# The Risks of RDP and How to Mitigate Them

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# Some ~~The~~ Risks of RDP and How to Mitigate Them And a vuln reported to Microsoft

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# About Us

## Olivier Bilodeau

Cybersecurity Research Lead at GoSecure

- Jack of all trades, master of none
- Speaker BlackHat, RSAC, SecTor, etc.
- Co-founder MontréHack (hands-on security workshops)
- NorthSec VP Training / Hacker Jeopardy

## Lisandro Ubiedo

Security Researcher at GoSecure

- Cloud-based trickery
- Malware analysis and Threat research
- Stratosphere Labs collaborator

# Introduction to RDP

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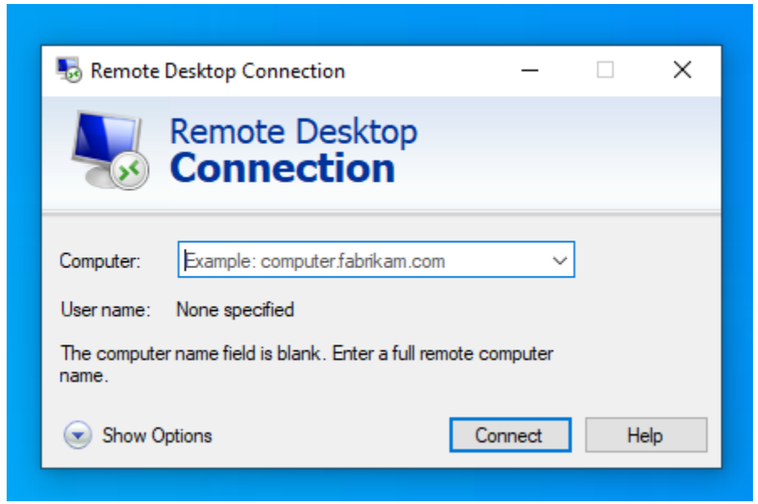
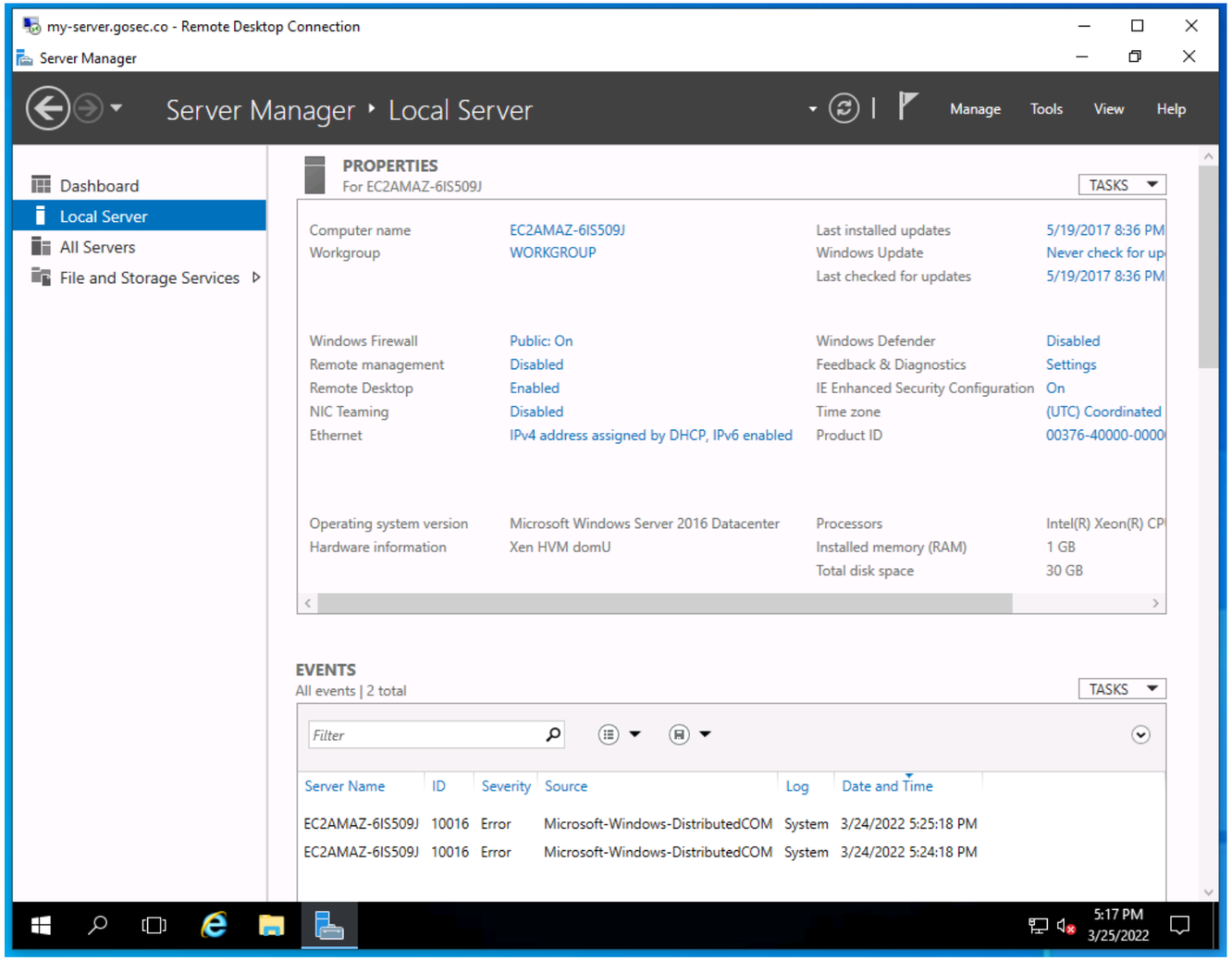
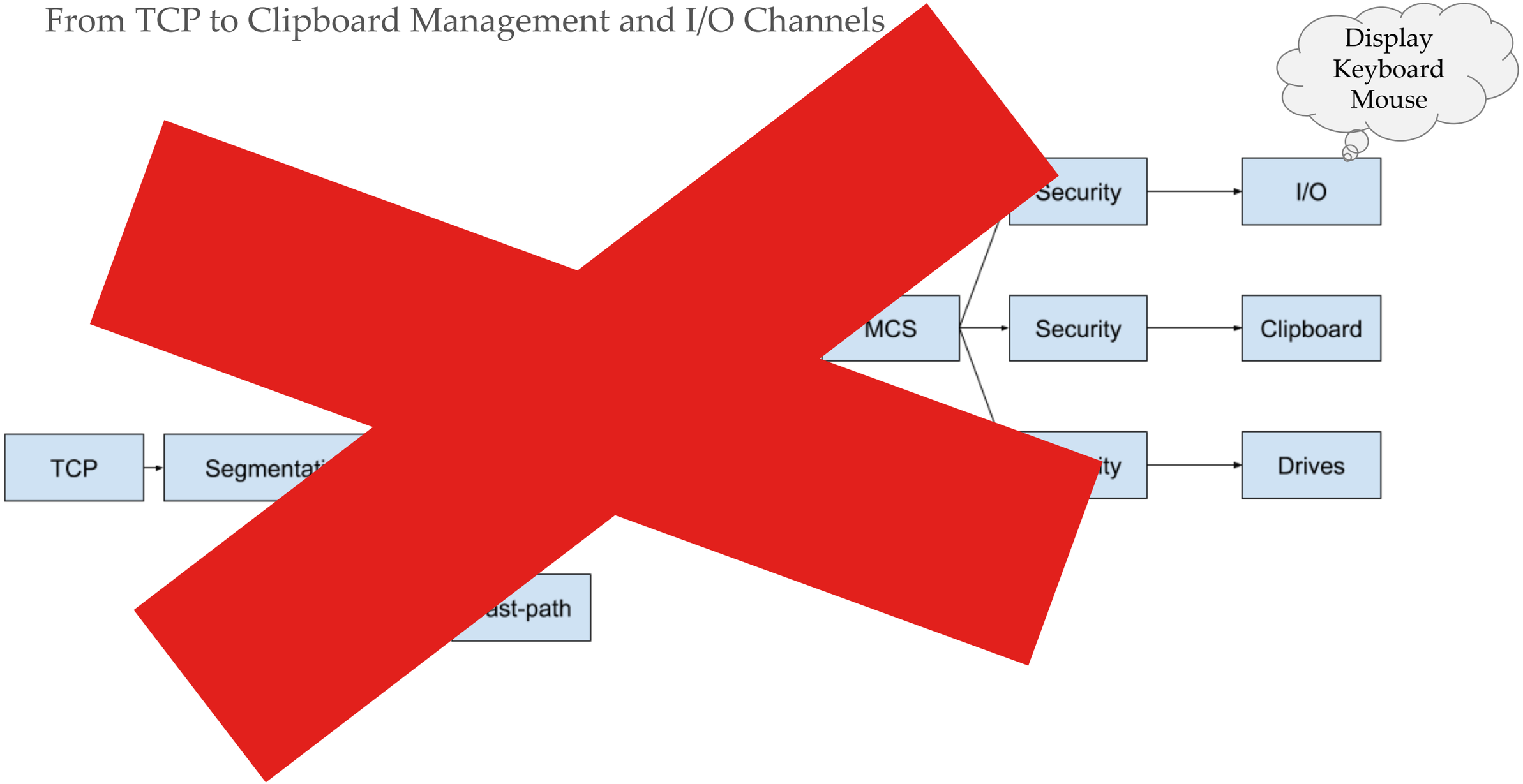
# Remote Desktop Protocol

