Sample Code Programming Guide for Moxa Embedded Computers

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Introduction

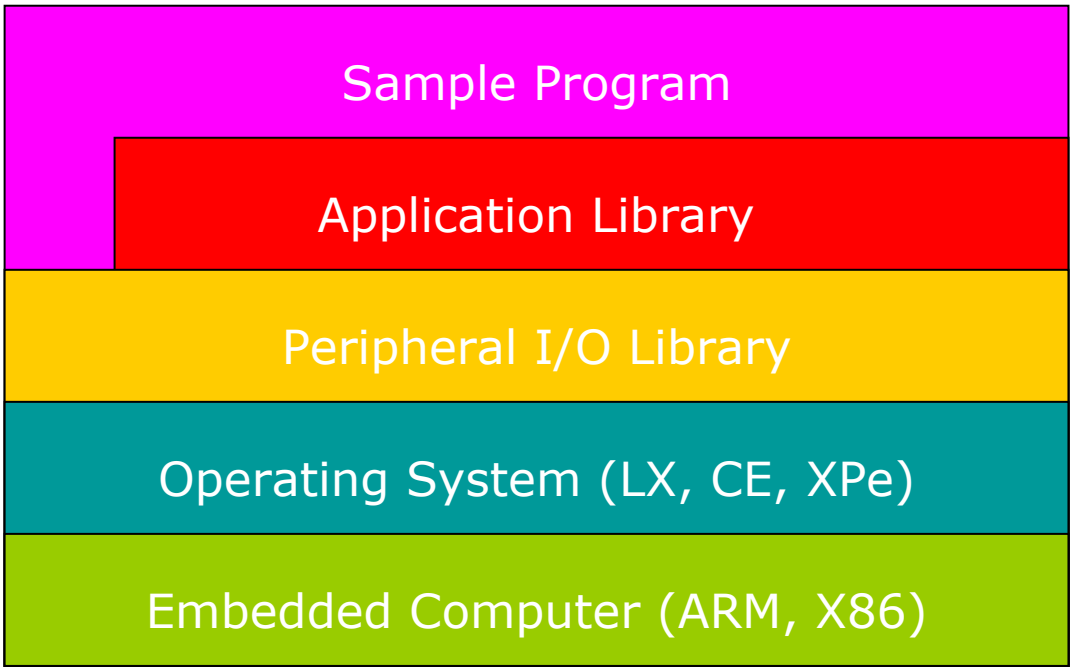
To help end-users reduce development costs, Moxa provides sample code for a wide range of embedded applications, such as serial-to-Ethernet (S2E), serial-to-serial (S2S), and MODBUS TCP, RTU, and ASCII. The high-level sample code provided by Moxa implements complex data communication concepts with simple functions, making it easier for users to understand how to use the code for their own applications. In addition, low-level sample code that manages direct access to peripheral IOs, such as the LCM, keypad, and digital IO, are also included. With ready access to such a rich assortment of embedded applications, programmers obtain a much greater flexibility than would otherwise be possible.

Moxa's sample code provides a common C/C++ programming function interface that can be used with all of Moxa's Linux and Windows embedded computers. The function interface helps developers create portable applications for Moxa's embedded computers. The purpose of this Programming Guide is to provide the information needed to use the sample code. Here is a brief description of the contents of this guide:

- **Chapter 1**
  Sample code architecture and related applications.
- **Chapter 2**
  Installing the sample code and building procedures.
- **Chapter 3**
  Lower layer peripheral I/O library.
- **Chapter 4**
  Useful sample programs based on the peripheral I/O library.
- **Chapters 5 and 6**
  Higher layer application library and related sample programs.
- **Chapter 7**
  MODBUS functions and related sample programs.

Sample Code Architecture

Moxa's sample code supports a peripheral I/O library, application library, and related sample programs under Linux, Windows CE, and Windows XPe for Moxa ARM and x86 embedded computers. The sample code uses a layered architecture to build up supported libraries. The peripheral I/O library provides functions to access different kinds of peripherals. The application library provides higher layer functions for networking and serial programming based on corresponding functions in the lower layer peripheral I/O library. Finally, sample programs are provided to illustrate how to use the functions from both libraries.



Applications Using Moxa Sample Code

The first example of an application using Moxa sample code is Moxa Device Manager (MDM), which is used with Moxa's embedded computers. MDM was created using the application library and peripheral I/O library to implement MDM TCP and UDP requests and response message services.

The next example is to build a MODBUS gateway that supports both MODBUS TCP master and MODBUS RTU/ASCII slave, as well as MODBUS RTU/ASCII master and MODBUS TCP slave. The application library and peripheral I/O library support all required functions for data communication and message verification, and for writing the MODBUS TCP and MODBUS RTU/ASCII applications.

Another example is to build an S2E or S2S gateway for devices with proprietary serial protocol to provide public MODBUS TCP or RTU/ASCII protocol to access the devices. The application library and peripheral I/O library also support all necessary functions for this example.

The final example is to build a configuration program to serve the setup and display of configuration parameters of networking interfaces and application configuration files using LCM and keypad functions in the peripheral I/O library. The example presents another user interface that is suitable for applications that need to be configured on site.

2

Installation and Development

This chapter introduces how to install sample code, the contents of the sample code, and how to create sample code.

Installation

Sample code can be downloaded from the Rcore Community website. For Linux products download the code that corresponds to your product model (e.g., download the file **moxalib_UC84XX-LX.tar.gz** for UC-8400 series products). For Windows, one file is available for all models: **moxalib_XPE_CE.zip**.

Next, upload the file to your development machine. For Linux, run the tar command to extract the sample code file to your target directory. For Windows, use the appropriate Windows tool to extract sample code zip file to your target folder.

