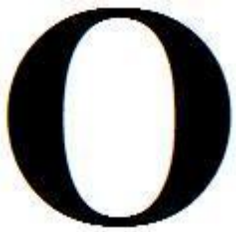
The oark book: http://code.google.com/p/oark/



The Open Source Anti Rootkit

David Reguera Garcia aka Dreg - Dreg@fr33project.org

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Contents

Chapter 1
Call Gates

A Call Gate[1] is a mechanism in the Intel x86 architecture to change privilege levels of the CPU when running a predefined function that is called by the instruction CALL/JMP FAR.

A call to a Call Gate allows you to obtain higher privileges than the current, for example we can execute a routine in ring0 using a CALL FAR in ring3. A Call Gate is an entry in the GDT (Global Descriptor Table) or LDT (Local Descriptor Table).

Windows doesn't use Call Gate for anything special, but there are malware, as the worm Gurong.A[2] , that installs a Call Gate via DevicePhysicalMemory to execute code on ring0. An article that talks about it is "Playing with Windows/dev/(k)mem"[3].

Nowadays we can't easily access to /Device/PhysicalMemory, I recommend reading the presentation by Alex Ionescu at RECON 2006 "Subverting Windows 2003 SP1 Kernel Integrity Protection"[4]. Also, there are examples in the wired that use the API ZwSystemDebugControl[5] to install a Call Gate, but Ionescu's article says that it doesn't work nowadays (although there are techniques to reactivate them).

An entry in the GDT/LDT looks like this:

```
typedef struct _SEG_DESCRIPTOR
{
    WORD size_00_15;
    WORD baseAddress_00_15;
    WORD baseAddress_16_23:8;
    WORD type:4;
    WORD sFlag:1;
    WORD dpl:2;
    WORD pFlag:1;
    WORD size_16_19:4;
    WORD notUsed:1;
    WORD lFlag:1;
    WORD DB:1;
    WORD gFlag:1;
    WORD baseAddress_24_31:8;
} SEG_DESCRIPTOR, *PSEG_DESCRIPTOR;
```

Listing 1.1: GDT/LDT Descriptor structure

[1] *Intel 64 and IA-32 Architectures, Software Developers Manual, System Programming Guide, Part 1.* URL: http://www.intel.com/design/processor/manuals/253668.pdf.

[2] F-secure. "W32/Gurong.A: A worm in e-mails and in Kazaa shared folders. It has a rootkit functionality. This worm appeared on the 21st of March 2006." In: (2006). URL: http://www.f-secure.com/v-descs/gurong_a.shtml.

[3] crazylord. "Playing with Windows /dev/(k)mem". In: (2002). URL: http://www.phrack.com/issues.html?issue=59&id=16.

[4] Alex Ionescu. "RECON 2006: Subverting Windows 2003 SP1 Kernel Integrity Protection". In: (2006). URL: http://www.alex-ionescu.com/recon2k6.pdf.

[5] Undocumented NT Internals. *Function NtSystemDebugControl is used by some low-level debuggers written by Microsoft and avaiable typically in DDK.* URL: http://undocumented.ntinternals.net/UserMode/Undocumented%20Functions/Debug/NtSystemDebugControl.html.

A Call Gate is an entry type in the GDT/LDT which has the following appearance:

```
typedef struct _CALL_GATE_DESCRIPTOR
{
    WORD offset_00_15;
    WORD selector;
    WORD argCount:5;
    WORD zeroes:3;
    WORD type:4;
    WORD sFlag:1;
    WORD dpl:2;
    WORD pFlag:1;
    WORD offset_16_31;
} CALL_GATE_DESCRIPTOR, *PCALL_GATE_DESCRIPTOR;
```

Listing 1.2: Call Gate Descriptor structure

- **offset_00_15:** is the bottom of the address of the routine to be executed in ring0, **offset_16_31** is the top.
- **selector:** specifies the code segment with the value KGDT_R0_CODE (0x8), the routine will run ring0 privileges.
- **argCount:** the number of arguments of the routine in DWORDs.
- **type:** the descriptor type for a 32-bit Call Gate needs the value 0xC
- **dpl:** minimum privileges that the code must have to call the routine, in this case 0x3, because it will be called by the routine ring3

