Practical Reversing III – Malware Memory Forensics

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Acknowledgement

- Special thanks to **null** & **Garage4Hackers** community for their extended support and cooperation.
- Thanks to all the trainers who have devoted their precious time and countless hours to make it happen.

Reversing & Malware Analysis Training

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Who am I

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  - http://www.securityphresh.com
- For Q&A, join our mailing list.
  - http://groups.google.com/group/securityxploded

Contents

Why Memory Forensics?

- Finding and extracting forensic artefacts
- Helps in malware analysis
- Determining process, network, registry activities
- Reconstructing original state of the system
- Assists with unpacking, rootkit detection and reverse engineering

Steps in Memory Forensics

- **Memory acquisition - Dumping the memory of a target machine**

  - **tools: Win32dd/Win64dd, Memoryze, DumpIt, FastDump**

  - **In Virtual machine: Suspend the VM and use .vmem file**

- **Memory analysis - Analyzing the memory dump for forensic artifacts**

  - **tools: Volatility, Memoryze**

Volatility Quick Overview

- **Advanced memory Forensics Framework written in python**

- **Installation details:**
  - **http://code.google.com/p/volatility/wiki/FullInstallation**

- **Use -h or --help option to get list of command-line switches**
  - **example: python vol.py –h**

- **Use -f <filename> and --profile to indicate the memory dump you are analyzing**

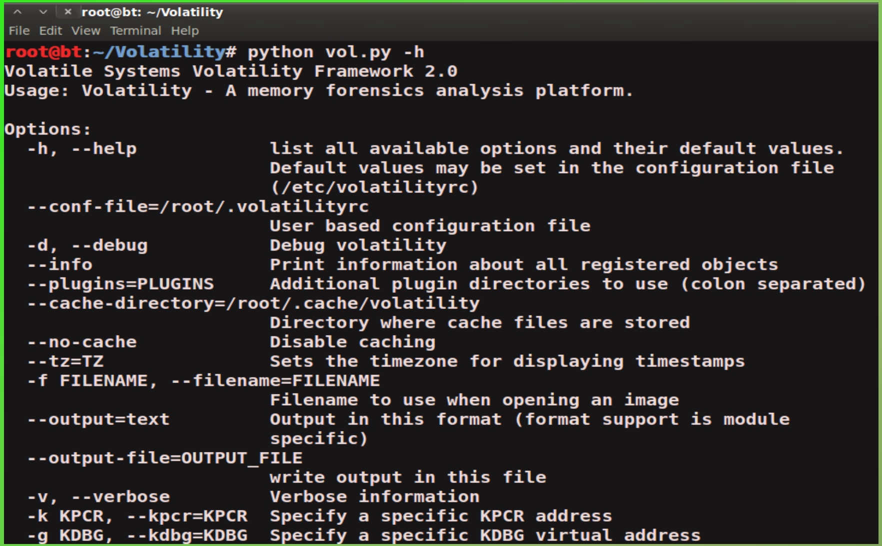
  example: python vol.py -f mem.dmp --profile=WinXPSP3x86

- **To know the --profile info use below command:**

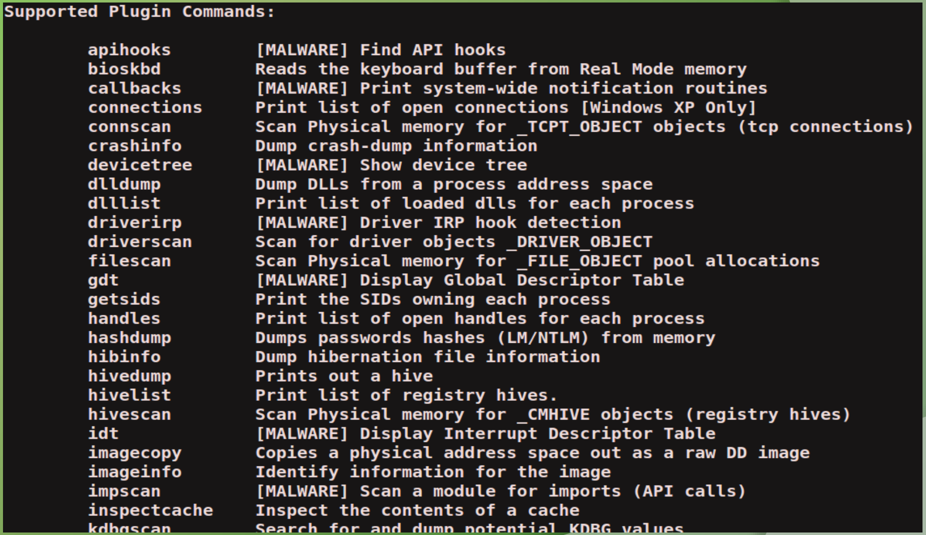
  example: python vol.py -f mem.dmp imageinfo

Volatility help and plugins

-h or –help option displays help and available plug-in commands in volatility.



```
root@bt:~/Volatility# python vol.py -h
Volatile Systems Volatility Framework 2.0
Usage: Volatility - A memory forensics analysis platform.

Options:
  -h, --help            list all available options and their default values.
                        Default values may be set in the configuration file
                        (/etc/volatilityrc)
  --conf-file=/root/.volatilityrc
                        User based configuration file
  -d, --debug           Debug volatility
  --info                Print information about all registered objects
  --plugins=PLUGINS     Additional plugin directories to use (colon separated)
  --cache-directory=/root/.cache/volatility
                        Directory where cache files are stored
  --no-cache            Disable caching
  --tz=TZ               Sets the timezone for displaying timestamps
  -f FILENAME, --filename=FILENAME
                        Filename to use when opening an image
  --output=text         Output in this format (format support is module
                        specific)
  --output-file=OUTPUT_FILE
                        write output in this file
  -v, --verbose         Verbose information
  -k KPCR, --kpcr=KPCR  Specify a specific KPCR address
  -g KDBG, --kdbg=KDBG  Specify a specific KDBG virtual address
```



```
Supported Plugin Commands:

        apihooks        [MALWARE] Find API hooks
        bioskbd         Reads the keyboard buffer from Real Mode memory
        callbacks       [MALWARE] Print system-wide notification routines
        connections     Print list of open connections [Windows XP Only]
        connscan        Scan Physical memory for _TCPT_OBJECT objects (tcp connections)
        crashinfo       Dump crash-dump information
        devicetree      [MALWARE] Show device tree
        dlldump         Dump DLLs from a process address space
        dlllist         Print list of loaded dlls for each process
        driverirp       [MALWARE] Driver IRP hook detection
        driverscan      Scan for driver objects _DRIVER_OBJECT
        filescan        Scan Physical memory for _FILE_OBJECT pool allocations
        gdt             [MALWARE] Display Global Descriptor Table
        getsids         Print the SIDs owning each process
        handles         Print list of open handles for each process
        hashdump        Dumps passwords hashes (LM/NTLM) from memory
        hibinfo         Dump hibernation file information
        hivedump        Prints out a hive
        hivelist        Print list of registry hives.
        hivescan        Scan Physical memory for _CMHIVE objects (registry hives)
        idt             [MALWARE] Display Interrupt Descriptor Table
        imagecopy       Copies a physical address space out as a raw DD image
        imageinfo       Identify information for the image
        impscan         [MALWARE] Scan a module for imports (API calls)
        inspectcache    Inspect the contents of a cache
        kdbgscan        Search for and dump potential KDBG values
```

DEMO

http://youtu.be/YcVusDjnBxw

Demo-Scenario

Your security device alerts, show malicious http connection to ip address 208.91.197.54 from a source ip 192.168.1.100 on 8th june 2012 at around 13:30hrs...you are asked to investigate and do memory forensics on that machine 192.168.1.100

