Security APRIL 07, 2022 | 13 MINUTE READ

You Bet Your Lsass: Hunting LSASS Access

By Splunk Threat Research Team

One of the most commonly used techniques is to dump credentials after gaining initial access. Adversaries will use one of many ways, but most commonly Mimikatz is used. Whether it be with PowerShell Invoke-Mimikatz, Cobalt Strike's Mimikatz implementation, or a custom version. All of these methods have a commonality: targeting LSASS. The Local Security Authority Subsystem Service (LSASS) is a process in Microsoft Windows operating systems that is responsible for enforcing the security policy on the system. It verifies users logging on to a Windows computer or server, handles password changes, and creates access tokens (per Wikipedia).

With that, the Splunk Threat Research Team dug into how Mimikatz, and a few other tools found in Atomic Red Team, access credentials via LSASS memory, T1003.001. Part of this process for the Splunk Threat Research Team is to continuously update older analytics to ensure we are providing up to date coverage on latest techniques and behaviors.

To begin, we'll look at our current analytics related to LSASS memory dumping. We will then simulate T1003.001, OS Credential Dumping: LSASS Memory, by using Mimikatz, Cobalt Strike, Atomic Red

Team T1003.001, and Invoke-Mimikatz. Last, we will update our current analytics or create new ones.

Access LSASS Memory for Dump Creation

Our first analytic identifies the image load dbgcore.dll or dbghelp.dll and a TargetImage of lsass.exe. Dbgcore.dll or dbghelp.dll are two core Windows debug DLLs that have minidump functions which provide a way for applications to produce crashdump files that contain a useful subset of the entire process context.

This analytic focuses on the CallTrace and identifies whether dbgcore.dll or dbghelp.dll are loaded to dump credentials.

```
`sysmon` EventCode=10 TargetImage=*lsass.exe CallTrace=*dbgcore.
```

```
| stats count min(_time) as firstTime max(_time) as lastTime by
| rename Computer as dest
| `security_content_ctime(firstTime)`
| `security_content_ctime(lastTime)`
```

We found, as we'll show in our simulation, that dbgcore.dll and dbghelp.dll are no longer utilized with the latest version of Mimikatz or Cobalt Strike. However, it still does capture the more basic utilities that access LSASS memory.

Detect Credential Dumping through LSASS access

This analytic looks for GrantedAccess of 0x1010 or 0x1410 against lsass.exe. These are common access types and it's probably a good time to understand what they are and the common values.

```
`sysmon` EventCode=10 TargetImage=*lsass.exe (GrantedAccess=0x10
| stats count min(_time) as firstTime max(_time) as lastTime by
| rename Computer as dest
| `security_content_ctime(firstTime)`
| `security_content_ctime(lastTime)`
```

This query is limited to two GrantedAcess rights that are familiar to older versions of Mimikatz, but does not stand the test of time in capturing the latest rights request.

GrantedAccess is the requested permissions by the SourceImage into the TargetImage. Microsoft details out

be combined to create, for example, 0x1400 (PROCESS_QUERY_LIMITED_INFORMATION and PROCESS_QUERY_INFORMATION). You may notice some

Value	Meaning
PROCESS_ALL_ACCESS (0x1fffff)	All possible access rights for a process object.
PROCESS_CREATE_PROCESS (0x0080)	Required to create a process.
PROCESS_CREATE_THREAD (0x0002)	Required to create a thread.
PROCESS_DUP_HANDLE (0x0040)	Required to duplicate a handle using DuplicateHandle.
PROCESS_QUERY_INFORMATION (0x0400)	Required to retrieve certain information about a process, such as its token, exit code, and priority class (see OpenProcessToken).
PROCESS_QUERY_LIMITED_INFORMATION (0x1000)	Required to retrieve certain information about a process (see GetExitCodeProcess, GetPriorityClass, IsProcessInJob, QueryFullProcessImageName). A handle that has the PROCESS_QUERY_INFORMATION access right is automatically granted PROCESS_QUERY_LIMITED_INFORMATION.
PROCESS_SET_INFORMATION (0x0200)	Required to set certain information about a process, such as its priority class (see SetPriorityClass).
PROCESS_SET_QUOTA (0x0100)	Required to set memory limits using SetProcessWorkingSetSize.
PROCESS_SUSPEND_RESUME (0x0800)	Required to suspend or resume a process.
PROCESS_TERMINATE (0x0001)	Required to terminate a process using TerminateProcess.
PROCESS_VM_OPERATION (0x0008)	Required to perform an operation on the address space of a process (see VirtualProtectEx and WriteProcessMemory).
PROCESS_VM_READ (0x0010)	Required to read memory in a process using ReadProcessMemory.
PROCESS_VM_WRITE (0x0020)	Required to write to memory in a process using WriteProcessMemory.
SYNCHRONIZE (0x00100000L)	Required to wait for the process to terminate using the wait functions.