Source Tree

After installing the sample code for your product, you will have ready access to the files you need to develop your own software.

The files for Linux are located in the top-level directory *moxalib*, and are organized as shown below. There are three prebuilt libraries: *libmxphio.a*, *libmxconn.a*, and *libmodbus.a*, called the peripheral I/O library, connection library, and MODBUS library, respectively.

README.txt -- sample code build procedure
makefile -- top-level makefile
rules.make -- makefile rule
inc -- include directory
    mxphio -- header files for peripheral I/O library functions
    mxconn -- header files for connection library functions
    modbus -- header files for MODBUS library functions
lib -- three prebuilt libraries
samples -- sample program source directory
    mxphio -- sample program source code using peripheral I/O library functions
    mxconn -- sample program source code using connection library functions
    modbus -- sample program source code using MODBUS library functions
src -- source directory
    mxphio -- sources of peripheral I/O library

The files for Windows are located in the top-level directory *moxalib*, and are organized as shown below. The three prebuilt libraries in sample code are *mxphio.lib*, *mxconn.lib*, and *modbus.lib*, called the peripheral I/O library, connection library, and MODBUS library, respectively.

README.txt -- sample code build procedure
bin -- prebuilt sample programs for each product series
inc -- include directory
    mxphio -- header files for peripheral I/O library functions
    mxconn -- header files for connection library functions

modbus -- header files for MODBUS library functions
lib -- three prebuilt libraries for each product series
samples -- sample program source directory
mxphio -- sample program source code using peripheral I/O library functions
mxconn -- sample program source code using connection library functions
modbus -- sample program source code using MODBUS library functions
src -- source directory
mxphio -- sources of peripheral I/O library

If you want to rebuild the peripheral library and sample programs for your Windows product, you must create Visual Studio projects for them. The following example shows one way to organize your project files.

projects -- Windows Visual Studio 2005 project directory
CE -- Visual Studio 2005 project directory for Windows CE
samples
mxphio
mxconn
modbus
src
mxphio
XPe -- Visual Studio 2005 project directory for Windows XPe
samples
mxphio
mxconn
modbus
src
mxphio

Build Procedure

To build sample code for Linux, change your working directory to the moxalib directory on your development machine and then type the command **make ARCH=***arch*, where *arch* is one of the following architecture values.

uc74xx	UC-74xx-LX, DA-660-LX
da66x	DA-66x-LX, UC-74xx-LX Plus
ia24x	IA24x-LX, W3xx-LX, UC-7112-LX Plus, IA26x-LX, W406-LX
uc711x	UC-7101-LX, UC-711x-LX
uc84xx	UC-84xx-LX

To build sample code for Windows, follow the instructions in the previous section to set up your projects. Next, build three libraries first and then build their corresponding sample programs.

3

Peripheral I/O Library

Moxa's sample code uses ten kinds of programming functions for nine peripherals; the sample programs are provided by the peripheral I/O library. The peripherals include buzzer, LCM, keypad, RTC, watchdog timer, digital IO, serial, network interface, and socket. In this chapter, programming functions for each peripheral will be introduced; Sample programs from the sample code will be introduced in the next chapter.

Buzzer Functions

In some cases, such as when the embedded computer detects a high pressure in a vacuum device, your applications may need the attention of the operator. A low volume buzzer is the perfect component for this purpose.

In the following sections we describe how to activate the buzzer and use its programming functions. The header file of all buzzer functions is *mxbuzzer.h* in the Linux directory *inc/mxphio*. For Windows, the header file is located in folder *inc\mxphio*.

mxbuzzer_open function

This function opens a handle that operates the buzzer.

HANDLE mxbuzzer_open(void);
Inputs
None.
Return Value
When successful, this function returns a positive value (or handle) that represents the buzzer device.

mxbuzzer_close function

This function closes the open handle of the buzzer.

void mxbuzzer_close(HANDLE fd);	
Inputs	
fd	Specifies the open handle of the buzzer.
Return Value	
None.	

mxbuzzer_beep function

This function regulates the buzzer for Linux.

void mxbuzzer_beep(HANDLE fd, int time);	
Inputs	
fd	Specifies the open handle of the buzzer.
time	Specifies the amount of time (in milliseconds) that the beep lasts.
Return Value	
None.	

This function regulates the buzzer for Windows.

void mxbuzzer_beep(HANDLE fd, int time, int freq);	
Inputs	
fd	Specifies the open handle of the buzzer.
time	Specifies the amount of time (in milliseconds) that the beep lasts.
freq	the frequency of the beep.
Return Value	
None.	

LCM Functions

Moxa's UC-7400 series and DA-660 series embedded computers have an LCM on the top panel. The LCM on the UC-7420 and UC-7410 embedded computers has an English text display area that holds 8x16 characters, while the LCM on the DA-660 series embedded computers has a display area that holds 2x16 characters.

For each embedded computer with an LCM, an internal service is pre-installed at the software kernel level. Application programs drive the service by opening and writing data in, and controlling a device file. The following sections describe each LCM function and their usage. The header file of LCM functions is *mxlcm.h*, which is located in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

mxlcm_open function

This function opens a device file associated with the LCM hardware.

