

在笔者上一篇文章《驱动开发：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。

我们来看一款闭源ARK工具是如何实现的：

进程	驱动模块	内核层	内核钩子	应用层钩子	设置	监控	启动信息	注册表	服务	文件	网络	调试引擎
系统回调	过滤驱动	DPC定时器	IO定时器	系统线程	卸载的驱动							
回调入口	通知类型	模块路径										
0xFFFFF80636A2D760	ThreadObCall	C:\Windows\System32\drivers\PYArkSafe.sys										
0xFFFFF8063C39D890	Registry	C:\Windows\system32\drivers\WdFilter.sys										
0xFFFFF8063A065BE0	Registry	C:\Windows\system32\ntoskrnl.exe										
0xFFFFF8063C3A8410	ProcessObCall	C:\Windows\system32\drivers\WdFilter.sys										
0xFFFFF80636A2D420	ProcessObCall	C:\Windows\System32\drivers\PYArkSafe.sys										
0xFFFFF80636A2C550	LoadImage	C:\Windows\System32\drivers\PYArkSafe.sys										

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。

```
Kernel 'com:port=\\.\pipe\com_1,baud=115200,pipe' - WinDbg:10.0.16299.15 AMD64
File Edit View Debug Window Help
[Icons]
Command
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,rcx
fffff806`3a4271c2 4889442440  mov     qword ptr [rsp+40h],rax
fffff806`3a4271c7 4885c0      test    rax,rax
fffff806`3a4271ca 0f84c7000000 je      nt!CmUnRegisterCallback+0x157 (fffff806`3a427297)

nt!CmUnRegisterCallback+0x90:
fffff806`3a4271d0 48395818    cmp     qword ptr [rax+18h],rbx
fffff806`3a4271d4 75d5      jne     nt!CmUnRegisterCallback+0x6b (fffff806`3a4271ab)
```

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。

```
// 署名权
// right to sign one's name on a piece of work
// PowerBy: LyShark
// Email: me@lyshark.com
```

```
// 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，并将其后面的基址取出来，在上一篇《驱动开发：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。

```
// 署名权
// right to sign one's name on a piece of work
// PowerBy: LyShark
// Email: me@lyshark.com

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

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

    // 扫描内存
    for (i = (PCHAR)pStartAddress; i < (PCHAR)pEndAddress; i++)
    {
        // 判断特征码
        for (m = 0; m < ulMemoryDataSize; m++)
        {
            if (*(PCHAR)(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
// PowerBy: LyShark.com
PVOID SearchCallbackListHead(PCHAR 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 ffffffff806`3a4271b3 488d0d06eac3ff lea rcx,[nt!CallbackListHead
(fffffffff806`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
(fffffffff806`3a065bc0)]
fffff806`3a4271ba e855e2e2ff       call    nt!CmListGetNextElement
(fffffffff806`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
(fffffffff806`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 + 1*SpecialOffset);
pCallbackListHead = (PVOID)((PUCHAR)pAddress + 1*SpecialOffset + 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：

#	Time	Debug Print
1	0.00000000	4836406250 - STORMINI: StorNVMe - POWER: IDLE
2	0.34673479	4839687500 - STORMINI: StorNVMe - POWER: ACTIVE
3	1.06057155	hello lyshark.com
4	1.06527448	[LyShark.com] CallbackListHead => FFFFF8063A065BC0
5	1.48369396	4849843750 - STORMINI: StorNVMe - POWER: IDLE
6	1.62090075	4851093750 - STORMINI: StorNVMe - POWER: ACTIVE
7	2.89499855	4861250000 - STORMINI: StorNVMe - POWER: IDLE
8	3.17070532	4863906250 - STORMINI: StorNVMe - POWER: ACTIVE

