CNIT 581: CYBER FORENSICS OF MALWARE – FINALS

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Final Exams

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Abstract

This report is CNIT 581: Cyber Forensics of Malware finals. The report contains the analysis of two malware files **pFPpHVqOjicpiWc.000** and **sample.zip**. Both malwares undergoes all the analysis taught during the period of the class. These analyses are the Basic Static Analysis, Basic Dynamic Analysis, Advanced Static Analysis, and Advanced Dynamic Analysis. We decided to call the first malware analyses Part I and the second malware Part II.

The first malware is identified as a Win32.exe file designed for Windows OS, while the second malware is an ELF file (Executable and Linkable Format), which is a standard binary format for UNIX systems. The first malware was successfully analyzed with no problems, but considering the last malware is designed for UNIX systems we ran into multiple problems.

We conclude the analyses with an explanation of the malware functionality and behaviors, which provides a summary of how we classify applications as malwares.

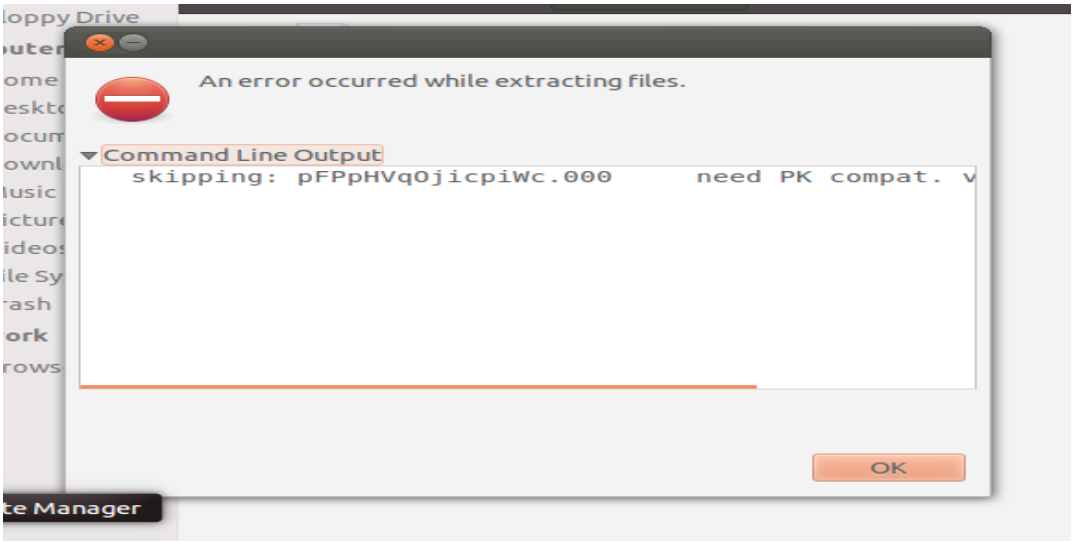
Part I

Malware 1 Analysis

File: **pFPpHVqOjicpiWc.zip**

Extracting the file

The malware file couldn't be extracted on Windows so we have to use a Linux environment. We decided to use Ubuntu 12.04 (The choice of Ubuntu not Kali was based on the available Linux distribution I have). Extracting the file in Ubuntu seems to be a struggle too. It requires a password. However when using the password provided which is "malware" it shows an error "**need PK compat. V5.1**" as shown in Figure 1 below:



It appears an update is required for the file to be extracted. Installing **p7zip-full** package using Ubuntu Terminal seems to solve the problem. As shown in Figure 2 below:

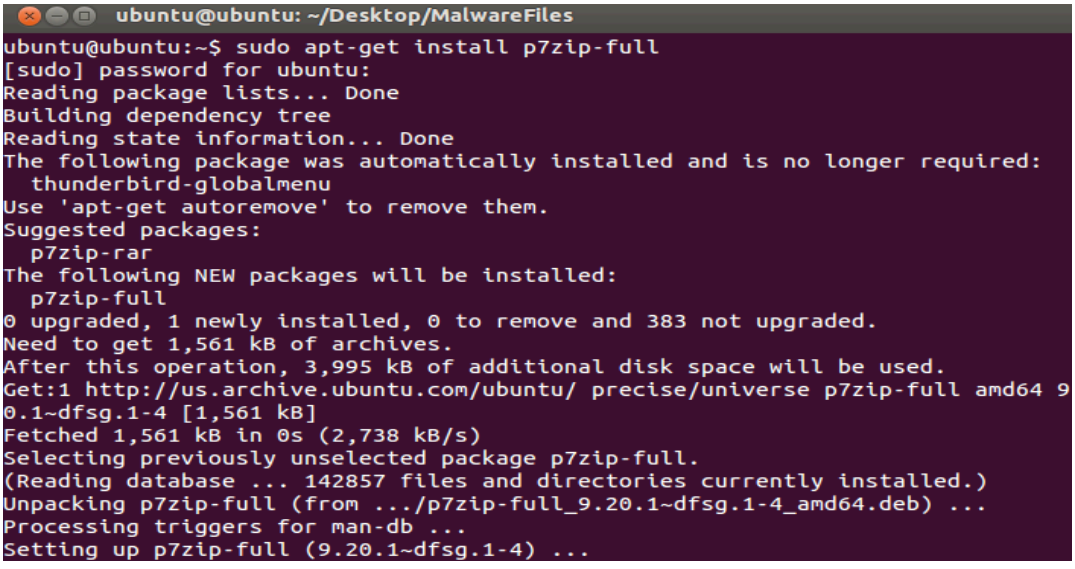


Figure 2 above shows **p7zip-full** package installed using the Ubuntu terminal by using the command **sudo apt-get install p7zip-full**.

The file was successful extracted as **pFPpHVqOjicpiWc.000** and then copied to windows for analysis.

Basic Static Analysis

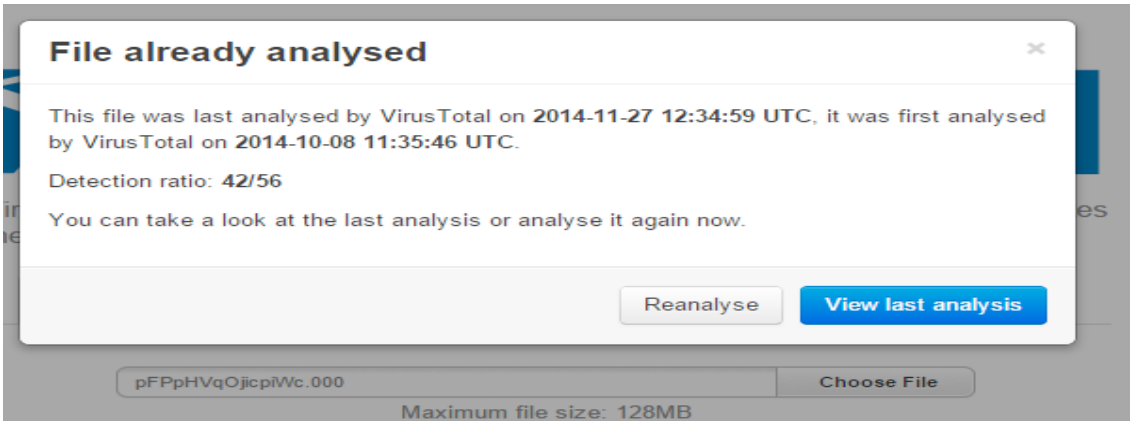
Basic Static Analysis is the analysis of a malware to examine the executable file without viewing the actual instruction. Basic static analysis can confirm whether a file is malicious, provide information about its functionality, and sometimes provide information that will allow you to produce simple network signature. Basic static analysis can be done without running the malware.

Analysis:

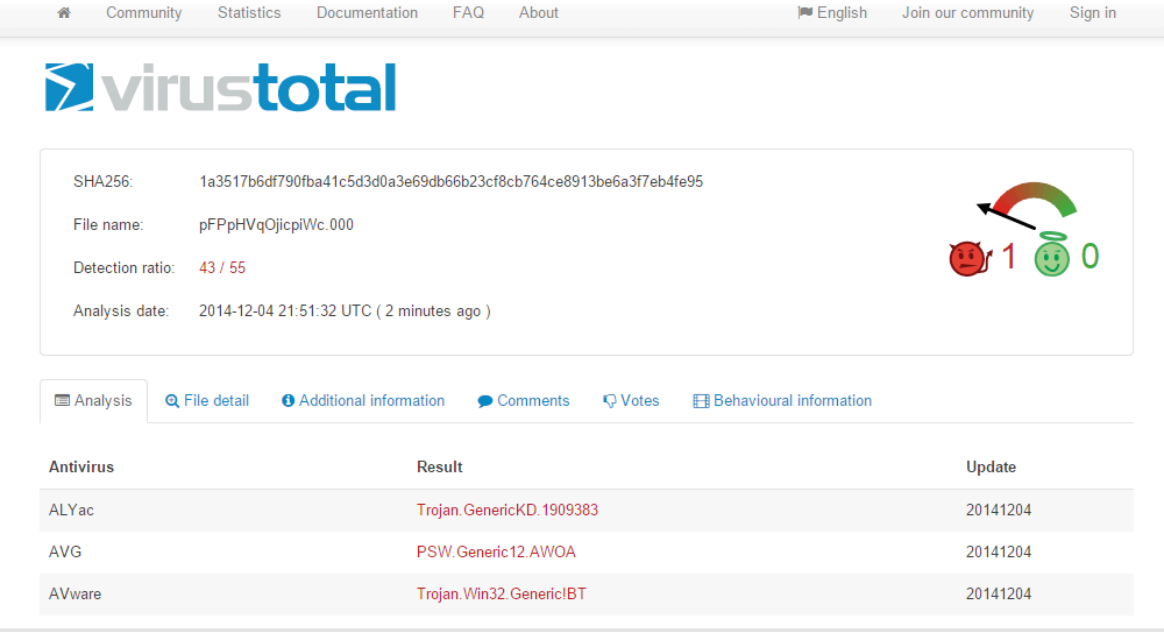
We used windows 8.1 with the entire analysis package described installed already.

First thing we did before running the malware was uploading it virustotal.com to see if the file matches existing virus signatures.

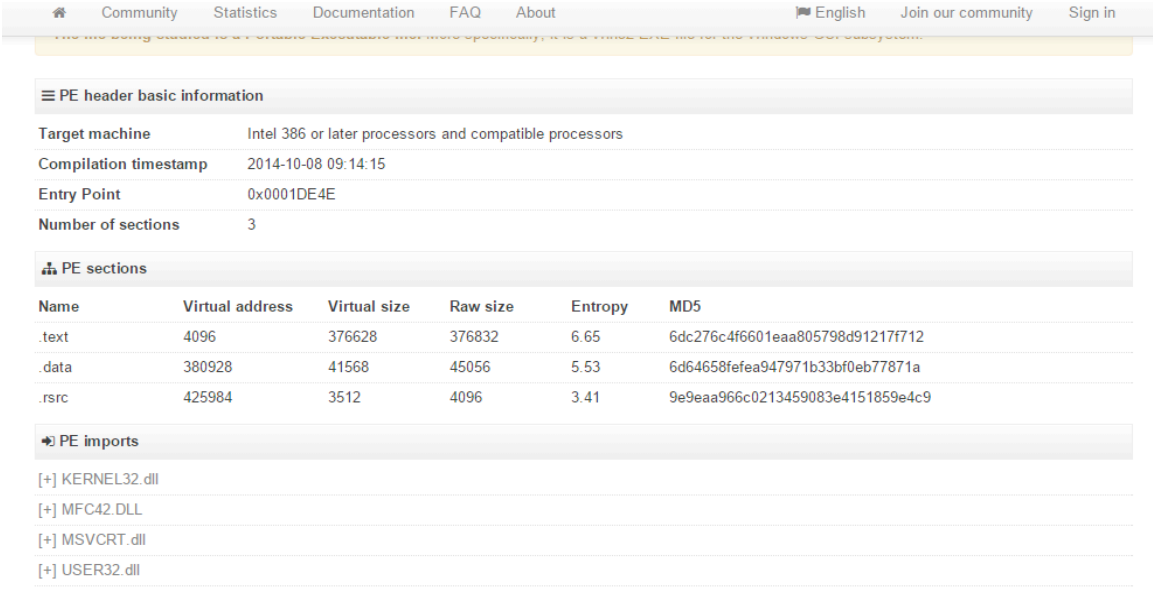
As shown in Figure 3 below, we see that the file was previously analyzed



We then reanalyze it to see the result. Reanalyzing the malware shows that the malware matches 43 of 55 virus signatures as shown in figure 4 below:



Navigating to the "File Details" tab shows the compilation date as **"2014-10-08 09:14:15"** we could also see the imports of the file, which helps us understand what the malware was intended to do. These imports are KERNEL32.dll, MFC42.dll, MSVCRT.dll, and USER32.dll.



The "**Additional Information**" tab shows us the file type, size and what type of operating system it is designed for. Which are: The file is a Win32.exe file, it size is 420.0KB and it is a PE32 executable file designed for windows OS using Intel processor.

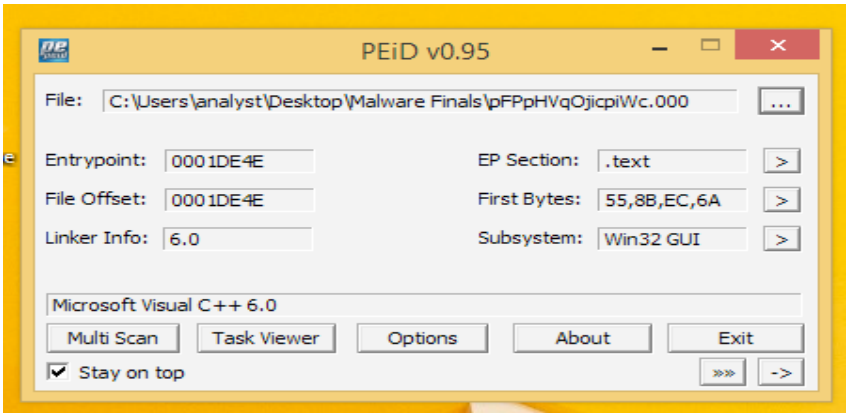
Analysis | File detail | Additional information | Comments | Votes | Behavioural information

File identification

MD5	32206ea7534debc3af5f0a0a9bd01f14
SHA1	64a3780a143b8c57c2a1ade4fb6d09f4f72a4b2b
SHA256	1a3517b6df790fba41c5d3d0a3e69db66b23cf8cb764ce8913be6a3f7eb4fe95
ssdeep	6144:oy0sr70Ekt+GGnQO2zC8bTfmJ80wlijwKelDtNfz3Vm/NZfSCA:oNs0tAQPCbhwmwKepk/6/
authentihash	5ca4aafb53a84e9370a715ff2968e5963879c75172906d1eafc28c4e1915c7d5
imphash	3da42dbe61b3b81acd989c34baaa9a87
File size	420.0 KB (430080 bytes)
File type	Win32 EXE
Magic literal	PE32 executable for MS Windows (GUI) Intel 80386 32-bit
TrID	Win32 Dynamic Link Library (generic) (43.5%) Win32 Executable (generic) (29.8%) Generic Win/DOS Executable (13.2%) DOS Executable Generic (13.2%) Autodesk FLIC Image File (extensions: flc, fli, cel) (0.0%)
Tags	peexe

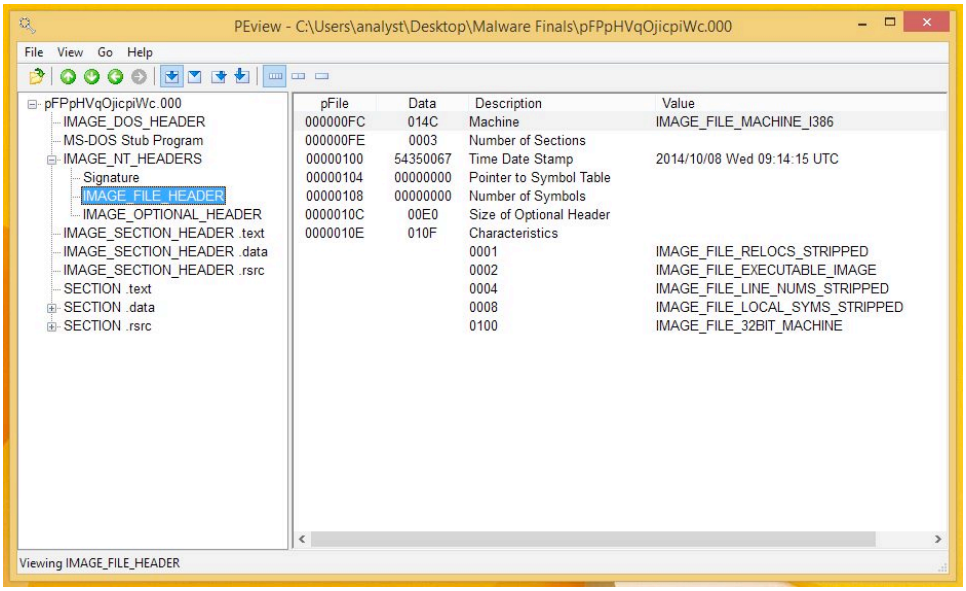
PEiD:

We next try to do another basic analysis on the malware using the PEiD tool to see if the file is packed or unpacked and to see the compiler used to compile the malware. And figure 7 below shows us that the file is unpacked and compiled using Microsoft Visual C++ 6.0.



