SIGPwny

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Active Directory I

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sigpwny{Domain Expansion}

Overview

- Active Directory Overview
  - Why does it exist
  - How does it work
  - Why it's a good target
  - Domain Controllers
- Kerberos Protocol
  - Kerberoasting & AS-REProasting
- NTLM & Net-NTLMv2
  - Pass-the-hash revisited
  - Responder & Hash Relaying
- Offensive Flow
  - Recon
  - Lateral movement
  - Domain Dominance

Why & How

Why have AD?

- Think about the system of University of Illinois
- 3 campuses, in total 100k+ students, so 25k+ students every year
- They all need
  - An email account
  - Access to school computers (Windows and Linux)
  - Everyone needs a different “view” of the computer
  - Access to different locations

- UIUC has 35k+ computers alone

How do we manage them?

Why have AD?

- Built to centralize authentication, authorization, and user management in enterprise Windows environments
- Introduced by Microsoft in 1999, built to merge LDAP (directory access), Kerberos (authentication) and DNS (name resolution) into one monolithic enterprise management solution
- LDAP is the Active Directory protocol (like HTTP is for the web)
- If we didn't have this, we would be connecting computers in an ad-hoc fashion (decentralized)

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- LDAP is the Active Directory protocol (like HTTP is for the web)
- If we didn't have this, we would be connecting computers in an ad-hoc fashion (decentralized)
- **Putting all of your trust in one place is dangerous…**

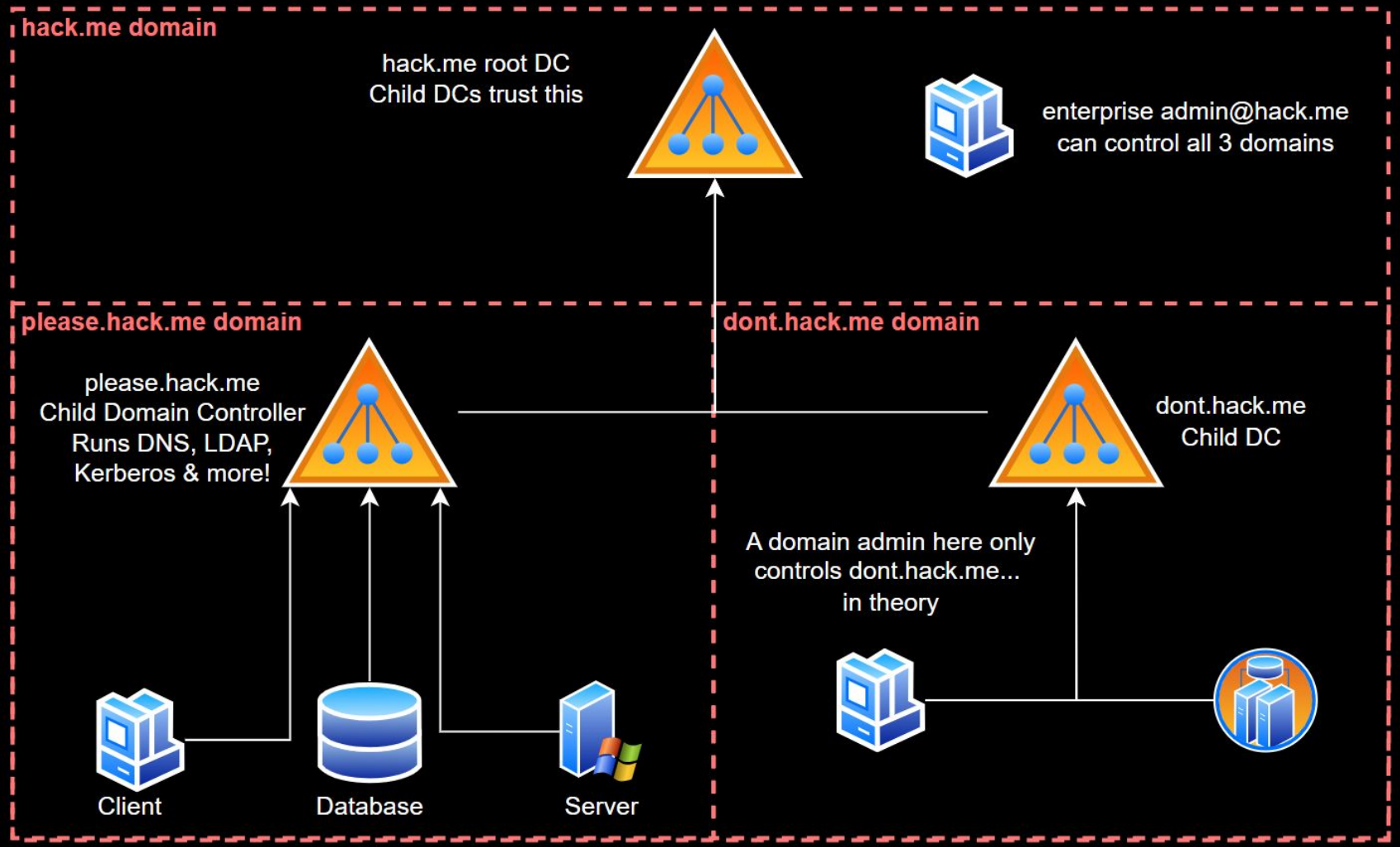
What is Active Directory?

- Basically a system for a bunch of computers to interact with one another in a work setting with configurable privileges and remote access
- Machines will be joined to an Active Directory Domain (illinois.edu)
- Each domain will *at least* have a Domain Controller
  - This is your centralized source of truth for every record in LDAP
  - When you request something over LDAP / DNS / Kerberos, it goes here
- It's also possible to have parent/child domains and other Forests
  - LDAP is set up like a tree data structure - each child domain requires a child domain controller
  - Crossing domains is not a security boundary but crossing Forests is

What is Active Directory?

- Active Directory is very permissive by default and changes some default settings to allow additional remote access
- This is by design. We can focus on targeting features of Active Directory and attacking misconfigurations to abuse trust relationships rather than traditional vulnerabilities
- You can log in to other domain-joined computers using NTLM (remember Pass-the-Hash from Windows!) as well as Kerberos

Toy Domain Example



How does AD work?

- The key service that runs AD is "Active Directory Domain Services"
  - The domain controller is the server for this
  - This stores information about domain users and computers, as well as their access rights
  - This is contacted whenever a user logs into a machine
  - All of the user credentials are usually stored on the Domain Controller in a database called **NTDS.dit**
- AD manages your ability to do things to certain objects, e.g. create a user, remote log in to a computer, manage a service
  - The security check for this is SDDLs, everyone's favorite!
  - Each user and group will have a SID that the domain recognizes
- **Owning the domain controller means owning the target domain, effectively forever**

Why target Active Directory?

- Something like >95% of the Fortune 500 use Active Directory
- Permissive by default and extremely difficult to configure securely
- Tons of niche or poorly documented features that are often misconfigured (ADCS, SCCM)
- You likely don't need **ANY** vulnerabilities to get domain admin, meaning you can chain a phish or credential with features to achieve complete compromise
- A domain compromise is game over for defenders and will almost guarantee you access to your objective
- **If you can hack this one piece of software, you can hack 95% of companies & organizations**

