在前面的文章`《驱动开发：运用MDL映射实现多次通信》`LyShark教大家使用`MDL`的方式灵活的实现了内核态多次输出结构体的效果，但是此种方法并不推荐大家使用原因很简单首先内核空间比较宝贵，其次内核里面不能分配太大且每次传出的结构体最大不能超过`1024`个，而最终这些内存由于无法得到更好的释放从而导致坏堆的产生，这样的程序显然是无法在生产环境中使用的，如下`LyShark`将教大家通过在应用层申请空间来实现同等效果，此类传递方式也是多数ARK反内核工具中最常采用的一种。

与MDL映射相反，MDL多数处理流程在内核代码中，而应用层开堆复杂代码则在应用层，但内核层中同样还是需要使用指针，只是这里的指针仅仅只是保留基本要素即可，通过`EnumProcess()`模拟枚举进程操作，传入的是`PPROCESS_INFO`进程指针转换，将数据传入到`PPROCESS_INFO`直接返回进程计数器即可。

```
// --------------------------------------------------
// R3传输结构体
// --------------------------------------------------

// 进程指针转换
typedef struct
{
  DWORD PID;
  DWORD PPID;
}PROCESS_INFO, *PPROCESS_INFO;

// 数据存储指针
typedef struct
{
  ULONG_PTR nSize;
  PVOID BufferPtr;
}BufferPointer, *pBufferPointer;

// 模拟进程枚举
ULONG EnumProcess(PPROCESS_INFO pBuffer)
{
  ULONG nCount = 0;

  for (size_t i = 0; i < 10; i++)
  {
    pBuffer[i].PID = nCount * 2;
    pBuffer[i].PPID = nCount * 4;

    nCount = nCount + 1;
  }
  return nCount;
}
```

内核层核心代码： 内核代码中是如何通信的，首先从用户态接收`pIoBuffer`到分配的缓冲区数据，并转换为`pBufferPointer`结构，`ProbeForWrite`用于检查地址是否可写入，接着会调用`EnumProcess()`注意传入的其实是应用层的指针，枚举进程结束后，将进程数量`nCount`通过`*(PULONG)pIrp->AssociatedIrp.SystemBuffer = (ULONG)nCount`回传给应用层，至此内核中仅仅回传了一个长度，其他的都写入到了应用层中。

```
// 署名权
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// PowerBy: LyShark
// Email: me@lyshark.com

pBufferPointer pinp = (pBufferPointer)pIoBuffer;

__try
{
  DbgPrint("缓冲区长度: %d \n", pinp->nSize);
  DbgPrint("缓冲区基地址: %p \n", pinp->BufferPtr);

  // 检查地址是否可写入
  ProbeForWrite(pinp->BufferPtr, pinp->nSize, 1);

  ULONG nCount = EnumProcess((PPROCESS_INFO)pinp->BufferPtr);
  DbgPrint("进程计数 = %d \n", nCount);
  if (nCount > 0)
  {
    // 将进程数返回给用户
    *(PULONG)pIrp->AssociatedIrp.SystemBuffer = (ULONG)nCount;
    status = STATUS_SUCCESS;
  }
}
__except (1)
{
  status = GetExceptionCode();
  DbgPrint("IOCTL_GET_EPROCESS %x \n", status);
}

// 返回通信状态
status = STATUS_SUCCESS;
break;
```

应用层核心代码： 通信的重点在于应用层，首先定义`BufferPointer`用于存放缓冲区头部指针，定义`PPROCESS_INFO`则是用于后期将数据放入该容器内，函数`HeapAlloc`分配一段堆空间，并`HEAP_ZERO_MEMORY`将该堆空间全部填空，将这一段初始化后的空间放入到`pInput.BufferPtr`缓冲区内，并计算出长度放入到`pInput.nSize`缓冲区内，一切准备就绪之后，再通过`DriveControl.IoControl`将`BufferPointer`结构传输至内核中，而`bRet`则是用于接收返回长度的变量。

当收到数据后，通过`(PPROCESS_INFO)pInput.BufferPtr`强制转换为指针类型，并依次`pProcessInfo[i]`读出每一个节点的元素，最后是调用`HeapFree`释放掉这段堆空间。至于输出就很简单了`vectorProcess[x].PID`循环容器元素即可。

```
// 署名权
