
Malware Design
Abusing legacy Microsoft transports and session architecture

About Me

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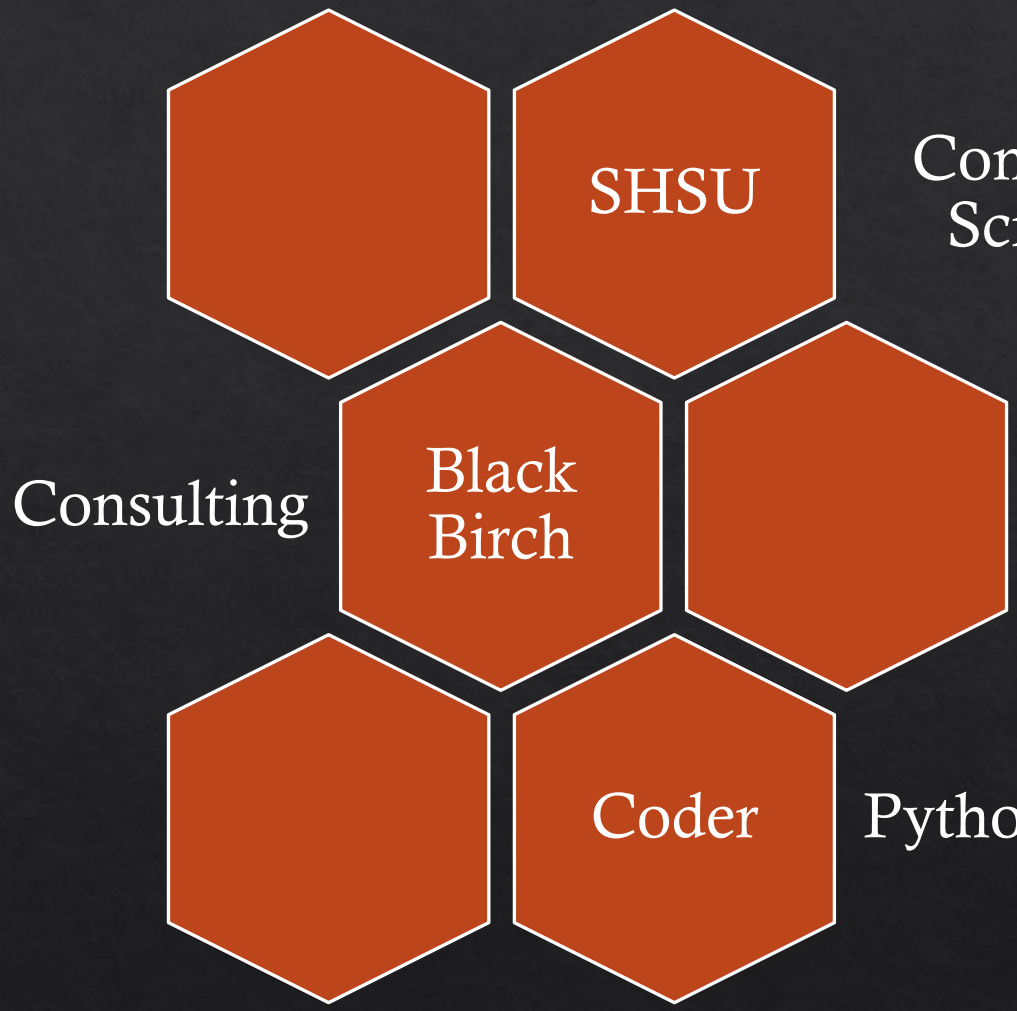
A computer scientist who has made a career out of hacking into numerous fortune 500 companies through consulting red team engagements.



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Introduction

Red Team Challenges

- Compromise networks, endpoints, and data
- Remaining undetected
- Long term access

Solution Requirements

- Employ stealthy TTPs at multiple levels
- Provide enough functionality to be effective