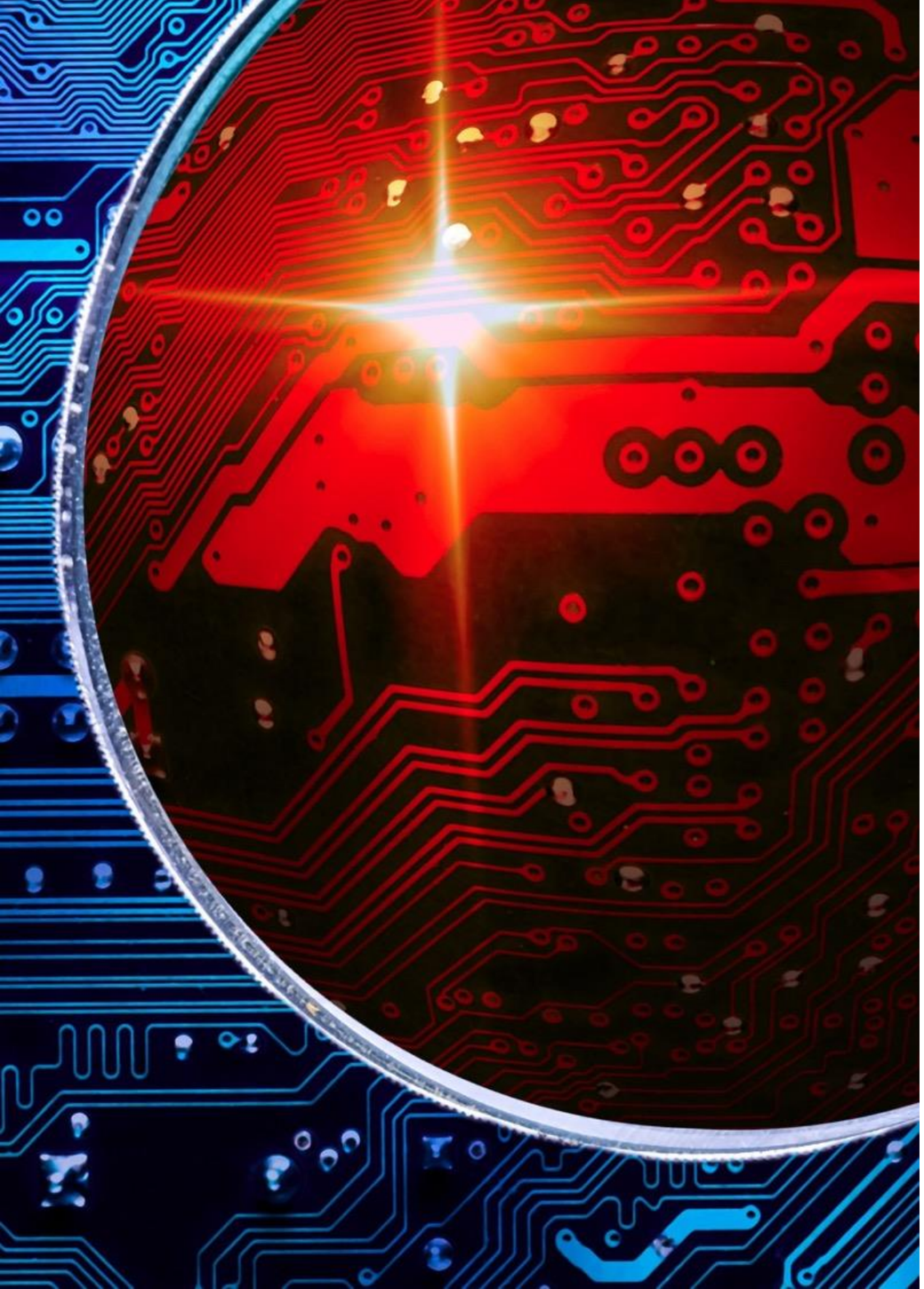


# RDP Layers

From TCP to Clipboard Management and I/O Channels





# RDP Security

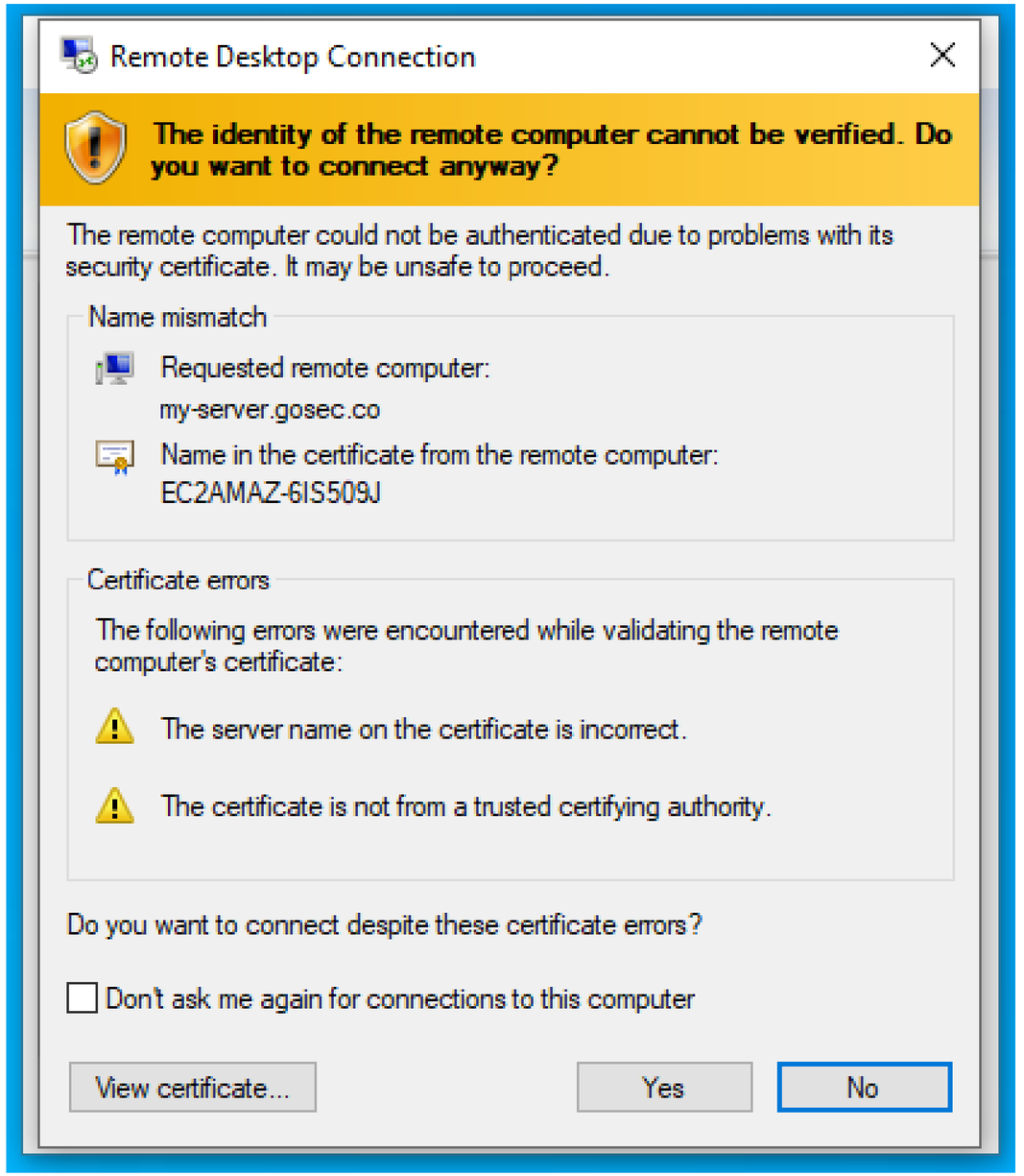
- RC4 + Graphical login (dead)
- TLS + Graphical login (legacy)
- TLS + Network Level Authentication (NLA) which relies on CredSSP
- Re[illegible]ard and Resti[illegible]

# A Risk of RDP: MITM

GoSecure

# MITM Risks

- **Security Downgrade Attacks**
  - NLA -> TLS
- **Clicking Through Warnings**
- **Impact**
  - Display
  - Keyboard
  - Clipboard
  - Server-side takeover
  - Client-side file stealing
  - Client-side takeover*




*: implementation pending

# How? By Our Open Source Attack Tool: PyRDP

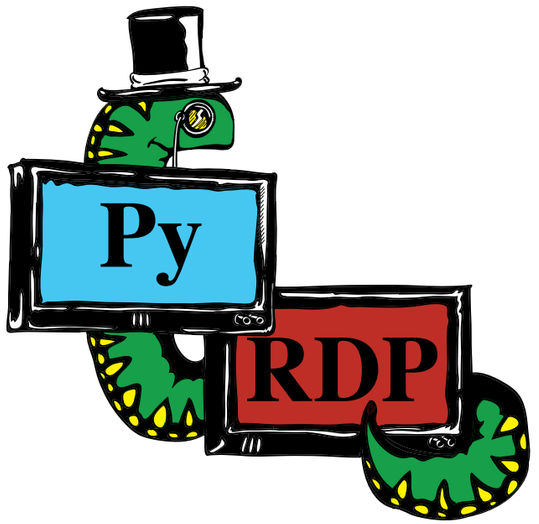
Learn More About It!

## Source Code / Documentation

- https://github.com/GoSecure/pyrdp
- PyRDP ReadMe
- PyRDP Transparent Proxying Guide
- Windows RDP Certificate Extraction
- RDP Connection Sequence
- RDP Basic Protocol Specification