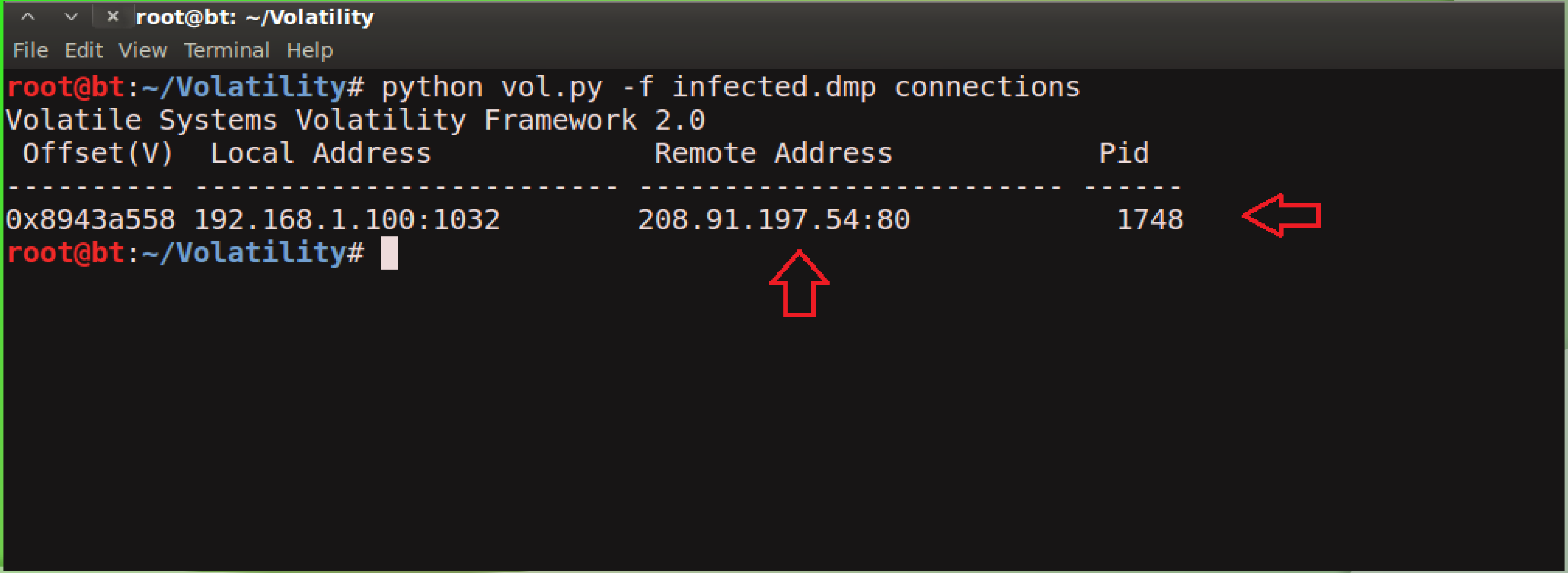
- To start with, acquire the memory image "infected.dmp" from 192.168.1.100, using memory acquistion tools (win32dd)

command: win32dd.exe /f infected.dmp

- Analyze the memory dump "infected.dmp"

Step 1 – Start With what you know

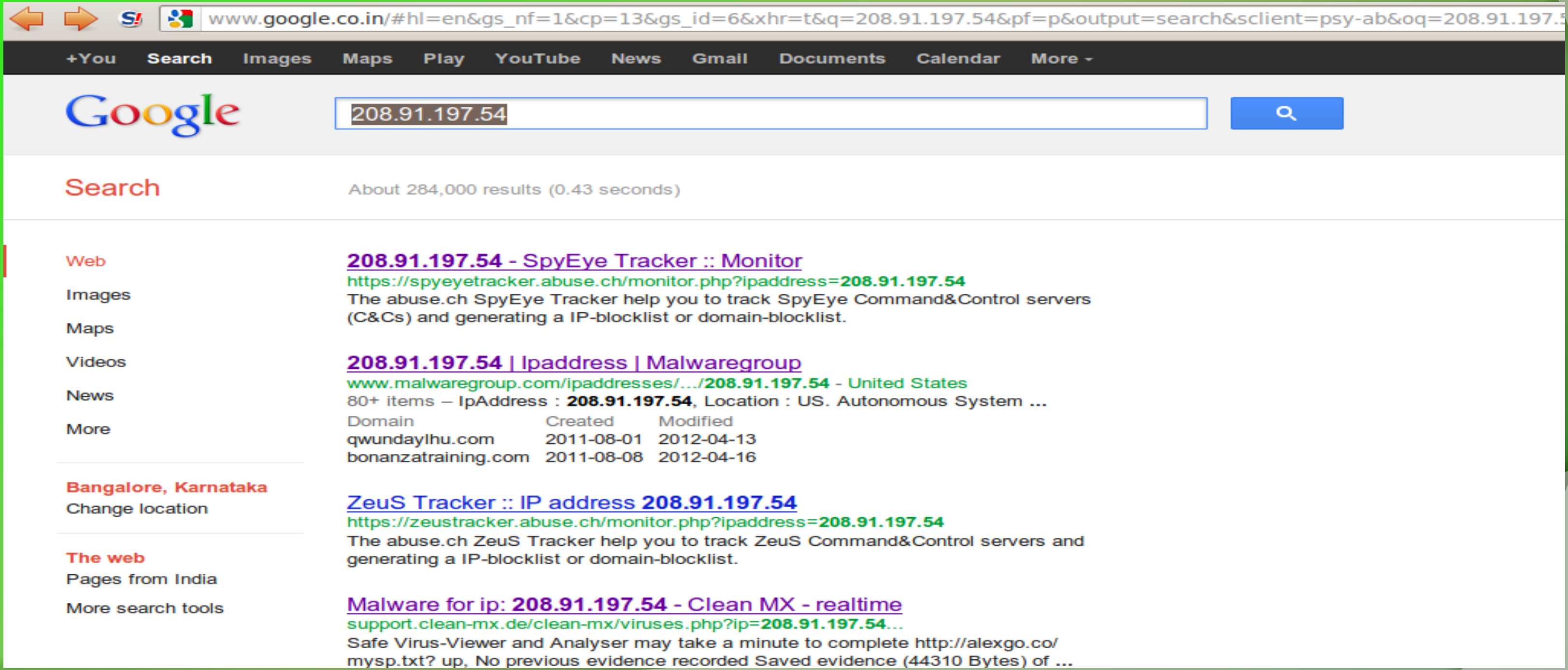
Volatility's connections module shows connection to the malicious ip by pid 1748



```
root@bt:~/Volatility# python vol.py -f infected.dmp connections
Volatile Systems Volatility Framework 2.0
 Offset(V)  Local Address             Remote Address            Pid
---------- ------------------------- ------------------------- ------
0x8943a558 192.168.1.100:1032        208.91.197.54:80            1748
root@bt:~/Volatility#
```

Step 2 – Info about 208.91.197.54

Google search shows 208.91.197.54 associated with malware, probably “spyeye”, we need to confirm that yet.


www.google.co.in/#hl=en&gs_nf=1&cp=13&gs_id=6&xhr=t&q=208.91.197.54&pf=p&output=search&sclient=psy-ab&oq=208.91.197.5
+You Search Images Maps Play YouTube News Gmail Documents Calendar More
208.91.197.54
Search
Web
Images
Maps
Videos
News
More
Bangalore, Karnataka
Change location
The web
Pages from India
More search tools

About 284,000 results (0.43 seconds)

208.91.197.54 - SpyEye Tracker :: Monitor
https://spyeyetracker.abuse.ch/monitor.php?ipaddress=208.91.197.54
The abuse.ch SpyEye Tracker help you to track SpyEye Command&Control servers (C&Cs) and generating a IP-blocklist or domain-blocklist.

208.91.197.54 | Ipaddress | Malwaregroup
www.malwaregroup.com/ipaddresses/.../208.91.197.54 - United States
80+ items – IpAddress : 208.91.197.54, Location : US. Autonomous System ...

