AT91 USB CDC Driver Implementation

AT91 ARM Thumb Microcontrollers

Application Note

1. Introduction

The **Communication Device Class** (CDC) is a general-purpose way to enable all types of communications on the Universal Serial Bus (USB). This class makes it possible to connect **telecommunication devices** such as digital telephones or analog modems, as well as **networking devices** like ADSL or Cable modems.

While a CDC device enables the implementation of quite complex devices, it can also be used as a very simple method for communication on the USB. For example, a CDC device can appear as a **virtual COM port**, which greatly simplifies application programming on the host side.

The purpose of this document is to explain how to implement CDC on AT91 ARM® Thumb® based microcontrollers using the AT91 USB Framework offered by Atmel®. For this purpose, a sample implementation of a **USB to Serial converter** is described step-by-step.

2. Related Documents

[1] Universal Serial Bus Class Definitions for Communication Devices, Version 1.1, January 19, 1999.

[2] Atmel Corp., AT91 USB Framework, 2006.

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3. Communication Device Class Basics

This section gives some basic information about the Communication Device Class, such as when to use it and which drivers are available for it. Its architecture is also described.

3.1 Purpose

CDC is used to connect communication devices, such as modems (digital or analog), telephones or networking devices. Its generic framework supports a wide variety of physical layers (xDSL, ATM, etc.) and protocols.

In this document, CDC is used to implement a USB to a serial data converter. Serial ports (also known as COM or RS-232 ports) are still widely used, but most modern PCs (especially laptops) are now shipped without serial ports. A USB to serial converter can be used in this case to bridge a legacy RS-232 interface with a USB port.

3.2 Architecture

3.2.1 Interfaces

Two interfaces are defined by the *CDC specification 1.1*. The first one, the **Communication Class Interface**, is used for device management. This includes requests to manage the device state, its responses, as well as event notifications. This interface can also be optionally used for call management, i.e., setting up and terminating calls as well as managing their parameters.

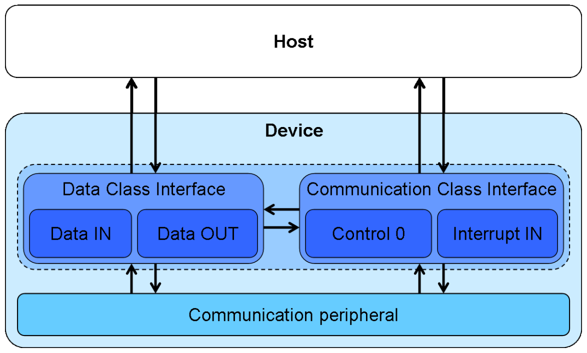
Another interface is defined for generic data transmissions. It is referred to as the **Data Class Interface**. It provides a means for a communication device to actually transfer data to and from the host. In addition, it also enables the multiplexing of data and commands on the same interface, through the use of wrappers.

3.2.2 Endpoints

The Communication Class Interface requires at least one endpoint, which is used for device management. Default control endpoint 0 is used for this task. Optionally, another endpoint can be dedicated to events notification. This will usually be an **Interrupt IN** endpoint.

For the Data Class Interface, endpoints must exist in pairs of the same type. This is necessary to allow both IN and OUT communication. Only the **Bulk** and **Isochronous** types can be used for these endpoints.

Figure 3-1. CDC Class Driver Architecture



3.2.3 Models

To account for the wide variety of existing communication devices, several **models** have been defined. They describe the requirements in term of interfaces, endpoints and requests that a device must fulfill to perform a particular role. Here is a list of models defined in the *CDC specification 1.1*, grouped by their intended functionality:

- POTS (Plain Old Telephone Service)
  – Direct Line Control Model
  – Datapump Model
  – Abstract Control Model
- Telephone
  – Telephone Control Model
- ISDN
  – Multi-Channel Model
  – USB CAPI Model
- Networking
  – Ethernet Networking Model
  – ATM Networking Control Model

Some of these models and their uses will be detailled further in this document, along with the corresponding implementation cases.

3.2.4 Class-Specific Descriptors

CDC-specific information is described using **Functional Descriptors**. They define various parameters of an interface, such as how the device handles call management, or model-specific attributes.

Since the CDC specification defines quite a number of functional descriptors, they are not detailed here. Instead, they are presented in the various case studies of this document in which they are used.

3.3 Host Drivers

Most Operating Systems (OS) now include generic drivers for a wide variety of USB classes. This makes developing a device simpler, since the host complexity is now handled by the OS. Manufacturers can thus concentrate on the device itself, not on developing specific host drivers.