Now that we have a basic understanding of how these

Capture Data

To get started with capturing process access event data with Sysmon, we have provided a simple config that identifies TargetImage of lsass.exe. For other EDR products, the name may be similar - Cross Process Open for Carbon Black, or CrowdStrike Falcon SuspiciousCredentialModuleLoad or LsassHandleFromUnsignedModule (reference Falcon Data Dictionary).

```
<Sysmon schemaversion="4.81">

<!-- Capture all hashes -->

<HashAlgorithms>md5</HashAlgorithms>

<EventFiltering>

<!-- Event ID 1 == Process Creation. -->

<ProcessCreate onmatch="include"/>

<!-- Event ID 2 == File Creation Time. -->

<FileCreateTime onmatch="include"/>

<!-- Event ID 3 == Network Connection. -->

<NetworkConnect onmatch="include"/>

<!-- Event ID 5 == Process Terminated. -->

<ProcessTerminate onmatch="include"/>

<!-- Event ID 6 == Driver Loaded.-->
```

```
<DriverLoad onmatch="include"/>
```



```
<ImageLoad onmatch="include"/>

<!-- Event ID 8 == CreateRemoteThread. -->

<CreateRemoteThread onmatch="include"/>

<!-- Event ID 9 == RawAccessRead. -->

<RawAccessRead onmatch="include"/>

<!-- Event ID 10 == ProcessAccess. -->

<ProcessAccess onmatch="include">

<TargetImage condition="is">C:\Windows\system32\lsass.exe</Targe

</ProcessAccess>

<!-- Event ID 11 == FileCreate. -->

<FileCreate onmatch="include"/>

<!-- Event ID 12,13,14 == RegObject added/deleted, RegValue Set,

<RegistryEvent onmatch="include"/>

<!-- Event ID 15 == FileStream Created. -->

<FileCreateStreamHash onmatch="include"/>

<!-- Event ID 17 == PipeEvent. -->

<PipeEvent onmatch="include"/>
```

```
</EventFiltering>
```


The Sysmon Modular project by Olaf Hartong has some filtering that may be useful to enhance the configuration. In our testing, we utilized an open Sysmon configuration and the latest version of Sysmon.

Now we are ready to simulate.

Simulate

To simulate LSASS Memory Access, we will start with Atomic Red Team and follow up with Mimikatz, Invoke-Mimikatz, and Cobalt Strike.

Atomic Red Team

For T1003.001, LSASS Memory access, we can run individual tests or all. In this instance, we will download all the prerequisites and then run them all. There are cases where the tests may not complete and may need to be fixed or run manually (this is all based on operating environment variables).

To download Invoke-Atomicredteam and the Atomic Tests, run the following

```
[Net.ServicePointManager]::SecurityProtocol =
```

```
[Net.SecurityProtocolType]::Tls12
```

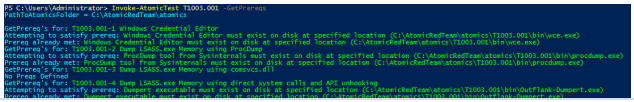
```
IEX (IWR 'https://raw.githubusercontent.com/redcanaryco/invoke-a
```

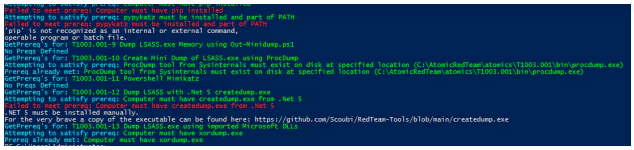
```
Install-AtomicRedTeam -getAtomics -force
```

```
Install prerequisites
```

```
Some Atomic tests have prerequisites and it is very simple to ge
```