HANDLE mxlcm_open(void);
Return Value
When successful, this function returns a positive file descriptor or handle. A negative value will be returned if the LCM device does not exist.

mxlcm_close function

This function closes a device file associated with the LCM hardware.

void mxlcm_close(HANDLE fd);	
Inputs	
fd	An open file descriptor or handle representing the LCM.

mxlcm_get_cursor function

This function gets the position of the cursor on the LCM screen.

int mxlcm_get_cursor(HANDLE fd, int *x, int *y);	
Inputs	
fd	An open file descriptor or handle representing the LCM.
Outputs	
x	Pointer to the horizontal position of the cursor.
y	Pointer to the vertical position of the cursor.
Return Value	
Returns 0, if successful.	

mxlcm_set_cursor function

This function moves the cursor to a specified position on the LCM screen.

int mxlcm_set_cursor(HANDLE fd, int x, int y);	
Inputs	
fd	An open file descriptor or handle representing the LCM.
x	Horizontal position of the cursor.
y	Vertical position of the cursor.
Return Value	
Returns 0, if successful.	

mxlcm_control function

This function controls LCM features such as backlight on/off, cursor blink on/off, etc.

int mxlcm_control(HANDLE fd, int flag);	
Inputs	
fd	An open file descriptor or handle representing the LCM.
flag	Indicates the combinational features of the LCM.
Return Value	
Returns 0, if successful.	

mxlcm_write function

This function writes a string of English text onto the LCM screen starting from a specified position.

int mxlcm_write(HANDLE fd, int x, int y, char *data, int len);	
Inputs	
fd	An open file descriptor or handle representing the LCM.
x	Horizontal position of the text string.
y	Vertical position of the text string.
data	Pointer to the text string.
len	Length of the text string.
Return Value	
Returns the number of characters written, if successful.	

mxlcm_write_screen function

This function writes a full screen text string in English onto the LCM.

int mxlcm_write_screen(HANDLE fd, char text[MAX_LCM_ROWS][MAX_LCM_COLS]);	
Inputs	
fd	An open file descriptor or handle representing the LCM.
text	Full screen text string.
Return Value	
Returns 0, if successful.	
Note: **MAX_LCM_ROWS** and **MAX_LCM_COLS** are constants that represent the number of rows and the number of columns of the LCM display, respectively.	

Keypad Functions

Moxa's UC-7400 and DA-660 series embedded computers are equipped with keypad buttons for your touch-and-control applications. The UC-7420 and UC-7410 computers have five keypad buttons and the DA-660 series have four keypad buttons.

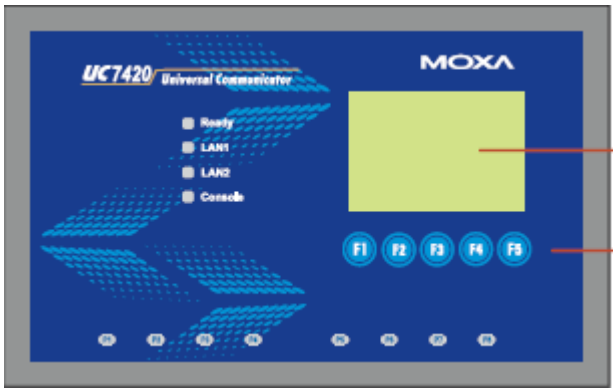


Figure 3-1: UC-7420

Figure 3-2: DA660

When programming keypad buttons, developers need to recognize that F1 to F5 of the UC-7420 and UC-7410 computers (as shown in Figure 3-1) are represented by key numbers 0 to 4, respectively, and for the DA-660 series computers (Figure 3-2), MENU, up arrow, down arrow, and SEL are represented by key numbers 0, 3, 2, and 1, respectively.

Your programs drive these keypad buttons by opening, writing data in, reading data from, and controlling a device file whose location is hidden by the API function **keypad_open**. The following sections will describe each keypad programming function and its usage. The header file of keypad functions is *mxkeypad.h*, located in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

keypad_open function

This function opens a device file associated with the keypad buttons.

int keypad_open(void);
Return Value
When successful, this function returns a positive value of a file descriptor or a handle representing the keypad buttons. Otherwise, it returns a negative value if the device file does not exist.

keypad_close function

This function closes a device file associated with the keypad buttons.

void keypad_close(int fd);	
Inputs	
fd	An open file descriptor or handle representing the keypad buttons.
Return Value	
None.	

keypad_get_pressed_key function

This function gets the number corresponding to the keypad button that was pressed (zero to four for the UC-7400 series or zero to three for the DA-660 series).

int keypad_get_pressed_key(int fd);	
Inputs	
fd	An open file descriptor or handle representing the keypad buttons.
Return Value	
When successful, this function returns a number (starting from 0) when a keypad button is pressed. Otherwise it returns a negative value if there is an error in the device.	

RTC Functions

RTC (real time clock) is the hardware clock. It is an integrated circuit used by a computer or device to keep track of the current time. The functions in this section can be used to get the current hardware clock time, set the hardware clock time to a specified time, set the hardware clock time to the system time, or set the system time to the hardware clock time. The header file of RTC functions is *mxrtc.h*, located in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

mxrtc_ge function

This function gets the current hardware clock time.

int mxrtc_get(unsigned int *t);	
Inputs	
t	Pointer to an empty array (at least 6 elements) of time values: year, month, day, hour, minute, and second.
Return Value	
This function returns 0 if successful. Otherwise, there is an error.	

mxrtc_set function

This function sets the hardware clock time to a specified time.

int mxrtc_set(unsigned int *t);	
Inputs	
t	Pointer to time values: year, month, day, hour, minute, and second.
Return Value	
When successful, this function returns 0. Otherwise, there is an error.	

mxrtc_set_system_time function

This function sets the hardware clock time to the system time.

int mxrtc_set_system_time(void);
Inputs
None.
Return Value
When successful, this function returns 0. Otherwise, there is an error.

mxrtc_get_system_time function

This function sets the system time to the hardware clock time.

int mxrtc_get_system_time(void);
Inputs
None.
Return Value
When successful, this function returns 0. Otherwise, there is an error.