Kerberos

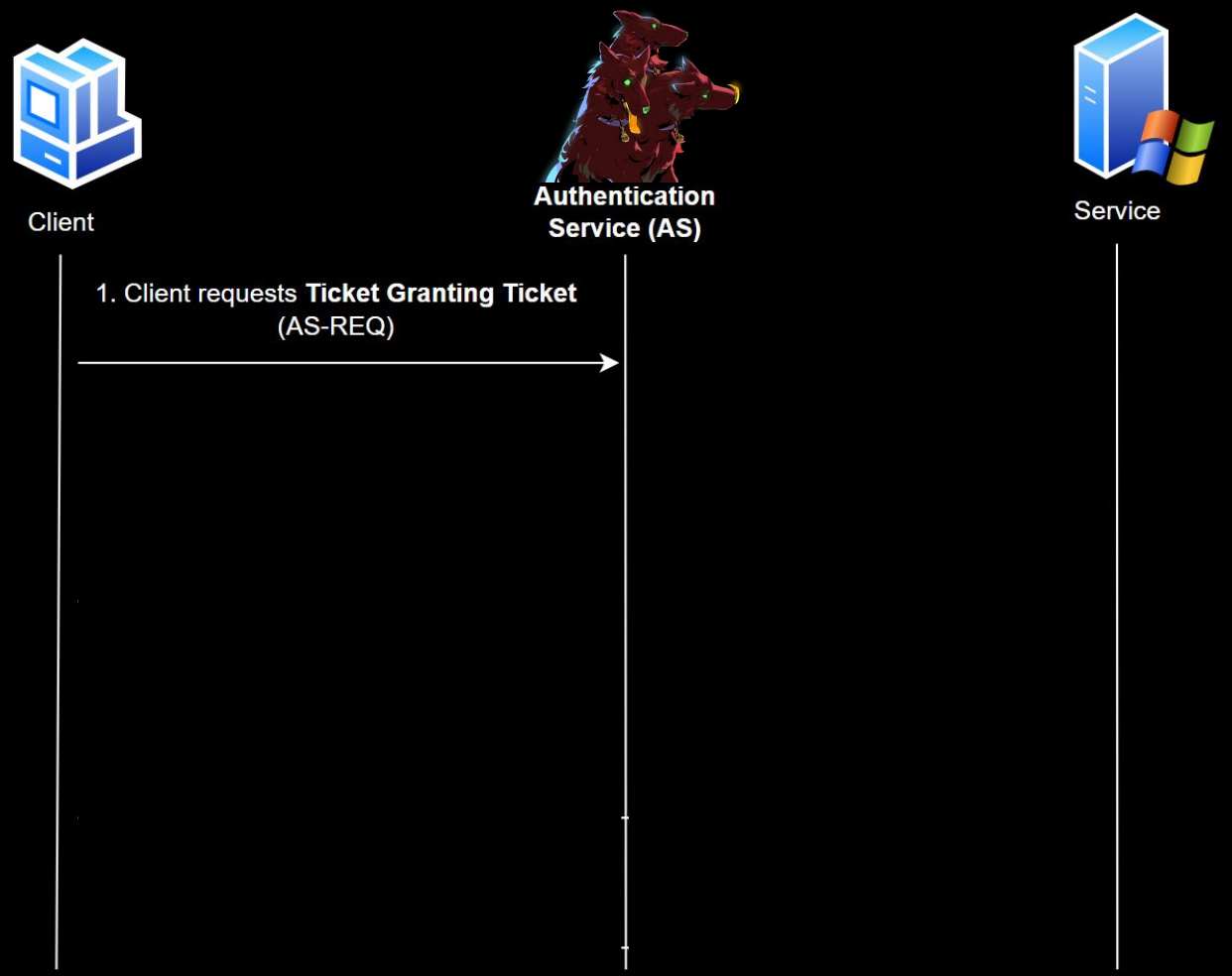
Guardian of the Domain

Kerberos

- Kerberos does authentication differently than NTLM
  - Goal was to provide mutual authentication between clients and services without transmitting passwords over the network
  - Proves identity via cryptographic keys derived from passwords instead
  - Functions similarly to a zero-knowledge proof where the client proves knowledge of a secret (their password) without revealing the secret to the verifier
- You will have **tickets** that let you do **stuff** to **things**
  - Surprisingly good mnemonic to remember Kerberos versus NTLM

Kerberos

- The KDC knows all passwords
- AS-REQ: Client sends username and realm to the server, and optionally a pre-auth to proof their identity



Kerberos

- The KDC knows all password hashes
- AS-REQ: Client sends username and realm to the server, and optionally a pre-auth to prove their identity
- AS-REP: Server then sends a ticket (TGT) that is encrypted with server's hash, and a session key that the client can decrypt

Kerberos

- This provides mutual authentication between the client and server
- The client now has a ticket (TGT), that can be used to request service access (TGS)
- Since TGT is service-independent, TGT = NTLM hash in terms of power

Kerberos

- With TGT, the client now asks the server for ~~a candy because it's halloween~~ a *specific* ticket to access the service
- TGS-REQ: the client sends the previous TGT and pre-authentication data to prove its identity

Side note: TGT is like a TGS to kerberos itself - thus it is encrypted **with the kerberos service hash**

Kerberos

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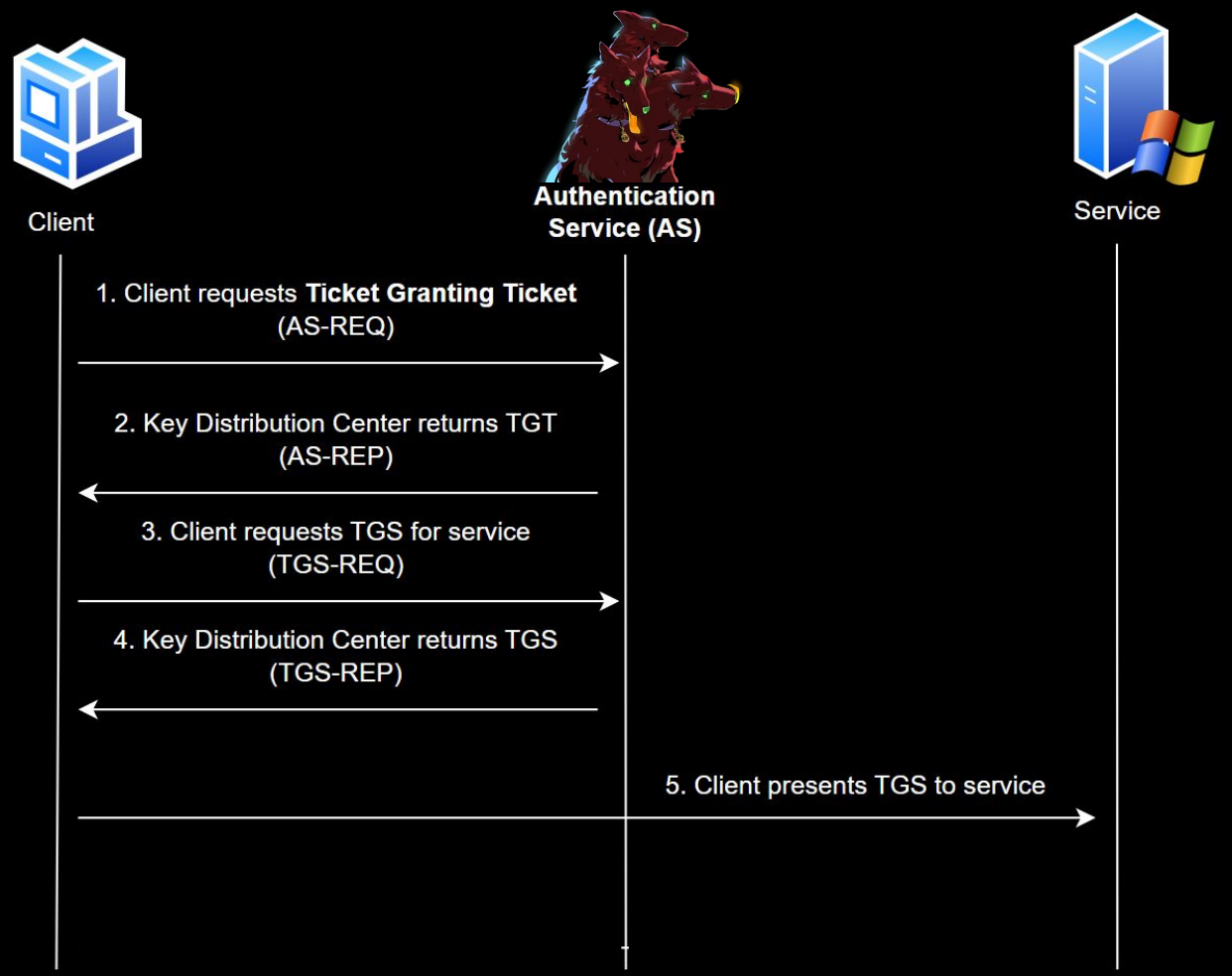
- TGS-REQ: the client sends the previous TGT and pre-authentication data to prove its identity
- TGS-REP: the server sends a TGS that is encrypted with the service's hash, as well as a session key that the client can decrypt

