A look inside the Windows Kernel

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LSE

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Plan

1. Introduction

Introduction

What this talk is about?

- Security of the Windows Kernel
- Presentation of some exploits
- What changed in the security of the kernel, since Windows NT 5.1 (Windows XP)

Motivation for attacking the kernel

- Sandbox bypassing
- Full access to everything
- The fun

Plan

1. Introduction
2. Basics of Windows Kernel
3. CVE-2011-1237
4. Evolution from XP to 8
5. CVE-2013-3660
6. Conclusion

Plan

2 Basics of Windows Kernel

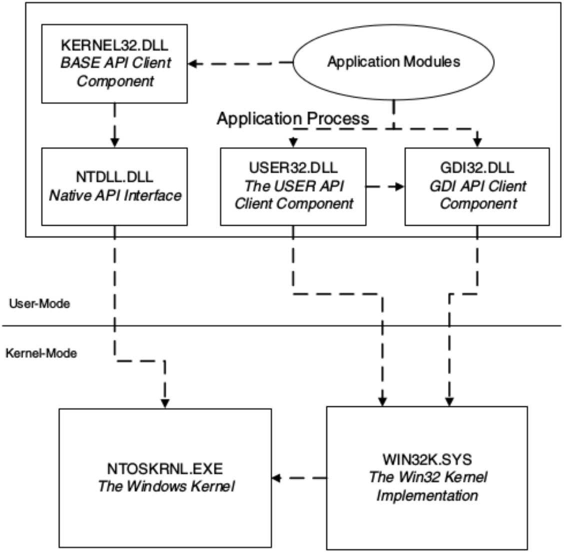

Figure 3.3 The Win32 interface DLLs and their relation to the kernel components.

HAL

- HAL : The hardware abstraction layer (hal.dll)
- ”a layer of software that deals directly with your computer hardware.” (msdn)
- Layer for suporting different hardware with the same software
- HalDispatchTable : holds the addresses of a few HAL routines

Win32k.sys

- Kernel mode driver
- Introduce in NT 4.0 for performance reason
- Two parts :
  - The Graphics Device Interface (GDI)
  - The Window Manager

User objects

- User entities (Windows, menu, keyboard layout. . .)
- Managed by the Window Manager
- Represented by a handle
- Handle table keeps track of each user object
  - The address of the object
  - The type of the object
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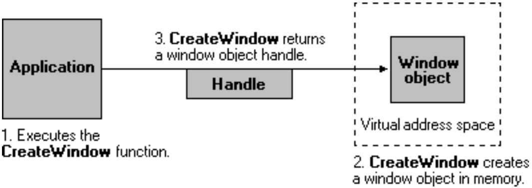

User-Mode Callback

- A way to communicate between kernel and user:
  - access to some structures in user mode
  - used to support hooking
  - ...
- CBT-Hook: receive notifications from windows
- WindowProc: callback function wich processes the messages sent to a window

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- Use After Free of a window object (User Object)
  - During the creation of a new window, you can give a parent in a CBT-Hook
  - Using another hook during the creation, you can destroy this window
  - We have a way to allocate a buffer with our content and the size we want with *SetWindowTextW*. We will use it to put what we want at the position of the free window
  - The parent is used at the end of *LinkWindow*, and it has been freed
- We can map the Null page and put our shellcode in it, in userland. Our goal is to call it

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Link Window

- Basically, it just adds an element in a double chained list of windows
- clockObj: part of each User Object, reference counter
- Since we control one of the objects we can decrement an arbitrary a word by one
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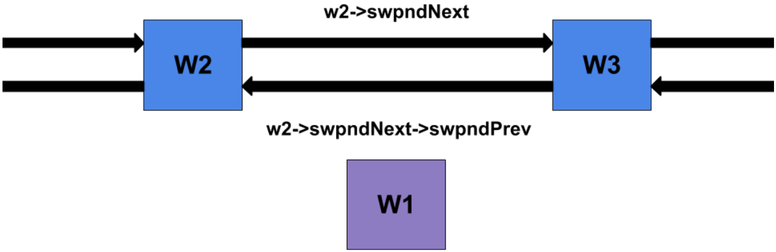