Here is a brief list of the various CDC implementations supported by several OS:

- Windows®
  – Abstract Control Model
  – Remote NDIS
- Linux®
  – Abstract Control Model
  – Ethernet Model

4. USB to Serial Converter

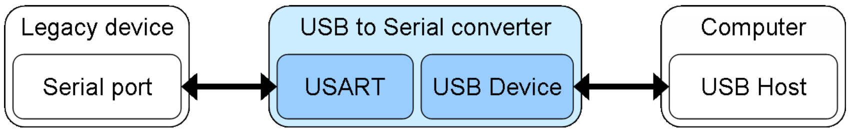
This section describes the implementation of an USB to serial converter using the CDC class and the AT91 USB Framework. Refer to the Atmel document, literature no. 6263 for information on the USB framework, and to the *CDC Specification 1.1* and the *USB Specification 2.0* for USB/CDC-related details.

4.1 Purpose

While the USB is increasingly used for a lot of new products, many legacy devices still use a basic RS-232 (also named serial or COM) port to connect to a PC. This kind of product is still widely available, but most computer manufacturers are starting to ship their machines without any COM port. A USB to serial converter can be used to add a **virtual COM port** to a computer, enabling the connection to a legacy RS-232 device.

A virtual COM port could also be used to provide a way for an USB device to connect to older PC applications. This is also a simple way to communicate through the USB, as no custom driver programming is needed.

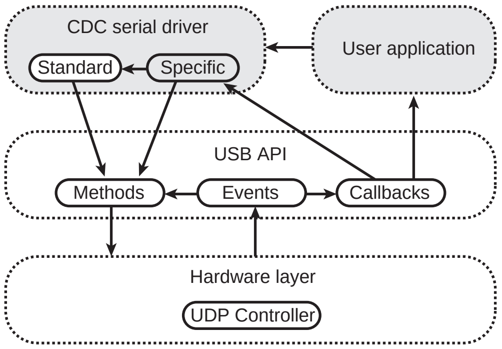
Figure 4-1. Bridging a Legacy Device and a PC with a USB to Serial Converter



4.2 Architecture

The AT91 USB Framework offers an API which makes it easy to build USB class drivers. The example software provided with this application note is based on this framework. Figure 4-2 shows the application architecture with the framework.

Figure 4-2. Software Architecture Using the AT91 USB Framework



4.3 Model

The CDC specification defines a model which suits this application perfectly: the **Abstract Control Model** (ACM). It implements the requests and notifications necessary to communicate with an RS-232 interface.

The Abstract Control Model requires two interfaces, one **Communication Class Interface** and one **Data Class Interface**. Each of them must have two associated endpoints. The former shall have one endpoint dedicated to device management (default Control endpoint 0) and one for events notification (additional Interrupt IN endpoint).

The Data Class Interface needs two endpoints through which to carry data to and from the host. Depending on the application, these endpoints can either be *Bulk* or *Isochronous*. In the case of a USB to serial converter, using *Bulk* endpoints is probably more appropriate, since the reliability of the transmission is important and the data transfers are not time-critical.

4.4 Descriptors

The descriptors used by the USB to serial converter are mostly standard ones, i.e., defined in the *USB Specification 2.0*. The following code examples thus use the structures described in the *AT91 USB Framework* application note.

For CDC-specific descriptors, new types are needed. Their implementation is trivial however, as they are fully described in the CDC specification. Only the values contained in each descriptor are detailed, but the list of the necessary structures for this example is found below:

- CDCHeaderDescriptor
- CDCCallManagementDescriptor
- CDCAbstractControlManagementDescriptor
- CDCUnionDescriptor

4.4.1 Device Descriptor

The **Device Descriptor** must specify the value 02h, corresponding to the Communication Device Class, in its *bDeviceClass* field. This is necessary to have the host driver correctly enumerate the device: since a CDC device often displays more than one interface, they have to be logically grouped together and not considered separate functionalities.

No subclass codes or protocol codes are defined for the CDC.

Here is how the device descriptor looks when using the S_usb_device_descriptor structure of the AT91 USB Framework:

```
const USBDeviceDescriptor deviceDescriptor = {

    sizeof(USBDeviceDescriptor),
    USBGenericDescriptor_DEVICE,
    USBDeviceDescriptor_USB2_00,
    CDCDeviceDescriptor_CLASS,
    CDCDeviceDescriptor_SUBCLASS,
    CDCDeviceDescriptor_PROTOCOL,
    BOARD_USB_ENDPOINTS_MAXPACKETSIZE(0),
    CDCDSerialDriverDescriptors_VENDORID,
    CDCDSerialDriverDescriptors_PRODUCTID,
    CDCDSerialDriverDescriptors_RELEASE,
    0, // No string descriptor for manufacturer
    1, // Index of product string descriptor is #1
    0, // No string descriptor for serial number
    1 // Device has 1 possible configuration
};
```

The Vendor ID and Product ID fields are used to determine which driver to use when the device is enumerated. The Vendor ID is provided by the USB-IF organization after registration; the product ID is completely vendor-specific. In the example implementation provided with this document, the Atmel vendor ID (03EBh) is used along with a custom product ID (6119h).

