that would require the use of an external program, and then the virus would no longer be ‘pure batch’), so a file will not be infected if it has the read-only attribute set.

LYME DISEASE

The virus has a fatal bug when run under *Windows XP*: the line ‘set _out=!_out!%%~’, which is supposed to append ‘%~’ (the double ‘%’ is required in order to emit a single ‘%’), does not append anything. It is not known why this happens, but it appears that a line cannot end with that sequence of special characters. The bug appears to be in *Windows*, not in the virus. If an additional character is added to the line, then all of the characters are appended correctly. If the virus had added that additional character, and then removed it after the characters were appended, then the virus would work on *Windows XP*, too. The bug causes the virus to fail to parse anything, and then to delete itself, because there is no new representation.

The virus has an ‘even more’ fatal bug when run under *Windows 2000* (the bug that exists in the *Windows XP* command processor is present here, too). The line ‘set /a _val1 += “_ind”’, which is supposed to select the case of the randomly selected letter, does not make use of the ‘_ind’ variable. Instead, the value is always treated as a zero. This might be considered to be a bug in *Windows*, rather than in the virus, however the behaviour is undefined because the documentation regarding the use of quotes is ambiguous regarding this situation. The virus contains another line in the same style, but without the quotes, so we can assume that this is a bug in the virus. If the quotes were removed, and if the fix were applied as for the *Windows XP* case, then the virus would work on *Windows 2000*, too. The bug causes the virus to emit strings that are composed solely of the letter ‘A’.

The virus works correctly on *Windows 7* without modification. This is especially interesting, because the virus writer is known for producing very compatible code. For example, most of his binary viruses still support *Windows 95*. His more recent viruses ‘merely’ require *Windows NT*. It is clear that he did not test this virus on anything other than a relatively recent platform such as *Windows Vista* (assuming that it works there – I did not try it) or *Windows 7*. Perhaps he finally upgraded his machine.

CONCLUSION

It’s clear that some people have too much time on their hands, to have found a way around all of the limitations and quirks of the batch language, and produced a virus like this. However, if we can’t stop them from writing viruses at all, then we can at least be thankful that they’re not writing something much worse than this.

TECHNICAL FEATURE 1

MALWARE DESIGN STRATEGIES FOR CIRCUMVENTING DETECTION AND PREVENTION CONTROLS – PART ONE

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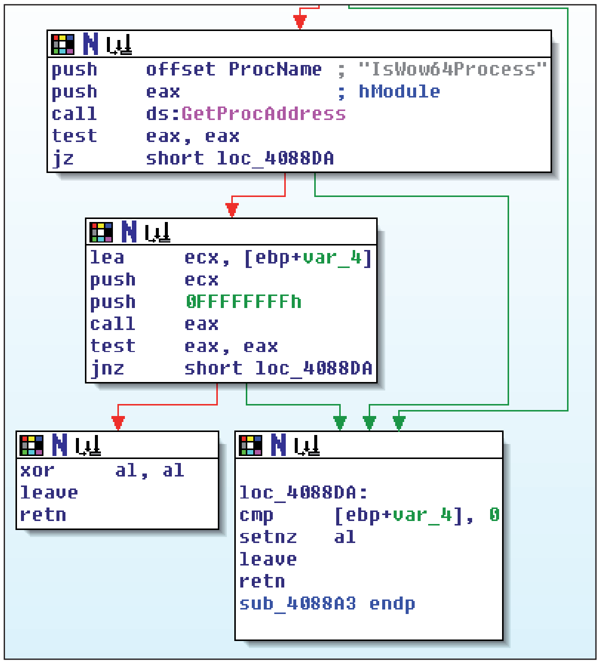
In this paper, we discuss some of the different techniques that are used by present-day malware to circumvent protection mechanisms.

