KMDF

How to develop framework drivers

Kumar Rajeev
SDET
Microsoft Corporation

KMDF And HID Minidriver

KMDF does not support HID minidrivers natively due to conflicting KMDF and HID architecture requirements

HID architecture requires that HIDclass driver own the driver dispatch table, while KMDF requires that it own the dispatch table of the minidriver

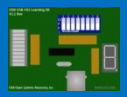
Solution is to use a driver stack that consists of a minimum WDM pass-through driver and a complete KMDF driver

Pass-through driver registers with HIDclass as HID minidriver and forwards all requests to KMDF driver

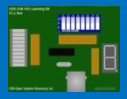
KMDF driver processes all the requests

The sample HIDUSBFX2 demonstrates this solution

Driver Stack
WDM



Driver Stack
KMDF



Purpose Of The Sample

Encourage use of KMDF for writing custom HID minidrivers

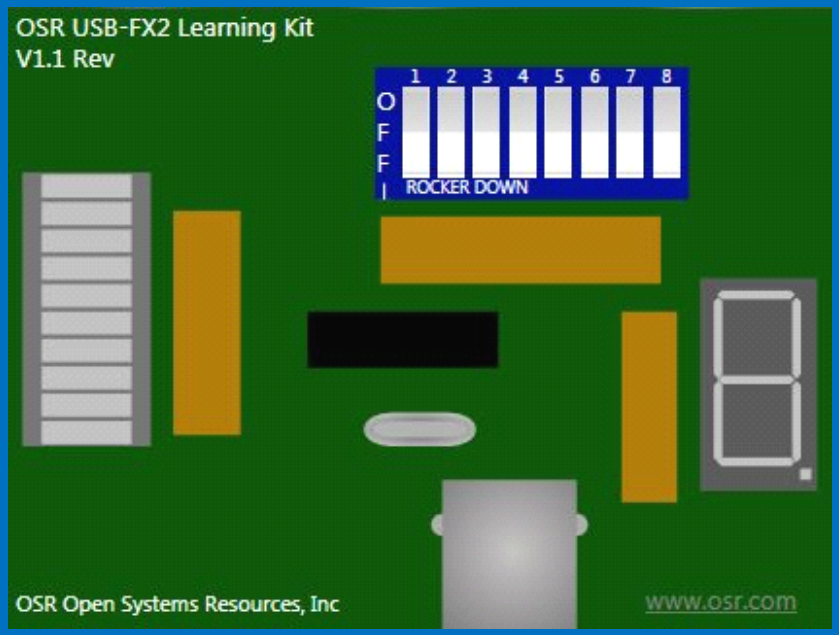
Demonstrate KMDF features suitable for HID minidrivers

Some of the reasons one may end up writing HID minidriver are

- Easier to provide complex HID logic in s/w than in firmware
- Making a change in s/w may be cheaper than in firmware when device is already in market
- Need to make an existing non-HID USB device appear as HID device w/o updating firmware
- When there is no inbox support for the device
- When sideband communication with minidriver is needed, since HIDclass driver doesn't allow user IOCTLs/WMI. With KMDF you can easily enumerate PDOs and use them for sideband communication

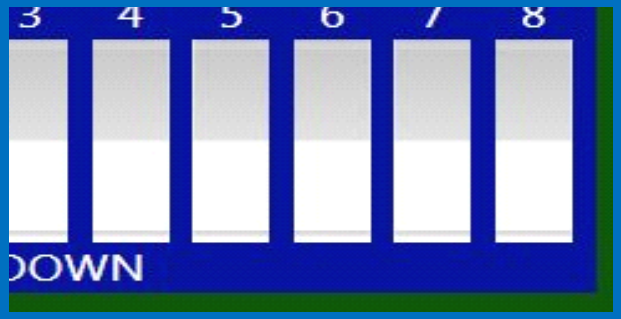
Sample
HIDUSBFX2

- For OSR USB-FX2 device (non-HID device)
- Maps USB-FX2 device's switch pack to HID controls for keyboard hot-keys: Browser, Mail, Sleep etc
- Maps 7-segment display and bar graph display as HID features