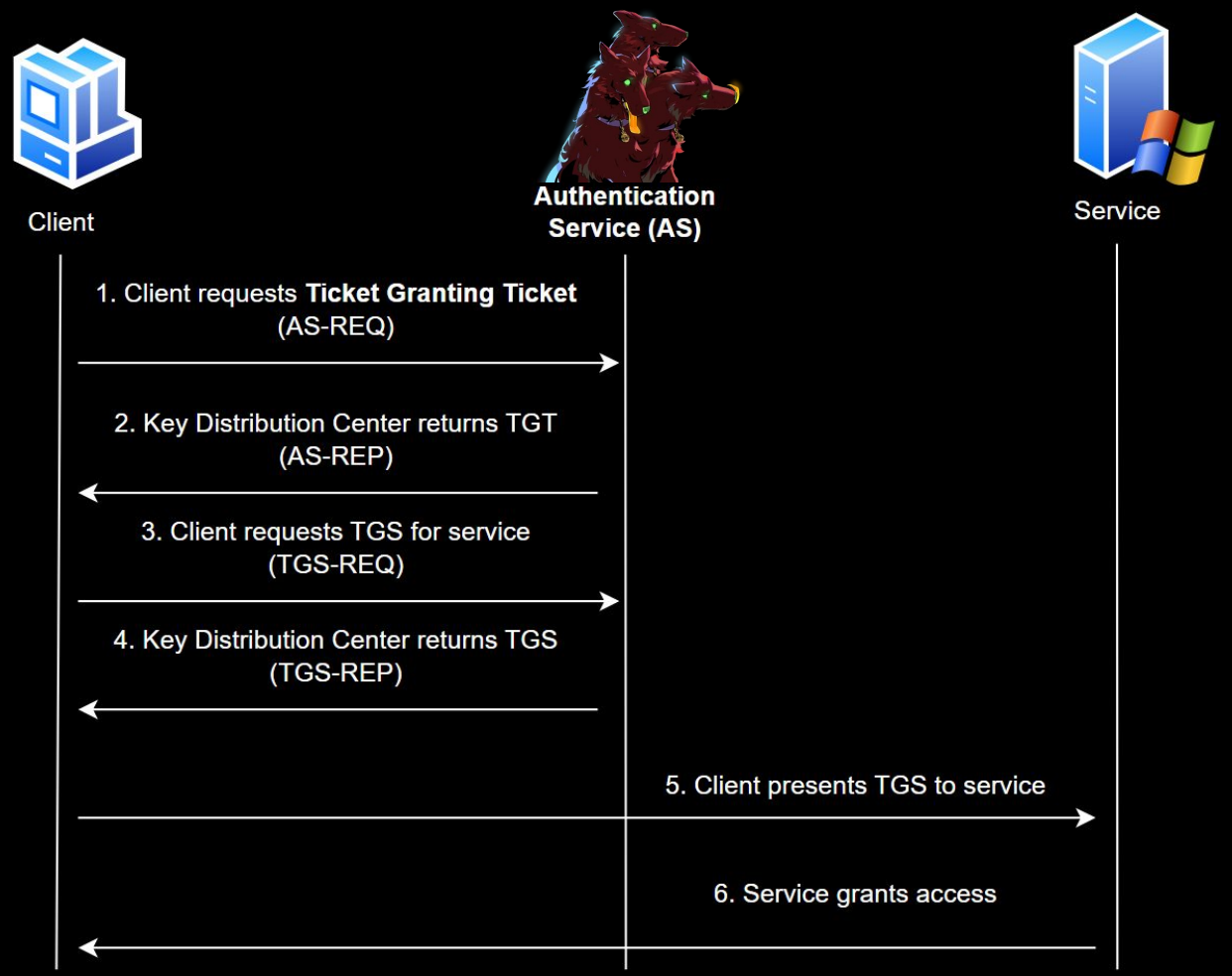
Kerberos

- Client now presents TGS and its own session key to the service. TGS contains client information and the session key.



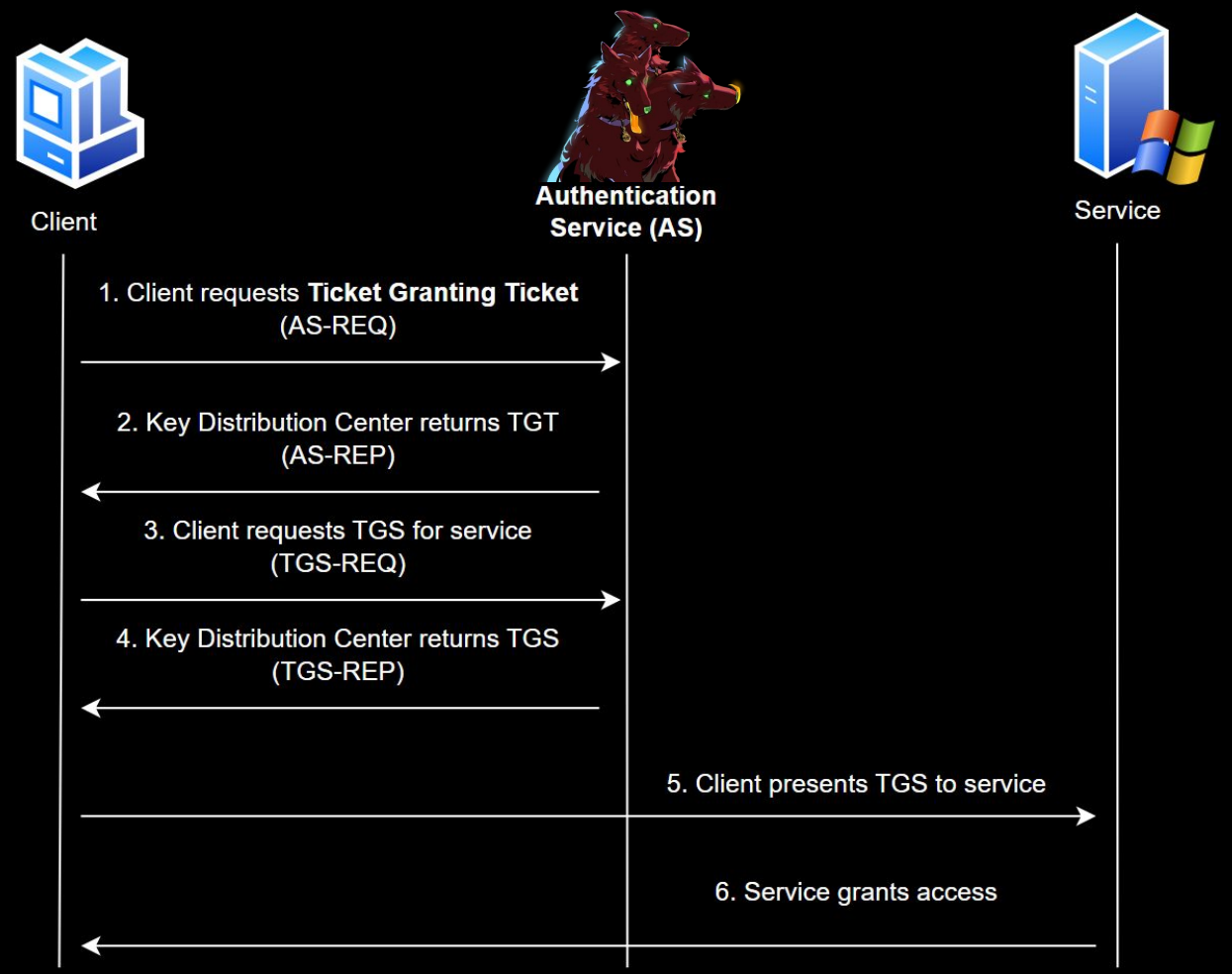
Kerberos

- Client now presents TGS and its own session key to the service. TGS contains client information and the session key.
- Service decrypts the TGS, reads the client name and privileges, and then grants or denies access.



Kerberos

- Client now presents TGS and its own session key to the service. TGS contains client information and the session key.
- Service decrypts the TGS, reads the client name and privileges, and then grants or denies access.
- **Can you find any problems with this flow?**

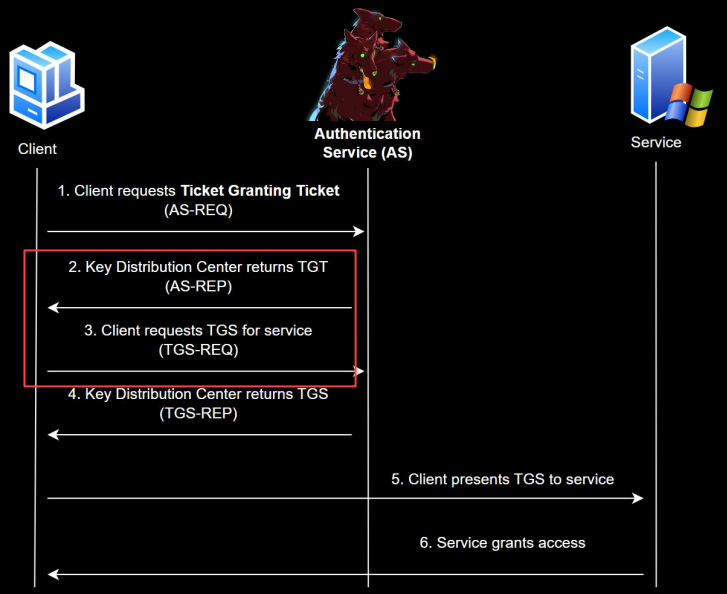


Kerberos Points of Failure: TGS

- Working as normal, we can abuse **where** secrets come from
  - Part of the TGS returned by the KDC is encrypted with a secret derived from the password of the user account running that service
  - We can request TGS's for services running under domain accounts and crack them offline to recover their password! (**Kerberoasting**)