Prerequisite High-level Overview

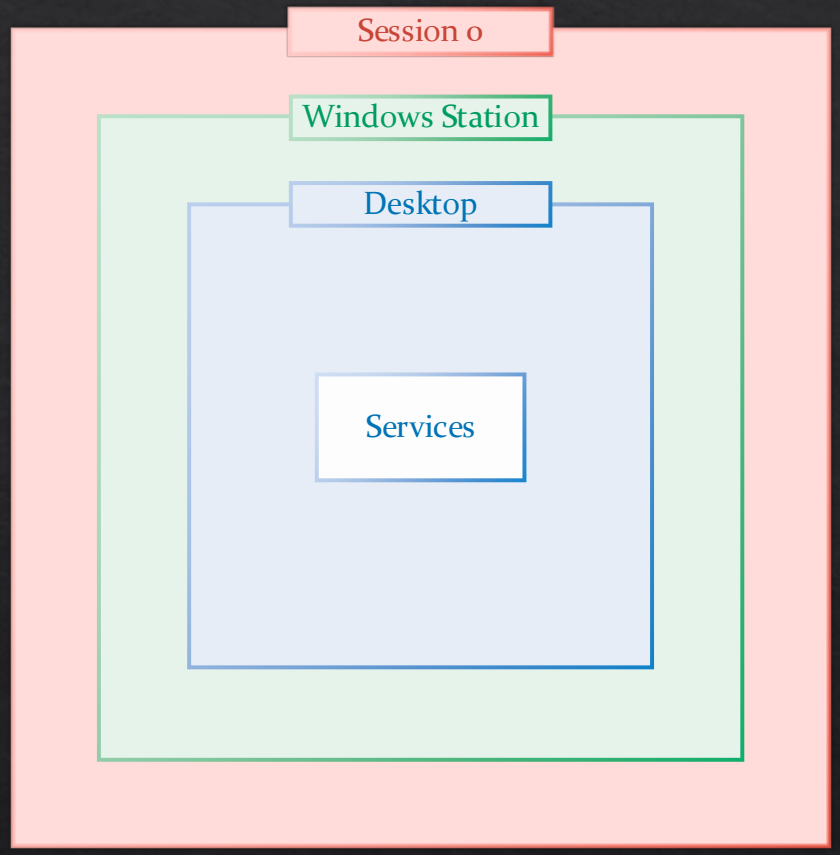
Windows Architecture

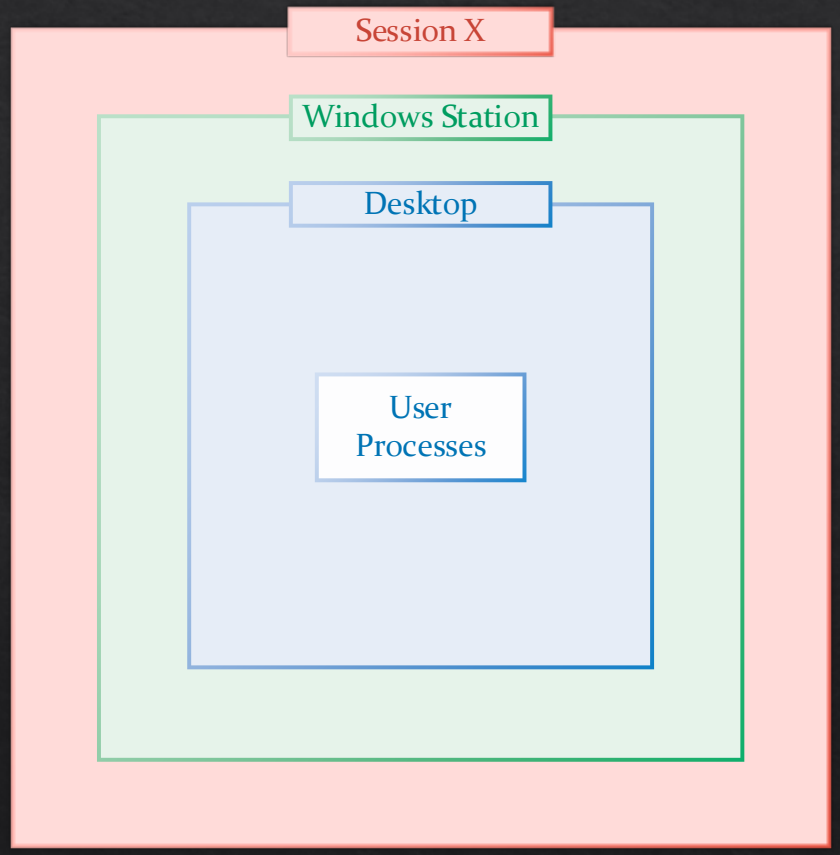
- Sessions
- Stations
- Desktops
- Processes
- Tokens

