



CYBER JUDO: OFFENSIVE CYBER DEFENSE

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Speaker Info – Tal Be'ery






- Sr. Security Research Manager @Microsoft
- Developing MicrosoftATA (Advanced Threat Analytics)
- Former VP for Research @Aorato (Acquired by Microsoft)
- 15 years of security research experience
- Author of the TIME attack on SSL
- Regular speaker in top international security conferences
- Named a “Facebook Whitehat”
- Twitter: @TalBeerySec



Speaker Info – Itai Grady

- Security Researcher @Microsoft
- Developing MicrosoftATA (Advanced Threat Analytics)
- Twitter : @ItaiGrady

Agenda

- Intro
 - The Cyber Boxer vs. the Cyber Judoka
 - Targeted attacks: TTPs, Kill-chain, MicrosoftATA
- Lateral Movement Reconnaissance
 - Attacker's TTPs + BloodHound + Automated Lateral Movement 
 - Cyber Boxer Defense: Net Cease and Friends 
 - Cyber Judo Defense
 - NetSess to Detect Pth 
 - SAMR to Detect Local Users attacks 
- Kerberos Error Injection:
 - Attacks, Cyber Boxer Defense, Cyber Judo Defense 
- Outro

Intro

Level 0: The “Fighting in the Dark” Model

“If you know the enemy and know yourself, you need not fear the result of a hundred battles.

If you know yourself but not the enemy, for every victory gained you will also suffer a defeat.

If you know neither the enemy nor yourself, you will succumb in every battle.”



Level 1 : The "Boxer" Model

- Defenders Learn attackers' TTPs:
 - Tactics
 - Techniques
 - Procedures
- Defenders build their own TTPs
- Defenders practice the attackers' TTPs
 - Red Team
- Defenders practice their TTPs
 - Blue Team
- Some time same team for both
 - Purple Team



Level 2 : The Judoka Model

- Judoka, a Judo warrior, uses the opponent's strength and movement against him
- Defenders Learns attackers' TTPs:
- Defenders **adopts** some attackers' TTPs in order to defeat them!
- That's our topic for today's talk



Defenders and Attackers: Not so Apart

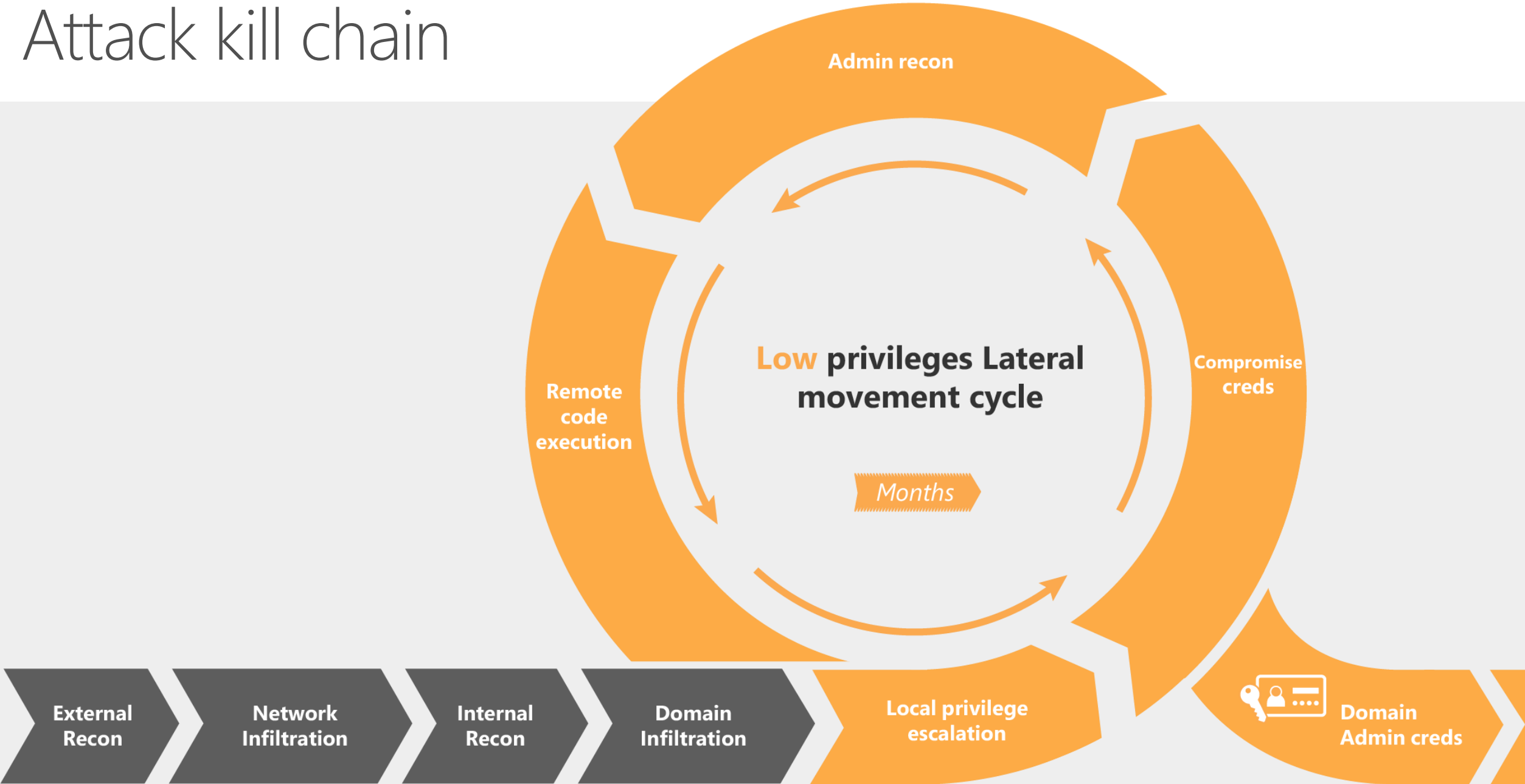
- Similar tools, challenges and scenarios

	Defenders	Attackers
Network Deployment	Proxy / Network Monitoring	MITM / Eavesdropper
Host Deployment	Agent (but the prefer to refrain: compatibility, performance)	Malware (but the prefer to refrain: compatibility, performance, detection)
Privileges	Least, o.w. part of the problem (see: @taviso)	Least, privileged user are more monitored
Integrations	“living off the land”. Core functionality must be delivered independently, opportunistic integrations	“living off the land”. Core functionality must be delivered independently, opportunistic existing non-default capabilities abuse
Expertise	OS internals, networking	OS internals, networking