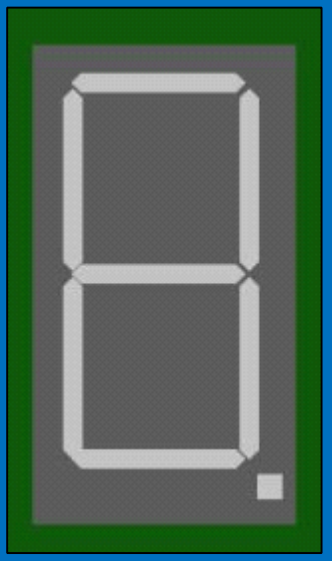
Switch Pack Mapping

- Mapped as HID “Input Report”
- Lower 7 bits represent usages from Consumer Control Collection for keyboard hot-keys
- One highest bit is mapped to “Sleep” usage in System Control Collection



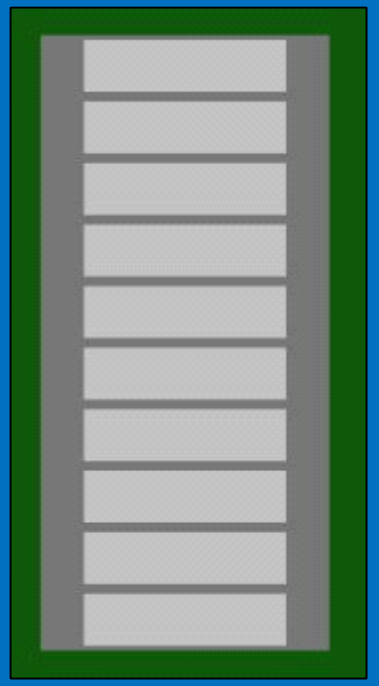
7-Segment Display

- Mapped as HID “Feature”
- HID clients can send SetFeature request to display numbers 1 thru 8 on the segment display
- Vendor Defined Usage Page (0xff00)
- Vendor Defined Usages
  - Usage 0x1 thru 0x8
  - Each usage corresponds to numbers 1 through 8 displayed on segment display. For example, sending usage 0x7 causes the display to show number 7



Bar Graph Display

- Mapped as HID “Feature”
- HID clients can send SetFeature request to light up LEDs on the bar display
- Vendor Defined Usage Page (0xff00)
- Vendor Defined Usages
  - Usage 9 through 18
  - E.g. Sending usage 9 causes the display to turn on LED 1



Sample Details

- Sample has a default parallel queue and a manual queue
- HID data is generally provided by USB interrupt endpoints. KMDF provides “Continuous Reader” mechanism to read such data
- Minidriver relinquishes power policy ownership since HIDclass driver owns power policy

Request Cancellation In A Framework Driver

Eliyas Yakub
Development Lead
Microsoft Corporation

Request Cancelation

- Long term request should be held in a cancelable state for better user experience
- Difficult to get it right in WDM
- Framework provides following options to deal with the complexity
  - Manual queues to hold request
  - Polling for canceled state of request
  - Using cancel-routine

Using Queues

- Request waiting for hardware event should be placed in a manual queue
- When the request is canceled, framework will complete the request on driver's behalf
  - If you want to be notified before the request is completed, you can register for
    - EvtIoCanceledOnQueue callback on Queue
      - Can defer completion if the request is consumed by the hardware
      - Callback is subject to synchronization scope and execution level of the queue
    - EvtContextCleanup callback on Request object

Sample Code
Smartcard

```
NTSTATUS CBCardTracking(PSMARTCARD_EXTENSION SmartcardExtension)
{
    request = GET_WDFREQUEST_FROM_IRP(
                  SmartcardExtension->OsData->NotificationIrp);

    status = WdfRequestForwardToIoQueue(request,
                                DeviceExtension->NotificationQueue);
    if (!NT_SUCCESS(status)) {
        InterlockedExchangePointer(
                  &(SmartcardExtension->OsData->NotificationIrp), NULL);
       WdfRequestComplete(request, status);
    }
    return status;
}

VOID PscrEvtIoCanceledOnQueue(WDFQUEUE Queue, WDFREQUEST Request)
{
    InterlockedExchangePointer(
          &(smartcardExtension->OsData->NotificationIrp), NULL);
    WdfRequestComplete(Request, STATUS_CANCELLED);
}
```

Polling For Cancellation

- Framework provides WdfRequestIsCanceled to check the state of the IRP
- Useful if you are staging single I/O into multiple transactions or actively pooling the hardware before initiating the I/O
- Check the canceled stated before initiating the next transfer