Watchdog Timer Functions

For certain fault conditions, such as when the system hangs or your program cannot complete an operation successfully, you will need the system to return to normal operation. The watchdog timer can be used for this purpose. The following functions allow you to implement a watchdog timer in your program. The header file of watchdog timer functions is *mxwdg.h*, which is in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

mxwdg_open function

This function starts a watchdog timer.

int mxwdg_open(unsigned long time);	
Inputs	
time	Specifies an exact time period in milliseconds. Note that the watchdog timer needs to be refreshed to avoid reset.
Return Value	
When successful, this function returns a positive value representing a file descriptor. Otherwise, it returns a negative value.	

mxwdg_close function

This function stops the watchdog timer.

void mxwdg_close(int fd);	
Inputs	
fd	Specifies the file descriptor of the watchdog timer.
Return Value	
None.	

mxwdg_refresh function

This function refreshes the watchdog timer, and should be called periodically during timer timeouts.

int mxwdg_refresh(int fd);	
Inputs	
fd	Specifies the file descriptor of the watchdog timer.
Return Value	
When successful, this function returns 0. Otherwise, it returns a negative value.	

DIO Functions

Digital input/output channels are featured in some models of Moxa embedded computers, including the UC-7408, UC-8410, IA240, IA260, and W406. These channels can be accessed at run-time for control or monitoring using the functions in the following sections. Digital Output channels can be set to high or low via each port starting from 0. The Digital Input channels can be used to detect the state change of the digital input signal. The header file of digital I/O functions is *mxdgio.h*, which is located in the *inc/mxphio* directory for Linux, and in the *inc**mxphio* folder for Windows.

mxdgio_open function

This function opens an access to the DIO device.

HANDLE mxdgio_open(void);
Inputs
None.
Return Value
When successful, this function returns an access to the DIO device. Otherwise, there is an error.

mxdgio_close function

This function closes the access to the DIO device.

void mxdgio_close(HANDLE fd);	
Inputs	
fd	The access to the device.
Return Value	
None.	

mxdgio_get_input_signal function

This function gets the signal state of a digital input channel.

int mxdgio_get_input_signal(HANDLE fd, int port);	
Inputs	
fd	The access to the device.
port	port #
Return Value	
Returns 1 for a high signal or 0 for a low signal, if successful. Otherwise, it returns a value of -1.	

mxdgio_get_output_signal function

This function gets the signal state of a digital output channel.

int mxdgio_get_output_signal(HANDLE fd, int port);	
Inputs	
fd	The access to the device.
port	port number
Return Value	
Returns 1 for a high signal or 0 for a low signal, if successful. Otherwise, it returns a value of -1.	

mxdgio_set_output_signal_high function

This function sets a high signal to a digital output channel.

int mxdgio_set_output_signal_high(HANDLE fd, int port);	
Inputs	
fd	The access to the device.
port	port number
Return Value	
When successful, this function returns 0. When an error occurs, it returns -1.	

mxdgio_set_output_signal_low function

This function sets a low signal to a digital output.

int mxdgio_set_output_signal_low(HANDLE fd, int port);	
Inputs	
fd	The access to the device.
port	port #
Return Value	
When successful, this function returns 0. When an error occurs, it returns -1.	

Serial Functions

The Moxa peripheral I/O library provides a set of functions to set and get serial parameters, including baudrate, data bits, stop bits, parity, interface, and flow control, and to read and write data. The header file of all serial functions is *mserial_port.h*, located in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

mxsp_open function

This function opens a serial port.

unsigned int mxsp_open(int port);	
Inputs	
port	Port number (starting from 1).
Return Value	
When successful, this function returns the handle of the open port. When an error occurs, it returns a negative value.	

mxsp_close function

This function closes a serial port.

int mxsp_close(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns 0. When an error occurs, it returns a negative value.	

mxsp_set_baudrate function

This function sets the communication baudrate of a serial port.

int mxsp_set_baudrate (unsigned int fd, int baudrate);	
Inputs	
fd	Handle of the open port.
baudrate	Specified baudrate.
Return Value	
When successful, this function returns 0. If it does not return 0, you can consider it to be unsuccessful.	

mxsp_get_baudrate function

This function gets the baudrate of a serial port.

int mxsp_get_baudrate(unsigned int fd);	
Input	
fd	Handle of the open port.
baudrate	Specified baudrate.
Return Value	
When successful, this function returns a positive value. This function returns a negative value when an error occurs.	

mxsp_set_databits function

This function sets the number of data bits for communication through a serial port.

int mxsp_set_databits(unsigned int fd, int bits);	
Inputs	
fd	Handle of the open port.
bits	5, 6, 7, or 8
Return Value	
When successful, this function returns 0.	

mxsp_get_databits function

This function gets the number of data bits in for communication through a serial port.

int mxsp_get_databits(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns the number of bits (5, 6, 7, or 8).	

mxsp_set_stopbits function

This function sets the number of stop bits for communication through a serial port.

int mxsp_set_stopbits(unsigned int fd, int bits);	
Inputs	
fd	Handle of the open port.
bits	stop bits; 1, 2, or 3 (for 1.5)
Return Value	
When successful, this function returns 0.	

mxsp_get_stopbits function

This function gets the number of stop bits for communication through a serial port.

int mxsp_get_stopbits(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns the number of stop bits (1, 2, or 3).	

mxsp_set_parity function

This function sets the parity of a serial port.

int mxsp_set_parity(unsigned int fd, int parity);	
Inputs	
fd	Handle of the open port.
parity	0: none, 1: odd, 2: even, 3: space, 4: mark, otherwise: none
Return Value	
When successful, this function returns 0.	