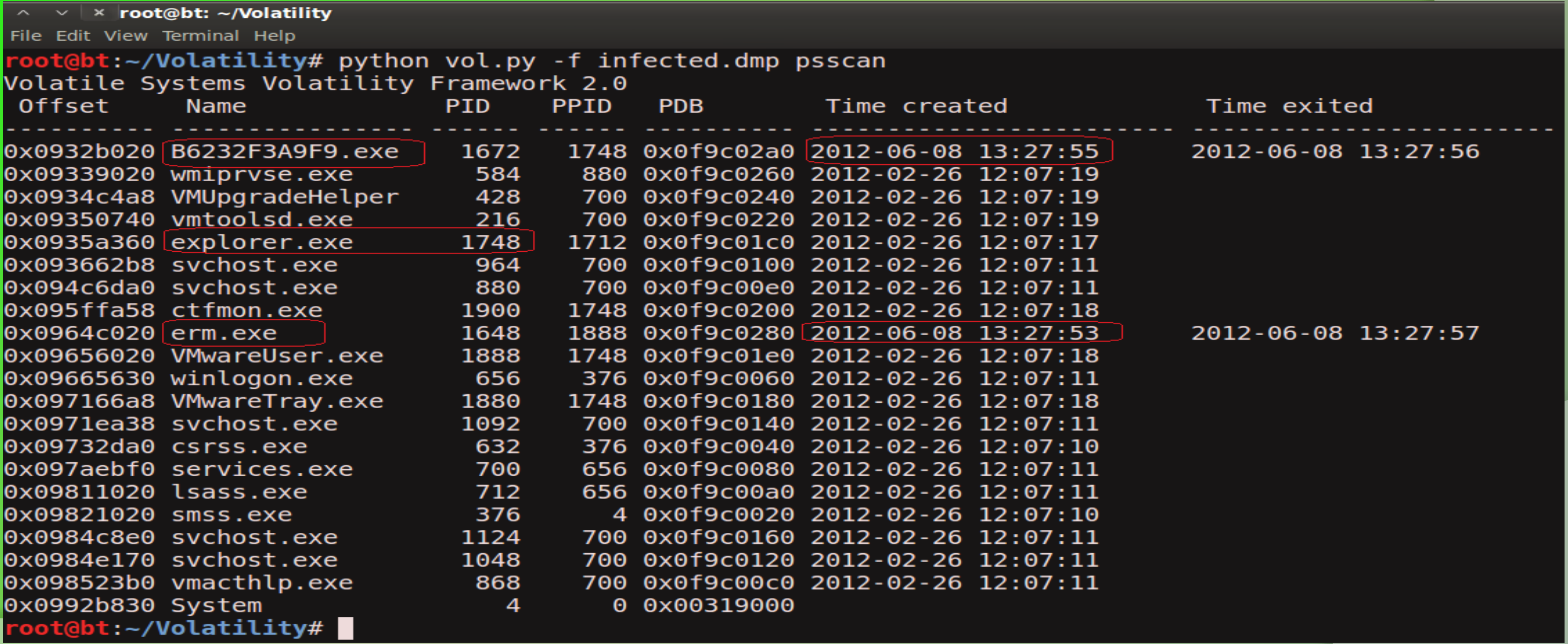
Domain	Created	Modified
qwundaylhu.com	2011-08-01	2012-04-13
bonanzatraining.com	2011-08-08	2012-04-16

ZeuS Tracker :: IP address 208.91.197.54
https://zeustracker.abuse.ch/monitor.php?ipaddress=208.91.197.54
The abuse.ch ZeuS Tracker help you to track ZeuS Command&Control servers and generating a IP-blocklist or domain-blocklist.

Malware for ip: 208.91.197.54 - Clean MX - realtime
support.clean-mx.de/clean-mx/viruses.php?ip=208.91.197.54...
Safe Virus-Viewer and Analyser may take a minute to complete http://alexgo.co/mysp.txt? up, No previous evidence recorded Saved evidence (44310 Bytes) of ...

Step 3 – Who is Pid 1748?

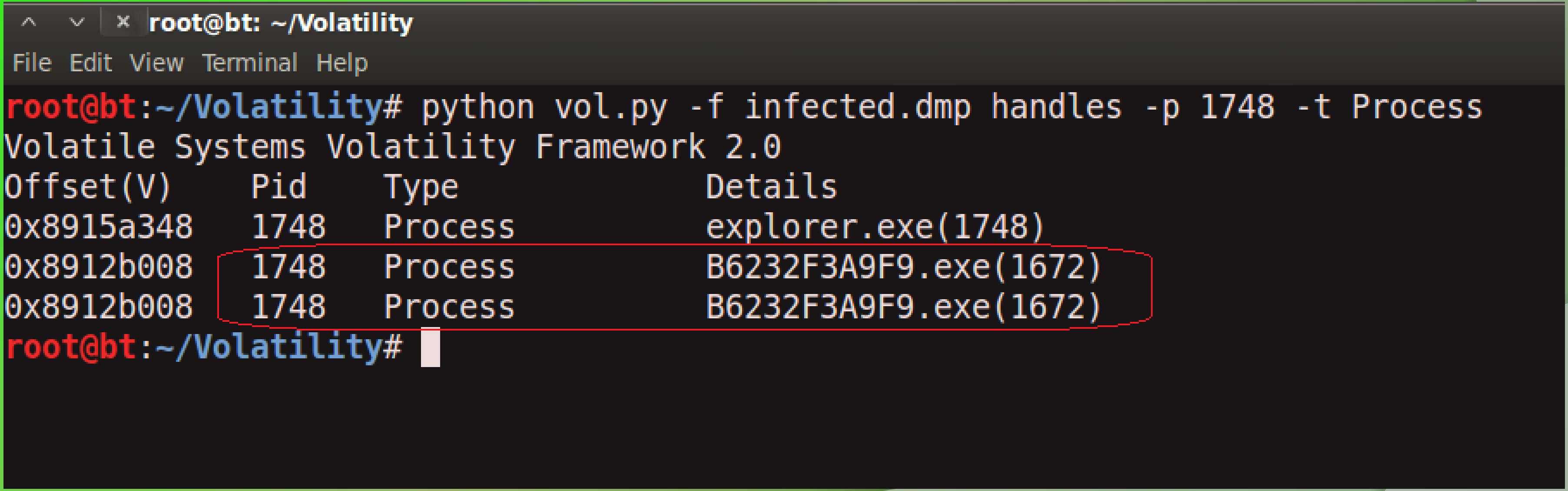
"psscan" shows pid 1748 belongs to explorer.exe, also two process created during same time reported by security device (i.e june 8th 2012)



```
root@bt:~/Volatility# python vol.py -f infected.dmp psscan
Volatile Systems Volatility Framework 2.0
 Offset     Name                 PID    PPID   PDB        Time created                 Time exited
---------- ---------------- ------ ------ ---------- ------------------------ ------------------------
0x0932b020 B6232F3A9F9.exe    1672   1748 0x0f9c02a0 2012-06-08 13:27:55      2012-06-08 13:27:56
0x09339020 wmiprvse.exe        584    880 0x0f9c0260 2012-02-26 12:07:19
0x0934c4a8 VMUpgradeHelper     428    700 0x0f9c0240 2012-02-26 12:07:19
0x09350740 vmtoolsd.exe        216    700 0x0f9c0220 2012-02-26 12:07:19
0x0935a360 explorer.exe       1748   1712 0x0f9c01c0 2012-02-26 12:07:17
0x093662b8 svchost.exe         964    700 0x0f9c0100 2012-02-26 12:07:11
0x094c6da0 svchost.exe         880    700 0x0f9c00e0 2012-02-26 12:07:11
0x095ffa58 ctfmon.exe         1900   1748 0x0f9c0200 2012-02-26 12:07:18
0x0964c020 erm.exe            1648   1888 0x0f9c0280 2012-06-08 13:27:53      2012-06-08 13:27:57
0x09656020 VMwareUser.exe     1888   1748 0x0f9c01e0 2012-02-26 12:07:18
0x09665630 winlogon.exe        656    376 0x0f9c0060 2012-02-26 12:07:11
0x097166a8 VMwareTray.exe     1880   1748 0x0f9c0180 2012-02-26 12:07:18
0x0971ea38 svchost.exe        1092    700 0x0f9c0140 2012-02-26 12:07:11
0x09732da0 csrss.exe           632    376 0x0f9c0040 2012-02-26 12:07:10
0x097aebf0 services.exe        700    656 0x0f9c0080 2012-02-26 12:07:11
0x09811020 lsass.exe           712    656 0x0f9c00a0 2012-02-26 12:07:11
0x09821020 smss.exe            376      4 0x0f9c0020 2012-02-26 12:07:10
0x0984c8e0 svchost.exe        1124    700 0x0f9c0160 2012-02-26 12:07:11
0x0984e170 svchost.exe        1048    700 0x0f9c0120 2012-02-26 12:07:11
0x098523b0 vmacthlp.exe        868    700 0x0f9c00c0 2012-02-26 12:07:11
0x0992b830 System                4      0 0x00319000
root@bt:~/Volatility#
```