Using CancelRoutine

- Use this approach when you cannot keep long-term requests in queue
- This is by far the most difficult approach
  - Complexity level of this approach is equivalent to the WDM model
- Call WdfRequestMarkCancelable to set EvtRequestCancel on a request
- Call WdfRequestUnMarkCancelable to clear the cancel routine before completing the request

Using CancelRoutine (2)

- Request must be a valid uncompleted request when you call WdfRequestUnmarkCancelable
- That means you have to manage the race between cancel routine and another asynchronous routine that tries to complete the request

Using CancelRoutine (3)

- Framework enables you to manage the complexity
  - By using framework provided synchronization scope
  - By tracking state in the request context area using your own lock

Using Synchronization Scope

```
NTSTATUS EVtDeviceAdd() {
    attributes.SynchronizationScope = WdfSynchronizationScopeDevice;
    status = WdfDeviceCreate(&DeviceInit, &attributes, &device);
    ...
}
VOID EchoEvtIoRead(Queue, Request, Length) {
    WdfRequestMarkCancelable(Request, EchoEvtRequestCancel);
    queueContext->CurrentRequest = Request;
}
VOID  EchoEvtRequestCancel(Request) {
    WdfRequestComplete(Request, STATUS_CANCELLED);
    queueContext->CurrentRequest = NULL;
}
VOID EchoEvtTimerFunc(WDFTIMER  Timer) {
    Request = queueContext->CurrentRequest;
    if( Request != NULL ) {
        status = WdfRequestUnmarkCancelable(Request);
        if(status != STATUS_CANCELLED) {
            queueContext->CurrentRequest = NULL;
            WdfRequestComplete(Request, status);
        }
    }
}
```

Using Driver Lock

Track the cancel state in the context area of the request

```
typedef struct _REQUEST_CONTEXT {
    BOOLEAN IsCancelled;
    BOOLEAN IsTerminateFailed;
    KSPIN_LOCK Lock;
} REQUEST_CONTEXT, *PREQUEST_CONTEXT;

EvtDriverDeviceAdd(Driver, DeviceInit) {
    WDF_OBJECT_ATTRIBUTES  attributes;
    WDF_OBJECT_ATTRIBUTES_INIT_CONTEXT_TYPE(&attributes,REQUEST_CONTEXT);
    WdfDeviceInitSetRequestAttributes(DeviceInit, &attributes);
}
EvtIoDispatch(Queue, Request) {
        reqContext->IsCancelled = FALSE;
    reqContext->IsTerminateFailed = FALSE;
    KeInitializeSpinLock(&reqContext->Lock);
    WdfObjectReference(Request);
    WdfRequestMarkCancelable(Request, EvtRequestCancelRoutine);
}
```

Using Driver Lock (2)

```
EvtRequestCancelRoutine(Request)
{
    KeAcquireSpinlock(&reqContext->Lock,
&oldIrql);

    reqContext-> IsCancelled = TRUE;

    if (TerminateIO() == TRUE) {
        WdfObjectDereference(Request);
        completeRequest = TRUE;
    }
    else {
        reqContext->IsTerminateFailed = TRUE;
        completeRequest = FALSE;
    }
    KeReleaseSpinlock(&reqContext->Lock, oldIrql);

    if (completeRequest) {
        WdfRequestComplete(Request,
STATUS_CANCELLED);
    };
}
```

```
EvtDpcForIsr(Interrupt)
{
    completeRequest = TRUE;
    KeAcquireSpinlock(&reqContext->Lock,
&oldIrql);

    if (reqContext-> IsCancelled == FALSE) {
        status =
WdfRequestUnmarkCancelable(Request);
        if (status == STATUS_CANCELLED) {
            completeRequest = FALSE;
        }
        status = STATUS_SUCCESS;
    } else {
        if (reqContext->IsTerminateFailed {
            status = STATUS_CANCELLED;
        } else {
            completeRequest = FALSE
        }
    }
    KeReleaseSpinlock(&reqContext->Lock,
oldIrql);

    WdfObjectDereference(Request);
    if (completeRequest) {
        WdfRequestComplete(Request, status);
    };
}
```

Microsoft®

Your potential. Our passion.™