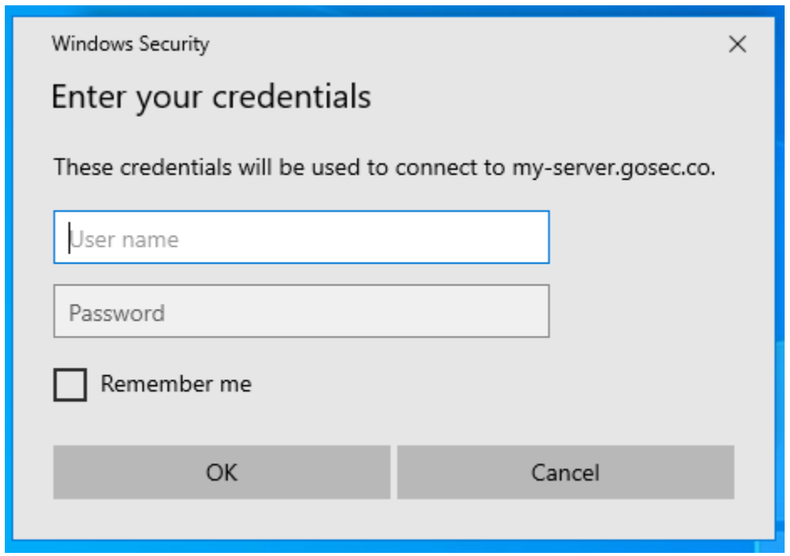
## Past Presentations & Blogs

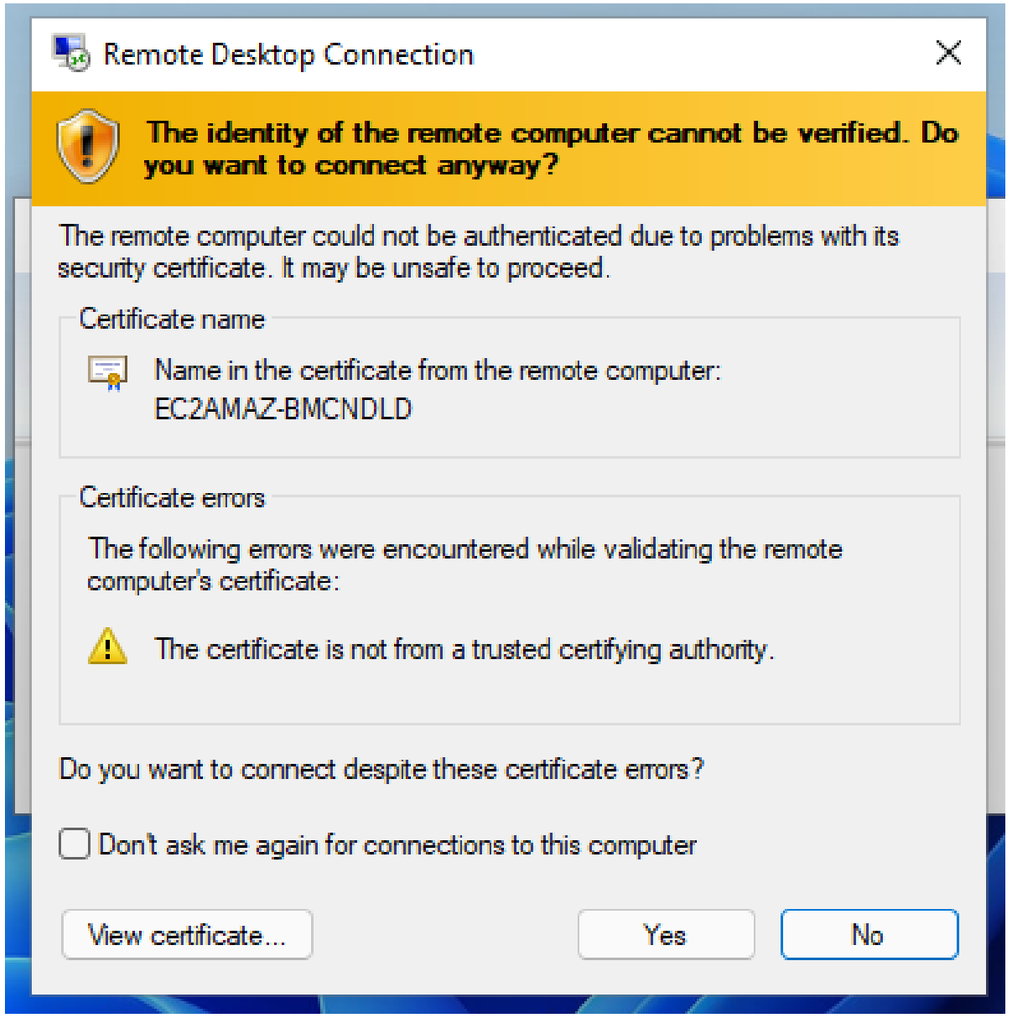
- Introduction Blog Post
- NorthSec 2019 Talk
- BlackHat Arsenal 2019
- Blog: PyRDP on Autopilot
- DerbyCon 2019 (Video)
- DEFCON 28 Demo Labs
- Blog: Announcing PyRDP 1.0
- 1.0 released at SecTor 2020
- BlackHat Arsenal 2021