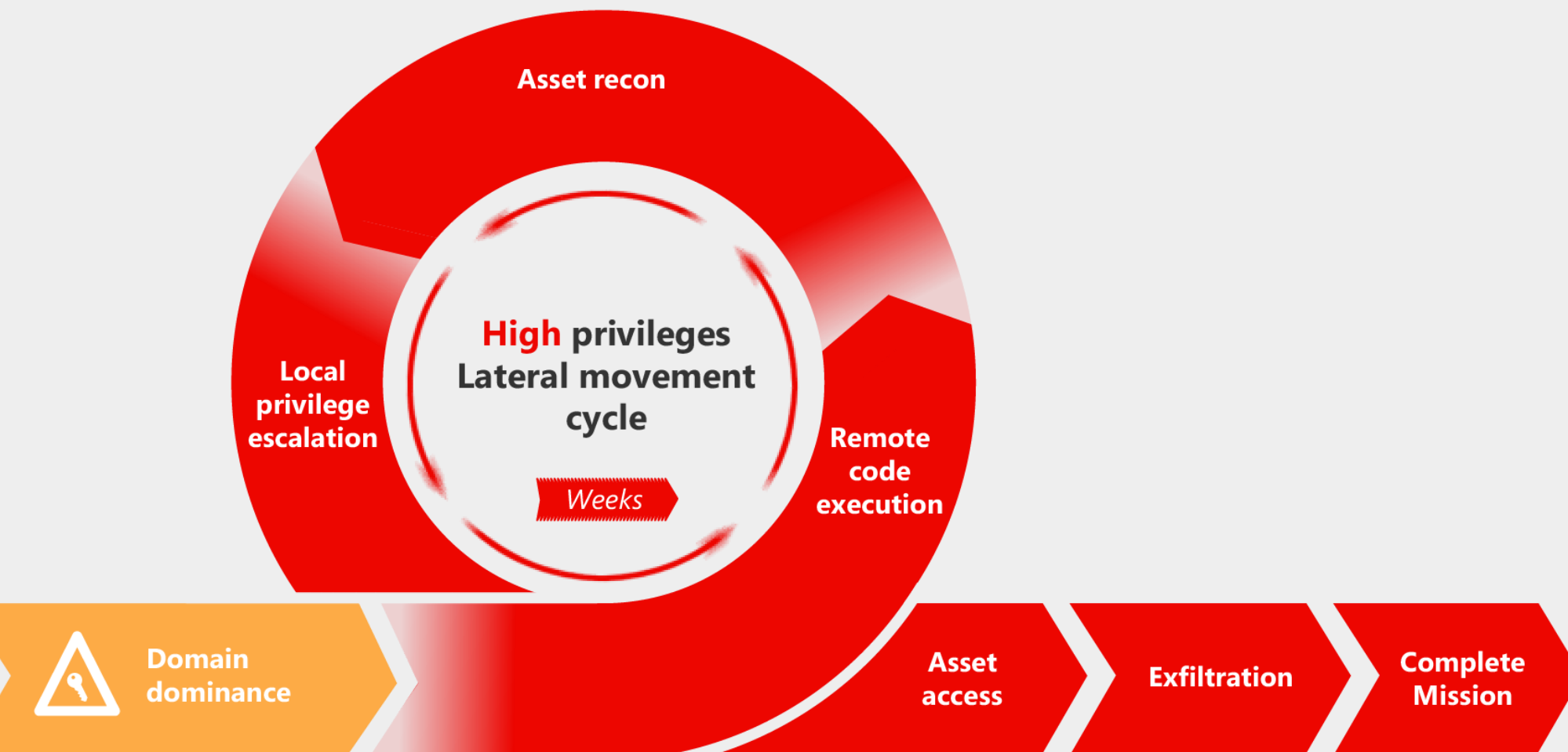
Targeted Attacks



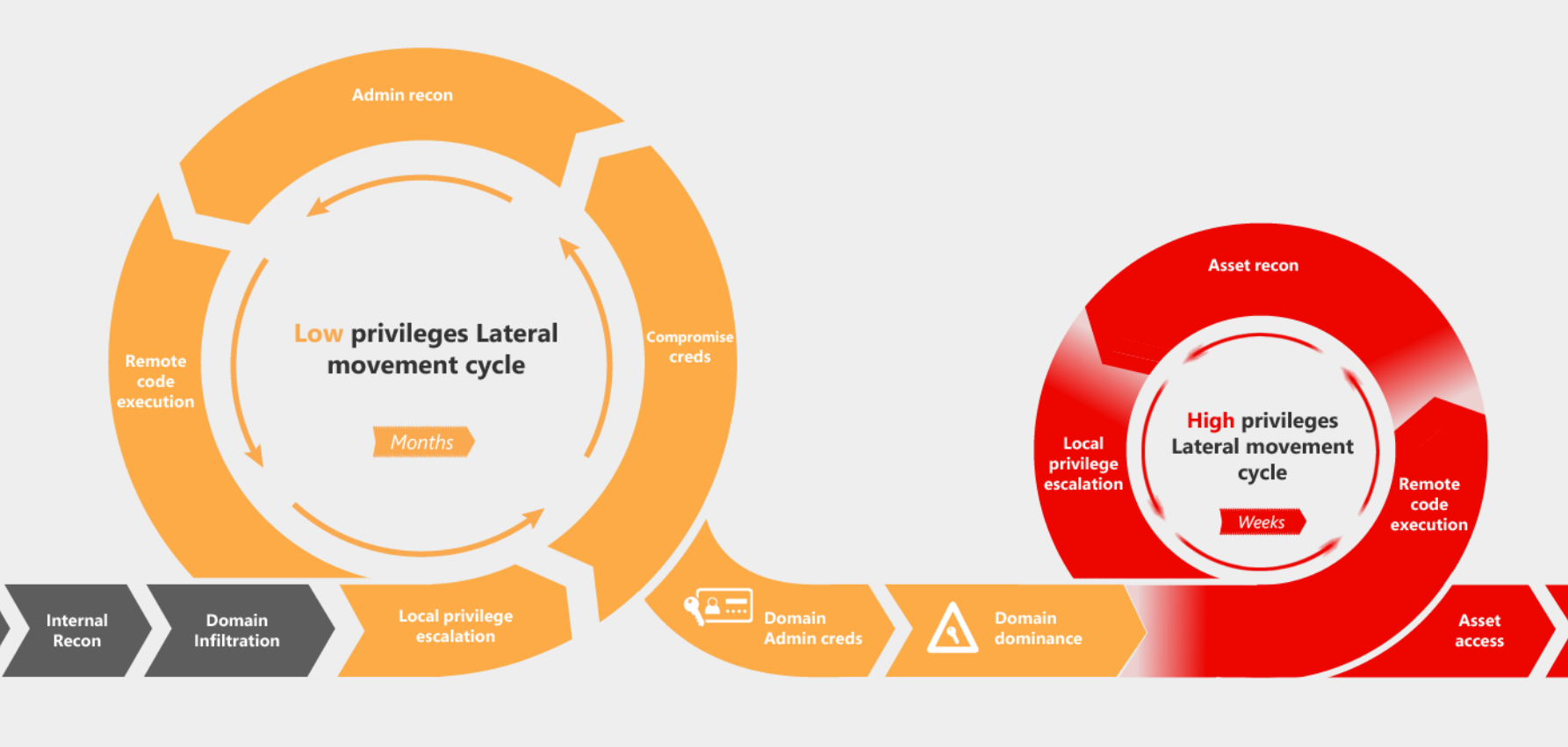
Attack kill chain



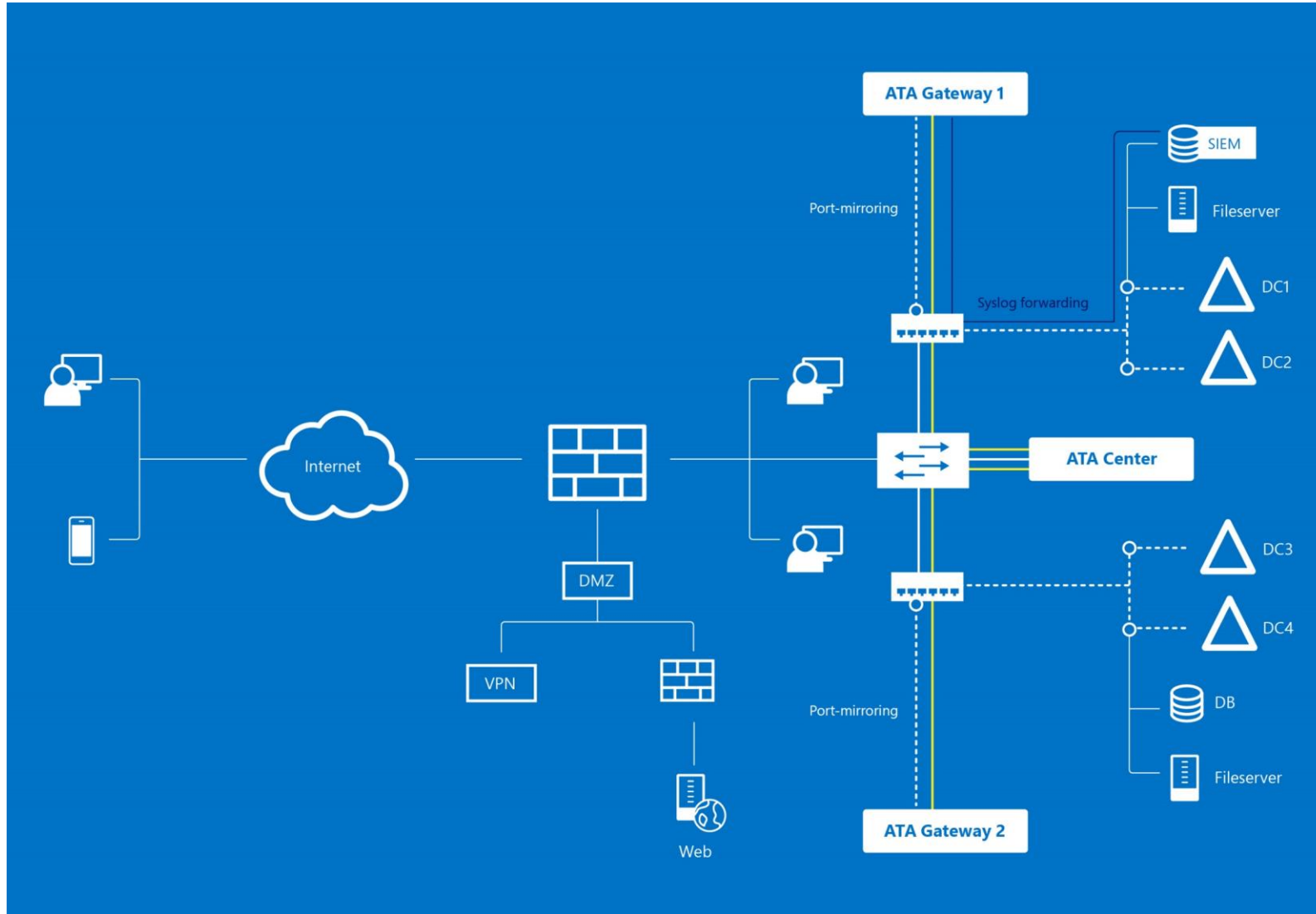
Attack kill chain



Attack kill chain and ATA

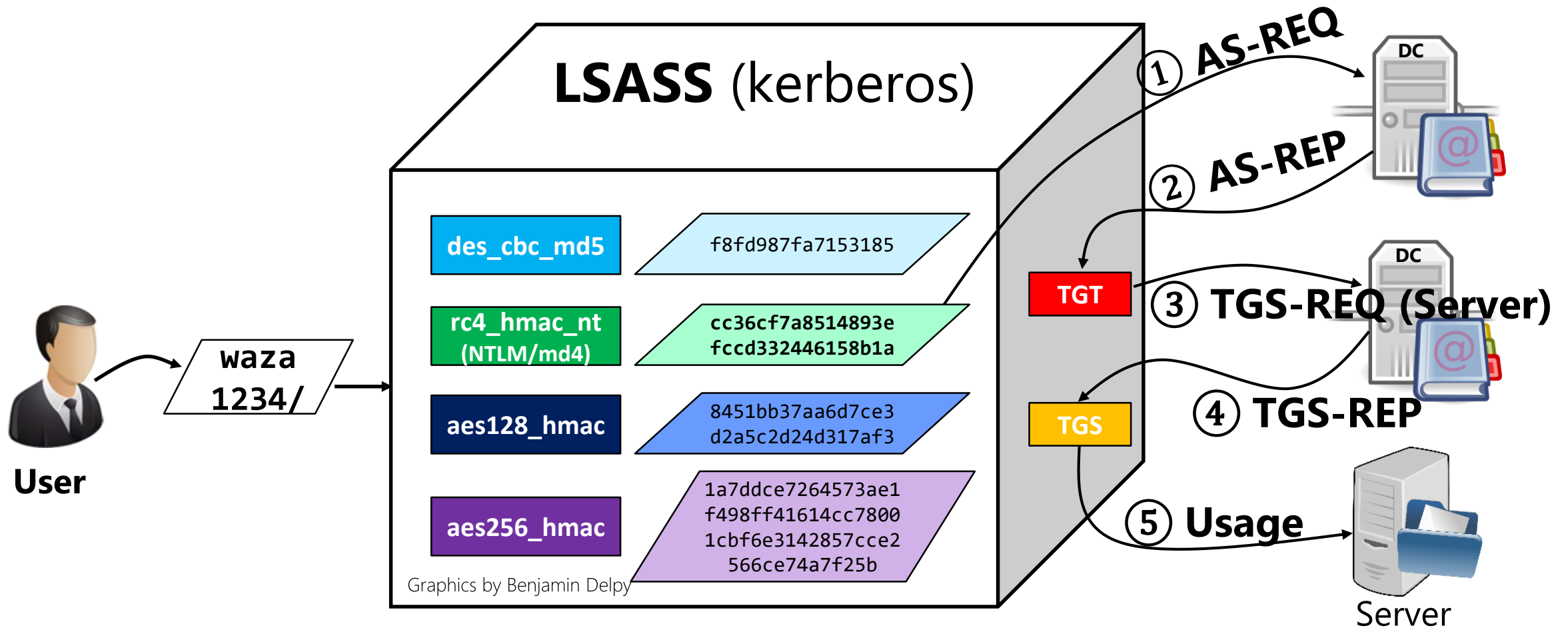


Microsoft ATA topology



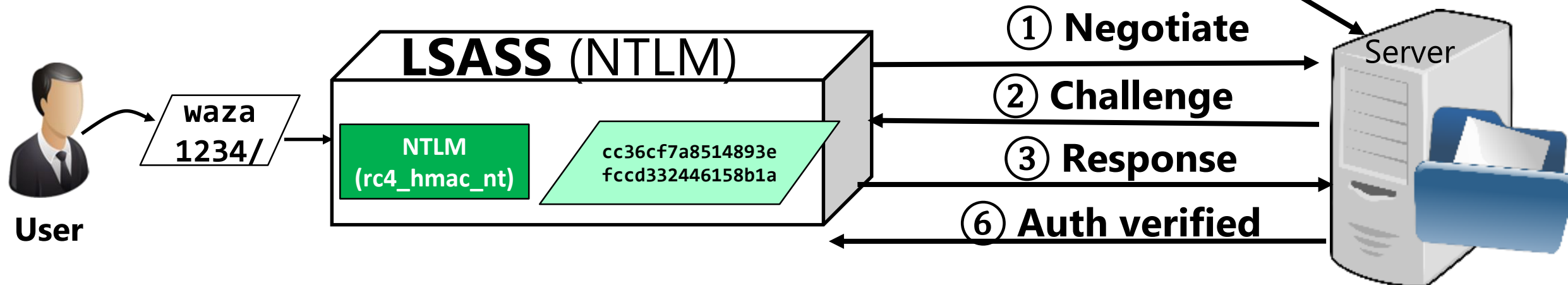
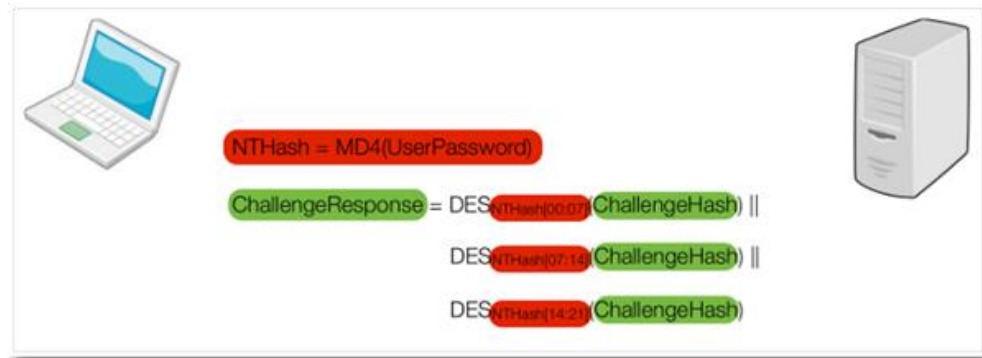
Kerberos Authentication

- Windows default authentication (+ authorization) protocol



NTLM Authentication

- Authentication
- Authorization



Lateral Movement Reconnaissance

Lateral Movement

- Attackers' mission
- Get from **HERE**:
 - The gullible user who clicked the phishing email
 - Not always the manager 😊
 - Probably low privileged
- To **THERE**:
 - Full domain dominance
 - Control the Domain Controller



How to get from **HERE** to **THERE**?

- A map! (CS: Graph)
- Cities (CS: Nodes)
 - Computers and logon user
- Roads (CS: Edges)
 - Computer and users permissions
- Computer A → Computer B
 - Logged on users in computer A have code execution permissions on Computer B



Building the map

- To build the map attackers need to know:
 - Cities: Where users are logged-on
 - Roads: User's permissions to computers
 - Destination: Who are the Domain Admins
- Knowledge must be gained with just a low privileged user account
- "Reconnaissance": Gaining knowledge on adversary in a hostile environment



Logged-on User Recon

- SMB service can be remotely queried for active sessions
 - Returns: IP address, User
 - Implemented in NetSess tool (others)
 - On the wire SRVSVC protocol
 - Required Permissions: Any domain user
- Every logged-on user fetches Group Policy (GP) from DC
 - On logon and periodically (every ~1.5 hour)
 - GP is a bunch of files, sent over SMB
- 1.5 hour of periodic sampling of DC is enough to find all currently logged-on users' computers

SRVSVC 350 NetSessEnum request

```
C:\Research>NetSess.exe win-2008r2 /full
NetSess V02.00.00cpp Joe Richards <joe@joeware.net> January 2004
Enumerating Host: win-2008r2
Client      User Name      Client Type      Opens  Time
  Idle Time Transport
-----
\\10.0.0.2  theadmin      1  000:0
0:00 000:00:00
Total of 1 entries enumerated
```

Computer's Local Admin Recon

- PS cmdlet
 - 'Get-NetLocalGroup'
 - PowerSploit by @mattifestation
 - <https://github.com/PowerShellMafia/PowerSploit>
- Can list local groups & users
- Queries the Computer over SAMR protocol
- Required Permissions: Any domain user

SAMR	222 GetMembersInAlias request
SAMR	362 GetMembersInAlias response

```
PS C:\Users\DomainUser2> Get-NetLocalGroup -ComputerName Client1 -ListGroups
```

Server	Group	SID	Description
Client1	Access Control Assistance ...	S-1-5-32-579	Members of this group can ...
Client1	Administrators	S-1-5-32-544	Administrators have comple...
Client1	Backup Operators	S-1-5-32-551	Backup Operators can overr...
Client1	Cryptographic Operators	S-1-5-32-569	Members are authorized to ...
Client1	Distributed COM Users	S-1-5-32-562	Members are allowed to lau...
Client1	Event Log Readers	S-1-5-32-573	Members of this group can ...
Client1	Guests	S-1-5-32-546	Guests have the same acces...
Client1	Hyper-V Administrators	S-1-5-32-578	Members of this group have...
Client1	IIS_IUSRS	S-1-5-32-568	Built-in group used by Int...