4.4.2 Configuration Descriptor

When requested by the host, the configuration descriptor is followed by interface, endpoint and class-specific descriptors. While the CDC specification does not define any special values for the configuration descriptor, a set of class-specific descriptors is provided. They are referred to as **Functional Descriptors**, and some of them have to be implemented.

```
// Standard configuration descriptor
    {
        sizeof(USBConfigurationDescriptor),
        USBGenericDescriptor_CONFIGURATION,
        sizeof(CDCDSerialDriverConfigurationDescriptors),
        2, // There are two interfaces in this configuration
        1, // This is configuration #1
        0, // No string descriptor for this configuration
        BOARD_USB_BMATTRIBUTES,
        USBConfigurationDescriptor_POWER(100)
    },
```

4.4.3 Communication Class Interface Descriptor

The first interface to follow the configuration descriptor should be the **Communication Class Interface** descriptor. It should specify the Communication Class Interface code (02h) in its *bInterfaceClass* field.

The *bInterfaceSubClass* value selects the CDC Model used by the interface. In this case, the code corresponding to the Abstract Control Model is 02h.

Finally, a protocol code can be supplied if needed. Since this is not necessary for the USB to serial converter, it can be left at 0x00.

```
// Communication class interface standard descriptor
    {
        sizeof(USBInterfaceDescriptor),
        USBGenericDescriptor_INTERFACE,
        0, // This is interface #0
        0, // This is alternate setting #0 for this interface
        1, // This interface uses 1 endpoint
        CDCCommunicationInterfaceDescriptor_CLASS,
        CDCCommunicationInterfaceDescriptor_ABSTRACTCONTROLMODEL,
        CDCCommunicationInterfaceDescriptor_NOPROTOCOL,
        0  // No string descriptor for this interface
    },
```

While the Communication Class Interface uses two endpoints (one for device management and one for events notification), the interface descriptor should have its *bNumEndpoints* field set to 0x01: the default control endpoint 0 is not included in the count.

4.4.4 Functional Descriptors

Several **Functional Descriptors** must follow the communication class interface descriptor. They are necessary to define several attributes of the device. The functional descriptor structure contains the descriptor length, type and subtype, followed by functional information.

The *bDescriptorType* value is always equal to CS_INTERFACE (24h), since CDC-specific descriptors only apply to interfaces. The values for the other two fields, *bFunctionLength* and *bDescriptorSubType*, are function-dependent.

4.4.4.1 *Header*

The first functional descriptor must always be the **Header Functional Descriptor**. It is used to specify the CDC version on which the device is based (current version is 1.1):

```
// Class-specific header functional descriptor
    {
        sizeof(CDCHeaderDescriptor),
        CDCGenericDescriptor_INTERFACE,
        CDCGenericDescriptor_HEADER,
        CDCGenericDescriptor_CDC1_10
    },
```

4.4.4.2 *Call Management*

Next comes the **Call Management Functional Descriptor**. This one indicates how the device processes call management. If the device performs the call management duty itself, the first bit of the *bmCapabilities* field must be set to one. In addition, call management requests can be multiplexed over the data class interface instead of being sent on the Control endpoint 0, by setting the second bit. According to the CDC specification, a device using the Abstract Control Model should process call management itself, so bit D0 will be set. The last byte (*bDataInterface*) has no meaning here, since bit D1 of *bmCapabilities* is cleared.

```
// Class-specific call management functional descriptor
    {
        sizeof(CDCCallManagementDescriptor),
        CDCGenericDescriptor_INTERFACE,
        CDCGenericDescriptor_CALLMANAGEMENT,
        CDCCallManagementDescriptor_SELFCALLMANAGEMENT,
        0 // No associated data interface
    },
```