Protocols

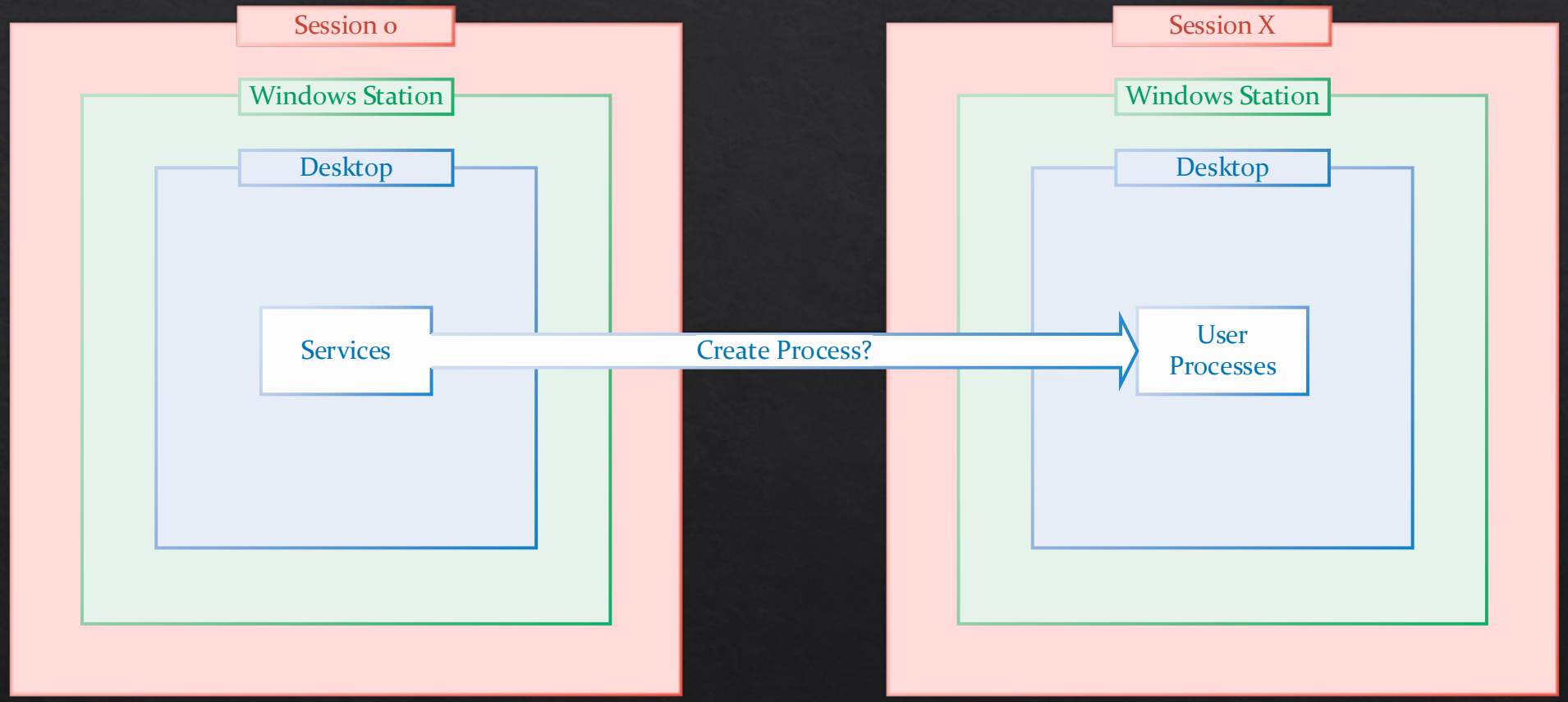
- Mailslots
- NetBIOS
- UDP

Windows Architecture



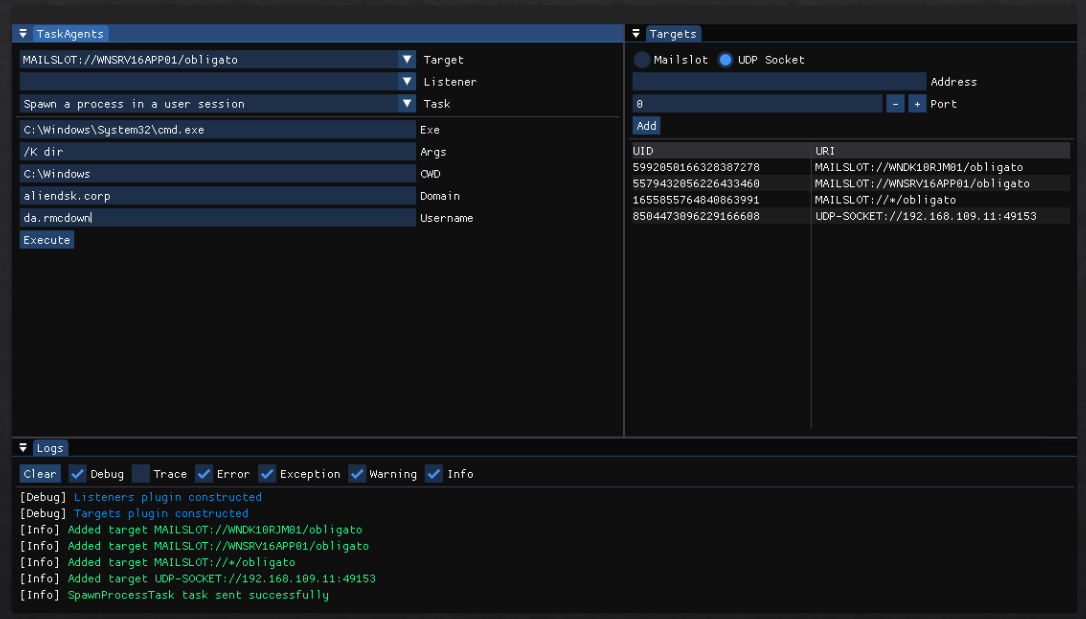


Windows Architecture



Obligato Overview

- Reliable long-term access without agent check-in requirements
- Recover access if primary interactive C2 is detected
- Custom messaging protocol
  - Operator issues Tasks
  - Messages delivered via Routes
  - Notifications (responses) are optional
- Agent runs as a Windows service in Session 0



Implant Messaging Protocol

- Obligato implements a custom messaging protocol that is transport agnostic, regardless of it being unidirectional or bidirectional
  - **Bidirectional** transports
    - Stateful protocols (i.e., TCP) or app layer protocols that use them, such as, HTTP(S)
  - **Unidirectional** transports
    - Stateless protocols (i.e., UDP) or app layer protocols that use them, such as, DNS and Mailslots over NetBIOS datagrams
- Operators leverage messages to task Obligato implants and to optionally receive responses, even over a unidirectional transport
- Accomplished through three key concepts: **Tasks**, **Routes**, and **Notifications**

Implant Messaging Protocol

Tasks

- Inbound messages requesting for some action to occur
- An operator could send a task message to an endpoint to spawn a process in a user's logon session, optionally yielding a response "notification“
- **Question**: since the messaging protocol is decoupled from the transport layer, how can it deliver a response, especially when considering a transport can be unidirectional?

