Mitigating the unkn0wn

When your SMB exploit fails

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HITCON

Aug. 25-26 2017 in Taipei

Microsoft

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- Exploiting stuff, breaking things
- Have played pwn2own before, now judging entries…

HITCON

Aug. 25-26 2017 in Taipei

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Protecting customers and evaluating risk

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MSRC Team April 14, 2017

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Today, Microsoft triaged a large release of exploits made publicly available by Shadow Brokers. Understandingly, customers have expressed concerns around the risk this disclosure potentially creates. Our engineers have investigated the disclosed exploits, and most of the exploits are already patched. Below is our update on the investigation.

When a potential vulnerability is reported to Microsoft, either from an internal or external source, the Microsoft Security Response Center (MSRC) kicks off an immediate and thorough investigation. We work to swiftly validate the claim and make sure legitimate, unresolved vulnerabilities that put customers at risk are fixed. Once validated, engineering teams prioritize fixing the reported issue as soon as possible, taking into consideration the time to fix it across any impacted product or service, as well as versions, the potential threat to customers, and the likelihood of exploitation.

Most of the exploits that were disclosed fall into vulnerabilities that are already patched in our supported products. Below is a list of exploits that are confirmed as already addressed by an update. We encourage customers to ensure their computers are up-to-date.

Code Name	Solution
"**EternalBlue**"	Addressed by MS17-010
"**EmeraldThread**"	Addressed by MS10-061
"**EternalChampion**"	Addressed by MS17-010
"**ErraticGopher**"	Addressed prior to the release of Windows Vista. CVE-2017-8461
"**EsikmoRoll**"	Addressed by MS14-068
"**EternalRomance**"	Addressed by MS17-010
"**EducatedScholar**"	Addressed by MS09-050
"**EternalSynergy**"	Addressed by MS17-010
"**EclipsedWing**"	Addressed by MS08-067

https://blogs.technet.microsoft.com/msrc/2017/04/14/protecting-customers-and-evaluating-risk/

Microsoft

Microsoft Security Bulletin MS17-010 - Critical

Security Update for Microsoft Windows SMB Server (4013389)

Published: March 14, 2017

Operating System	Windows SMB Remote Code Execution Vulnerability – CVE-2017-0143	Windows SMB Remote Code Execution Vulnerability – CVE-2017-0144	Windows SMB Remote Code Execution Vulnerability – CVE-2017-0145	Windows SMB Remote Code Execution Vulnerability – CVE-2017-0146	Windows SMB Information Disclosure Vulnerability – CVE-2017-0147	Windows SMB Remote Code Execution Vulnerability – CVE-2017-0148
Windows Vista						
Windows Vista Service Pack 2 (4012598)	**Critical** Remote Code Execution	**Critical** Remote Code Execution	**Critical** Remote Code Execution	**Critical** Remote Code Execution	**Important** Information Disclosure	**Critical** Remote Code Execution

6 CVEs, 5 Critical

https://technet.microsoft.com/en-us/library/security/ms17-010.aspx

Microsoft

EternalBlue

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt

```
if (variableBuffer >= lastValidLocation ||
    (variableBuffer + fea->cbName + 1 + SmbGetUshort(&fea->cbValue)) > lastValidLocation) {

    SmbPutUshort( &FeaList->cbList, PTR_DIFF_SHORT(fea, FeaList) );
    break;

}
```

```
typedef struct _FEA {

    BYTE fEA;
    BYTE cbName;
    USHORT cbValue;

} FEA;
```

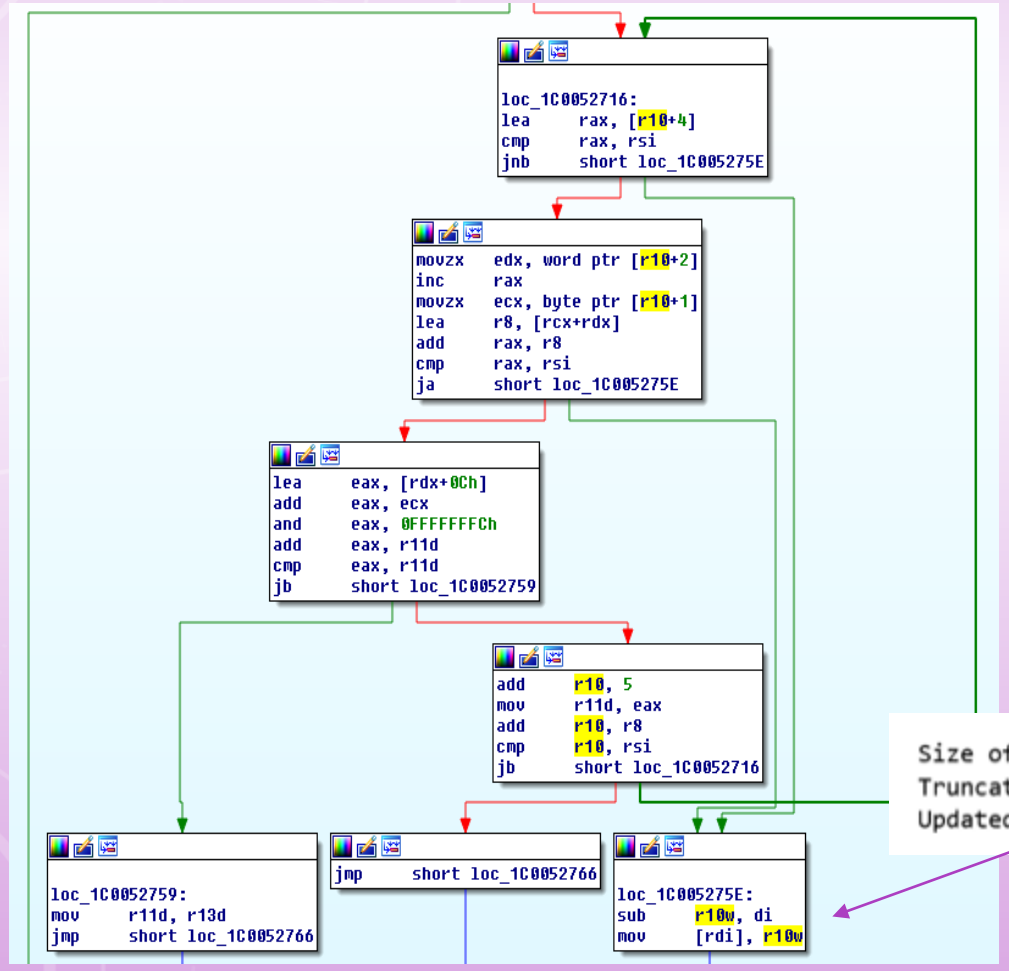
```
typedef struct _FEALIST {

    ULONG   cbList;
    FEA list[1];

} FEALIST, *PFEALIST;
```

http://blog.trendmicro.com/trendlabs-security-intelligence/ms17-010-eternalblue/

Microsoft

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt



SrvOs2FeaListSizeToNt inlined in

SrvOs2FeaListToNt

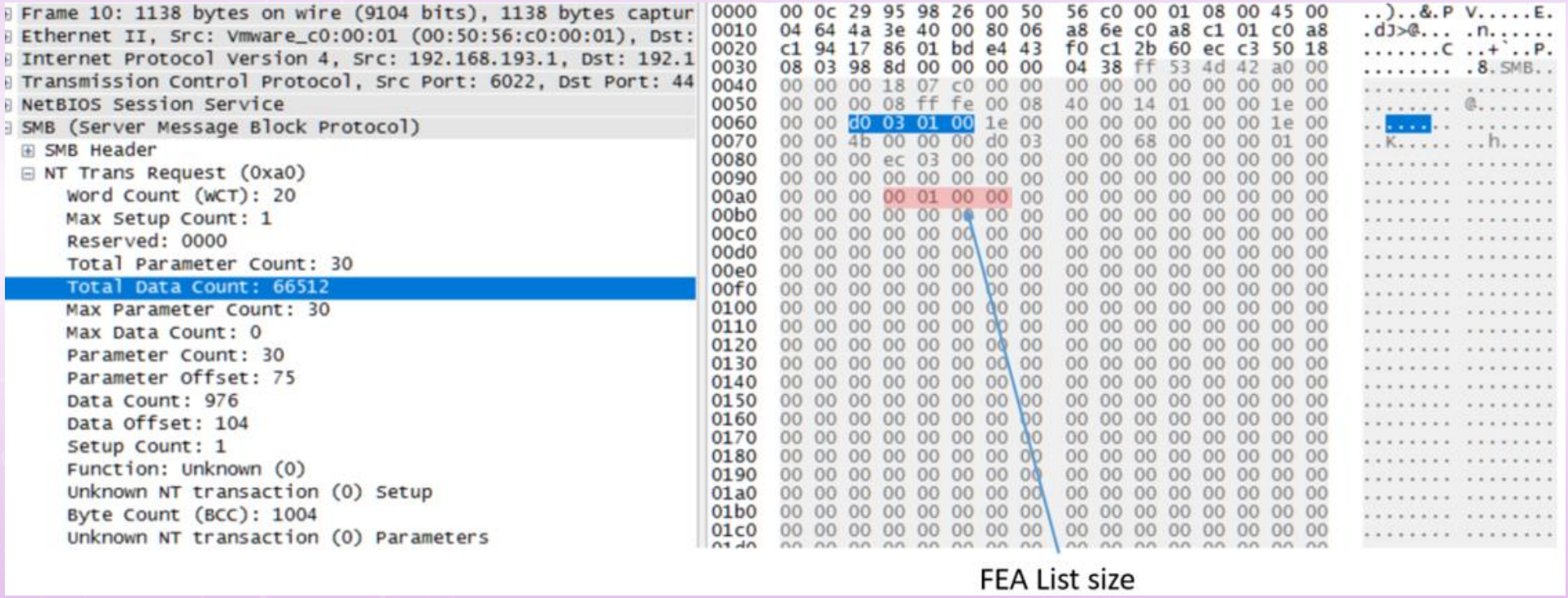
Integer truncation here

```
Size of list:          0x00010000
Truncated size:        0x0000FF5D
Updated size of list:  0x0001FF5D [actually larger than the original]
```