4.4.4.3 *Abstract Control Management*

Since the USB to serial converter uses the Abstract Control Model, the corresponding functional descriptor (**Abstract Control Management Functional Descriptor**) must be transmitted to give more information on which requests/notifications are implemented by the device. For this example, the driver is going to support all optional requests/notification except *NetworkConnection*; thus, the *bmCapabilities* field value will be set to 07h.

```
// Class-specific abstract control management functional descriptor
    {
        sizeof(CDCAbstractControlManagementDescriptor),
        CDCGenericDescriptor_INTERFACE,
        CDCGenericDescriptor_ABSTRACTCONTROLMANAGEMENT,
        CDCAbstractControlManagementDescriptor_LINE
    },
```

4.4.4.4 *Union*

Finally, the **Union Functional Descriptor** makes it possible to group several interfaces into one global function. In this case, the Communication Class Interface will be set as the master interface of the group, with the Data Class Interface as slave 0:

```
// Class-specific union functional descriptor with one slave interface
    {
        sizeof(CDCUnionDescriptor),
        CDCGenericDescriptor_INTERFACE,
        CDCGenericDescriptor_UNION,
        0, // Number of master interface is #0
        1 // First slave interface is #1
    },
```

4.4.5 Notification Endpoint Descriptor

As said previously, the notification element used by the Abstract Control Model is an Interrupt IN endpoint. The user-defined attributes are the endpoint address and the polling rate.

When choosing endpoint addresses, the specificities of the USB controller should be taken into account. For example, on AT91SAM7S chips, the UDP has only four endpoints, one of which is used by the default Control endpoint 0. Since only the second and third endpoints have dual FIFO banks, it seems wiser to use them for the Data Class Interface and have the last one used for events notification.

Finally, the polling rate should be set depending on the interrupt source. In this case, this will be a USART. Since this is a fairly slow interface, the polling rate can be relatively low, meaning the *bInterval* value can be high.

Here is how the notification endpoint descriptor is declared in the example software:

```
// Notification endpoint standard descriptor
    {
        sizeof(USBEndpointDescriptor),
        USBGenericDescriptor_ENDPOINT,
        USBEndpointDescriptor_ADDRESS(USBEndpointDescriptor_IN,
                                 CDCDSerialDriverDescriptors_NOTIFICATION),
        USBEndpointDescriptor_INTERRUPT,
         MIN(
BOARD_USB_ENDPOINTS_MAXPACKETSIZE(CDCDSerialDriverDescriptors_NOTIFICATION)
, USBEndpointDescriptor_MAXINTERRUPTSIZE_FS),
        10 // Endpoint is polled every 10ms
    },
```

4.4.6 Data Class Interface Descriptor

The **Data Class Interface Descriptor** follows the Communication Class Interface and its related functional and endpoint descriptors. The Data Class Interface itself will have two endpoint descriptors following it.

The Data Class Interface code is 0Ah, and there is no subclass code. Several protocol codes are available; in this example, none is used. However, the v.42bis protocol could be used to compress the data if supported by the legacy device.

```
// Data class interface standard descriptor
```

```
        {
            sizeof(USBInterfaceDescriptor),
            USBGenericDescriptor_INTERFACE,
            1, // This is interface #1
            0, // This is alternate setting #0 for this interface
            2, // This interface uses 2 endpoints
            CDCDataInterfaceDescriptor_CLASS,
            CDCDataInterfaceDescriptor_SUBCLASS,
            CDCDataInterfaceDescriptor_NOPROTOCOL,
            0  // No string descriptor for this interface
        },
```

4.4.7 Data IN & OUT Endpoint Descriptors

The Data Class Interface requires two additional endpoints, so the corresponding **Endpoint Descriptors** must follow. It was decided previously that those endpoints would be *Bulk* IN/OUT, since it is more appropriate for this particular application.

Since addresses 00h and 03h are already taken by the default Control endpoint 0 and the Interrupt IN notification endpoint (respectively), the data OUT and IN endpoints will take addresses 01h and 02h.

Here are the two descriptors:

```
    // Bulk-OUT endpoint standard descriptor
        {
            sizeof(USBEndpointDescriptor),
            USBGenericDescriptor_ENDPOINT,
            USBEndpointDescriptor_ADDRESS(USBEndpointDescriptor_OUT,
                                          CDCDSerialDriverDescriptors_DATAOUT),
            USBEndpointDescriptor_BULK,
    MIN(BOARD_USB_ENDPOINTS_MAXPACKETSIZE(CDCDSerialDriverDescriptors_DATAOUT),
                USBEndpointDescriptor_MAXBULKSIZE_FS),
            0 // Must be 0 for full-speed bulk endpoints
        },
        // Bulk-IN endpoint descriptor
        {
            sizeof(USBEndpointDescriptor),
            USBGenericDescriptor_ENDPOINT,
            USBEndpointDescriptor_ADDRESS(USBEndpointDescriptor_IN,
                                          CDCDSerialDriverDescriptors_DATAIN),
            USBEndpointDescriptor_BULK,
    MIN(BOARD_USB_ENDPOINTS_MAXPACKETSIZE(CDCDSerialDriverDescriptors_DATAIN),
                USBEndpointDescriptor_MAXBULKSIZE_FS),
            0 // Must be 0 for full-speed bulk endpoints
        },
```

4.4.8 String Descriptors

Several descriptors (device, configuration, interface, etc.) can specify the index of a string descriptor to comment their use. These strings are completely user-defined and have no impact on the actual choice of driver made by the OS for the device.