To create a Call Gate we can follow the following steps:

1. Build the Call Gate that points to our routine.
2. Set the code only in a core (remember: there are a GDT for each CORE).
3. Read the GDTR register in order to find the GDT address and the size using SGDT instruction:

   ```
   typedef struct _GDTR
   {
       WORD nBytes;
       DWORD baseAddress;
   } GDTR;
   ```

   Listing 1.3: GDTR register

   We can obtain the number of entries (number of GDT descriptors) with GDTR.nBytes/8.
4. Find a free entry in the GDT/LDT.
5. Write the Call Gate descriptor.
6. To call the Call Gate is only necessary to make a CALL/JMP FAR to the GDT/LDT selector:

- ie if we've introduced the Call Gate at the entry **100** of the **GDT**, the user space application must execute a CALL/JMP FAR **0x320**:00000000. 0x320 is in binary 1100100 **0** 00, then the entry is:1100100 (100 in binary is 1100100), **TI=0** (entry is in **GDT**) RPL=00.. The other part of the FAR CALL is not useful but must be in the instruction.
- ie if we've introduced the Call Gate at the entry **100** of the **LDT**, the user space application must execute a CALL/JMP FAR **0x324**:00000000. 0x324 is in binary 1100100 **1** 00, then the entry is:1100100 (100 in binary is 1100100), **TI=1** (entry is in **LDT**) RPL=00..

Chapter 2
PEB Hooking

Chapter 3
Introduction

This chapter's content.. keyword1

Pasting code...

3.1 Introduction Section

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3.1.1 sub Introduction

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[1] **usserman**.

Bibliography

[AK04] Chris Anley and Jack Koziol. *The Shellcoder's Handbook: Discovering and Exploiting Security Holes*. Wiley, 2004. ISBN: 0764544683. URL: http://www.amazon.com/Shellcoders-Handbook-Discovering-Exploiting-Security/dp/0764544683.

[Bak00] Art Baker. *The Windows 2000 Device Driver Book: A Guide for Programmers (2nd Edition)*. Prentice Hall, 2000. ISBN: 0130204315. URL: http://www.amazon.com/Windows-2000-Device-Driver-Book/dp/0130204315.

[Blu09] Bill Blunden. *The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System*. Jones And Bartlett Publishers, 2009. ISBN: 1598220616. URL: http://www.amazon.com/Rootkit-Arsenal-Escape-Evasion-Corners/dp/1598220616.

[cra02] crazylord. "Playing with Windows /dev/(k)mem". In: (2002). URL: http://www.phrack.com/issues.html?issue=59&id=16.

[Dab99] Prasad Dabak. *Undocumented Windows NT*. Hungry Minds, 1999. ISBN: 0764545698. URL: http://www.amazon.com/Undocumented-Windows-NT%C2%AE-Prasad-Dabak/dp/0764545698.

[EC05] Eldad Eilam and Elliot J. Chikofsky. *Reversing: Secrets of Reverse Engineering*. Wiley, 2005. ISBN: 0764574817. URL: http://www.amazon.com/Reversing-Secrets-Engineering-Eldad-Eilam/dp/0764574817/ref=pd_sim_b_2.

[Eri08] Jon Erickson. *Hacking: The Art of Exploitation, 2nd Edition*. No Starch Press, 2008. ISBN: 1593271441. URL: http://www.amazon.com/Hacking-Art-Exploitation-Jon-Erickson/dp/1593271441/ref=pd_sim_b_12.

[Fs06] F-secure. "W32/Gurong.A: A worm in e-mails and in Kazaa shared folders. It has a rootkit functionality. This worm appeared on the 21st of March 2006." In: (2006). URL: http://www.f-secure.com/v-descs/gurong_a.shtml.