Routes

- Entries within an Obligato implant describing destinations, which includes the transport type and any information needed for that type to function
- An example Mailslot route would include the NetBIOS name and Mailslot name while a UDP route would include a hostname/IP address and a port number
- Each route entry is mapped to a unique identifier that are used in route lookups

Implant Messaging Protocol

Notifications

- Response messages generated and sent by a completed task
- Only sent if the inbound task message included a valid and existing route ID

Takeaway

- Allows for tasks to be sent from an arbitrary location and transport while optionally receiving response notifications to a different location and transport

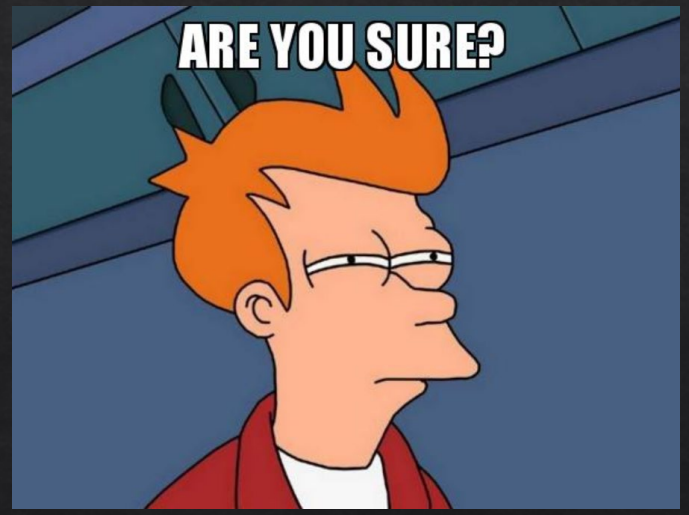
Mailslots as an Implant Messaging Transport

"The Remote Mailslot Protocol is a simple, unreliable, insecure, and unidirectional inter-process communications (IPC) protocol between a client and server … A mailslot is represented locally on the server as a file." [2]

- Why use Mailslots as an implant messaging transport?
  - network traffic not associated with the process
  - monitoring tools won't associate network activity with implant process
  - legacy APIs showing minimum support to Windows 2000 [10]
- Usage for successful Mailslot message delivery
  - Use the NetBIOS name, not the IP address
  - Broadcast message support
- Authentication is not required or supported

DEMO 1

> *"With the release of Windows 11 Insider Preview Build 25314, we have started disabling the Remote Mailslot protocol by default. This is a precursor to deprecation and eventual removal from Windows. You aren't using this extremely legacy protocol unless you're also using the deprecated and disabled-by-default SMBv1 protocol, so 99.97% of you have nothing to worry about."*[1]