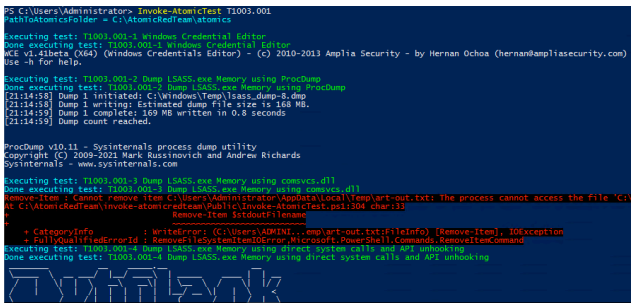
```
Invoke-AtomicTest T1003.001 -GetPrereqs
```





Now we will invoke T1003.001.

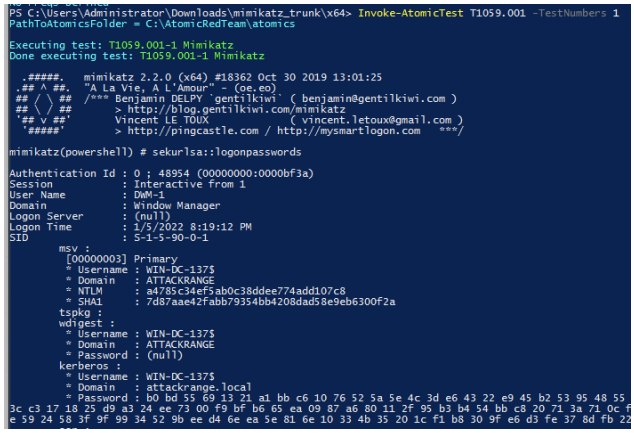
Invoke-AtomicTest T1003.00



Before we hop into Splunk, let's run the other two simulations.

Invoke-mimikatz

For invoke-Mimikatz, we utilized Atomic Red Team T1059.001 test number 1. This uses the 2019 version of Mimikatz. Roberto Rodriguez called out the differences in his blog from 2017 as well, in that older versions request different permissions. Upon successful execution, it will invoke Mimikatz in memory and dump credentials.

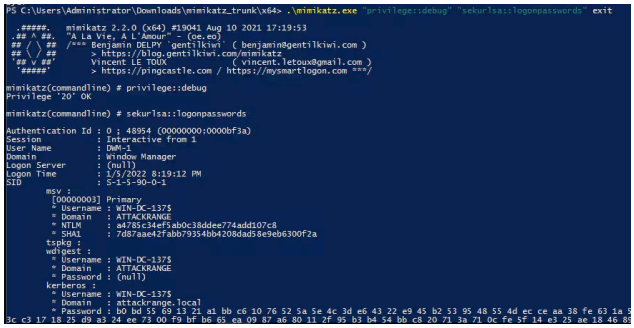


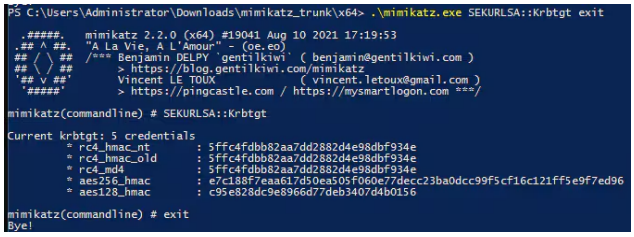
Mimikatz

other products are turned off to avoid any issues.

