在笔者上一篇文章`《内核枚举LoadImage映像回调》`中`LyShark`教大家实现了枚举系统回调中的`LoadImage`通知消息，本章将实现对`Registry`注册表通知消息的枚举，与`LoadImage`消息不同`Registry`消息不需要解密只要找到`CallbackListHead`消息回调链表头并解析为`_CM_NOTIFY_ENTRY`结构即可实现枚举。

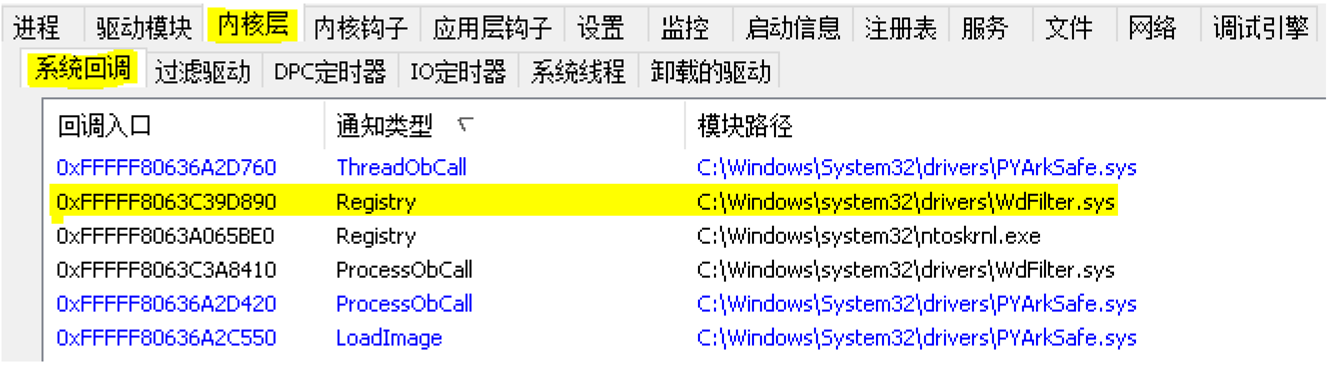
Registry注册表回调是Windows操作系统提供的一种机制，它允许开发者在注册表发生变化时拦截并修改注册表的操作。Registry注册表回调是通过操作系统提供的注册表回调机制来实现的。

当应用程序或系统服务对注册表进行读写操作时，操作系统会触发注册表回调事件，然后在注册表回调事件中调用注册的Registry注册表回调函数。开发者可以在Registry注册表回调函数中执行自定义的逻辑，例如记录日志，过滤敏感数据，或者阻止某些操作。

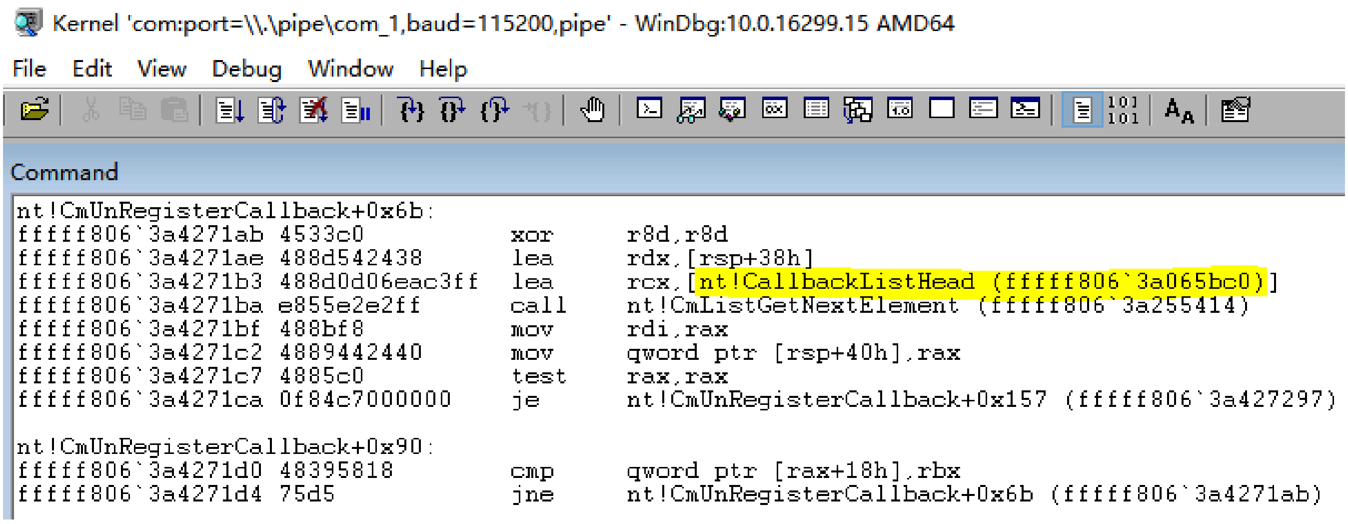
Registry注册表回调可以通过操作系统提供的注册表回调函数CmRegisterCallback和CmUnRegisterCallback来进行注册和注销。同时，Registry注册表回调函数需要遵守一定的约束条件，例如不能在回调函数中对注册表进行修改，不能调用一些内核API函数等。