1. DETECTING WINDOWS X86 EMULATOR

With the advent of *Windows* x64 systems, the x86 emulator has been added to provide backward compatibility. WOWx64 is an x86 emulator that allows 32-bit *Windows* applications to run on 64-bit *Windows*. Malware writers use an x86 emulator detection routine to get detailed information about the environment in which the malware is going to be executed. This is a critical step from the attacker’s perspective because in order to trigger successful DLL injection, a 32-bit process has to load a 32-bit DLL, thereby avoiding collisions with 64-bit DLLs. Malware writers harness the power of inbuilt



```
push     offset ProcName ; "IsWow64Process"
push     eax             ; hModule
call     ds:GetProcAddress
test     eax, eax
jz       short loc_4088DA
```

```
lea      ecx, [ebp+var_4]
push     ecx
push     0FFFFFFFFh
call     eax
test     eax, eax
jnz      short loc_4088DA
```

```
xor      al, al
leave
retn
```

```

loc_4088DA:
cmp      [ebp+var_4], 0
setnz    al
leave
retn
sub_4088A3 endp
```

Figure 1: x86 emulator detection using ‘IsWOW64Process’ in ICE bot.

APIs to call ‘IsWOW64Process()’ to detect the x86 environment. This function is called in conjunction with ‘CreateEnvironmentBlock()’, which is present in userenv.dll, to retrieve environmental information for a specific user. The extracted information is passed to the ‘CreateProcessAsUser()’ function to create a process within the security context of the targeted user. Figure 1 shows a code snippet extracted from ICE bot.

2. ANTI-VIRTUAL-MACHINE CODE

This technique has been used widely by malware writers to detect the presence of virtual machines. The primary aim is to make analysis of the malware harder by shutting down some of its functionality if a virtual machine is detected. There are several techniques that can be used to detect the presence of a Virtual Machine Environment (VME), as follows:

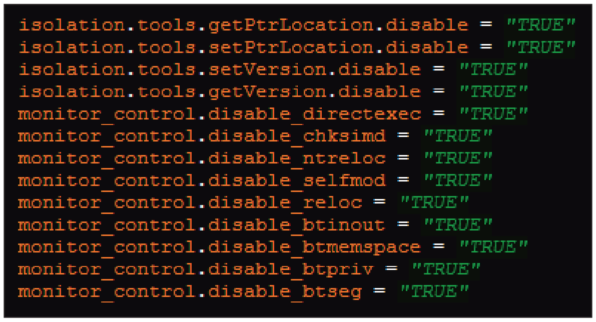
- Memory-specific techniques include Red Pill, which is a proof of concept that utilizes the Store Interrupt Descriptor Table (SIDT) to collect information about the Interrupt Descriptor Table Register (IDTR). The IDTR points directly to the Interrupt Descriptor Table (IDT) and, based on the memory address, Red Pill can detect the presence of a virtual machine. ScoopyNG [1] is another proof of concept that scrutinizes the location of the Local Descriptor Table (LDT), Global Descriptor Table (GDT), Interrupt Descriptor Table (IDT) and Store Task Register (STR) to determine the presence of a virtual machine. It also runs additional checks using *VMware* commands such as ‘get version’, ‘get memory size’ and ‘emulation check’. Any of these techniques can easily be deployed by malware to detect whether the code is inside a virtual machine. Listing 1 shows the output of ScoopyNG.

  VMDetect [2] uses an invalid opcode mechanism that acts as a backdoor code to detect a virtual machine. It uses the privileged ‘IN’ (reading from communication ports) instruction to check if an exception occurs as ‘EXCEPTION_PRIV_INSTRUCTION’, and uses this information to verify whether the code is executing under *VMware*. However, these protections can easily be subverted by disabling all the protection flags in the VM configuration files, as shown in Figure 2.

  Several samples of malware have been found using one of these memory-based techniques to design an anti-virtual-machine routine to subvert detection. (More details about virtual machine detection and analysis can be found at [3].)

```
C:\ScoopyNG>ScoopyNG.exe

####################################################
::       ScoopyNG - The VMware Detection Tool      ::
::              Windows version v1.0               ::

[+] Test 1: IDT
IDT base: 0x8003f400
Result  : Native OS

[+] Test 2: LDT
LDT base: 0xdead0000
Result  : Native OS

[+] Test 3: GDT
GDT base: 0x8003f000
Result  : Native OS

[+] Test 4: STR
STR base: 0x28000000
Result  : Native OS

[+] Test 5: VMware “get version” command
Result  : VMware detected
Version : Workstation

[+] Test 6: VMware “get memory size” command
Result  : VMware detected

[+] Test 7: VMware emulation mode
Result  : Native OS or VMware without emulation mode
          (enabled acceleration)

::                   tk,  2008                     ::
::                [ www.trapkit.de ]               ::
####################################################
```

Listing 1: ScoopyNG in action.