Step 4 – Process handles of explorer.exe

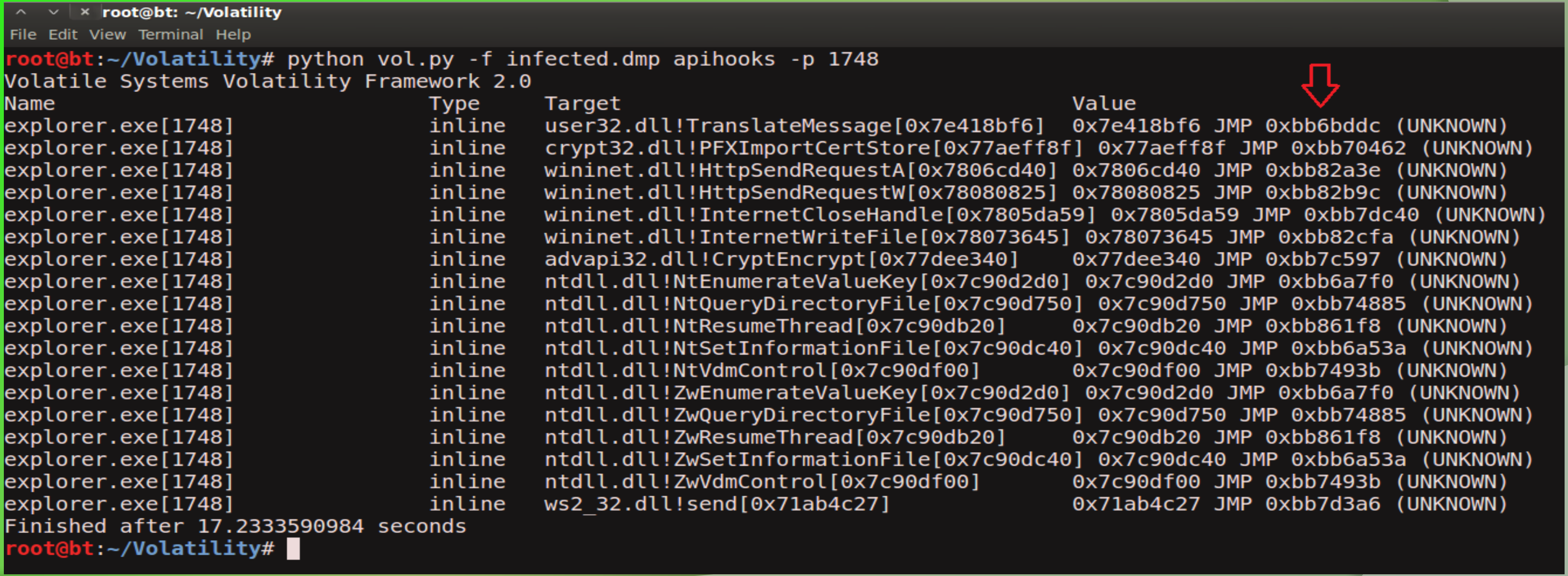
Explorer.exe opens a handle to the B6232F3A9F9.exe, indicating explorer.exe created that process, which might be malicious…focusing on explorer.exe for now.



```
root@bt:~/Volatility# python vol.py -f infected.dmp handles -p 1748 -t Process
Volatile Systems Volatility Framework 2.0
Offset(V)     Pid     Type                Details
0x8915a348    1748    Process             explorer.exe(1748)
0x8912b008    1748    Process             B6232F3A9F9.exe(1672)
0x8912b008    1748    Process             B6232F3A9F9.exe(1672)
root@bt:~/Volatility#
```

Step 5 – apihooks in explorer.exe

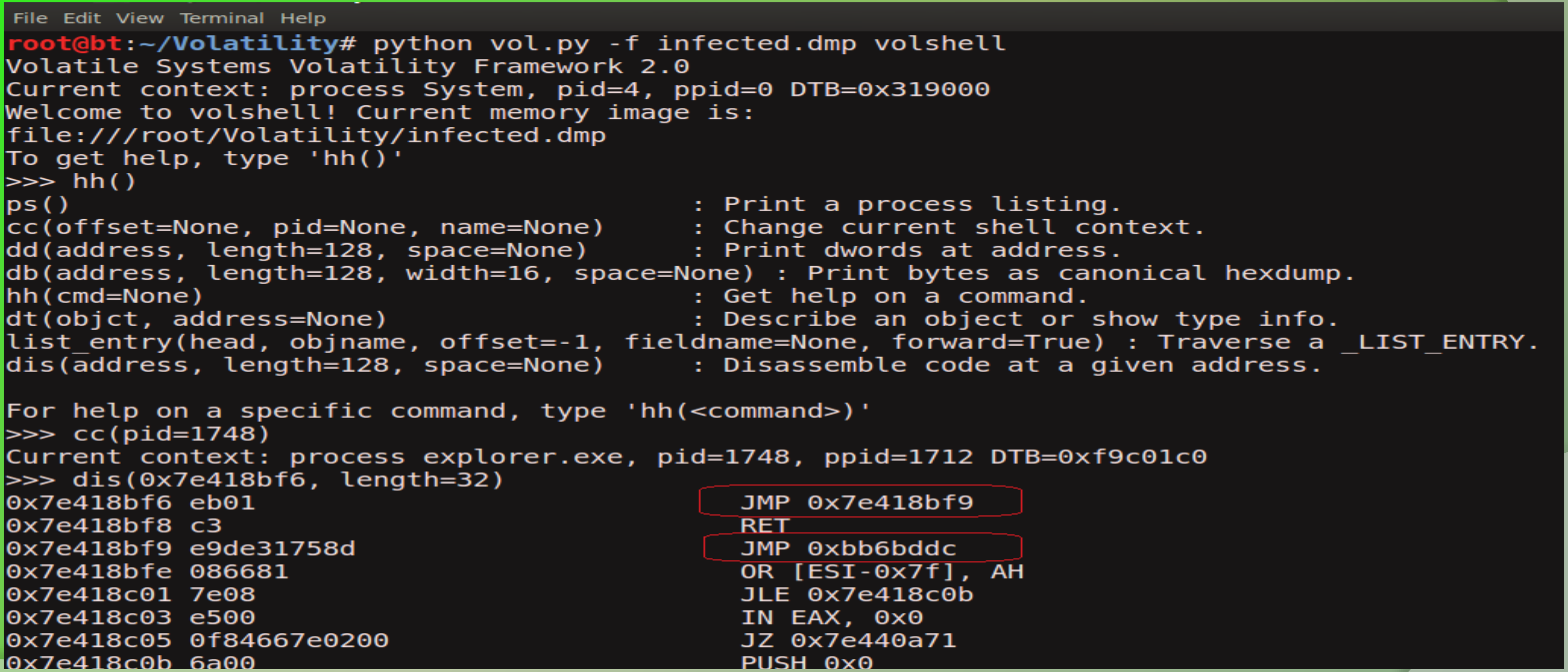
apihooks module show, inline api hooks in explorer.exe and jump to an unknown location



```
root@bt:~/Volatility# python vol.py -f infected.dmp apihooks -p 1748
Volatile Systems Volatility Framework 2.0
Name                           Type     Target                                   Value
explorer.exe[1748]             inline   user32.dll!TranslateMessage[0x7e418bf6]  0x7e418bf6 JMP 0xbb6bddc (UNKNOWN)
explorer.exe[1748]             inline   crypt32.dll!PFXImportCertStore[0x77aeff8f] 0x77aeff8f JMP 0xbb70462 (UNKNOWN)
explorer.exe[1748]             inline   wininet.dll!HttpSendRequestA[0x7806cd40] 0x7806cd40 JMP 0xbb82a3e (UNKNOWN)
explorer.exe[1748]             inline   wininet.dll!HttpSendRequestW[0x78080825] 0x78080825 JMP 0xbb82b9c (UNKNOWN)
explorer.exe[1748]             inline   wininet.dll!InternetCloseHandle[0x7805da59] 0x7805da59 JMP 0xbb7dc40 (UNKNOWN)
explorer.exe[1748]             inline   wininet.dll!InternetWriteFile[0x78073645] 0x78073645 JMP 0xbb82cfa (UNKNOWN)
explorer.exe[1748]             inline   advapi32.dll!CryptEncrypt[0x77dee340]    0x77dee340 JMP 0xbb7c597 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!NtEnumerateValueKey[0x7c90d2d0] 0x7c90d2d0 JMP 0xbb6a7f0 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!NtQueryDirectoryFile[0x7c90d750] 0x7c90d750 JMP 0xbb74885 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!NtResumeThread[0x7c90db20]     0x7c90db20 JMP 0xbb861f8 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!NtSetInformationFile[0x7c90dc40] 0x7c90dc40 JMP 0xbb6a53a (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!NtVdmControl[0x7c90df00]       0x7c90df00 JMP 0xbb7493b (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!ZwEnumerateValueKey[0x7c90d2d0] 0x7c90d2d0 JMP 0xbb6a7f0 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!ZwQueryDirectoryFile[0x7c90d750] 0x7c90d750 JMP 0xbb74885 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!ZwResumeThread[0x7c90db20]     0x7c90db20 JMP 0xbb861f8 (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!ZwSetInformationFile[0x7c90dc40] 0x7c90dc40 JMP 0xbb6a53a (UNKNOWN)
explorer.exe[1748]             inline   ntdll.dll!ZwVdmControl[0x7c90df00]       0x7c90df00 JMP 0xbb7493b (UNKNOWN)
explorer.exe[1748]             inline   ws2_32.dll!send[0x71ab4c27]              0x71ab4c27 JMP 0xbb7d3a6 (UNKNOWN)
Finished after 17.2333590984 seconds
root@bt:~/Volatility#
```