- a principal program manager at Microsoft -

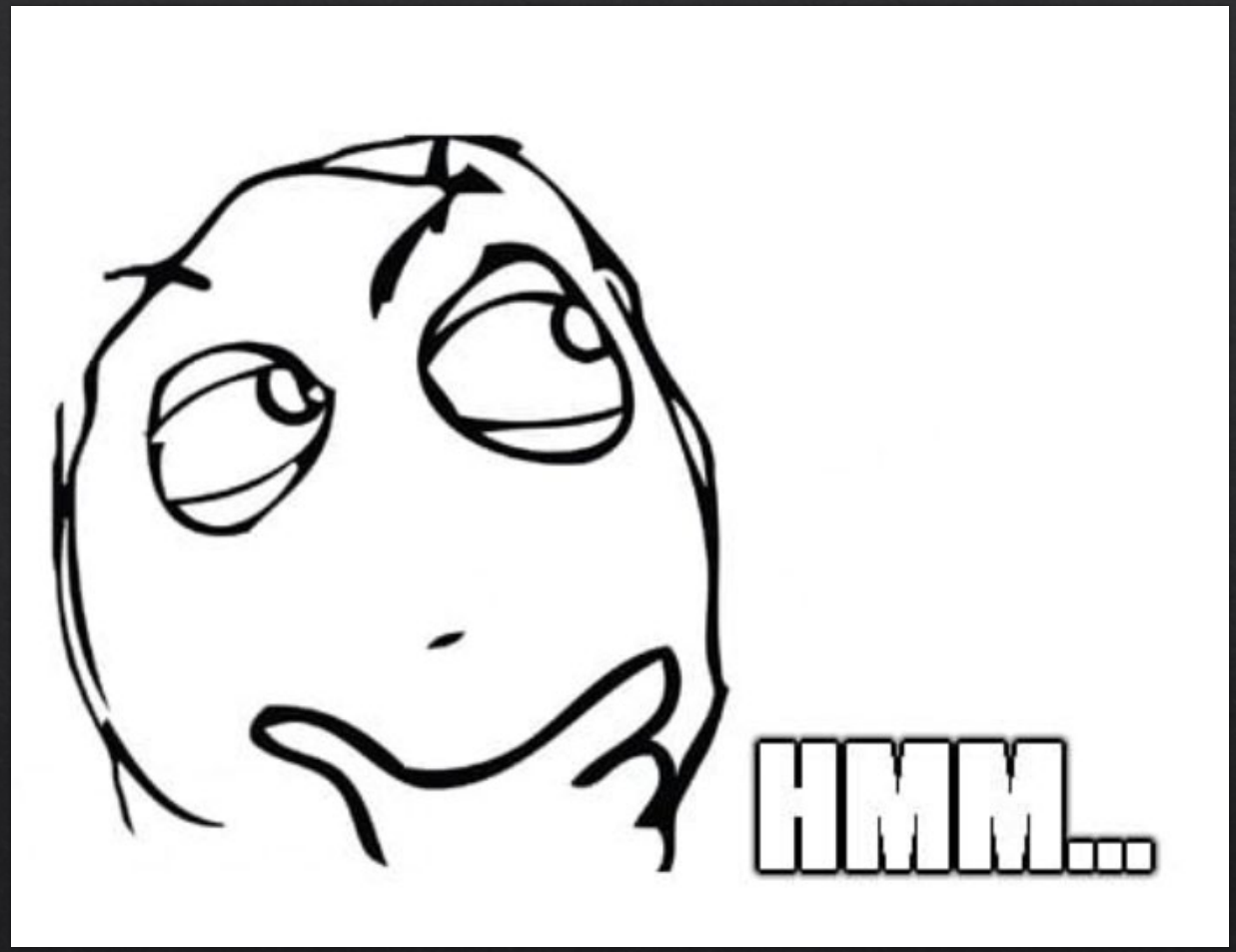
DEMO 2

Windows Logon Session Compromise

- Two key components of any engagement
  - Elevating permissions
  - Moving laterally to new endpoints within the enterprise
- Often accomplished by compromising privileged users and services
  - Credentials – LSASS process memory, LSA secrets, cached credentials, etc. (T1003) [4]
  - Logon Session – code execution in target user's Windows logon session (T1055) [4]
- Mainstream techniques for logon session compromise
  - Execute code in a logon sessions process (T1055) [4]
  - Open handle to process, duplicate token, then impersonation or process creation (T1134) [4]

Question:

What if we want to create a process, on demand, inside a target user's logon session without executing code in, or opening a handle to, another process?



Windows Task Scheduler

- Create a scheduled task to run as the target user
  - Configure to only run if user is logged-in or credentials will be required
- Process is created in user's session using WinSta0 and the default desktop
  - New windows could be displayed to the end user
- Process chain makes it obvious it stems from a scheduled task
  - taskhostw.exe and the malware have the same svchost.exe parent process
- Generates several event logs which may be scrutinized by defenders