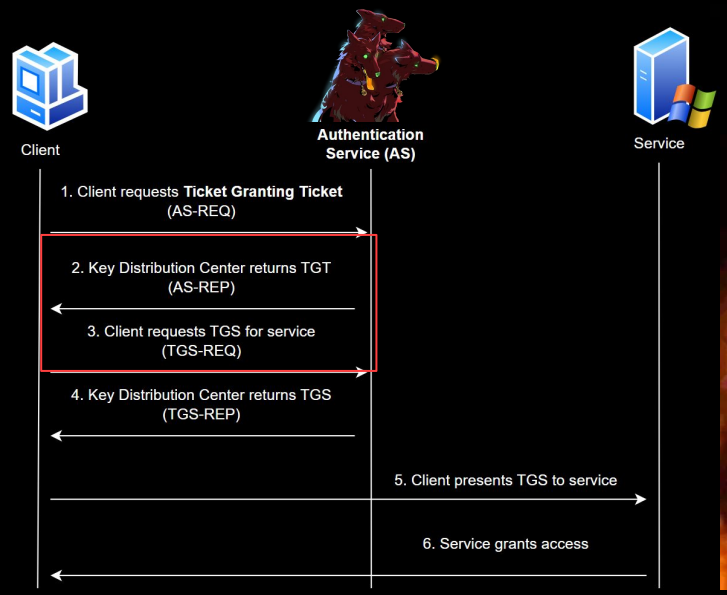
Kerberos Points of Failure: TGT

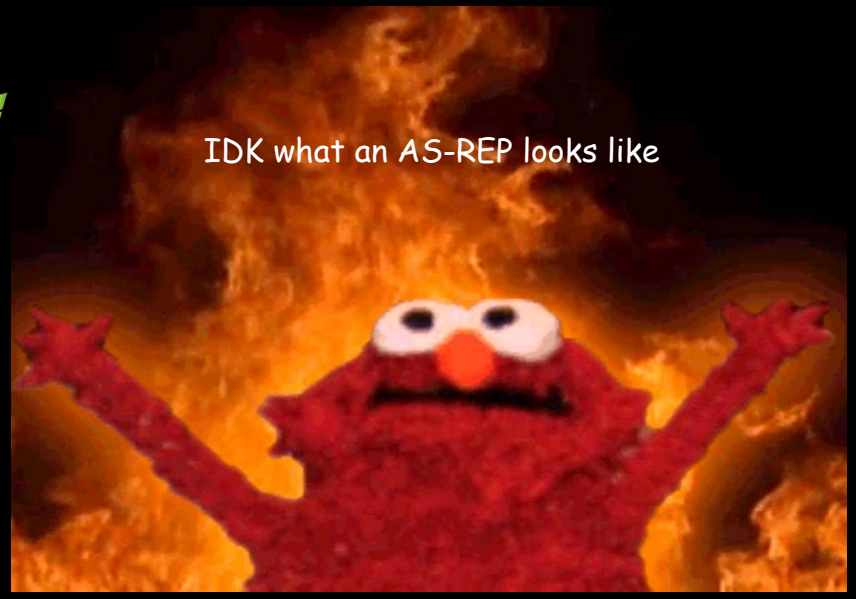
- For all things that require a TGT (Kerberos pre-auth), they all rely on **password** of a special account (**krbtgt**)!
  - If I were able to obtain the Kerberos account hash, then I could forge TGTs and therefore TGSs that give me access to anything
  - This requires a domain controller compromise, but if you can do it, you now own everything in the domain (called a **Golden Ticket**)



Kerberos Points of Failure: Pre-Auth

- Remember when I said “optionally a pre-auth to prove their identity”?
- What if we don't require the TGT?
  - If a user or service does NOT require the TGT, then anyone can send an AS-REQ for the account to get an AS-REP for that user, which we can crack to obtain their password
  - This technique is called **AS-REP roasting**





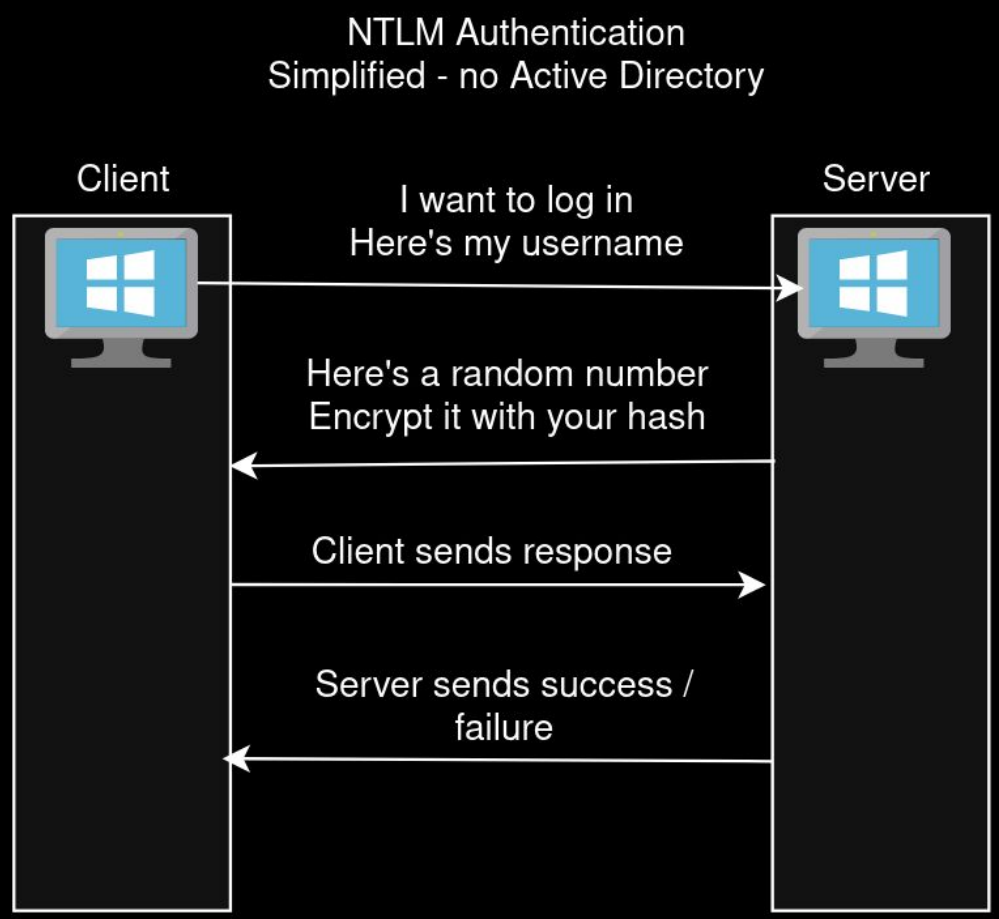
Kerberos will return in AD 2...

NTLM

"*I roll all my own crypto*" - Bill Gates, probably

NTLM Authentication

- NTLM authentication functions as a zero knowledge proof where the secret is the password hash
- The auth mechanism is challenge / response
- Key point is that **the hash is the authentication material, not the password**
- Stealing the hash **allows authentication**



Hash Theft

- AD user hashes are in LSASS process memory
  - This is generally not possible to access if Credential Guard is enabled
  - Different threat model - an AD user could have access to other boxes!
- Before Windows 11, all you needed to do was get SYSTEM, dump LSASS process memory, and get hashes

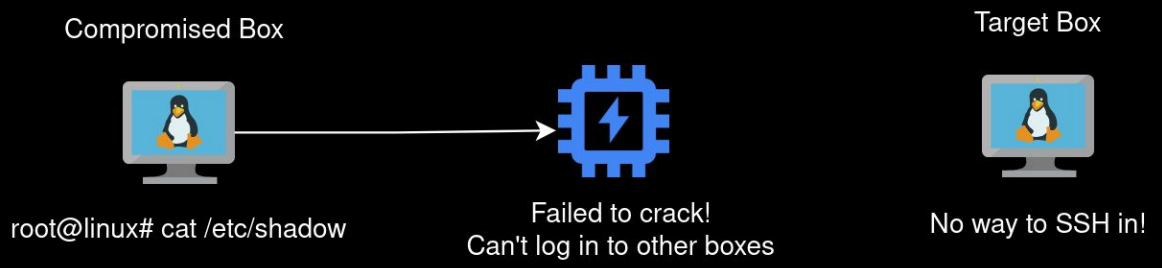
```
beacon> mimikatz !sekurlsa::logonpasswords

Authentication Id : 0 ; 579458 (00000000:0008d782)
Session           : Batch from 0
User Name         : jking
Domain            : DEV
Logon Server      : DC-2
Logon Time        : 8/31/2022 11:49:48 AM
SID               : S-1-5-21-569305411-121244042-2357301523-1105
        msv :
         [00000003] Primary
         * Username: jking
         * Domain    : DEV
         * NTLM      : 59fc0f884922b4ce376051134c71e22c
         * SHA1      : 74fa9854d529092b92e0d9ebef7ce3d065027f45
```