Step 6 – exploring the hooks

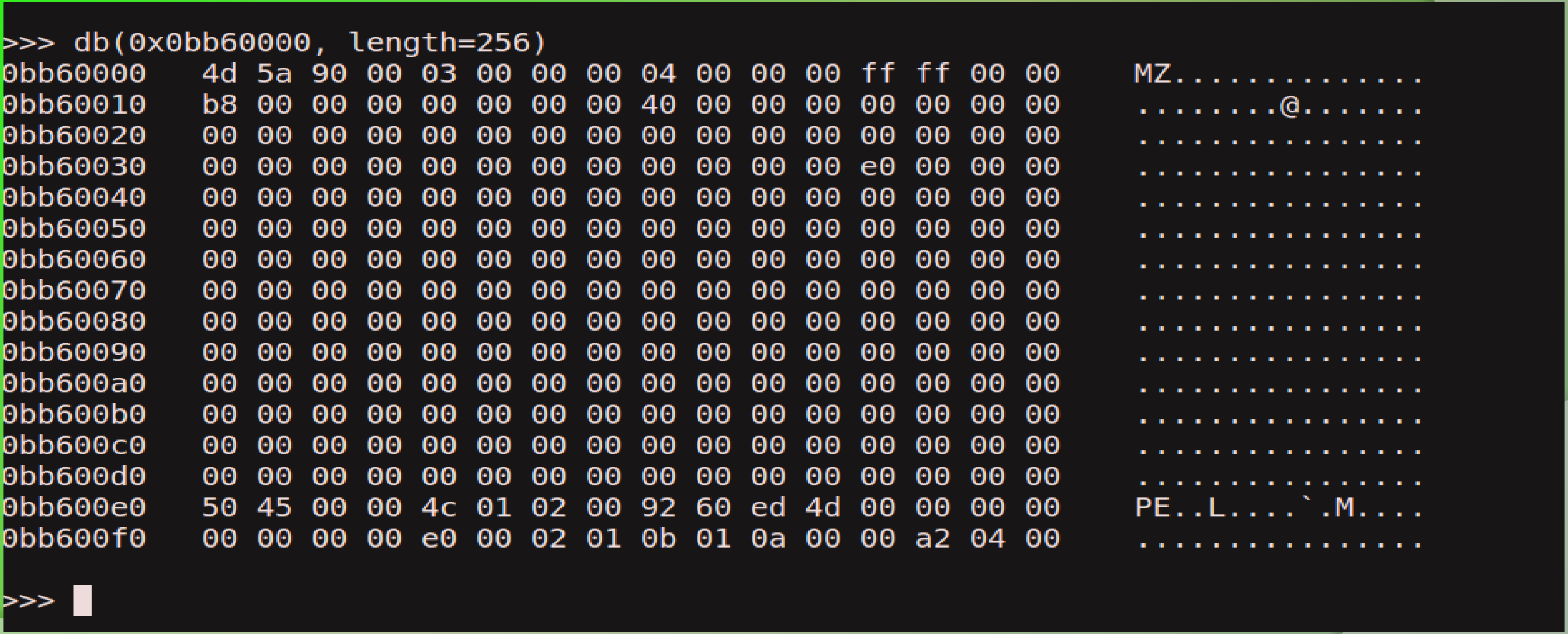
Disassembled hooked function (TranslateMessage), shows a short jump and then a long jump to malware location


File Edit View Terminal Help

```
root@bt:~/Volatility# python vol.py -f infected.dmp volshell
Volatile Systems Volatility Framework 2.0
Current context: process System, pid=4, ppid=0 DTB=0x319000
Welcome to volshell! Current memory image is:
file:///root/Volatility/infected.dmp
To get help, type 'hh()'
>>> hh()
ps()                                     : Print a process listing.
cc(offset=None, pid=None, name=None)     : Change current shell context.
dd(address, length=128, space=None)      : Print dwords at address.
db(address, length=128, width=16, space=None) : Print bytes as canonical hexdump.
hh(cmd=None)                             : Get help on a command.
dt(objct, address=None)                  : Describe an object or show type info.
list_entry(head, objname, offset=-1, fieldname=None, forward=True) : Traverse a _LIST_ENTRY.
dis(address, length=128, space=None)     : Disassemble code at a given address.

For help on a specific command, type 'hh(<command>)'
>>> cc(pid=1748)
Current context: process explorer.exe, pid=1748, ppid=1712 DTB=0xf9c01c0
>>> dis(0x7e418bf6, length=32)
0x7e418bf6 eb01                            JMP 0x7e418bf9
0x7e418bf8 c3                              RET
0x7e418bf9 e9de31758d                      JMP 0xbb6bddc
0x7e418bfe 086681                          OR [ESI-0x7f], AH
0x7e418c01 7e08                            JLE 0x7e418c0b
0x7e418c03 e500                            IN EAX, 0x0
0x7e418c05 0f84667e0200                    JZ 0x7e440a71
0x7e418c0b 6a00                            PUSH 0x0
```

Step 7 – Embedded exe in explorer.exe

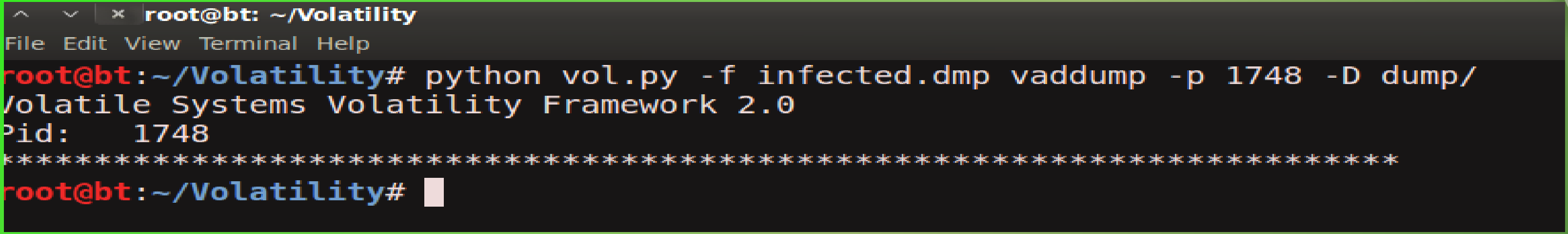
Printing the bytes show the presence of embedded executable in explorer.exe