PEview:

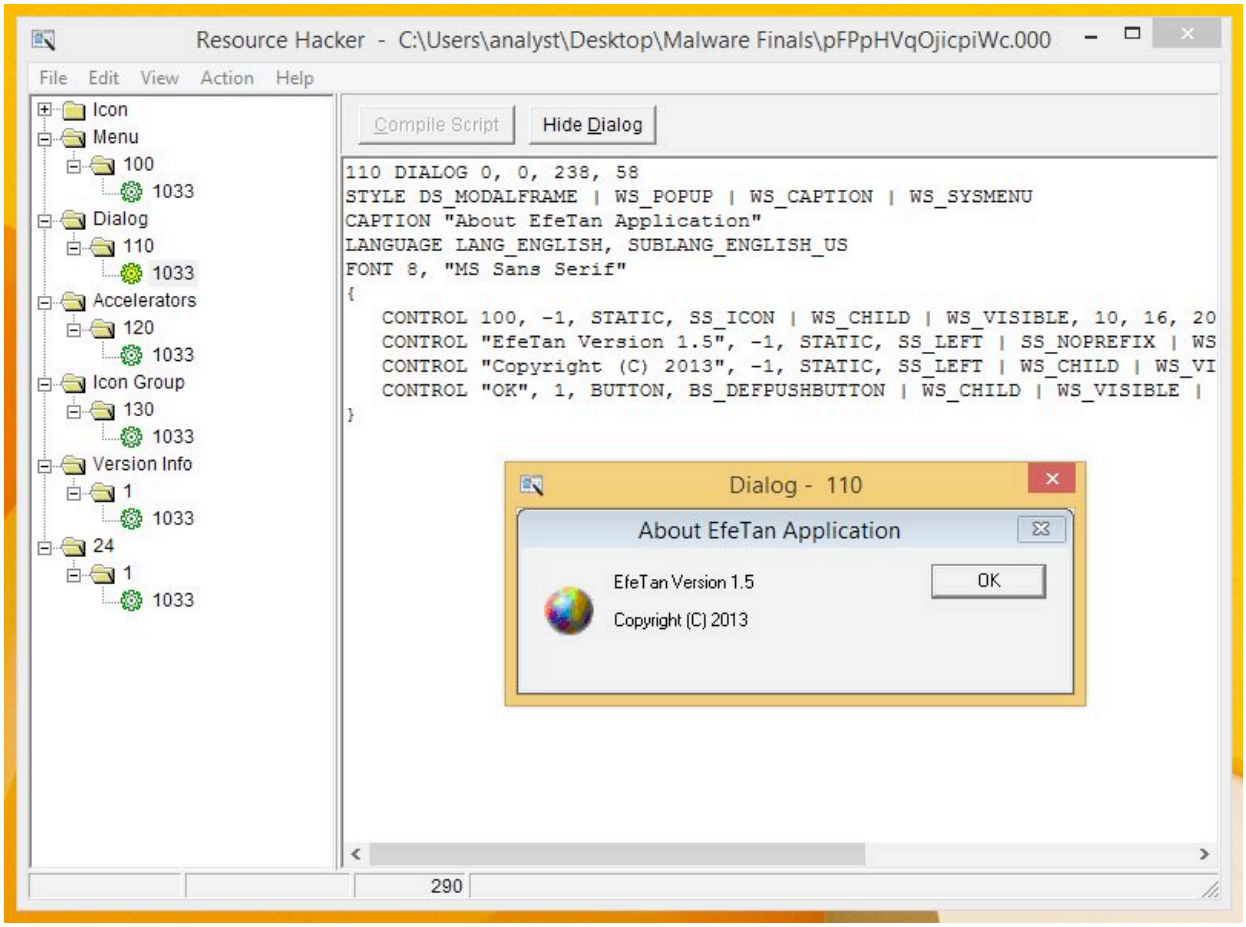
Using PEview, we open the file and navigate to the **IMAGE_FILE_HEADER** Under this section we see elements like Machine, Number of Sections, Time Date Stamp which is **2014/10/08 Wed 09:14:15 UTC** as shown in Figure 8 below. We can use PEview to further explore and analyze the file and have a look at its imports and exports. However we are going to explore that using another Tool.



From PEview we can see **IMAGE_SECTION_HEADER.text, IMAGE_SECTION_HEADER.data** and **IMAGE_SECTION_HEADER.rsrc.** The **.text** sections contains instructions that the cpu executes. All other sections store data and supporting information. The **.data** section contains the program global data, which can be accessible from anywhere in the program. The **.rsrc** section includes the resources used by the executables that are not considered part of the executable such as icons, images, menus and strings.

Resource Hacker:

We will use the tool resource hacker to further analyze the malware. As shown in figure 9 below, resource hacker has several panels such as: **Icon, Menu, Dialog, Accelerators, Icon Group, Version Info and 24.** For this file, the panel we are interested in viewing is the **Dialog** panel because it contains the programs dialog menus and what it is designed to do. However for this malware we really couldn't tell what it is designed to do. It appears that further analysis will be required to full investigate and understand what the malware is intended for. It only shows a dialog box, containing the creator information, version and copyright as shown below:

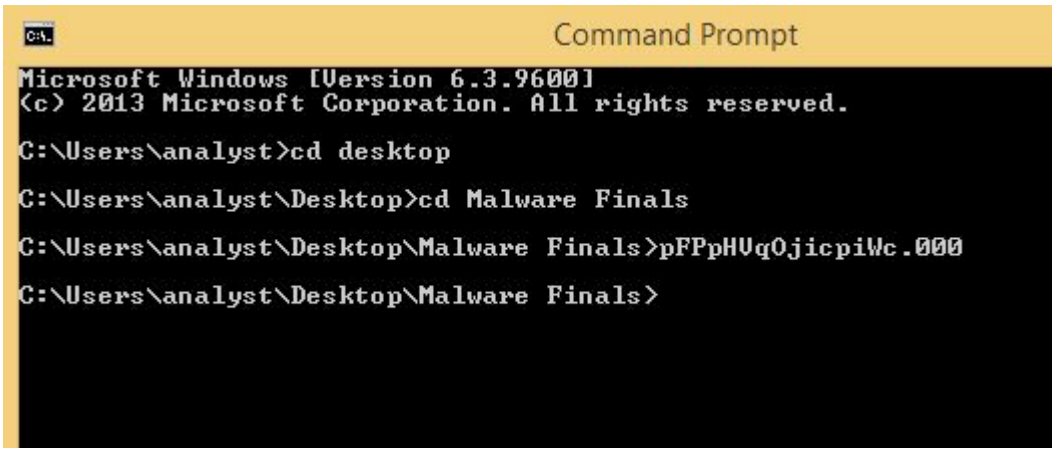


Basic Dynamic Analysis

Basic dynamic analysis is running the malware and observing its behavior on the system in order to remove the infection, produces effective signatures or both.

Analysis:

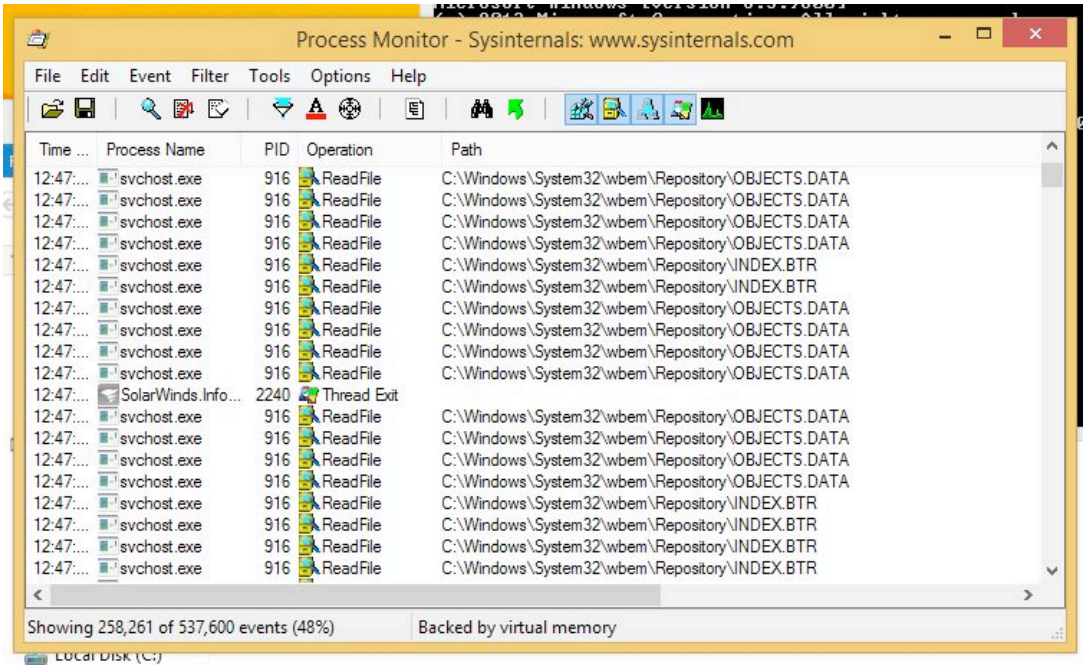
The first step is running the malware; using the command prompt we run the malware as shown in Figure 10 below:



Issue: Running the malware deletes the original final, however it seems like the process is running, we will use process monitor to explore that.

Process Monitor (Procmon):

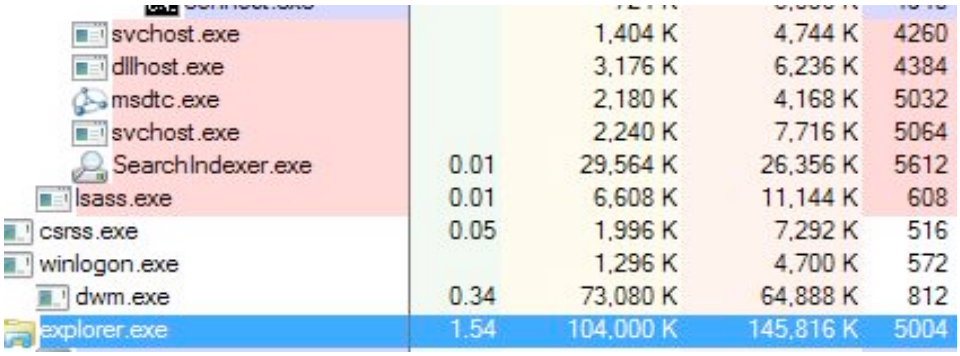
We run process monitor to see if the malware is running and what it is doing. We decided to filter the processes using the Procmon filter as shown in Figure 11 below, but we couldn't find anything related to showing the malware running. Therefore we can assume that the malware self terminates and deletes itself ones it runs. It could be possible that it happens so that it doesn't leave any trails for what is does. However further analysis will reveal what the malware is intended and will provide more information as to why it deletes itself automatically.



In other to continue with the analysis we decided to use Process Explorer to see where the program is, or what is out of order.

Process Explorer:

Running the malware again and viewing the process explorer, we see the process **explorer.exe** which located in C:\Windows\System32. Another process dllhost.exe which is located under svchost.exe appears too as shown in figure 12 below. These processes happened to be part of the malware because they only appear when we start running the malware.



To further analyze this malware we do an Advance Static Analysis

Advanced Static Analysis

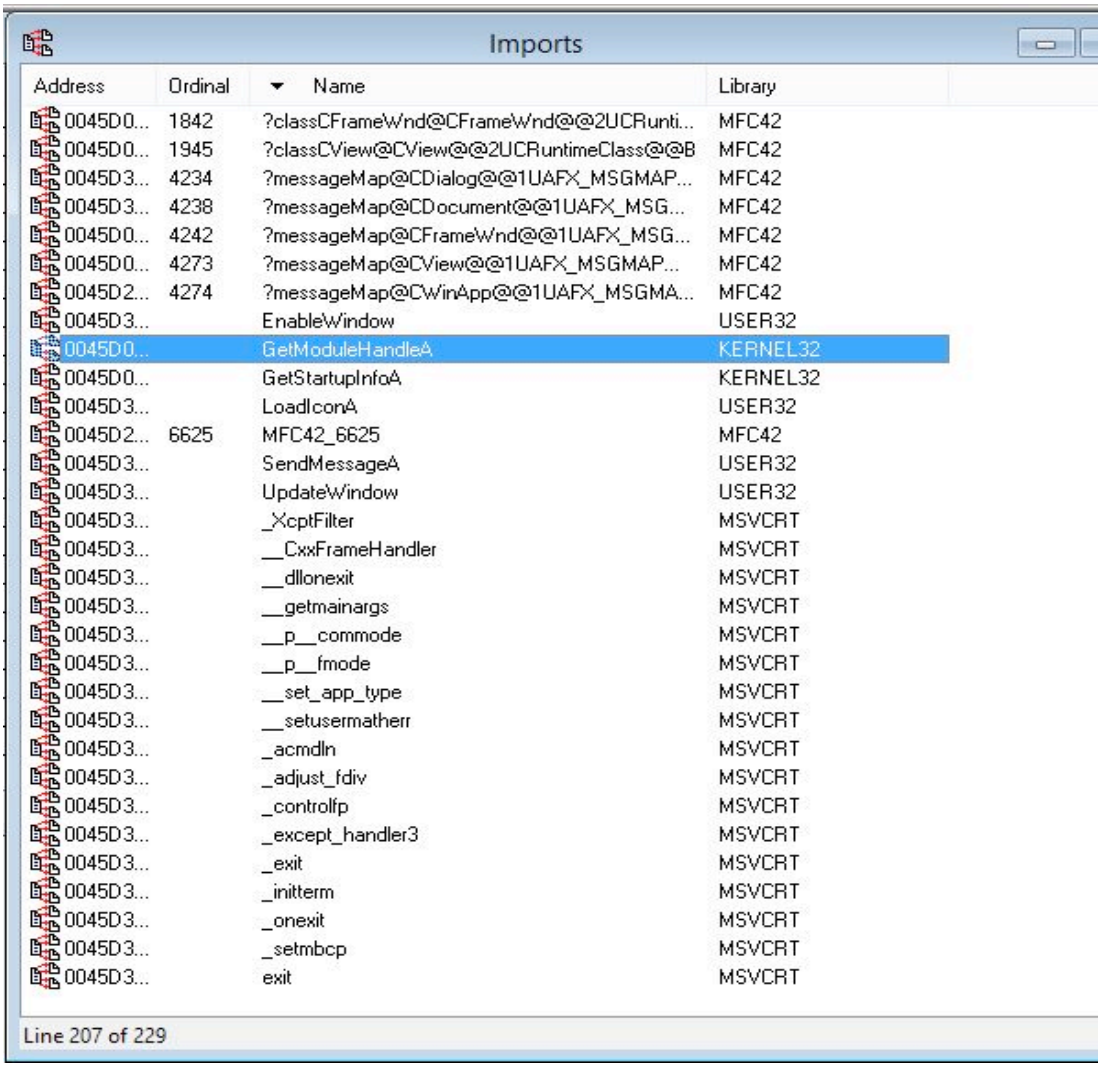
Advanced static analysis consists of reverse engineering the malware's internals by loading executable into a disassembler and looking at the program instruction in order to discover what the program does.

Analysis:

To start the advance static analysis, we upload the file into a special disassembler tool known as IDAPro.

IDAPro:

We successfully load the malware into IDAPro for analysis, and the first thing we will like to do is view the import and export because that will tell us about what the malware is designed for. As shown in fig 13 below. The imports appear to have a lot of gibberish imports. However few imports will be really helpful in telling us about the malware. These imports are: *GetModuleHandleA, GetStartupInfoA, exit, and SendMessageA.* We will go over all these imports soon enough to make understanding of each.



Understanding the imports:

- GetModuleHandleA - From the string figure above we can see that this import is a KERNEL32 library. This import retrieves a module handle for a specified module. The module is usually loaded by a calling process. This tells us that somewhere there is a call to this function which we shall analyze soon. Next to the import, we can see the import address located at **0045D000.** We then go to the **IDA View-A** tab on IDAPro and click **G** on the keyboard, this will enable us to search for the address we are looking for. We can see that GetModuleHandleA is a call by the imports from **KERNEL32.dll** library as shown in figure 14 and 15 below:

```
.idata:0045D000 ; Imports from KERNEL32.dll
.idata:0045D000 ;
.idata:0045D000 ; ---------------------------------------------
.idata:0045D000
.idata:0045D000 ; Segment type: Externs
.idata:0045D000 ; _idata
.idata:0045D000 ; HMODULE __stdcall GetModuleHandleA(LPCSTR l
.idata:0045D000                 extrn GetModuleHandleA:dword
.idata:0045D004 ; void __stdcall GetStartupInfoA(LPSTARTUPINF
.idata:0045D004                 extrn GetStartupInfoA:dword ;
.idata:0045D004                                         ; sub
.idata:0045D008
```

```
loc_41DF72:                     ; nShowCmd
push    eax
push    esi                     ; lpCmdLine
push    ebx                     ; hPrevInstance
push    ebx                     ; lpModuleName
call    GetModuleHandleA
push    eax                     ; hInstance
call    _WinMain@16             ; WinMain(x,x,x,x)
mov     [ebp+var_68], eax
push    eax                     ; int
call    exit
start endp
```

We see the malware calling the GetModuleHandleA which definitely returns a module handle for the current process. We then see another import *SendMessageA* with address 0045D394. This malware is extracting resources and sending a message, but sending a message to where? We will know that we start viewing at the exports.

- GetStartupInfoA: This is also an import that is part of the KERNEL32.dll library. This import retrieves a structure containing details about how the current process was configured to run, such as where the standard handles are directed. So we can understand that this malware also collects the information about the processes that is running on the targeted computer and then sends it using the SendMessageA import. As shown in Figure 15 below, we can see a call to the import, which tells us it collect the Startup process information.

```
loc_41DF4B:
mov     [ebp+StartupInfo.dwFlags], ebx
lea     eax, [ebp+StartupInfo]
push    eax                     ; lpStartupInfo
call    GetStartupInfoA
test    byte ptr [ebp+StartupInfo.dwFlags], 1
jz      short loc_41DF6F
```

- Exit – As the name implies, this is a self-destructive command that allows the malware to exit, and blind fold the target as if it never existed. That is the reason why the malware automatically deletes itself allowing no trace after it runs.