Registry注册表回调在安全软件、系统监控和调试工具等领域有着广泛的应用。

我们来看一款闭源ARK工具是如何实现的：



注册表系统回调的枚举需要通过特征码搜索来实现，首先我们可以定位到`uf CmUnRegisterCallback`内核函数上，在该内核函数下方存在一个`CallbackListHead`链表节点，取出这个链表地址。



当得到注册表链表入口`0xfffff8063a065bc0`直接将其解析为`_CM_NOTIFY_ENTRY`即可得到数据，如果要遍历下一个链表则只需要`ListEntryHead.Flink`向下移动指针即可。

```c
// 注册表回调函数结构体定义
typedef struct _CM_NOTIFY_ENTRY
{
  LIST_ENTRY  ListEntryHead;
  ULONG   UnKnown1;
  ULONG   UnKnown2;
  LARGE_INTEGER Cookie;
  PVOID   Context;
  PVOID   Function;
}CM_NOTIFY_ENTRY, *PCM_NOTIFY_ENTRY;
```

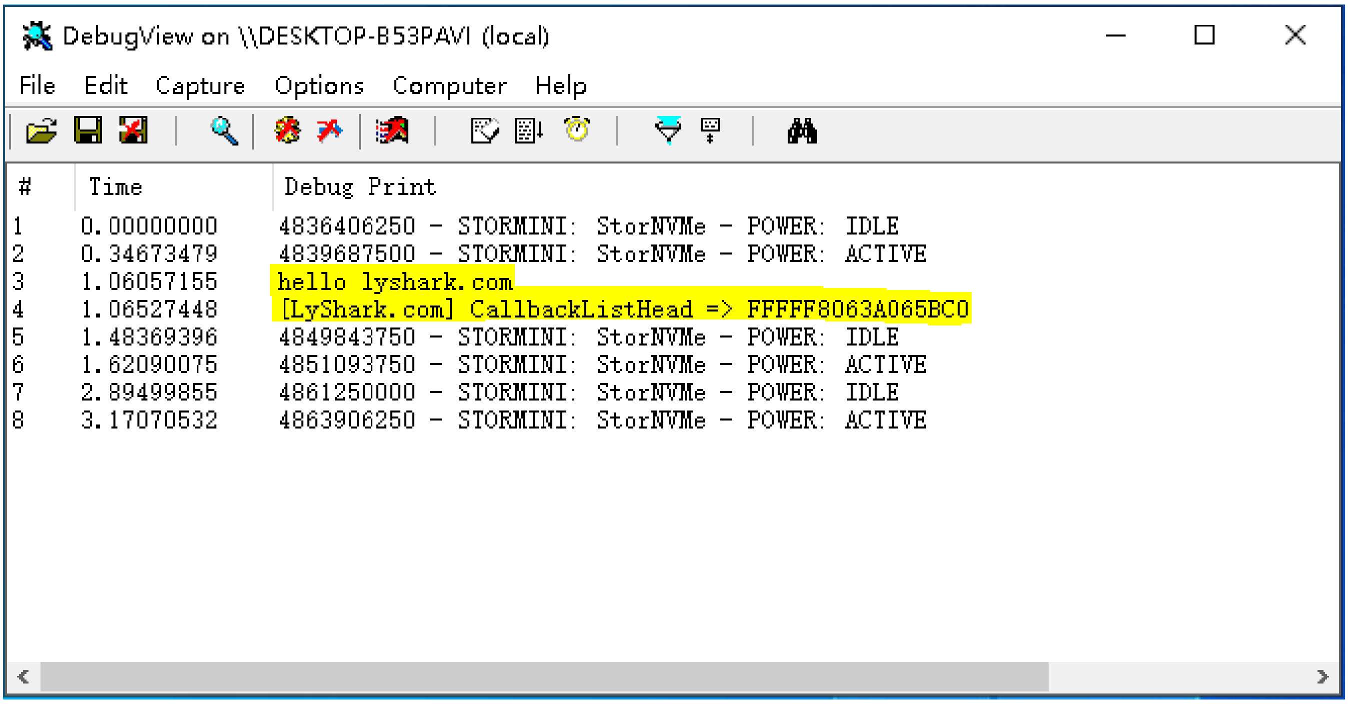
要想得到此处的链表地址，需要先通过`MmGetSystemRoutineAddress()`获取到`CmUnRegisterCallback`函数基址，然后在该函数起始位置向下搜索，找到这个链表节点，并将其后面的基地址取出来，在上一篇`《内核枚举LoadImage映像回调》`文章中已经介绍了定位方式此处跳过介绍，具体实现代码如下。

```c
#include <ntifs.h>
#include <windef.h>

// 指定内存区域的特征码扫描
PVOID SearchMemory(PVOID pStartAddress, PVOID pEndAddress, PUCHAR pMemoryData, ULONG
ulMemoryDataSize)
{
    PVOID pAddress = NULL;
    PUCHAR i = NULL;
    ULONG m = 0;

    // 扫描内存
    for (i = (PUCHAR)pStartAddress; i < (PUCHAR)pEndAddress; i++)
    {
        // 判断特征码
        for (m = 0; m < ulMemoryDataSize; m++)
        {
            if (*(PUCHAR)(i + m) != pMemoryData[m])
            {
                break;
            }
        }
        // 判断是否找到符合特征码的地址
        if (m >= ulMemoryDataSize)
        {
            // 找到特征码位置, 获取紧接着特征码的下一地址
            pAddress = (PVOID)(i + ulMemoryDataSize);
            break;
        }
    }

    return pAddress;
}

// 根据特征码获取 CallbackListHead 链表地址
PVOID SearchCallbackListHead(PUCHAR pSpecialData, ULONG ulSpecialDataSize, LONG
lSpecialOffset)
```

```
{
    UNICODE_STRING ustrFuncName;
    PVOID pAddress = NULL;
    LONG lOffset = 0;
    PVOID pCmUnRegisterCallback = NULL;
    PVOID pCallbackListHead = NULL;

    // 先获取 CmUnRegisterCallback 函数地址
    RtlInitUnicodeString(&ustrFuncName, L"CmUnRegisterCallback");
    pCmUnRegisterCallback = MmGetSystemRoutineAddress(&ustrFuncName);
    if (NULL == pCmUnRegisterCallback)
    {
        return pCallbackListHead;
    }

    // 查找 fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
    /*
    lyshark.com>
        nt!CmUnRegisterCallback+0x6b:
        fffff806`3a4271ab 4533c0          xor     r8d,r8d
        fffff806`3a4271ae 488d542438      lea     rdx,[rsp+38h]
        fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
        fffff806`3a4271ba e855e2e2ff      call    nt!CmListGetNextElement
(fffff806`3a255414)
        fffff806`3a4271bf 488bf8          mov     rdi,rax
        fffff806`3a4271c2 4889442440      mov     qword ptr [rsp+40h],rax
        fffff806`3a4271c7 4885c0          test    rax,rax
        fffff806`3a4271ca 0f84c7000000    je      nt!CmUnRegisterCallback+0x157
(fffff806`3a427297)  Branch
    */
    pAddress = SearchMemory(pCmUnRegisterCallback, (PVOID)((PUCHAR)pCmUnRegisterCallback +
0xFF), pSpecialData, ulSpecialDataSize);
    if (NULL == pAddress)
    {
        return pCallbackListHead;
    }

    // 先获取偏移再计算地址
    lOffset = *(PLONG)((PUCHAR)pAddress + lSpecialOffset);
    pCallbackListHead = (PVOID)((PUCHAR)pAddress + lSpecialOffset + sizeof(LONG) + lOffset);

    return pCallbackListHead;
}


VOID UnDriver(PDRIVER_OBJECT Driver)
{
}

NTSTATUS DriverEntry(IN PDRIVER_OBJECT Driver, PUNICODE_STRING RegistryPath)
{
```

```
    PVOID pCallbackListHeadAddress = NULL;
    RTL_OSVERSIONINFOW osInfo = { 0 };
    UCHAR pSpecialData[50] = { 0 };
    ULONG ulSpecialDataSize = 0;
    LONG lSpecialOffset = 0;

    DbgPrint("hello lyshark.com \n");

    // 查找 fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
    /*
    lyshark.com>
    nt!CmUnRegisterCallback+0x6b:
    fffff806`3a4271ab 4533c0          xor     r8d,r8d
    fffff806`3a4271ae 488d542438      lea     rdx,[rsp+38h]
    fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead (fffff806`3a065bc0)]
    fffff806`3a4271ba e855e2e2ff      call    nt!CmListGetNextElement (fffff806`3a255414)
    fffff806`3a4271bf 488bf8          mov     rdi,rax
    fffff806`3a4271c2 4889442440      mov     qword ptr [rsp+40h],rax
    fffff806`3a4271c7 4885c0          test    rax,rax
    fffff806`3a4271ca 0f84c7000000    je      nt!CmUnRegisterCallback+0x157
(fffff806`3a427297)  Branch
    */
    pSpecialData[0] = 0x48;
    pSpecialData[1] = 0x8D;
    pSpecialData[2] = 0x0D;
    ulSpecialDataSize = 3;

    // 根据特征码获取地址
    pCallbackListHeadAddress = SearchCallbackListHead(pSpecialData, ulSpecialDataSize,
lSpecialOffset);

    DbgPrint("[LyShark.com] CallbackListHead => %p \n", pCallbackListHeadAddress);

    Driver->DriverUnload = UnDriver;
    return STATUS_SUCCESS;
}
```