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// 应用层数据结构体数据
BOOL bRet = FALSE;
BufferPointer pInput = { 0 };
```

```
PPROCESS_INFO pProcessInfo = NULL;

// 分配堆空间
pInput.BufferPtr = (PVOID)HeapAlloc(GetProcessHeap(), HEAP_ZERO_MEMORY,
sizeof(PROCESS_INFO) * 1000);
pInput.nSize = sizeof(PROCESS_INFO) * 1000;

ULONG nRet = 0;

if (pInput.BufferPtr)
{
  bRet = DriveControl.IoControl(IOCTL_IO_R3StructAll, &pInput,
sizeof(BufferPointer), &nRet, sizeof(ULONG), 0);
}

std::cout << "返回结构体数量: " << nRet << std::endl;

if (bRet && nRet > 0)
{
  pProcessInfo = (PPROCESS_INFO)pInput.BufferPtr;
  std::vector<PROCESS_INFO> vectorProcess;

  for (ULONG i = 0; i < nRet; i++)
  {
    vectorProcess.push_back(pProcessInfo[i]);
  }

  // 释放空间
  bRet = HeapFree(GetProcessHeap(), 0, pInput.BufferPtr);
  std::cout << "释放状态: " << bRet << std::endl;

  // 输出容器内的进程ID列表
  for (int x = 0; x < nRet; x++)
  {
    std::cout << "PID: " << vectorProcess[x].PID << " PPID: " <<
vectorProcess[x].PPID << std::endl;
  }
}

// 关闭符号链接句柄
CloseHandle(DriveControl.m_hDriver);
```

如上就是内核层与应用层的部分代码功能分析，接下来我将完整代码分享出来，大家可以自行测试效果。

驱动程序`WinDDK.sys`完整代码；

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

#define _CRT_SECURE_NO_WARNINGS
```

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

// 定义符号链接，一般来说修改为驱动的名字即可
#define DEVICE_NAME        L"\\Device\\WinDDK"
#define LINK_NAME          L"\\DosDevices\\WinDDK"
#define LINK_GLOBAL_NAME   L"\\DosDevices\\Global\\WinDDK"

// 定义驱动功能号和名字，提供接口给应用程序调用
#define IOCTL_IO_R3StructAll     CTL_CODE(FILE_DEVICE_UNKNOWN, 0x806,
METHOD_BUFFERED, FILE_ANY_ACCESS)

// 保存一段非分页内存,用于给全局变量使用
#define FILE_DEVICE_EXTENSION 4096

// -------------------------------------------------
// R3传输结构体
// -------------------------------------------------

// 进程指针转换
typedef struct
{
    DWORD PID;
    DWORD PPID;
}PROCESS_INFO, *PPROCESS_INFO;

// 数据存储指针
typedef struct
{
    ULONG_PTR nSize;
    PVOID BufferPtr;
}BufferPointer, *pBufferPointer;

// 模拟进程枚举
ULONG EnumProcess(PPROCESS_INFO pBuffer)
{
    ULONG nCount = 0;

    for (size_t i = 0; i < 10; i++)
    {
        pBuffer[i].PID = nCount * 2;
        pBuffer[i].PPID = nCount * 4;

        nCount = nCount + 1;
    }
    return nCount;
}

// 驱动绑定默认派遣函数
NTSTATUS DefaultDispatch(PDEVICE_OBJECT _pDeviceObject, PIRP _pIrp)
{
    _pIrp->IoStatus.Status = STATUS_NOT_SUPPORTED;
    _pIrp->IoStatus.Information = 0;
