

EXHIBIT 2



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ZeroAccess Malware Part 4: Tracing the Crimeware Origins by Reversing Injected Code

Part 1: Introduction and De-Obfuscating and Reversing the User-Mode Agent Dropper

Part 2: Reverse Engineering the Kernel-Mode Device Driver Stealth Rootkit

Part 3: Reverse Engineering the Kernel-Mode Device Driver Process Injection Rootkit

Part 4: Tracing the Crimeware Origins by Reversing the Injected Code

In this final part we will trace the origins of the ZeroAccess rootkit. We will discover that the purpose of this rootkit is to set up a stealthy, undetectable and un-removable platform to deliver malicious software to victim computers. We will also see that ZeroAccess is being currently used to deliver FakeAntivirus crimeware applications that trick users into paying \$70 to remove the antivirus. It could be used to delivery any malicious application, such as one that steals bank and credit card information in the future. Further analysis and network forensics supports that ZeroAccess is being hosted and originates from the Ecatel Network, which is controlled by the cybercrime syndicate RBN (Russian Business Network).

Let's take a look at the max++ DLL. It is injected into other processes address space by the kernel mode driver reversed in Part 3. Here are the hashes for this DLL:

FileSize: 36.00 KB (36864 bytes)

MD5: 4CE2F6BA808954FA7B1257D4C754D5B0

SHA-1: E74EA961ADCA942623AE721283D33F6907A7C86D

No VersionInfo Available.

Resource: "TYPELIB".

max++.00.x86.dll does not have an ET (Export Table) entire code is contained into DllEntryPoint() function.

This malicious DLL is injected via APC and ZwAllocateVirtualMemory by the second installed driver. Recall that this driver finds newly loaded processes via PsSetLoadImageNotifyRoutine.

```

35672E02      and     esp, 0FFFFFFF8h
35672E05      mov     eax, [ebp+fdwReason]
35672E08      sub     esp, 194h
35672E0E      push   ebx
35672E0F      xor     ebx, ebx
35672E11      sub     eax, ebx
35672E13      push   esi
35672E14      push   edi
35672E15      jz     short loc_35672E8C ; if (fdwReason == 1)
35672E17      dec     eax
35672E18      jnz    loc_35672F12      ; Exit
35672E1E      call   ds:ZwTestAlert ; tests if current thread has been alerted
35672E24      push   [ebp+hLibModule] ; hLibModule
35672E27      call   ds:DisableThreadLibraryCalls
35672E2D      lea    eax, [esp+1A0h+WSAData]
35672E31      push   eax ; lpWSAData
35672E32      push   202h ; wVersionRequested
35672E37      call   ds:WSAStartup ; load WinSock 2.2
35672E3D      mov     eax, offset unk_356761E0
35672E42      mov     edi, offset unk_35676200
35672E47      mov     esi, eax
35672E49      cmp     eax, edi
35672E4B      jnb    short loc_35672E5C
35672E4D      loc_35672E4D: ; CODE XREF: DllEntryPoint+5B↓j
35672E4D      mov     eax, [esi]
35672E4F      add     esi, 4
35672E52      cmp     eax, ebx
35672E54      jz     short loc_35672E58
35672E56      call   eax ; Call a different routine for each iteration

```

This DLL can be debugged by using OllyDbg 1.10 LoadDLL utility. As this component is the just a small feature of ZeroAccess, we won't go into as much detail on it as we did with the two drivers and the user-mode agent.

The above ZwTestAlert function tests whether the current thread has been alerted (and clears the alerted flag). It also enables the delivery of queued user APCs. NextDisableThreadLibraryCalls disables the DLL_THREAD_ATTACH and DLL_THREAD_DETACH notifications for the DLL. By disabling the notifications, the DLL initialization code is not paged in because a thread is created or deleted, thus reducing the size of the application's working code set. This use of DisableThreadLibraryCalls increases invisibility for the injected DLL.