[Har10] Johnson M. Hart. *Windows System Programming (4th Edition)*. Addison-Wesley Professional, 2010. ISBN: 0321657748. URL: http://www.amazon.com/Windows-Programming-Addison-Wesley-Microsoft-Technology/dp/0321657748/ref=pd_sim_b_19.

[HB05] Greg Hoglund and James Butler. *Rootkits: Subverting the Windows Kernel*. Addison-Wesley Professional, 2005. ISBN: 0321294319. URL: http://www.amazon.com/Rootkits-Subverting-Windows-Greg-Hoglund/dp/0321294319.

[Inta] *Intel 64 and IA-32 Architectures, Software Developers Manual, System Programming Guide, Part 1*. URL: http://www.intel.com/design/processor/manuals/253668.pdf.

[Intb] Undocumented NT Internals. *Function NtSystemDebugControl is used by some low-level debuggers written by Microsoft and avaiable typically in DDK*. URL: http://undocumented.ntinternals.net/UserMode/Undocumented%20Functions/Debug/NtSystemDebugControl.html.

[Ion06] Alex Ionescu. "RECON 2006: Subverting Windows 2003 SP1 Kernel Integrity Protection". In: (2006). URL: http://www.alex-ionescu.com/recon2k6.pdf.

[Nag97] Rajeev Nagar. *Windows NT File System Internals : A Developer's Guide*. O'Reilly Media, 1997. ISBN: 1565922492. URL: http://www.amazon.com/Windows-File-System-Internals-Developers/dp/1565922492.

[One02] Walter Oney. *Programming the Microsoft Windows Driver Model*. Microsoft Press, 2002. ISBN: 0735618038. URL: http://www.amazon.com/Programming-Microsoft-Windows-Driver-Model/dp/0735618038.

[Orw07] Penny Orwick. *Developing Drivers with the Windows Driver Foundation*. Microsoft Press, 2007. ISBN: 0735623740. URL: http://www.amazon.com/Developing-Drivers-Windows-Foundation-Developer/dp/0735623740.

[PH07] Daniel Pravat and Mario Hewardt. *Advanced Windows Debugging*. Addison-Wesley Professional, 2007. ISBN: 0321374460. URL: http://www.amazon.com/Advanced-Windows-Debugging-Mario-Hewardt/dp/0321374460/ref=pd_sim_b_24.

[Ree10] Ron Reeves. *Windows 7 Device Driver*. Addison-Wesley Professional, 2010. ISBN: 0321670213. URL: http://www.amazon.com/Windows-Device-Addison-Wesley-Microsoft-Technology/dp/0321670213.

[RSI09] Mark E. Russinovich, David A. Solomon, and Alex Ionescu. *Windows Internals: Including Windows Server 2008 and Windows Vista, Fifth Edition (PRO-Developer)*. Microsoft Press; 5th ed. edition, 2009. ISBN: 0735625301. URL: http://www.amazon.com/Windows%C2%AE-Internals-Including-Windows-PRO-Developer/dp/0735625301/ref=pd_sim_b_3.

[Sch01] Sven B. Schreiber. *Undocumented Windows 2000 Secrets: A Programmer's Cookbook*. Addison-Wesley Professional, 2001. ISBN: 0201721872. URL: http://www.amazon.com/Undocumented-Windows-2000-Secrets-Programmers/dp/02017218722.

[Szo05] Peter Szor. *The Art of Computer Virus Research and Defense*. Addison-Wesley Professional, 2005. ISBN: 0321304543. URL: http://www.amazon.com/Art-Computer-Virus-Research-Defense/dp/0321304543/ref=sr_1_1?ie=UTF8&s=books&qid=1296406709&sr=8-1.

[Vie07] Ric Vieler. *Professional Rootkits (Programmer to Programmer)*. Wrox, 2007. ISBN: 0470101547. URL: http://www.amazon.com/Professional-Rootkits-Programmer-Ric-Vieler/dp/0470101547.

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