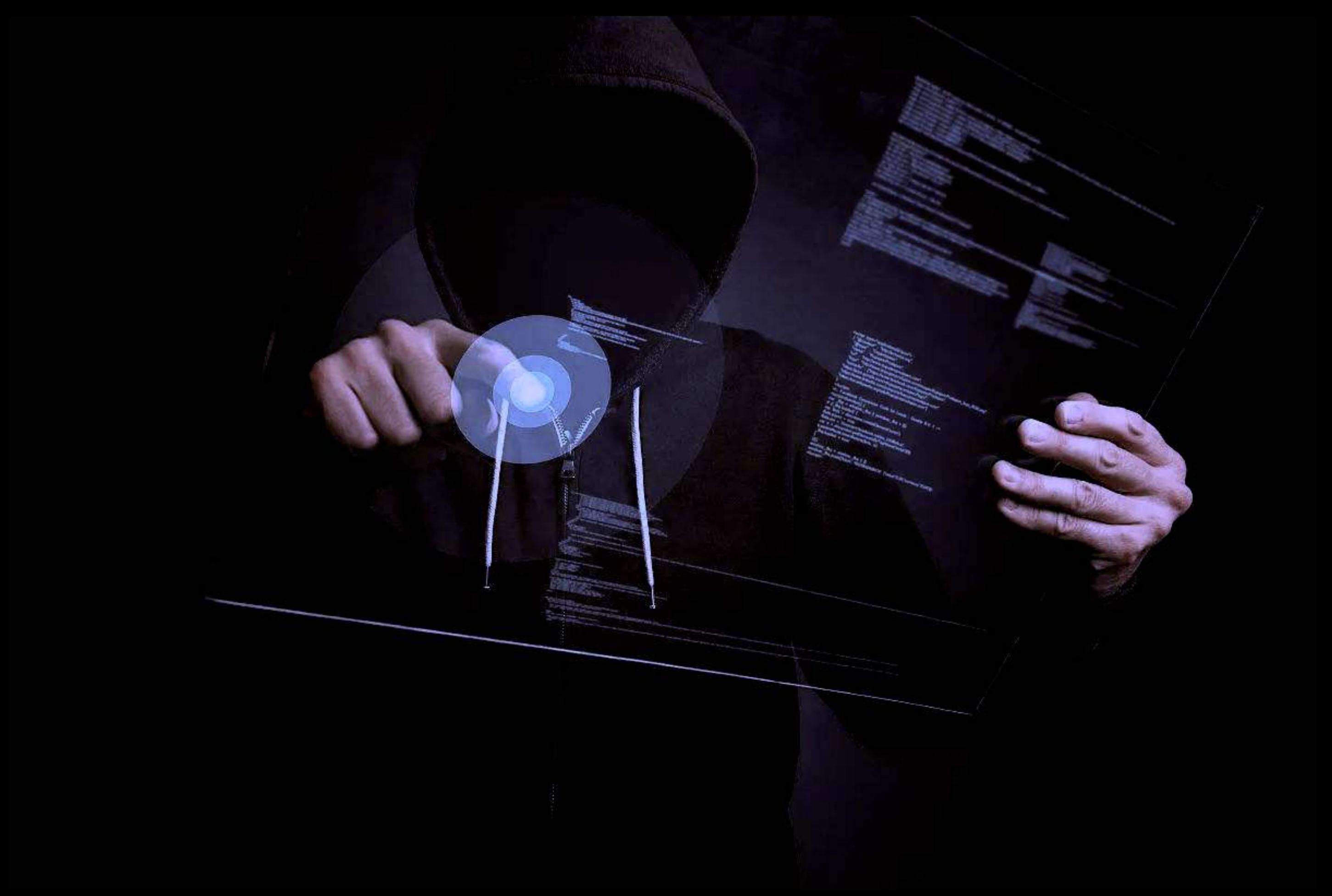
All Java applications use a class blacklist to mitigate deserialization attack are affected.

Bypass all Java Deserialization Blacklist
Directly lead to RCE

NTLM Reflection

New era in NTLM Reflection

- ✓ SSRF
- ✓ Deserialization
- ✓ XXE
- ✓ Database
- ✓ Sandbox
- ✓ Java Security Scanner
- ✓ Java Crawler
- ✓ Cloud Service
- ✓ Man-In-The-Middle
- ✓ **Anything sends an HTTP request to us**



- HTTP
- SM
- LDAP
- etc…

Pwned

Acknowledgement

- Typhooncon
- Impacket (@SecureAuthCorp)
- Responder (@SpiderLabs)
- mitm6 (@Foxglove Security)
- ZackAttack(@Urbane Security)

Thanks!

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