Understanding the Exports:

From figure 17 below, we see that the export has only one single file "**start**" with address **0041DE4E.** Double-clicking the address, we can see that the malware have memory operands like **eax, ebx, ecx, esi, ebp and esp** which refers to memory address that contains the value of interest as shown in figure 18 below. These are typically registers and can be either 32 or 16bits in assembly code.


```
StartupInfo= _STARTUPINFOA ptr -5Ch
var_18= dword ptr -18h
var_4= dword ptr -4

push    ebp
mov     ebp, esp
push    0FFFFFFFFh
push    offset unk_466098
push    offset loc_401096
mov     eax, large fs:0
push    eax
mov     large fs:0, esp
sub     esp, 68h
push    ebx
push    esi
push    edi
mov     [ebp+var_18], esp
xor     ebx, ebx
mov     [ebp+var_4], ebx
push    2
call    __set_app_type
pop     ecx
or      dword_466CAC, 0FFFFFFFFh
or      dword_466CB0, 0FFFFFFFFh
call    __p__fmode
mov     ecx, dword_466C98
mov     [eax], ecx
call    __p__commode
mov     ecx, dword_466C94
```

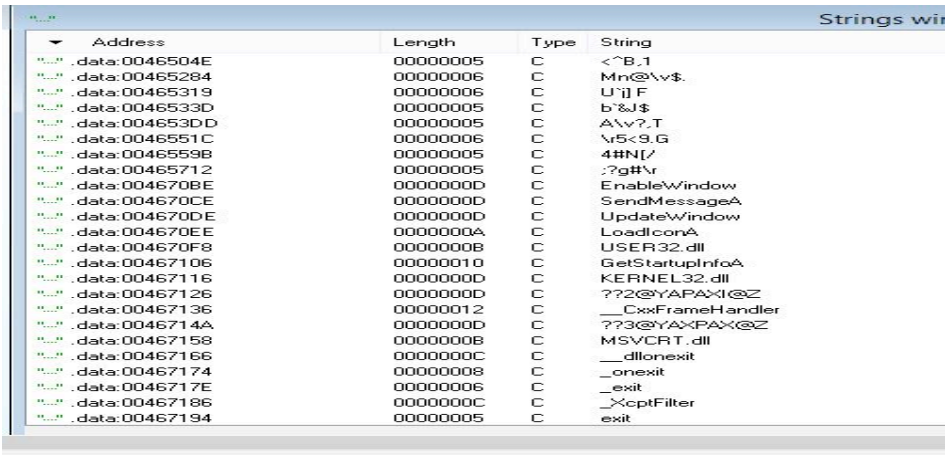
From figure 18 above, we see **move eax** – this mov instruction copies a value into the eax register and stores it, therefore **move [eax], ecx** copies the memory location specified by the ECX register into the EAX register.

Another **mov** instruction we see is the **mov [ebp+var 18], esp** which copies the 18 bytes var characters located at the memory location specified by **ebp** into the **esp** register and then **mov [ebp+var 4], ebx** copies the 4 bytes characters located at the memory location specified by **ebp** into the **ebx** register.

Basically what these command and instructions tells us is that the malware copies content located at on the targeted computer registers and then stores in it other registers it has access to. Pretty much the malware manipulates data by copying it to other locations.

Understanding the strings:

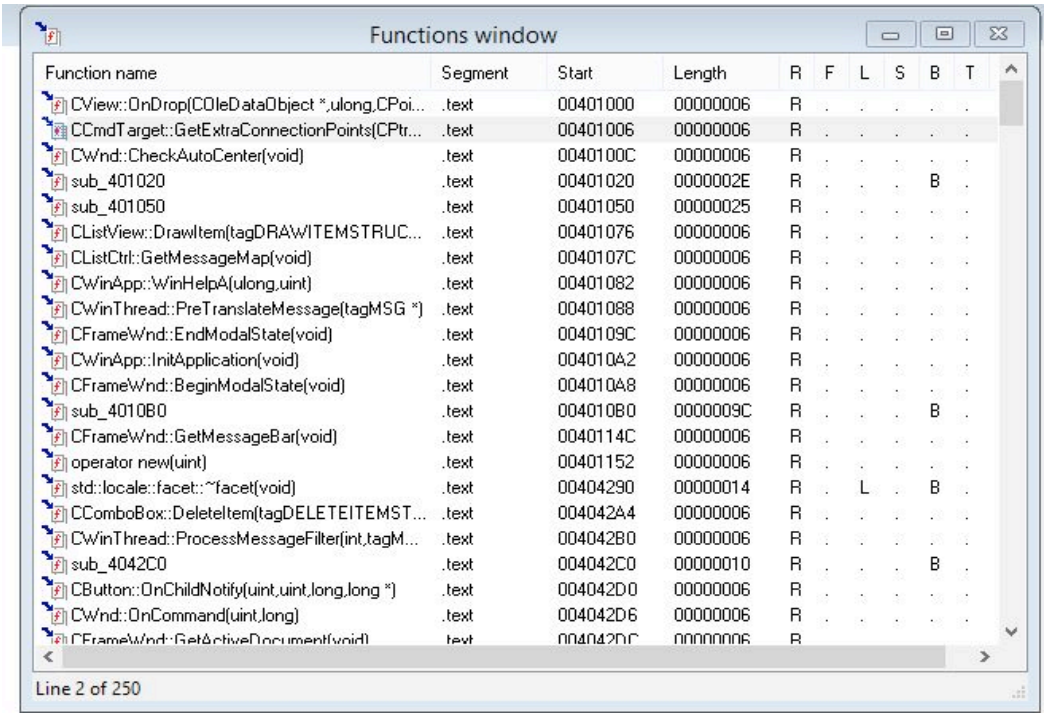
The strings figure shown in 19 below has the same content as the imports which we already explained above. However we see a special string **MSVCRT.dll**. This is module library containing standard C library functions. This tells us that the malware uses this string for manipulation, memory allocation, C-style input/output calls etc.



Understanding the functions:

Functions are portions of code within a program that perform a specific task and that are relatively independent of the remaining code. The main code calls and temporarily

transfers execution to functions before returning to the main code. As seen in figure 20 below, the function just shows the use, function and what the malware does. Functions like getmessage, translate message etc.



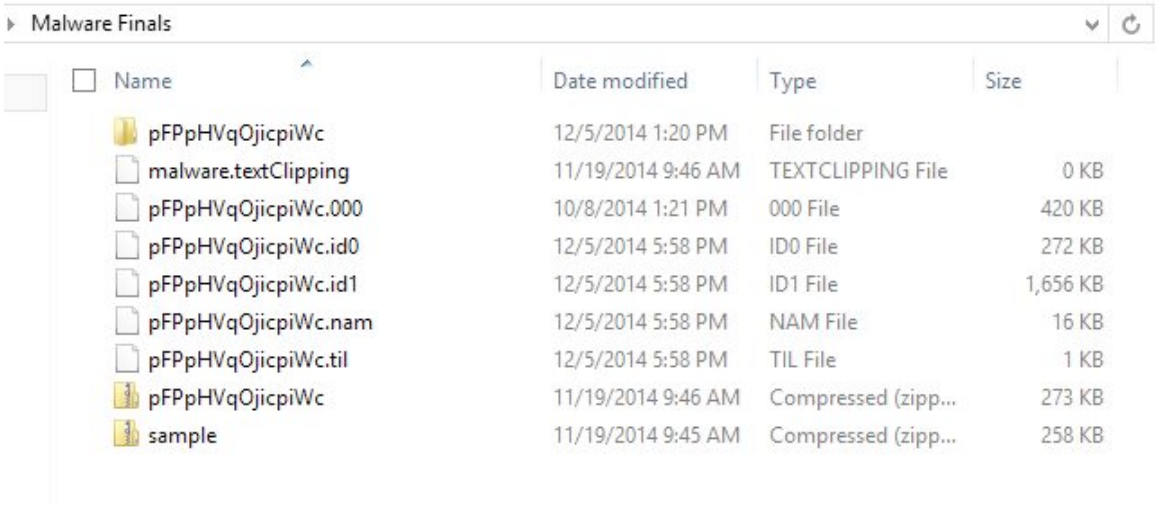
We now have an idea of what the malware is designed to do, and we are going to analyze the malware again to examine its internal state. In order to do this we have to run the malware again to complete the analysis while it is running.

Advance Dynamic Analysis

Advanced dynamic analysis uses a debugger to examine the internal state of a running malicious executable. Advanced dynamic analysis techniques provide another way to extract detailed information from an executable.

In other to start the advance dynamic analysis, we first run the program again using the command prompt like we did in the basic dynamic analysis. This time around, the

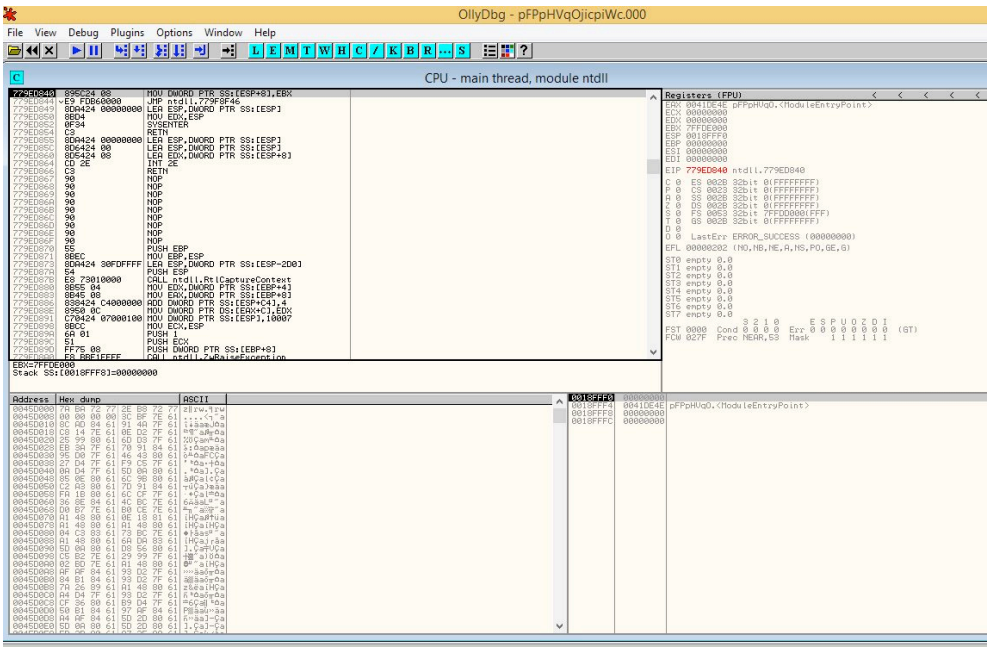
programmed runs successfully, however it replicates itself into other files: as shown in Figure 21 below:



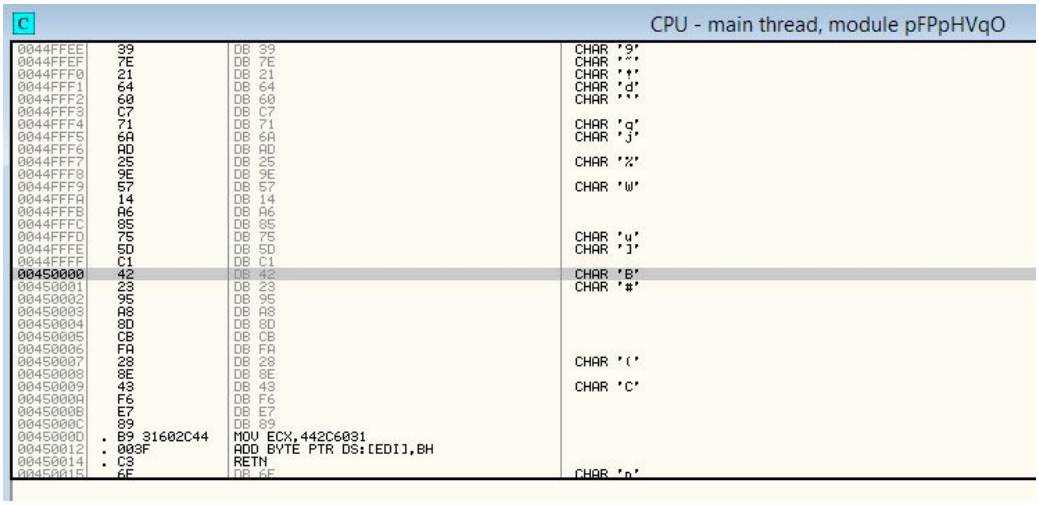
Now we use a special tool designed to analyze malware while it is running. An x86 debugger known as OllyDbg.

OllyDbg

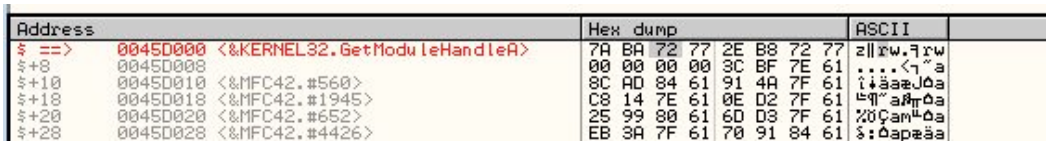
After running the malware, we load the file into OllyDbg as shown in Fig 22 below:



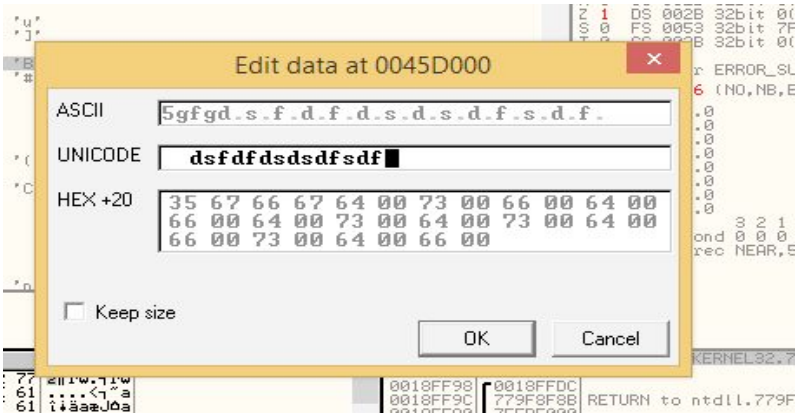
From the OllyDbg Disassembler's window above, we see the debugged malwares code, the registers window, the stack window, and the dump window. For this analysis, we shall go over each window and see what the content of the window means. From figure 15 above during advance basic analysis, we can see that the main call was a call made to GetModuleHandleA which has address 0045D000. Therefore we use the F8 key in OllyDbg to step-over until we arrive at the main address 0045D000. As shown in figure 23 below: The only thing we could find on the 00450000 address is the 'CHAR "B"' which doesn't make sense.



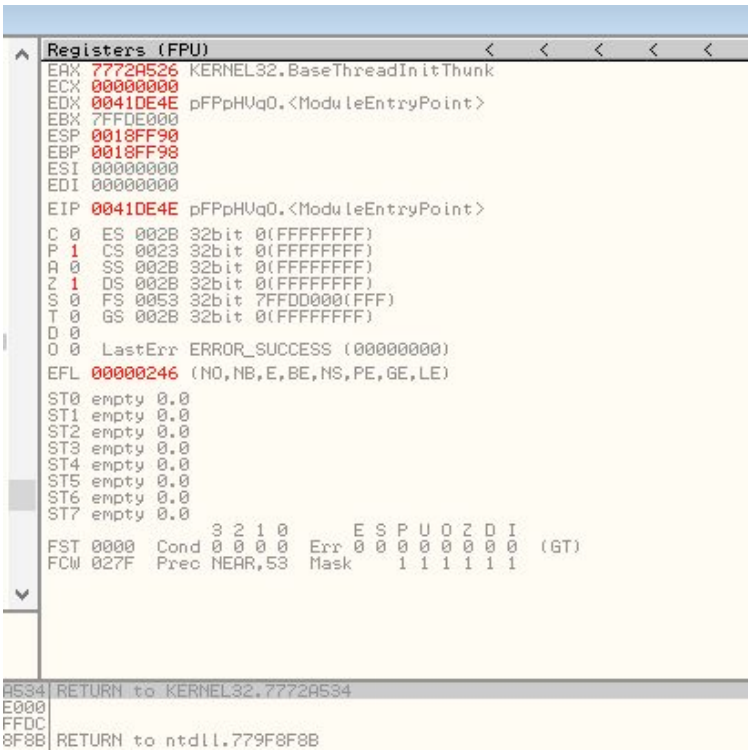
Now the register window shown below shows us the call to the main function.



We then right-click the hex dump codes to see the binary, and it shows 8 continues strings, which contains some gibberish values in the ASCII, this could be another way to make the malware untraceable.