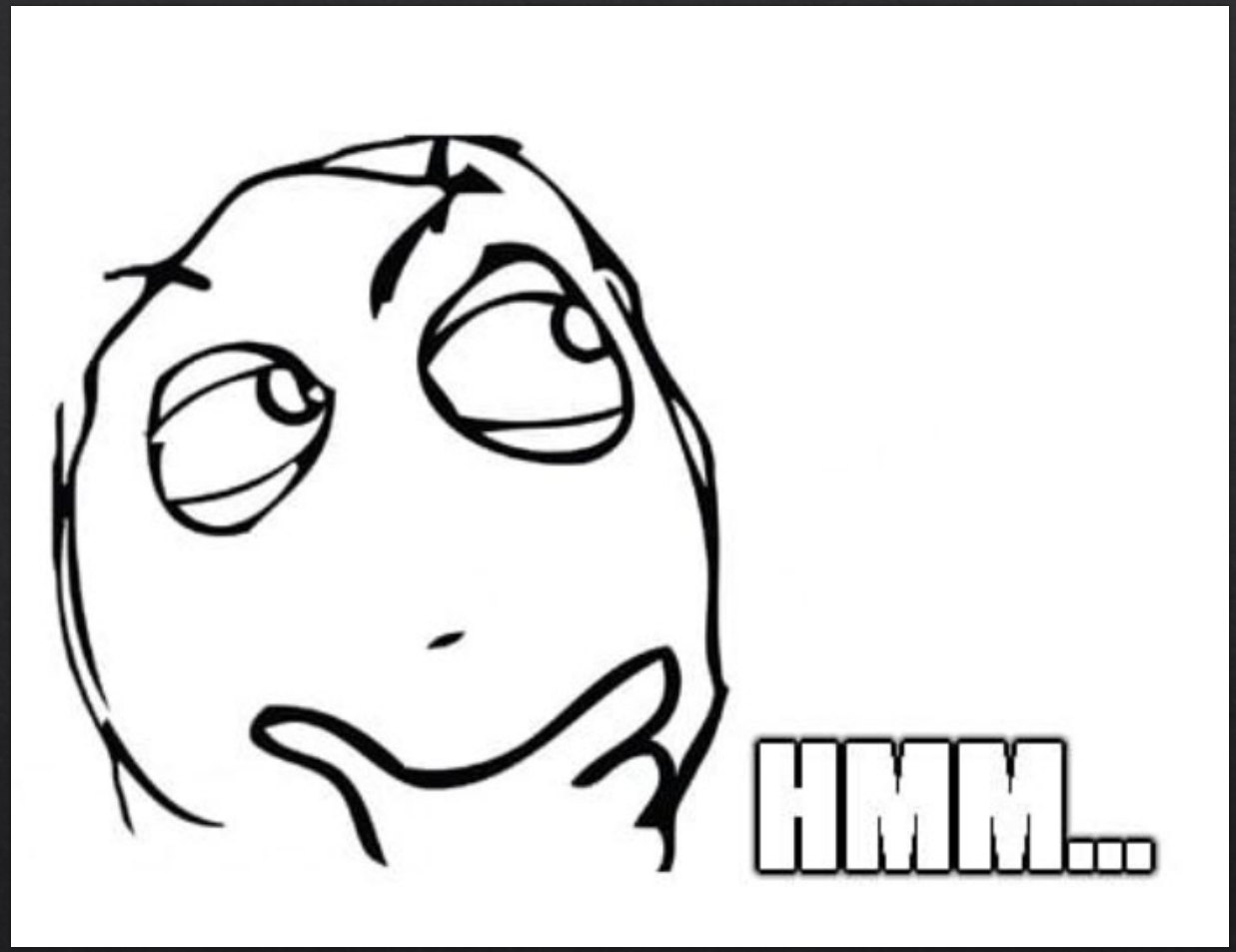
DEMO 3

Question:

What if we want to create a process, on demand, inside a target user's logon session without executing code in, or opening a handle to, another process

and…

not generate the obvious event logs, only display windows to the end user if we want, specify the parent creator process, and evade ETW?



DEMO 4

How does it work?

- Enable required privileges
  - SeDebugPrivilege will be required for spoofing the parent creator process
  - SeTcbPrivilege will be required for creating a process in a different logon session from the caller
- Spoof the Parent Process [5]
  - Open a handle to the desired parent process, not the process token, with the PROCESS_CREATE_PROCESS flag
  - Create a thread attributes list and add the parent process handle to it with UpdateProcThreadAttribute() along with the PROC_THREAD_ATTRIBUTE_PARENT_PROCESS flag

How does it work?

- CreateProcessAsUser() vs. CreateProcessWithToken()
  - *"The caller's process always runs in the caller's session, not in the session specified in the token. To run a process in the session specified in the token, use the CreateProcessAsUser function."* [12]
  - CreateProcessAsUser() is required to start a process in another user's session
- CreateProcessAsUser() requires a token to create the process, but we don't want to access/steal a token from another process, so we leverage WTSQueryUserToken()
  - gets the primary access token of the logged-on user for a specified session [13]
  - to use this function the caller must run within the context of NT Authority\SYSTEM and have "SeTcbPrivilege" enabled [13]
  - what I could not find to be documented, but is a requirement, is **the caller must be running in session 0**; performing this activity in any other session failed even if running as NT Authority\SYSTEM with all privileges enabled

Can this be detected?

- *"… is for kernel drivers that register for process creation notifications with PsSetCreateProcessNotifyRoutineEx() (or one of its variants)."* [5]

```
typedef struct _PS_CREATE_NOTIFY_INFO {
  SIZE_T               Size;
  union {
    ULONG Flags;
    struct {
      ULONG FileOpenNameAvailable : 1;
      ULONG IsSubsystemProcess : 1;
      ULONG Reserved : 30;
    };
  };
  HANDLE               ParentProcessId;
  CLIENT_ID            CreatingThreadId;
  struct _FILE_OBJECT *FileObject;
  PCUNICODE_STRING     ImageFileName;
  PCUNICODE_STRING     CommandLine;
  NTSTATUS             CreationStatus;
} PS_CREATE_NOTIFY_INFO, *PPS_CREATE_NOTIFY_INFO;
```

Can this be detected?

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- ParentProcessId member is the parent process ID set by CreateProcess()

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  HANDLE               ParentProcessId;
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Can this be detected?