mxsp_get_parity function

This function gets the parity for a serial port.

int mxsp_get_parity(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns the parity of the open port (0, 1, 2, 3, or 4).	

mxsp_set_flow_control function

This function sets the type of flow control for a serial port.

int mxsp_set_flow_control(unsigned int fd, int mode);	
Inputs	
fd	Handle of the open port.
mode	1: software, 2: hardware, otherwise: none
Return Value	
When successful, this function returns 0.	

mxsp_get_flow_control function

This function gets the type of flow control of a serial port.

int mxsp_get_flow_control(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns the type of flow control being used by that port. The function returns a negative value when an error occurs.	

mxsp_set_interface function

This function sets the type of communication interface for a serial port.

int mxsp_set_interface(unsigned int fd, int mode);	
Inputs	
fd	Handle of the open port.
mode	0: RS232, 1: RS485_2WIRE, 2: RS422, 3: RS485_4WIRE
Return Value	
When successful, this function returns 0.	

mxsp_get_interface function

This function gets the type of communication interface of a serial port.

int mxsp_get_interface(unsigned int fd);	
Inputs	
fd	Handle of the open port.
Return Value	
When successful, this function returns one of the values from 0 to 3. The function returns a negative value when an error occurs.	

mxsp_purge_buffer function

This function clears a serial port's data buffer.

int mxsp_purge_buffer(unsigned int fd, int purge);	
Inputs	
fd	Handle of the open port.
purge	0: received buffer, 1: transmitting buffer, 2: both
Return Value	
When successful, this function returns 0.	

mxsp_set_nonblocking function

For Linux programming, this function sets the open port to operate in non-blocking mode.

void mxsp_set_nonblocking(unsigned int fd);	
Inputs	
fd	Handle of the open port.

mxsp_read function

This function reads data into a buffer from an open serial port in non-blocking mode for Windows. For Linux, if the function **mxsp_set_nonblocking** is called, it reads in non-blocking mode; otherwise it reads in blocking mode.

mxsp_read(unsigned int fd, char *buffer, int size, void *dummy);	
Inputs	
fd	Handle of the open port.
buffer	Pointer to the buffer.
size	Maximum size to be read.
dummy	Reserved argument.
Return Value	
If it fails, this function returns a negative value. If no data is read in non-blocking mode, it returns 0; otherwise, it returns the number of bytes read.	

mxsp_blocking_read function

This function reads data into a buffer from an open serial port in blocking mode (for Windows only).

mxsp_blocking_read(unsigned int fd, char *buffer, int size, void *dummy);	
Inputs	
fd	Handle of the open port.
buffer	Pointer to the buffer.
size	Maximum size to be read.
dummy	Reserved argument.
Return Value	
If it fails, this function returns a negative value. Otherwise, it returns the number of bytes read.	

mxsp_write function

This function writes data from a buffer to an open serial port.

mxsp_write(unsigned int fd, char *buffer, int size, void *dummy);	
Inputs	
fd	Handle of the open port.
buffer	Pointer to the buffer.
size	Size of data to be written.
Return Value	
If it fails, this function returns a negative value. Otherwise, it returns the number of bytes written.	

Network Interface Functions

Network interface functions provide interfaces for manipulating parameters for an embedded computer's network interfaces and DNS servers. Network interface parameters include interface name, MAC address, IP address, default gateway address, network address, broadcast address, and a flag for static or dynamic IP. The parameters are included in the definition of the **MXIFACE** data structure.

```
typedef struct _MXIFACE
{
    char ifname[32];
    unsigned char macaddr[8];
    char ipaddr[16];
    char gateway[16];
    char netmask[16];
    char network[16];
    char broadaddr[16];
    char dhcpsrv[16];
    unsigned int enable_dhcp;
} MXIFACE;
```

The network interface parameters can be obtained from the runtime and interface files for Linux, or from the registry settings for Windows. Windows registry settings take effect at bootup or when the network interface is restarted. Linux parameters can be updated in both the runtime and interface files, but the Windows runtime parameters for the network interface cannot be updated directly. The header file for network interface functions is *netiface.h*, which is located in the *inc/mxphio* directory for Linux, or in the *inc\mxphio* folder for Windows.

mxiface_get_info function

This function gets the interface configuration from the runtime.

int mxiface_get_info(char *ifname, MXIFACE *ifaces, int max);	
Inputs	
ifname	The name of the interface; NULL for all interfaces.
max	The maximum number of interfaces.
Outputs	
ifaces	The buffer containing interface information.
Return Value	
The number of interfaces.	

mxiface_get_info_from_file function

This function gets the interface configuration from the interface file for Linux.

int mxiface_get_info_from_file(char *ifname, MXIFACE *ifaces, int max);	
Inputs	
ifname	The name of the interface; NULL for all interfaces.
max	The maximum number of interfaces.
Outputs	
ifaces	The buffer containing interface information.
Return Value	
The number of interfaces.	

mxiface_get_info_static function

This function gets the interface configuration from registry settings for Windows CE.

int mxiface_get_info_static(char *ifname, MXIFACE *ifaces, int max);	
Inputs	
ifname	The name of the interface; NULL for all interfaces.
max	The maximum number of interfaces.
Outputs	
ifaces	The buffer containing interface information.
Return Value	
The number of interfaces.	

mxiface_get_mac_address function

This function gets the MAC address of an interface.

int mxiface_get_mac_address(char *ifname, unsigned char *mac);	
Inputs	
ifname	The name of the interface.
Outputs	
mac	MAC address
Return Value	
When successful, this function returns 0.	