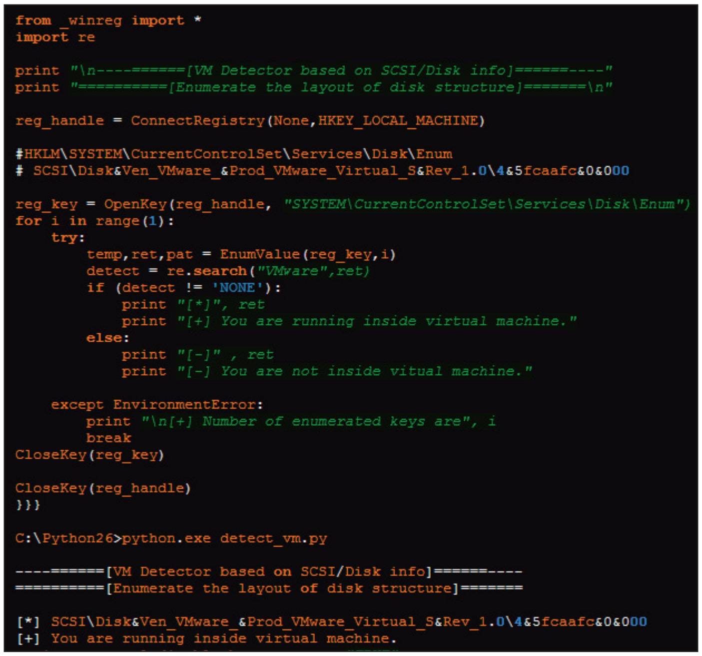


```
isolation.tools.getPtrLocation.disable = "TRUE"
isolation.tools.setPtrLocation.disable = "TRUE"
isolation.tools.setVersion.disable = "TRUE"
isolation.tools.getVersion.disable = "TRUE"
monitor_control.disable_directexec = "TRUE"
monitor_control.disable_chksimd = "TRUE"
monitor_control.disable_ntreloc = "TRUE"
monitor_control.disable_selfmod = "TRUE"
monitor_control.disable_reloc = "TRUE"
monitor_control.disable_btinout = "TRUE"
monitor_control.disable_btmemspace = "TRUE"
monitor_control.disable_btpriv = "TRUE"
monitor_control.disable_btseg = "TRUE"
```

Figure 2: Memory bypassing configuration parameters.

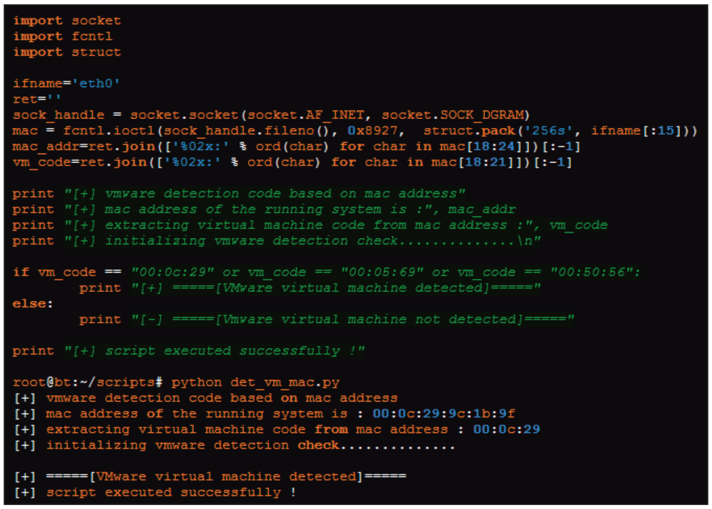
- Virtual machines make a number of adjustments in the *Windows* registry and create certain specific processes that can be utilized to detect the presence of a virtual machine environment. We have come across several registry-based settings that can be used to harness information about virtual machines. One of these is very critical as it is very hard for analysts to work around, as tampering with this key information could interfere with the booting state of the virtual machine. Figure 3 shows the *VMware* detection check based on SCSI/Disk info.