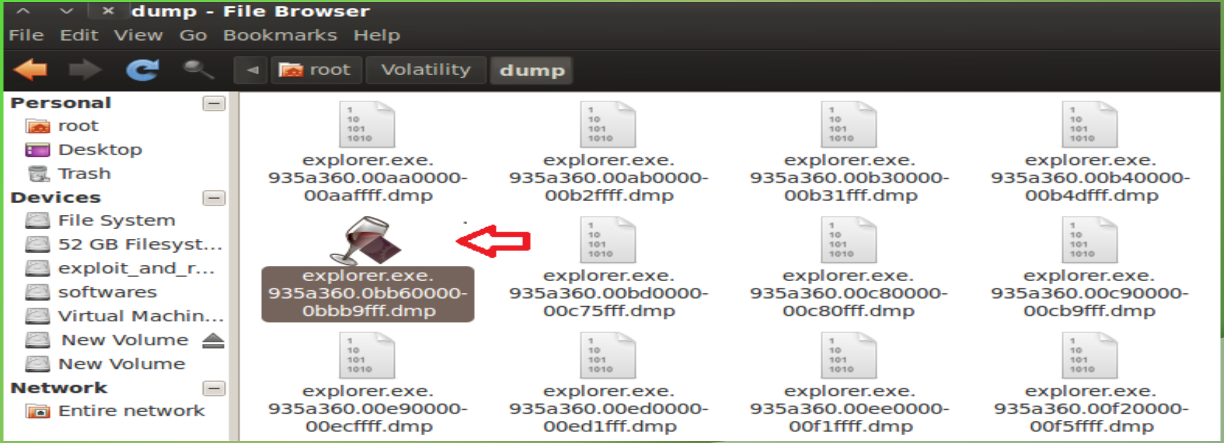
```
>>> db(0x0bb60000, length=256)
0bb60000   4d 5a 90 00 03 00 00 00 04 00 00 00 ff ff 00 00    MZ..............
0bb60010   b8 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00    ........@.......
0bb60020   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60030   00 00 00 00 00 00 00 00 00 00 00 00 e0 00 00 00    ................
0bb60040   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60050   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60080   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb60090   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb600a0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb600b0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb600c0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb600d0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
0bb600e0   50 45 00 00 4c 01 02 00 92 60 ed 4d 00 00 00 00    PE..L....`.M....
0bb600f0   00 00 00 00 e0 00 02 01 0b 01 0a 00 00 a2 04 00    ................

>>>
```

Step 8 – dumping the embedded exe

vaddump dumps the embedded exe from explorer.exe



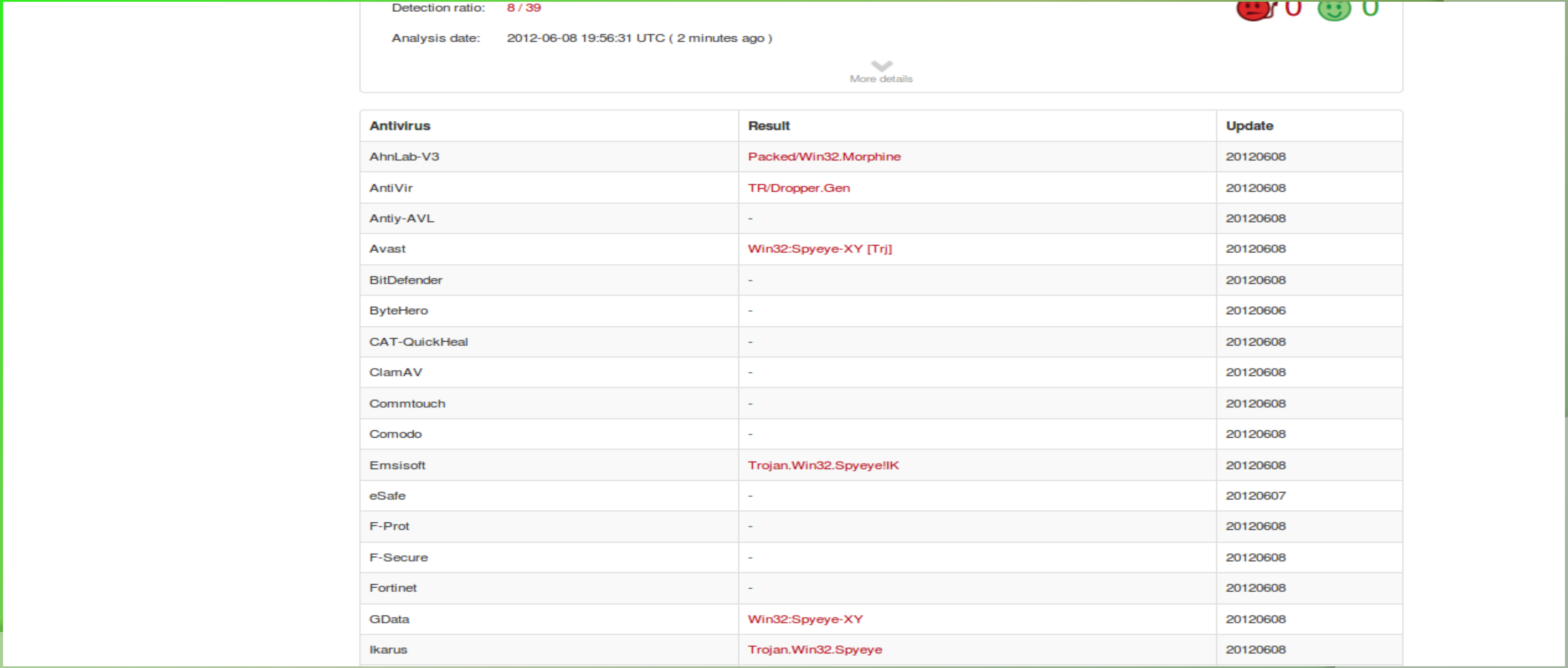
```
root@bt:~/Volatility# python vol.py -f infected.dmp vaddump -p 1748 -D dump/
Volatile Systems Volatility Framework 2.0
Pid:    1748
************************************************************************
root@bt:~/Volatility#
```



```
explorer.exe.935a360.00aa0000-00aaffff.dmp
explorer.exe.935a360.00ab0000-00b2ffff.dmp
explorer.exe.935a360.00b30000-00b31fff.dmp
explorer.exe.935a360.00b40000-00b4dfff.dmp
explorer.exe.935a360.0bb60000-0bbb9fff.dmp
explorer.exe.935a360.00bd0000-00c75fff.dmp
explorer.exe.935a360.00c80000-00c80fff.dmp
explorer.exe.935a360.00c90000-00cb9fff.dmp
explorer.exe.935a360.00e90000-00ecffff.dmp
explorer.exe.935a360.00ed0000-00ed1fff.dmp
explorer.exe.935a360.00ee0000-00f1ffff.dmp
explorer.exe.935a360.00f20000-00f5ffff.dmp
```

Step 9 – virustotal submission

Submission to virustotal, confirms the dumped executable as component of "spyeye"



Detection ratio: 8 / 39

Analysis date: 2012-06-08 19:56:31 UTC (2 minutes ago)