Users + Group Membership Recon

- Simple command line
- Full enumeration
 - Net User /domain
 - Net Group /domain
- Specific entity info
 - Net user /domain <user name>
 - Net group /domain <group name>
- Queries the DC over SAMR protocol
- Required Permissions: Any domain user

```
C:\>net user /domain
The request will be processed at a domain controller for domain redacted.computerworld.com.

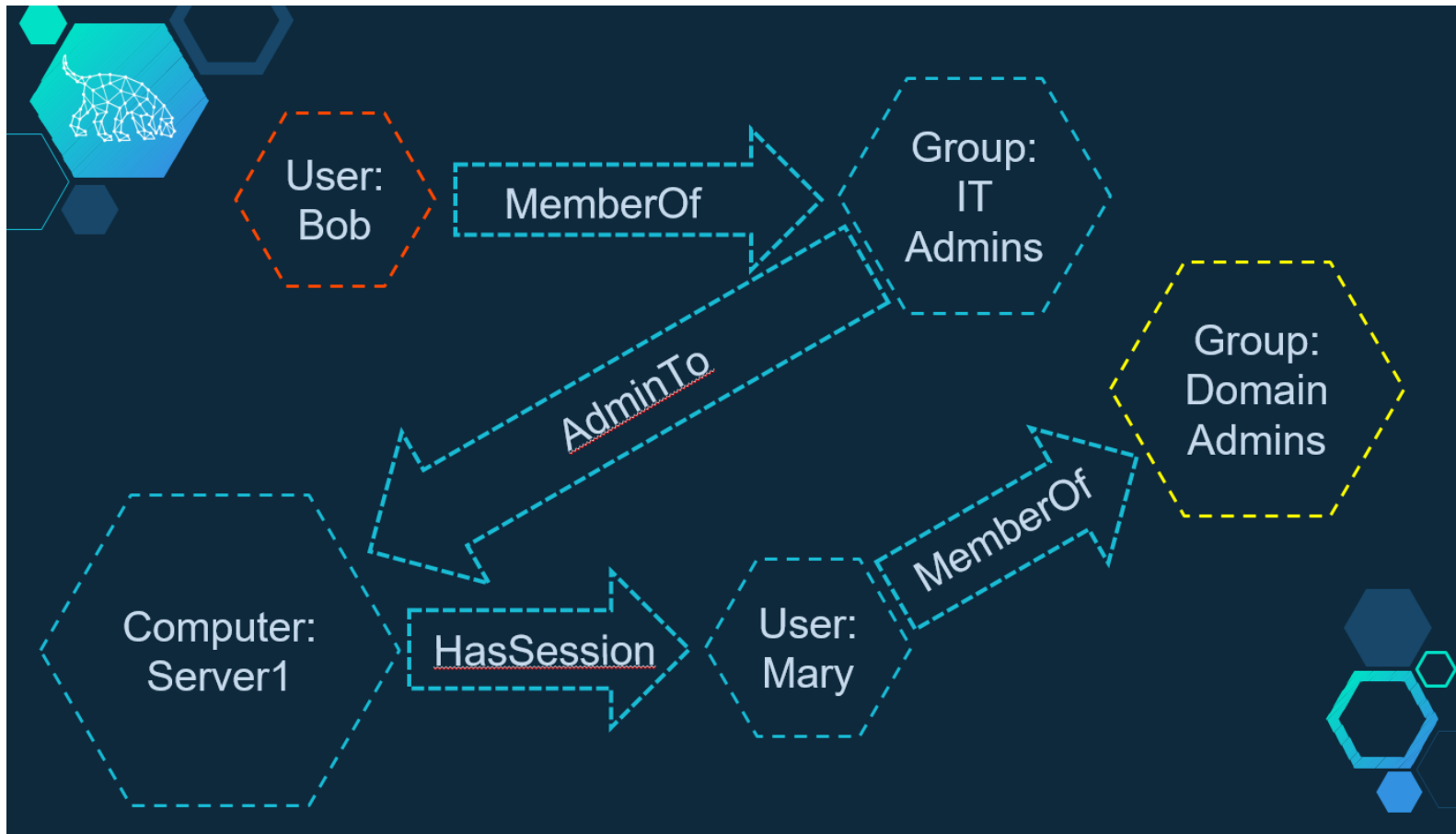
User accounts for \\192.168.1.16.redacted.computerworld.com
-----
Name          Password               Last set
-----          -
Administrator  1234567890             12/12/2011
Guest          1234567890             12/12/2011
krbtgt         1234567890             12/12/2011
...

```

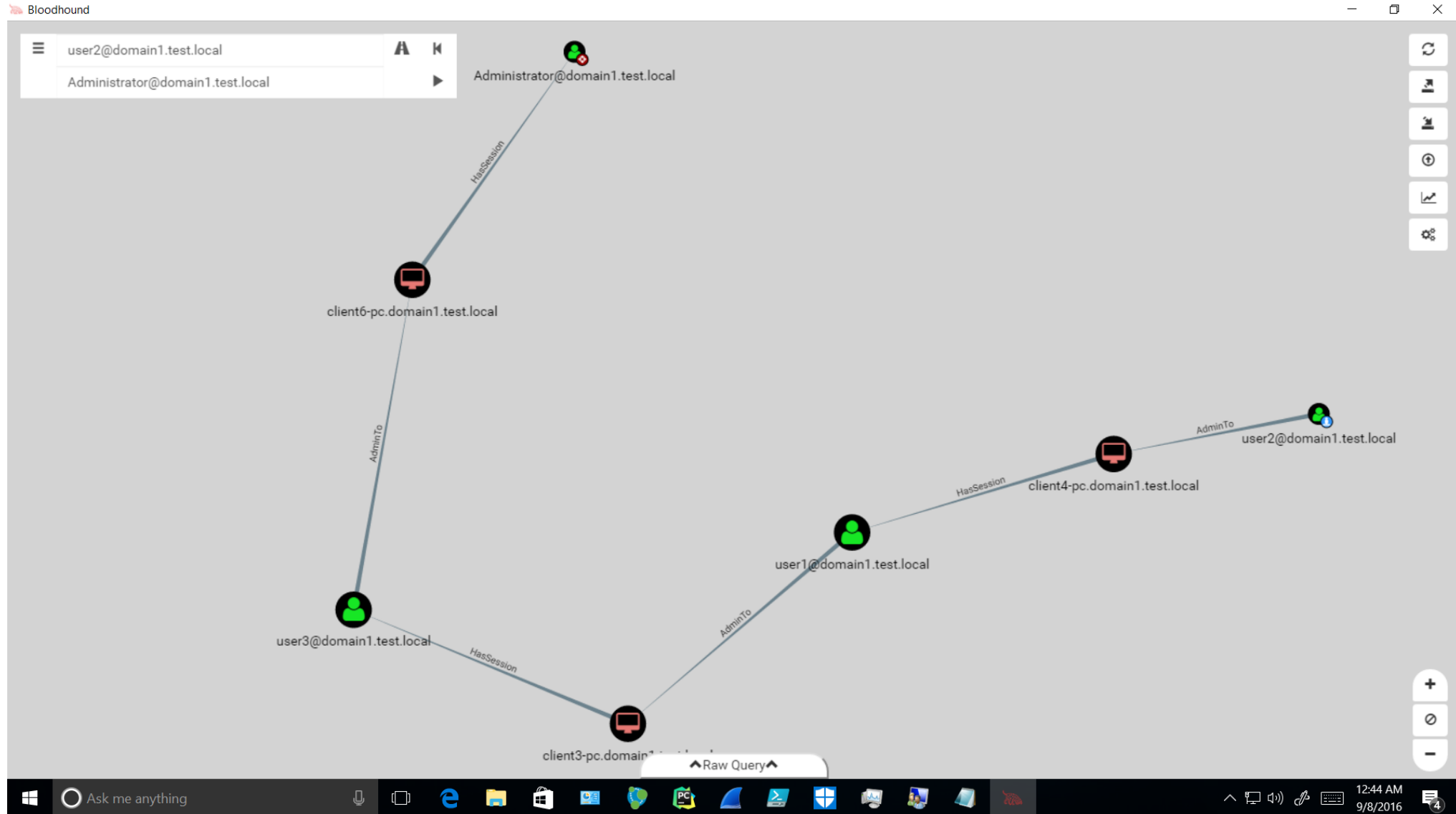
Info
Connect5 request
Connect5 response
EnumDomains request
EnumDomains response
LookupDomain request,
LookupDomain response
OpenDomain request
OpenDomain response
EnumDomainUsers request
EnumDomainUsers response
Close request
Close response
Close request
Close response

Putting it All Together: BloodHound

- BloodHound: developed by @_wald0, @CptJesus, and @harmj0y.
- <https://github.com/adaptivethreat/BloodHound>

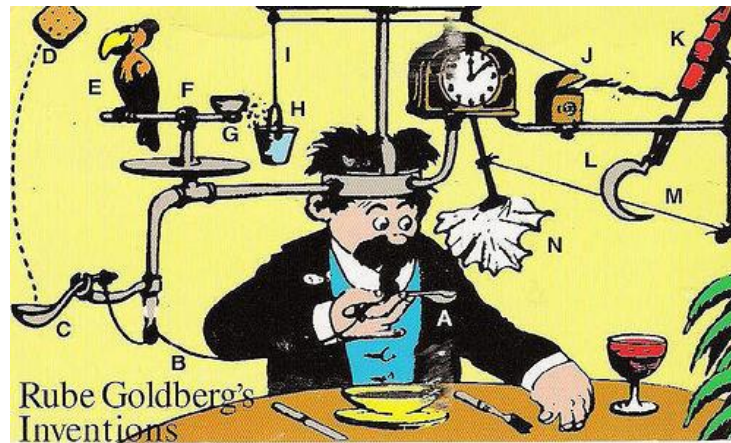


BloodHound's Shortest Path Functionality



Imagine: Automatic Internal Network Campaign

- Attackers launch a massive phishing email campaign
 - A single low privileged domain user Clicks phishing email
 - gets infected with a malware
- The malware *automatically* executes a “bloodhound” style recon
 - Computes shortest path to Domain Admin
- The malware *automatically* do Lateral Movement all the way to domain admin
- The malware *automatically* downloads all users’ domain keys using DC-SYNC
 - All domain keys are sent to attackers