- *VMware* can easily be detected based on the Media Access Control (MAC) address. This is not a widely used technique because it is not difficult to tweak the MAC address of a system. *VMware* can be detected in this way because the first 24 bits of the MAC address define the manufacturer of the machine. Generally, MAC addresses for *VMware* machines always start with ‘00-05-69-xx-xx-xx’, ‘00-0c-29-xx-xx-xx’ or ‘00-50-56-xx-xx-xx’. If the MAC address matches any of the 24 bits discussed above then it is a *VMware* machine. Figure 4 shows *VMware* detection using this method.



```
from _winreg import *
import re

print "\n----======[VM Detector based on SCSI/Disk info]======----"
print "==========[Enumerate the layout of disk structure]=======\n"

reg_handle = ConnectRegistry(None,HKEY_LOCAL_MACHINE)

#HKLM\SYSTEM\CurrentControlSet\Services\Disk\Enum
# SCSI\Disk&Ven_VMware_&Prod_VMware_Virtual_S&Rev_1.0\4&5fcaafc&0&000

reg_key = OpenKey(reg_handle, "SYSTEM\CurrentControlSet\Services\Disk\Enum")
for i in range(1):
    try:
        temp,ret,pat = EnumValue(reg_key,i)
        detect = re.search("VMware",ret)
        if (detect != 'NONE'):
            print "[*]", ret
            print "[+] You are running inside virtual machine."
        else:
            print "[-]" , ret
            print "[-] You are not inside vitual machine."

    except EnvironmentError:
        print "\n[+] Number of enumerated keys are", i
        break
CloseKey(reg_key)

CloseKey(reg_handle)
}}}

C:\Python26>python.exe detect_vm.py

----======[VM Detector based on SCSI/Disk info]======----
==========[Enumerate the layout of disk structure]=======

[*] SCSI\Disk&Ven_VMware_&Prod_VMware_Virtual_S&Rev_1.0\4&5fcaafc&0&000
[+] You are running inside virtual machine.
```

Figure 3: SCSI/Disk-based VM detection.



```
import socket
import fcntl
import struct

ifname='eth0'
ret=''
sock_handle = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
mac = fcntl.ioctl(sock_handle.fileno(), 0x8927,  struct.pack('256s', ifname[:15]))
mac_addr=ret.join(['%02x:' % ord(char) for char in mac[18:24]])[:-1]
vm_code=ret.join(['%02x:' % ord(char) for char in mac[18:21]])[:-1]

print "[+] vmware detection code based on mac address"
print "[+] mac address of the running system is :", mac_addr
print "[+] extracting virtual machine code from mac address :", vm_code
print "[+] initializing vmware detection check..............\n"

if vm_code == "00:0c:29" or vm_code == "00:05:69" or vm_code == "00:50:56":
        print "[+] =====[VMware virtual machine detected]====="
else:
        print "[-] =====[Vmware virtual machine not detected]====="

print "[+] script executed successfully !"

root@bt:~/scripts# python det_vm_mac.py
[+] vmware detection code based on mac address
[+] mac address of the running system is : 00:0c:29:9c:1b:9f
[+] extracting virtual machine code from mac address : 00:0c:29
[+] initializing vmware detection check..............

[+] =====[VMware virtual machine detected]=====
[+] script executed successfully !
```

Figure 4: VMware detection based on MAC address.

- The Virtual Machine Communication Interface (VMCI) [4] is another target that can provide details about the running state of a virtual machine. VMCI provides an effective communication interface between the virtual machine and the host operating system. To detect whether code is running inside a virtual machine, malware writers can trace the installed VMCI device on the system. Simply, the malware can open a handle to the VMCI device(s) present on the system to verify the presence of a virtual machine. Table 1 presents the information that is required to query the VMCI interfaces on *Linux* and *Windows* operating systems.

Operating system	**VMware VMCI details**
Linux	• Host machine: /dev/vmmon • Guest machine: /dev/vmci
Windows	• Host machine: \\.\vmx86 • Guest machine: \\.\VMCI

Table 1: VMCI details of VMware.

Malware writers typically look for ‘\\.\VBoxGuest’ to determine if a virtual box is present on the system.