4.5 Class-specific Requests

The CDC specification defines a set of **class-specific requests** for devices implementing the Abstract Control Model. This section details those requests, including their uses and implementation. Please refer to section 3.6.2.1 of the *CDC specification 1.1* for more information about the Abstract Control Model Serial Emulation and the associated requests and notifications.

4.5.1 SendEncapsulatedCommand, GetEncapsulatedResponse

4.5.1.1 Purpose

These two requests are used when a particular control protocol is used with the communication class interface. This is not the case for a virtual COM port, so they do not have to be implemented, even though they are supposed to be mandatory. In practice, they should never be received.

4.5.2 SetCommFeature, GetCommFeature, ClearCommFeature

4.5.2.1 Purpose

The **Set/Get/ClearCommFeature** requests are used to modify several attributes of the communication.

The first attribute is the currently used **Country Code**. Some devices perform differently, or have different legal restrictions depending on the country in which they operate. Therefore, a country code is necessary to identify the corresponding parameters. However, this is useless for a USB to serial converter, since it does not connect to a national or country-dependent network.

The **Abstract State** of the device can also be modified through the use of those requests. The first feature which can be altered is whether or not calls are multiplexed over the data class interface. Since it has already been specified in the call management functional descriptor (see Section 4.4.4.2 on page 7) that this is not supported in this example, it is not meaningful.

The **Idle** state of the device can be toggled using this request. When in idle state, a device shall not accept or send data to and from the host.

4.5.3 SetLineCoding, GetLineCoding

4.5.3.1 Purpose

These two requests are sent by the host to either modify or retrieve the configuration of the serial line, which includes:

- Baudrate
- Number of stop bits
- Parity check
- Number of data bits

When the terminal application (such as *HyperTerminal*) on the host (PC) side changes the setting of the COM port, a *SetLineCoding* request is sent with the new parameters. The host may also retrieve the current setting using *GetLineCoding*, not modifying them if they are correct.

4.5.3.2 *Implementation*

When a **SET_LINE_CODING** request is received, the device should first read the new parameters, which are held in a 7-byte structure described in the *CDC specification 1.1*, section 6.2.13. The device must then program the new parameters in the USART. A callback must be provided to the *USBD_Read* function, with a pointer to access the received data.

The code handling **GET_LINE_CODING** shall simply invoke the *USBD_Write* function to send the current settings of the USART to the host.

There are two possible options for storing the current settings. The most obvious one is to store and retrieve them directly from the USART. This has the advantage of saving memory. But, since the parameters are unlikely to be stored in the same way as the CDC-defined structure, they will have to be parsed for each **GET_LINE_CODING** request. Another option is to store the received values in a dedicated member structure of the class driver, for easy access.

4.5.4 SetControlLineState

4.5.4.1 *Purpose*

This request is sent by the host to notify the device of two state changes. The first bit (D0) of the *wValue* field of the request indicates whether or not a terminal is connected to the virtual COM port. Bit D1 indicates that the USART should enable/disable its carrier signal to start/stop receiving and transmitting data.

In practice, the USB to serial converter should operate only when those two bits are set. Otherwise, it should not transmit or receive data.

4.5.4.2 *Implementation*

Since the **SET_CONTROL_LINE_STATE** request does not have a data payload, the device only has to acknowledge the request by sending a ZLP (zero-length packet), using the *USBD_Write* method with data sent zero.

Before that, the *wValue* field should be parsed to retrieve the new control line state. A single boolean variable can be used to keep track of the connection state. If both the D0 and D1 bits are set, then the converter should operate normally, i.e., forward data between the USART and the USB host. Otherwise, it should stop its activity.

4.5.5 SendBreak

4.5.5.1 *Purpose*

The **SendBreak** request is used to instruct the device to transmit a break of the specified length on the RS-232 line. This signal is sometimes used to get the attention of the connected machine.