    IoCompleteRequest(_pIrp, IO_NO_INCREMENT);
    return _pIrp->IoStatus.Status;
}

// 驱动卸载的处理例程
VOID DriverUnload(PDRIVER_OBJECT pDriverObj)
{
    if (pDriverObj->DeviceObject)
    {
        UNICODE_STRING strLink;

        // 删除符号连接和设备
        RtlInitUnicodeString(&strLink, LINK_NAME);
        IoDeleteSymbolicLink(&strLink);
        IoDeleteDevice(pDriverObj->DeviceObject);
        DbgPrint("[kernel] # 驱动已卸载 \n");
    }
}

// IRP_MJ_CREATE 对应的处理例程，一般不用管它
NTSTATUS DispatchCreate(PDEVICE_OBJECT pDevObj, PIRP pIrp)
{
    DbgPrint("[kernel] # 驱动处理例程载入 \n");
    pIrp->IoStatus.Status = STATUS_SUCCESS;
    pIrp->IoStatus.Information = 0;
    IoCompleteRequest(pIrp, IO_NO_INCREMENT);
    return STATUS_SUCCESS;
}

// IRP_MJ_CLOSE 对应的处理例程，一般不用管它
NTSTATUS DispatchClose(PDEVICE_OBJECT pDevObj, PIRP pIrp)
{
    DbgPrint("[kernel] # 关闭派遣 \n");
    pIrp->IoStatus.Status = STATUS_SUCCESS;
    pIrp->IoStatus.Information = 0;
    IoCompleteRequest(pIrp, IO_NO_INCREMENT);
    return STATUS_SUCCESS;
}

// IRP_MJ_DEVICE_CONTROL 对应的处理例程，驱动最重要的函数
NTSTATUS DispatchIoctl(PDEVICE_OBJECT pDevObj, PIRP pIrp)
{
    NTSTATUS status = STATUS_INVALID_DEVICE_REQUEST;
    PIO_STACK_LOCATION pIrpStack;
    ULONG uIoControlCode;
    PVOID pIoBuffer;
    ULONG uInSize;
    ULONG uOutSize;

    // 获得IRP里的关键数据
    pIrpStack = IoGetCurrentIrpStackLocation(pIrp);
```

```
// 获取控制码
uIoControlCode = pIrpStack->Parameters.DeviceIoControl.IoControlCode;

// 输入和输出的缓冲区（DeviceIoControl的InBuffer和OutBuffer都是它）
pIoBuffer = pIrp->AssociatedIrp.SystemBuffer;

// EXE发送传入数据的BUFFER长度（DeviceIoControl的nInBufferSize）
uInSize = pIrpStack->Parameters.DeviceIoControl.InputBufferLength;

// EXE接收传出数据的BUFFER长度（DeviceIoControl的nOutBufferSize）
uOutSize = pIrpStack->Parameters.DeviceIoControl.OutputBufferLength;

// 对不同控制信号的处理流程
switch (uIoControlCode)
{
// 测试R3传输多次结构体
case IOCTL_IO_R3StructAll:
{
    pBufferPointer pinp = (pBufferPointer)pIoBuffer;

    __try
    {
        DbgPrint("[lyshark] 缓冲区长度: %d \n", pinp->nSize);
        DbgPrint("[lyshark] 缓冲区基地址: %p \n", pinp->BufferPtr);

        // 检查地址是否可写入
        ProbeForWrite(pinp->BufferPtr, pinp->nSize, 1);

        ULONG nCount = EnumProcess((PPROCESS_INFO)pinp->BufferPtr);
        DbgPrint("[lyshark.com] 进程计数 = %d \n", nCount);
        if (nCount > 0)
        {
            // 将进程数返回给用户
            *(PULONG)pIrp->AssociatedIrp.SystemBuffer = (ULONG)nCount;