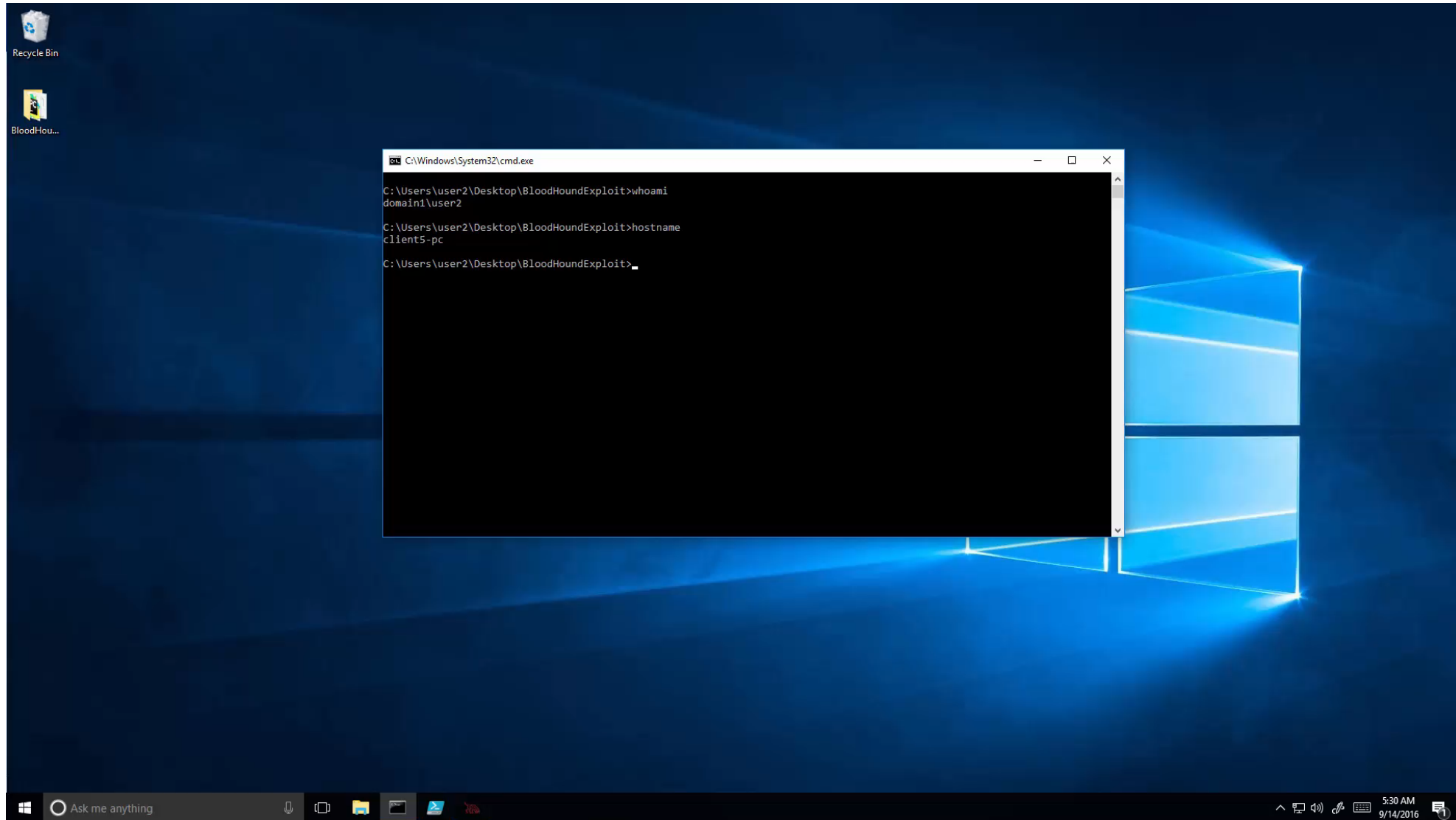


Now Open Your Eyes.. 😊

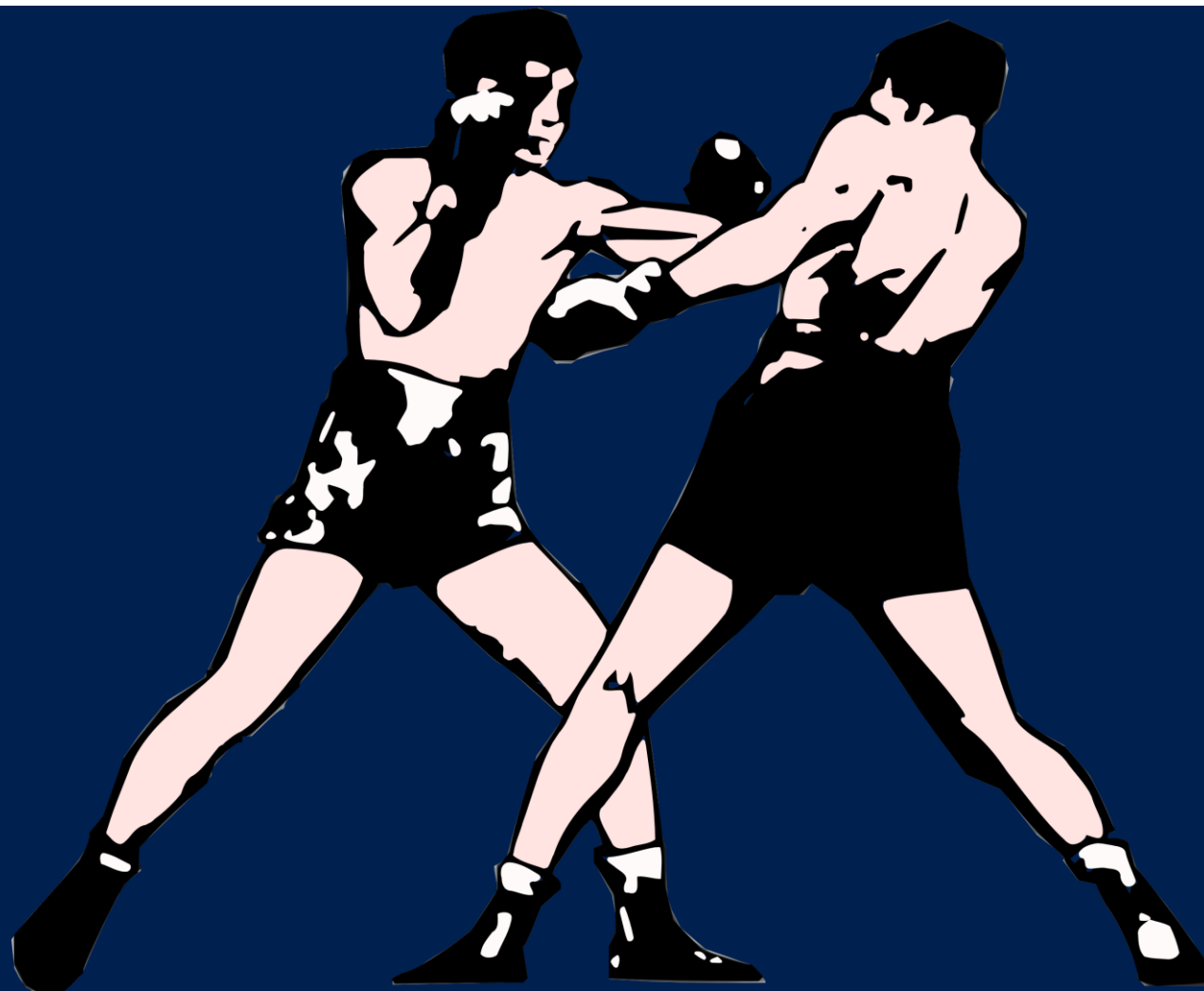
- Automatic Lateral Movement tool
- Developed by Microsoft ATA researcher @talthemator
- Gets a bloodhound exported graph (JSON) as “attack plan” input
- Executes the attack plan
 - Remote Code Execution (RCE) via Remote PS
 - Credential harvesting via Mimikatz



DEMO!



Lateral Movement Reconnaissance: Defense



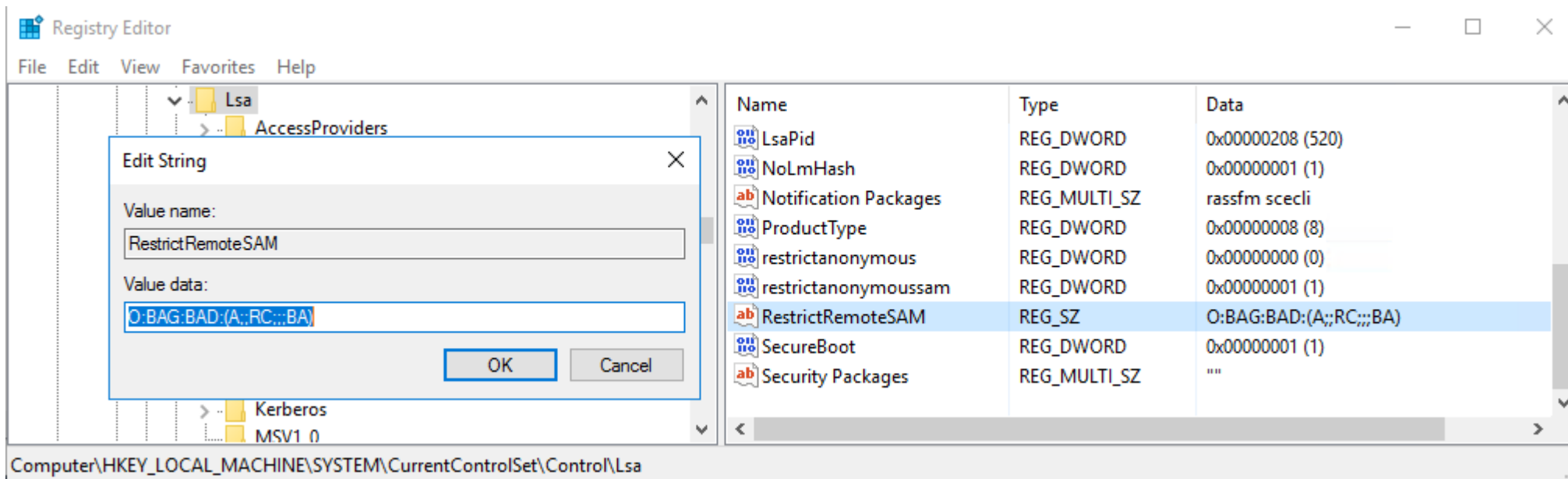
"SAMR Moved On" Hardening #1

- Win10 allows admins to control SAMR Recon
 - Registry: HKLM/System/CurrentControlSet/Control/Lsa/RestrictRemoteSAM
 - GP: "Network Access: Restrict clients allowed to make remote calls to SAM"

Win version	Who can query SAMR by default	Can default be changed
< Win10	Any domain user	No
Win10	Any domain user	Yes (only via registry)
> Win10 (e.g. anniversary)	Only local administrators	Yes (registry or GPO)

"SAMR Moved On" Hardening #2

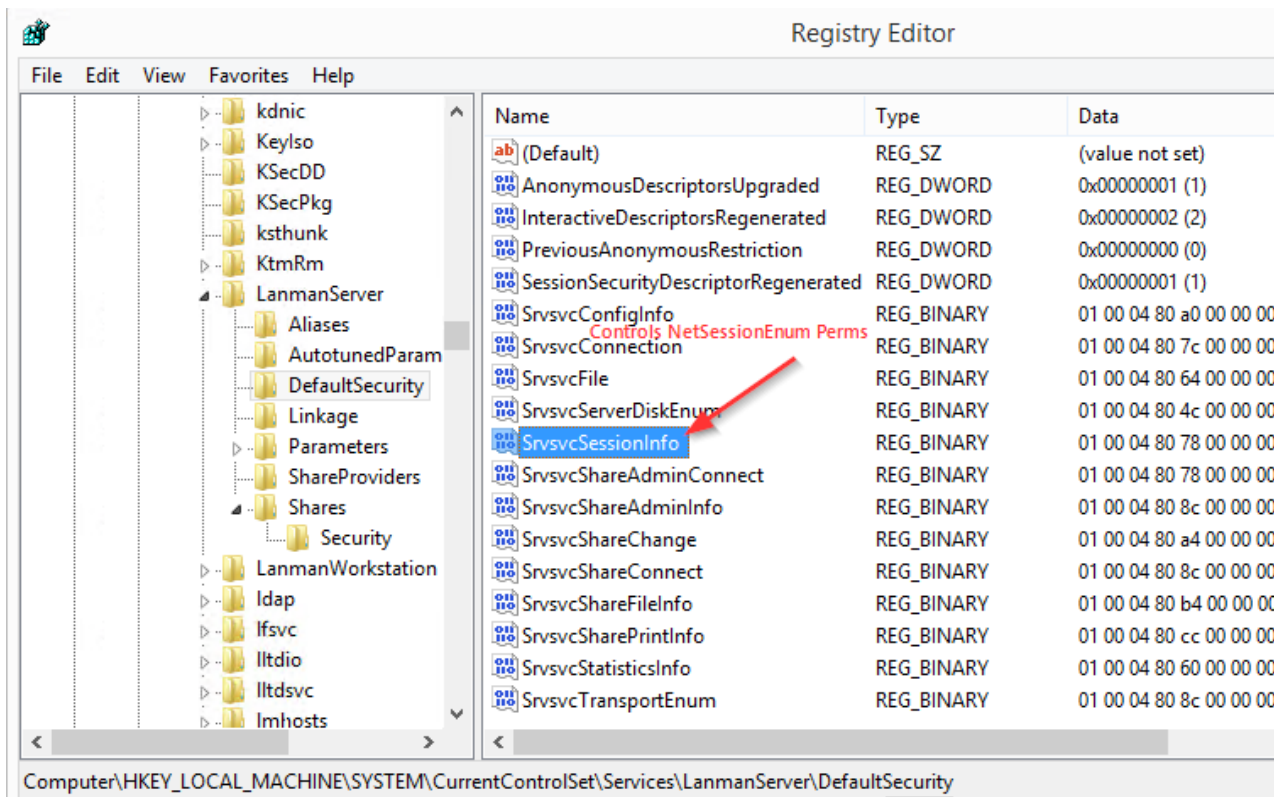
- Windows Server 2016 allows admins to control SAMR Recon on DC
- Net User/Group queries on Domain can be limited!



```
C:\Users\user1>net group "Domain Admins" /Domain
The request will be processed at a domain controller for domain domain2016.local
System error 5 has occurred.
Access is denied.
C:\Users\user1>
```

"Net Cease" Hardening

- NetSess API access can be controlled by ACL in the Registry!
- Remove "Authenticated Users" group manually, or use our tool
- <https://gallery.technet.microsoft.com/Net-Cease-Blocking-Net-1e8dcb5b>



```
C:\Tools\NetSsess>NetSsess.exe 192.168.0.3
NetSsess V02.00.00cpp Joe Richards (joe@joeware.net) January 2004

Enumerating Host: 192.168.0.3
Client      User Name      Time      Idle Time
-----
\\\\192.168.0.2    spAdmin      002:17:35  000:03:39
\\\\192.168.0.1    user3        000:00:03  000:00:02
\\\\192.168.0.1    user3        000:00:02  000:00:02
\\\\192.168.0.1    user3        000:00:02  000:00:02
\\\\192.168.0.1    user3        000:00:02  000:00:02
\\\\192.168.0.2    spAdmin      000:00:00  000:00:00

Total of 6 entries enumerated

C:\Tools\NetSsess>NetSsess.exe 192.168.0.3
NetSsess V02.00.00cpp Joe Richards (joe@joeware.net) January 2004

Enumerating Host: 192.168.0.3
Client      User Name      Time      Idle Time
-----
Error: NetSessionEnum (5) Access is denied.

Total of 0 entries enumerated
```


Detection (Microsoft ATA): NetSess Recon

Reconnaissance using SMB Session Enumeration
SMB session enumeration attempts were successfully performed from USER1-PC against DC1, exposing 4 accounts.

Note Share Export to Excel Details Input Open

Session Enumeration

The diagram illustrates the session enumeration process. On the left, a computer icon represents 'USER1-PC'. A horizontal arrow points from 'USER1-PC' to a central server icon labeled 'Session Enumeration'. From this central icon, another horizontal arrow points to a server icon on the right labeled 'DC1'. Below the 'Session Enumeration' icon, a box titled 'Exposed Accounts (4)' contains a list of accounts.

Account Name	IP Address
SECRETS-DB\$	on 192.168.0.210
user1	on 192.168.0.1
APP2\$	on 192.168.0.5
user2	on 192.168.0.5

Recommendations

- Disconnect USER1-PC from the network, or move it into an isolated environment and start a forensics procedure by investigating: unknown processes, services, registry entries, unsigned files, and more
- Verify that all enumerated accounts use a strong password.

Detection (Microsoft ATA): SAMR Recon

Reconnaissance using directory services enumeration

The following directory services enumerations using SAMR protocol were attempted against DC5 from CLIENT4:

- Successful enumeration of all users in domain2.test.local by user4

 Note  Share  Export to Excel  Details  Input

 Open



user4

On →



CLIENT4

Directory Services Enumeration



DCS

Operations (1)



Enumerate all users
in domain2.test.local

Recommendations

- Disconnect CLIENT4 from the network, or move it into an isolated environment and start a forensics procedure by investigating: unknown processes, services, registry entries, unsigned files, and more

Detection (Microsoft ATA): Abnormal Access

5:24 AM > 4:24 PM
Monday, July 18, 2016


Suspicion of identity theft based on abnormal behavior ?

user2 exhibited abnormal behavior when performing activities that were not seen over the last month and are also not in accordance with the activities of other accounts in the organization. The abnormal behavior is based on the following activities:

- Requested access to 6 abnormal resources.

 Note  Share  Export to Excel  Details  Input

 Open

 user2
Software Engine...