Microsoft

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt



http://blog.trendmicro.com/trendlabs-security-intelligence/ms17-010-eternalblue/

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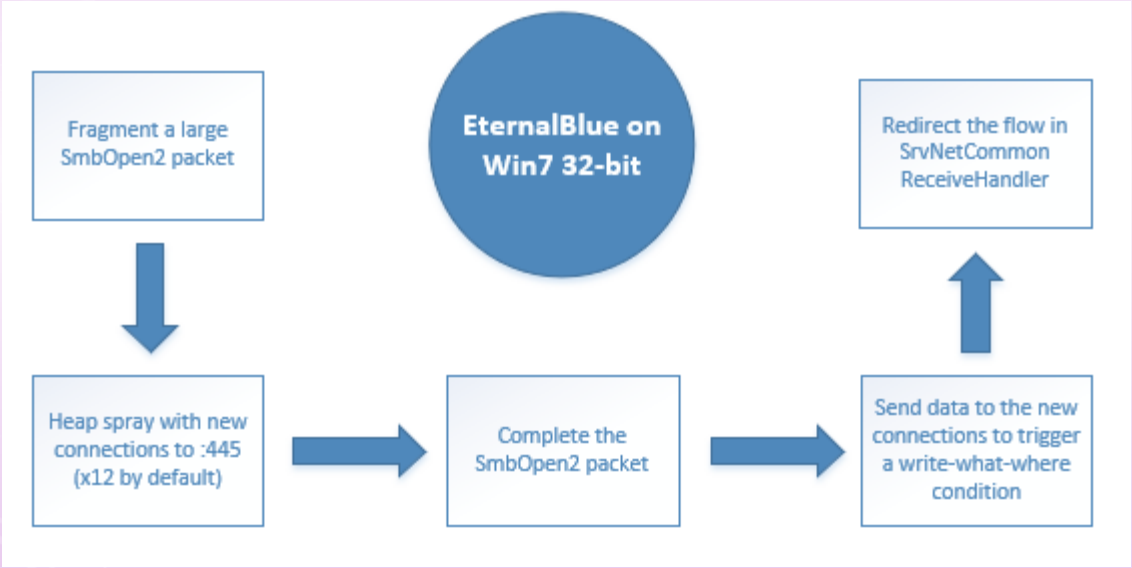
EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt



EternalBlue in action

Microsoft

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt

114	0.128374	33.0.0.15	33.0.0.2	TCP	66 49827 → 445 [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
115	0.128744	33.0.0.2	33.0.0.15	TCP	66 445 → 49827 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
116	0.128798	33.0.0.15	33.0.0.2	TCP	54 49827 → 445 [ACK] Seq=1 Ack=1 Win=2102272 Len=0
117	0.128845	33.0.0.15	33.0.0.2	TCP	186 [TCP segment of a reassembled PDU]
118	0.129051	33.0.0.15	33.0.0.2	TCP	66 49828 → 445 [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
119	0.129179	33.0.0.2	33.0.0.15	TCP	66 445 → 49828 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
120	0.129227	33.0.0.15	33.0.0.2	TCP	54 49828 → 445 [ACK] Seq=1 Ack=1 Win=262656 Len=0
121	0.129279	33.0.0.15	33.0.0.2	TCP	186 [TCP segment of a reassembled PDU]
122	0.129430	33.0.0.15	33.0.0.2	TCP	66 49829 → 445 [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
123	0.129530	33.0.0.2	33.0.0.15	TCP	66 445 → 49829 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
124	0.129577	33.0.0.15	33.0.0.2	TCP	54 49829 → 445 [ACK] Seq=1 Ack=1 Win=262656 Len=0
125	0.129617	33.0.0.15	33.0.0.2	TCP	186 [TCP segment of a reassembled PDU]

158	1.142216	33.0.0.15	33.0.0.2	TCP	4126 [TCP segment of a reassembled PDU]
159	1.142276	33.0.0.15	33.0.0.2	TCP	4126 [TCP segment of a reassembled PDU]
160	1.142333	33.0.0.15	33.0.0.2	TCP	4126 [TCP segment of a reassembled PDU]
161	1.142385	33.0.0.15	33.0.0.2	TCP	4126 [TCP segment of a reassembled PDU]
162	1.142443	33.0.0.15	33.0.0.2	TCP	4126 [TCP segment of a reassembled PDU]

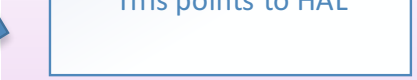
Spraying with new connections to :445

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt

Sending new connections leads to spray the pool with MDLs:

```
854aeff0 da 79 3c 1f 00 00 00 00 00 00 06 2a 00 00 00 00
854af000 00 10 01 00 00 00 00 00 42 00 00 00 00 00 00 00
854af010 08 00 12 c0 00 00 00 00 00 00 00 00 60 f1 4a 85
854af020 a0 0e 01 00 00 00 00 00 3c f0 4a 85 00 00 00 00
854af030 f7 ff 00 00 78 6b 45 87 a4 f0 4a 85 00 00 00 00
854af040 60 00 04 10 00 00 00 00 60 f1 4a 85 00 f0 4a 85
854af050 a0 0e 01 00 60 01 00 00 af fc 07 00 b0 fc 07 00
```



This points to HAL

```
854aeff0 b4 00 00 00 80 00 a8 00 00 00 00 00 00 00 00 00
854af000 00 00 00 00 00 00 00 00 ff ff 00 00 00 00 00 00
854af010 ff ff 00 00 00 00 00 00 00 00 00 00 00 00 00 00
854af020 00 00 00 00 00 00 00 00 00 f1 df ff 00 00 00 00
854af030 00 00 00 00 20 f0 df ff 00 f1 df ff ff ff ff ff
854af040 60 00 04 10 00 00 00 00 80 ef df ff 00 00 00 00
854af050 10 00 d0 ff ff ff ff ff 18 01 d0 ff ff ff ff ff
```

Pool before and after the overflow

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt

```
95d1b26a 8b866c010000    mov     eax,dword ptr [esi+16Ch]
95d1b270 85c0            test    eax,eax
95d1b272 0f8493000000    je      srvnet!SrvNetCommonReceiveHandler+0xff (95d1b30b)
95d1b278 837e0803        cmp     dword ptr [esi+8],3
95d1b27c 7557            jne     srvnet!SrvNetCommonReceiveHandler+0xc9 (95d1b2d5)
95d1b27e ff7528          push    dword ptr [ebp+28h]
95d1b281 ff7524          push    dword ptr [ebp+24h]
95d1b284 ff751c          push    dword ptr [ebp+1Ch]
95d1b287 ff7514          push    dword ptr [ebp+14h]
95d1b28a 51              push    ecx
95d1b28b ff750c          push    dword ptr [ebp+0Ch]
95d1b28e ff7518          push    dword ptr [ebp+18h]
95d1b291 ffb6ac000000    push    dword ptr [esi+0ACh]
95d1b297 ffb6a8000000    push    dword ptr [esi+0A8h]
95d1b29d ff5004          call    dword ptr [eax+4]
```

Redirecting the flow in srvnet!SrvNetCommonReceiveHandler

Microsoft

EternalBlue

CVE-2017-0144 – Integer overflow due to storing a Ulong as a Ushort in SrvOs2FeaListSizeToNt

Fix? Use PTR_DIFF instead of PTR_DIFF_SHORT

Here is the correct vulnerable code path for Windows 10 version 1511:

```
srv!SrvOs2FeaListToNt+0x8a:
fffff801`8de5247e 66442bd7        sub     r10w,di
fffff801`8de52482 66448917        mov     word ptr [rdi],r10w
```

How the vulnerability was patched with MS17-010:

```
srv!SrvOs2FeaListSizeToNt+0x6e:
fffff800`a2521d72 452bc2          sub     r8d,r10d
fffff800`a2521d75 458902          mov     dword ptr [r10],r8d
```

The 16-bit registers were replaced with 32-bit versions, to prevent the mathematical miscalculation leading to buffer overflow.