运行这段代码，并可得到注册表回调入口地址，输出效果如下所示：



得到了注册表回调入口地址，接着直接循环遍历输出这个链表即可得到所有的注册表回调。

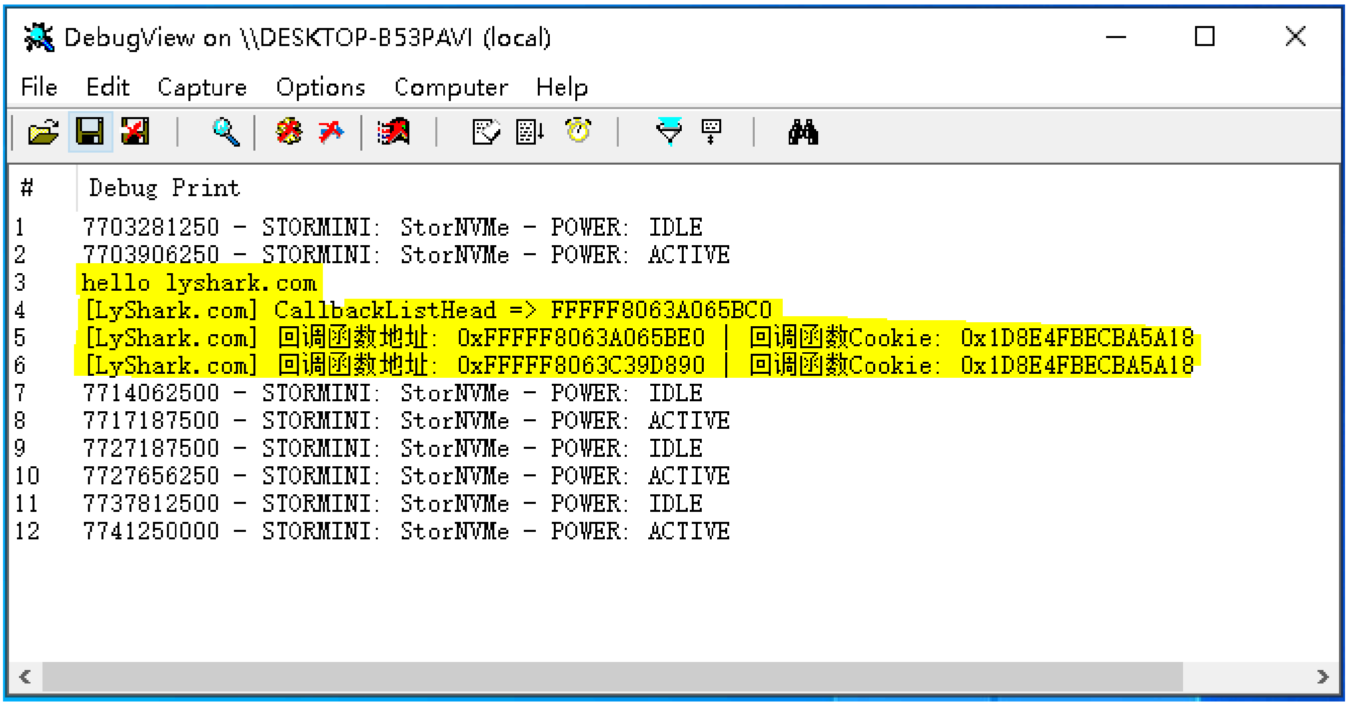
```
#include <ntifs.h>
#include <windef.h>

// 指定内存区域的特征码扫描
PVOID SearchMemory(PVOID pStartAddress, PVOID pEndAddress, PUCHAR pMemoryData, ULONG
ulMemoryDataSize)
{
    PVOID pAddress = NULL;
    PUCHAR i = NULL;
    ULONG m = 0;

    // 扫描内存
    for (i = (PUCHAR)pStartAddress; i < (PUCHAR)pEndAddress; i++)
    {
        // 判断特征码
        for (m = 0; m < ulMemoryDataSize; m++)
        {
            if (*(PUCHAR)(i + m) != pMemoryData[m])
            {
                break;
            }
        }
        // 判断是否找到符合特征码的地址
        if (m >= ulMemoryDataSize)
        {
            // 找到特征码位置, 获取紧接着特征码的下一地址
            pAddress = (PVOID)(i + ulMemoryDataSize);
            break;
        }
    }

    return pAddress;
```

```
}

// 根据特征码获取 CallbackListHead 链表地址
PVOID SearchCallbackListHead(PUCHAR pSpecialData, ULONG ulSpecialDataSize, LONG
lSpecialOffset)
{
    UNICODE_STRING ustrFuncName;
    PVOID pAddress = NULL;
    LONG lOffset = 0;
    PVOID pCmUnRegisterCallback = NULL;
    PVOID pCallbackListHead = NULL;

    // 先获取 CmUnRegisterCallback 函数地址
    RtlInitUnicodeString(&ustrFuncName, L"CmUnRegisterCallback");
    pCmUnRegisterCallback = MmGetSystemRoutineAddress(&ustrFuncName);
    if (NULL == pCmUnRegisterCallback)
    {
        return pCallbackListHead;
    }

    // 查找 fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
    /*
    lyshark.com>
        nt!CmUnRegisterCallback+0x6b:
        fffff806`3a4271ab 4533c0          xor     r8d,r8d
        fffff806`3a4271ae 488d542438      lea     rdx,[rsp+38h]
        fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