15 normal
computers

Accessed



25 normal
resources

+



6 abnormal
resources

Recommendations

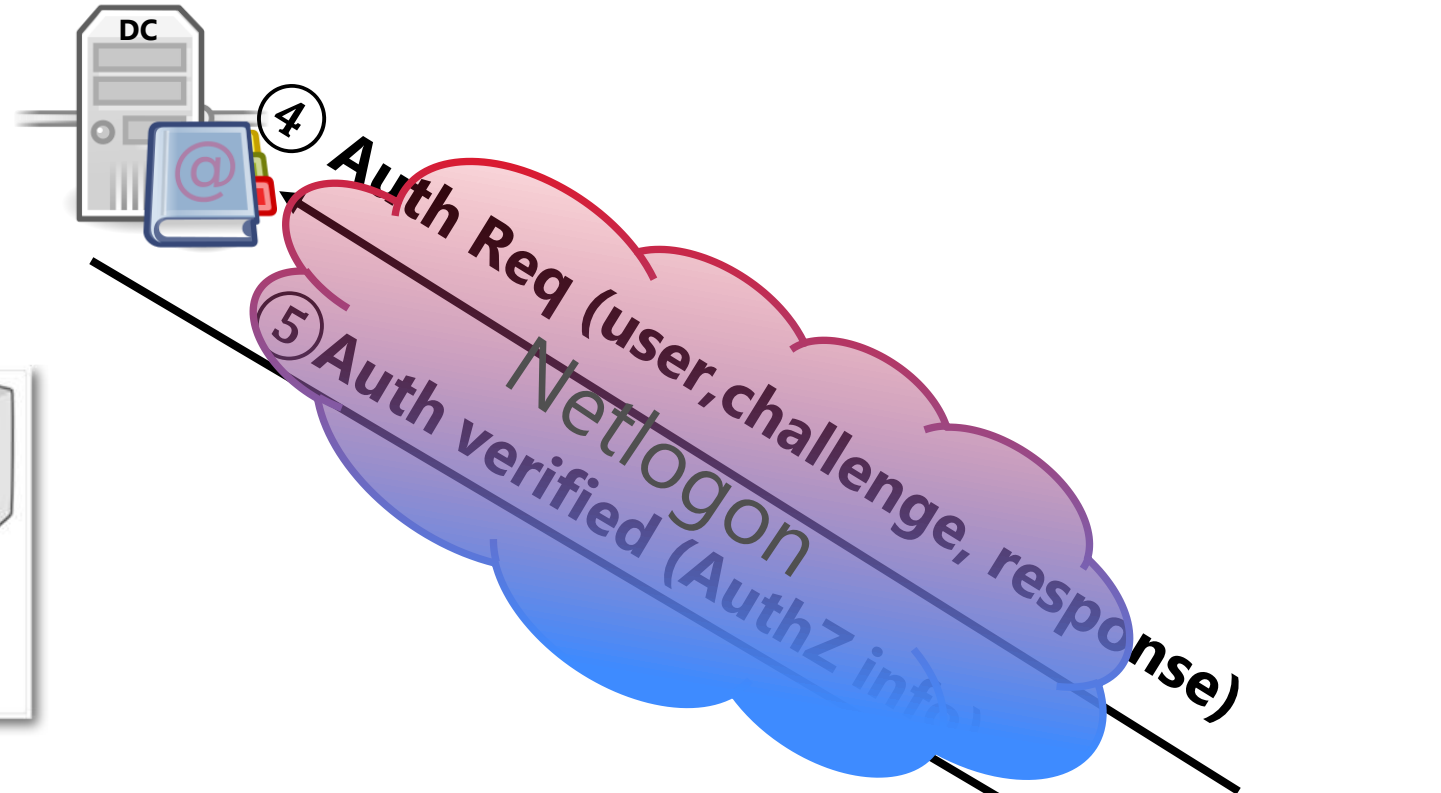
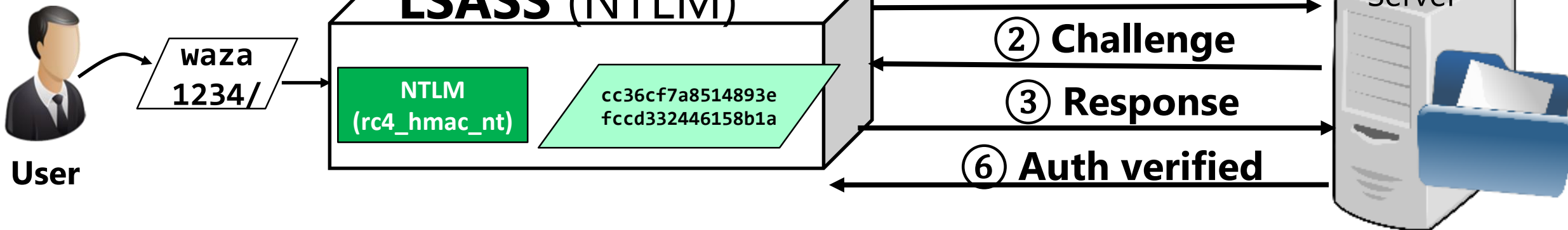
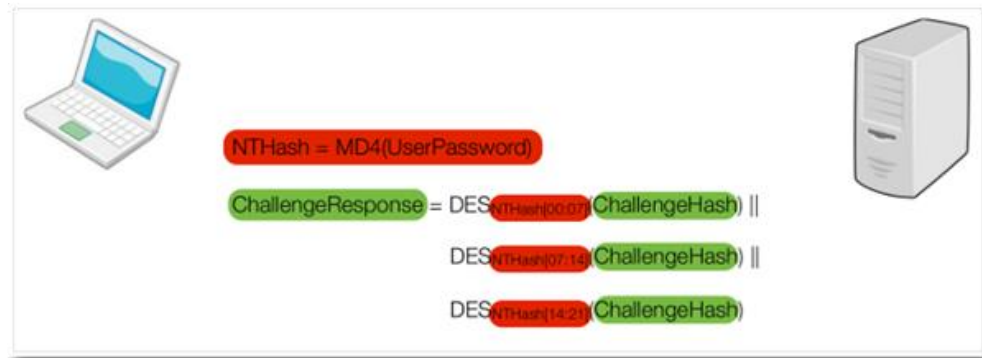
- Contact user2 and investigate if the user has logged in to abnormal computers and accessed abnormal resources.

Cyber Judo with NetSess



NTLM Authentication

- Authentication
- Authorization



NTLM in attacks

- NTLM is the essence
 - NTLM authentication is very relevant to Pass-the-Hash attacks
 - NTLM relay attack
- NTLM by default:
 - Many attack tools did not “upgrade” to Kerberos
 - Access by IP (e.g. “\\10.0.0.1\C\$”) defaults to NTLM (no SPN for Kerberos)
 - Kerberos failures (e.g. port 88 is blocked in FireWall)

NTLM Visibility Problem

- Netlogon messages are encrypted ☹
 - The opcode is visible, but parameters are encrypted
- A security device eavesdropping to DC traffic only learns
 - “Someone performed NTLM logon to a computer”
- Missing info
 - Which user?
 - From which computer?



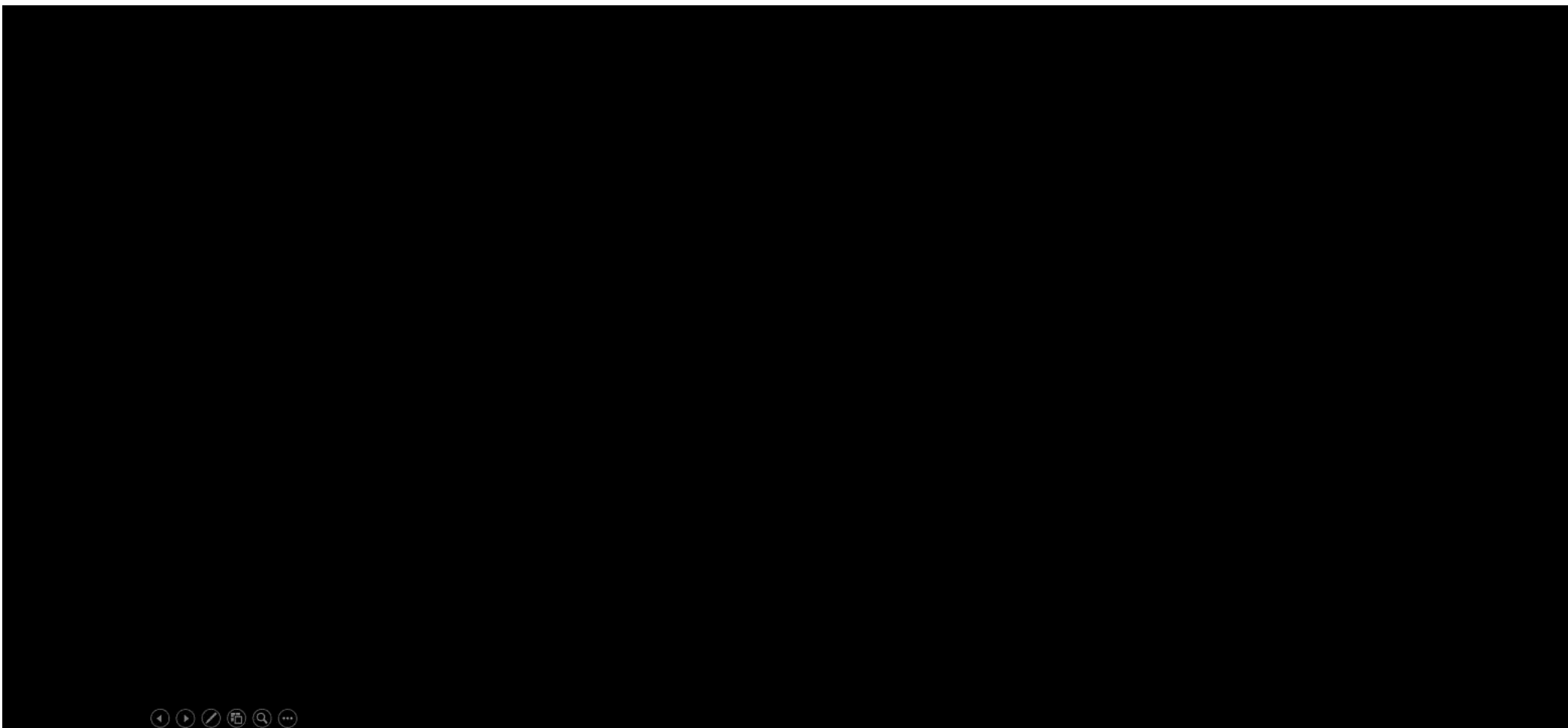
```
RPC NETLOGON      NetrLogonSamLogonWithFlags request
> Frame 28: 1090 bytes on wire (8720 bits), 1090 bytes captured (8720 bits) on interface 0
> Ethernet II, Src: Microsof_c5:46:b0 (00:15:5d:c5:46:b0), Dst: Microsof_c5:46:9e (00:15:5d:
> Internet Protocol Version 6, Src: daf::5, Dst: daf::200
> Transmission Control Protocol, Src Port: 49754 (49754), Dst Port: 49158 (49158), Seq: 222,
> Distributed Computing Environment / Remote Procedure Call (DCE/RPC) Request, Fragment: Sin
v Microsoft Network Logon, NetrLogonSamLogonWithFlags
  Operation: NetrLogonSamLogonWithFlags (45)
  [Response in frame: 29]
  Encrypted stub data: 0cc2bb6864ebd473e2a7a883b73abe9964612ac424cf6f37...
```

NTLM Visibility Solution

- When observing a relevant successful NETLOGON message
 - **Extract source IP**
- Perform NetSess Recon on that IP
- Extract original user information from NetSess results
- Win! (at least for SMB)



Demo!



Cyber Judo with SAMR



Local User in Attacks

- Very relevant
 - Identical passwords problem
 - PtH against local admins is successfully Used in 60% of Praetorian's pen-tests

Local Administrator Attacks (aka Pass the Hash)

Summary of the Attack

Organizations often configure all systems with the same Local Admin password. If an attacker is able to compromise the LM/NT hash representation of the password, then the attacker can use the hash to authenticate and execute commands on other systems that have the same password. This is exacerbated by the fact that the attacker only needs the LM/NT hashes; the attacker doesn't need to crack the password at all. Having a very good understanding of this attack, how it works, and what it looks like from a defensive perspective is the best way to be able to properly mitigate it.



61%

Attack Vector #3: Out of 100 internal pentests, Pass the Hash was used to compromise the environment 61% of the time.