mxiface_update_info function

This function updates the runtime configuration of a Linux network interface.

int mxiface_update_info(MXIFACE *iface);	
Inputs	
iface	Info of the interface.
Return Value	
When successful, this function returns 0; otherwise, you can consider it to be a failure.	

mxiface_update_interface_file function

This function updates the configuration of an interface into the Linux file or Windows registry settings.

int mxiface_update_interface_file(MXIFACE *ifr);	
Inputs	
iface	Info of the interface.
Return Value	
When successful, this function returns 0.	

mxhost_get_dns function

This function gets the list of DNS servers from a networking interface.

int mxhost_get_dns(char *ifname, char *dns_list, int size);	
Inputs	
ifname	The name of an interface.
dns_list	Buffer for the list of DNS servers.
size	Size of buffer for the list of DNS servers.
Outputs	
dns_list	The list of DNS servers separated by a space.
Return Value	
When successful, this function returns 0.	

mxhost_update_dns function

This function updates the list of DNS servers to a networking interface.

int mxhost_update_dns(char *ifname, char *dns_list);	
Inputs	
ifname	The name of the updated interface.
dns_list	The list of DNS servers separated by a space.
Return Value	
When successful, this function returns 0.	

mxiface_restart function

This function restarts the network interfaces.

int mxiface_restart(void);
Return Value
When successful, this function returns 0; otherwise, you can consider it to be a failure.

Socket Functions

Moxa's embedded computers are equipped with network interfaces that allow your client-server applications to communicate with each other across a computer network. These applications are normally implemented in socket programming with TCP or UDP protocols. Moxa provides a set of socket functions to help you with your software development. The header file of all socket functions is *network.h*, which is located in the *inc/mxphio* directory for Linux, or in the *inc**mxphio* folder for Windows.

net_library_init function

This function initiates the socket library for Windows programming. This function must be called before the user program can use the associated socket functions in the library.

void net_library_init(void);

net_library_release function

This function releases the socket library for Windows programming.

void net_library_release(void);

tcp_make_client function

This function initiates a TCP client connection to a server program.

int tcp_make_client (const char *host, int *port, unsigned int *ip, int nonblocking);	
Inputs	
host	Pointer to the name of the server.
port	The listening port of the server.
ip	The network byte ordered IP address of the server; if <host> is a NULL value, use the ip value.
nonblocking	Non-zero value for a non-blocking socket.
Outputs	
ip	The ip value of the server.
port	The local port of the client connection.
Return Value	
When successful, this function returns a positive value of a file descriptor representing a communication socket. When an error occurs, it returns a negative value.	

tcp_startup_server function

This function starts up a TCP server on a specified listening port.

int tcp_startup_server(unsigned int ip, int port);	
Inputs	
ip	The network byte ordered IP address that the server binds to; a value of zero means that it can bind to any interface.
port	The listening port of the server.
Return Value	
When successful, this function returns a positive value of a file descriptor representing a communication socket. When an error occurs, it returns a negative value.	

tcp_accept_client function

The server program accepts a TCP client connection and assigns a socket to the connection.

int tcp_accept_client (int fd, int *port, unsigned int *ip, int nonblocking);	
Inputs	
fd	The open socket of the server.
nonblocking	Non-zero value for a client socket in non-blocking mode.
Outputs	
port	The local port of the client socket.
ip	The IP address of the client machine that is making the request for this connection.
Return Value	
When successful, this function returns a positive value of a file descriptor for the client socket. When an error occurs, it returns a negative value.	

tcp_nonblocking_write function

This function sends data to the communication peer on a non-blocking TCP socket.

int tcp_nonblocking_write(int fd, char *buf, int len, void *dummy);	
Inputs	
fd	The TCP socket.
buf	Pointer to the data to be sent.
len	The length of the data.
dummy	ignored
Return Value	
This function returns the number of bytes sent. When an error occurs, it returns a negative value.	

tcp_nonblocking_read function

This function reads data from a connected non-blocking TCP socket.

int tcp_nonblocking_read(int fd, char *buf, int size, void *dummy);	
Inputs	
fd	The TCP socket.
buf	Pointer to a buffer for incoming data.
size	The size of the buffer.
dummy	ignored
Return Value	
This function returns the number of bytes received. When an error occurs, it returns a negative value.	

tcp_nonblocking_wait function

This function waits for a just connected non-blocking TCP socket to be available for reading or writing. It is used after calling ***tcp_make_client*** for a non-blocking TCP client connection.

int tcp_nonblocking_wait(int fd, int sec, int write);	
Inputs	
fd	The TCP socket.
sec	The number of seconds to wait.
write	Non-zero value to represent a wait for writing, or a zero value to represent a wait for reading.
Return Value	
When the socket is ready for reading or writing before the time is up, this function returns a positive value. When a connection is not established or an error occurs, this function returns 0. #define tcp_nonblocking_writeable(f,s) tcp_nonblocking_wait(f,s,1) #define tcp_nonblocking_readable(f,s) tcp_nonblocking_wait(f,s,0)	

udp_make_client function

This function establishes a UDP client connection to a server.

int udp_make_client(char *host, int port, struct sockaddr_in *addr_in);	
Inputs	
host	The name of the server host.
port	The listen port of the server.
Outputs	
addr_in	Pointer to a data structure that contains the information of the server.
Return Value	
When successful, this function returns a positive value of a file descriptor representing the client socket. When an error occurs, it returns a negative value.	

udp_startup_server function

This function starts up a UDP server.