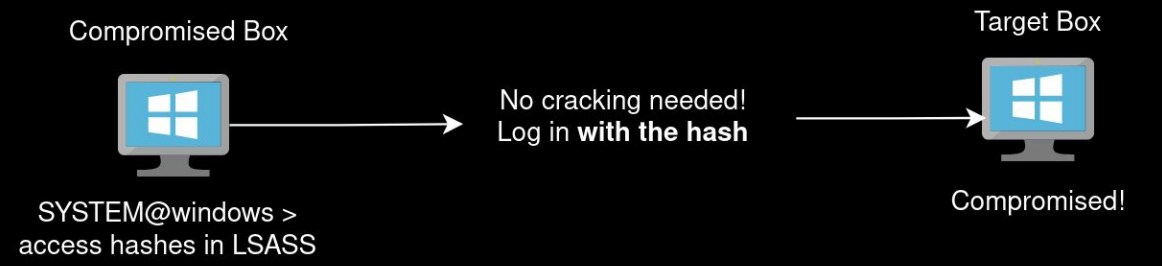
The Pass-the-Hash attack

- Suppose we have compromised a user's NTLM hash, but not their password
- Since NTLM is like a proof, we can prove to anyone else that we are the user in question by presenting a permutation of their hash
- So, we can obtain persistent access as any user whose hash we have obtained
- The usual flow for this would be to compromise a box, dump hashes, and log into everything we can with the new credentials
  - You could rinse-repeat this however many degrees of separation it would take to become Domain Admin
- Hash theft on Windows 11 requires a kernel and hypervisor exploit, or to just lie in wait by backdooring LSASS

Pass-the-Hash Example Scenario

Suppose we have a domain admin with a strong password
logged into a compromised box. Can we access another box?





Credential Guard

Suppose we have a domain admin with a strong password
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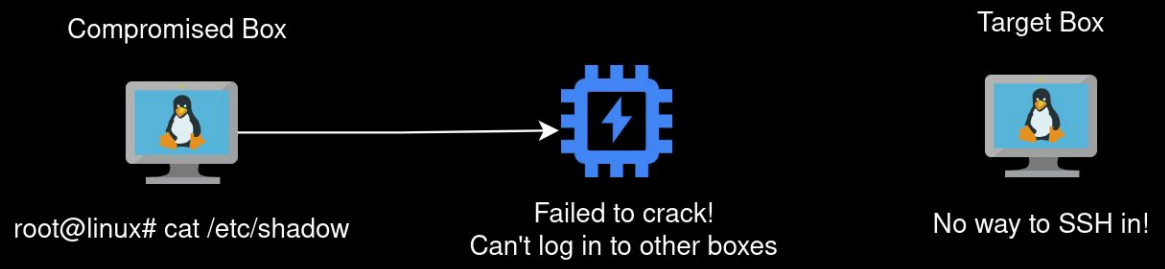
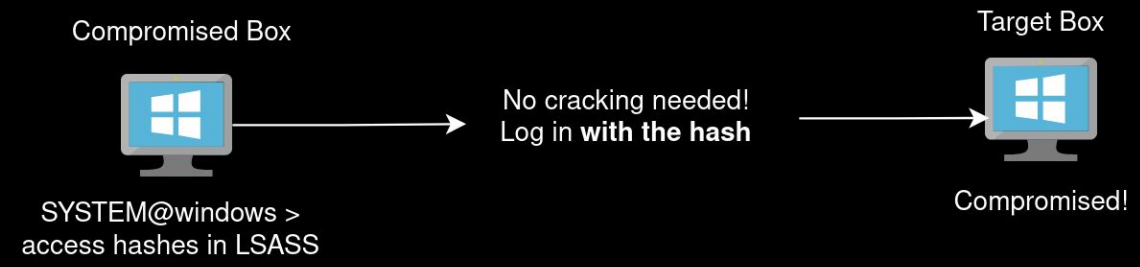
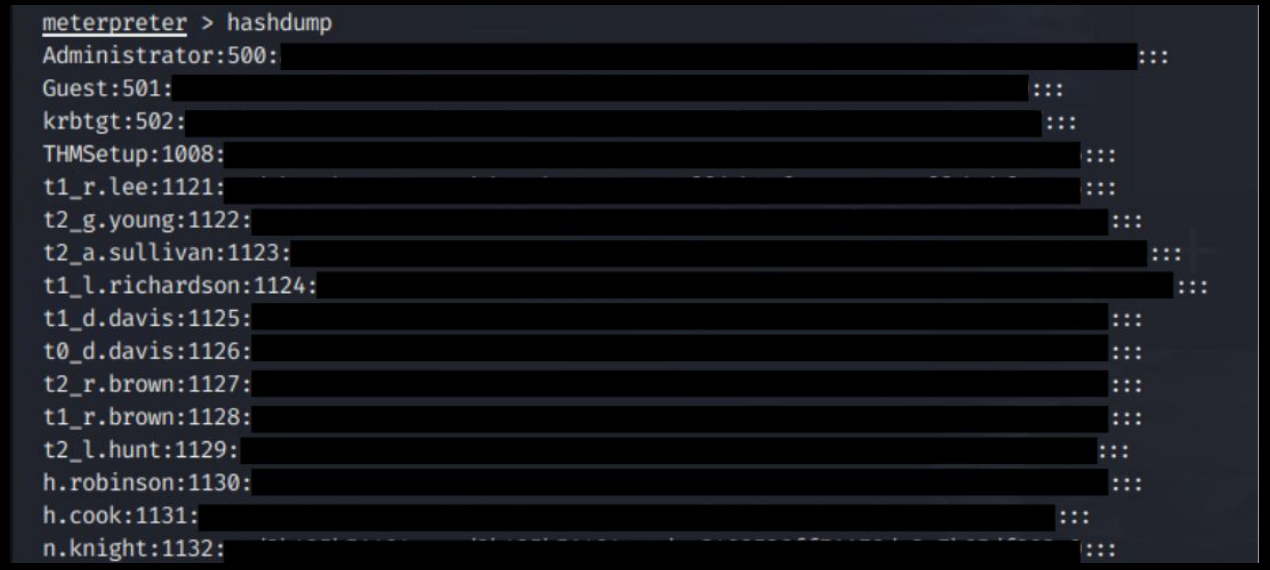