Source: Praetorian

Local Users Attacks in the Wild

<https://twitter.com/JohnLaTwC/status/777569424156921856>



John Lambert
@JohnLaTwC



Following

Common post-compromise steps by RDP brute forcers on [#Azure](#) IaaS. Spot them w/ sysmon or [#AzureSecurityCenter](#). [#DFIR](#)

```
//They don't like those pesky "unauthorized use is prohibited" dialogs during login
reg delete "HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Policies\System" /v legalnoticecaption /f
reg delete "HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Policies\System" /v legalnoticetext /f
```

```
//They don't like IE and install Chrome & FF :-/
"C:\Program Files (x86)\Google\Chrome\Application\52.0.2743.116\Installer\chrmstp.exe" --configure-user-settings --verbose-logging --system-level --multi-install --chrome
"C:\Users\<user>\Downloads\Firefox Setup Stub 48.0.2.exe"
```

```
//They create backdoor admin accounts
net.exe user admin kast43 /ADD /ACTIVE:YES /EXPIRES:NEVER /FULLNAME:admin
net.exe localgroup Administrators admin /ADD
```

```
net user ASPNET crystal123!@# /add
net localgroup Administrators ASPNET /add
```

```
net user __VMware_Conv_SA__ crystal123!@# /add
net localgroup Administrators __VMware_Conv_SA__ /add
```

Local User Visibility Problem

- Local users authentication is... well... Local
- A network security device cannot see it ☹️



Local Users Visibility Solution

- Periodically query Local Users over SAMR
 - Users Info
 - Group membership
- To discover:
 - Abnormal login patterns
 - BruteForce attempts
 - Privileged group modifications
 - Password configuration issues
- And much more...

```
test (1004)/LastPassChange: 2016-07-05 11:13:38.657533
USER1 (1001)/FullName:
USER1 (1001)/UserComment:
USER1 (1001)/PrimaryGroupId: 513
USER1 (1001)/BadPasswordCount: 0
USER1 (1001)/LogonCount: 3
USER1 (1001)/LastLogon: 2016-08-29 09:54:53.853097
USER1 (1001)/LastPassChange: 2016-08-29 08:42:47.516191
[...]
```



Local User Logon Anomalies Detection

- Dormant Local User Logon:
 - Compare current last logon time to previous last logon time
 - If user never logged-on, time is 0 ("1.1.1601 00:00:00")

```
newuser (1004)/FullName: New User
newuser (1004)/UserComment:
newuser (1004)/PrimaryGroupId: 513
newuser (1004)/BadPasswordCount: 0
newuser (1004)/LogonCount: 0
newuser (1004)/LastLogon: 1601-01-01 00:00:00
```



```
newuser (1004)/FullName: New User
newuser (1004)/UserComment:
newuser (1004)/PrimaryGroupId: 513
newuser (1004)/BadPasswordCount: 0
newuser (1004)/LogonCount: 1
newuser (1004)/LastLogon: 2016-09-15 12:42:12.675018
```

- Local User Brute Force
 - Compare current BadPwdCount with previous

```
Administrator (500)/FullName:
Administrator (500)/UserComment:
Administrator (500)/PrimaryGroupId: 513
Administrator (500)/BadPasswordCount: 0
Administrator (500)/LogonCount: 7
```



```
Administrator (500)/FullName:
Administrator (500)/UserComment:
Administrator (500)/PrimaryGroupId: 513
Administrator (500)/BadPasswordCount: 12964
Administrator (500)/LogonCount: 7
```

User Added to Privileged Local Group Detection

```
PS C:\Windows\system32> Get-NetLocalGroup -ComputerName CLIENT2
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/Administrator  
SID        : S-1-5-21-2855241813-3116034789-286929080-500  
Disabled   : True  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 4/13/2014 5:37:53 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/testadmin  
SID        : S-1-5-21-2855241813-3116034789-286929080-1001  
Disabled   : False  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 8/5/2015 2:51:48 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/USER2  
SID        : S-1-5-21-2855241813-3116034789-286929080-1002  
Disabled   : False  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 8/31/2016 11:25:41 AM
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/Domain Admins  
SID        : S-1-5-21-3383964581-1309953776-2693364552-512  
Disabled   : False  
IsGroup    : True  
IsDomain   : True  
LastLogin  :
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/USER2  
SID        : S-1-5-21-3383964581-1309953776-2693364552-1106  
Disabled   : False  
IsGroup    : False  
IsDomain   : True  
LastLogin  : 9/15/2016 5:19:55 PM
```



```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/Administrator  
SID        : S-1-5-21-2855241813-3116034789-286929080-500  
Disabled   : True  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 4/13/2014 5:37:53 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/testadmin  
SID        : S-1-5-21-2855241813-3116034789-286929080-1001  
Disabled   : False  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 8/5/2015 2:51:48 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/USER2  
SID        : S-1-5-21-2855241813-3116034789-286929080-1002  
Disabled   : False  
IsGroup    : False  
IsDomain   : False  
LastLogin  : 8/31/2016 11:25:41 AM
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/Domain Admins  
SID        : S-1-5-21-3383964581-1309953776-2693364552-512  
Disabled   : False  
IsGroup    : True  
IsDomain   : True  
LastLogin  :
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/USER2  
SID        : S-1-5-21-3383964581-1309953776-2693364552-1106  
Disabled   : False  
IsGroup    : False  
IsDomain   : True  
LastLogin  : 9/15/2016 5:19:55 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/MaliciousUser  
SID        : S-1-5-21-2855241813-3116034789-286929080-1005  
Disabled   : False  
IsGroup    : False  
IsDomain   : False  
LastLogin  :
```


Users Removed from Privileged Group Detection

```
PS C:\Windows\system32> Get-NetLocalGroup -ComputerName CLIENT2
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/Administrator  
SID         : S-1-5-21-2855241813-3116034789-286929080-500  
Disabled    : True  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 4/13/2014 5:37:53 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/testadmin  
SID         : S-1-5-21-2855241813-3116034789-286929080-1001  
Disabled    : False  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 8/5/2015 2:51:48 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/USER2  
SID         : S-1-5-21-2855241813-3116034789-286929080-1002  
Disabled    : False  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 8/31/2016 11:25:41 AM
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/Domain Admins  
SID         : S-1-5-21-3383964581-1309953776-2693364552-512  
Disabled    : False  
IsGroup     : True  
IsDomain    : True  
LastLogin   :
```

```
Server      : CLIENT2  
AccountName : VLAB1.com/USER2  
SID         : S-1-5-21-3383964581-1309953776-2693364552-1106  
Disabled    : False  
IsGroup     : False  
IsDomain    : True  
LastLogin   : 9/15/2016 5:19:55 PM
```



```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/Administrator  
SID         : S-1-5-21-2855241813-3116034789-286929080-500  
Disabled    : True  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 4/13/2014 5:37:53 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/testadmin  
SID         : S-1-5-21-2855241813-3116034789-286929080-1001  
Disabled    : False  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 8/5/2015 2:51:48 PM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/USER2  
SID         : S-1-5-21-2855241813-3116034789-286929080-1002  
Disabled    : False  
IsGroup     : False  
IsDomain    : False  
LastLogin   : 8/31/2016 11:25:41 AM
```

```
Server      : CLIENT2  
AccountName : VLAB1/CLIENT2/MaliciousUser  
SID         : S-1-5-21-2855241813-3116034789-286929080-1005  
Disabled    : False  
IsGroup     : False  
IsDomain    : False  
LastLogin   :
```

Local User Password Configuration Issues

- “Shallow copied” Local users:
 - E.g. Created via HD copy, VM export, etc.
 - Shares the same password
 - Can be identified via same username, password change time

```
PS C:\Users\user1.TESTDOMAIN.000> Get-NetLocalGroup -ComputerName "Client3Prep" -GroupName "Guests"

ComputerName : Client3Prep
AccountName  : TESTDOMAIN/Client3Prep/Guest
SID          : S-1-5-21-2937651619-4167467795-303580696-501
Description  : Built-in account for guest access to the computer/domain
Disabled     : True
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/19/2016 11:24:21 AM
PwdExpired   : False
UserFlags    : 66147

ComputerName : Client3Prep
AccountName  : TESTDOMAIN/Client3Prep/test_user
SID          : S-1-5-21-2937651619-4167467795-303580696-1006
Description  :
Disabled     : False
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/13/2016 3:30:29 PM
PwdExpired   : False
UserFlags    : 66049

ComputerName : Client3Prep
AccountName  : TESTDOMAIN/Client3Prep/new_user
SID          : S-1-5-21-2937651619-4167467795-303580696-1008
Description  :
Disabled     : False
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/18/2016 11:46:17 AM
PwdExpired   : False
UserFlags    : 66049
```



```
PS C:\Users\user1.TESTDOMAIN.000> Get-NetLocalGroup -ComputerName "client3" -GroupName "Guests"

ComputerName : client3
AccountName  : TESTDOMAIN/client3/Guest
SID          : S-1-5-21-473845342-2774817237-2297341088-501
Description  : Built-in account for guest access to the computer/domain
Disabled     : True
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/18/2016 11:46:47 AM
PwdExpired   : False
UserFlags    : 66147

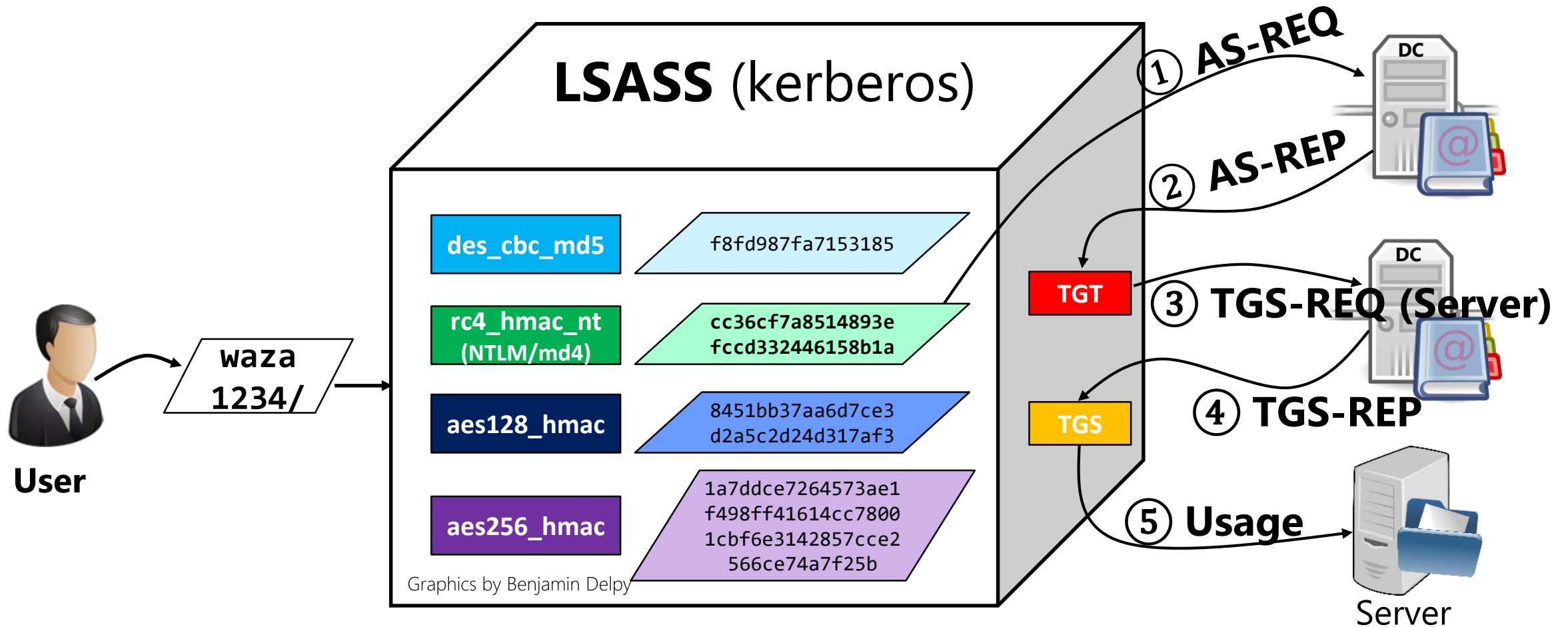
ComputerName : client3
AccountName  : TESTDOMAIN/client3/test_user
SID          : S-1-5-21-473845342-2774817237-2297341088-1006
Description  :
Disabled     : False
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/13/2016 3:30:29 PM
PwdExpired   : False
UserFlags    : 66049

ComputerName : client3
AccountName  : TESTDOMAIN/client3/new_user
SID          : S-1-5-21-473845342-2774817237-2297341088-1008
Description  :
Disabled     : False
IsGroup      : False
IsDomain     : False
LastLogin    :
PwdLastSet   : 9/18/2016 11:46:17 AM
PwdExpired   : False
UserFlags    : 66049
```

Kerberos Error Message Injection

Kerberos Authentication

- Windows default authentication (+ authorization) protocol



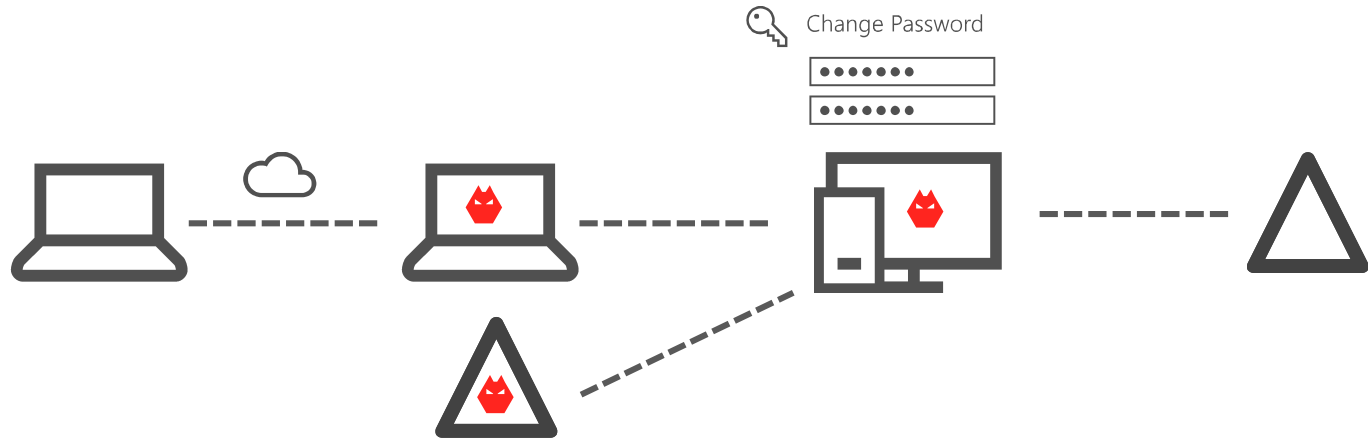
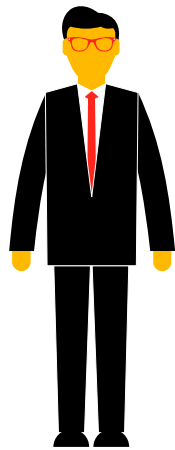
Malicious Kerberos Error Injection

- A MITM Attacker can cause the following effects by sending the following error messages:
 - Downgrade encryption: KDC_ERR_PREAUTH_REQUIRED
 - Change password: KDC_ERR_KEY_EXPIRED
 - Re-enter password: KDC_ERR_TGT_REVOKED
 - Block users: KDC_ERR_CLIENT_REVOKED