4.6 Notifications

Notifications are sent by the device when an event, such as a serial line state change, has occurred. In this example, they are transmitted through a dedicated Interrupt IN endpoint. A special header must precede the data payload of each notification. This header has the same format of a SETUP request, so the *USBGenericRequest* structure defined in the AT91 USB framework can be used.

Note that the device should only send a notification when there is a state change, and not continuously. This does not really matter in practice, but only sending notifications sporadically will reduce the stress on the device.

4.6.1 NetworkConnection

4.6.1.1 Purpose

The *NetworkConnection* notification is used to tell the host whether the USB to serial converter is connected on its RS-232 side. In the case of a USART, there is no way get this information, unless coupled with an extra signal. Therefore, this notification is not supported by the USB to serial converter.

4.6.2 ResponseAvailable

4.6.2.1 Purpose

This notification allows the device to tell the host that a response is available. However, since it has already been mentioned that the *GetEncapsulatedResponse* request is not relevant to this case study (see Section 4.5.1.1 on page 10), this notification is useless.

4.6.3 SerialState

4.6.3.1 Purpose

This command acts as an interrupt register for the serial line. It notifies the host that the state of the device has changed, or that an event has occured. The following events are supported:

- Buffer overrun
- Parity error
- Framing error
- Ring signal detection mechanism state
- Break detection mechanism state
- Transmission carrier state
- Receiver carrier detection mechanism state

Several of these values are only used for modem device, namely ring signal detection, transmission carrier state and receiver carrier detection.

4.6.3.2 Implementation

This notification can be directly tied with the status register of the USART. Indeed, the latter contains all the required information. An interrupt can be used to notify the device when the USART state changes; the corresponding notification can then be sent to the host.

To send a SERIAL_STATE notification, the device should first transmit the corresponding notification header. As noted previously, it has a format identical to a SETUP request, so a *USBGenericRequest* instance can be used to store the necessary information. In the following example, a typedef has been defined to rename *USBGenericRequest* to *CDCNotificationHeader*:

```
CDCNotificationHeader cdcNotificationHeader = {

    CDC_NOTIFICATION_TYPE,
    CDC_NOTIFICATION_SERIAL_STATE,
    0,
    0,
    0
};
```

The actual state information is transmitted in two bytes. Only the first 7 bits of the first byte are significant; the others can be set to 0. The device should set the bits corresponding to the current USART state, and then send the data using *USBD_Write*.

Depending on the size of the interrupt endpoint, the header and data will have either have to be transmitted in one chunk (size superior to 8 bytes), or separately. In the first case, the simplest is probably to define a *CDCSerialState* structure to hold both the header and the data payload.

In the second case, the transmission can be done by two consecutive *USBD_Write* calls (since the header is 8 bytes long); however, this may not be convenient, as the first transfer must be finished before the second one can start. This means that the second call must either be done in a callback function (invoked upon the first transfer completion), or in a loop verifying that the returned result code is *USB_STATUS_SUCCESS* (indicating that the endpoint is not locked anymore).

4.7 Main Application

The job of the main application is to **bridge** the USART and the USB. This means that data read from one end must be forwarded to the other end. This section describes several possibilities to do this.

4.7.1 USB Operation

Reading data coming from the host is done using the *USBD_Read* function on the correct endpoint. Since this is an asynchronous function, it does not block the execution flow. This means that other actions (like reading data from the USART) can be performed while the transfer is going on. Whenever some data is sent by the host, the transfer terminates and the associated callback function is invoked. This callback can be programmed to forward the received data through the USART.

Likewise, the *USBD_Write* function can be called as soon as there is data to transmit, again without block the program flow. However, there cannot be two write operations at the same time, so the program must check whether or not the last transfer is complete. This can be done by checking the result code of the *USBD_Write* method. If USB_STATUS_LOCKED is returned, then there is already another operation in progress. The device will have to buffer the data retrieved from the USART until the endpoint becomes free again.

4.7.2 USART Operation

The USART peripheral present on AT91 chips can be used in two different ways. The classic way is to read and write one byte at a time in the correct registers to send and receive data.

A more powerful method is available on AT91SAM chips, by using the embedded Peripheral DMA Controller (PDC). The PDC can take care of transfers between the processor, memory and peripherals, thus freeing the processor to perform other tasks.

Since the focus of this application note is on the USB component, the USART usage will not be described further here.