# Detect Security Protocol Downgrade

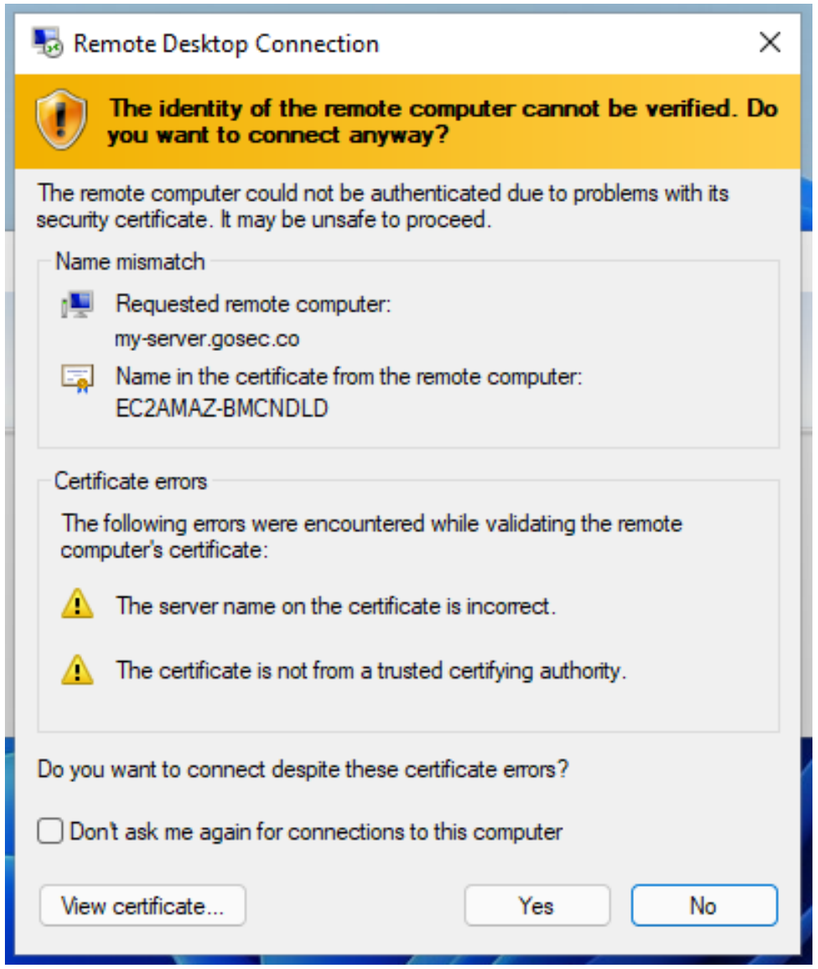
## Normal Flow

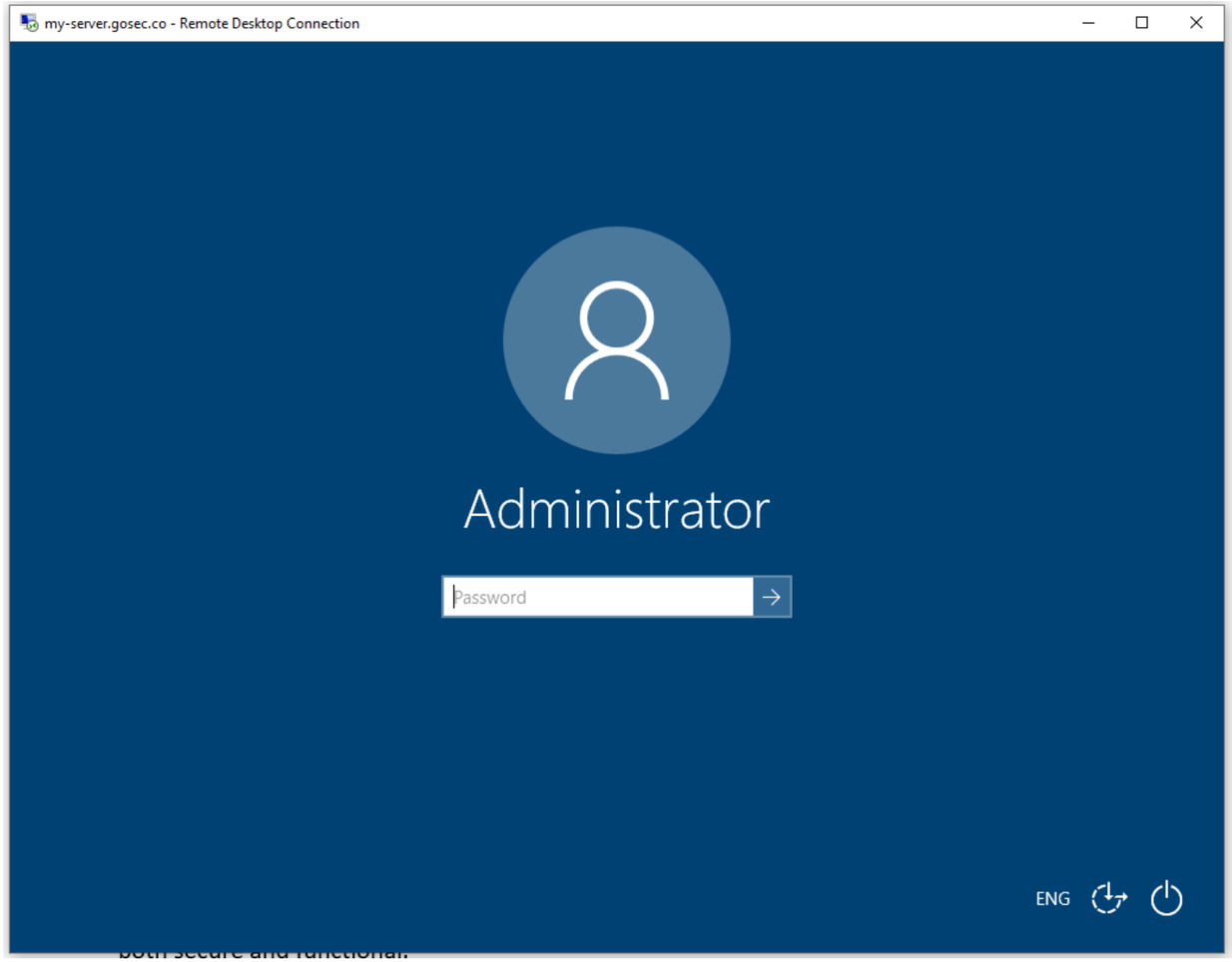


# Detect Security Protocol Downgrade

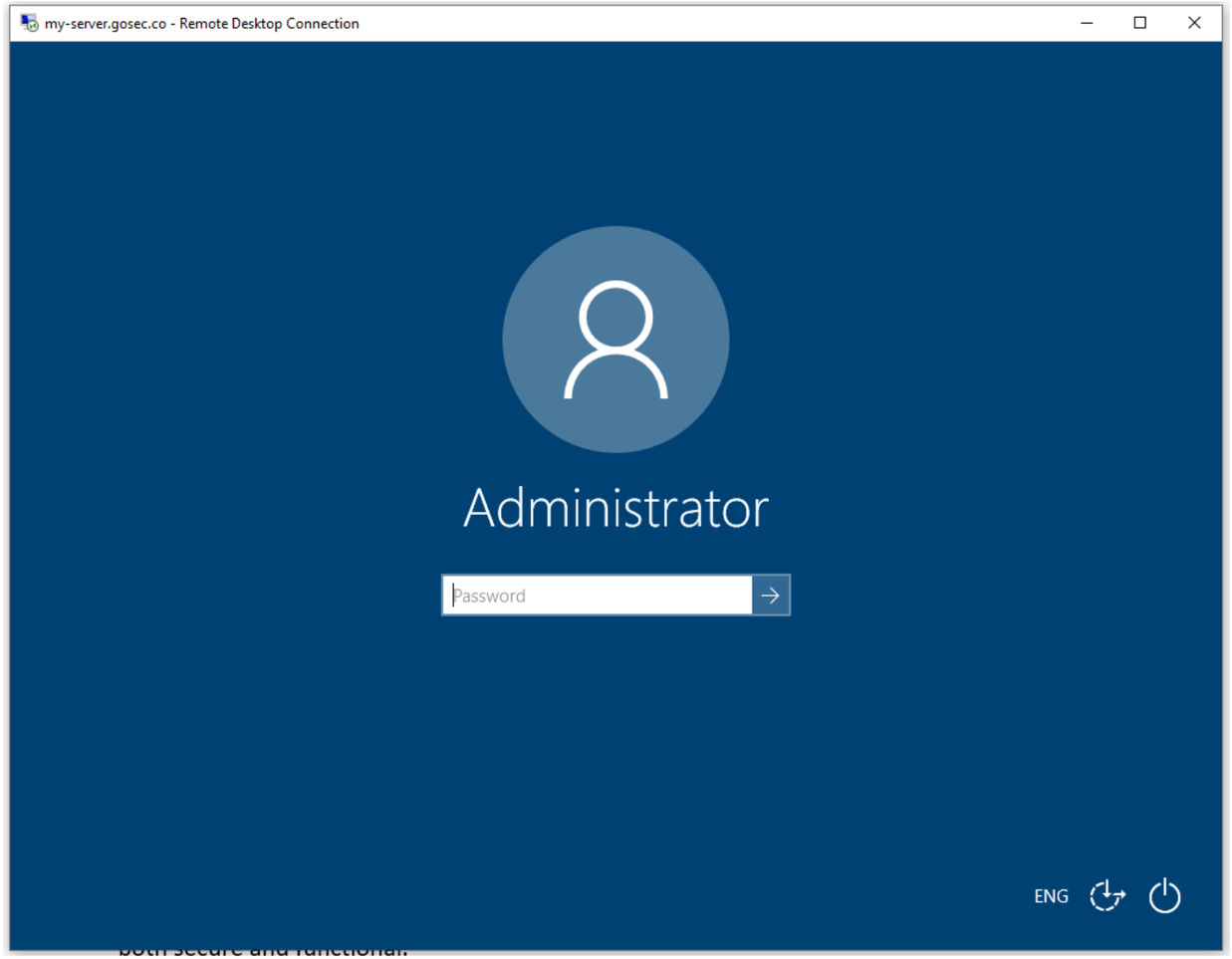
## Degraded Flow

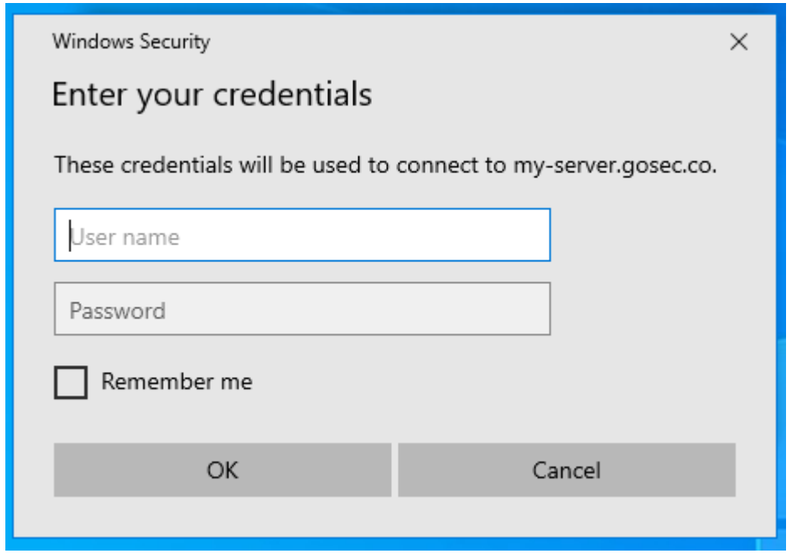


# Detect Security Protocol Downgrade

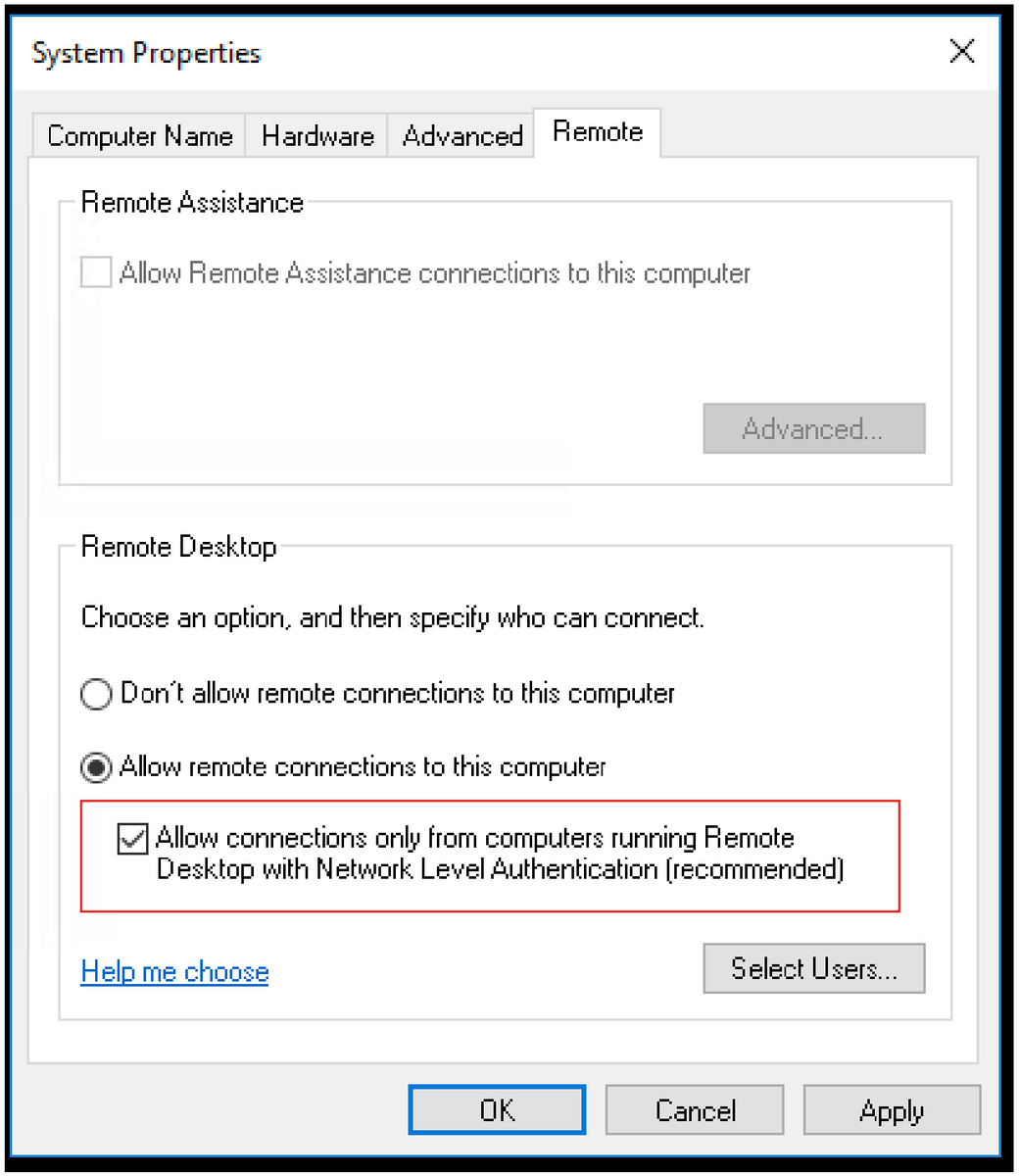
## Graphical Login instead of NLA Prompt



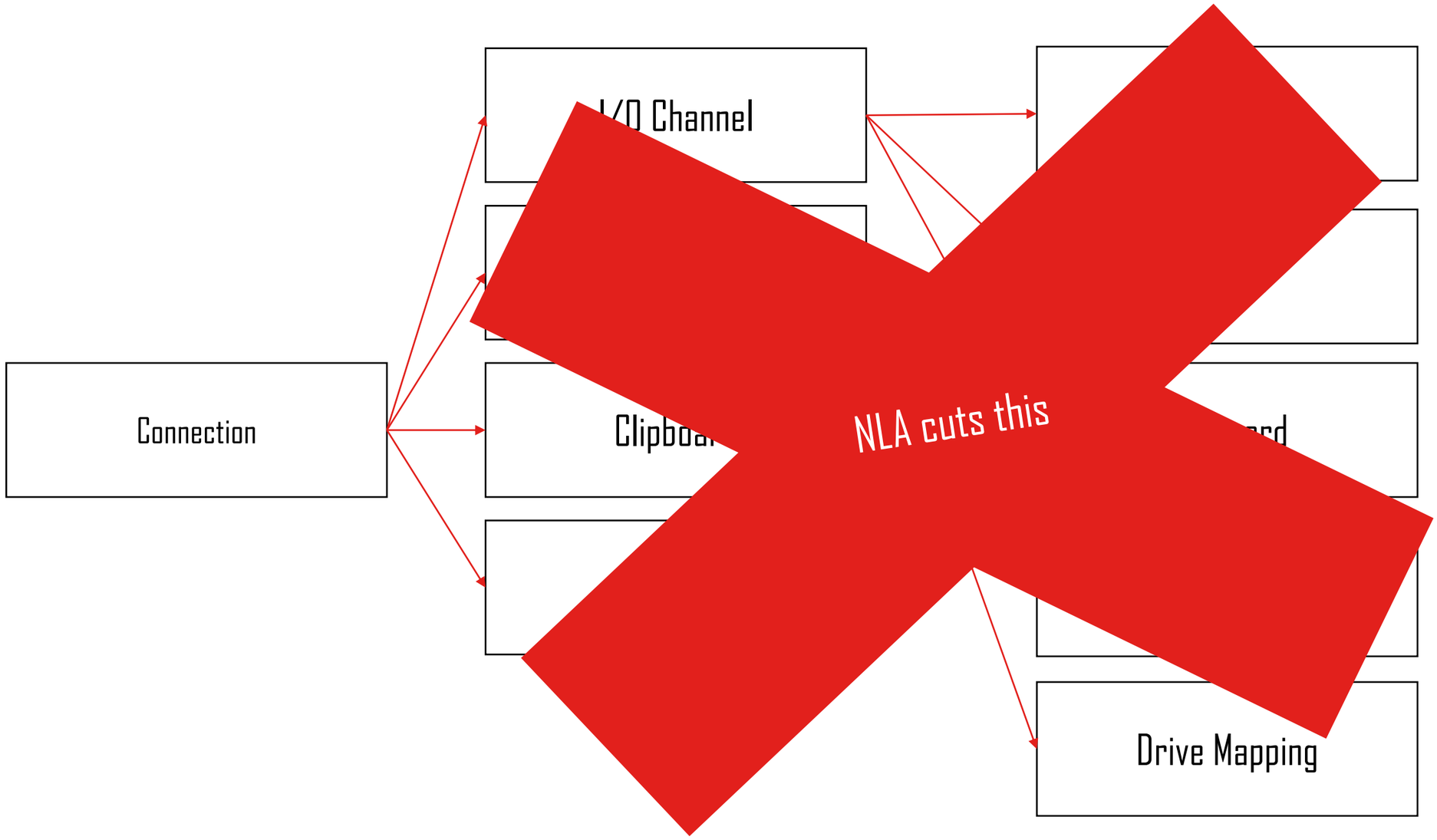



# What is Network Level Authentication (NLA)?

- Authentication **before** session establishment
- Security Advantages
  - Attack Surface Reduction
  - DoS Resistance
  - Single Sign-On
- Introduced in RDP 6.0
- By default since Server 2012 and Windows 8