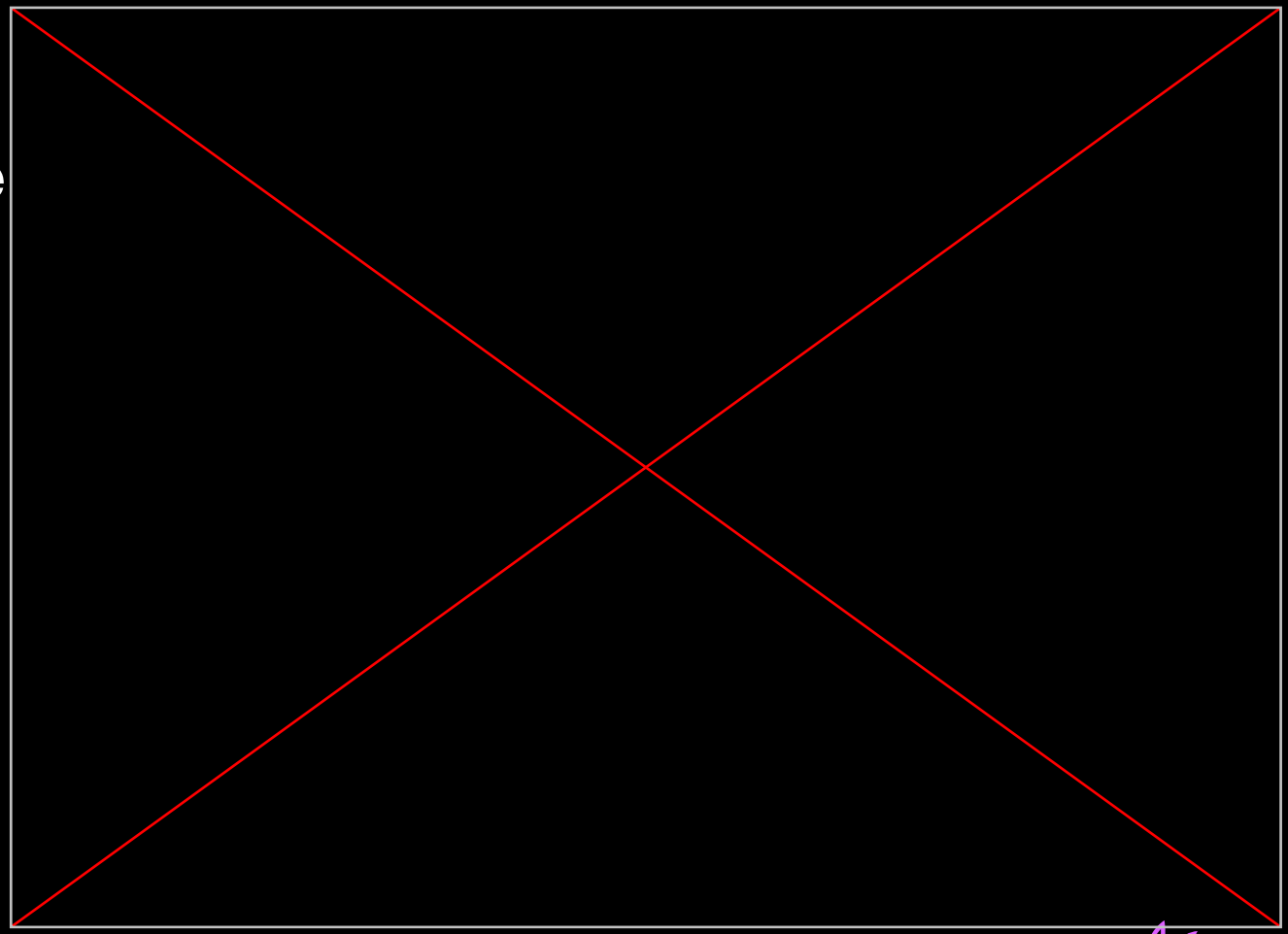
Practical Uses

- **Mimikatz**
  - Does a variety of things to access confidential information
  - The most signatured piece of malware in existence
  - Can steal everything stored in LSASS & registry
  - Actual EXE dropped on-target
  - Built in to meterpreter as an extension (kiwi)



Practical Uses

- **Impacket-Secretsdump**
  - Steals as much as possible while executing no agent (network only)
  - Does not access LSASS but accesses everything in registry
  - Can also leverage legitimate RPCs for domain replication (DCSync)



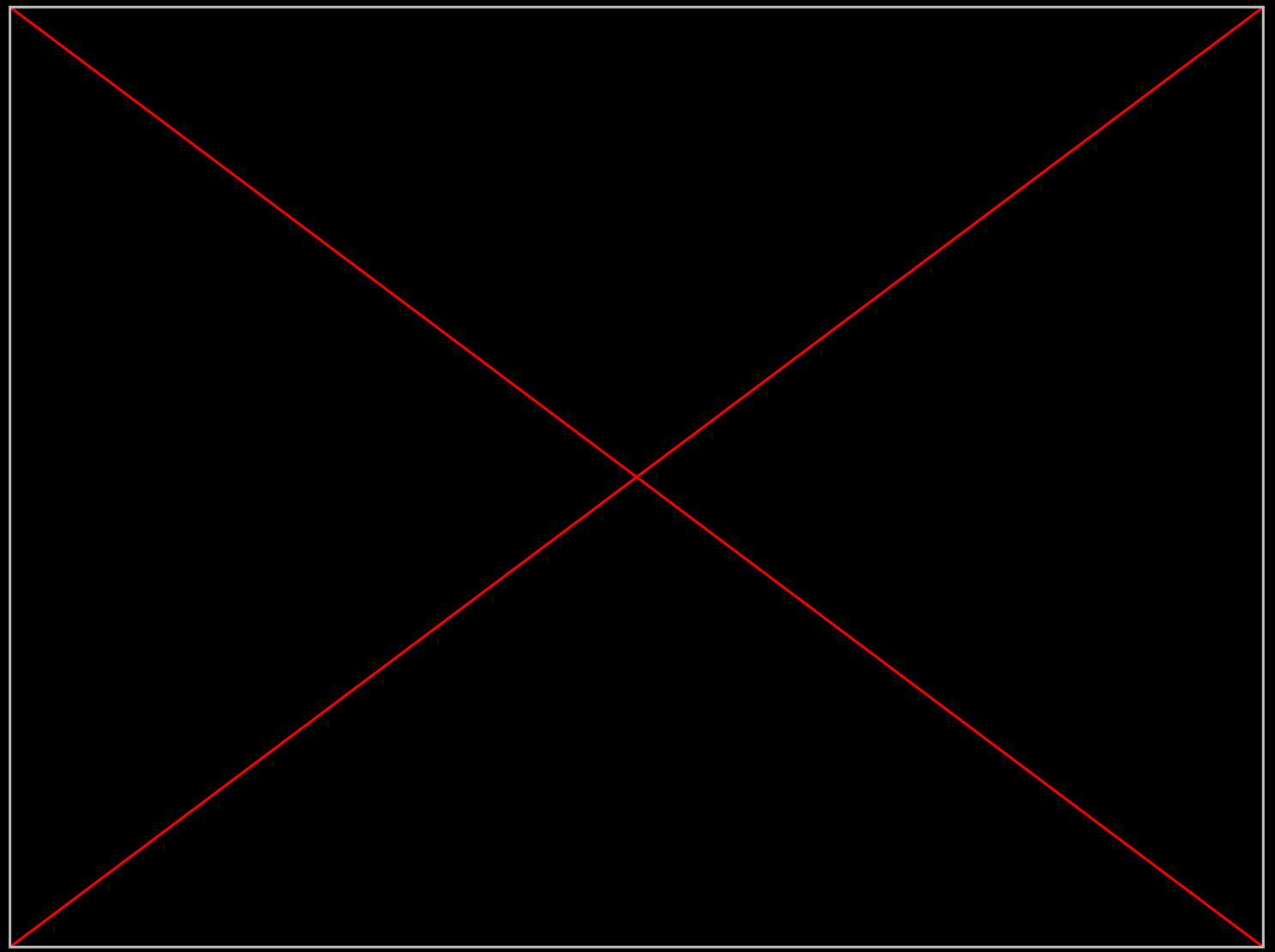
Net-NTLMv2

- For designated remote logins, there's Net-NTLMv2
- Net-NTLMv2 is NOT NTLM!
- **Net-NTLMv2 cannot log in to the computer that sent the hash**, but it can log in to anywhere else
- We can attempt to crack this to recover the plaintext password
- Tricks to get Net-NTLMv2 hashes over a network
  - If we can trick someone into click on a .lnk or similar, that can log them into our SMB server
  - When you access an SMB server in windows, you will **automatically** log in via Net-NTLMv2
  - So, a common phish would be to host shortcut files that point to a legitimate file hosting on an attacker's SMB server

Net-NTLMv2

- We can also try to MITM Net-NTLMv2 instead of phishing
  - You can use a tool called Responder, which will leverage (among many other techniques) Link Local Multicast Name Resolution to say that your attacker share corresponds to certain hostnames
  - They then visit it and you get their Net-NTLMv2 hash
- **Using responder in poisoning mode on a public network is super illegal (and very effective 😉)**