        fffff806`3a4271ba e855e2e2ff      call    nt!CmListGetNextElement
(fffff806`3a255414)
        fffff806`3a4271bf 488bf8          mov     rdi,rax
        fffff806`3a4271c2 4889442440      mov     qword ptr [rsp+40h],rax
        fffff806`3a4271c7 4885c0          test    rax,rax
        fffff806`3a4271ca 0f84c7000000    je      nt!CmUnRegisterCallback+0x157
(fffff806`3a427297)  Branch
    */
    pAddress = SearchMemory(pCmUnRegisterCallback, (PVOID)((PUCHAR)pCmUnRegisterCallback +
0xFF), pSpecialData, ulSpecialDataSize);
    if (NULL == pAddress)
    {
        return pCallbackListHead;
    }

    // 先获取偏移再计算地址
    lOffset = *(PLONG)((PUCHAR)pAddress + lSpecialOffset);
    pCallbackListHead = (PVOID)((PUCHAR)pAddress + lSpecialOffset + sizeof(LONG) + lOffset);

    return pCallbackListHead;
}

// 注册表回调函数结构体定义
typedef struct _CM_NOTIFY_ENTRY
```

```
{
    LIST_ENTRY  ListEntryHead;
    ULONG   UnKnown1;
    ULONG   UnKnown2;
    LARGE_INTEGER Cookie;
    PVOID   Context;
    PVOID   Function;
}CM_NOTIFY_ENTRY, *PCM_NOTIFY_ENTRY;

VOID UnDriver(PDRIVER_OBJECT Driver)
{
}

NTSTATUS DriverEntry(IN PDRIVER_OBJECT Driver, PUNICODE_STRING RegistryPath)
{
    PVOID pCallbackListHeadAddress = NULL;
    RTL_OSVERSIONINFOW osInfo = { 0 };
    UCHAR pSpecialData[50] = { 0 };
    ULONG ulSpecialDataSize = 0;
    LONG lSpecialOffset = 0;

    DbgPrint("hello lyshark.com \n");

    // 查找 fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead
(fffff806`3a065bc0)]
    /*
    lyshark.com>
    nt!CmUnRegisterCallback+0x6b:
    fffff806`3a4271ab 4533c0          xor     r8d,r8d
    fffff806`3a4271ae 488d542438      lea     rdx,[rsp+38h]