3. INJECTIONS USING APC

DLL injection has been around for several years and is used very effectively by malware writers. This technique is used to inject an unauthorized DLL into the target process at runtime to hook specific functions so that execution flow can be redirected. Until now, malware writers have explicitly used three standard techniques for performing DLL injection: ‘CreateRemoteThread’, ‘SetWindowsHook’ and ‘Appinit_dlls’. However, recently APC-based DLL injection has been seen in the wild. Both user- and kernel-mode Asynchronous Procedure Calls (APCs) [5, 6] are used to build robust malware. All the APC-based routines require the _KAPC structure, which is called using the ‘nt!KeInitializeApc’ call. The details are shown in Listing 2.

The kernel-mode and user-mode functions executed through the APC procedure are termed kernel-mode and user-mode routines, respectively. APC-based DLL injection can be used by both user-land and kernel-land rootkits, as discussed in the following sections.

```
nt!_KAPC
   +0x000 Type             : UChar
   +0x001 SpareByte0       : UChar
   +0x002 Size             : UChar
   +0x003 SpareByte1       : UChar
   +0x004 SpareLong0       : Uint4B
   +0x008 Thread           : Ptr32 _KTHREAD
   +0x00c ApcListEntry     : _LIST_ENTRY
   +0x014 KernelRoutine    : Ptr32
   +0x018 RundownRoutine   : Ptr32
   +0x01c NormalRoutine    : Ptr32
   +0x020 NormalContext    : Ptr32 Void
   +0x024 SystemArgument1  : Ptr32 Void
   +0x028 SystemArgument2  : Ptr32 Void
   +0x02c ApcStateIndex    : Char
   +0x02d ApcMode          : Char
   +0x02e Inserted         : Uchar

NTKERNELAPI VOID KeInitializeApc (
IN PRKAPC Apc,
IN PKTHREAD Thread,
IN KAPC_ENVIRONMENT Environment,
IN PKKERNEL_ROUTINE KernelRoutine,
IN PKRUNDOWN_ROUTINE RundownRoutine OPTIONAL,
IN PKNORMAL_ROUTINE NormalRoutine OPTIONAL,
IN KPROCESSOR_MODE ApcMode,
IN PVOID NormalContext
);
nt!_KAPC_STATE
   +0x000 ApcListHead      : [2] _LIST_ENTRY
   +0x010 Process          : Ptr32 _KPROCESS
   +0x014 KernelApcInProgress : UChar
   +0x015 KernelApcPending : UChar
   +0x016 UserApcPending   : Uchar
```

Listing 2: Details of _KAPC structure.

3.1 User-mode APC injection

Malware writers define a custom APC function that is allowed to execute asynchronously in the context of the target thread, provided that the thread is in a waiting (alertable) state. User-mode rootkits use APC techniques extensively to inject unauthorized code into target processes. Generally, in every process the thread has its own APC queue. Rootkits queue a malicious APC for an alertable thread in the process. When the thread receives a queued APC, its waiting state is over and it processes the queued request, resulting in execution of the malicious APC procedure. Before executing the APC routine, a thread triggers one of the four waiting functions: KeWaitForSingleObject, KeWaitForMultipleObjects, KeWaitForMutexObject, or KeDelayExecutionThread. In user-mode APCs, the primary calling routine is defined in user mode so the APC procedure (implementation) has to switch back to ring 3 for successful execution.

3.2 Kernel-mode APC injection

Kernel-mode APC injection is categorized into two types: regular kernel-mode APC and special kernel-mode APC. In regular kernel-mode APC, the target kernel-mode routine is executed at passive interrupt request level (IRQL), whereas special kernel-mode APC triggers the target kernel-mode routine at APC IRQL. Both special and regular kernel-mode APCs are asynchronous events that have the ability to direct the flow of execution in threads from normal state to the target kernel routine by taking them out of their waiting states. The only difference is that regular kernel-mode APC is executed in more restricted conditions.

The complete details of kernel-mode and user-mode APC can be found in [7]. ZeroAccess [8] (and see p.4) is an example of malware that has shown the usage of code execution through APC. Listing 3 shows a simple prototype of APC injection in action.

4. MUTEX-BASED DETECTION

Many malware writers use mutex-based detection techniques to determine whether an operating system has any security programs installed on it. A mutex [9] is typically a mutual exclusion lock and is used to protect the different resources and data from being accessed concurrently. Malware writers define the mutex routine in the main entry point of the malware. The primary aim is to detect whether any other installed program is using that mutex. Generally, malware writers have knowledge of the mutexes (unique mutex names) that are used by different protection programs or anti-virus software that may be installed on the system. In *Windows*-based malware, the CreateMutex() API is used extensively to detect the presence of any type of mutex in the system. The entry routine defined in the malware code triggers this API to scrutinize whether the mutex is already present in the system. If the mutex exists, the API returns an error message – which shows that protection programs have already been installed on the running machine. Based on this information, the malware stops its execution and becomes dormant. Zeus, SpyEye, ICEX and several other bots use this technique.