Federal Crime Speedrun

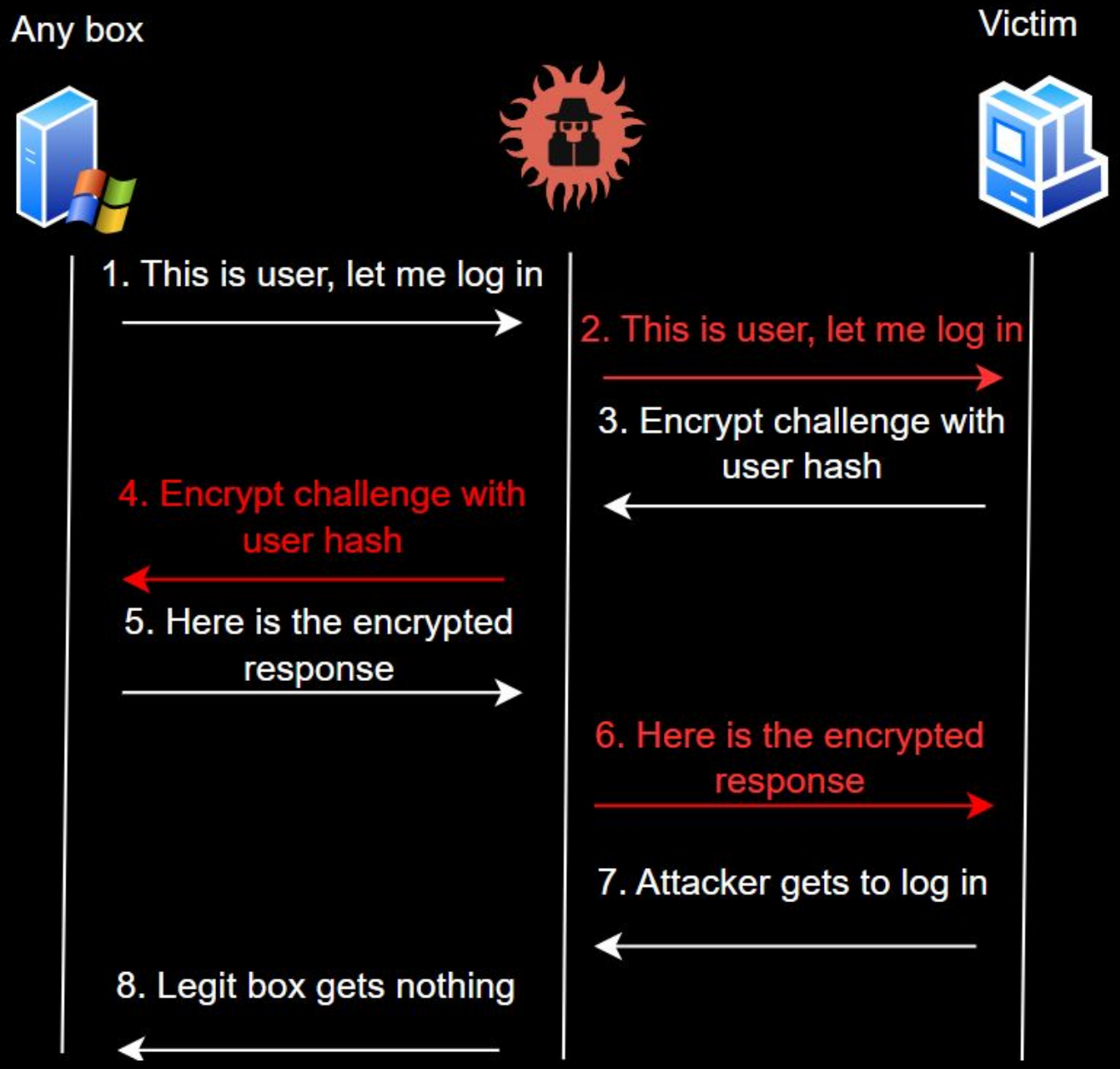


Authentication Coercion

- We do not need to MITM or phish if the target is vulnerable to authentication coercion
- Many of these bugs still exist
- There are a number of authentication coercion "**features**" like the infamous Printer Bug, which, under certain circumstances, **will force the target machine to authenticate to an attacker-controlled host**
  - For the Printer Bug, the Print Spooler must be running on the target
- So, there are some circumstances where we can disclose a Net-NTLMv2 hash **at will** (google PetitPotam, Printer Bug)
- Can we use any of these bugs (or combine them) to compromise the sender machine?

Hash Relay Attack

- Recall that *everyone else* respects the Net-NTLM hash, so we can just be a man in the middle and bounce the hash back and forth
- Any time we can force a Net-NTLMv2 login in an AD environment (auth coercion, .lnk file, xp_dirtree, responder), we can pull this trick
- *More such tricks exist…*



Hands-on-keyboard

Domain Recon

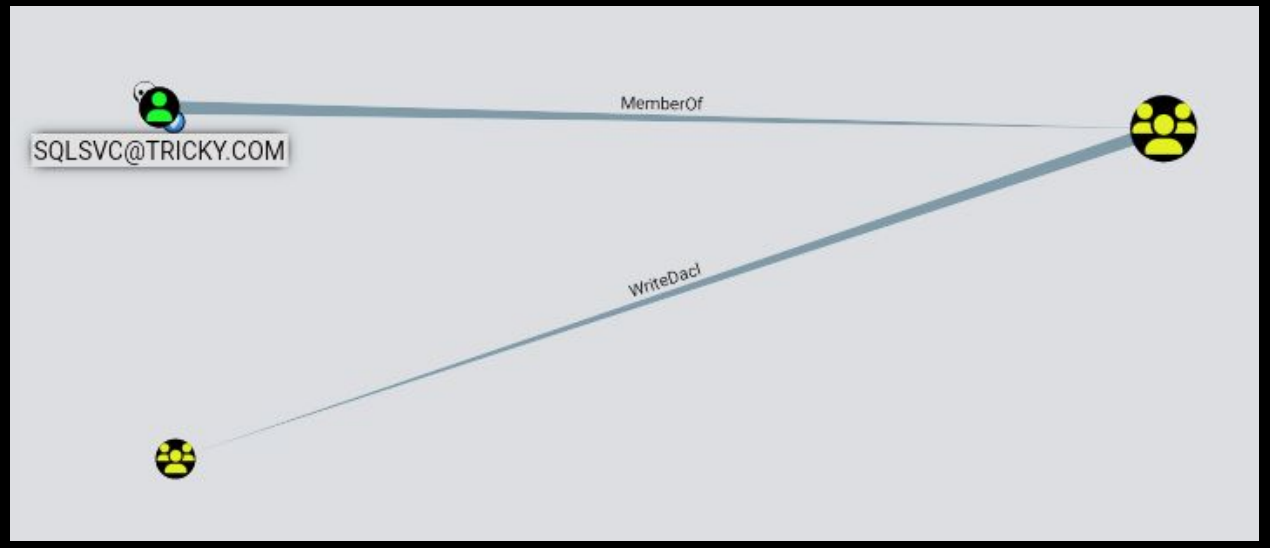
- Like NetSec and WebSec, we need to recon our target before we do anything
- For example, it is **trivial** to detect Kerberoasting via Honeypots
  - We want to do manual recon to figure out the lay of the land and avoid active defense and deception measures
  - Use this information to do selective, targeted attacks
- Like PrivEsc, we can do either manual or fully automated enumeration - full auto has poor stealth but some amazing tooling
- We want to look up users, computers, groups, and privileged relationships
- A common tool for this would be **SharpView**, or the more recent Python PowerView port

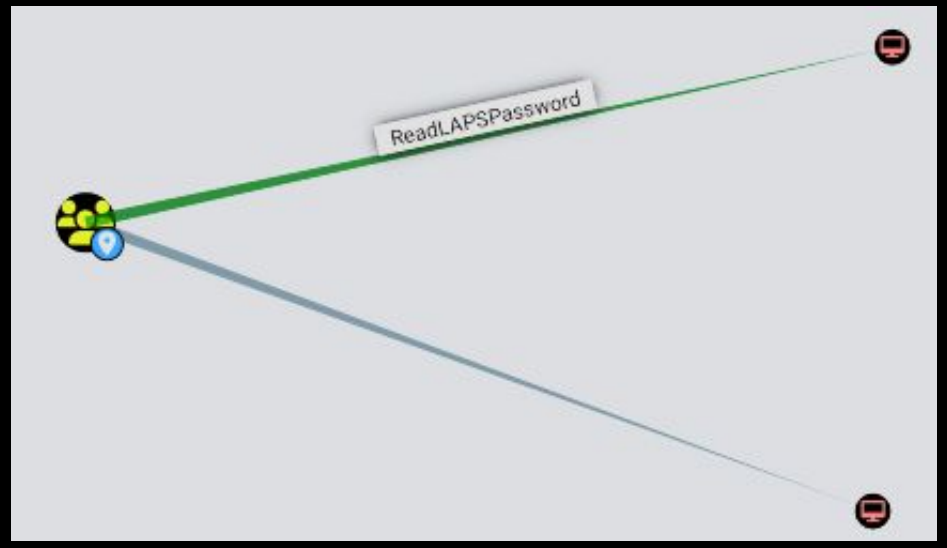
SharpView Cheat Sheet

Command	Description
Get-Domain	Returns information about the current domain or the domain specified with -Domain
Get-DomainController	Returns information about the domain controller for the current or specified domain
Get-ForestDomain	Returns all domains for the current or specified forest
Get-DomainPolicyData	Returns the default domain policy, which can reveal things like the password policy
Get-DomainUser	Returns all users in the domain
Get-DomainComputer	Returns all computers in the domain
Get-DomainOU	Search for all Organizational Units or specific ones
Get-DomainGroup	Returns all groups on the domain
Get-DomainGroupMember	Returns all members of a given group on the domain
Get-DomainGPO	Returns all GPO objects on the domain
Get-DomainGPOLocalGroup	Returns all GPOs that modify local group membership through restricted groups or group policy preferences.
Get-DomainGPOUserLocalGroupMapping	This enumerates the machines where a specific domain user / group is a member of a specific local group. This can be used to cross reference to find administrative privileges.
Get-DomainTrust	Returns all domain trusts for the current or specified domain

BloodHound

- Keeping users and relationships in your head is very difficult
- It is **substantially** more difficult when there are thousands of them
- What if we map out all people and computers and their relationships, then run Dijkstra's algorithm to speedrun Domain Admin?
  - Auto ingest data with SharpHound or Bloodhound-Python