int udp_startup_server(unsigned int ip, int port, struct sockaddr_in * addr_in);	
Inputs	
ip	The network byte ordered IP address that the server binds to; a value of zero means that it can bind to any interface.
port	The listen port of the server.
Outputs	
addr_in	Pointer to a data structure that contains the information of the server.
Return Value	
When successful, this function returns a positive value of a file descriptor representing the client socket. When an error occurs, it returns a negative value.	

udp_send function

This function sends data to the communication peer on a UDP socket.

int udp_send(int fd, char *buf, int len, struct sockaddr_in *peer);	
Inputs	
fd	UDP socket.
buf	Pointer to the data to be sent.
len	The length of the data.
peer	Pointer to a data structure that contains the information of the peer that will receive the data.
Return Value	
This function returns the number of bytes sent. When an error occurs, it returns a negative value.	

udp_recv function

This function receives data from a UDP socket.

int udp_recv(int fd, char *buf, int size, struct sockaddr_in *peer);	
Inputs	
fd	The UDP socket.
buf	Pointer to a buffer for incoming data.
size	The size of the buffer.
Outputs	
peer	Pointer to a data structure that contains the information of the peer that sent the data.
Return Value	
This function returns the number of bytes received. When an error occurs, it returns a negative value.	

IP Multicast Functions

The IP multicast transmission method is used for efficient one-to-many communications, and is different from unicast and broadcast. Class D addresses from 224.0.0.0 to 239.255.255.255 are designated as multicast addresses. The sender sends a single datagram to the multicast address, and the intermediary routers automatically make copies and send them to all receivers that have registered with the multicast address. IP multicast support is included in most embedded computer models. Developers can easily use IP multicast programming functions in sample code to write their own IP multicast programs. The header file of all IP multicast functions is *mcast.h*, which is located in the *inc/mxphio* directory for Linux, and in the *inc\mxphio* folder for Windows.

mcast_make_client function

This function creates a multicast client (sender) socket.

SOCKET mcast_make_client(int onoff, char *grp, int port, struct sockaddr_in *addr);	
Inputs	
onoff	The flag to turn on (1) or off (0) multicast packets sent to the loopback interface.
grp	The multicast group address.
port	The multicast port number.
addr	Pointer to the multicast socket address structure.
Return Value	
When successful, this function returns a socket fd. Otherwise, there is an error.	

mcast_make_server function

This function creates a multicast server (receiver) socket.

SOCKET mcast_make_server(char *grp, int port, struct sockaddr_in *addr);	
Inputs	
grp	The multicast group address.
port	The multicast port number.
addr	Pointer to the multicast socket address structure.
Return Value	
When successful, this function returns a socket fd. Otherwise, there is an error.	

mcast_join function

This function joins a multicast group as a multicast receiver.

int mcast_join(SOCKET fd, char *grp, struct ip_mreq *mreq);	
Inputs	
fd	The socket fd.
grp	The multicast group address.
mreq	Pointer to the multicast request structure.
Return Value	
When successful, this function returns 0. Otherwise, it returns -1 when a failure occurs.	

mcast_leave function

This function leaves a multicast group as a multicast receiver.

int mcast_leave(SOCKET fd, struct ip_mreq *mreq);	
Inputs	
fd	The socket fd.
mreq	Pointer to the multicast request structure.
Return Value	
When successful, this function returns 0. Otherwise, it returns -1 when a failure occurs.	

4

Peripheral I/O Library Sample Programs

In this chapter a set of higher layer functions for LCM/Keypad using LCM/Keypad peripheral I/O functions and related sample programs are introduced. In addition, a sample program defining a set of higher layer functions for DIO using DIO peripheral I/O functions is presented.

Keypad Callback Functions

In the previous chapter we have described some preliminary keypad functions, including **keypad_open** and **keypad_get_pressed_key**. These functions give programmers full access to the keypad buttons from within a program.

In addition to these preliminary functions, we provide programmers with another set of API functions that allow user applications to focus on event handling when keypad buttons are pressed. A callback function is defined to associate with an event. The header file of all keypad callback functions is *keypad_callback.h*, which is located in the *inc/mxphio* directory Linux or the *inc\mxphio* folder for Windows.

keypad_callback_init function

This function registers a handle for user-defined callback operations on the keypad buttons. It must be called before any other function is called.

KEYPAD *keypad_callback_init(void);
Return Value
If successful, it returns a positive value for the handle, or it returns 0 if the system falls short on memory allocation.

keypad_callback_add function

This function associates a user-defined function with a keypad button. This function will be called when the keypad button is pressed.

int keypad_callback_add(KEYPAD *hndl, int key, keypad_callback_t func, void *arg);	
Inputs	
hndl	The open handle representing a set of callback operations.
key	The key number of the keypad button; note that key numbers start from 0.
func	User-defined function.
arg	The user-defined parameter of the callback function.
Return Value	
Returns 0 if successful.	
Remarks	
The user-defined callback function has prototype *func(void *arg, int key)* where parameter <*arg*> is the user-defined argument for this function, and parameter <*key*> is the key number of the keypad button.	

keypad_callback_dispatch function

This function forces the user program to enter an infinite loop, where the program dispatches the logic flow to call the associated user-defined function when a keypad button is pressed.

void keypad_callback_dispatch(KEYPAD *hndl);	
Inputs	
hndl	The open handle representing a set of callback operations.
Return Value	
None	

keypad_callback_quit function

This function forces all keypad operations to stop.

void keypad_callback_quit(KEYPAD *hndl);	
Inputs	
hndl	The open handle representing a set of callback operations.
Remarks	
If these keypad callback operations are part of a user program, the program can create a child thread to handle the function **keypad_callback_dispatch** and leave the control rights to the main thread to stop the dispatch (or thread) if necessary.	