            status = STATUS_SUCCESS;
        }
    }
    __except (1)
    {
        status = GetExceptionCode();
        DbgPrint("IOCTL_GET_EPROCESS %x \n", status);
    }

    // 返回通信状态
    status = STATUS_SUCCESS;
    break;
}
}

// 设定DeviceIoControl的*lpBytesReturned的值（如果通信失败则返回0长度）
if (status == STATUS_SUCCESS)
```

```
    {
        pIrp->IoStatus.Information = uOutSize;
    }
    else
    {
        pIrp->IoStatus.Information = 0;
    }

    // 设定DeviceIoControl的返回值是成功还是失败
    pIrp->IoStatus.Status = status;
    IoCompleteRequest(pIrp, IO_NO_INCREMENT);
    return status;
}

// 驱动的初始化工作
NTSTATUS DriverEntry(PDRIVER_OBJECT pDriverObj, PUNICODE_STRING pRegistryString)
{
    NTSTATUS status = STATUS_SUCCESS;
    UNICODE_STRING ustrLinkName;
    UNICODE_STRING ustrDevName;
    PDEVICE_OBJECT pDevObj;

    // 初始化其他派遣
    for (ULONG i = 0; i < IRP_MJ_MAXIMUM_FUNCTION; i++)
    {
        // DbgPrint("初始化派遣: %d \n", i);
        pDriverObj->MajorFunction[i] = DefaultDispatch;
    }

    // 设置分发函数和卸载例程
    pDriverObj->MajorFunction[IRP_MJ_CREATE] = DispatchCreate;
    pDriverObj->MajorFunction[IRP_MJ_CLOSE] = DispatchClose;
    pDriverObj->MajorFunction[IRP_MJ_DEVICE_CONTROL] = DispatchIoctl;
    pDriverObj->DriverUnload = DriverUnload;

    // 创建一个设备
    RtlInitUnicodeString(&ustrDevName, DEVICE_NAME);

    // FILE_DEVICE_EXTENSION 创建设备时，指定设备扩展内存的大小，传一个值进去，就会给设备分配一块非页面内存。
    status = IoCreateDevice(pDriverObj, sizeof(FILE_DEVICE_EXTENSION), &ustrDevName, FILE_DEVICE_UNKNOWN, 0, FALSE, &pDevObj);
    if (!NT_SUCCESS(status))
    {
        return status;
    }

    // 判断支持的WDM版本，其实这个已经不需要了，纯属WIN9X和WINNT并存时代的残留物
    if (IoIsWdmVersionAvailable(1, 0x10))
    {
        RtlInitUnicodeString(&ustrLinkName, LINK_GLOBAL_NAME);
    }
    else
    {
        RtlInitUnicodeString(&ustrLinkName, LINK_NAME);
    }

    // 创建符号连接
    status = IoCreateSymbolicLink(&ustrLinkName, &ustrDevName);
    if (!NT_SUCCESS(status))
    {
        DbgPrint("创建符号链接失败 \n");
        IoDeleteDevice(pDevObj);
        return status;
    }
    DbgPrint("[hello LyShark.com] # 驱动初始化完毕 \n");

    // 返回加载驱动的状态（如果返回失败，驱动讲被清除出内核空间）
    return STATUS_SUCCESS;
}
```

应用层客户端程序`lyshark.exe`完整代码；

```
// 署名权
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// PowerBy: LyShark
// Email: me@lyshark.com

#include <iostream>
#include <Windows.h>
#include <vector>

#pragma comment(lib,"user32.lib")