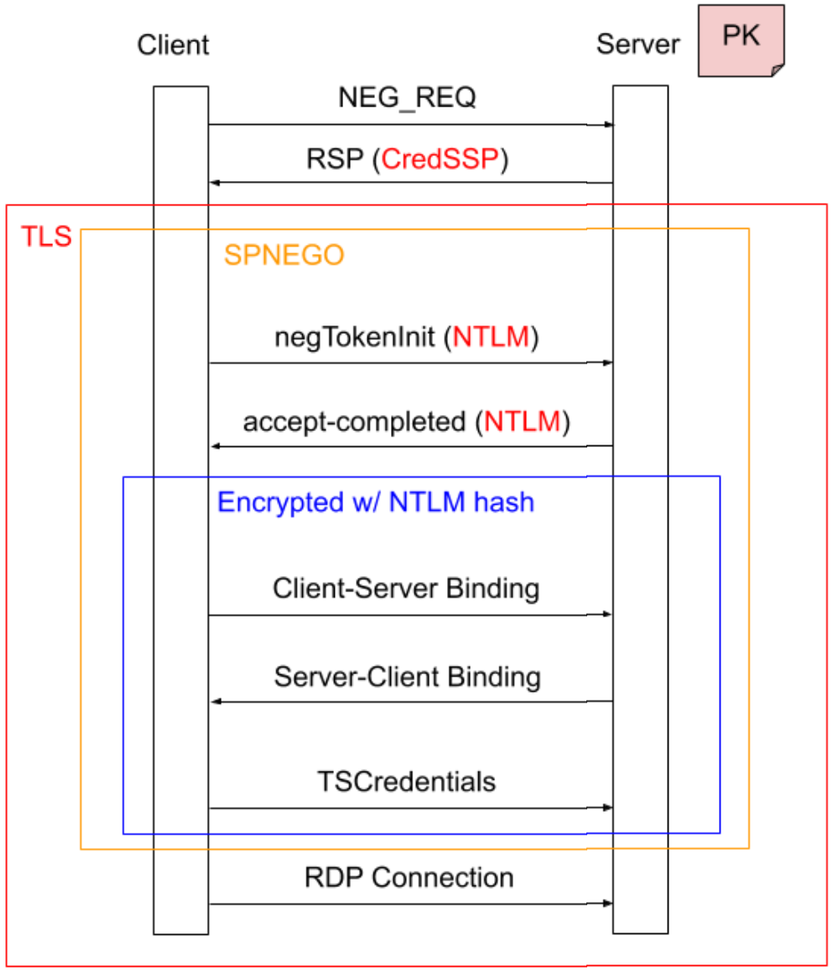
# Attack Surface Reduction



# Authentication: CredSSP

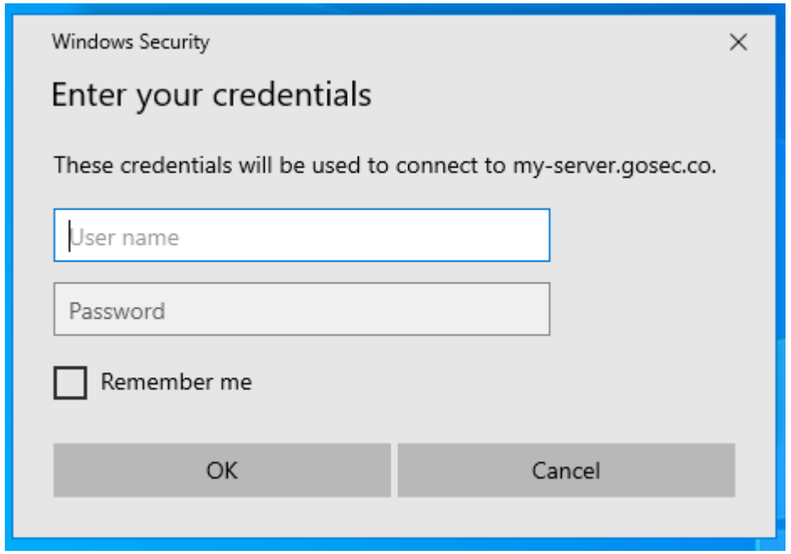
NLA's Authentication Mechanism

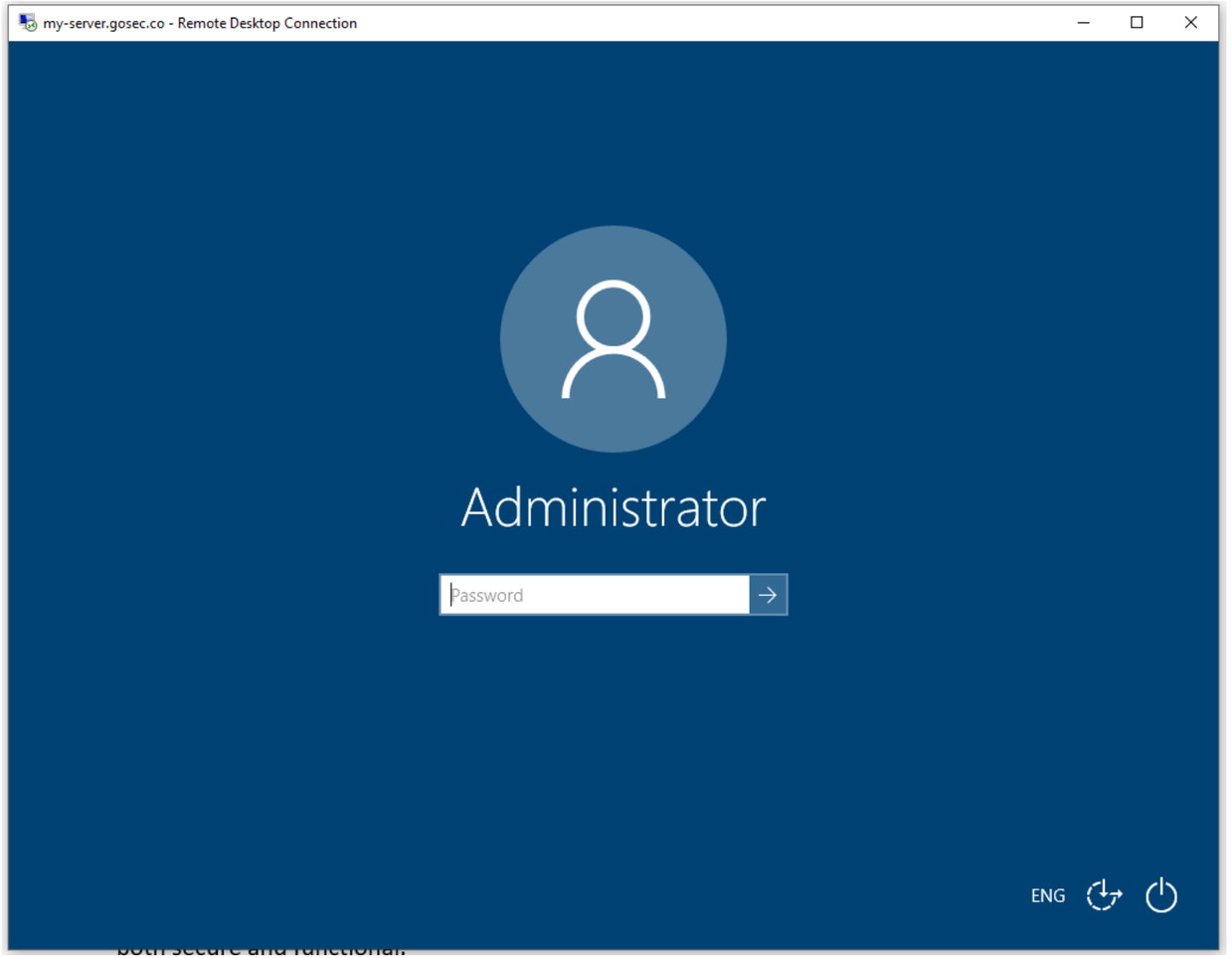
- **Initial plaintext negotiation method**
- **TLS Channel**
- **SPNEGO**
  - NTLM
  - Kerberos
- **Crypto should prevents MITM**
  - E( H( PK | Challenge ), NTLM-Hash)



# NLA Attack #1: Downgrade Attack

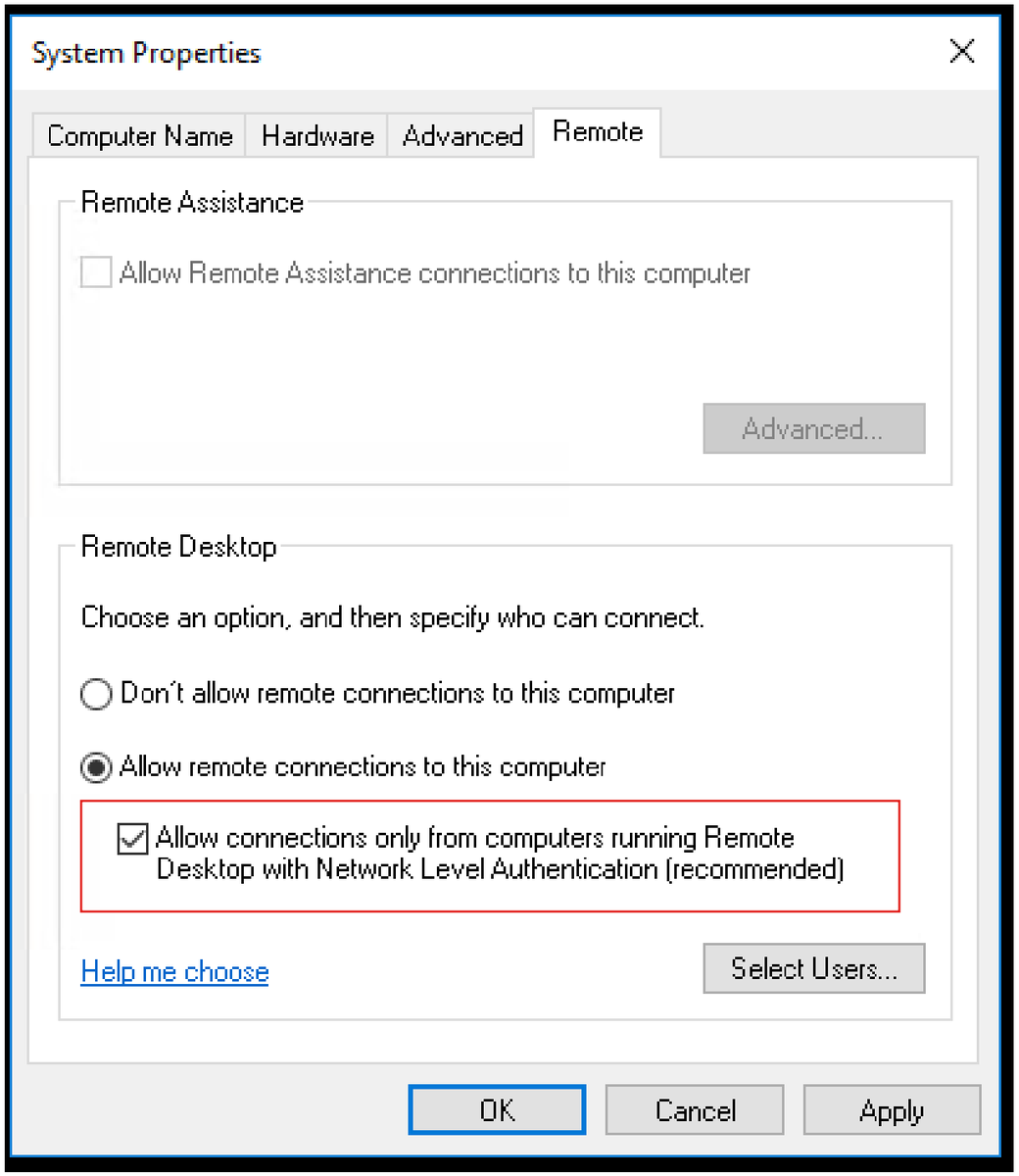
## Downgrade the NEG_REQ to remove CredSSP from supported protocols