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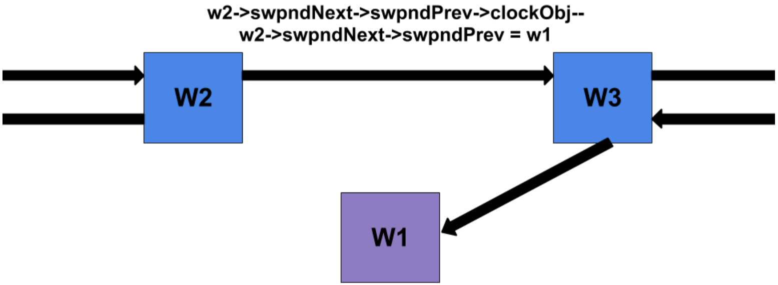

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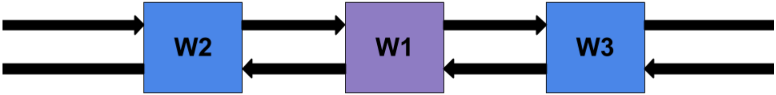

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- Activate the hook
- Create a third window (E)
  - HCBT_CREATEWND: link with the window A
  - WM_NCCREATE: destroy A (DestroyWindow), realloc with a fake object (SetWindowTextW on B)
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  - Kernel Address = User Address - Local module base + Kernel module base
- Enhanced /GS
- Guard pages
- DEP improvements
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- Exploit by Tavis Ormandy and progmboy
- In *win32k!EPATHOBJ::pprFlattenRec*
- Uninitialized pointer for the next in a double linked list (part of a Path object in the GDI in win32k)
- To-userspace dereferences vulnerability
- We want to trigger a write-what-where vulnerability

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Pathrec struct

```
struct _PATHRECORD {
    struct _PATHRECORD *next;
    struct _PATHRECORD *prev;
    ULONG flags;
    ULONG count;
    POINTFIX points[x];
}
```

- We need to make a specific AllocObject fail to trigger the exploitable condition: we need memory pressure.
- Allocation of the struct of a PATHREC is done of two possible ways
  - The PATHALLOC system use *HeavyAllocPool* for allocating object but have is own implementation of the free list
  - After allocating from *HeavyAllocPool*, it memsets to 0
  - But in the case of taking an element of the freelist it's not set to 0
- If we can spam the freelist with what we want we have big chances to have the next pointer where we want (in userspace)
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bFlatten and pprFlatten

- *EPATHOBJ::bFlatten* just goes through a list and calls *pprFlattenRec* if a flag is set on the element
- *EPATHOBJ::pprFlattenRec*
  - allocates a new pathrec
  - initialises the new (but not the next at this point)
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Getting execution

- We can write the address of something we don't control but we control the contents of the first pointer in it: it's the address of our next element in the list
- We can write in the *HalDispatchTable* our pointer on the next will be considered as code when calling the function.
- So we need an address which is a valid pointer for the *bFlatten* loop and a valid code for execution like

```
inc eax ; 0x40
jmp dword ptr [ebp+0x40] ; 0xff6540
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- We will rewrite the *HALDispatchTable[1]*, called by *NtQueryIntervalProfile* and not used for a lot of other things
- The `ebp+0x40` corresponds to the second argument of the *NtQueryIntervalProfile* where we put the address of our shellcode

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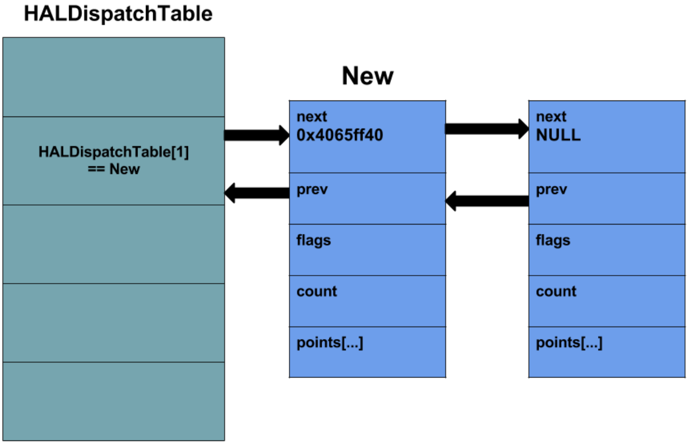

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- Allocate three structs PATHRECORD that we need, in particular the one at a precise address (0x4065ff40)
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Plan

6 Conclusion

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- A lot of improvements between XP and Windows 8
- Lot of checks so exploits are really harder
- Still doable

Questions ?

- Tarjei Mandt (@kernelpool)
- Tavis Ormandy (@taviso)
- Mateusz Jurvczyk (@j00ru)
- Alex Ionescu (@aionescu)
- Ivanlefou (@Ivanlef0u)