#pragma comment(lib,"advapi32.lib")

// 定义驱动功能号和名字，提供接口给应用程序调用
#define IOCTL_IO_R3StructAll    0x806

class cDrvCtrl
{
public:
    cDrvCtrl()
    {
        m_pSysPath = NULL;
        m_pServiceName = NULL;
        m_pDisplayName = NULL;
        m_hSCManager = NULL;
        m_hService = NULL;
        m_hDriver = INVALID_HANDLE_VALUE;
    }
    ~cDrvCtrl()
    {
        CloseServiceHandle(m_hService);
        CloseServiceHandle(m_hSCManager);
        CloseHandle(m_hDriver);
    }

    // 安装驱动
    BOOL Install(PCHAR pSysPath, PCHAR pServiceName, PCHAR pDisplayName)
    {
        m_pSysPath = pSysPath;
        m_pServiceName = pServiceName;
        m_pDisplayName = pDisplayName;
        m_hSCManager = OpenSCManagerA(NULL, NULL, SC_MANAGER_ALL_ACCESS);
        if (NULL == m_hSCManager)
        {
            m_dwLastError = GetLastError();
            return FALSE;
        }
        m_hService = CreateServiceA(m_hSCManager, m_pServiceName, m_pDisplayName,
            SERVICE_ALL_ACCESS, SERVICE_KERNEL_DRIVER, SERVICE_DEMAND_START, SERVICE_ERROR_NORMAL,
            m_pSysPath, NULL, NULL, NULL, NULL, NULL);
        if (NULL == m_hService)
        {
            m_dwLastError = GetLastError();
            if (ERROR_SERVICE_EXISTS == m_dwLastError)
            {
                m_hService = OpenServiceA(m_hSCManager, m_pServiceName, SERVICE_ALL_ACCESS);
                if (NULL == m_hService)
                {
                    CloseServiceHandle(m_hSCManager);
                    return FALSE;
                }
            }
            else
            {
                CloseServiceHandle(m_hSCManager);
                return FALSE;
            }
        }
        return TRUE;
    }

    // 启动驱动
    BOOL Start()
    {
        if (!StartServiceA(m_hService, NULL, NULL))
        {
            m_dwLastError = GetLastError();
            return FALSE;
        }
        return TRUE;
    }
    // 关闭驱动
    BOOL Stop()
    {
        SERVICE_STATUS ss;
        GetSvcHandle(m_pServiceName);
        if (!ControlService(m_hService, SERVICE_CONTROL_STOP, &ss))
        {
            m_dwLastError = GetLastError();
            return FALSE;
        }
        return TRUE;
    }

    // 移除驱动
    BOOL Remove()
    {
        GetSvcHandle(m_pServiceName);
        if (!DeleteService(m_hService))
        {
            m_dwLastError = GetLastError();