# Prevent NLA Downgrade Attacks

- Enforce NLA at the Server Side
  - This is the **default**



# Prevent NLA Downgrade Attacks

For Reference

## PowerShell/Registry

```
reg add "HKLM\SYSTEM\CurrentControlSet\Control\Terminal Server\WinStations\RDP-Tcp" /v
UserAuthentication /t REG_DWORD /d 0 /f;
```

## Group policy

### Under

```
Computer Configuration/Administrative Templates/Windows Components/Remote Desktop Settings/Remote
Desktop Session Host/Security
```

### Set

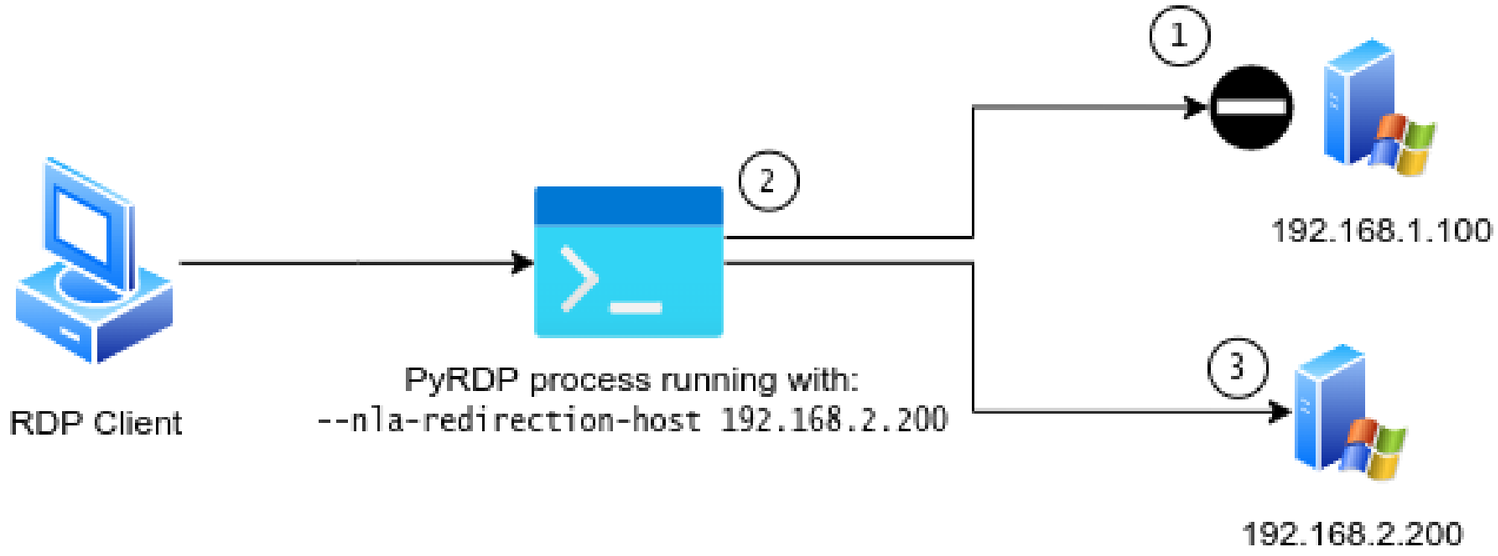
```
Require user authentication for remote connections by using Network Level Authentication
```

### To **Enable**

*Can't be disabled by users afterwards* 👍

# NLA Attack #2: Redirection to Non-NLA

1. Detects NLA enforcement
2. Transparently redirects
3. To an attacker controlled non-NLA system



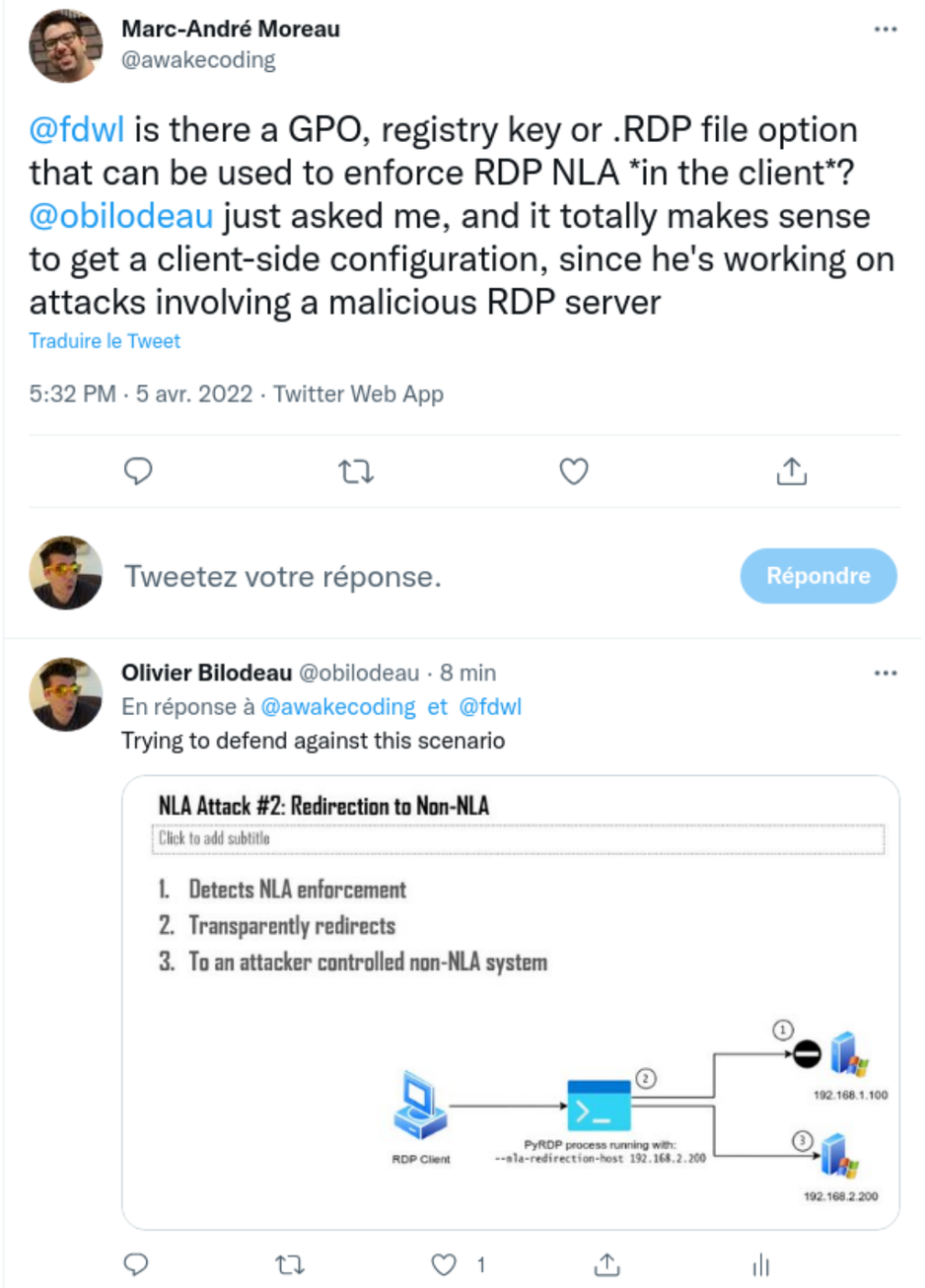
# Prevent Redirection to Non-NLA

Bad News

No specific way to enforce NLA on the client side

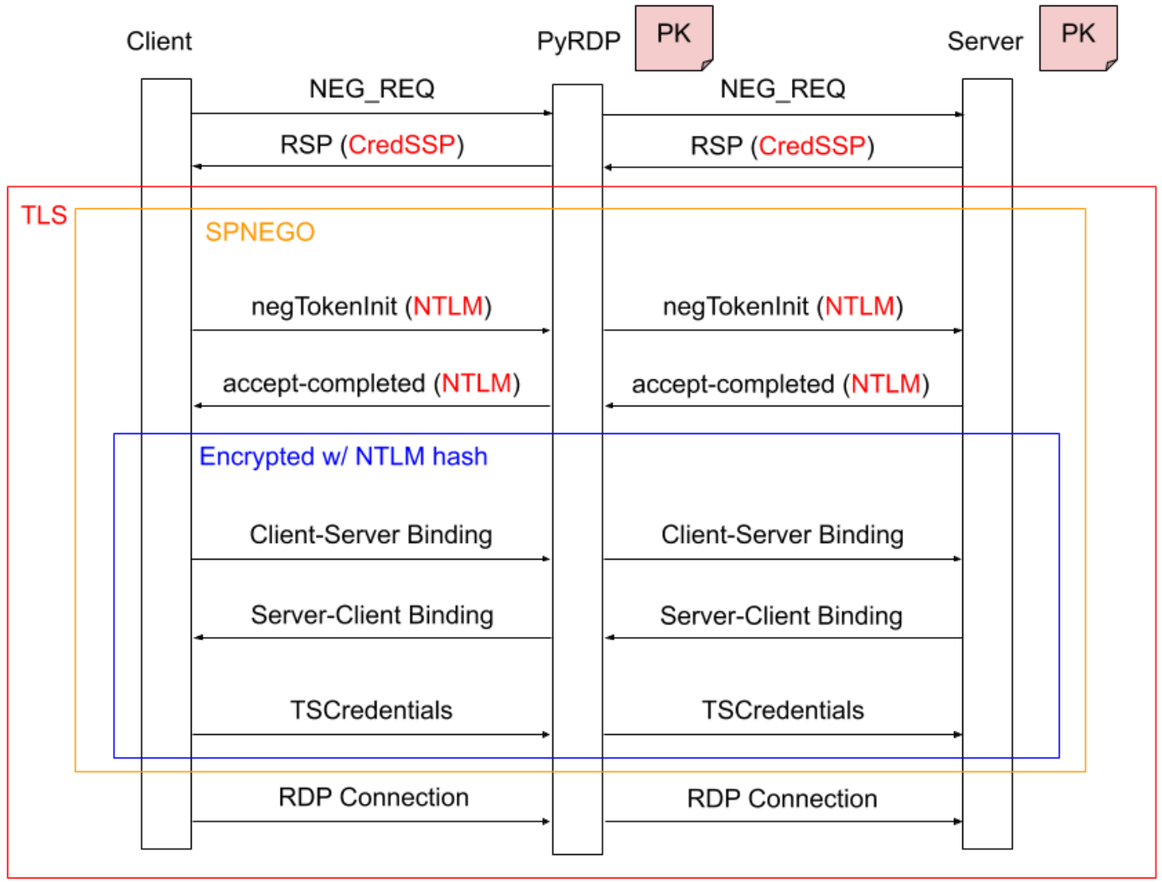
Good News

More general mitigation advice coming up



# NLA Attack #3: NLA MITM

- No tampering at the SPNEGO layer
- But the crypto said?
  - E( H( PK | Challenge ), NTLM-Hash)
- Requires substantial setup
  - Server certificate and private key*




*: https://github.com/GoSecure/pyrdp/blob/master/docs/cert-extraction.md

# Attack Video Demo

NLA Bypass, Legit Certificates (lets encrypt), as bad as it can get...