The call EAX is placed inside a do-while that updates the value pointed by EAX in iteration. This involves in calling a different routine each time. Let's look at the next code block:

```

call     eax                ; Call a different routine for each iteration

loc_35672E58:
; CODE XREF: DllEntryPoint+55↑j
cmp     esi, edi
jb     short loc_35672E4D

loc_35672E5C:
; CODE XREF: DllEntryPoint+4C↑j
push    1
call    sub_356752D7        ; Dll Stuff -> sub_356752D7(1)
push    ebx                ; lpThreadId
push    ebx                ; dwCreationFlags
push    ebx                ; lpParameter
push    offset StartAddress ; lpStartAddress
push    ebx                ; dwStackSize
push    ebx                ; lpThreadAttributes
call    ds:CreateThread
mov     handleThread, eax
cmp     eax, 0FFFFFFFFh
jnz    loc_35672F12
mov     handleThread, ebx
jmp     loc_35672F12        ; Exit

```

We see the API call completed. A thread is created, and we can inspect it by reaching the StartAddress argument. This new thread will invoke a couple of calls that will talk to a Command and Control (C&C) server. The C&C server will issue requests to websites that contain code to install further malicious code to be executed on the victim's machine.

From string analysis we can obtain some valuable information:

```

a??C2cad97240_0:
; DATA XREF: .rdata:356765A0↑o
nullcode 0, <\\?\C2CAD972#4079#4fd3#A68D#AD34CC121074\L\{FF1D3D65-8EB9}>
nullcode 0, <-4347-B8C5-C2EC822C6CC2>,0
aU
db 'ó',0 ; DATA XREF: .data:3567804↓o
aD_0
db 'ñ',0
dd offset a??C2cad97240_0 ; "\\?\C2CAD972#4079#4fd3#A68D#AD34CC12107"...
align 8

a??C2cad97240_1:
; DATA XREF: .rdata:356766E0↑o
nullcode 0, <\\?\C2CAD972#4079#4fd3#A68D#AD34CC121074\L\{7D718C60-B241}>
nullcode 0, <-4bcc-97C5-88875550460C>,0
aU_0
db 'ó',0 ; DATA XREF: .data:3567800↓o
aD_1
db 'ñ',0
dd offset a??C2cad97240_1 ; "\\?\C2CAD972#4079#4fd3#A68D#AD34CC12107"...
align 8

a??C2cad97240_2:
; DATA XREF: .rdata:35676700↑o
nullcode 0, <\\?\C2CAD972#4079#4fd3#A68D#AD34CC121074\L\{76620BB4-6C08}>
nullcode 0, <-49d2-AE35-480385646585>,0
aU_1
db 'ó',0 ; DATA XREF: .data:35678004↓o
aD_2
db 'ñ',0
dd offset a??C2cad97240_2 ; "\\?\C2CAD972#4079#4fd3#A68D#AD34CC12107"...
align 8

a??C2cad97240_3:
; DATA XREF: .rdata:356767B0↑o
nullcode 0, <\\?\C2CAD972#4079#4fd3#A68D#AD34CC121074\L\{F8E9DFD7-1EFD}>
nullcode 0, <-4f4a-96B1-5A693CF787B9>,0
aU_2
db 'ó',0 ; DATA XREF: .data:3567800C↓o
aD_3
db 'ñ',0
dd offset a??C2cad97240_3 ; "\\?\C2CAD972#4079#4fd3#A68D#AD34CC12107"...

```

All these entries as you can see are placed into the hidden NTFS volume that was analyzed previously. There are also other interesting strings like:

Want to learn more?? The InfoSec Institute **Reverse Engineering** course teaches you everything from reverse engineering malware to discovering vulnerabilities in binaries. These skills are required in order to properly secure an organization from today's ever evolving threats. **In this 5 day hands-on course, you will gain the necessary binary analysis skills to discover the true nature of any Windows binary.** You will learn how to recognize the high level language constructs (such as branching statements, looping functions and network socket code) critical to performing a thorough and professional reverse engineering analysis of a binary. Some features of this course include:

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- Learn the methodologies, tools, and manual reversing techniques used real world situations in our reversing lab.