https://zerosum0x0.blogspot.co.uk/2017/06/

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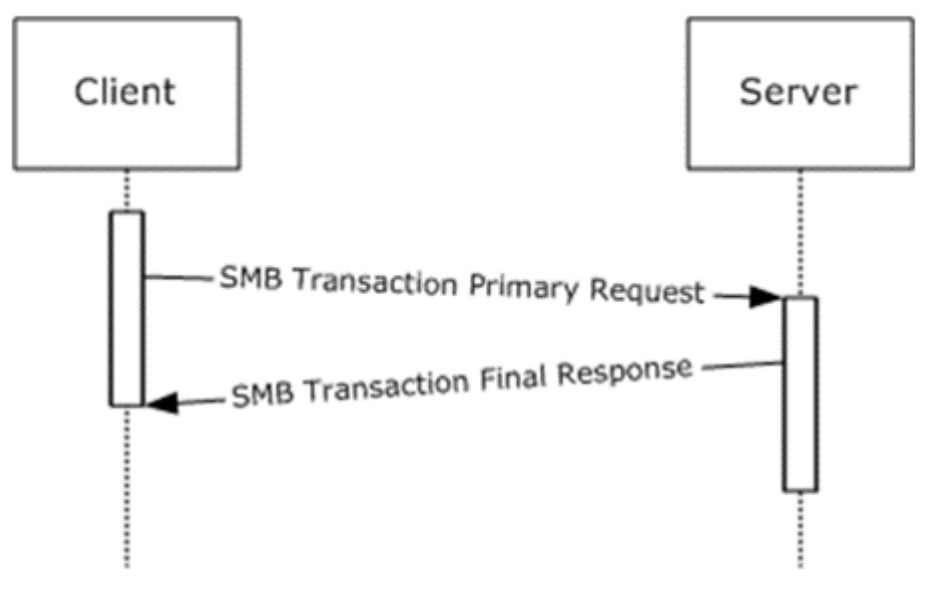
EternalChampion

EternalChampion

CVE-2017-0146 – Race condition with Transaction requests

Sending simple transactions




```
srv!TRANSACTION
…
   +0x010 Connection        : Ptr64 _CONNECTION
…
   +0x058 cMaxBufferSize    : Uint4B
   +0x060 InSetup           : Ptr64 Uint2B
   +0x068 OutSetup          : Ptr64 Uint2B
   +0x070 InParameters      : Ptr64 Char
   +0x078 OutParameters     : Ptr64 Char
   +0x080 InData            : Ptr64 Char // data received
   +0x088 OutData           : Ptr64 Char // data to send (same buffer as InData)
   +0x090 SetupCount        : Uint4B
   +0x098 ParameterCount    : Uint4B
   +0x09c TotalParameterCount : Uint4B
   +0x0a4 DataCount         : Uint4B // data received so far
   +0x0a8 TotalDataCount    : Uint4B // total data being expected
…
   +0x0e3 Executing         : UChar
```

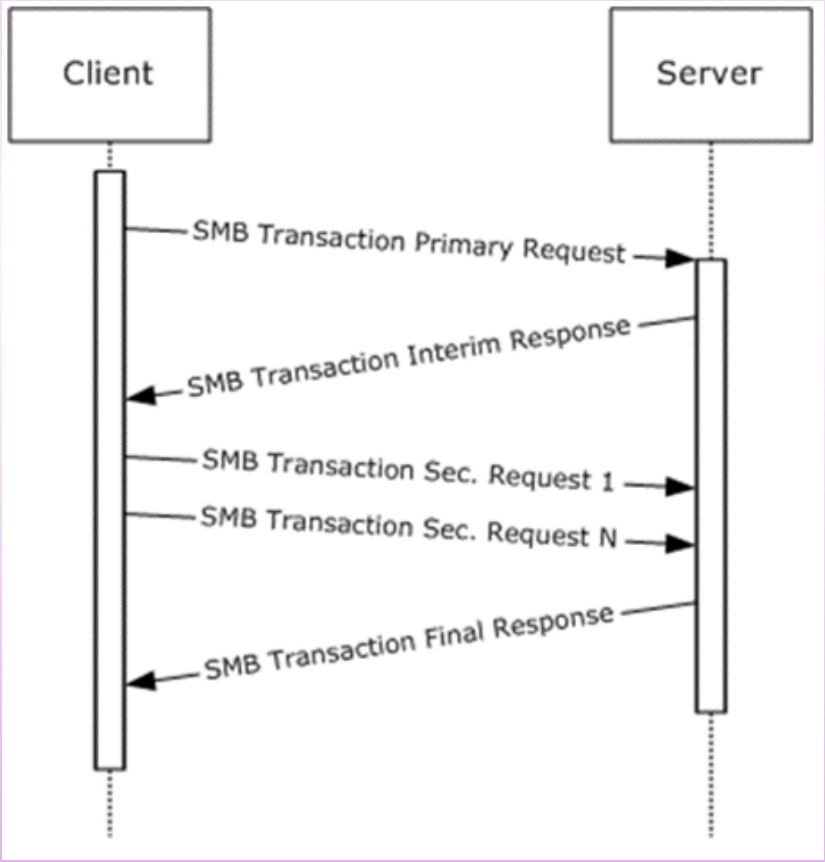
https://msdn.microsoft.com/en-us/library/ee441928.aspx

Microsoft

EternalChampion

CVE-2017-0146 – Race condition with Transaction requests

But, if parameters or data don't fit in the first Transaction, we can use secondary transactions (while xCount < TotalxCount, send…)



https://msdn.microsoft.com/en-us/library/ee441928.aspx

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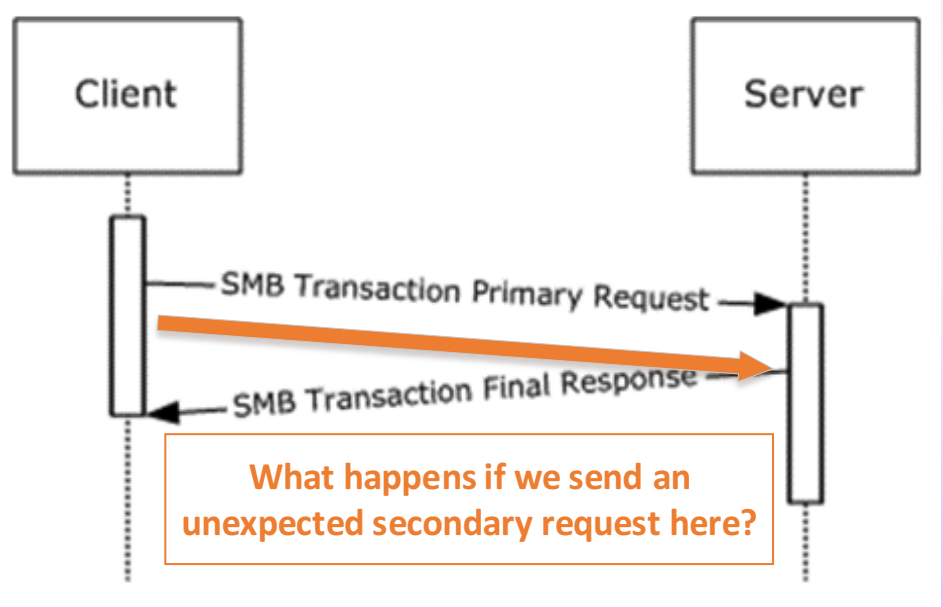
CVE-2017-0146 – Race condition with Transaction requests

How does the server knows when to process the request? Can we race it?



https://msdn.microsoft.com/en-us/library/ee441928.aspx

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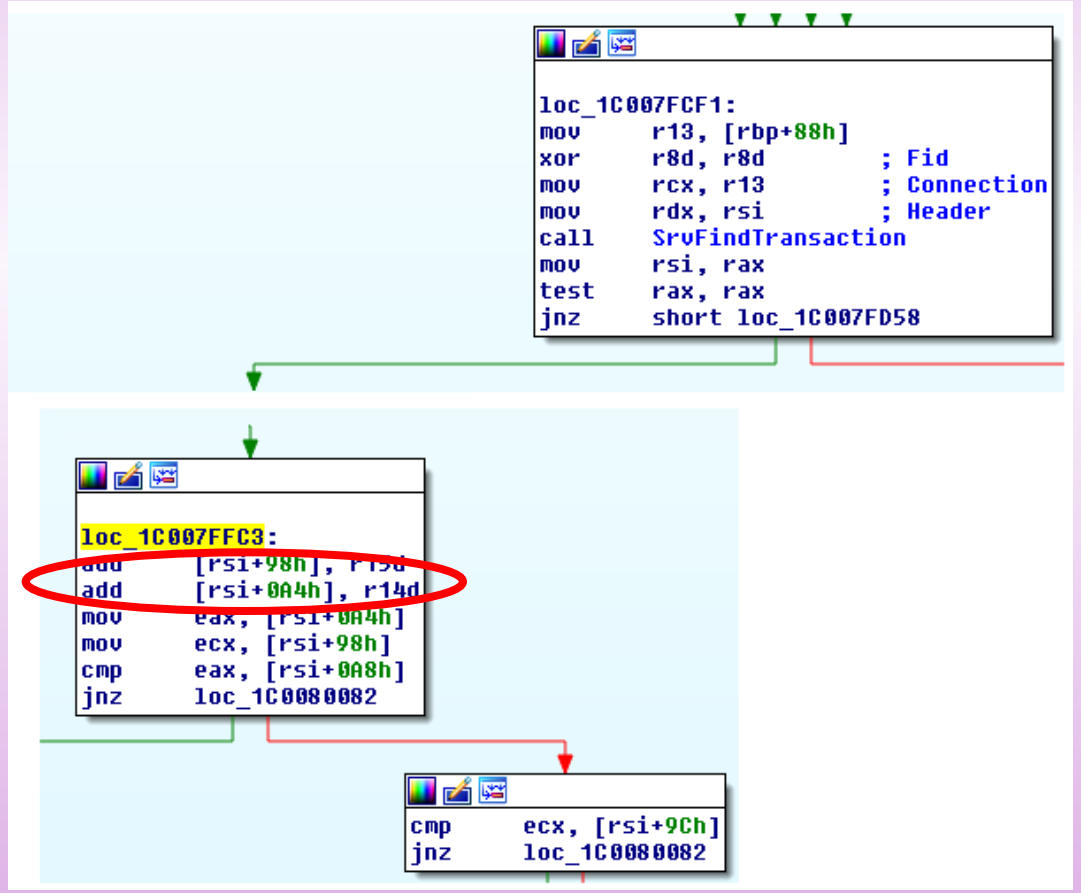
CVE-2017-0146 – Race condition with Transaction requests