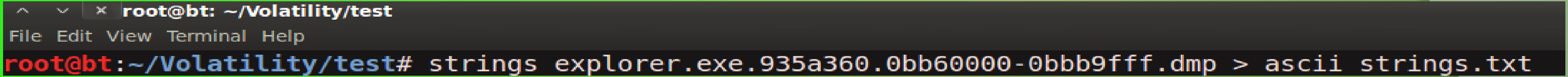
0 0

More details

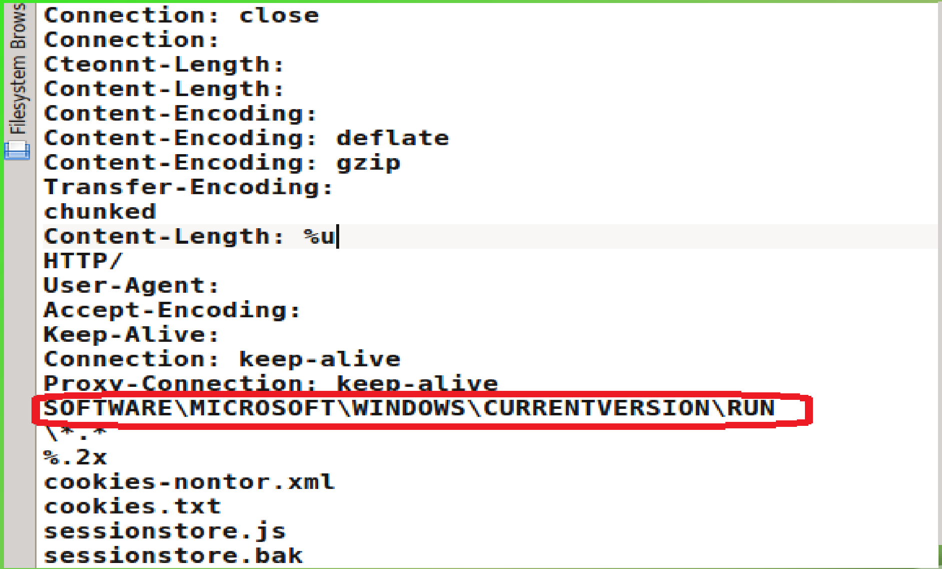
Antivirus	Result	Update
AhnLab-V3	Packed/Win32.Morphine	20120608
AntiVir	TR/Dropper.Gen	20120608
Antiy-AVL	-	20120608
Avast	Win32:Spyeye-XY [Trj]	20120608
BitDefender	-	20120608
ByteHero	-	20120606
CAT-QuickHeal	-	20120608
ClamAV	-	20120608
Commtouch	-	20120608
Comodo	-	20120608
Emsisoft	Trojan.Win32.Spyeye!IK	20120608
eSafe	-	20120607
F-Prot	-	20120608
F-Secure	-	20120608
Fortinet	-	20120608
GData	Win32:Spyeye-XY	20120608
Ikarus	Trojan.Win32.Spyeye	20120608

Step 10 – Can we get more info?

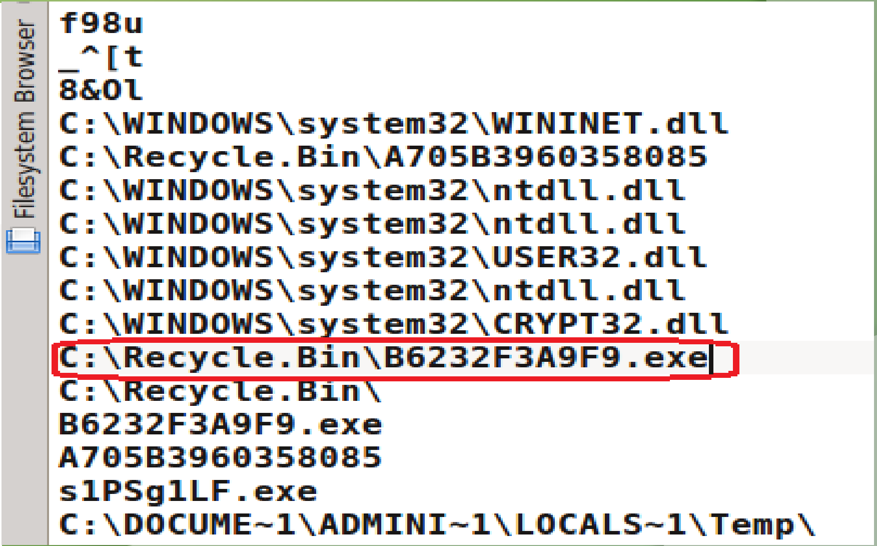
Strings extracted from the dumped executable, show reference to interesting artifacts (executable and the registry key)



```
root@bt:~/Volatility/test# strings explorer.exe.935a360.0bb60000-0bbb9fff.dmp > ascii strings.txt
```



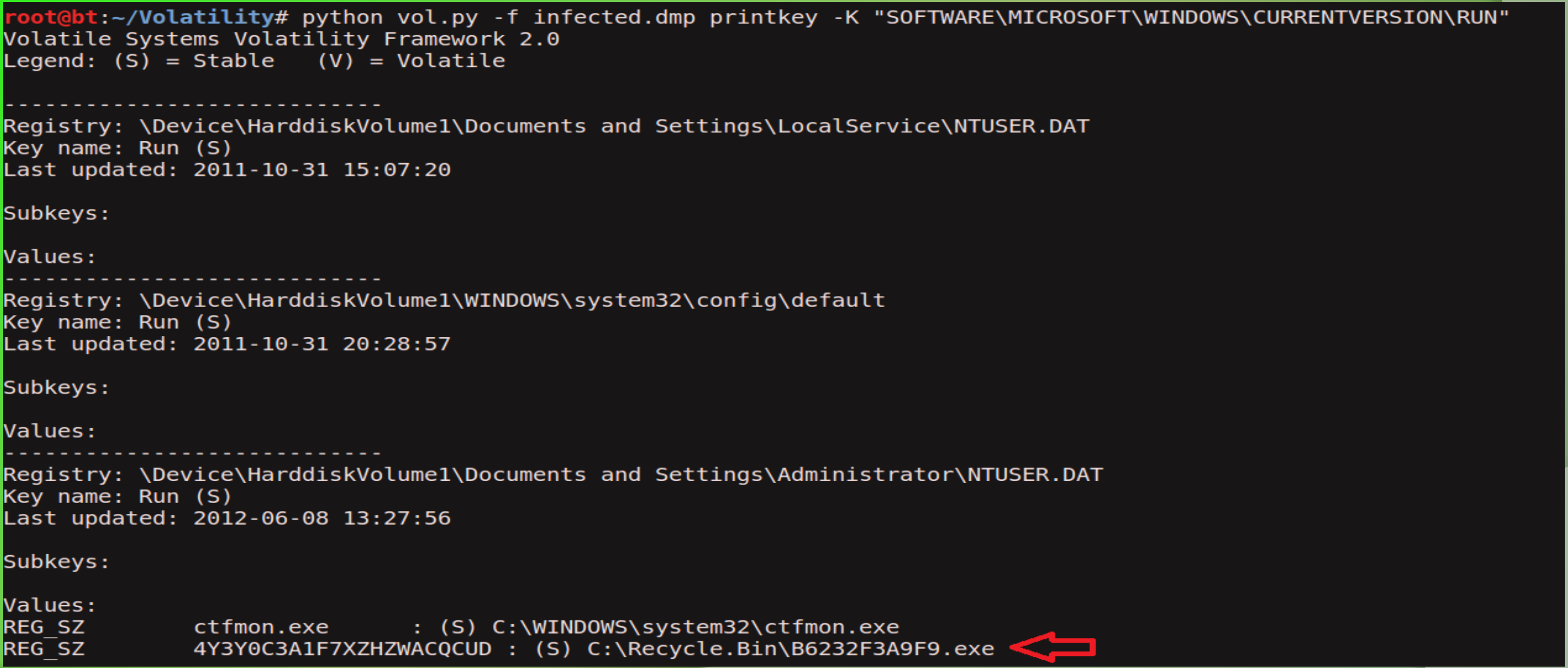
```
Connection: close
Connection:
Cteonnt-Length:
Content-Length:
Content-Encoding:
Content-Encoding: deflate
Content-Encoding: gzip
Transfer-Encoding:
chunked
Content-Length: %u
HTTP/
User-Agent:
Accept-Encoding:
Keep-Alive:
Connection: keep-alive
Proxy-Connection: keep-alive
SOFTWARE\MICROSOFT\WINDOWS\CURRENTVERSION\RUN
\*.*
%.2x
cookies-nontor.xml
cookies.txt
sessionstore.js
sessionstore.bak
```



```
f98u
_^[t
8&0l
C:\WINDOWS\system32\WININET.dll
C:\Recycle.Bin\A705B3960358085
C:\WINDOWS\system32\ntdll.dll
C:\WINDOWS\system32\ntdll.dll
C:\WINDOWS\system32\USER32.dll
C:\WINDOWS\system32\ntdll.dll
C:\WINDOWS\system32\CRYPT32.dll
C:\Recycle.Bin\B6232F3A9F9.exe
C:\Recycle.Bin\
B6232F3A9F9.exe
A705B3960358085
s1PSg1LF.exe
C:\DOCUME~1\ADMINI~1\LOCALS~1\Temp\
```