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```
\registry\machine\Software\Microsoft\Internet Explorer\Main\{F9197A7E-CE10-458e-85F8-5B0CE6DF2BBE}
```

The CLSID encoding is of great help during malware forensics. It can be used to determine univocally malware type and version. A quick search show us that this CLSID belongs to Trojan-Ransom.Win32.Digitala.b which is a downloader Aagent.

The above code blocks are executed if fdwReason is satisfied. Otherwise execution flows to another block of code that essentially acts as a cleanup routine.

This injected DLL serves the purpose of generating web redirections to malicious websites that contain FakeAntivirus software. Fake antivirus software (a.k.a misleading applications or rogue antivirus) is big business nowadays with Symantec reporting 43 million installation attempts from over 250 distinct programs between July 1, 2009, to June 30, 2010. With fake AV software costing the victim anywhere from \$30 to \$100, this is a lucrative earner for criminals.

The malicious URLs are:

- <http://intensedive.com/install/setup.php?m=d310b08f1d6d&i=1&id=000069000>

- <http://intensedive.com/install/setup.php?m=d310b08f1d6d>
- <http://intensedive.com/updates/cleaner.dll?m=d310b08f1d6d>

The IP address behind these domains is 94.102.63.99. From www.robtex.com we can see the following graph



AS29073 belongs to Ecatel Network which is a well known crimeware friendly ISP.

<http://hphosts.blogspot.com/2009/11/crimeware-friendly-isps-ecatel-as29073.html>

Ecatel is infamous for the massive hosting of malware and spambots, the most widely used IPs are:

- 94.102.60.151
- 94.102.60.152
- 94.102.60.153
- 94.102.60.182
- 94.102.60.43
- 94.102.60.77

Detailed information on Ecatel activities can be seen here: <http://www.sudosecure.net/archives/333>

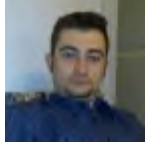
Often Ecatel was involved into fakeAV campaigns, and ZeroAccess drives to fake software download. From sudosecure.net we see a relation with the well-know cybercrime ring, RBN (Russian Business Network).

By Giuseppe Bonfa|November 15th, 2010|Reverse Engineering|6 Comments

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About the Author: **Giuseppe Bonfa**



Giuseppe is a security researcher for InfoSec Institute and a seasoned InfoSec professional in reverse-engineering and development with 10 years of experience under the Windows platforms. He is currently deeply focused on Malware Reversing (Hostile Code and Extreme Packers) especially Rootkit Technology and Windows Internals.

He has previously worked as Malware Analyst for Comodo Security Solutions as a member of the most known Reverse Engineering Teams and is currently a consultant for private customers in the field of Device Driver Development, Malware Analysis and Development of Custom Tools for Digital Forensics.

He collaborates with Malware Intelligence and Threat Investigation organizations and has even discovered vulnerabilities in PGP and Avast Antivirus Device Drivers.

As a technical author, Giuseppe has over 10 years of experience and hundreds of published pieces of research.

6 Comments

1. **Step-by-Step Reverse Engineering Malware: ZeroAccess / Max++ / Smiscer Crimeware Rootkit | InfoSec Resources** November 15, 2010 at 6:42 pm - Reply
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4.

ps November 18, 2010 at 11:04 am - Reply

Thank you for a great job!

A very worthwhile piece of reading to bookmark. After all, a single pass is not enough to truly absorb the information.

Even for those familiar with assembler and machine code, having a mechanical frame of reference to work from has a value in addition to having the tools collected together.

5. **InfoSec Training | SimplicIT Blog** February 4, 2011 at 6:52 pm - Reply

[...] He dives deep enough to determine the source of the botnet, and who the likely authors are: The RBN (Russian Business Network). His analysis has been featured in eWeek, Information Week, The Register, Packet Storm, and Threat [...]



6.

John March 26, 2012 at 2:17 pm - Reply

The programming techniques used to inject and hide ZeroAccess were very informative and demonstrate a sophisticated understanding of using the kernel.

But now what? What steps should be taken to delete or neutralize this rootkit? What tools are needed to remove the code?