Also in OllyDbg we see the stacks of registers we saw in IDAPro as shown below:



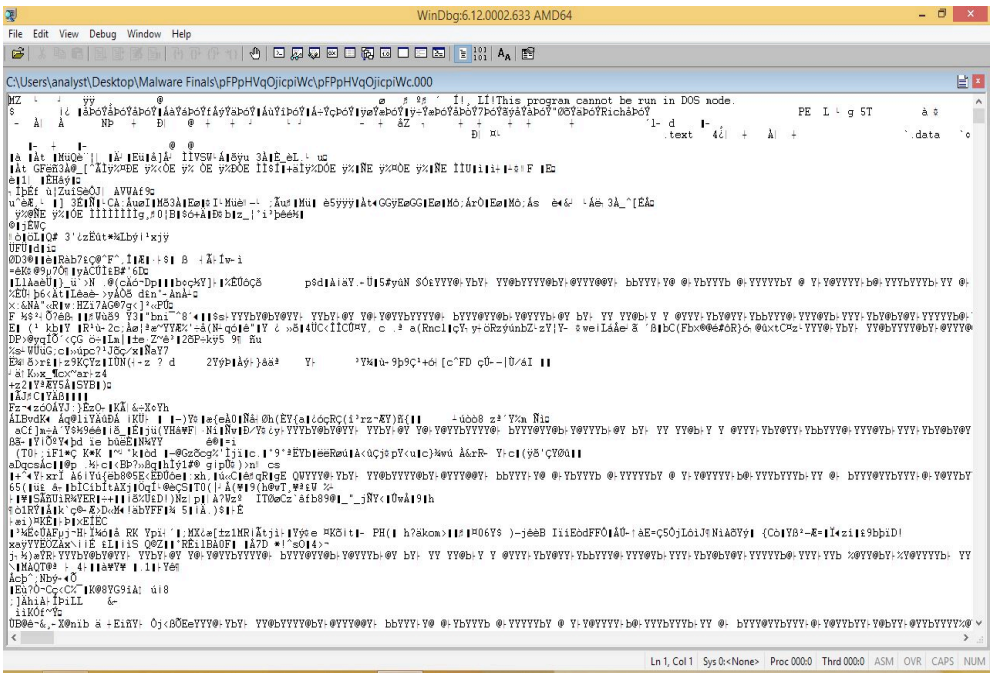
These are the same registers we analyzed using IDAPro. At the beginning of the advance dynamic analysis we see how the malware replicates itself into different files after we run it. Figure 27 below shows us the address of those replicate files.

```
0018F3E0  0033006D
0018F3E4  005C0032
0018F3E8  0046004D  pFPpHVqO.0046004D
0018F3EC  00340043
0018F3F0  004C0032
0018F3F4  0043004F  pFPpHVqO.0043004F
0018F3F8  0044002E  pFPpHVqO.0044002E
0018F3FC  004C004C
0018F400  0044002E  pFPpHVqO.0044002E
0018F404  004C004C
0018F408  00000000
0018F40C  00000000
0018F410  0018F4B8
0018F414  77A0AC19  ntdll.77A0AC19
0018F418  00000000
0018F41C  0018F438
0018F420  00420040  pFPpHVqO.00420040
0018F424  006446F0
0018F428  0018F640
```

Next we are going to use another debugger known as Windbg to analyze the malware and see if we can reach the same result and conclusion like we did with OllyDbg.

Windbg:

We try to upload the malware into Windbg for further analysis, however we keeps receiving errors, and after further research an analysis, it's because this malware it is because this malware is not an executable. The file format for this malware is in **.000** whereas Windbg is designed for executables (.exe) and source files such as C, C++, C# and Assembly source files. Figure 28 and 29 below shows the error pages we encountered.



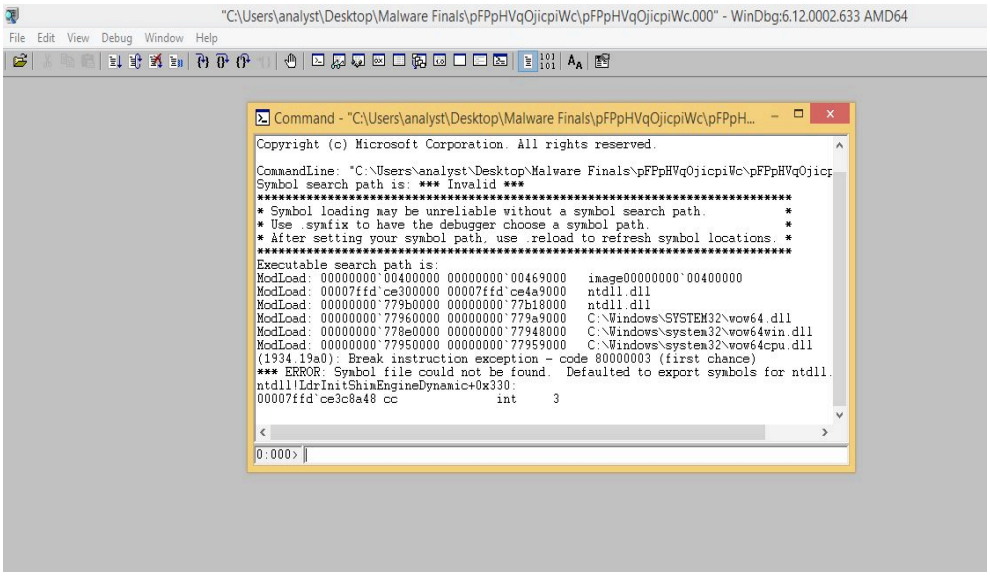
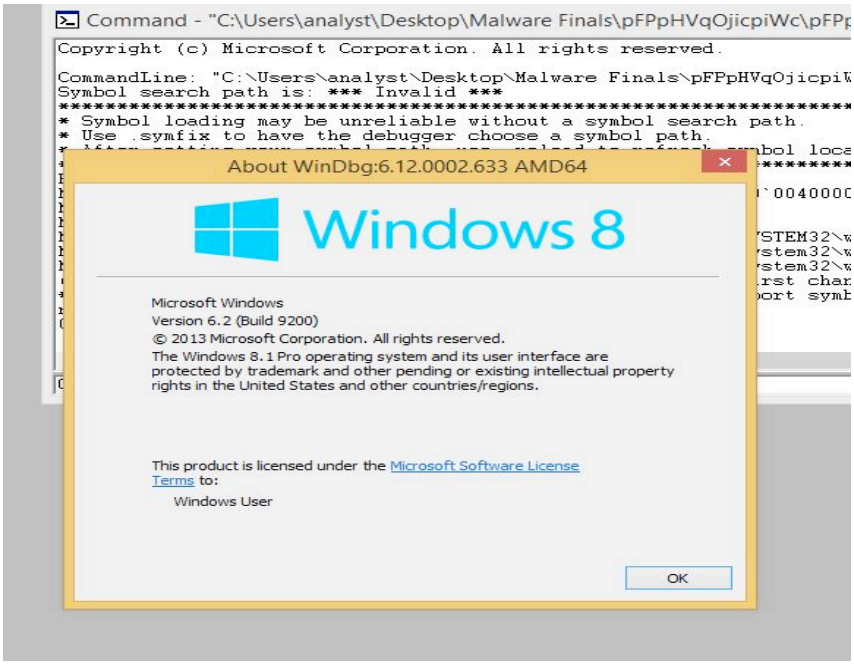
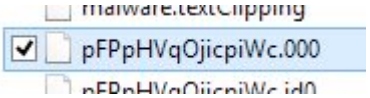


Figure 30 below shows the Windbg software license and figure 31 shows the malware file format (.000) and .000 is not a recognized windows format, which makes Windbg unsupportive in terms of this malware analysis.





Malware Behavior
(Understanding the malware)

So far we have been analyzing the malware to understand its characteristics and categorize it as a malware and what type of malware it is. We have 2 types of malwares. The downloaders, which downloads other malwares and the launchers, which are executables that installs itself for covert executions.

Throughout our analysis, we haven't encountered any download characteristics or capability associated with this malware, however we see the way it can manipulates the system processes and copy it between registers. Therefore we categorize this malware as a **launcher.**

This malware monitors the processes running on the target computer and then copies it and store in the register it can access for retrieval. The processes running could be victim's credentials or other resourceful information depending on what is running.

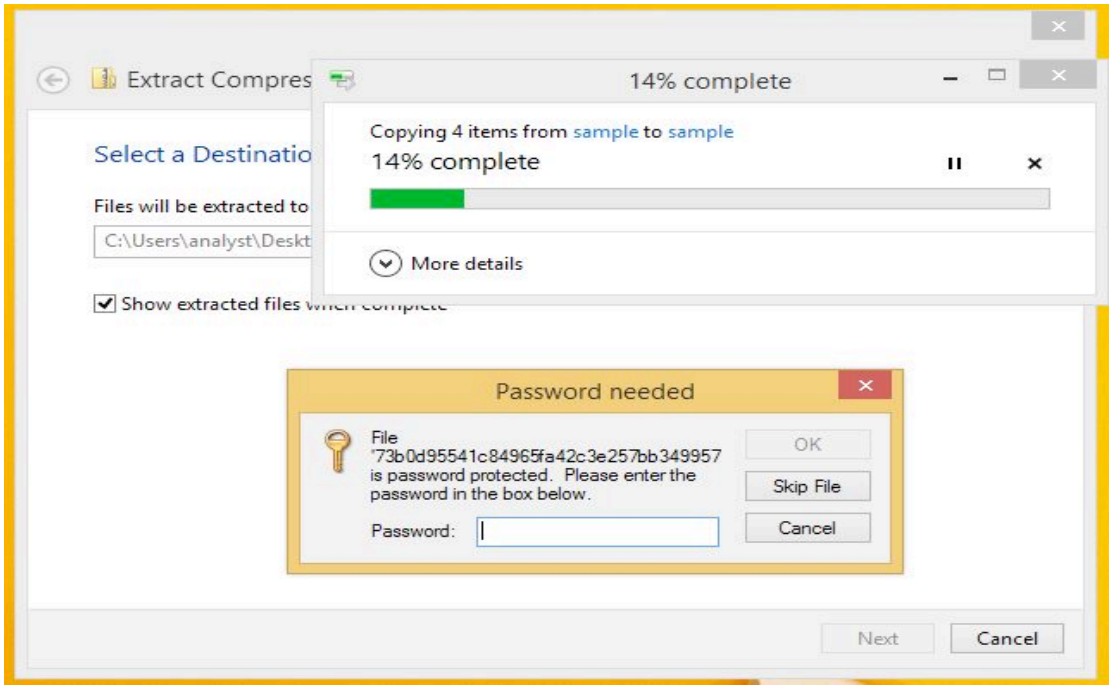
Part II

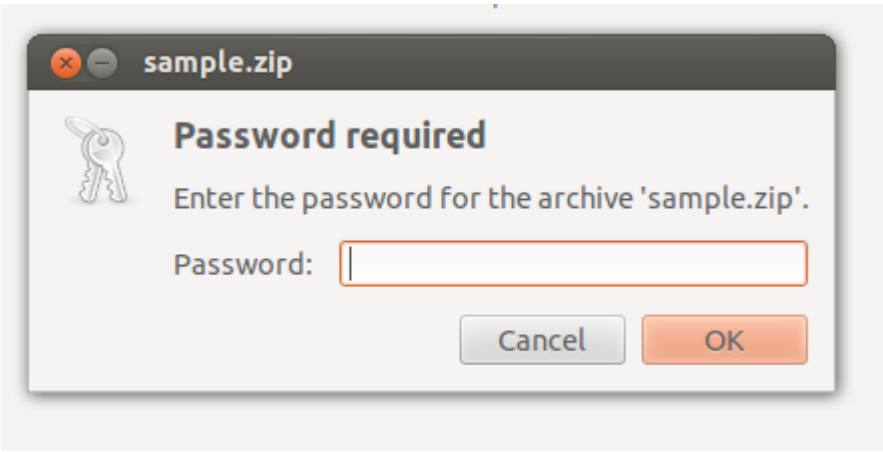
Malware 2 Analysis

File: **sample.zip**

Extracting the file

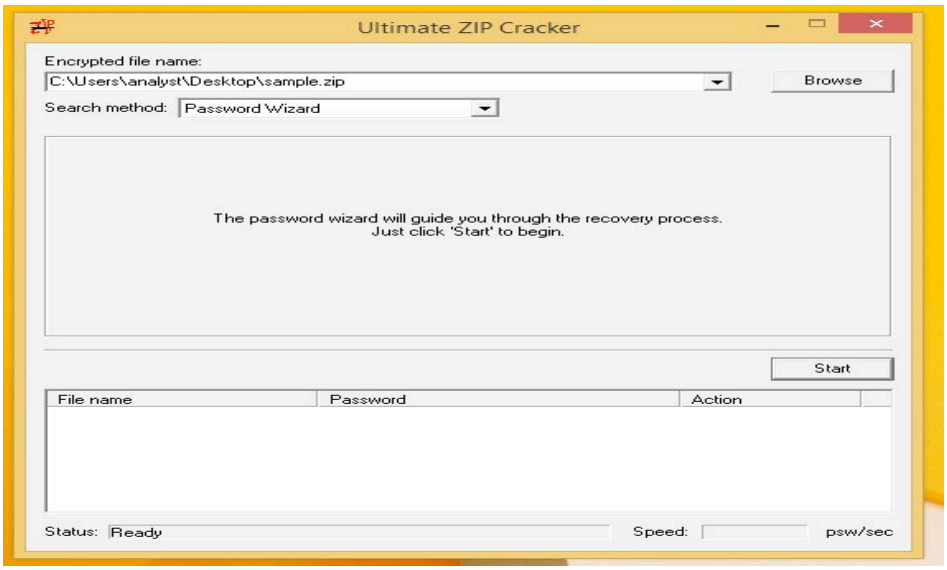
The file is located in a zip folder, and has is supposedly not pass worded (as per the exams instructions). However it keeps asking for a password before it could be extracted. Trying it both in Windows & Linux proves that the file requires a password before extraction as shown in Figure 32 and 33 respectively below:





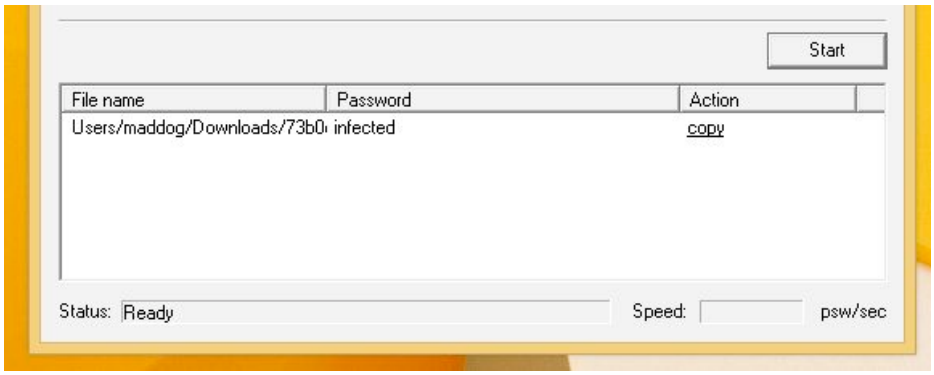
Now since we were not given any password for the zip file, we have to brute force it to see if we could crack the password. For easier use we decide to use a special program in

windows known as **UZC. UZC** also known as the Ultimate Zip Cracker is a software designed to crack password zip, word and excel files. The interface of the Zip Cracker is shown in figure 34 below.

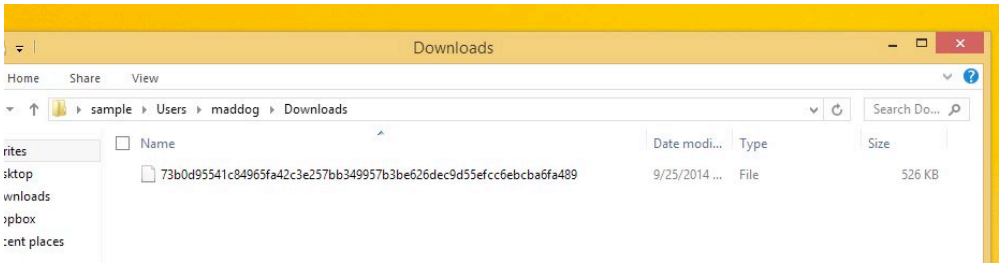


The way we used it is we located the zip files directory as shown above, then select **Password Wizard** as the search method and then click **Start**. We then follow the **Password Recovery Wizard** shown in figure 35 below:

As shown as the wizard is done, it shows you the password of the zip file, and below in figure 36, we can see that the password for this zip file has been identified as **"infected"**.



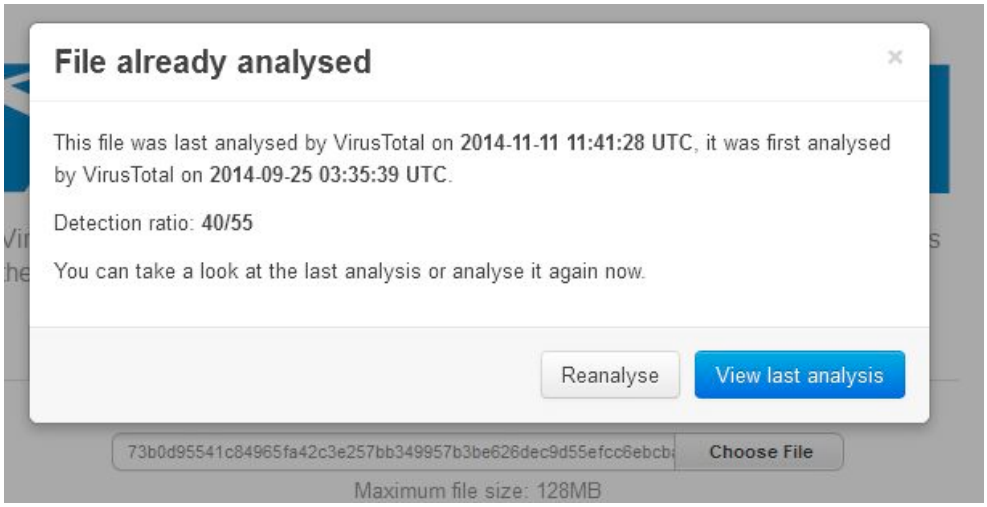
Now that we have the password we can use it to extract the zip file. Extracting the zip file, we see different directories before locating malware. These directory are **sample\users\maddog\downloads.** And the malware file name is a long alphanumeric characters that will be too long to write here. The malware file type is identified as **"File"** and the size is **526KB.** Hopefully after the analysis we will be able to know and understand more about the malware. Figure 37 below shows the extracted file.