4.8 Example Software Usage

4.8.1 File Architecture

In the example program provided with this application note, the actual driver is divided into three files:

- **at91lib\usb\common\cdc**: folder contains all generic CDC definitions and methods.
- *CDCAbstractControlManagementDescriptor.h*: header file with CDC ACM definitions.
- *CDCCallManagementDescriptor.h*: header file with CDC Call Management definitions.
- *CDCCommunicationInterfaceDescriptor.h*: header file with Communication Interface Definitions.
- *CDCDataInterfaceDescriptor.h*: header file with definitions for the Data Interface.
- *CDCDeviceDescriptor.h*: definitions used in CDC device descriptor.
- *CDCGenericDescriptor.h*: definitions used for CDC descriptors.
- *CDCGenericRequest.h*: definitions used for CDC requests handling.
- *CDCHeaderDescriptor.h*: definitions for CDC Header Descriptor.
- *CDCUnionDescriptor.h*: definitions for CDC Union Descriptor.
- *CDCLineCoding.h*: definitions for CDC LineCoding requests.
- *CDCLineCoding.c*: methods to handle CDC LineCoding requests.
- *CDCSetControlLineStateRequest.h*: definitions for CDC SetControlLineState request.
- *CDCSetControlLineStateRequest.c*: methods to handle CDC SetControlLineState request.
- **at91lib\usb\device\cdc-serial**: Folder with all files used for CDC serial driver.
- *CDCSerialDriver.h*: header file with definitions for the USB to serial converter driver.
- *CDCSerialDriver.c*: source file for the USB to serial converter driver.
- *CDCSerialDriverDescriptors.h*: header file with definitions for the USB to serial converter driver descriptors.
- *CDCSerialDriverDescriptors.c*: source file for the USB to serial converter driver descriptors.
- **usb-device-cdc-serial-project**: folder containes main application code.
- **main.c**: main application source code

Having all generic CDC definitions in a separate file makes it possible to easily reuse it for other CDC-related drivers.

The main application, which uses the driver to bridge the USART and USB interfaces, is implemented in the **main.c** file.

4.8.2 Compilation

The software is provided with a **Makefile** to build it. It requires the *GNU make* utility, which is available on www.GNU.org. Please refer to the *AT91 USB Device Framework* application note for more information on general options and parameters of the Makefile.

To build the USB to serial converter example just run "make" in directory **usb-device-cdc-serial-project**, and two parameters may be assigned in command line, the CHIP= and BOARD=, the default value of these parameters are "at91sam7s256" and "at91sam7s-ek":

```
make CHIP=at91sam7se512 BOARD=at91sam7se-ek
```

In this case, the resulting binary will be named usb-device-cdc-serial-project-at91sam7se-ek-at91sam7se512-flash.*bin* and will be located in the usb-device-cdc-serial-project/*bin* directory.

4.9 Using a Generic Host Driver

Both Microsoft® Windows and Linux offer a generic driver for using a USB to serial converter device. This section details the steps required to make use of them.

4.9.1 Windows

On Microsoft Windows, the standard USB serial driver is named **usbser.sys** and is part of the standard set of drivers. It has been available since Windows 98SE. However, conversely to other generic driver such as the one for Mass Storage Devices (MSD), *usbser.sys* is not automatically loaded when a CDC device is plugged in.

4.9.1.1 Writing a Windows Driver File

For Windows to recognize the device correctly, it is necessary to write a *.inf* file. The Windows **Driver Development Kit** (DDK) contains information on this topic. A basic driver, named *6119.inf* in the example software provided, will now be described. The driver file is made up of several sections.

The first section of the *.inf* file must be the **[Version]** section. It contains information about the driver version, provider, release data, and so on.

```
[Version]
Signature="$Chicago$"
Class=Ports
ClassGuid={4D36E978-E325-11CE-BFC1-08002BE10318}
Provider=%ATMEL%
DriverVer=09/12/2006,1.1.1.1
```

The *Signature* attribute is mandatory and can be either “$Windows 95$”, “$Windows NT$” or “$Chicago$”, depending on which Windows version(s) the driver supports. “$Chicago$” is used to notify that every Windows version is supported. Since in this example, the USB to serial converter is a virtual COM port, the *Class* attribute should be equal to “Ports”. The value of *ClassGuid* depends on which class the device uses. The *Provider* value indicates that the string descriptor for the driver provider will be defined further, under the tag ATMEL. Finally, the last tag show the driver version and release date. For the version number, each digit is optional (except the first one), but must not be null if present.

Next come two sections, **[SourceDisksNames]** and **[SourceDisksFiles]**. They are used to specify the installation disks required and the location of each needed files on these disks.

```
[SourceDisksNames]
1="Windows Install CD"

[SourceDisksFiles]
usbser.sys=1
```

The first one lists the names of source disks on which the user can find missing files. Since the driver requires *usbser.sys*, present on the Windows install CD, it will have to be listed here. The disk ID must be a unique and non-null digit. The second section indicates on which disk each file can be found. In this case, *usbser.sys* can be found on disk #1 (which is “Windows Install CD”). Optionally, the exact path of the file on the CD can be specified.