- *"… is for kernel drivers that register for process creation notifications with PsSetCreateProcessNotifyRoutineEx() (or one of its variants)."* [5]
- ParentProcessId member is the parent process ID set by CreateProcess() [5]
- CreatingThreadId member is a struct containing the real creator parent process ID [5]
- *"… that information goes away, leaving only the parent ID, as it's the one stored in the EPROCESS kernel structure of the child process."* [5]

```
typedef struct _PS_CREATE_NOTIFY_INFO {
  SIZE_T               Size;
  union {
    ULONG Flags;
    struct {
      ULONG FileOpenNameAvailable : 1;
      ULONG IsSubsystemProcess : 1;
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  PCUNICODE_STRING     ImageFileName;
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} PS_CREATE_NOTIFY_INFO, *PPS_CREATE_NOTIFY_INFO;
```
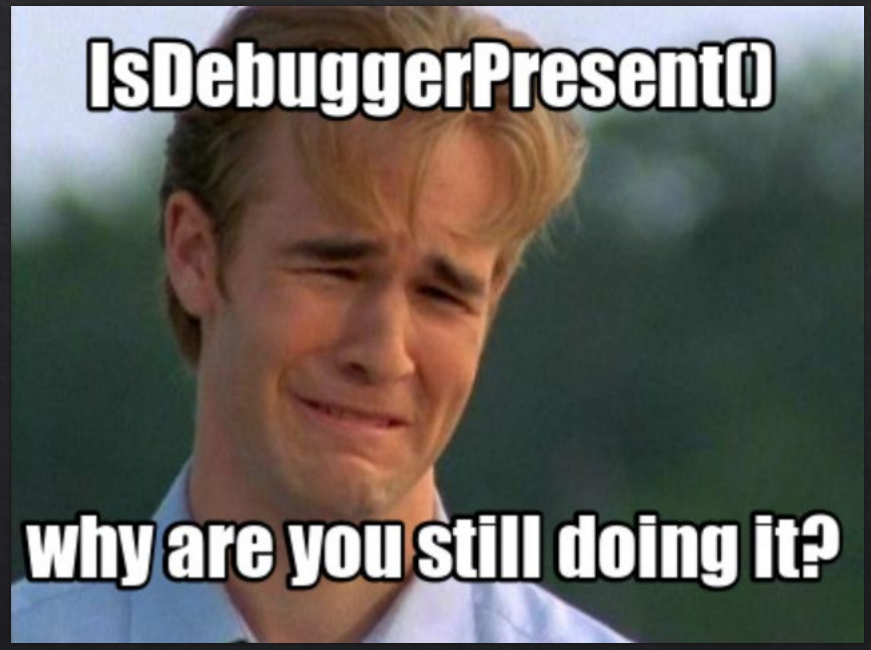

What about Event Tracing for Windows (ETW)?

DEMO 5

Early Execution Anti-debug & Runtime Awareness

- TLS Callbacks
- ThreadHideFromDebugger
- BeingDebugged
- Environment Variables



Thread Local Storage (TLS) Callbacks

- Allow a function to execute when a thread is created
  - Execution occurs before the main entry point
- Usage does **not** necessarily indicate malicious intent
  - Used legitimately in mainstream applications, including Chromium [7]

```
6   thread_local HANDLE hTlsCbThread;
7
8   DWORD WINAPI TlsCbThread(PVOID) {
9       // [3] Execution Trace - Race with wmain()
10      __debugbreak();
11
12      std::wstring msg = std::format(L"TLS Callback Thread - TID:{}", GetCurrentThreadId());
13      MessageBox(NULL, msg.c_str(), L"TLS CB Thread", MB_OK);
14
15      return 1;
16  }
17
18
19  typedef void(__stdcall* TLS_CALLBACK_PTR)(void* instance, int reason, void* reserved);
20
21  void __stdcall tls_callback(void* instance, int reason, void* reserved)
22  {
23      if (reason == DLL_PROCESS_ATTACH) {
24          // [1] Execution Trace
25          __debugbreak();
26
27          wchar_t msg[1024];
28          swprintf_s(msg, 1024, L"Entry TLS Callback - TID:%lu", GetCurrentThreadId());
29          MessageBox(NULL, msg, L"TLS CB", MB_OK);
30
31          hTlsCbThread = CreateThread(nullptr, 0, TlsCbThread, nullptr, 0, nullptr);
32          if (hTlsCbThread != NULL) {
33              WaitForSingleObject(hTlsCbThread, 5000);
34          }
35
36          // [2] Execution Trace
37          __debugbreak();
38      }
39  }
40
```

Anti-Debug

ThreadHideFromDebugger

- This can be set for a thread using NtSetInformationThread() and ThreadHideFromDebugger [8][9][17]
- Setting this on a thread causes it to be ignored by a debugger that attaches to the process
- The feature exists because a debugger needs to be able to ignore its own thread to function correctly
- Guess what happens when a breakpoint is set in a thread that can't be debugged... yes, it crashes the process

BeingDebugged

- We have our threads set to not allow debugging, but how do we know if one attaches so we can set a breakpoint and crash the process?
- Everyone knows about the Windows API function IsDebuggerPresent(), so maybe we don't want to use it
- We just need the address of the process environment block (PEB) then access the value at the offset of 'BeingDebugged' [14]