            return FALSE;
        }
        return TRUE;
    }

    // 打开驱动
    BOOL Open(PCHAR pLinkName)
    {
        if (m_hDriver != INVALID_HANDLE_VALUE)
            return TRUE;
        m_hDriver = CreateFileA(pLinkName, GENERIC_READ | GENERIC_WRITE, 0, 0,
OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, 0);
        if (m_hDriver != INVALID_HANDLE_VALUE)
            return TRUE;
        else
            return FALSE;
    }

    // 发送控制信号
    BOOL IoControl(DWORD dwIoCode, PVOID InBuff, DWORD InBuffLen, PVOID OutBuff,
DWORD OutBuffLen, DWORD *RealRetBytes)
    {
        DWORD dw;
        BOOL b = DeviceIoControl(m_hDriver, CTL_CODE_GEN(dwIoCode), InBuff,
InBuffLen, OutBuff, OutBuffLen, &dw, NULL);
        if (RealRetBytes)
            *RealRetBytes = dw;
        return b;
    }
private:
    // 获取服务句柄
    BOOL GetSvcHandle(PCHAR pServiceName)
    {
        m_pServiceName = pServiceName;
        m_hSCManager = OpenSCManagerA(NULL, NULL, SC_MANAGER_ALL_ACCESS);
        if (NULL == m_hSCManager)
        {
            m_dwLastError = GetLastError();
            return FALSE;
        }
        m_hService = OpenServiceA(m_hSCManager, m_pServiceName, SERVICE_ALL_ACCESS);
        if (NULL == m_hService)
        {
            CloseServiceHandle(m_hSCManager);
            return FALSE;
        }
        else
        {
            return TRUE;
        }
    }

    // 获取控制信号对应字符串
    DWORD CTL_CODE_GEN(DWORD lngFunction)
    {
        return (FILE_DEVICE_UNKNOWN * 65536) | (FILE_ANY_ACCESS * 16384) | (lngFunction * 4) | METHOD_BUFFERED;
    }

public:
    DWORD m_dwLastError;
    PCHAR m_pSysPath;
    PCHAR m_pServiceName;
    PCHAR m_pDisplayName;
    HANDLE m_hDriver;
    SC_HANDLE m_hSCManager;
    SC_HANDLE m_hService;
};

void GetAppPath(char *szCurFile)
{
    GetModuleFileNameA(0, szCurFile, MAX_PATH);
    for (SIZE_T i = strlen(szCurFile) - 1; i >= 0; i--)
    {
        if (szCurFile[i] == '\\')
        {
            szCurFile[i + 1] = '\0';
            break;
        }
    }
}
```
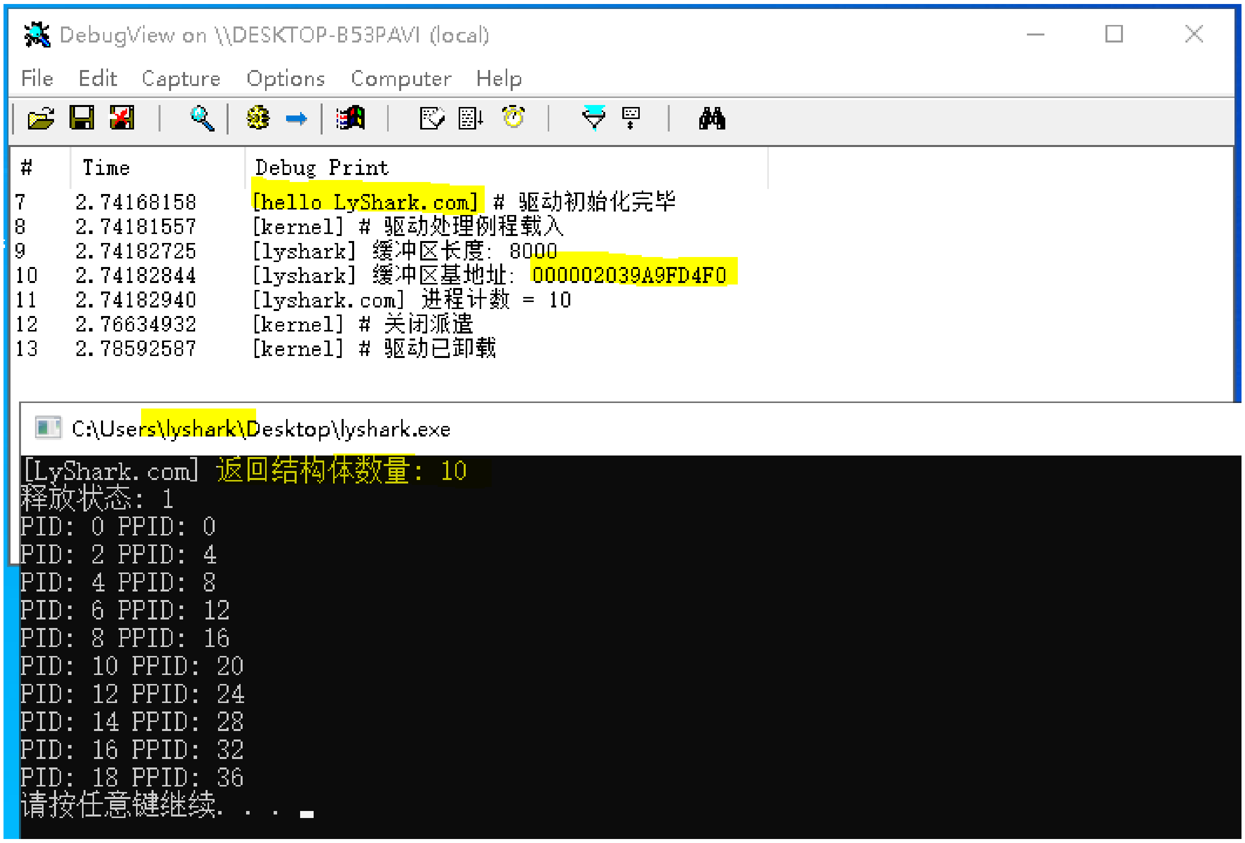

```
// --------------------------------------------------
// R3数据传递变量
// --------------------------------------------------
// 进程指针转换
typedef struct
{
    DWORD PID;
    DWORD PPID;
}PROCESS_INFO, *PPROCESS_INFO;

// 数据存储指针
typedef struct
{
    ULONG_PTR nSize;
    PVOID BufferPtr;
}BufferPointer, *pBufferPointer;