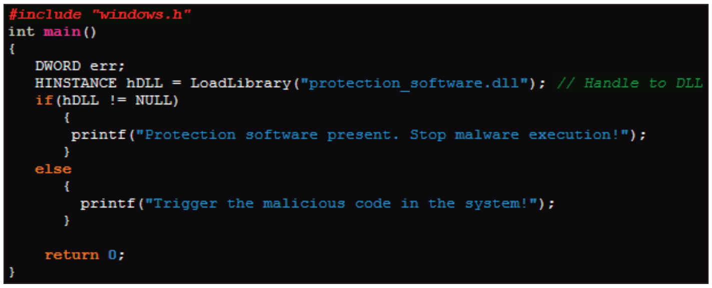
Mutexes are also used in bot wars. Based on mutex information, one bot can kill another to increase its kingdom of infections. In this case, the OpenMutex() API is used to access the running mutex in the system. The kind of API used for collecting mutex information from the system depends on the malware writer's choice. This functionality has been seen in earlier versions of SpyEye, which had an inbuilt Zeus-killing routine that used named pipes and designated commands to kill the Zeus bot in the system.

```
#define _WIN32_WINNT 0x0500
#include <windows.h>
#include <ntdef.h>

DWORD Trigger_APCInject(PCHAR sProcName,PCHAR
sDllName){
 DWORD dRet=0;

 Step 1 : Define the NtMapViewOfSection by calling
GetProcAddress and GetModuleHandle
 to load the NtMapViewOfSection by importing ntdll.
dll

 Step 2 : Allocate buffer by calling
CreateFileMapping and defining the
 view of the file by calling MapViewOfFile

 Step 3 : Define the PROCESS_INFORMATION and
STARTUPINFO structure using ZeroMemory

 Step 4 : At this point, create the suspended process
by using CreateProcess then call
 NtMapViewOfSection, LoadLibrary, GetProcAddress and
QueueUserAPC

 Step 5: Trigger the UnmapViewOfFile to release the
address space in the process that
 is occupied during mapped view of the file.
 }

int main(void){
 DWORD dwHandle= Trigger_APCInject(Target_Process_
for_Injection,DLL_To_Be_Injected);
 if(!dwHandle)
 puts("[+] APC Injection Successfull”);
 else
 printf("[-] APC Injection Fails -> %d!”,dwHandle);
 return 0;

}
```

Listing 3: Prototype of APC injection.

5. EXPLICIT RUNTIME LINKING

To detect the presence of security programs in the *Windows* operating system, malware writers use the de facto standard of runtime dynamic linking of system DLLs. This technique allows malware writers to design a generic routine that calls the LoadLibrary() API to dynamically load the target library into the address space of the calling process. The GetProcAddress() API is used afterwards to resolve the address of the loaded library in the system. The detection routine is very simple. Since the malware writers have information about the specific set of DLLs used in sandbox programs, anti-virus software and many others, if the required DLL is loaded through the LoadLibrary() API, it means the system is equipped with the protection software and the malware stops its execution and does not interact with the system. If the required DLL is not found in the system, then the malware starts the infection process. Figure 5 shows the idea behind this detection technique.



```
#include "windows.h"
int main()
{
   DWORD err;
   HINSTANCE hDLL = LoadLibrary("protection_software.dll"); // Handle to DLL
   if(hDLL != NULL)
      {
       printf("Protection software present. Stop malware execution!");
      }
   else
      {
        printf("Trigger the malicious code in the system!");
      }

    return 0;
}
```

Figure 5: Detection-based explicit runtime linking.

In the first part of this article, we have presented some of the tactics used by malware writers to design code that is resistant to the detection routines used by malware analysts. We will continue the discussion in part two of the article, in which we will look at advanced anti-debugging, polymorphism, tactical encryption routines, subverting client-side protection software, bypassing anti-virus solutions, etc.

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