Even if the primary transaction is being processed, the secondary transaction will still increment some fields, like Transaction -> DataCount and ParameterCount



SrvSmbTransactionSecondary

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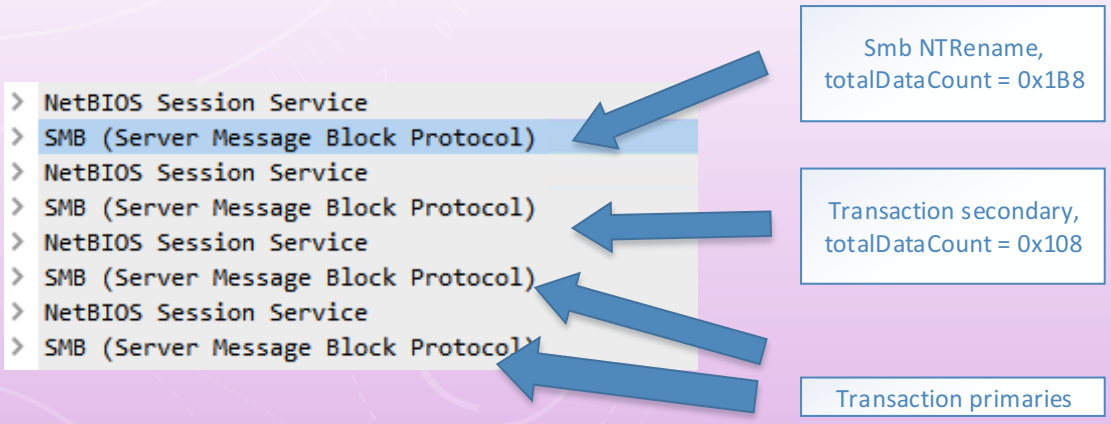
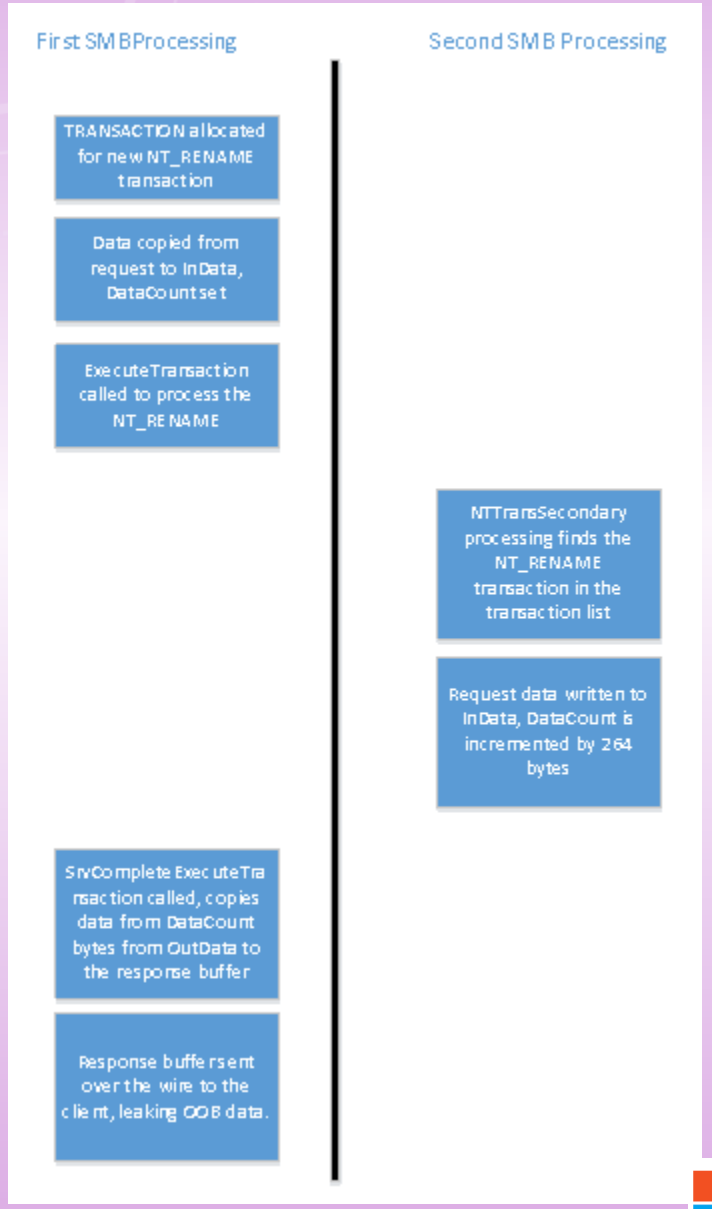
CVE-2017-0146 – Race condition with Transaction requests

Exploit is in two ways. First make an info leak with SrvSmbNtRename and an additional secondary transaction, followed by several transaction requests to spray the heap:





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CVE-2017-0146 – Race condition with Transaction requests

First response to the Smb NtRename

68	22.781089	33.0.0.2	33.0.0.15	SMB	570 NT Trans Response, NT RENAME
69	22.781099	33.0.0.2	33.0.0.15	SMB	93 Trans Response
70	22.781108	33.0.0.15	33.0.0.2	TCP	54 49997 → 445 [ACK] Seq=3610 Ack=1763 Win=2102272 Len=0
71	22.781126	33.0.0.2	33.0.0.15	SMB	93 Trans Response
72	22.781126	33.0.0.2	33.0.0.15	SMB	93 Trans Response
73	22.781137	33.0.0.15	33.0.0.2	TCP	54 49997 → 445 [ACK] Seq=3610 Ack=1841 Win=2102272 Len=0
74	22.781148	33.0.0.2	33.0.0.15	SMB	93 Trans Response
75	22.781156	33.0.0.2	33.0.0.15	SMB	93 Trans Response
76	22.781164	33.0.0.15	33.0.0.2	TCP	54 49997 → 445 [ACK] Seq=3610 Ack=1919 Win=2102016 Len=0
77	22.781172	33.0.0.2	33.0.0.15	SMB	93 Trans Response
78	22.781367	33.0.0.2	33.0.0.15	SMB	93 Trans Response
79	22.781368	33.0.0.2	33.0.0.15	SMB	93 Trans Response
80	22.781368	33.0.0.2	33.0.0.15	SMB	93 Trans Response
81	22.781368	33.0.0.2	33.0.0.15	SMB	93 Trans Response
82	22.781369	33.0.0.2	33.0.0.15	SMB	93 Trans Response
83	22.781369	33.0.0.2	33.0.0.15	SMB	93 Trans Response
84	22.781406	33.0.0.15	33.0.0.2	TCP	54 49997 → 445 [ACK] Seq=3610 Ack=2192 Win=2101760 Len=0
85	22.781426	33.0.0.2	33.0.0.15	SMB	93 Trans Response
86	22.781426	33.0.0.2	33.0.0.15	SMB	398 NT Trans Response, <unknown>[Unreassembled Packet]
87	22.781427	[illegible]	[illegible]	SMB	93 Trans Response

Second response to the secondary transaction, this time leaking memory

Microsoft

EternalChampion

CVE-2017-0146 – Race condition with Transaction requests

```
VOID SRVFASTCALL
RestartTransactionResponse (
    IN OUT PWORK_CONTEXT WorkContext
    )
   //
   //
   //
if ( paramLength != 0 ) {
    RtlMoveMemory(
        paramPtr,
        transaction->OutParameters + paramDisp,
        paramLength
        );
}

if ( dataLength != 0 ) {
    RtlMoveMemory(
        dataPtr,
        transaction->OutData + dataDisp,
        dataLength
        );
}
```

By spraying Transaction objects it becomes possible to have one located right after the SmbNtRename transaction buffer and leak some pointers from the Transaction object:

```
9a448188 68 25 4d 13 36 08 0e 52 7b 54 07 20 40 74 45 41  h%M.6..R{T. @tEA
9a448198 78 4b 7f 73 60 3e 30 00 26 22 1b 1d 29 1b 67 0a  xK.s`>0.&"..).g.
9a4481a8 7b 04 01 00 77 2c 01 5d 00 00 00 00 b8 51 00 00  {...w,.].....Q..
9a4481b8 00 02 01 06 46 72 61 67 01 02 01 00 46 72 65 65  ....Frag....Free
9a4481c8 01 02 c7 0b 4c 53 74 72 d0 e1 64 88 00 00 00 00  ....LStr..d.....
9a4481d8 0c 03 24 0e 00 00 00 00 58 90 48 85 70 9c 45 85  ..$.....X.H.p.E.
9a4481e8 58 8b 33 99 d8 1d 5a 88 28 c0 44 9a 20 30 44 9a  X.3...Z.(.D. 0D.
9a4481f8 00 00 00 00 00 00 02 00 78 82 44 9a f8 d9 00 00  ........x.D.....
9a448208 ff ff ff ff 00 00 00 00 7c 82 44 9a 00 00 00 00  ........|.D.....
9a448218 7c 82 44 9a fc 8f 44 9a 7c 82 44 9a fc 8f 44 9a  |.D...D.|.D...D.
9a448228 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
```

dataDisp goes out of bounds!