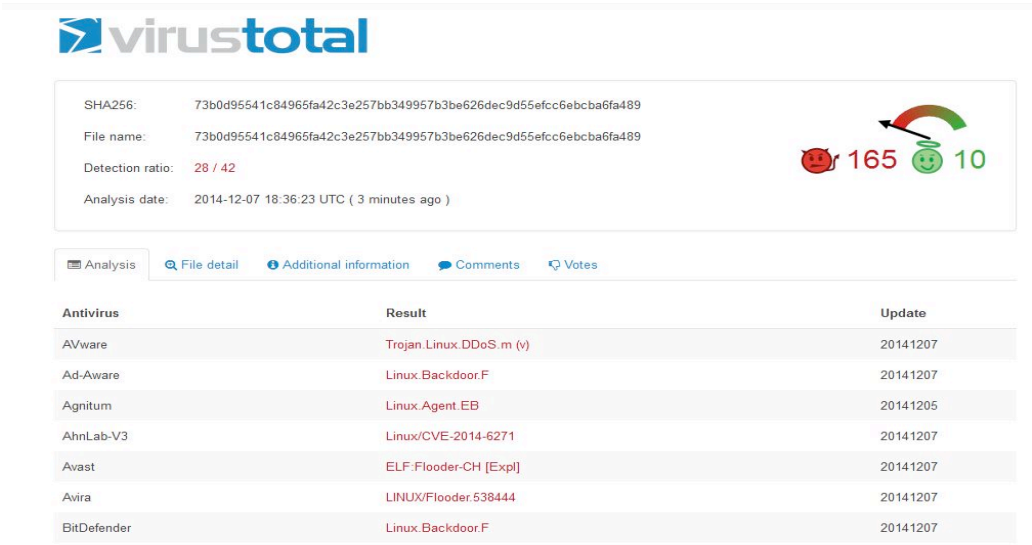
Basic Static Analysis

Analysis:

As usual we start the basic analysis with uploading the malware to see if it matches any existing virus signatures. As shown below, the file has been previously analyzed.

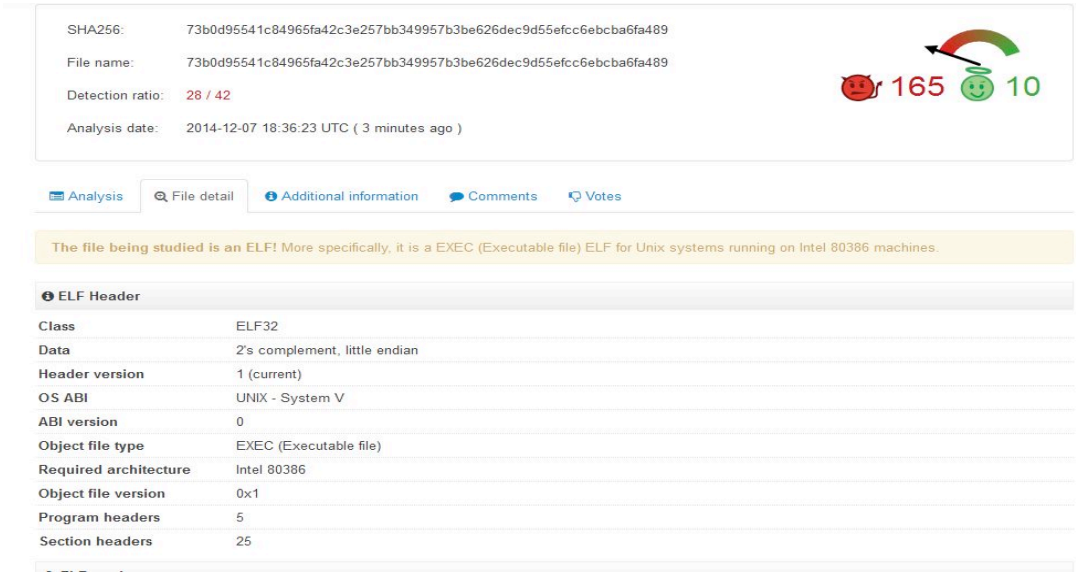


We then reanalyze the file again. We can see in figure 39 below that the malware matches 28 of 42 virus signatures.



From the **File Details** information provided in figure 40 and 41, we can see object file type is EXEC (Executable file), the required architecture for the malware is **Intel 80386,** and the malware class is **ELF32.** From the malware class we can understand that the malware is an **Executable and Linkable Format (ELF)** designed for **32bit** operating systems. However ELF files are the standard binary file formats for Unix and Unix-Like systems. From the architecture **Intel 80386** we see that the malware is only meant for systems with Intel Processors. Therefore before further analysis we can tell that the

malware is designed to target Unix systems (could be Apple OS X or Linux OS) with 32bit operating systems running with Intel Processor.



SHA256:	73b0d95541c84965fa42c3e257bb349957b3be626dec9d55efcc6ebcba6fa489
File name:	73b0d95541c84965fa42c3e257bb349957b3be626dec9d55efcc6ebcba6fa489
Detection ratio:	28 / 42
Analysis date:	2014-12-07 18:36:23 UTC (3 minutes ago)

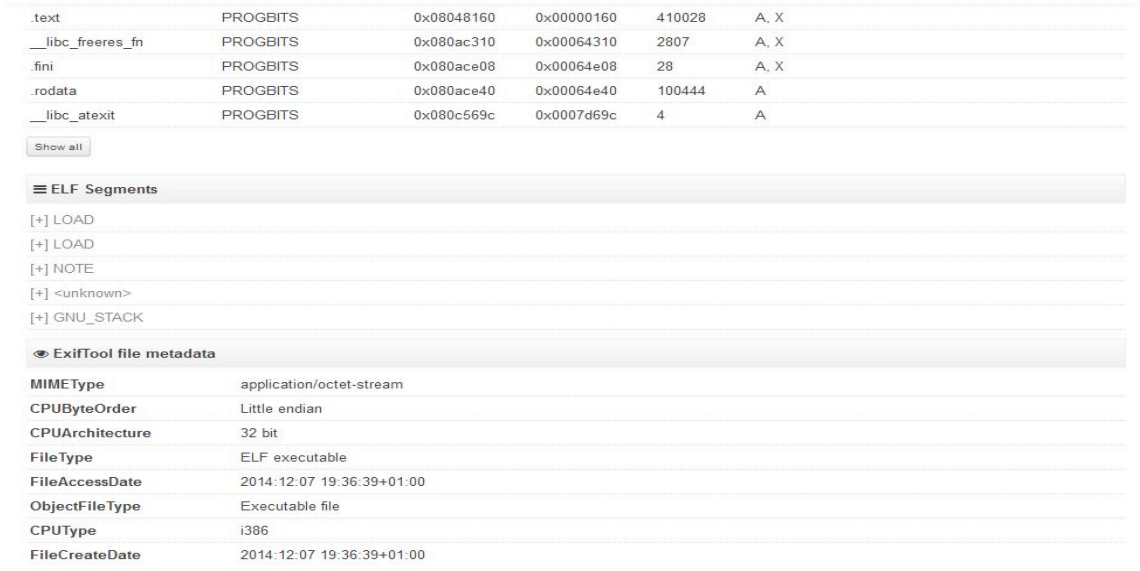
165 10

Analysis | File detail | Additional information | Comments | Votes

The file being studied is an ELF! More specifically, it is a EXEC (Executable file) ELF for Unix systems running on Intel 80386 machines.

ELF Header

Class	ELF32
Data	2's complement, little endian
Header version	1 (current)
OS ABI	UNIX - System V
ABI version	0
Object file type	EXEC (Executable file)
Required architecture	Intel 80386
Object file version	0x1
Program headers	5
Section headers	25



.text	PROGBITS	0x08048160	0x00000160	410028	A, X
__libc_freeres_fn	PROGBITS	0x080ac310	0x00064310	2807	A, X
.fini	PROGBITS	0x080ace08	0x00064e08	28	A, X
.rodata	PROGBITS	0x080ace40	0x00064e40	100444	A
__libc_atexit	PROGBITS	0x080c569c	0x0007d69c	4	A

Show all

ELF Segments

[+] LOAD
[+] LOAD
[+] NOTE
[+] <unknown>
[+] GNU_STACK

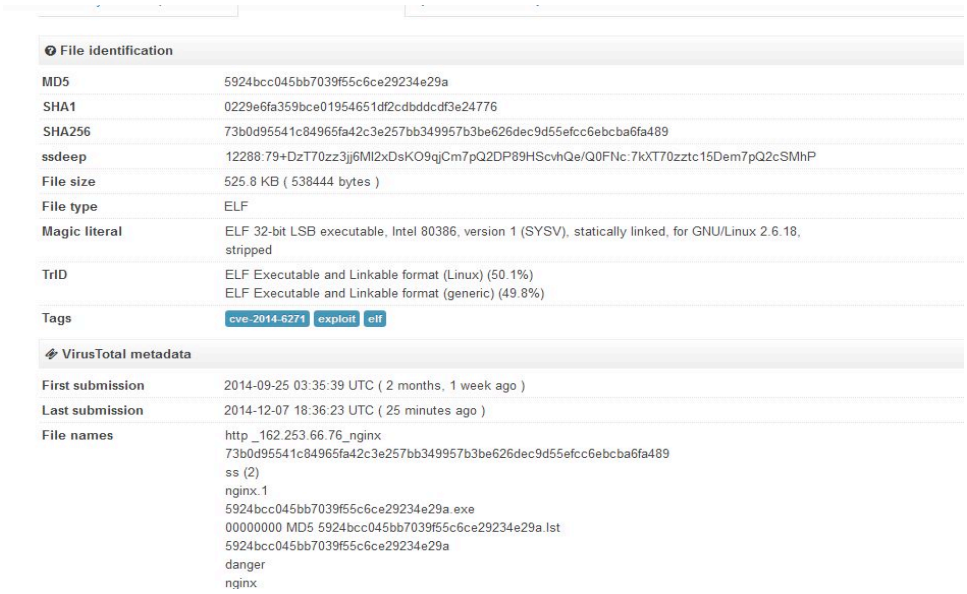
ExifTool file metadata

MIMEType	application/octet-stream
CPUByteOrder	Little endian
CPUArchitecture	32 bit
FileType	ELF executable
FileAccessDate	2014:12:07 19:36:39+01:00
ObjectFileType	Executable file
CPUType	i386
FileCreateDate	2014:12:07 19:36:39+01:00

We also see other information like the **FileCreateDate,** which is the day the file was created. It shows **2014:12:07 19:36:39** which really doesn't make any sense because it is the same with the **FileAccessDate** and that is the same day we are making the analysis.

However we believe that further analysis will reveal more about the malware and why the **FileCreateDate** is being faked.

The **Additional Information** tab shown in figure 42 below didn't really tell us much besides the thing we already knew like file type and size etc. The new details we can see are the cryptographic hash functions **MD5, SHA1, and SHA256.** The knowledge of cryptographic hash functions are outside the scope of this class or the malware analysis and will therefore not to discussed. The comments section is the opinion of other analysts, however both of the analysts identified the file as **ShellShock** exploit.



File identification

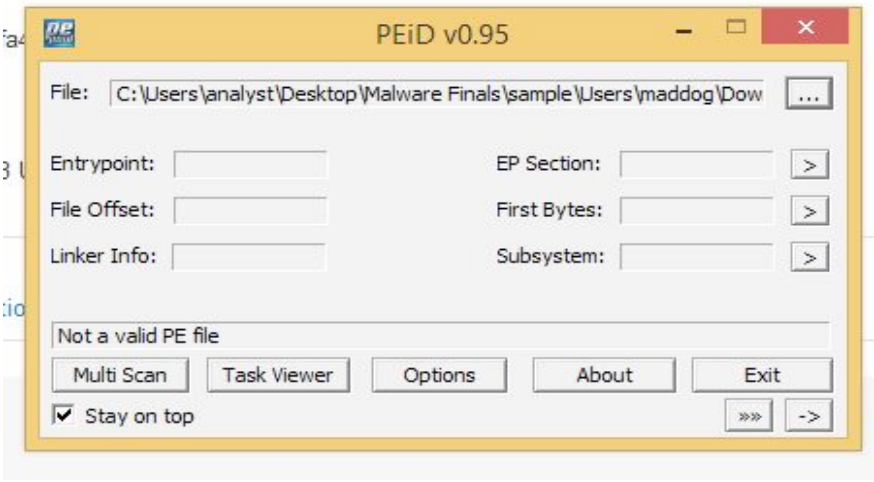
MD5	5924bcc045bb7039f55c6ce29234e29a
SHA1	0229e6fa359bce01954651df2cdbddcdf3e24776
SHA256	73b0d95541c84965fa42c3e257bb349957b3be626dec9d55efcc6ebcba6fa489
ssdeep	12288:79+DzT70zz3jj6Ml2xDsKO9qjCm7pQ2DP89HScvhQe/Q0FNc:7kXT70zztc15Dem7pQ2cSMhP
File size	525.8 KB (538444 bytes)
File type	ELF
Magic literal	ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), statically linked, for GNU/Linux 2.6.18, stripped
TrID	ELF Executable and Linkable format (Linux) (50.1%) ELF Executable and Linkable format (generic) (49.8%)
Tags	cve-2014-6271 exploit elf

VirusTotal metadata

First submission	2014-09-25 03:35:39 UTC (2 months, 1 week ago)
Last submission	2014-12-07 18:36:23 UTC (25 minutes ago)
File names	http _162.253.66.76_nginx 73b0d95541c84965fa42c3e257bb349957b3be626dec9d55efcc6ebcba6fa489 ss (2) nginx.1 5924bcc045bb7039f55c6ce29234e29a.exe 00000000 MD5 5924bcc045bb7039f55c6ce29234e29a.lst 5924bcc045bb7039f55c6ce29234e29a danger nginx

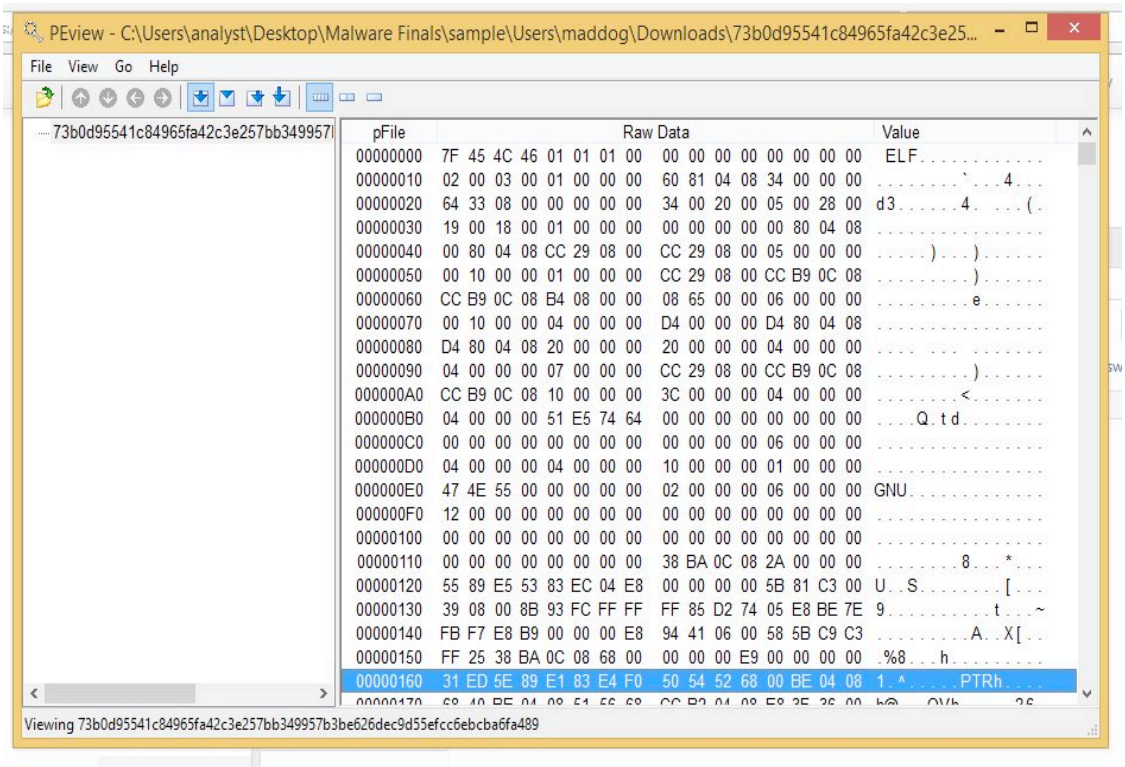
PEiD

To further the basic analysis we upload the file to **PEiD.** As shown in figure 43, we see that the malware is not a valid PE file. This will make our analysis a bit difficult considering we need to know if the file is packed or not, and also how the file is packed.