int main(int argc, char *argv[])
{
    cDrvCtrl DriveControl;

    // 设置驱动名称
    char szSysFile[MAX_PATH] = { 0 };
    char szSvcLnkName[] = "WinDDK";;
    GetAppPath(szSysFile);
    strcat(szSysFile, "WinDDK.sys");

    // 安装并启动驱动
    DriveControl.Install(szSysFile, szSvcLnkName, szSvcLnkName);
    DriveControl.Start();

    // 打开驱动的符号链接
    DriveControl.Open("\\\\.\\WinDDK");

    // 应用层数据结构体数据
    BOOL bRet = FALSE;
    BufferPointer pInput = { 0 };
    PPROCESS_INFO pProcessInfo = NULL;

    // 分配堆空间
    pInput.BufferPtr = (PVOID)HeapAlloc(GetProcessHeap(), HEAP_ZERO_MEMORY,
sizeof(PROCESS_INFO) * 1000);
    pInput.nSize = sizeof(PROCESS_INFO) * 1000;

    ULONG nRet = 0;

    if (pInput.BufferPtr)
    {
        bRet = DriveControl.IoControl(IOCTL_IO_R3StructAll, &pInput,
sizeof(BufferPointer), &nRet, sizeof(ULONG), 0);
    }
    std::cout << "[LyShark.com] 返回结构体数量: " << nRet << std::endl;

    if (bRet && nRet > 0)
    {
        pProcessInfo = (PPROCESS_INFO)pInput.BufferPtr;
        std::vector<PROCESS_INFO> vectorProcess;

        for (ULONG i = 0; i < nRet; i++)
        {
            vectorProcess.push_back(pProcessInfo[i]);
        }

        // 释放空间
        bRet = HeapFree(GetProcessHeap(), 0, pInput.BufferPtr);
        std::cout << "释放状态: " << bRet << std::endl;

        // 输出容器内的进程ID列表
        for (int x = 0; x < nRet; x++)
        {
            std::cout << "PID: " << vectorProcess[x].PID << " PPID: " <<
vectorProcess[x].PPID << std::endl;
        }
    }

    // 关闭符号链接句柄
    CloseHandle(DriveControl.m_hDriver);

    // 停止并卸载驱动
    DriveControl.Stop();
    DriveControl.Remove();

    system("pause");
    return 0;
}
```

手动编译这两个程序，将驱动签名后以管理员身份运行`lyshark.exe`客户端，此时屏幕中即可看到滚动输出效果，如此一来就实现了循环传递参数的目的。


DebugView on \\DESKTOP-B53PAVI (local)
File Edit Capture Options Computer Help
C:\Users\lyshark\Desktop\lyshark.exe

```
#   Time        Debug Print
7   2.74168158  [hello LyShark.com] # 驱动初始化完毕
8   2.74181557  [kernel] # 驱动处理例程载入
9   2.74182725  [lyshark] 缓冲区长度: 8000
10  2.74182844  [lyshark] 缓冲区基地址: 000002039A9FD4F0
11  2.74182940  [lyshark.com] 进程计数 = 10
12  2.76634932  [kernel] # 关闭派遣
13  2.78592587  [kernel] # 驱动已卸载
```

```
[LyShark.com] 返回结构体数量: 10
释放状态: 1
PID: 0 PPID: 0
PID: 2 PPID: 4
PID: 4 PPID: 8
PID: 6 PPID: 12
PID: 8 PPID: 16
PID: 10 PPID: 20
PID: 12 PPID: 24
PID: 14 PPID: 28
PID: 16 PPID: 32
PID: 18 PPID: 36
请按任意键继续. . .
```