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EternalChampion

CVE-2017-0146 – Race condition with Transaction requests

Several packets follow next:

- **A QueryPathInformation packet to have transaction->InData point to a stack address:**

```
if ( informationLevel == SMB_INFO_IS_NAME_VALID ) {

    transaction->InData = (PVOID)&objectName;

    //
    // Get the Share root handle.
    //
    smbStatus = SrvGetShareRootHandle( WorkContext->TreeConnect->Share );
```

- **A bunch of secondary transactions following to reach that memcpy and trigger a stack corruption in SrvSmbTransactionSecondary:**

```
if ( dataCount != 0 ) {
    RtlMoveMemory(
        transaction->InData + dataDisplacement,
        (PCHAR)header + dataOffset,
        dataCount
        );
}
```

Microsoft

EternalChampion

CVE-2017-0146 – Race condition with Transaction requests

That results in a 4-byte overwrite in the stack:

```
0: kd> g
Breakpoint 15 hit
srv!SrvSmbTransactionSecondary+0x1eb:
96c6b2d0 8b4648          mov     eax,dword ptr [esi+48h]
3: kd> !address poi(@esi+48)
Mapping user range ...
Mapping system range ...
Mapping page tables...
Mapping hyperspace...
Mapping HAL reserved range...
Mapping User Probe Area...
Mapping system shared page...
Mapping VAD regions...
Mapping module regions...
Mapping process, thread, and stack regions...
Mapping system cache regions...


Usage:                  Stack
Base Address:           955c1000
End Address:            955c4000
Region Size:            00003000
VA Type:                SystemPTEs
```

Leading to execute arbitrary code from a Paged pool:

```
3: kd> !address @eip
Mapping user range ...
Mapping system range ...
Mapping page tables...
Mapping hyperspace...
Mapping HAL reserved range...
Mapping User Probe Area...
Mapping system shared page...
Mapping VAD regions...
Mapping module regions...
Mapping process, thread, and stack regions...
Mapping system cache regions...


Usage:
Base Address:           9b200000
End Address:            9b400000
Region Size:            00200000
VA Type:                PagedPool
```

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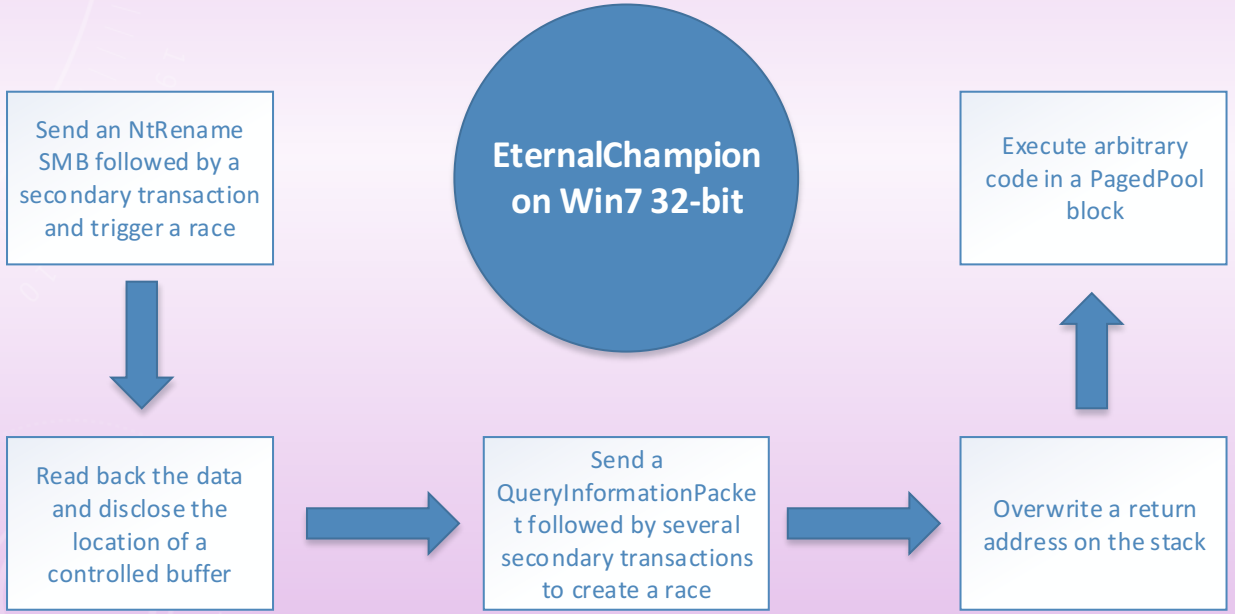
CVE-2017-0146 – Race condition with Transaction requests



EternalChampion in action

EternalRomance – 2 different bugs

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

RestartPeekNamedPipe and SrvCompleteExecuteTransaction could be abused together to return uninitialized memory after calling SrvPeekNamedPipe:

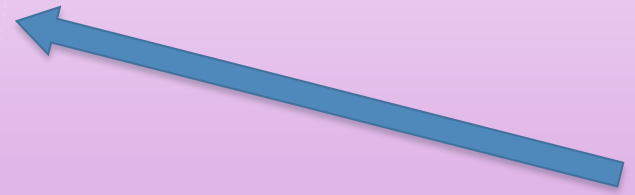
```
VOID SRVFASTCALL
RestartPeekNamedPipe (
    IN OUT PWORK_CONTEXT WorkContext
    )
```

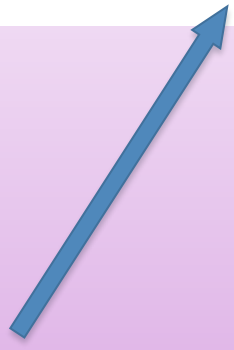
```
VOID
SrvCompleteExecuteTransaction (
    IN OUT PWORK_CONTEXT WorkContext,
    IN SMB_TRANS_STATUS ResultStatus
    )
```

```
transaction->SetupCount = 0;
transaction->ParameterCount = 6;
transaction->DataCount = (ULONG)WorkContext->Irp->IoStatus.Information -
                                    (4 * sizeof(ULONG));
```

```
if ( paramLength != 0 ) {
    RtlMoveMemory( paramPtr, transaction->OutParameters, paramLength );
}

if ( dataLength != 0 ) {
    RtlMoveMemory( dataPtr, transaction->OutData, dataLength );
}
```





dataLength was not checked against OutData, thus leaking memory

Microsoft

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

An initial request with Max Parameter Count = 0x5400 would lead to allocate 0x54A8 in the PagedPool bytes in SrvAllocateTransaction…

```
Max Parameter Count: 21504
Max Data Count: 1
Max Setup Count: 0
Reserved: 00
Flags: 0x0000
    .... .... .... ..0. = One Way Transaction: Two way transaction
```

```
0000  00 15 5d 63 72 32 00 15  5d 63 72 05 08 00 45 00   ..]cr2.. ]cr...E.
0010  00 6f 6c 59 40 00 80 06  00 00 21 00 00 0f 21 00   .olY@... ..!...!.
0020  00 02 c3 9a 01 bd 5a bc  a4 cc 7e 33 da dd 50 18   ......Z. ..~3..P.
0030  20 11 42 72 00 00 00 00  00 43 ff 53 4d 42 25 00    .Br.... .C.SMB%.
0040  00 00 00 18 07 c0 00 00  00 00 00 00 00 00 00 00   ........ ........
0050  00 00 00 08 dc 89 00 08  40 00 10 00 00 00 00 00   ........ @.......
0060  54 01 00 00 00 00 00 00  10 00 00 00 00 00 00 00   T....... ........
0070  00 00 00 00 00 02 00 23  00 00 40 00 00           .......# ..@..
```

Amount of bytes in the pipe

```
Reserved: 0000
Parameter Count: 6
Parameter Offset: 56
Parameter Displacement: 0
Data Count: 580
Data Offset: 64
```

```
0060  00 06 00 38 00 00 00 44  02 40 00 00 00 00 00 4d   ...8...D .@.....M
0070  02 00 44 02 44 02 03 00  00 00 00 00 00 00 00 00   ..D.D... ........
0080  00 00 b8 54 00 00 00 06  01 06 46 72 61 67 01 06   ...T.... ..Frag..
0090  68 01 46 72 65 65 38 90  24 85 38 90 24 85 00 00   h.Free8. $.8.$...
00a0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
00b0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
```

…which would lead to leak the bytes at @buffer + 0x54A8 in the response

```
178 405.882513   33.0.0.15   33.0.0.2    RPC_BR…   706 NetrBrowserStatisticsGet request[
179 405.883017   33.0.0.2    33.0.0.15   SMB       105 Write AndX Response, FID: 0x4000,
181 407.390234   33.0.0.15   33.0.0.2    SMB       125 Trans Request
232 542.046955   33.0.0.2    33.0.0.15   SMB       702 Trans Response
```

Microsoft

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

2.2.4.3 SMB_COM_WRITE_ANDX (0x2F)

2.2.4.3.1 Client Request Extensions

An SMB_COM_WRITE_ANDX request is sent by a client to write data to a file or **named pipe** on a server. These extensions allocate the **SMB_Parameters.Words.Reserved** field for use as the **DataLengthHigh** field. This field is used when the CAP_LARGE_WRITEX capability has been negotiated to allow for file writes larger than 0xFFFF bytes in length. All other fields are defined as specified in [MS-CIFS] section 2.2.4.43.1.

```
SMB_Parameters
  {
  UCHAR WordCount;
  Words
    {
    UCHAR  AndXCommand;
    UCHAR  AndXReserved;
    USHORT AndXOffset;
    USHORT FID;
    ULONG  Offset;
    ULONG  Timeout;
    USHORT WriteMode;
    USHORT Remaining;
    USHORT DataLengthHigh;
    USHORT DataLength;
    USHORT DataOffset;
    ULONG  OffsetHigh (optional);
    }
  }
SMB_Data
  {
  USHORT ByteCount;
  Bytes
    {
    UCHAR Pad;
    UCHAR Data[variable];
    }
  }
```