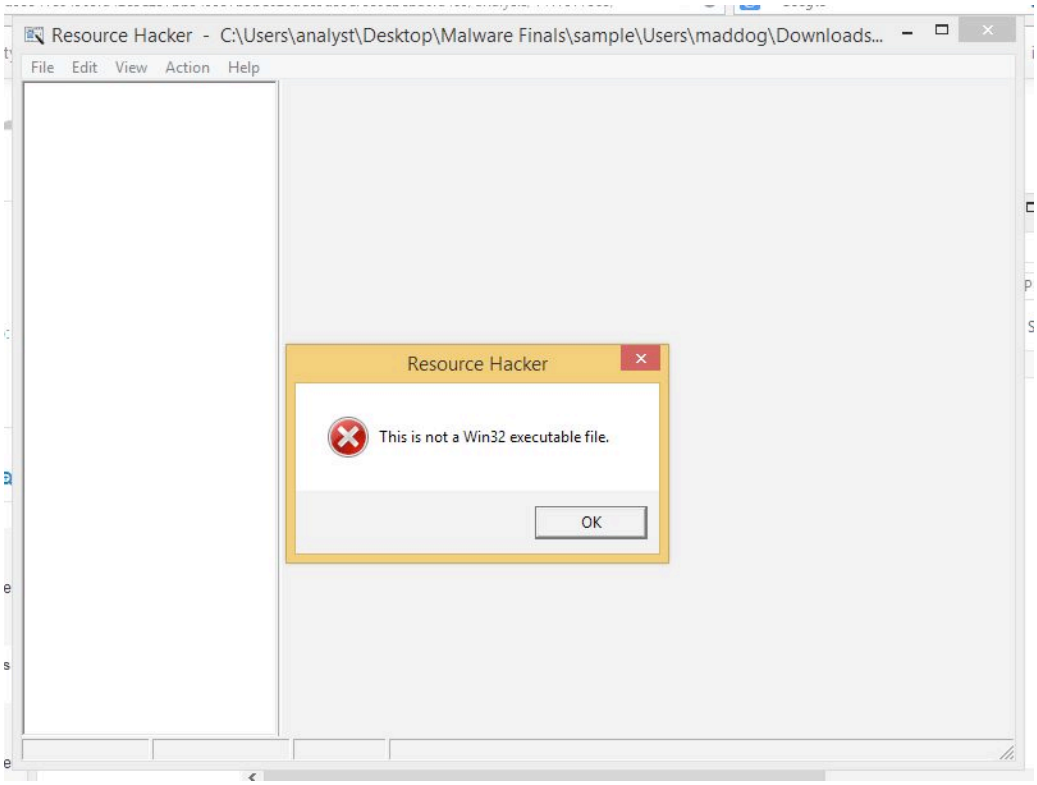
PEview

We use **PEview** with the hope of extracting more information about the malware, information such as the **Header and Imports.** However just like **PEiD,** the analysis using **PEview** doesn't show any results beside the file type **ELF** which we already know. Result of the **PEview** analysis is shown in figure 44 below:



Resource Hacker:

We conclude that extracting any basic static analysis information from this malware will be a hassle on windows considering this malware is designed for Unix OS. We use the tool Resource Hacker to extract some basic information about the malware. However it says that the file is not a Win32 executable file as shown in figure 45 below:



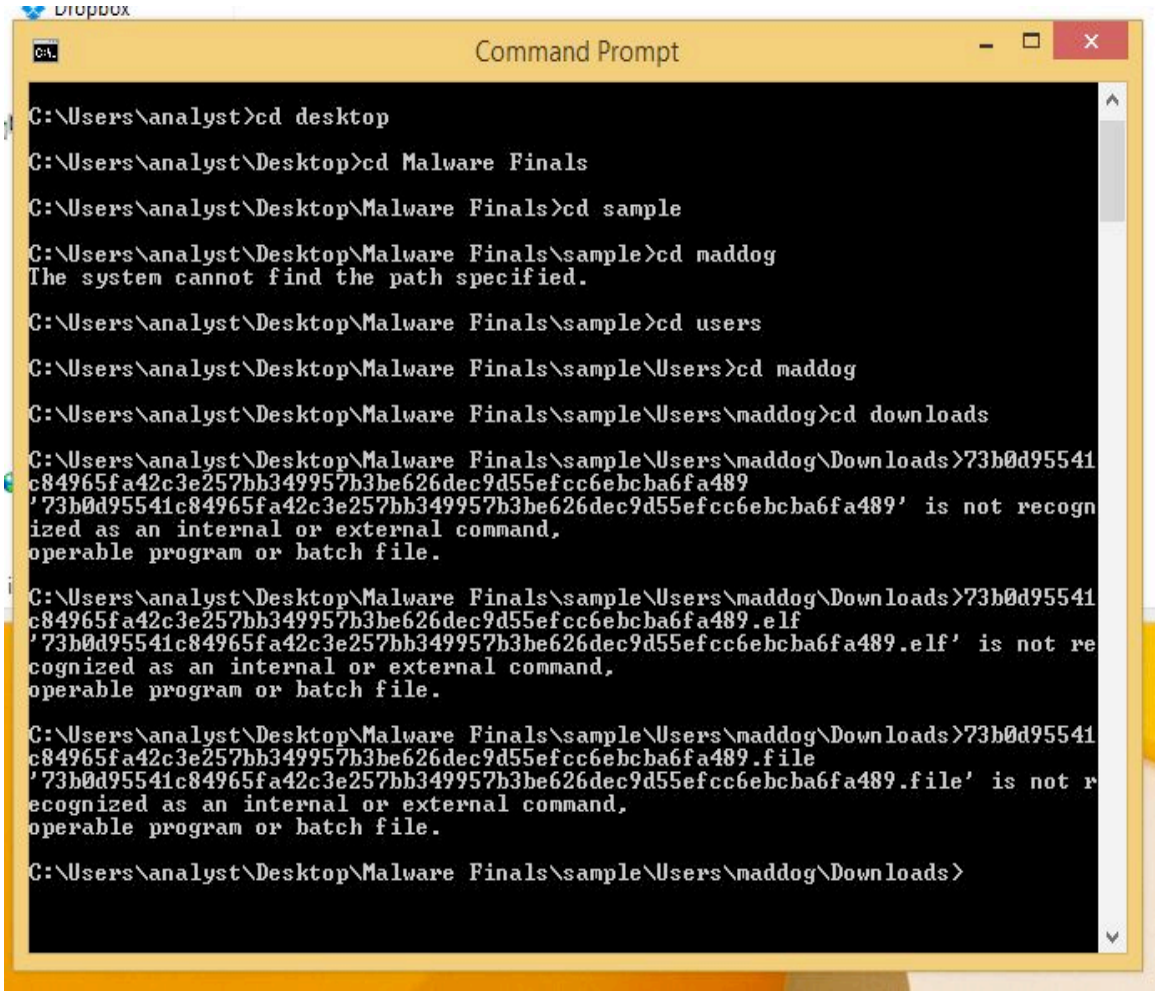
Basic Dynamic Analysis

It is time to run the malware and carryout a basic dynamic analysis in other to monitor its behavior.

Analysis:

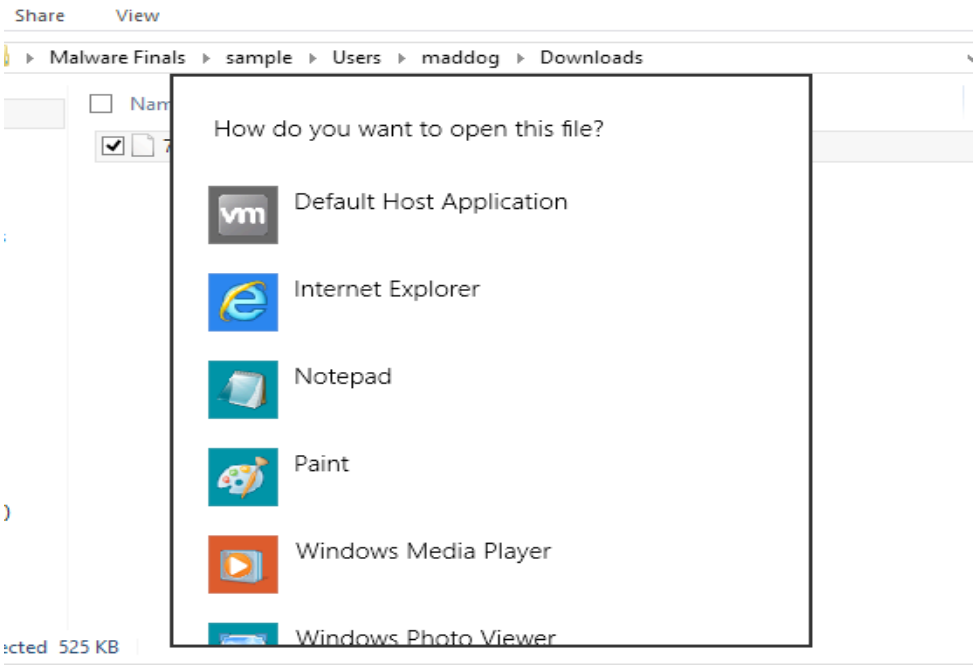
We first run the malware (even though at this stage we know that the malware is designed for Unix systems. We will attempt to run it on Windows OS to see what happens!).

Considering the file is not designed for Windows systems and it does not have a file format. An attempt to run it using the command prompt failed as shown in figure 46 below:



Therefore we are going to attempt running the malware by just double-clicking it to see what happens.

Doing so did not run the malware too; instead it asks how we want to open the file as shown in figure 47 below.



Without running the malware, there is no way we can carry out the basic dynamic analysis considering some of the tools used in basic dynamic analysis such as Process Monitor (Procmon) and Process Explorer will only yield results if the malware is running.

We will try and carry out an advance static analysis with the hope of understanding this malware designed for Unix.

Advanced Static Analysis

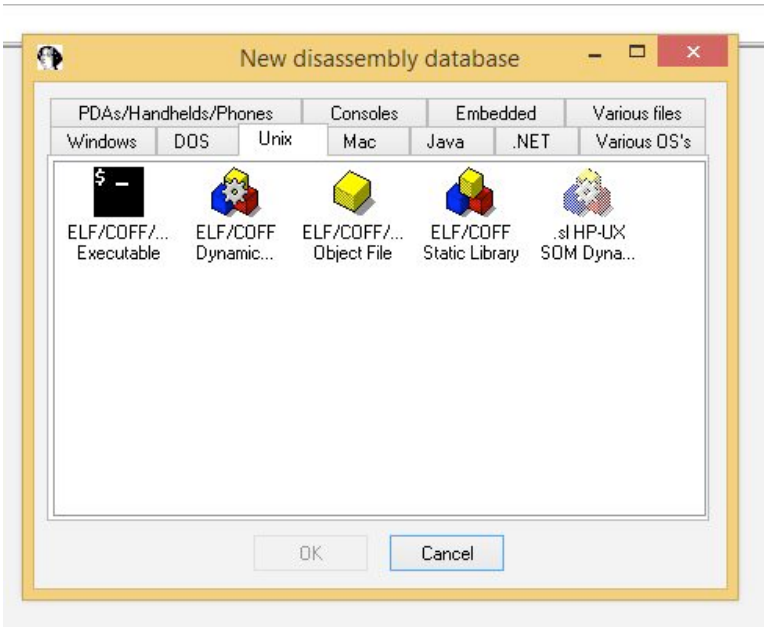
Here we will use an advanced tool IDAPro which is a disassembler designed to look at the programs instruction in order to discover what the program does.

Analysis:

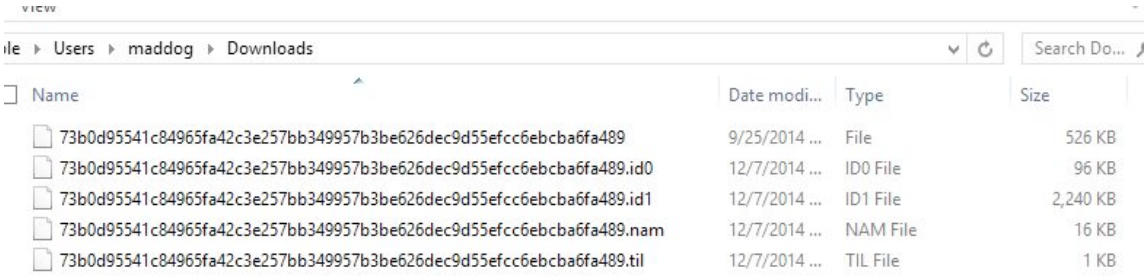
IDAPro

The first step is to load the file into IDAPro. Using IDAPro we can decide on the file type on the "New disassembly database" page and what we did is go to the UNIX tab, and select the ELF Executable file type (considering we were able to find out that the file is an

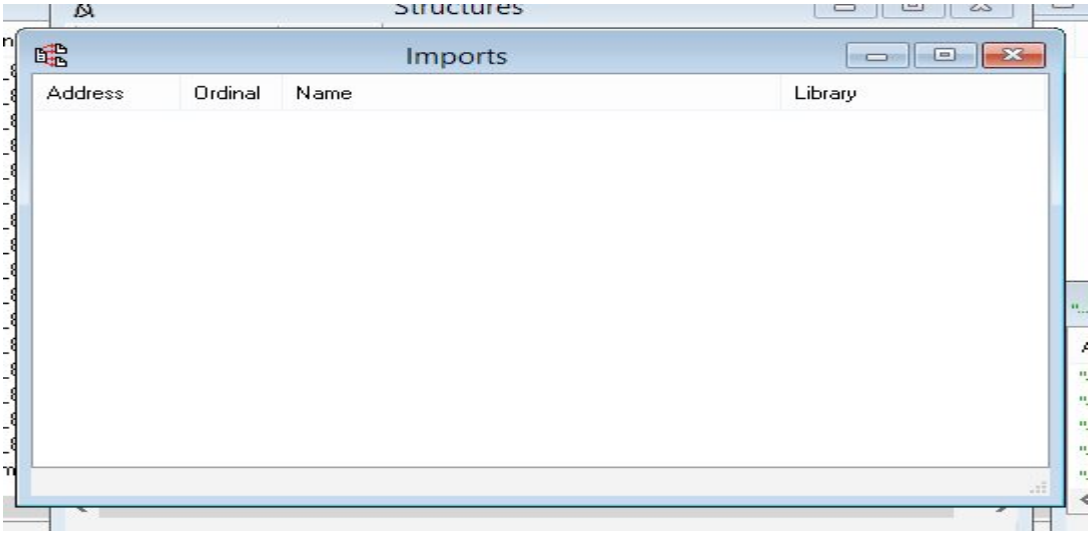
ELF file from basic static analysis). The new disassembly database page is as shown in figure 48 below.



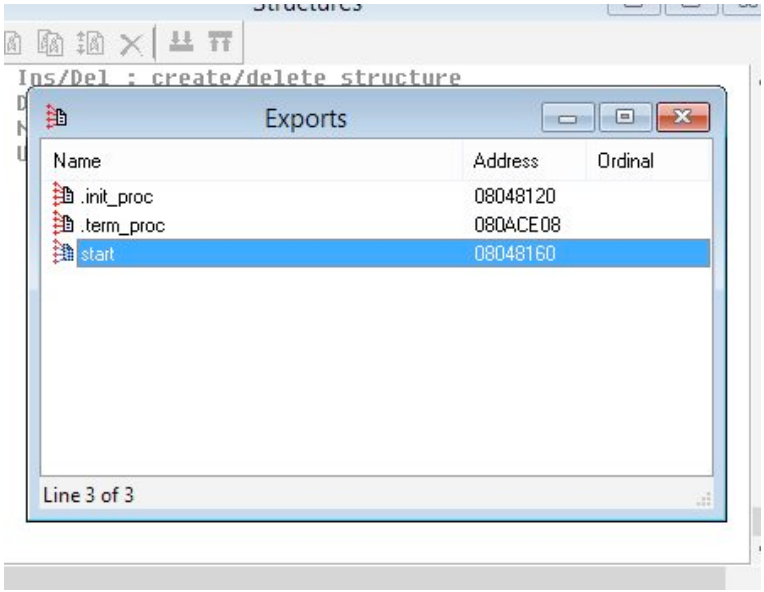
This time around the malware was successfully loaded into IDAPro considering IDAPro is a tool designed for both Windows & Unix systems. Loading the file into IDAPro results in the file being replicated as shown in figure 49 below. However we are going to analyze the file based on the information provided by IDAPro.



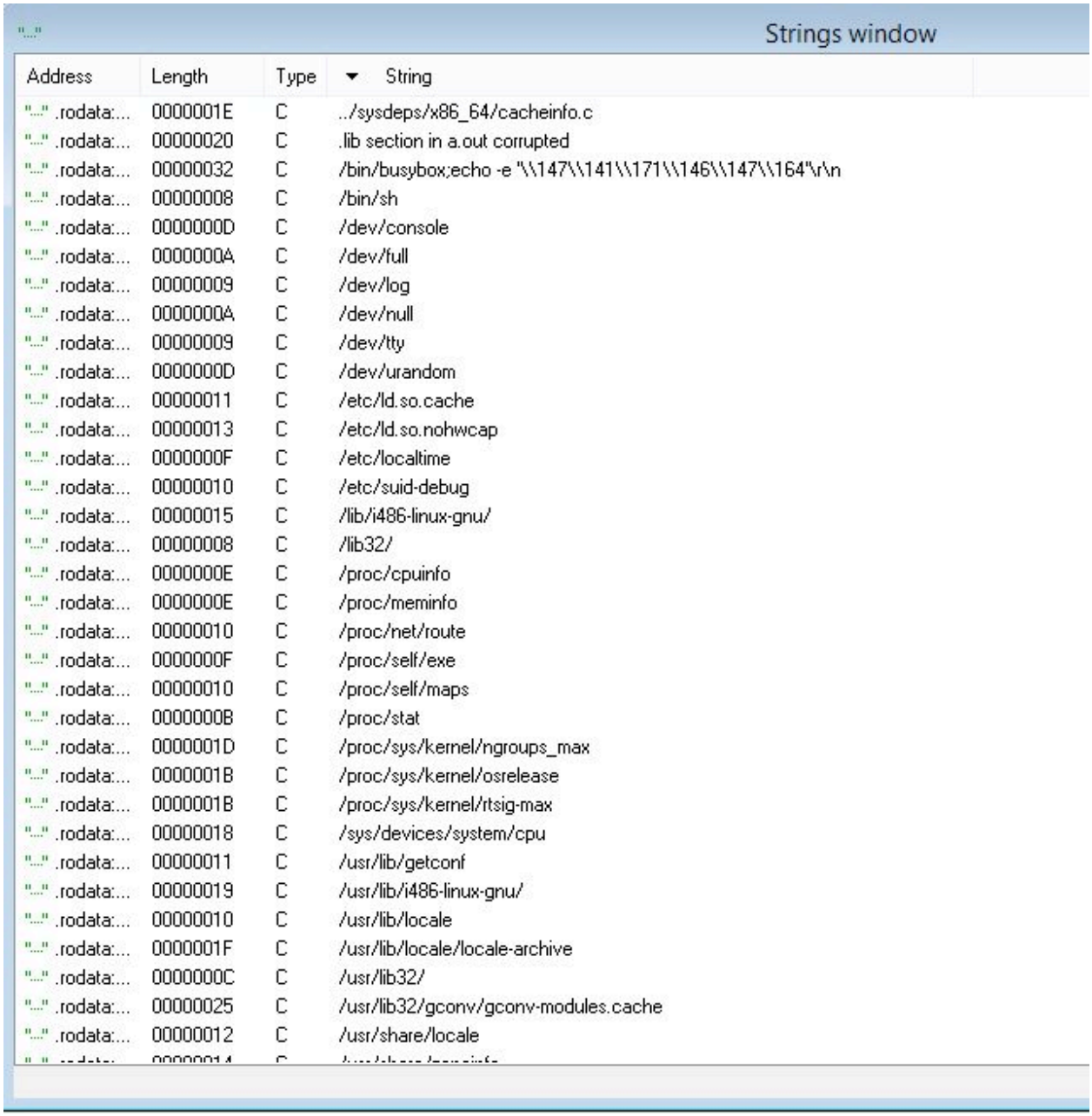
We see from IDAPro that the malware does not have any imports as shown in figure 50, this is interesting, it appears this malware will be tough to analyze without any imports.