(link to video)

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# NetNTLMv2 Hash Capture

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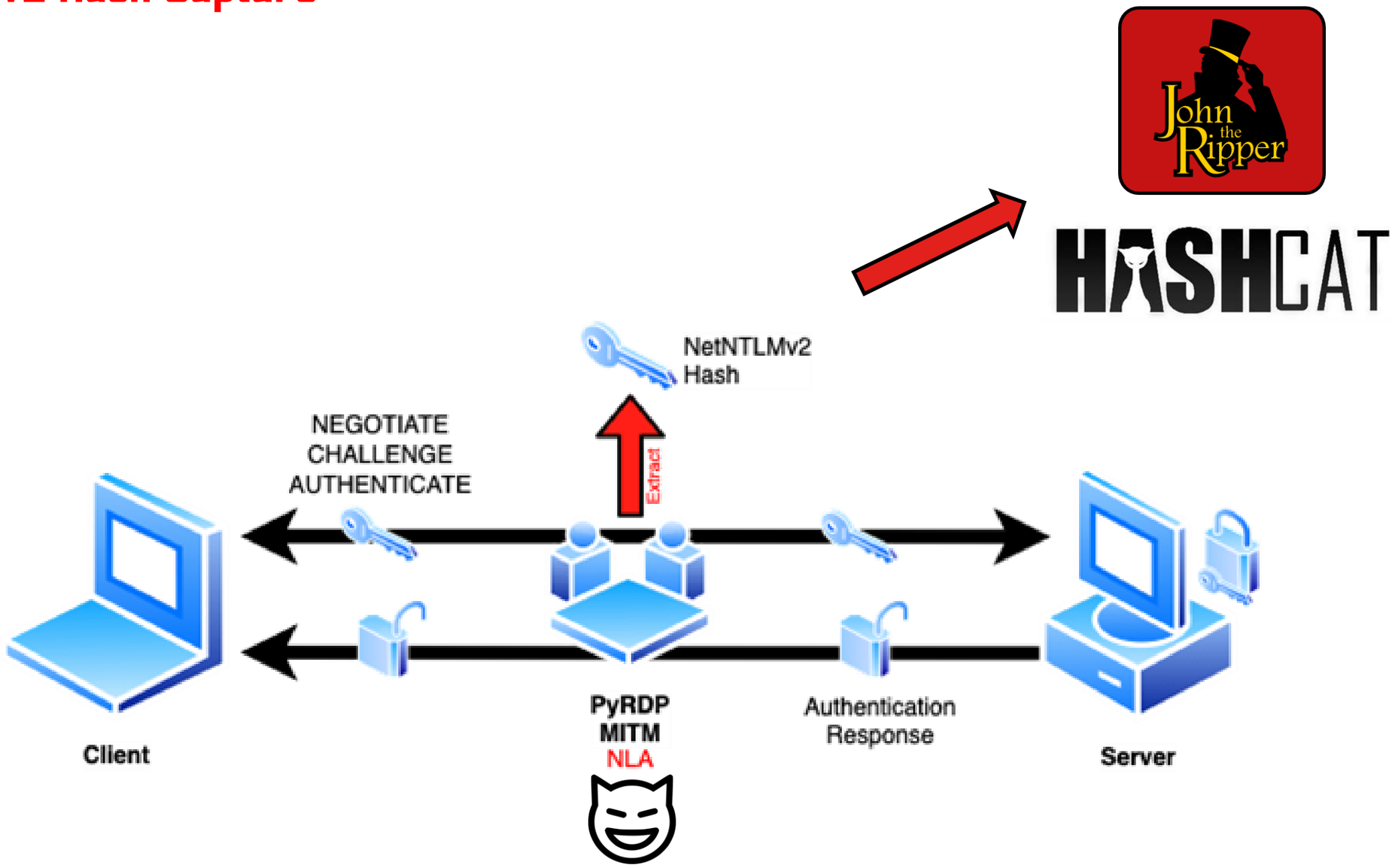
# NetNTLMv2 Hash Capture

- On an NLA authentication


- Victim is tricked into connecting to rogue RDP
- The NTLM hash capture is done on-the-fly
- Hashes can be cracked using password cracking tools

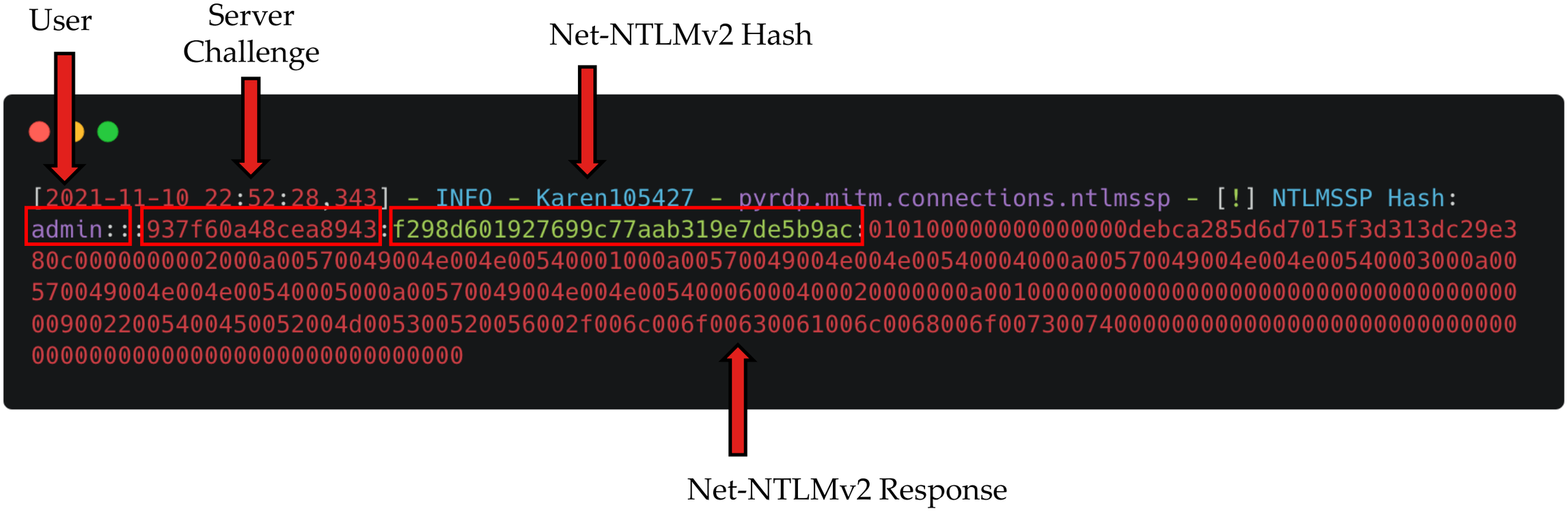
# NetNTLMv2 Hash Capture

(cont.)



# NetNTLMv2 Hash Capture

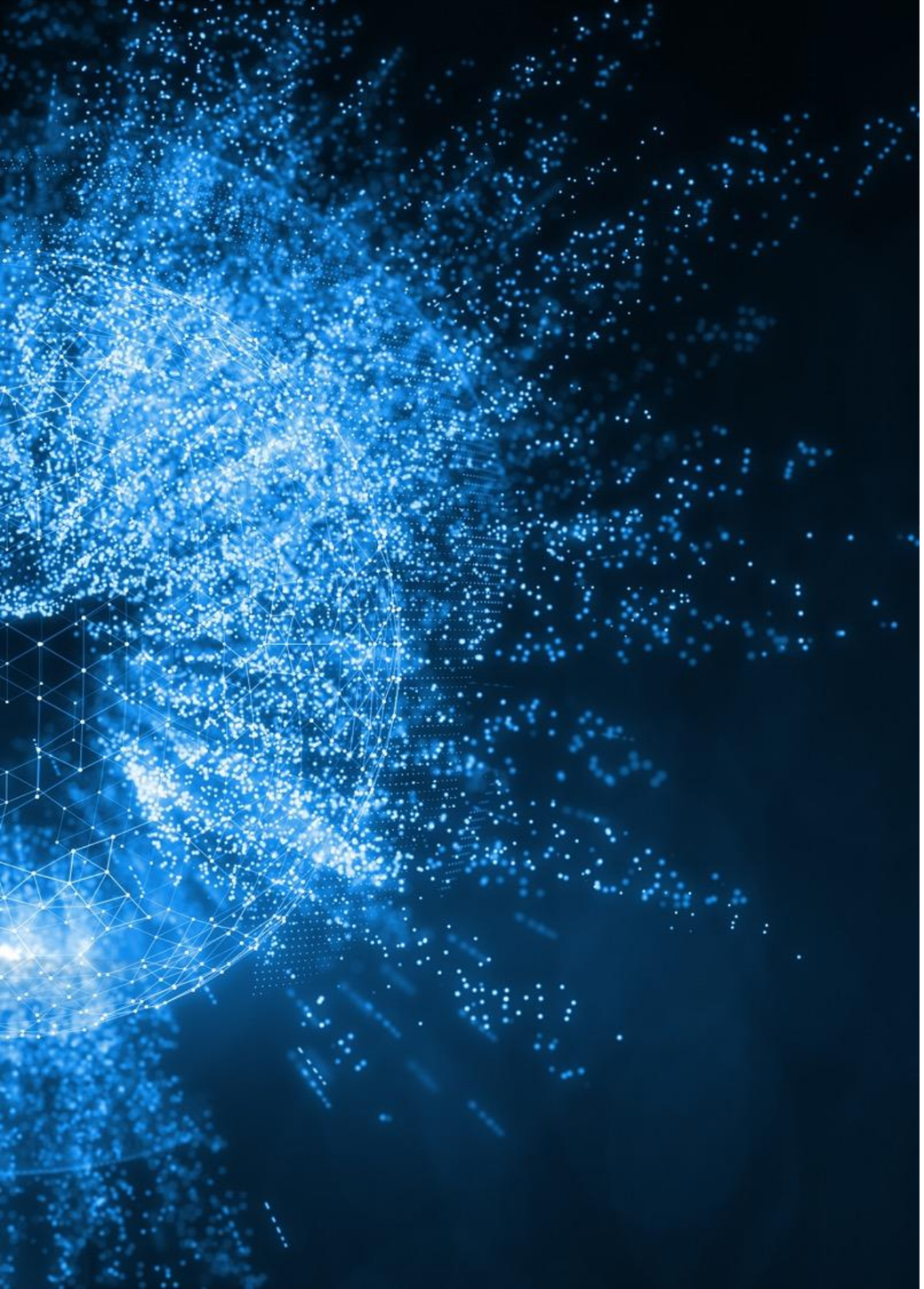
Example of captured hash



# NetNTLMv2 Hash Cracking

With john (hashcat works too)

```
$ john --format=netntlmv2 --wordlist=~/wordlist/rockyou.txt hashes.txt
Using default input encoding: UTF-8
Loaded 1 password hash (netntlmv2, NTLMv2 C/R [MD4 HMAC-MD5 32/64])
Will run 8 OpenMP threads
Press 'q' or Ctrl-C to abort, almost any other key for status
purple           (admin)
1g 0:00:00:00 DONE (2022-04-07 14:44) 14.28g/s 58514p/s 58514c/s 58514C/s
123456..oooooo
Session completed
```