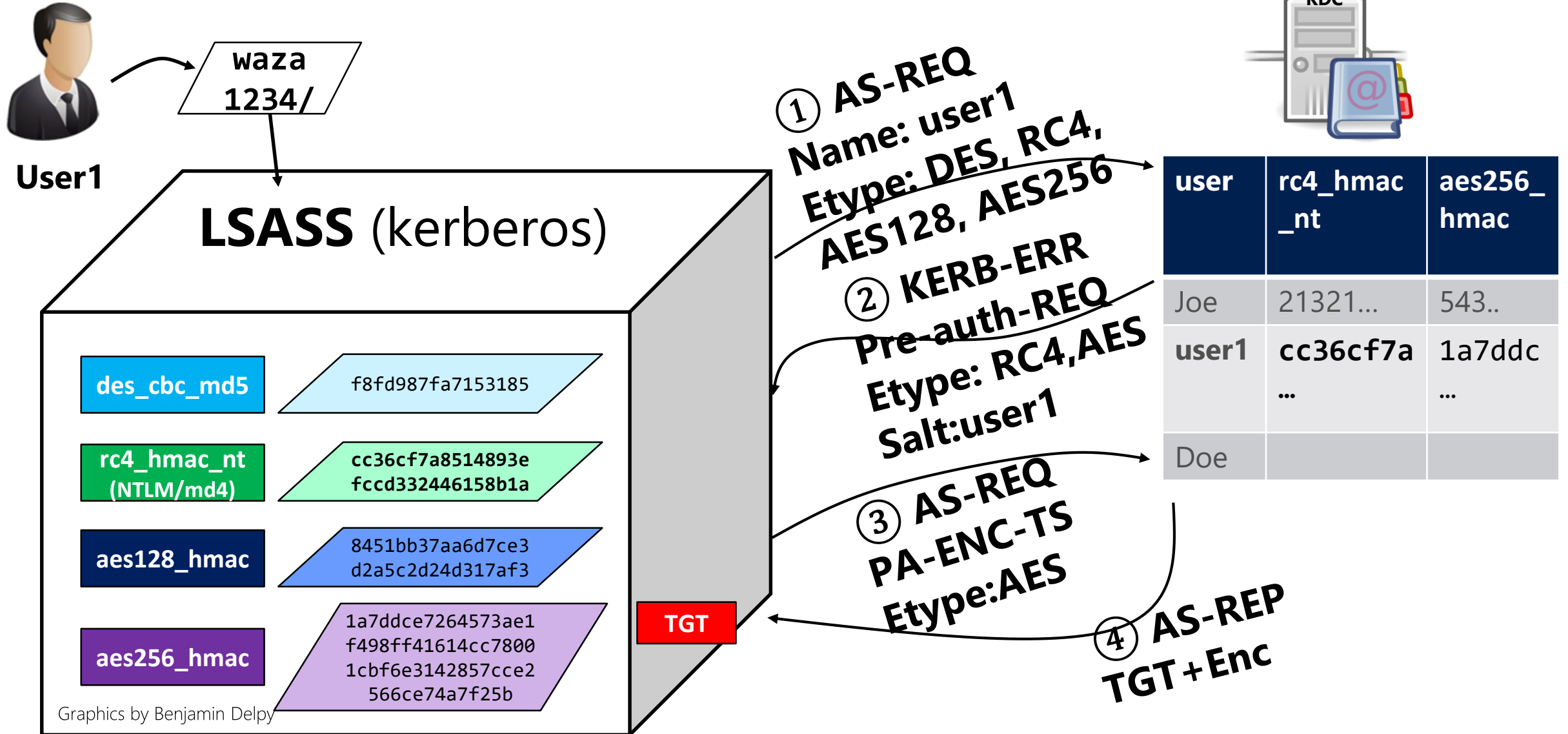
Password Expired Injection: Remote Butler

- Presented in BlackHat USA 2016 by Tal Be'ery & Chaim Hoch
- Demo: https://www.youtube.com/watch?v=CSdJ_-Phaul

Evil
Butler



Kerberos Encryption Negotiation



Kerberos Authentication: Over the Wire

```
as-req
  pvno: 5
  msg-type: krb-as-req (10)
  padata: 1 item
    PA-DATA PA-PAC-REQUEST
  req-body
    Padding: 0
    kdc-options: 40810010 (forwardable, renewable, canonicalize, renewable-ok)
    cname
      realm: aorato.research
    sname
      till: 2037-09-13 02:48:05 (UTC)
      rtime: 2037-09-13 02:48:05 (UTC)
      nonce: 160211996
    etype: 6 items
      ENCTYPE: eTYPE-AES256-CTS-HMAC-SHA1-96 (18)
      ENCTYPE: eTYPE-AES128-CTS-HMAC-SHA1-96 (17)
      ENCTYPE: eTYPE-ARCFOUR-HMAC-MD5 (23)
      ENCTYPE: eTYPE-ARCFOUR-HMAC-MD5-56 (24)
      ENCTYPE: eTYPE-ARCFOUR-HMAC-OLD-EXP (-135)
      ENCTYPE: eTYPE-DES-CBC-MD5 (3)
```

```
krb-error
  pvno: 5
  msg-type: krb-error (30)
  stime: 2014-03-10 20:05:07 (UTC)
  susec: 165032
  error-code: ERR-PREAUTH-REQUIRED (25)
  realm: aorato.research
  sname
  e-data: 30543031a103020113a22a04283026301da003020112a116...
  PA-DATA PA-ENCTYPE-INFO2
    padata-type: KRB5-PADATA-ETYPE-INFO2 (19)
      padata-value: 3026301da003020112a1161b14414f5241544f...
        ETYPE-INFO2-ENTRY
          etype: eTYPE-AES256-CTS-HMAC-SHA1-96 (18)
          salt: AORATO.RESEARCHbugsb
        ETYPE-INFO2-ENTRY
          etype: eTYPE-ARCFOUR-HMAC-MD5 (23)
```

```
as-req
  pvno: 5
  msg-type: krb-as-req (10)
  padata: 2 items
    PA-DATA PA-ENC-TIMESTAMP
      padata-type: KRB5-PADATA-ENC-TIMESTAMP (2)
        padata-value: 3041a003020112a23a0438c871bc029b90195c7d2981b0cd...
          etype: eTYPE-AES256-CTS-HMAC-SHA1-96 (18)
          cipher: c871bc029b90195c7d2981b0cd8e4c98fa5fa747689f86e1...
```


AES vs. RC4: Key Derivation

- Salting
 - Goal: Same passwords, different users = different keys
 - Create-Key(password + salt)
 - AES uses the username for salt
 - **RC4-HMAC does not have any!**
- "Key Stretching"
 - Goal: increase CPU load per password
 - AES uses PBKDF2= Thousands of SHA rounds
 - **RC4-HMAC does not have any!**



https://commons.wikimedia.org/wiki/File:Jodsalz_mit_Fluor_und_Folsaeure.jpg

Attacker + RC4 = 

- Due to salting, identical passwords create different AES keys for different users
 - Attacker cannot prepare a rainbow table in advance
- Due to “Key Stretching” Brute Force is much more CPU intensive
- Attacker’s Solution: Downgrade to RC4

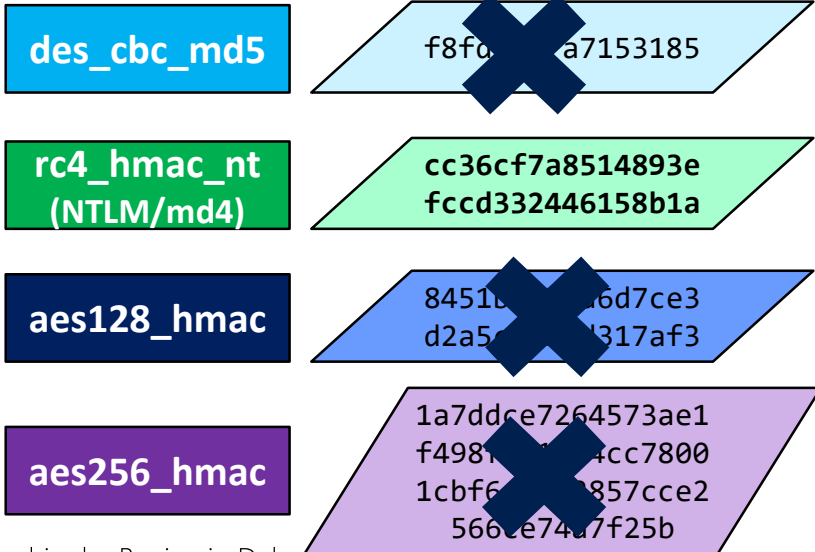
Encryption Downgrade Injection Attack



User1

waza
1234/

LSASS (kerberos)

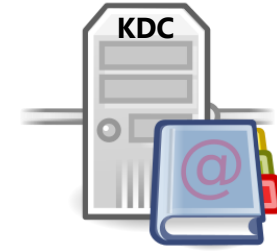


① AS-REQ
Name: user1
Etype: DES, RC4,
AES128, AES256

② KERB-ERR
Pre-auth-REQ
Etype: RC4, AES128, AES256
Salt: user1

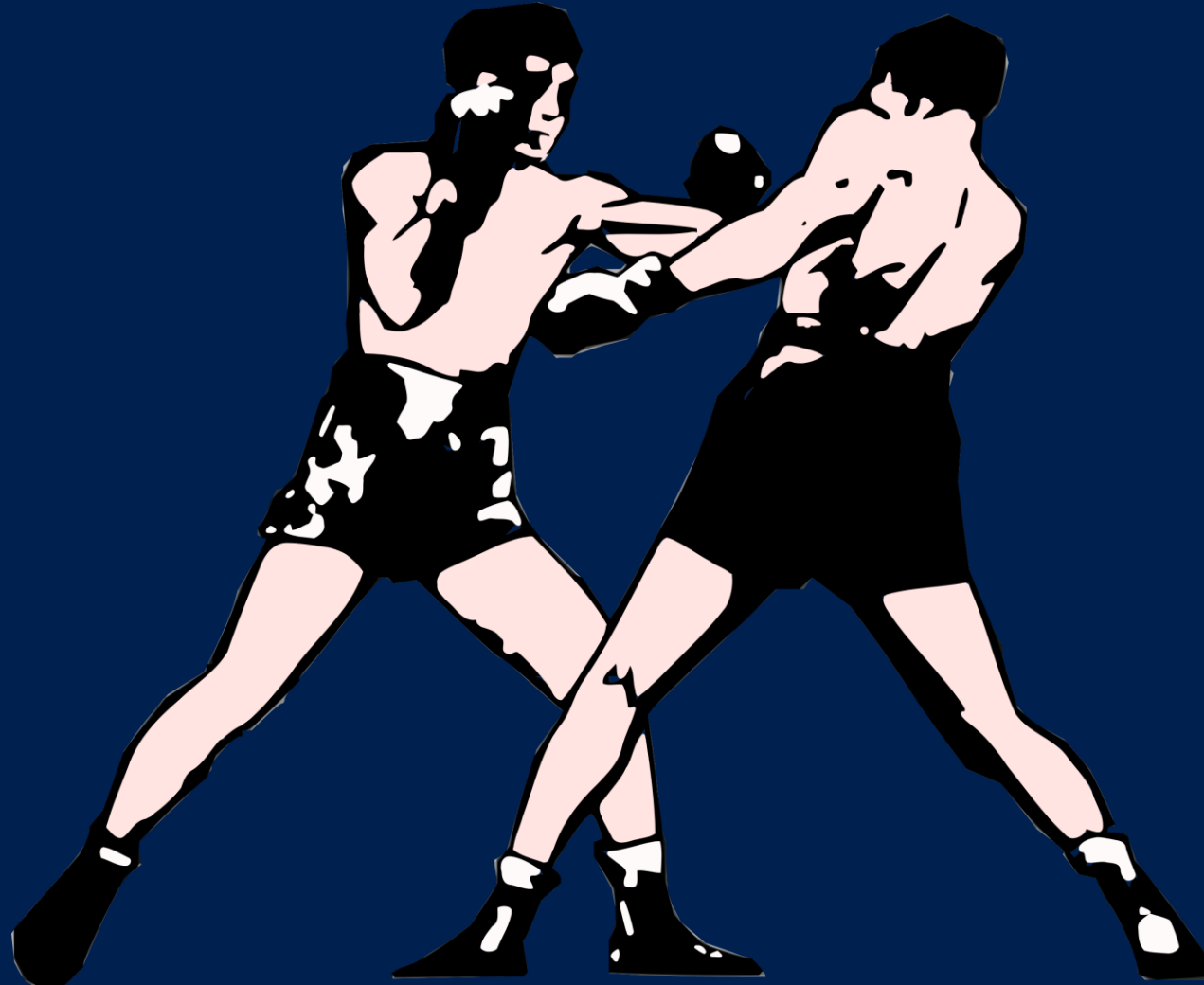
③ AS-REQ
PA-ENC-TS
Etype: RC4

④ AS-REP
TGT+Enc



user	rc4_hmac_nt	aes256_hmac
Joe	21321...	543..
user1	cc36cf7a ...	1a7ddc ...
Doe		