The driver file must now specify where copied files will be stored, using the **[DestinationDirs]** section.

```
[DestinationDirs]
DefaultDestDir=12
```

The target directory must be identified by its ID, which is system-defined. The ID for the *drivers* directory is 12.

The **[Manufacturer]** section lists the possible manufacturers for all devices supported by this driver. In this case, the only supported device is an ATMEL one, so this will be the only value.

```
[Manufacturer]
%ATMEL%=AtmelMfg
```

The attribute must be a string tag; its value must be the name of the *Models* section in which all supported devices from this manufacturer will be listed. In this case, it will be named *AtmelMfg*, which is the next section.

Each *Models* section must list the hardware ID of each supported device. For USB devices, the hardware ID is made up of the Vendor ID, the Product ID and (optionally) the Device Release Number. Those values are extracted from the device descriptor provided during the enumeration phase.

```
[AtmelMfg]
%USBtoSerialConverter%=USBtoSer.Install,USB\VID_03EB&PID_6119
```

The attribute name is again a string tag, which will be used to describe the device. The value is comprised of both the device install section name (USBtoSer.Install) and the hardware ID. The hardware ID is the same as the one specified in Section 4.4.1 on page 5.

Now, the *.inf* file must detail the install section of each device previously listed. In this example, there is only one install section, named *USBtoSer.Install*:

```
[USBtoSer.Install]
CopyFiles=USBtoSer.CopyFiles
AddReg=USBtoSer.AddReg

[USBtoSer.CopyFiles]
usbser.sys,,,0x00000002

[USBtoSer.AddReg
HKR,,DevLoader,,*ntkern
HKR,,NTMPDriver,,usbser.sys

[USBtoSer.Install.Services]
AddService=usbser,0x00000002,USBtoSer.AddService

[USBtoSer.AddService]
DisplayName=%USBSer%
ServiceType=1r
StartType=3
ServiceBinary=%12%\usbser.sys
```

The install section is actually divided in five. In the first section, two other section names are specified: one for the list of files to copy, and one for the keys to add to the Windows registry. There is only one file to copy, usbser.sys; a flag (0x00000002) is used to specify that the user cannot skip copying it. The registry keys are needed to install the driver on older versions of Windows (such as Windows 98). For newer versions, the **[USBtoSer.Install.Services]** registers the needed kernel services; each service is actually listed in a section on its own.

Finally, the last section, [Strings], defines all the string constants used through this file:

```
[Strings]
```

```
ATMEL="ATMEL Corp."
USBtoSerialConverter="AT91 USB to Serial Converter"
USBSer="USB Serial Driver"
```

4.9.1.2 *Using the Driver*

When a new device is plugged in for the first time, Windows looks for an appropriate specific or generic driver to use it. If it does not find one, the user is asked what to do.

This is the case with the USB to serial converter, since there is no generic driver for it. To install the custom driver given in the previous section, Windows must be told where to look for it. This can be done by selecting the second option, “Install from a list or specific location”, when the driver installation wizards pops up. It will then ask for the directory where the driver is located. After that, it should recognize the “AT91 USB to Serial Converter” driver as an appropriate one and display it in the list.

During the installation, the wizard asks for the location of the *usbser.sys* file. If it is already installed on the system, it can be found in “*C:\Windows\System32\Drivers\*”. Otherwise, it is present on the Windows installation CD.

Once the driver is installed properly, a new COM port is added to the system and can be used with *HyperTerminal*, for example.

4.9.2 Linux

Linux has two different generic drivers which are appropriate for a USB to serial converter. The first one is an Abstract Control Model driver designed for modem devices, and is simply named **acm**. The other one is a generic USB to serial driver named **usbserial**.

If the support for the *acm* driver has been compiled in the kernel, Linux will automatically load it. A new terminal device will be created under /dev/ttyACMx.

The *usbserial* driver must be loaded manually by using the modprobe command with the vendor ID and product ID values used by the device:

```
modprobe usbserial vendor=0x03EB product=0x6119
```

Once the driver is loaded, a new terminal entry appears and should be named /dev/ttyUSBx.

5. Revision History

Table 5-1.

Document Ref.	Date	Comments	Change Request Ref.
6269A	10-Oct-06	First issue.	
6269B	17-Jun-09	Section 4.8.2: Need more informations on the nmake utility Entire document: Update with new framework	3926 5842

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