[MS-SMB].pdf

```
if ( (SmbGetUshort( &request->WriteMode ) &
                        SMB_WMODE_WRITE_RAW_NAMED_PIPE) != 0 ) {

    //
    // This is a multipiece named pipe write, is this the first
    // piece?
    //

    if ( (SmbGetUshort( &request->WriteMode ) &
                        SMB_WMODE_START_OF_MESSAGE) != 0 ) ...

        transaction = SrvFindTransaction(
                          connection,
                          header,
                          fid
                          );
```

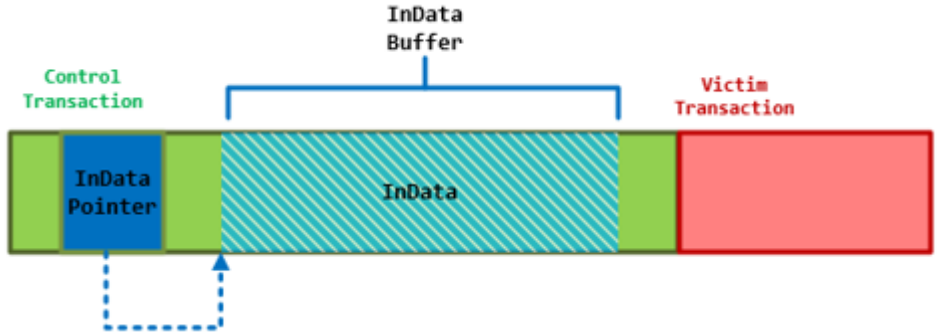
Microsoft

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

Multiple WriteAndX requests can follow to fill the Transaction buffer when WriteMode is in RAW_MODE…




```
            RtlCopyMemory(transaction->InData, writeAddress, writeLength );

            //
            // Update the transaction data pointer to where the next
            // WriteAndX data buffer will go.
            //

            transaction->InData += writeLength;
            transaction->DataCount += writeLength;

        } // secondary piece of multipart write
```

…leading to increment InData and DataCount in SrvSmbWriteAndX

Microsoft

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

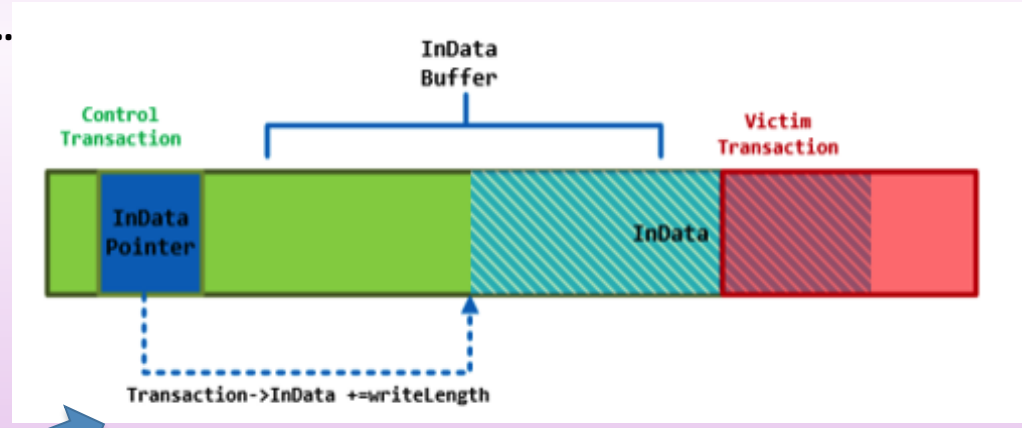
CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

But SrvSmbTransactionSecondary also calls SrvFindTransaction…

```
transaction = SrvFindTransaction( connection, header, 0 );
```

…and writes data to transaction->InData:

```
if ( dataCount != 0 ) {
    RtlMoveMemory(
        transaction->InData + dataDisplacement,
        (PCHAR)header + dataOffset,
        dataCount
        );
}
```



…leading to a buffer overflow on an adjacent Transaction object

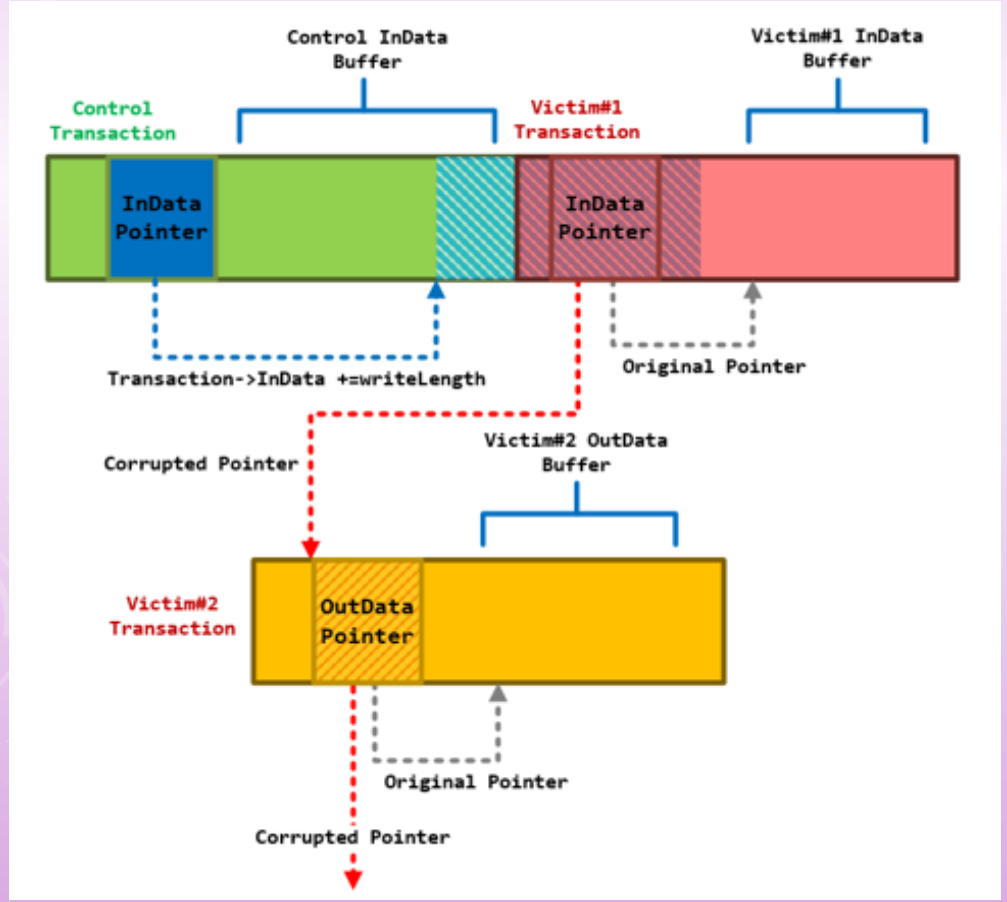
Microsoft

EternalRomance

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe

How to build an arbitrary read?



Microsoft

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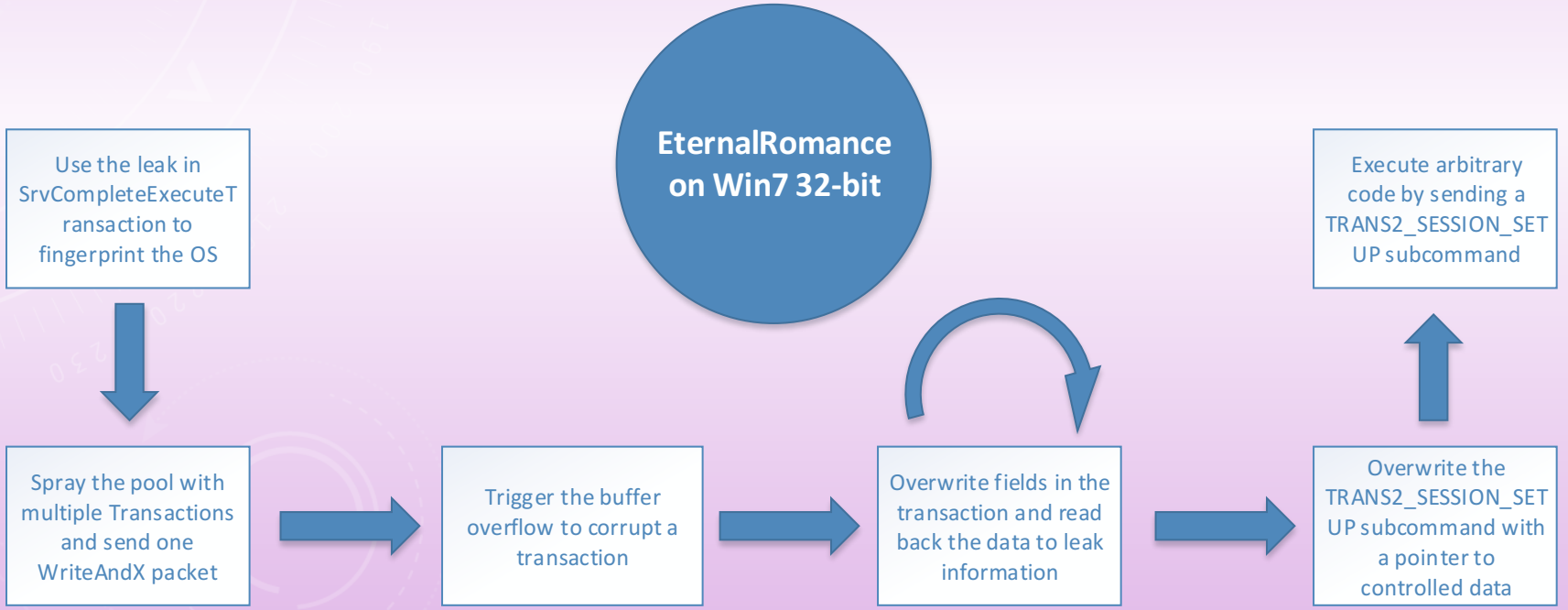
CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0147 – Info disclosure in SrvPeekNamedPipe