We see only 3 exports associated with the file. **.init_proc, .term_proc** and **start.** However we can only make sense of the **start** export on address **08048160.** We believe it is the export responsible for starting the malware.



We then take a look at the strings. The strings showed in figure 52 below shows some interesting strings that we can put into consideration. We see strings like **/bin/sh**, **/dev/full, /etc/localtime /proc/cpuinfo /proc/meminfo etc.** All these are Unix paths that the malware uses.



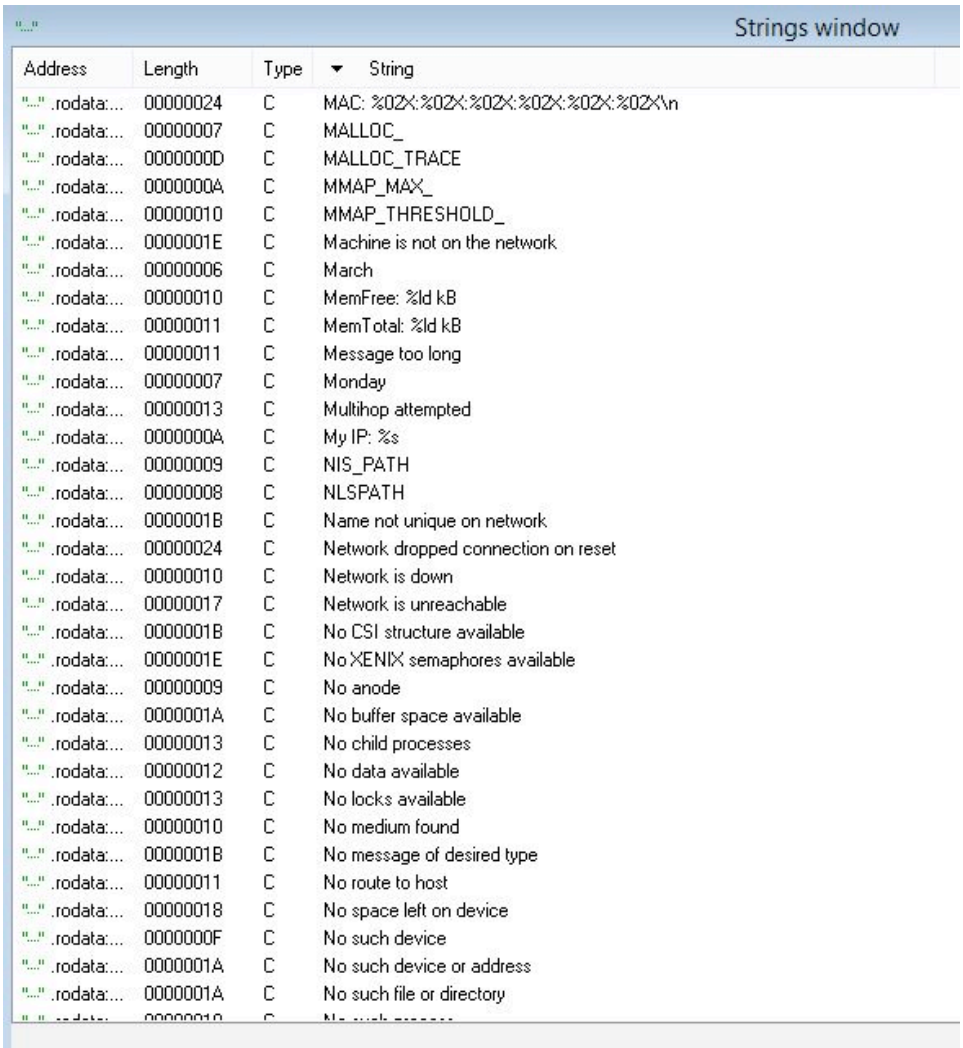
Strings window

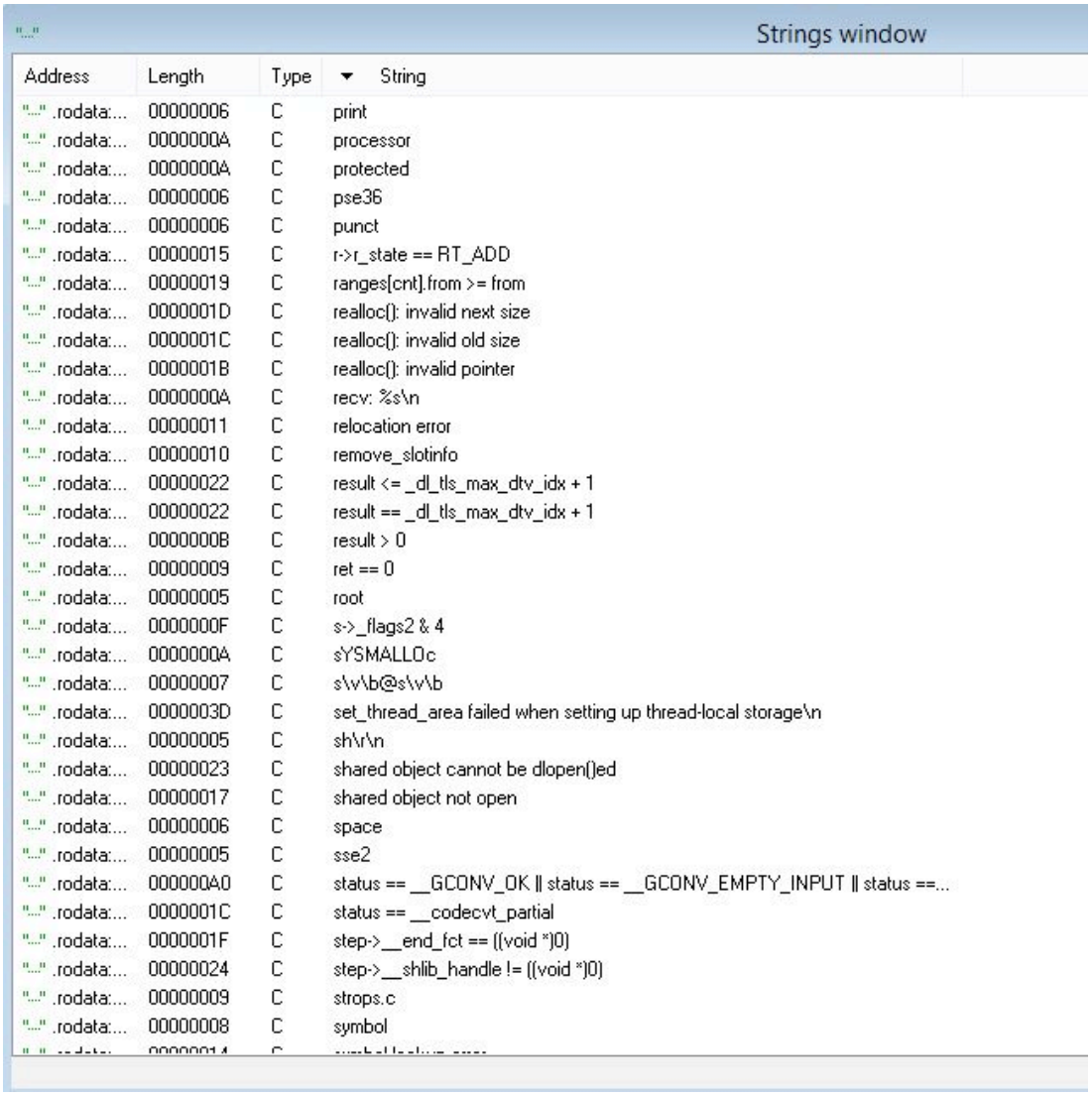
Address	Length	Type	String
".." .rodata:...	0000001E	C	../sysdeps/x86_64/cacheinfo.c
".." .rodata:...	00000020	C	.lib section in a.out corrupted
".." .rodata:...	00000032	C	/bin/busybox;echo -e "\\147\\141\\171\\146\\147\\164"\r\n
".." .rodata:...	00000008	C	/bin/sh
".." .rodata:...	0000000D	C	/dev/console
".." .rodata:...	0000000A	C	/dev/full
".." .rodata:...	00000009	C	/dev/log
".." .rodata:...	0000000A	C	/dev/null
".." .rodata:...	00000009	C	/dev/tty
".." .rodata:...	0000000D	C	/dev/urandom
".." .rodata:...	00000011	C	/etc/ld.so.cache
".." .rodata:...	00000013	C	/etc/ld.so.nohwcap
".." .rodata:...	0000000F	C	/etc/localtime
".." .rodata:...	00000010	C	/etc/suid-debug
".." .rodata:...	00000015	C	/lib/i486-linux-gnu/
".." .rodata:...	00000008	C	/lib32/
".." .rodata:...	0000000E	C	/proc/cpuinfo
".." .rodata:...	0000000E	C	/proc/meminfo
".." .rodata:...	00000010	C	/proc/net/route
".." .rodata:...	0000000F	C	/proc/self/exe
".." .rodata:...	00000010	C	/proc/self/maps
".." .rodata:...	0000000B	C	/proc/stat
".." .rodata:...	0000001D	C	/proc/sys/kernel/ngroups_max
".." .rodata:...	0000001B	C	/proc/sys/kernel/osrelease
".." .rodata:...	0000001B	C	/proc/sys/kernel/rtsig-max
".." .rodata:...	00000018	C	/sys/devices/system/cpu
".." .rodata:...	00000011	C	/usr/lib/getconf
".." .rodata:...	00000019	C	/usr/lib/i486-linux-gnu/
".." .rodata:...	00000010	C	/usr/lib/locale
".." .rodata:...	0000001F	C	/usr/lib/locale/locale-archive
".." .rodata:...	0000000C	C	/usr/lib32/
".." .rodata:...	00000025	C	/usr/lib32/gconv/gconv-modules.cache
".." .rodata:...	00000012	C	/usr/share/locale

The path **/dev** is used to mount disk, **/bin** contains the variables used in single user mode, **/etc** contains configuration files, **/proc** contains access to process and kernel infornations. From this string we can see that this malware pretty much hijacks the computer completely. We also see other strings like **MemFree** and **MemTotal,** and also **My IP.%s** . These are instructions used for memory count. We are talking about the physical memory allocation in the Unix kernel, not the hard disk storage. This tells us that the

malware is capable of controlling the physical memory of the hijacked computer. The **MyIP** string tells us that the malware have some networking functions attached to it. It could be masking the identity of the victim's computer so that the malware could not be detected. We see other string like **Networkisdown, Network is unreachable.** These are all part of the networking capabilities and functions associated with the malware.

The next interesting strings we see is **Print, processor** and **protected.** This are data processing instructions, it tells us that the malware stores some data or instructions using the command **print** and then controls the process while encrypting or protecting the data its prints.