We will run the following variations


```
.\mimikatz.exe SEKURLSA::Krbtgt exit
```

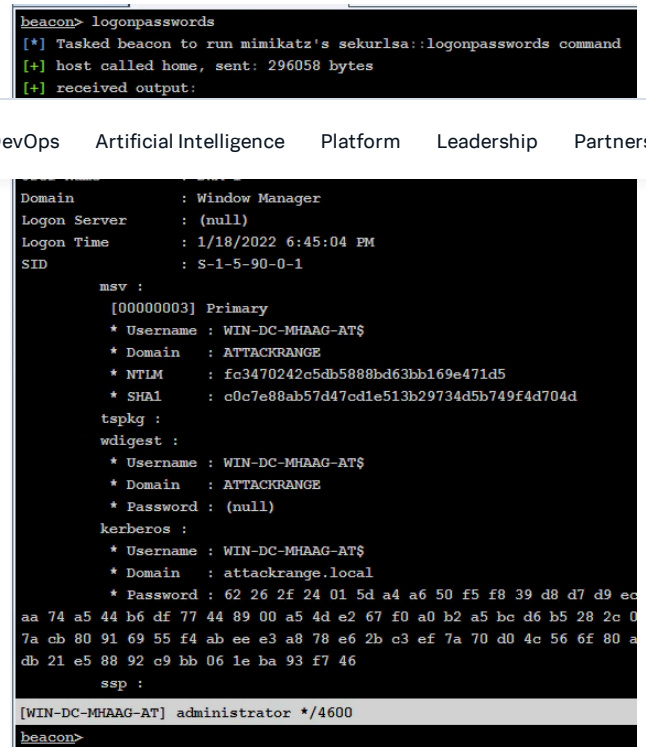




Alright, that finishes our easy tests for Mimikatz.

Mimikatz and Cobalt Strike

Similarly, run the same commands within a session using Cobalt Strike. The behavior we will look for here is similar to most Cobalt Strike behavior we've identified in the past, a spawned process, default of rundll32.exe, with no command-line arguments, with a process access event targeting LSASS.exe.



Notes on testing

Typically, our process is to simulate 1 test at a time and validate coverage. Iterate over each test and modify our query as needed. For brevity, the blog skips the thorough process and highlights a faster process.

Continuous Improvement

Access LSASS Memory for Dump Creation

For our first analytic that focuses on CallTrace image load dbgcore.dll or dbghelp.dll, we found that over time Mimikatz moved away from these two DLLs (dbgcore.dll or dbghelp.dll). The main DLL used by Mimikatz is now ntdll.dll. Ntdll.dll is a native Windows binary that provides similar native API paths to perform credential dumping. For example in the sekurlsa module there are many ntdll exported api's, but what stands out is RtlCopyMemory which is used to execute the module related to credential dumping.

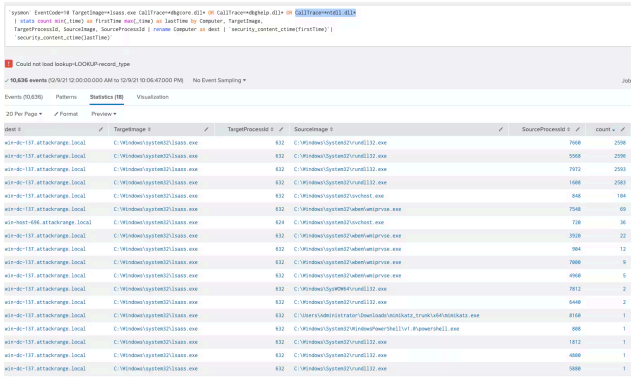
After simulating the behavior we needed, we get some results

```
| stats count min(_time) as firstTime max(_time) as lastTime by
```



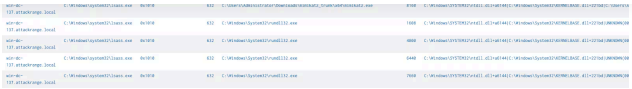
```
| rename Computer as dest | `security_content_ctime(firstTime)`
```

In our screenshot, we see some utilities that still use dbgcore.dll or dbghelp.dll when credential dumping occurs. However, we do not see Mimikatz.exe and a few other utilities using dbgcore.dll or dbghelp.dll. Based on CallTraces, we see a pattern of ntdll.dll being used by various credential dumping utilities. If we add ntdll.dll to our current query we get the following results:



We now have a list of processes (source) targeting lsass.exe. Sometimes legitimate applications will request access to lsass.exe for credential access, say to authenticate with AzureCLI or a software deployment application. What will differentiate these? This will be environment dependent based on roles and access associates may have, based on process hierarchy, or GrantedAccess. As we will dig into next, filtering may be much easier once we combine GrantedAccess with CallTrace.