EternalRomance in action

Microsoft

EternalSynergy

= [EternalChampion + EternalRomance]

EternalSynergy

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0146 – Race condition with Transaction requests

29	1.520218	33.0.0.15	33.0.0.52	SMB	5382 Trans Request
34	1.520650	33.0.0.52	33.0.0.15	SMB	1494 NT Trans Response, NT RENAME
36	1.520953	33.0.0.52	33.0.0.15	SMB	93 Trans Response
37	1.520954	33.0.0.52	33.0.0.15	SMB	93 Trans Response
38	1.520955	33.0.0.52	33.0.0.15	SMB	93 Trans Response
39	1.520955	33.0.0.52	33.0.0.15	SMB	93 Trans Response
40	1.520956	33.0.0.52	33.0.0.15	SMB	93 Trans Response
41	1.520956	33.0.0.52	33.0.0.15	SMB	93 Trans Response
42	1.520957	33.0.0.52	33.0.0.15	SMB	93 Trans Response
43	1.520957	33.0.0.52	33.0.0.15	SMB	93 Trans Response
45	1.543609	33.0.0.52	33.0.0.15	SMB	474 NT Trans Response, <unknown>[Unr ssembled Packet]
47	1.545361	33.0.0.15	33.0.0.52		125 Trans Request

```
0020  00 0f 01 bd c4 0c 03 2d  7b d9 40 74 58 dc 50 18   .......- {.@tX.P.
0030  01 fd df 99 00 00 00 00  01 a0 ff 53 4d 42 a0 00   ........ ...SMB..
0040  00 00 00 98 03 c0 00 00  00 00 00 00 00 00 00 00   ........ ........
0050  00 00 00 08 2d 51 00 08  6c a3 12 00 00 00 04 00   ....-Q.. l.......
0060  00 00 c0 10 00 00 00 00  00 00 48 00 00 00 04 00   ........ ..H.....
0070  00 00 58 01 00 00 48 00  00 00 b8 10 00 00 00 59   ..X...H. .......Y
0080  01 00 96 b3 6c e9 d9 00  fa 07 00 00 00 00 00 00   ....l... ........
0090  00 00 00 00 00 00 00 00  00 00 00 04 02 03 46 72   ........ ......Fr
00a0  61 67 00 00 00 00 00 00  00 00 20 51 00 00 00 00   ag...... .. Q....
00b0  00 00 00 00 00 00 00 00  00 00 02 04 01 00 46 72   ........ ......Fr
00c0  65 65 00 00 00 00 00 00  00 00 01 04 eb 03 4c 53   ee...... ......LS
00d0  74 72 f0 c4 07 00 83 fa  ff ff 8c 0e 00 00 00 00   tr...... ........
```

Race condition to leak a transaction object
Same exploit in EternalChampion

Microsoft

EternalSynergy

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0146 – Race condition with Transaction requests

998	707.241651	33.0.0.15	33.0.0.52	SMB	630 Write AndX Request, FID: 0x4000,
999	707.241743	33.0.0.52	33.0.0.15	SMB	105 Write AndX Response, FID: 0x4000,
1001	708.257619	33.0.0.15	33.0.0.52	SMB	126 Trans Secondary Request
1003	708.305569	33.0.0.15	33.0.0.52	SMB	125 Trans Secondary Request
1004	708.305883	33.0.0.52	33.0.0.15	SMB	93 Trans Secondary Response, Error:
1005	708.308095	33.0.0.15	33.0.0.52	SMB	132 Trans Secondary Request
1007	708.372613	33.0.0.15	33.0.0.52	SMB	754 Trans Secondary Request

```
Parameter Displacement: 0
Data Count: 40
Data Offset: 66
Data Displacement: 136
Byte Count (BCC): 55
Padding: 00000000000000000000000000000000
Extra byte parameters: 80b82f0183faffff0400000000
```

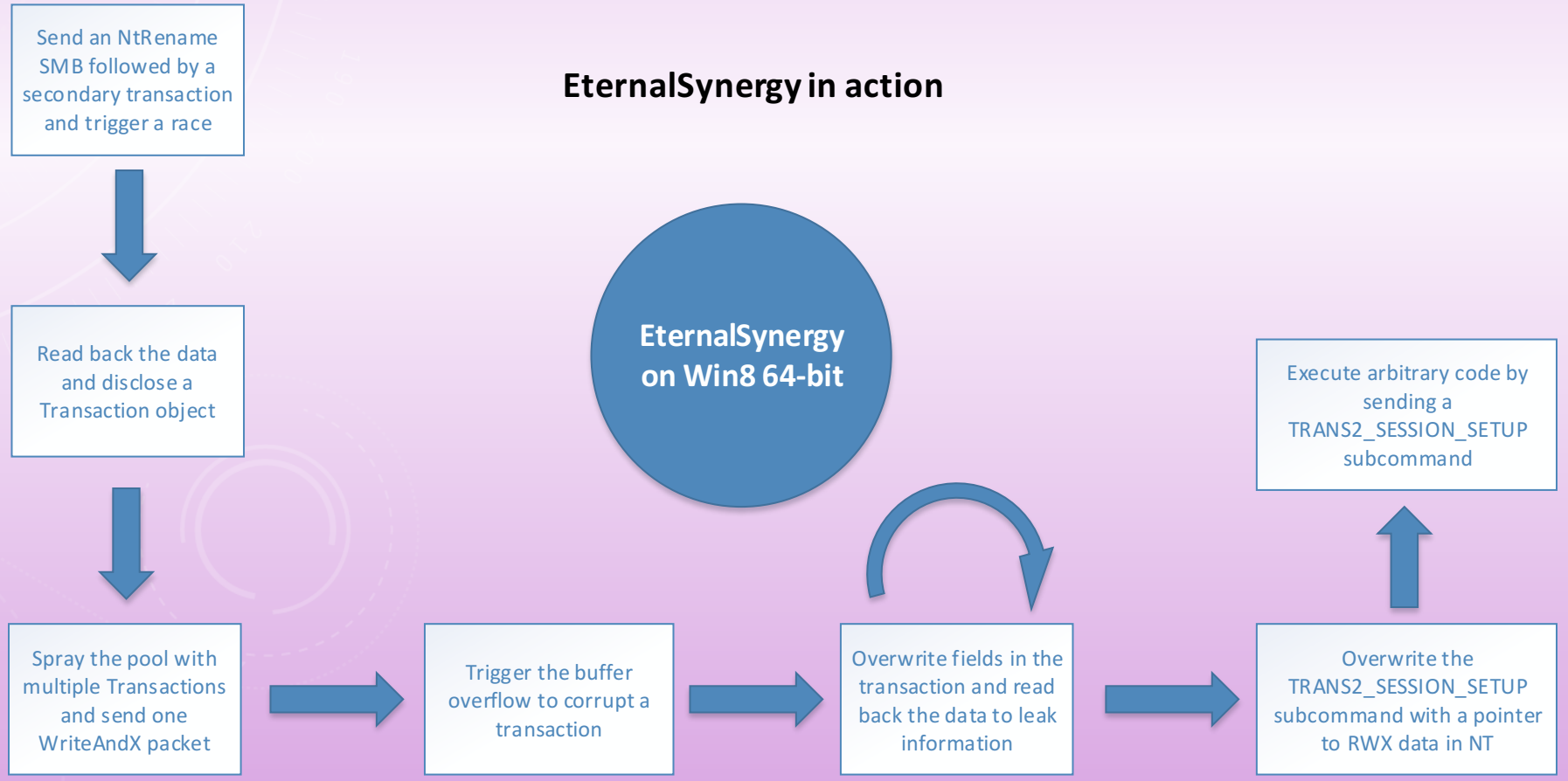
Several Transactions exchanged
Same exploit in EternalRomance

The main difference is the choice of an RWX section in NT to write the payload...

EternalSynergy

CVE-2017-0143 – Type confusion between WriteAndX and Transaction requests

CVE-2017-0146 – Race condition with Transaction requests



Microsoft

None of these worked on Windows 10…

Mitigations blocking these exploits

- Null sessions have disappeared by default since Windows 8
- Full ASLR, the HAL heap region is now randomized starting from RS2
- Kernel NX since Windows 8, making the HAL heap region and the non paged pool allocations used in srv.sys non executable
- Kernel CFG (kCFG) with HVCI enabled since RS2 prevents indirect calls to hijack the flow

```
movzx   eax, si
mov     rcx, rdi
call    rva SrvTransaction2DispatchTable[rdx+rax*8]
```

```
movzx   eax, di
mov     rax, ds:rva SrvTransaction2DispatchTable[rcx+rax*8]
mov     rcx, rbx
call    cs:__guard_dispatch_icall_ptr
```

- RWX areas in ntoskrnl have now disappeared
- **Windows 10 RS3 (Fall Creators Update) and Windows Server 2016 RS3 have SMB1 uninstalled by default under most circumstances**

Microsoft

And what else?