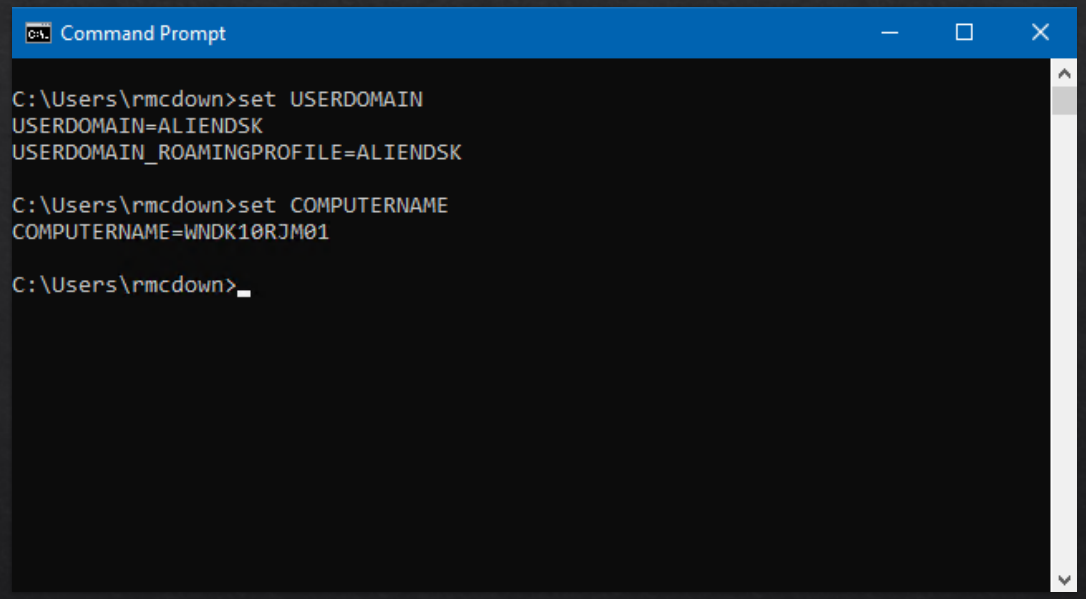
Anti-Debug

```cpp
/*
    Additional includes - Native API header files
    https://github.com/winsiderss/phnt
*/
#include "phnt_windows.h"
#include "phnt.h"

#include <iostream>
#include <Windows.h>


thread_local HANDLE hAntiDbgThread;

DWORD WINAPI AntiDbgThread(PVOID) {
    // Address of the Process Environment Block (PEB)
    uintptr_t pebAddr = __readgsqword(0x60);

    // Loop while value of 'BeingDebugged' in PEB struct
    // is 0 (not being debugged)
    while ((char)*(uintptr_t*)(pebAddr + 2) == 0) {
        pebAddr = __readgsqword(0x60);

        if (pebAddr == 0) {
            __debugbreak(); // Crash process
        }
    }

    __debugbreak(); // Crash process
    return 0;
}
```

```cpp
typedef void(__stdcall* TLS_CALLBACK_PTR)(void* instance, int reason, void* reserved);

void __stdcall tls_callback(void* instance, int reason, void* reserved) {
    if (reason == DLL_PROCESS_ATTACH) {
        unsigned char info = 5;
        hAntiDbgThread = CreateThread(nullptr, 0, AntiDbgThread, nullptr, 0, nullptr);

        if (hAntiDbgThread != NULL) {
            NTSTATUS ntSetStatus = NtSetInformationThread(
                hAntiDbgThread, THREADINFOCLASS::ThreadHideFromDebugger, &info, 0);
        }
    }
}

#pragma comment (linker, "/INCLUDE:_tls_used")
#pragma comment(linker, "/INCLUDE:p_tls_callback")
#pragma const_seg(".CRT$XLB")
EXTERN_C const TLS_CALLBACK_PTR p_tls_callback = tls_callback;
#pragma const_seg()


int wmain(int argc, wchar_t* argv[]) {
    int x, sum = 0;

    while (1) {
        std::wcout << L"Type a number: ";
        std::wcin >> x;
        sum += x;
        std::wcout << L"Sum: " << sum << std::endl;
    }

    return 0;
}
```

Environment Variables

- Detect if machine is domain joined by comparing 'USERDOMAIN' and 'COMPUTERNAME'; if they are the same the box is not domain joined
- Can help mitigate dynamic analysis as most sandboxes that I have observed do not run domain joined machines
- Have used this technique for many years successfully in many different custom payload stagers and tools



Conclusion

- Implant Messaging Protocol supports arbitrary unidirectional or bidirectional transports
  - Task response notifications are optional and can route across different transports and endpoints
  - Can extend to virtually any transport protocol
- Mailslots are available even if SMBv1 is disabled
  - Network traffic is disassociated from the server/client processes
  - Supports broadcasting a single task to all implanted endpoints in the domain network
  - Authentication not only isn't required, but not even supported

Conclusion

- User logon sessions can be compromised without touching their processes
  - Remote Desktop Services API allows primary token access given a Session ID
  - Needs special process privileges and running in Session 0
- Method for spoofing parent process is not captured by Sysinternals Process Monitor or Sysinternals Process Explorer
  - Activity can be captured by ETW, demonstrated by Process Monitor X v2
  - Process/thread callbacks capture activity, but it isn't stored in the child process kernel structure
- **Does your stack capture this activity correctly?**
- TLS Callbacks allow for early runtime code execution, providing a great place to incorporate runtime checks and anti-debugging

Questions?



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