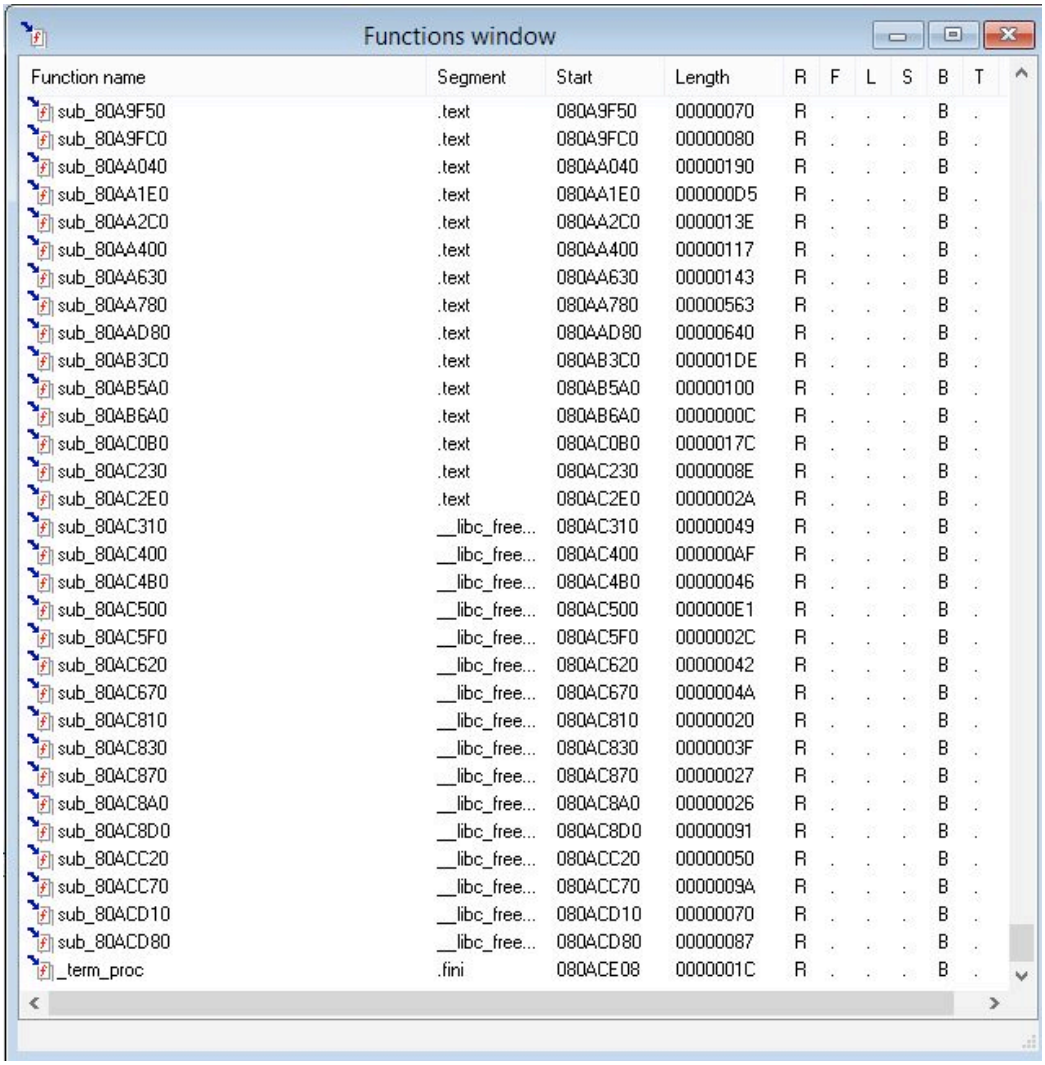




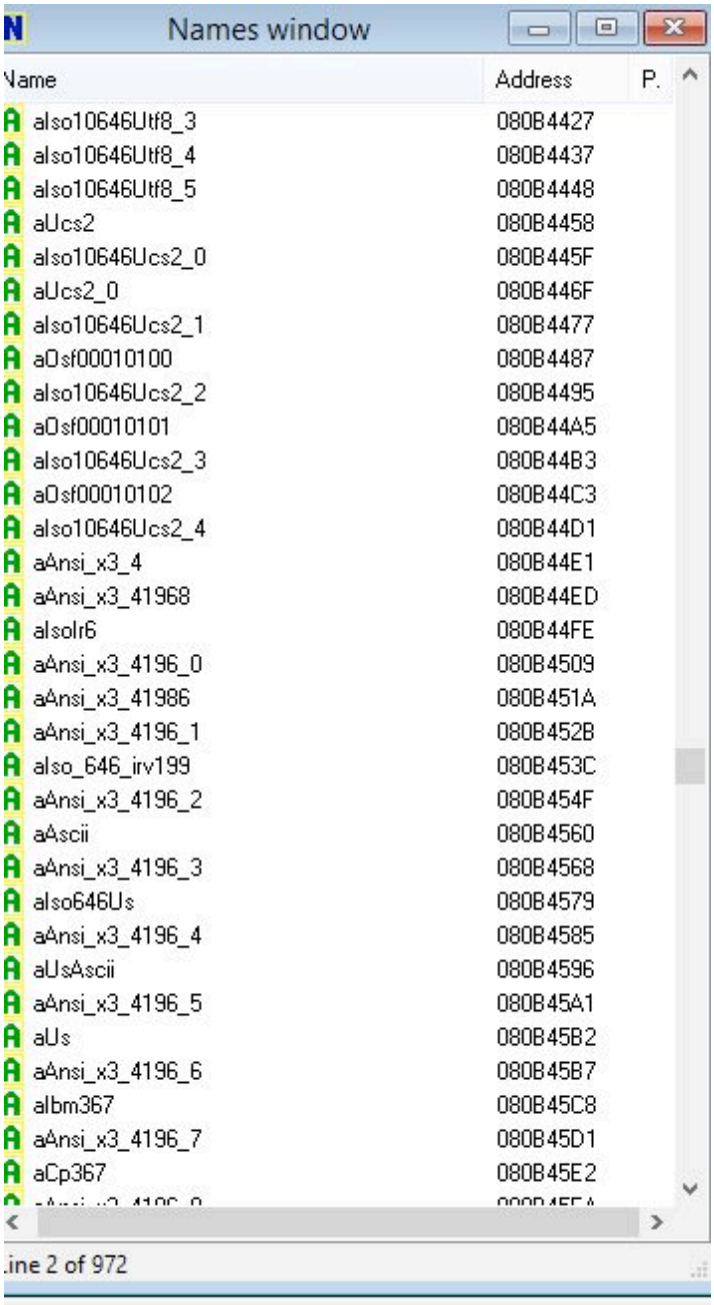
Strings window

Address	Length	Type	String
".rodata:...	00000006	C	print
".rodata:...	0000000A	C	processor
".rodata:...	0000000A	C	protected
".rodata:...	00000006	C	pse36
".rodata:...	00000006	C	punct
".rodata:...	00000015	C	r->r_state == RT_ADD
".rodata:...	00000019	C	ranges[cnt].from >= from
".rodata:...	0000001D	C	realloc(): invalid next size
".rodata:...	0000001C	C	realloc(): invalid old size
".rodata:...	0000001B	C	realloc(): invalid pointer
".rodata:...	0000000A	C	recv: %s\n
".rodata:...	00000011	C	relocation error
".rodata:...	00000010	C	remove_slotinfo
".rodata:...	00000022	C	result <= _dl_tls_max_dtv_idx + 1
".rodata:...	00000022	C	result == _dl_tls_max_dtv_idx + 1
".rodata:...	0000000B	C	result > 0
".rodata:...	00000009	C	ret == 0
".rodata:...	00000005	C	root
".rodata:...	0000000F	C	s->_flags2 & 4
".rodata:...	0000000A	C	sYSMALLOc
".rodata:...	00000007	C	s\v\b@s\v\b
".rodata:...	0000003D	C	set_thread_area failed when setting up thread-local storage\n
".rodata:...	00000005	C	sh\r\n
".rodata:...	00000023	C	shared object cannot be dlopen()ed
".rodata:...	00000017	C	shared object not open
".rodata:...	00000006	C	space
".rodata:...	00000005	C	sse2
".rodata:...	000000A0	C	status == __GCONV_OK || status == __GCONV_EMPTY_INPUT || status ==...
".rodata:...	0000001C	C	status == __codecvt_partial
".rodata:...	0000001F	C	step->__end_fct == ((void *)0)
".rodata:...	00000024	C	step->__shlib_handle != ((void *)0)
".rodata:...	00000009	C	strops.c
".rodata:...	00000008	C	symbol

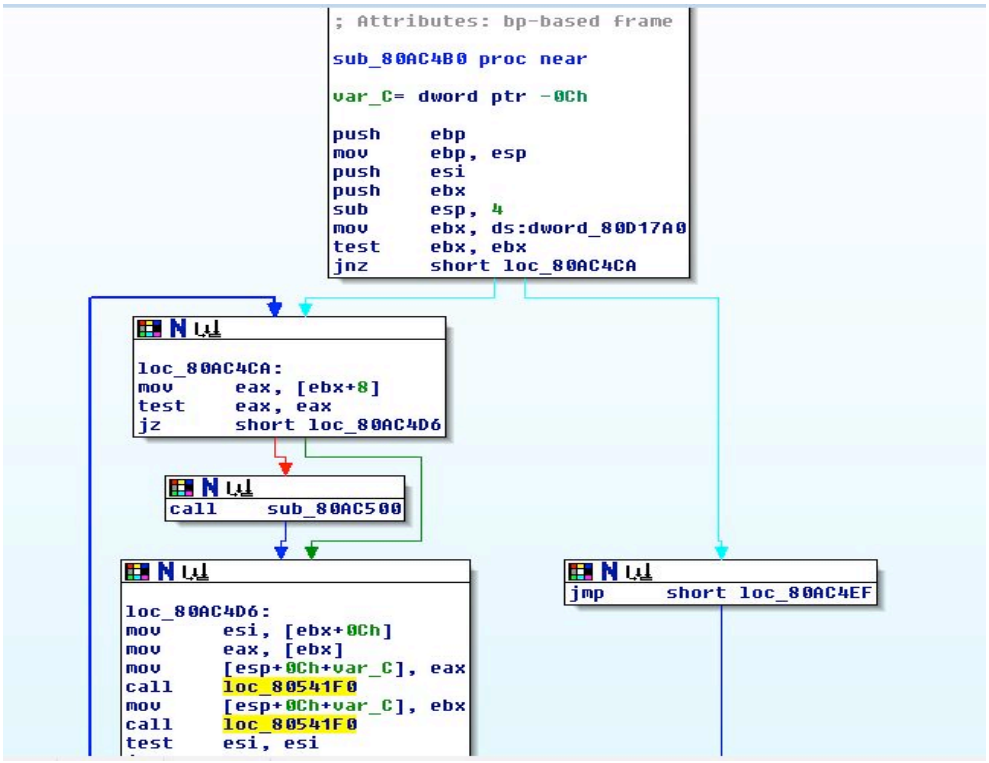
We check the functions shown in figure 55 below to see if we can find the call to the main function of the malware, however all we see is the functions name presented as address and then the length of the strings and where the functions starts.



The only information we could extract from the **names window** is the alphanumeric characters that appears like garbage, we couldn't really make sense of it, as it doesn't correlates to any information we have analyzed so far.



From the IDAview-A we see some **mov** functions between registers **eax, esp and esi.** We also call to address location **80541F0**. Following that address, we only see the move instructions between registers, and other few instructions, but nothing specific as to what and why these instructions are taking place.



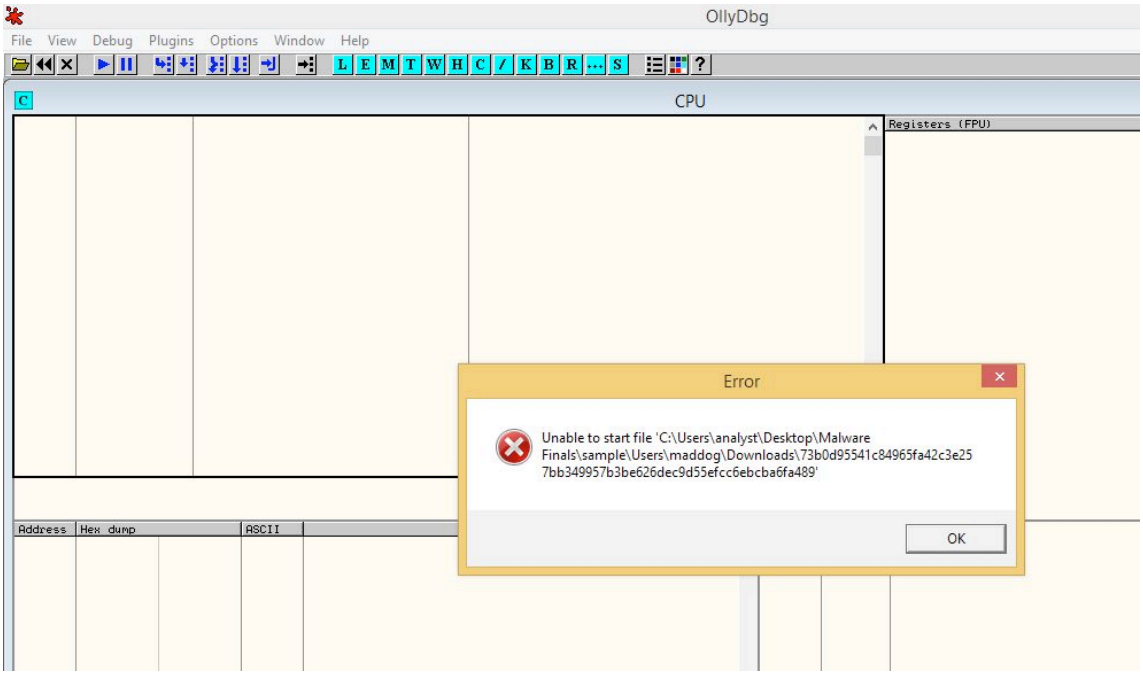

```
.text:080541DD                  jmp     loc_80540D0
.text:080541DD ; ---------------------------------------------------------------------------
.text:080541E2                  align 10h
.text:080541F0
.text:080541F0 loc_80541F0:                             ; CODE XREF: sub_804840E+96↑p
.text:080541F0                                          ; sub_8048DC8+57↑p ...
.text:080541F0                  push    ebp
.text:080541F1                  mov     ebp, esp
.text:080541F3                  push    ebx
.text:080541F4                  sub     esp, 8
.text:080541F7                  mov     eax, ds:dword_80D0BE4
.text:080541FC                  test    eax, eax
.text:080541FE                  mov     edx, [ebp+8]
.text:08054201                  jnz     loc_805429C
.text:08054207                  test    edx, edx
.text:08054209                  jz      short loc_805425D
.text:0805420B                  sub     edx, 8
.text:0805420E                  mov     eax, [edx+4]
.text:08054211                  test    al, 2
.text:08054213                  jnz     short loc_8054268
.text:08054215                  test    al, 4
.text:08054217                  mov     ebx, offset dword_80D0C00
.text:0805421C                  jz      short loc_8054227
.text:0805421E                  mov     eax, edx
.text:08054220                  and     eax, 0FFF00000h
.text:08054225                  mov     ebx, [eax]
.text:08054227
.text:08054227 loc_8054227:                             ; CODE XREF: .text:0805421C↑j
.text:08054227                  xor     eax, eax
.text:08054229                  mov     ecx, 1
.text:0805422E                  cmp     large dword ptr gs:0Ch, 0
.text:08054236                  jz      short near ptr loc_8054238+1
.text:08054238
.text:08054238 loc_8054238:                             ; CODE XREF: .text:08054236↑j
.text:08054238                  lock cmpxchg [ebx], ecx
.text:0805423C                  jnz     loc_80557A7
.text:08054242
.text:08054242 loc_8054242:                             ; CODE XREF: .text:080557AE↓j
```

Even though we know we can't run the malware on a Windows system, we attempt to do an Advanced Dynamic Analysis using 2 special tools OllyDbg and Windbg.

Advanced Dynamic Analysis

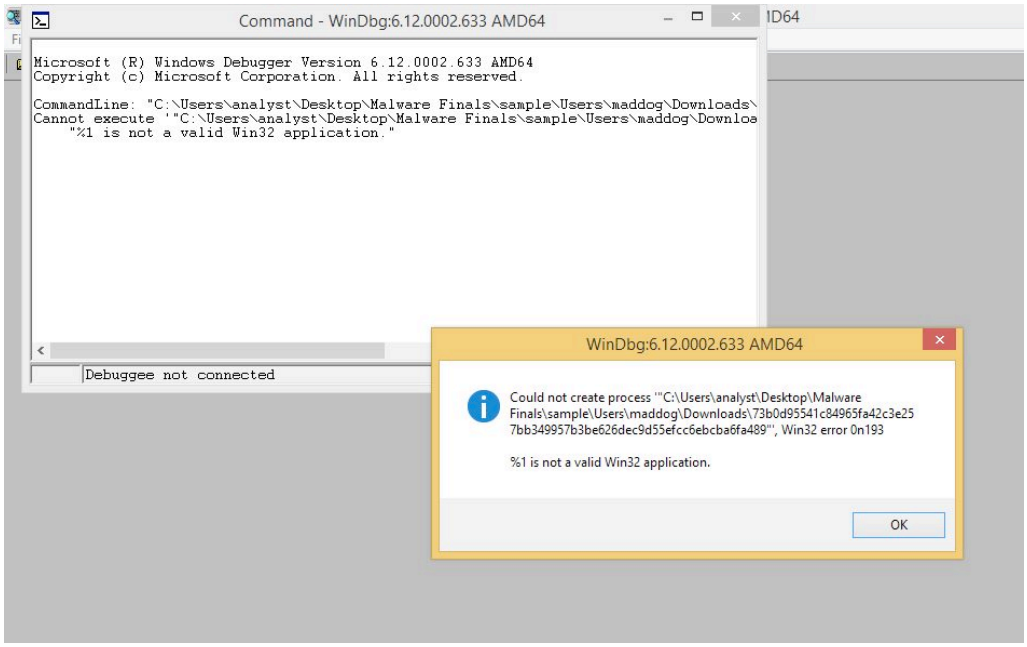
OllyDbg:

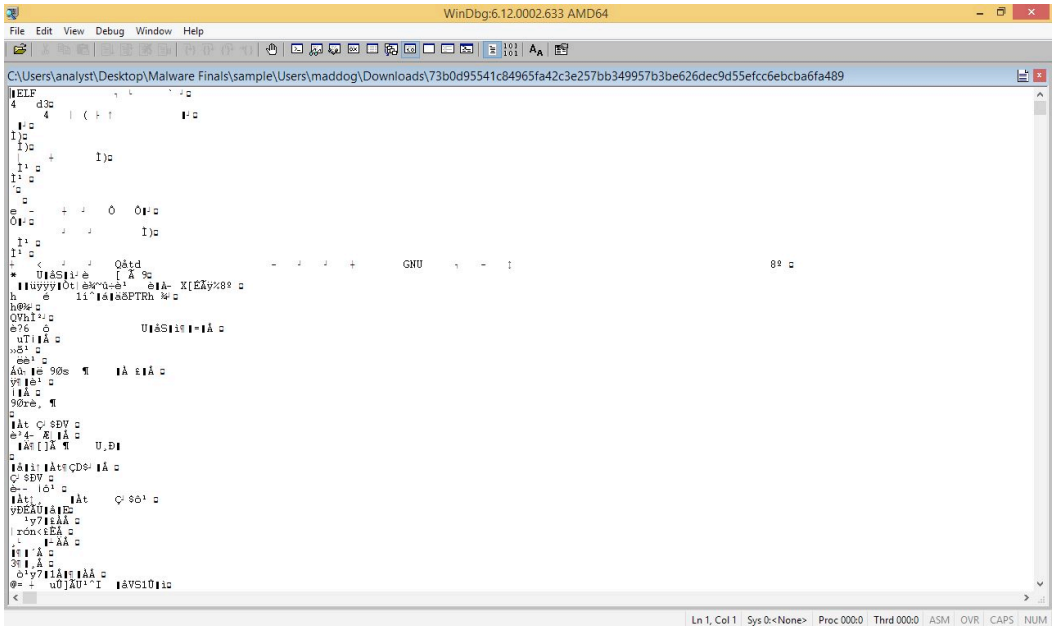
The malware was not successfully loaded to OllyDbg. It returns an error when an attempt was made to open the file.. Figure 59 below shows the error from OllyDbg.



WinDbg:

The file couldn't be loaded to Windbg, we tried opening it both as an executable file and also as an open source file. Figure 60 and 61 shows the result we get when we try to open it using both approaches.


Command - WinDbg:6.12.0002.633 AMD64
Microsoft (R) Windows Debugger Version 6.12.0002.633 AMD64
Copyright (c) Microsoft Corporation. All rights reserved.
CommandLine: "C:\Users\analyst\Desktop\Malware Finals\sample\Users\maddog\Downloads\
Cannot execute '"C:\Users\analyst\Desktop\Malware Finals\sample\Users\maddog\Downloa
"%1 is not a valid Win32 application."
Debuggee not connected
WinDbg:6.12.0002.633 AMD64
Could not create process '"C:\Users\analyst\Desktop\Malware Finals\sample\Users\maddog\Downloads\73b0d95541c84965fa42c3e25 7bb349957b3be626dec9d55efcc6ebcba6fa489"', Win32 error 0n193
%1 is not a valid Win32 application.
OK


WinDbg:6.12.0002.633 AMD64
File Edit View Debug Window Help
C:\Users\analyst\Desktop\Malware Finals\sample\Users\maddog\Downloads\73b0d95541c84965fa42c3e257bb349957b3be626dec9d55efcc6ebcba6fa489
Ln 1, Col 1 Sys 0:<None> Proc 000:0 Thrd 000:0 ASM OVR CAPS NUM

Malware Behavior
(Understanding the Malware).

Several approaches using different tools have been done to analyze this malware. However the malware is specifically designed for UNIX systems and we are attempting to analyze it on a Windows system. The reason of the major failures and drawbacks is that the malware needs to run in a UNIX environment and then it can only be analyzed using tools designed for UNIX malwares. This class and finals is aimed at analysis of malware designed for Windows system. As of this final we don't have the required knowledge to carryout analysis of UNIX based malwares.

From the attempts we made so far, we were able to program is a Unix Shellshock malware designed to be used for bash to process certain request using networking capabilities which allows an attacker to cause vulnerable bash commands so as to gain unauthorized administrative access to a computer system.

Conclusion

The first malware is identified as a Win32.exe file designed for Windows OS, while the second malware is an ELF file (Executable and Linkable Format), which is a standard binary format for UNIX systems. The first malware was successfully analyzed with no problems, but considering the last malware is designed for UNIX systems we ran into multiple problems.