Step 11 – Printing the registry key

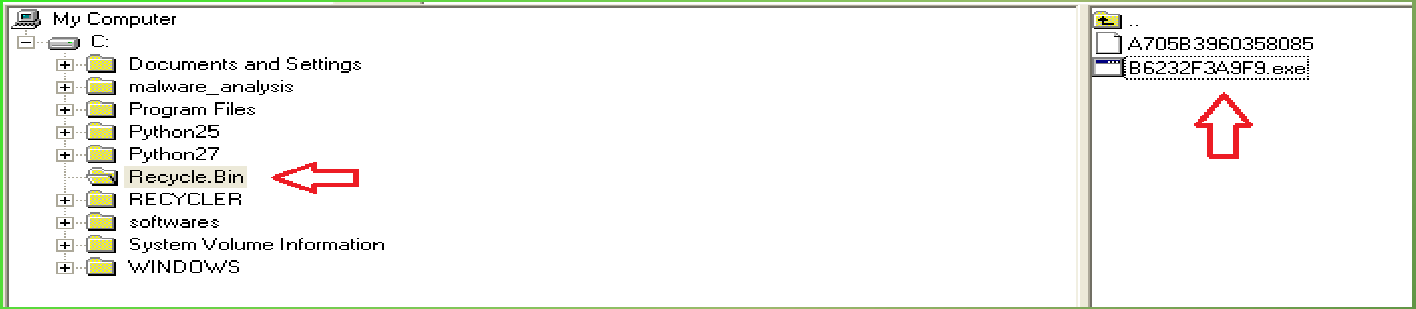
Malware creates registry key to survive the reboot



```
root@bt:~/Volatility# python vol.py -f infected.dmp printkey -K "SOFTWARE\MICROSOFT\WINDOWS\CURRENTVERSION\RUN"
Volatile Systems Volatility Framework 2.0
Legend: (S) = Stable   (V) = Volatile

----------------------------
Registry: \Device\HarddiskVolume1\Documents and Settings\LocalService\NTUSER.DAT
Key name: Run (S)
Last updated: 2011-10-31 15:07:20

Subkeys:

Values:
----------------------------
Registry: \Device\HarddiskVolume1\WINDOWS\system32\config\default
Key name: Run (S)
Last updated: 2011-10-31 20:28:57

Subkeys:

Values:
----------------------------
Registry: \Device\HarddiskVolume1\Documents and Settings\Administrator\NTUSER.DAT
Key name: Run (S)
Last updated: 2012-06-08 13:27:56

Subkeys:

Values:
REG_SZ        ctfmon.exe      : (S) C:\WINDOWS\system32\ctfmon.exe
REG_SZ        4Y3Y0C3A1F7XZHZWACQCUD : (S) C:\Recycle.Bin\B6232F3A9F9.exe
```

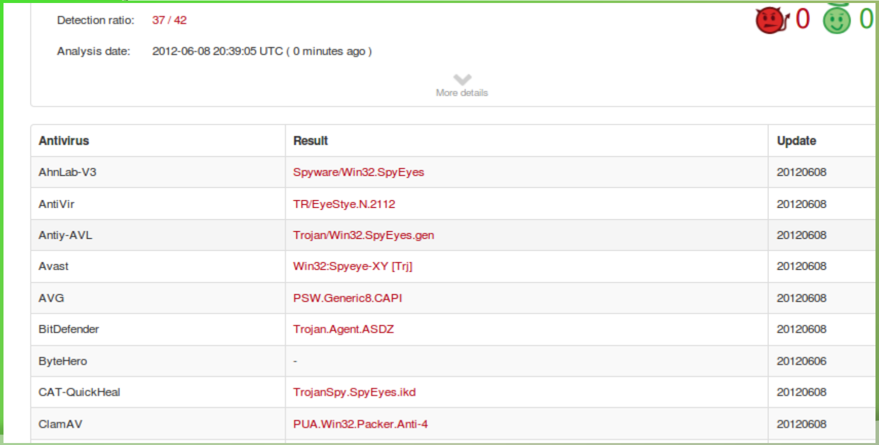
Step 12 – Finding the malicious exe on infected machine

Finding malicious sample from infected host and virustotal submission confirms spyeye infection



```
My Computer
  C:
    Documents and Settings
    malware_analysis
    Program Files
    Python25
    Python27
    Recycle.Bin
    RECYCLER
    softwares
    System Volume Information
    WINDOWS
```

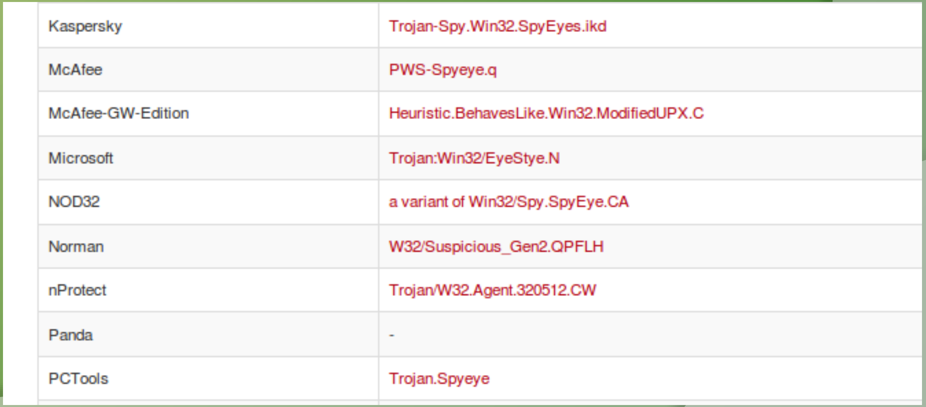
```
..
A705B3960358085
B6232F3A9F9.exe
```



Detection ratio: 37 / 42

Analysis date: 2012-06-08 20:39:05 UTC (0 minutes ago)

Antivirus	Result	Update
AhnLab-V3	Spyware/Win32.SpyEyes	20120608
AntiVir	TR/EyeStye.N.2112	20120608
Antiy-AVL	Trojan/Win32.SpyEyes.gen	20120608
Avast	Win32:Spyeye-XY [Trj]	20120608
AVG	PSW.Generic8.CAPI	20120608
BitDefender	Trojan.Agent.ASDZ	20120608
ByteHero	-	20120606
CAT-QuickHeal	TrojanSpy.SpyEyes.ikd	20120608
ClamAV	PUA.Win32.Packer.Anti-4	20120608



Kaspersky	Trojan-Spy.Win32.SpyEyes.ikd
McAfee	PWS-Spyeye.q
McAfee-GW-Edition	Heuristic.BehavesLike.Win32.ModifiedUPX.C
Microsoft	Trojan:Win32/EyeStye.N
NOD32	a variant of Win32/Spy.SpyEye.CA
Norman	W32/Suspicious_Gen2.QPFLH
nProtect	Trojan/W32.Agent.320512.CW
Panda	-
PCTools	Trojan.Spyeye

Reference

- Complete Reference Guide for Reversing & Malware Analysis Training

Thank You !

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