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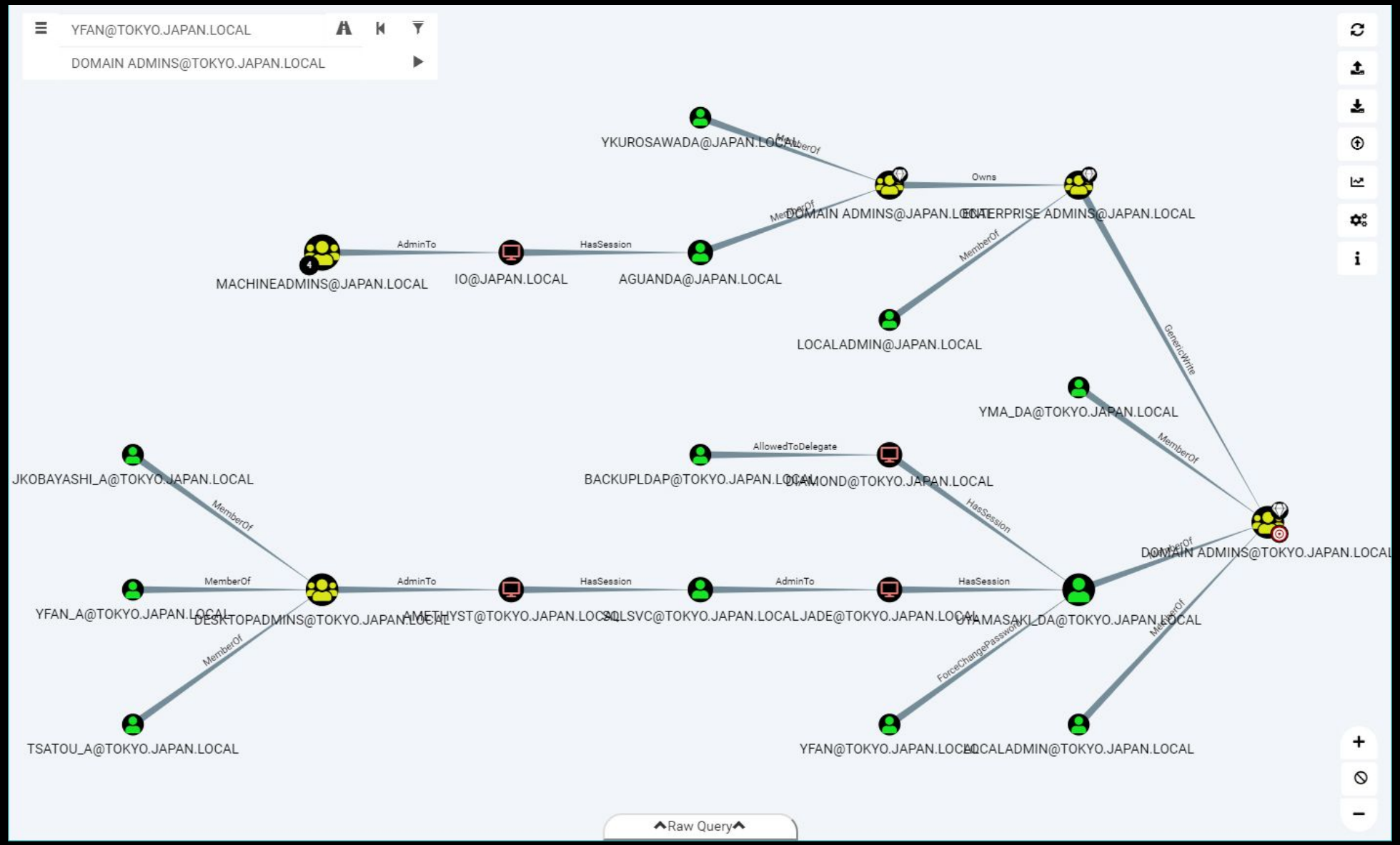
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DESKTOPADMINS@TOKYO.JAPAN.LOCAL
AMETHYST@TOKYO.JAPAN.LOCAL
SQLSVC@TOKYO.JAPAN.LOCAL
JADE@TOKYO.JAPAN.LOCAL
UYAMASAKI_DA@TOKYO.JAPAN.LOCAL
MemberOf
ForceChangePassword
MemberOf
TSATOU_A@TOKYO.JAPAN.LOCAL
YFAN@TOKYO.JAPAN.LOCAL
LOCALADMIN@TOKYO.JAPAN.LOCAL
Raw Query

Lateral Movement

- Let's say we have a credential onto some machine (TGT / NTLM)
- How do I turn that into Remote Code Execution?
- There are many techniques, since we can essentially arbitrarily read and write files via authenticated SMB
  - Write a file over SMB -> start a service over SMB (PSEXEC)
  - Use WMI's Win32_Process class to run commands (WMIEXEC)
    - A favorite of APT29!
  - Modify a service to point to cmd.exe and pipe stdout (SMBEXEC)
  - Utilize SCM manipulation for fileless lateral movement (SCSHELL)
    - A favorite of mine, defeats CrowdStrike Falcon & MDE with ease
- Check impacket / github to run these via command line

Practical Kerberos Attacks

- There are many great tools to do this, but the standard is **Rubeus**
- Kerberoast with `rubeus.exe kerberoast`
- Asreproast with `rubeus.exe asreproast`
- Create a golden ticket with `rubeus.exe golden /ldap /user:targetuser /aes256:<KRBTGT AES256 hash>`
- We can do Overpass the Hash, which is where we use an NTLM hash to get a Kerberos ticket
- `rubeus.exe asktgt /user:targetuser /ntlm:theirntlmhash /nowrap`
- We can use **ptt** (pass the ticket) to paste in a ticket and use it in-memory

Network Detections

- Kerberoasting will generate a 4769 event, which is normal for requesting TGS
  - However, a skilled defender could create a honeypot and monitor for 4769 events, so if stealth is a priority, enumerate first, and kerberoast targets one-by-one
  - Tools like Rubeus will automatically kerberoast every SPN. Very bad!
- AS-REP roasting will generate a 4768 event with an RC4 (!!!) encryption type and a preauth type of zero
  - There are some instances where RC4 is acceptable, but you generally want to be using AES256 whenever appropriate (mismatching encryption types stick out from normal activity)

OPSEC Considerations

- Rubeus will make a request with **randomly generated domain info** if it is not specified. It is trivial to identify ticket requests that go out to something like AqMvbnZ.local
- If your process shouldn't be making Kerberos requests (and you have Rubeus injected into it), you will generate an event for "**Kerberos activity from an anomalous process**". If you instead use Mimikatz, you will touch LSASS, which is even worse.

Domain Dominance

- Scenario: you've compromised a Domain Admin account and are now ready to own all the things
- First step: use your credentials to dump the Domain Controller's NTDS.dit remotely
  - There are many ways of doing this, including Mimikatz, NetExec, impacket-secretsdump
  - If you have a domain admin account, disabling all associated security software will be a walk in the park (if you can write malware, that is)
- Next, take the KRBTGT NTLM hash and use it to forge a Golden Ticket
- We can set the golden ticket expiration time to be 10 years or so

Golden Tickets

- It's what it sounds like - a magical skeleton key that lets you log into anywhere in the domain with all of the privileges, and, by default, *it works forever* (KRBTGT password is not rotated)
- Once generated, just pass-the-ticket with Rubeus or Impacket
- Make sure to specify the Domain SID (use SharpView etc.)

```
Rubeus.exe golden /aes256:51d7...4e7e /user:nlamb /domain:dev.cyberbotic.io
/sid:S-1-5-21-569305411-121244042-2357301523 /nowrap
```

```
Rubeus.exe createnetonly /program:C:\Windows\System32\cmd.exe /domain:DEV
/username:nlamb /password:FakePass /ticket:doIFLz[...snip...]MuaW8
```

Review

- This is only the most basic of AD attacks
  - The more complex the system becomes, the more vulnerable it becomes
  - Future topics: Delegation, DACL abuse, S4U, ADCS, MSSQL, GPO, SCCM
- Don't forget to chain this with other Windows vulnerabilities
- While you're learning, lean heavily on BloodHound, but also do manual as well so you can see what manual query corresponds to what relationship in BloodHound
  - Stealthy red teamers don't get to use BloodHound much because it makes a ton of LDAP queries
- There are tons of AD practice resources out there!

Next Meetings

`2025-10-29` • **This Thursday**

- No meeting, need time for CyberForce

`2025-11-03` • **Next Tuesday**

- Active Directory II
- Delegation, LAPS, DACLs, S4U, and more!

`2025-11-05` • **Next Next Tuesday**

- Active Directory III
- Asymmetric Cryptography, MSSQL, Smart Cards, cross-protocol attacks, and SCCM

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Meeting content can be found at sigpwny.com/meetings.

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