    fffff806`3a4271b3 488d0d06eac3ff  lea     rcx,[nt!CallbackListHead (fffff806`3a065bc0)]
    fffff806`3a4271ba e855e2e2ff      call    nt!CmListGetNextElement (fffff806`3a255414)
    fffff806`3a4271bf 488bf8          mov     rdi,rax
    fffff806`3a4271c2 4889442440      mov     qword ptr [rsp+40h],rax
    fffff806`3a4271c7 4885c0          test    rax,rax
    fffff806`3a4271ca 0f84c7000000    je      nt!CmUnRegisterCallback+0x157
(fffff806`3a427297)  Branch
    */
    pSpecialData[0] = 0x48;
    pSpecialData[1] = 0x8D;
    pSpecialData[2] = 0x0D;
    ulSpecialDataSize = 3;

    // 根据特征码获取地址
    pCallbackListHeadAddress = SearchCallbackListHead(pSpecialData, ulSpecialDataSize,
lSpecialOffset);

    DbgPrint("[LyShark.com] CallbackListHead => %p \n", pCallbackListHeadAddress);

    // 遍历链表结构
    ULONG i = 0;
    PCM_NOTIFY_ENTRY pNotifyEntry = NULL;
```

```
    if (NULL == pCallbackListHeadAddress)
    {
        return FALSE;
    }

    // 开始遍历双向链表
    pNotifyEntry = (PCM_NOTIFY_ENTRY)pCallbackListHeadAddress;
    do
    {
        // 判断pNotifyEntry地址是否有效
        if (FALSE == MmIsAddressValid(pNotifyEntry))
        {
            break;
        }
        // 判断回调函数地址是否有效
        if (MmIsAddressValid(pNotifyEntry->Function))
        {
            DbgPrint("[LyShark.com] 回调函数地址: 0x%p | 回调函数Cookie: 0x%I64X \n",
pNotifyEntry->Function, pNotifyEntry->Cookie.QuadPart);
        }

        // 获取下一链表
        pNotifyEntry = (PCM_NOTIFY_ENTRY)pNotifyEntry->ListEntryHead.Flink;

    } while (pCallbackListHeadAddress != (PVOID)pNotifyEntry);

    Driver->DriverUnload = UnDriver;
    return STATUS_SUCCESS;
}
```

最终运行这个驱动程序，输出如下效果：



目前系统中有两个回调函数，这一点在第一张图片中也可以得到，枚举是正确的。