# Preventing Hash Capture

- Verify connection to RDP server
  - Server address
  - Domain name
- Always look for valid certificates
  - Attack tools will often use hardcoded certificate values
- But…

# How Bad is it Really?

## Demo!

(link to video)

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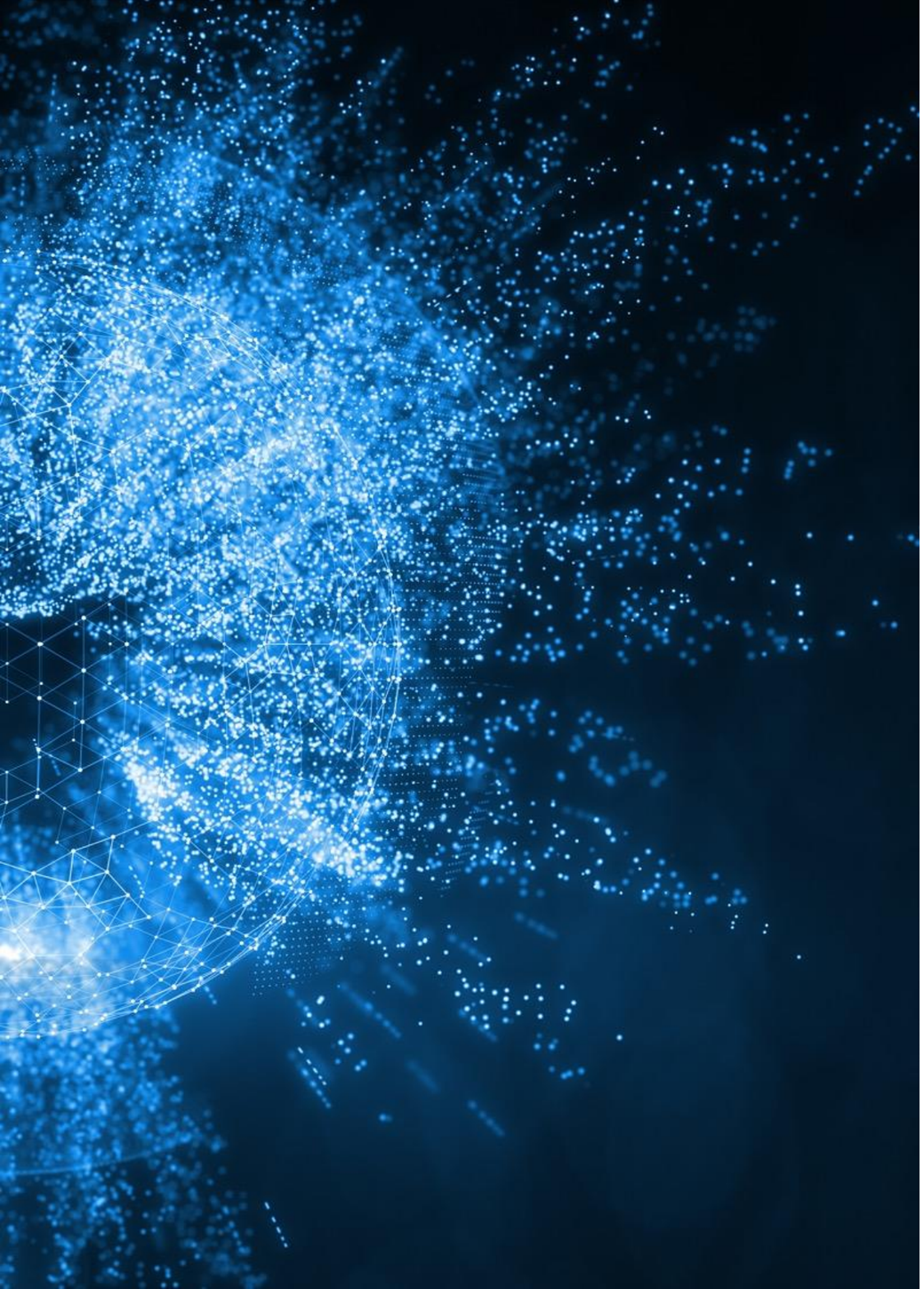


# Preventing Hash Capture

After what we found…

- Never use RDP on untrusted networks!
- Avoid NTLM => Use Kerberos
- Audit NTLM usage*

# Wrapping Up

# Recap of the Risks

## Attacks on the Client

- Stealing files, clipboard, keystrokes
- Recording screen
- Stealing hashed or plaintext credentials
- Code exec via DLL Sideloading*
- RDP Phishing aka Rogue RDP*

## Attacks on the Server

- Credential Bruteforcing
- Session takeover
- Command injection

# Future Work

## Defensive Side

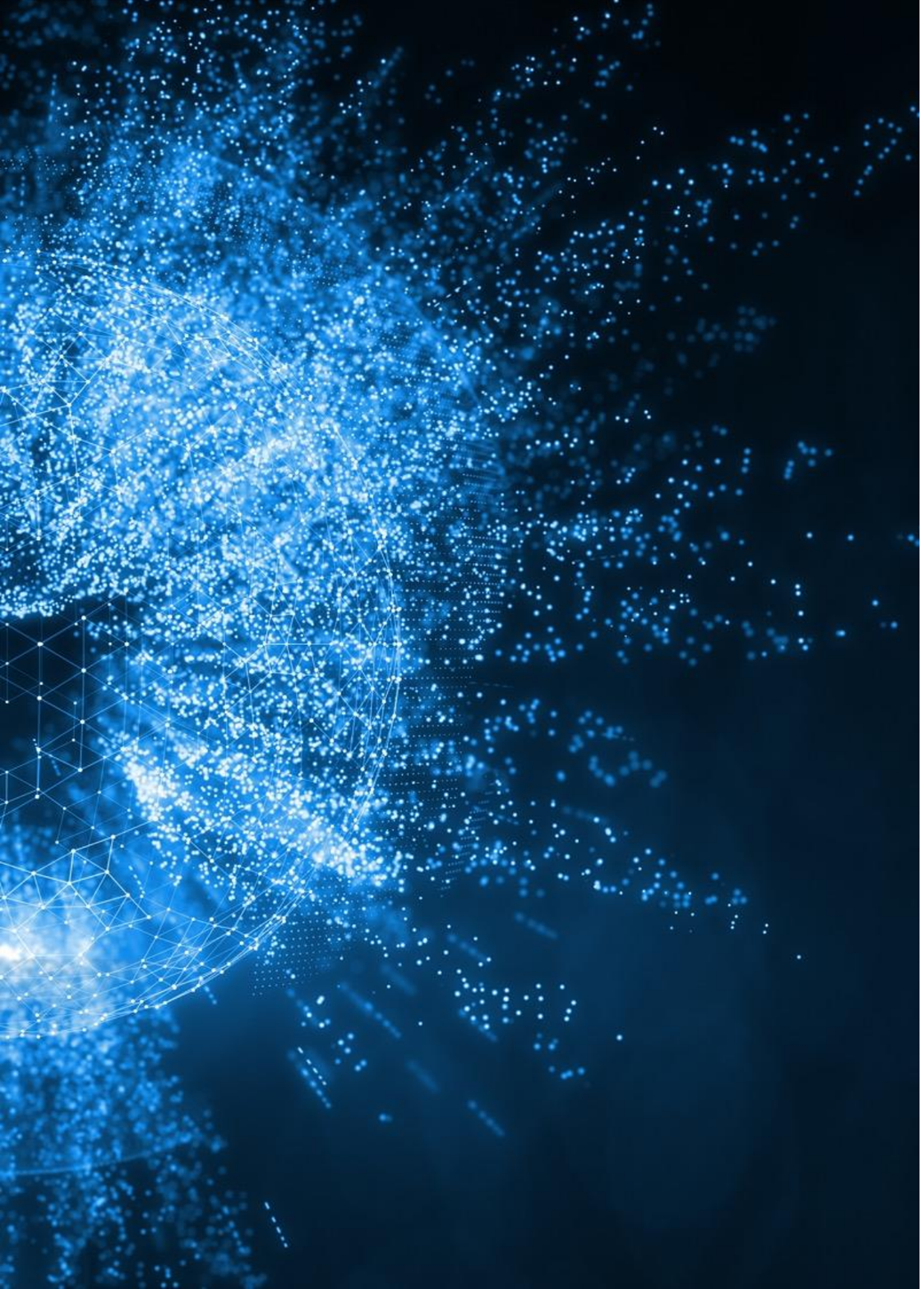
- RD Gateway
- Require valid TLS with specific CA
- NTLM Restrictions
- Shadow Attack Framework (AutoRDPwn)
- Enterprise-scale mitigation
- Blog, blog, blog!

## Offensive Side

- RestrictedAdmin with PyRDP
- Kerberos Downgrade
- Shadow Attack Framework (AutoRDPwn)
- RD Gateway


# Red Team Take Aways

- RDP is often misconfigured and under the radar
- You can do more than credential bruteforcing with it
  - Attack clients
  - Attack servers
  - Attack both!
  - No EDR/XDR coverage (that I'm aware of)



# Blue Team Take Aways

- Today: Never use RDP on unprotected networks!
- Today: Train users to not click through certificate errors!
- Soon: Make sure NLA is enforced on all RDP servers (default, often deactivated)
- Long-term: Carefully roll-out Remote Credential Guard or Restricted Admin client-side enforcement

# Special Shoutout!

Big shout out to Marc-André Moreau (@awakecoding)!

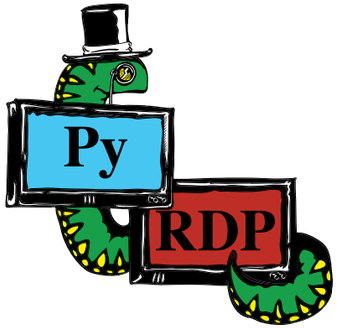
# Thank You!

And Resources

## Special Thanks to those that made PyRDP possible!

- Citronneur, Emilio Gonzalez, Francis Labelle, Maxime Carbonneau, Alexandre Beaulieu and coolacid

## ~~Questions?~~ See you at the panel!





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- https://www.gosecure.net/blog/2022/01/17/capturing-rdp-netntlmv2-hashes-attack-details-and-a-technical-how-to-guide/
- https://www.darkoperator.com/blog/2012/3/17/configuring-network-level-authentication-for-rdp.html
- https://docs.microsoft.com/en-us/windows-server/remote/remote-desktop-services/clients/rdp-files