Pool overflow in SrvSmbCreateWithExtraOptions

```
SMB_TRANS_STATUS
SrvSmbCreateWithExtraOptions (
    IN OUT PWORK_CONTEXT WorkContext
    )
```

```
if (transaction->Function != NT_TRANSACT_CREATE ||
    transaction->ParameterCount < sizeof(REQ_CREATE_WITH_SD_OR_EA) ||
    transaction->MaxParameterCount < sizeof(RESP_CREATE_WITH_SD_OR_EA) ) {
```

```
if ( extendedRequested ) {
    NTSTATUS ExtendedResponseStatus;

    PRESP_EXTENDED_CREATE_WITH_SD_OR_EA ExtendedResponse;

    ExtendedResponse = (PRESP_EXTENDED_CREATE_WITH_SD_OR_EA)response;

    RtlZeroMemory( ((PVOID)&ExtendedResponse->VolumeGuid[0]), sizeof(ExtendedResponse->VolumeGuid)+sizeof(ExtendedResponse->FileId) );
```

Extended Requests in SrvSmbCreateWithExtraOptions were not properly checked leading to pool overflow

Pool overflow in SrvCompleteExecuteTransaction

```
outputBufferSize = ((maxParameterCount * sizeof(CHAR) + 3) & ~3) +
                   ((maxDataCount * sizeof(CHAR) + 3) & ~3);

if ( sizeof(SMB_HEADER) +
        sizeof (RESP_TRANSACTION) +
        sizeof(USHORT) * request->SetupCount +
        sizeof(USHORT) +
        outputBufferSize
                <= MIN( (ULONG)session->MaxBufferSize, SrvReceiveBufferLength ) ) {
    outputBufferSize = 0;
}
```

```
if ( transaction->OutParameters == NULL ) {

    //
    // Parameters will go into the SMB buffer.  Calculate the pointer
    // then round it up to the next DWORD address.
    //

    transaction->OutParameters = (PCHAR)(transaction->OutSetup +
        transaction->MaxSetupCount);
```

Confusion due to using SetupCount at one point, and MaxSetupCount at another, leading to pool overflow

OOB Write in RestartWriteNamedPipe

```
    transaction = WorkContext->Parameters.Transaction;

    transaction->SetupCount = 0;
    transaction->ParameterCount = 2;
    transaction->DataCount = 0;

    SmbPutUshort( (PSMB_USHORT)transaction->OutParameters,
                  (USHORT)iosb->Information
                  );

    SrvCompleteExecuteTransaction(WorkContext, SmbTransStatusSuccess);

    IF_DEBUG(TRACE2) SrvPrint0( "RestartWriteNamedPipe complete\n" );
    return;

} // RestartWriteNamedPipe
```

RestartWriteNamedPipe was not checking whether there was enough space in OutParameters to write iosb->Information

Abusing SrvSmbNtRename

```
{
    IF_DEBUG(TRACE2) KdPrint(( "SrvSmbNtRename complete.\n" ));

    //
    // Dead code path.  Fail to prevent use in exploits
    //
    SrvSetSmbError(WorkContext, STATUS_SMB_BAD_COMMAND);

    return SmbTransStatusErrorWithoutData;
} // SrvSmbNtRename
```

SrvSmbNtRename was a noop, making exploits easier (especially combined with the next issue). It now returns an error.

Uninitialized memory in SrvSmbTransactionSecondary

```
if ( parameterCount != 0 ) {
    RtlMoveMemory(
        transaction->InParameters + parameterDisplacement,
        (PCHAR)header + parameterOffset,
        parameterCount
        );
}

if ( dataCount != 0 ) {
    RtlMoveMemory(
        transaction->InData + dataDisplacement,
        (PCHAR)header + dataOffset,
        dataCount
        );
}
```

Abusing dataDisplacement in SrvSmbTransactionSecondary or SrvSmbNtTransactionSecondary could lead to create a Transaction with dataCount = TotalDataCount but leaving the buffer uninitialized

Microsoft

Uninitialized memory in SrvSnapEnumerateSnapShots

```
PSRV_SNAPSHOT_ARRAY SnapShotArray = (PSRV_SNAPSHOT_ARRAY)transaction->OutData;
```

```
SnapShotArray->NumberOfSnapShots = SnapShotCount;
SnapShotArray->SnapShotArraySize = SNAPSHOT_NAME_LENGTH*SnapShotArray->NumberOfSnapShots+sizeof(WCHAR);
if( (SnapShotCount == 0) || (transaction->MaxDataCount < SnapShotArray->SnapShotArraySize + FIELD_OFFSET
{
    // The buffer is not big enough.  Return the required size
    SnapShotArray->NumberOfSnapShotsReturned = 0;
    transaction->DataCount = sizeof(SRV_SNAPSHOT_ARRAY);
    Status = STATUS_SUCCESS;
}
else
```

```
typedef struct _SRV_SNAPSHOT_ARRAY
{
    ULONG NumberOfSnapShots;              //
    ULONG NumberOfSnapShotsReturned;      //
    ULONG SnapShotArraySize;              //
    WCHAR SnapShotMultiSZ[1];             //
} SRV_SNAPSHOT_ARRAY, *PSRV_SNAPSHOT_ARRAY;
```

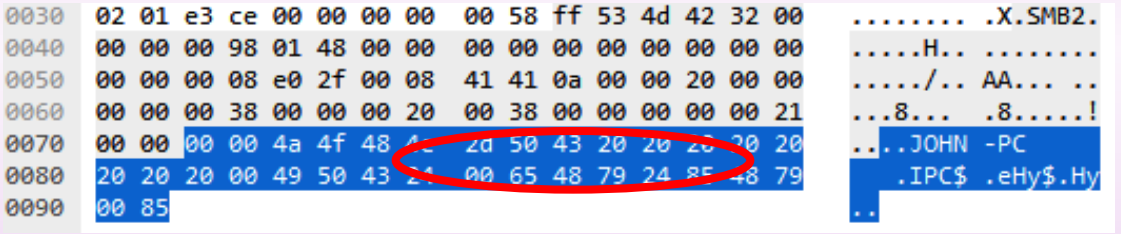
SrvSnapEnumerateSnapShots was leaking bytes when SnapShotCount = 0

Microsoft

Uninitialized memory in ProcessOs2Ioctl

```
if ( ansiShare.Length >= LM20_NNLEN ) {
    RtlCopyMemory(
            buffer,
            ansiShare.Buffer,
            LM20_NNLEN
            );
} else {
    RtlCopyMemory(
            buffer,
            ansiShare.Buffer,
            ansiShare.Length
            );
    buffer[ansiShare.Length] = '\0';

}
```



ProcessOs2Ioctl was leaking bytes when ansiShare.length < LM20_NNLEN

Microsoft

Return values not correctly initialized in SrvSmbQuerySecurityDescriptor

```
    SmbPutUlong( &response->LengthNeeded, lengthNeeded );
    transaction->ParameterCount = sizeof( RESP_QUERY_SECURITY_DESCRIPTOR );

    //
    // If an error occurred, return an appropriate response.
    //

    if ( !NT_SUCCESS(status) ) {

        transaction->ParameterCount = transaction->MaxParameterCount;
        transaction->DataCount = 0;
        SrvSetSmbError2( WorkContext, status, TRUE );
        return SmbTransStatusErrorWithData;
    } else {
        transaction->DataCount =
                RtlLengthSecurityDescriptor( transaction->OutData );
    }

    return SmbTransStatusSuccess;

} // SrvSmbQuerySecurityDescriptor
```

SrvSmbQuerySecurityDescriptor was not resetting some fields before returning

Microsoft

Return values not correctly initialized in RestartNtIoctl

```
if ( transaction->MaxSetupCount > 0 ) {
    transaction->SetupCount = 1;
    SmbPutUshort( transaction->OutSetup, (USHORT)length );
}

transaction->ParameterCount = transaction->MaxParameterCount;
transaction->DataCount = length;

if (!NT_SUCCESS(status) ) {
```

RestartNtIoctl was not resetting some fields before returning

Return values not correctly initialized in RestartCallNamedPipe

```
if ( status == STATUS_BUFFER_OVERFLOW ) {

    //
    // Down level clients, expect us to return STATUS_SUCCESS.
    //

    if ( !IS_NT_DIALECT( WorkContext->Connection->SmbDialect ) ) {
        status = STATUS_SUCCESS;

    } else {
```

```
} else if ( !NT_SUCCESS(status) ) ...

    //
    // Success.  Prepare to generate and send the response.
    //

    transaction->SetupCount = 0;
    transaction->ParameterCount = 0;
    transaction->DataCount = (ULONG)WorkContext->Irp->IoStatus.Information;

}
```

RestartCallNamedPipe

Is that all?

Enjoyed the talk? Join us!

Axel Souchet @0vercl0k · Aug 10

The MSRC Vulnerabilities & Mitigations team is hiring a security engineer, come join us! careers.microsoft.com/jobdetails.asp...

1 45 36

Nicolas Joly @n_joly · May 23

MSRC-UK is expanding again! If you want to play with bugz and 0dayz that's definitely the place to be. DM for fancy detailz :-)

29 22

THANKS!

HITCON

Aug. 25-26 2017 in Taipei

Microsoft