Now we add GrantedAccess to our query to identify any patterns



We can see the permissions being requested by the SourceImage and we will begin looking at what those values mean next.

Detect Credential Dumping through LSASS access

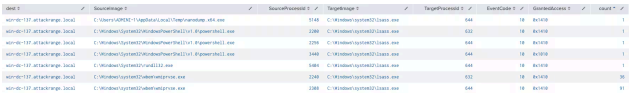
Now our second analytic is focused on GrantedAccess, which we explored earlier what the values are. Now that simulation is complete we can begin digging in.

The base query looks like this with some simulated data

```
`sysmon` EventCode=10 TargetImage=*lsass.exe (GrantedAccess=0x10
```

```
| stats count min(_time) as firstTime max(_time) as lastTime by
```

```
| rename Computer as dest | `security_content_ctime(firstTime)`
```



With all the simulation it was easy to spot the patterns between CallTrace and GrantedAccess, so we created a table to showcase these values:

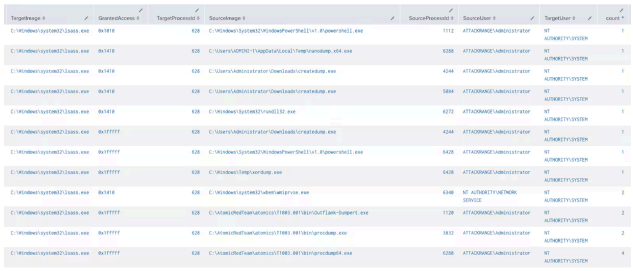
GrantedAccess	Process	CallTrace
0x1010	mimikatz.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1010	rundll32.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1fffff	rundll32.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1410	rundll32.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1410	nanodump.x64.exe	C:\Windows\SYSTEM32\ntdll.dll+a5c84|C:\Users\ADMINI~1\AppData\Local
0x1fffff	procdump.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\SYSTEM32\ntdll.dll+6c
0x1fffff	xordump.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\SYSTEM32\ntdll.dll+6c
0x1fffff	outflank-dumpert.exe	C:\AtomicRedTeam\atomics\T1003.001\bin\Outflank-Dumpert.exe+1d32|C:\
0x1410	[illegible]	[illegible]

0x1fffff	createdump.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\SYSTEM32\ntdll.dll+6c
0x1010	Invoke-mimikatz	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1438	mimikatz.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS
0x1410	PasswordHashesView.exe	C:\Windows\SYSTEM32\ntdll.dll+a6144|C:\Windows\System32\KERNELBAS x64\PasswordHashesView.exe+cf2d|C:\Users\Administrator\Downloads\nirs

With all this testing, our updated Sysmon query combines the two analytics we set out to enhance by focusing on specific GrantedAccess rights and CallTrace DLLs. Will this catch everything? Probably not, but it will at least catch the majority of tools used and allow us to filter out known good in environments and focus on the rare.

```
`sysmon` EventCode=10 TargetImage=*lsass.exe GrantedAccess IN ("
```

This will require some filtering as common system processes will access lsass.exe with GrantedAccess of 0x1400 and 0x1010.



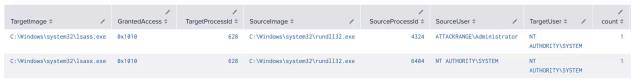
For Mimikatz and the various items that come with it, whenever it does make contact with LSASS.exe the results are mostly the same.

As noted in our table of CallTrace and GrantedAccess, dependent upon what is being executed with the utility (MimiKatz for example) the access will be different. This was also noted by Roberto Rodriguez here and Carlos Perez here.

Does this catch every variation of Mimikatz out there? Most likely not. However, it will be a great start to identify uncommon GrantedAccess rights to Lsass.exe. This may be expanded upon or converted to other utilities to assist with detecting suspicious LSASS access.