Kerberos Error Injection: Defense



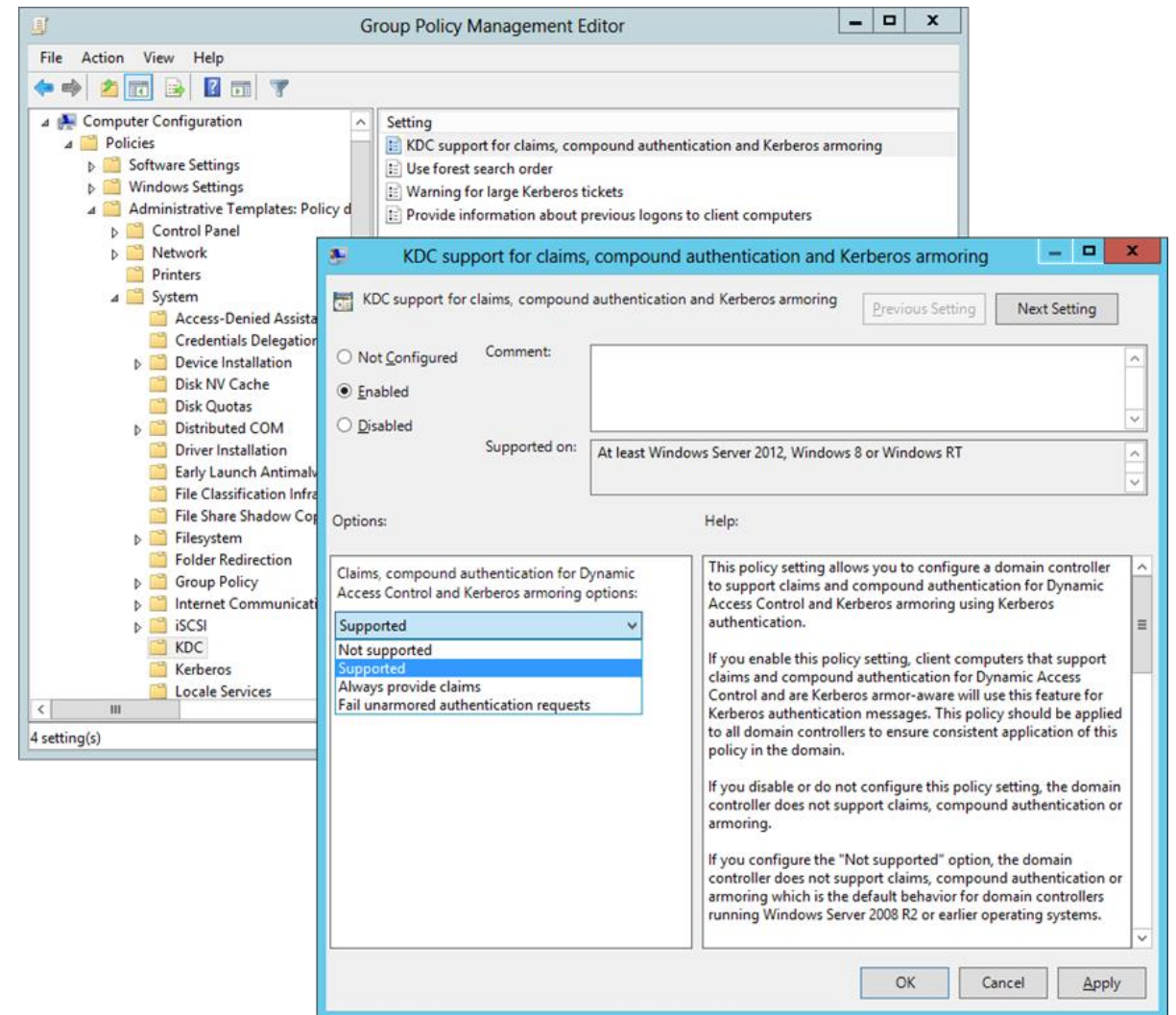
Hardening: Kerberos Armoring

- The computer's Kerberos session key protects the user's Kerberos messages
 - Kerberos errors gets signed with the computer's session key
- Prevents MITM Kerberoserror injections as attackers don't have the computer's credentials / keys

Name	Value	Bit Offset	Bit Length	Type
Length	Length: 430	0	32	Kerbero...
Message	KRB_ERROR	32	3440	Kerbero...
Pvno	5 (0x0000000000000005)	96	40	Int64
MsgType	KRB_ERROR(30) (0x000000000000001E)	136	40	MsgType
Stime	2014-03-10T22:10:56.0000000	176	152	DateTime
Susec	927784 (0x000000000000E2828)	328	56	Int64
ErrorCode	KDC_ERR_PREAUTH_REQUIRED(25) (0x0000000000000019)	384	40	ErrorCo...
Realm	aorato.research	424	152	String
Sname	krbtgt/aorato.research	576	304	Kerbero...
EData	MethodData{MethodData=[PA-FX-FAST (136)]}	880	2592	Kerbero...
MethodData	[PA-FX-FAST (136)]	0	2528	ArrayVa...
[0]	PA-FX-FAST (136)			Kerbero...
PADATAType	PA-FX-FAST (136) (0x0000000000000088)	64	48	Int64
PADATAValue	PA-FX-FAST-REPLY	112	2416	Kerbero...
PADATAValue	KrbFastArmoredRep{EncFastRep=EncryptedData{Etype=18,Kvno=not...	0	2352	Kerbero...

Hardening: Kerberos Armoring (Cont.)

- Available since Windows 8, Server 2012

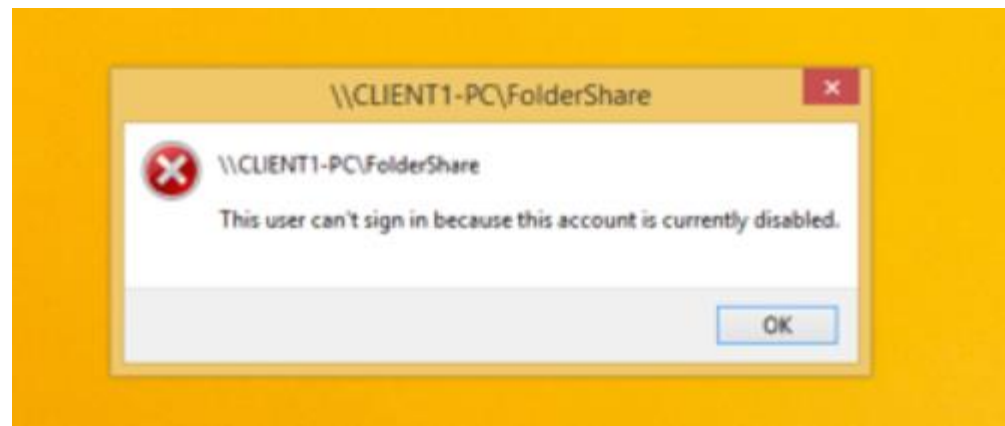
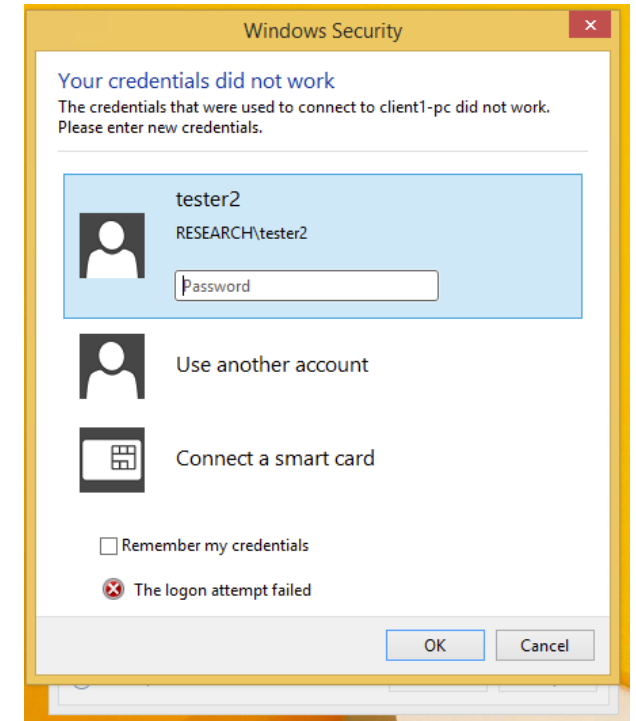


Cyber Judo with Kerberos Error Injection



Injecting to Client: Kerberos Error Injection

- Security Devices can use this method too!
 - Aorato (acquired by Microsoft) patent
 - "System, method and process for mitigating advanced and targeted attacks with authentication error injection"
- A "followed action" to detection
 - Force password change: KDC_ERR_KEY_EXPIRED
 - Force re-enter password: KDC_ERR_TGT_REVOKED
 - Elegantly block users: KDC_ERR_CLIENT_REVOKED



Parting Thoughts

Judo or Boxing?

- Should defenders
 - be boxers and block?
 - Be Judokas and use?
- Why not both?
- For reconnaissance APIs
 - Harden generic excessive access
 - But allow defenders' user
 - Detect failed attempts

```
Administrator: Windows PowerShell
PS C:\Research> .\NetCease.ps1
Starting NetCease 1.01
Permissions successfully updated
In order for the hardening to take effect, please restart the Server service
PS C:\Research>
```

Reconnaissance using SMB Session Enumeration
SMB session enumeration attempts **failed** by user1, from CLIENT2-PC against DC1. No accounts were exposed.

Note Share Export to Excel Details Input Open

Is running scanning tools allowed from the computer listed below?

Session Enumeration

user1 → CLIENT2-PC → DC1

Computers (1)

Computer	Is running scanning tools allowed
CLIENT2-PC	No <input type="checkbox"/> Yes <input checked="" type="checkbox"/>

Save Cancel

Once saved, this suspicious activity might be dismissed

Recommendations

- Disconnect CLIENT2-PC from the network, or move it into an isolated environment and start a forensics procedure by investigating: unknown processes, services, registry entries, unsigned files, and more

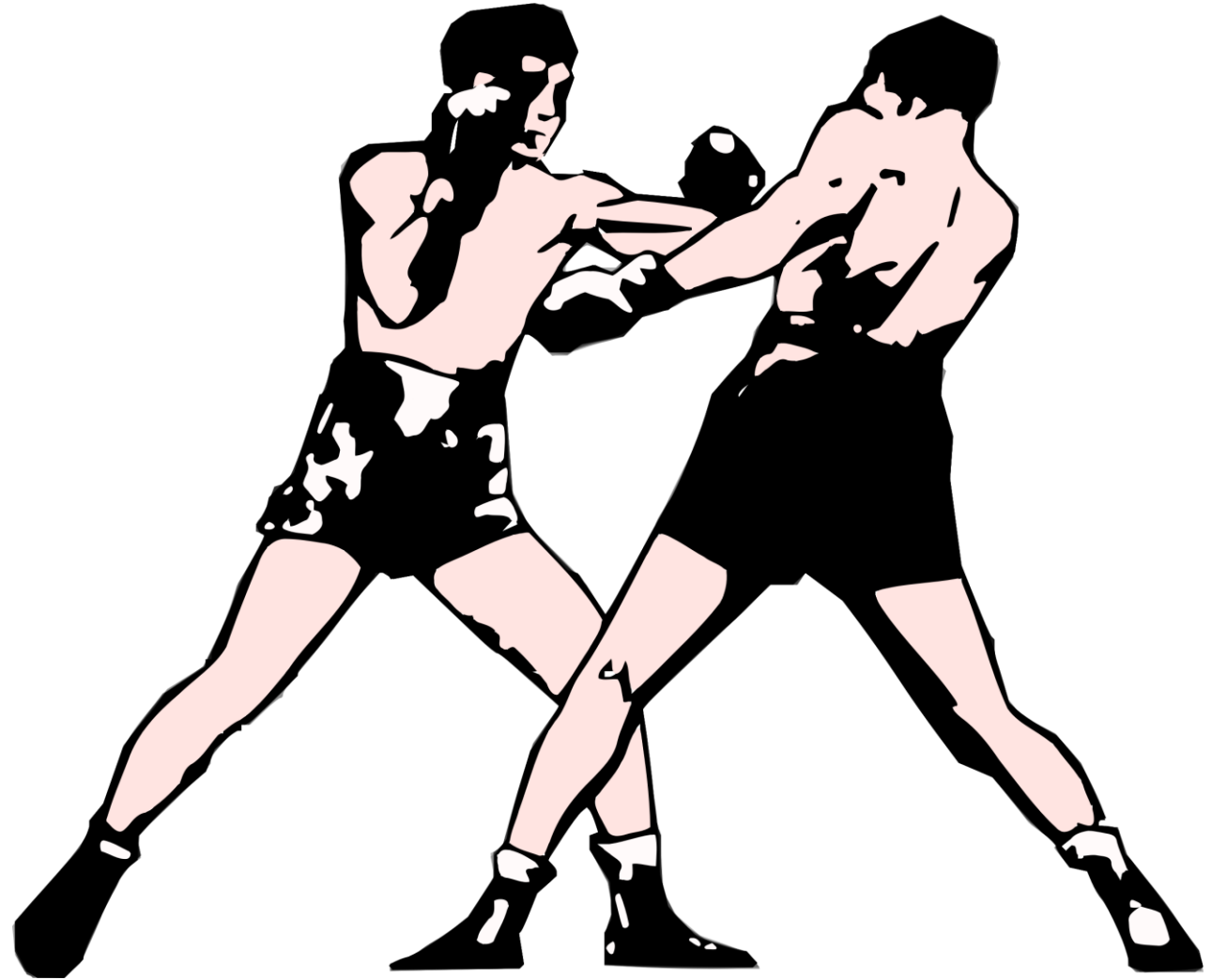
New Contributions

- Lateral Movement automation Module
- “Boxer” Defenses:
 - Detections
 - NetSess recon
 - SAMR recon
 - Hardening
 - Kerberos Armoring
 - SAMR access
- Judo defenses
 - Kerberos defensive error injection
 - NTLM authentication visibility via NetSess Recon
 - Local Users visibility via SAMR Recon



Conclusions

- To defeat the enemy
 - Learn the enemy
 - Know the enemy
 - Be the enemy



Credits and Thanks

- Reviewers
 - BloodHound's Andrew Robbins @_wald0
- Microsoft ATA Research team (other members)
 - Tal Maor @TaltheMaor
 - Marina Simakov
 - Chaim Hoch @chaimh90
- Microsoft ATA Designer
 - Dan Mor @danmor84

Questions?

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