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。

```

// 署名权
// right to sign one's name on a piece of work
// PowerBy: LyShark
// Email: me@lyshark.com

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

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

    // 扫描内存
    for (i = (PCHAR)pStartAddress; i < (PCHAR)pEndAddress; i++)
    {
        // 判断特征码
        for (m = 0; m < ulMemoryDataSize; m++)
        {
            if (*(PCHAR)(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
// PowerBy: LyShark.com
PVOID SearchCallbackListHead(PCHAR 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 ffffffff806`3a4271b3 488d0d06eac3ff lea rcx,[nt!CallbackListHead
(fffffffff806`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
(fffffffff806`3a065bc0)]
fffff806`3a4271ba e855e2e2ff call nt!CmListGetNextElement
(fffffffff806`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
(fffffffff806`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 == MmIsValidAddress(pNotifyEntry))
        {
            break;
        }

        // 判断回调函数地址是否有效
        if (MmIsValidAddress(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);
    }

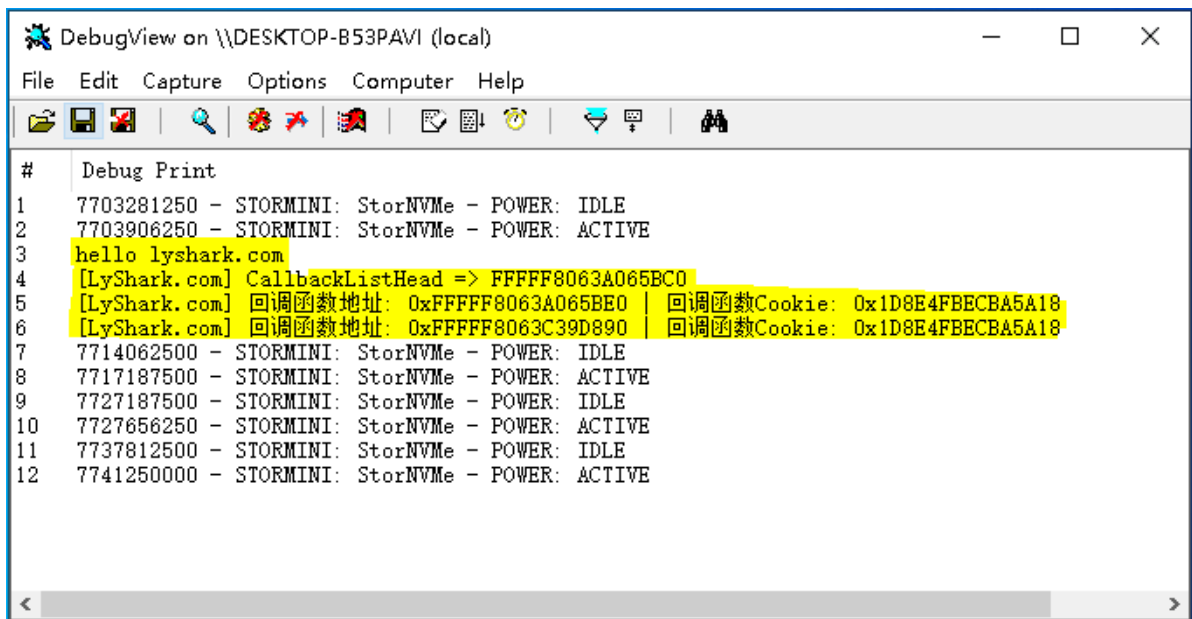
    // 获取下一链表
    pNotifyEntry = (PCM_NOTIFY_ENTRY)pNotifyEntry->ListEntryHead.Flink;

} 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：



```

# Debug Print
1 7703281250 - STORMINI: StorNVMe - POWER: IDLE
2 7703906250 - STORMINI: StorNVMe - POWER: ACTIVE
3 hello lyshark.com
4 [LyShark.com] CallbackListHead => FFFFFF8063A065BC0
5 [LyShark.com] 回调函数地址: 0xFFFFF8063A065BE0 | 回调函数Cookie: 0x1D8E4FBECBA5A18
6 [LyShark.com] 回调函数地址: 0xFFFFF8063C39D890 | 回调函数Cookie: 0x1D8E4FBECBA5A18
7 7714062500 - STORMINI: StorNVMe - POWER: IDLE
8 7717187500 - STORMINI: StorNVMe - POWER: ACTIVE
9 7727187500 - STORMINI: StorNVMe - POWER: IDLE
10 7727656250 - STORMINI: StorNVMe - POWER: ACTIVE
11 7737812500 - STORMINI: StorNVMe - POWER: IDLE
12 7741250000 - STORMINI: StorNVMe - POWER: ACTIVE

```

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。

作者：王瑞 (LyShark)

作者邮箱：me@lyshark.com

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