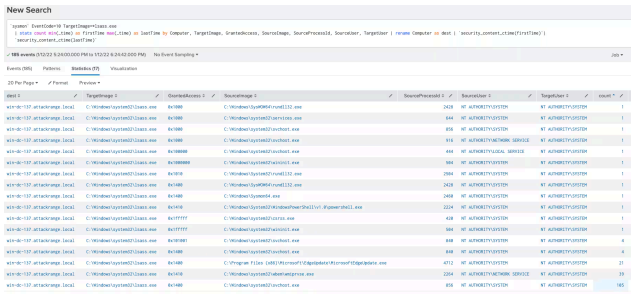
Additional Observations

During our simulations we identified behaviors that may assist teams in identifying suspicious SourceUser accessing LSASS. Typically, we will see source NT AUTHORITY\SYSTEM and TargetUser NT AUTHORITY\SYSTEM for normal system process behavior. However, seeing source ATTACKRANGE\administrator and Target NT AUTHORITY\SYSTEM is suspicious.



TargetImage	GrantedAccess	TargetProcessId	SourceImage	SourceProcessId	SourceUser	TargetUser	count
C:\Windows\system32\lsass.exe	0x1010	628	C:\Windows\system32\rundll32.exe	4324	ATTACKRANGE\Administrator	NT AUTHORITY\SYSTEM	1
C:\Windows\system32\lsass.exe	0x1010	628	C:\Windows\system32\rundll32.exe	6404	NT AUTHORITY\SYSTEM	NT AUTHORITY\SYSTEM	1

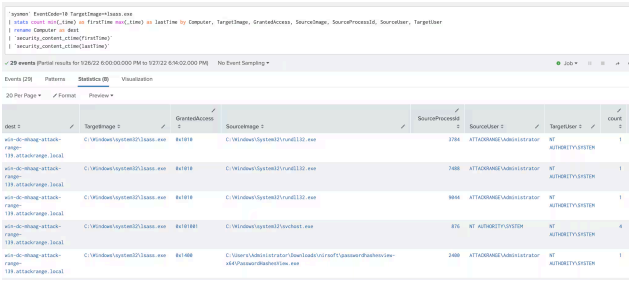
What if an adversary is already elevated? SourceUser will not be a user account, but NT AUTHORITY\SYSTEM. This may be a bit more difficult to detect, but it's worth a hunt.



With all this data we hope you found this informative and understand a bit of our continuous improvement for our content.

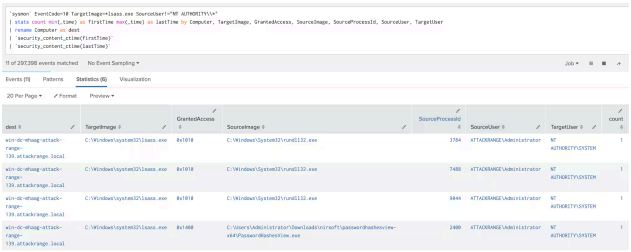
New Analytics

Windows Hunting System Account Targeting Lsass



Windows Non-System Account Targeting Lsass

The following analytic identifies non SYSTEM accounts requesting access to lsass.exe.



Name	Technique ID	Tactic	Description
Windows Hunting System Account Targeting Lsass	T1003.001	Credential Access	Identifies all processes requesting access into Lsass.exe
Windows Non-System Account Targeting Lsass	T1003.001	Credential Access	Identifies non SYSTEM accounts requesting access to lsass.exe.
Windows Possible Credential Dumping	T1003.001	Credential Access	The following analytic is an enhanced version of two previous analytics that identifies common

			permission requests and CallTrace DLLs in order to detect

References

- https://en.wikipedia.org/wiki/Local_Security_Authority_Subsystem_Service
- https://docs.microsoft.com/en-us/windows/win32/api/minidumpapiset/nf-minidumpapiset-minidumpwritedump
- https://cyberwardog.blogspot.com/2017/03/chronicles-of-threat-hunter-hunting-for_22.html
- https://raw.githubusercontent.com/PowerShellMafia/PowerSploit/master/Exfiltration/Invoke-Mimikatz.ps1
- https://docs.microsoft.com/en-us/windows/win32/procthread/process-security-and-access-rights
- https://github.com/trustedsec/SysmonCommunityGuide/blob/master/chapters/process-access.md

Splunk Threat Research Team

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