LCM/Keypad Context Functions

To enhance the usage of the keypad callback functions described in the previous section, a set of context functions to combine LCM and keypad callback functions are provided in this section. Developers can use these functions to associate keypad callback function with an LCM display. The header file of all LCM/Keypad context functions is *keypad_lcm.h*, which is in the *inc/mxphio* directory for Linux, or the *inc\mxphio* folder for Windows.

keypad_lcm_menu_init function

This function initiates a context of operating keypad buttons and LCM display.

LCMKPD *keypad_lcm_menu_init(void);
Inputs
None.
Return Value
When successful, this function returns a positive handle value representing a context of operating keypad buttons and LCM display. When an error occurs, this function returns 0.

keypad_lcm_menu_add function

This function adds a set of user-defined functions, each of which handles the data content of the LCM display when a keypad button is pressed.

int keypad_lcm_menu_add(LCMKPD *hndl, lcm_show_t *funs, void *data);	
Inputs	
hndl	The context of operations.
funs	Pointer to an array of user-defined functions. The number of functions is equivalent to the maximum number of keypads in the embedded computers. A user-defined function is called when an associated keypad is pressed. For example, when the first keypad button ("MENU" of a DA-660 series computer or "F1" of a UC-7400 series computer) is pressed, the user-defined function, funs[0] is called. Each user-defined function has the following prototype: **typedef void (*lcm_show_t) (LCMDAT*, void*data);** The data is an argument to the function. The structure *LCMDAT* is defined as: **typedef struct _LCMDAT {** **char text[MAX_LCM_ROWS][MAX_LCM_COLS];** **int cursor_x, cursor_y;** **} LCMDAT;** The text of each returned structure will contain *MAX_LCM_ROWS* rows of string characters. Each row has up to *MAX_LCM_COLS* characters. The user-defined function can also specify the position of the cursor by giving the values of cursor_x (0 to *MAX_LCM_ROWS* – 1) and cursor_y (0 to *MAX_LCM_COLS* – 1) of the returned structure.
data	the argument of the functions
Return Value	
When successful, this function returns 0. When an error occurs, this function returns a non-zero value.	

keypad_lcm_menu_dispatch function

This function detects pressed keypad button events; when a keypad button is pressed, the function will then call an associated user-defined function. When it is called, the program enters an infinite loop. The caller can initiate a thread for this function and call **keypad_lcm_menu_quit** to quit the dispatch function if necessary.

void keypad_lcm_menu_dispatch(LCMKPD *hndl);	
Inputs	
hndl	The context of operations.
Return Value	
None.	

keypad_lcm_menu_quit function

Call this function to jump out of the infinite dispatch loop.

void keypad_lcm_menu_quit(LCMKPD *hndl);	
Inputs	
hndl	The context of operations.
Return Value	
None.	

LCM/Keypad Sample Program

This LCM/Keypad sample program shows how a user can change the networking IP addresses of the embedded computers by simply pressing the keypad buttons, without needing to log on to the computers. The LCM is used to display the setting changes and the final results. The source code files of the sample program are in the *samples/mxphio/keypad_lcm* directory for Linux or in the *samples\mxphio\keypad_lcm* folder for Windows.

We use the DA-660 to illustrate. This embedded computer has 4 keypad buttons: MENU, up arrow, down arrow, and SEL, which are recognized by the computer internally as key 0, 3, 2, and 1, respectively. In the LCM display area, which accommodates 2x16 characters, this example shows an IP address for a LAN port in the format **LAN:eth0** in the first row and **xxx.xxx.xxx.xxx** in the second row.

The user presses the "MENU" button to select a LAN port from two LAN ports of the DA-660 computer. The IP address of the selected LAN port will be displayed on the LCM screen. The down arrow button is used to shift the cursor to each digit of the IP address. Pressing the up arrow button increases a digital value. When finished, press the "SEL" button to activate the IP address shown on the LCM screen.

The main advantage of the LCM/Keypad programming function is that it's easy to use and the design is based on four user-defined functions with a corresponding keypad button for each one. These functions are ***ipaddr_get***, ***ipaddr_set, ipaddr_digit_shift,*** and ***ipaddr_digit_up.*** For each LAN port, these functions must be registered once by calling **keypad_lcm_menu_add**.

```
int ipaddr_menu_init(LCMKPD *hndl)
{
    int i, max;
    lcm_show_t funs[4];
    MXIFACE gIPIfaces[MAX_IFACES];
    /* get network interfaces */
    memset(gIPIfaces, 0, MAX_IFACES*sizeof(MXIFACE));
    max = mxiface_get_info_from_file(NULL, gIPIfaces, MAX_IFACES);
    if (max < 0)
    {
        printf("fail to get interfaces\n");
        return -1;
    }
    funs[0] = ipaddr_get;
    funs[1] = ipaddr_set;
    funs[2] = ipaddr_digit_shift;
    funs[3] = ipaddr_digit_up;
        /* based on interfaces, each carries an IPADDR */
        for (i=0; i < max ; i++)
        {
        strcpy(gIPAddrs[i].ifname, gIPIfaces[i].ifname);
        if (keypad_lcm_menu_add(hndl, funs, &gIPAddrs[i]))
            return -1;
        }
        return 0;
}
```

The variable ***gIPAddrs*** is a global data structure array. Each array item contains a variable ***ifname*** for the interface name of the LAN port, a double character array ***addr*** representing the 12 digits of an IP address, and two integer values ***digit_i*** and ***digit_j*** to trace the position of the LCM cursor within the 12 digits.

```
#define MAX_IFACES 8 /* assume a maximum # of interfaces */
/* about a network interface */
typedef struct _IPADDR
{
    char ifname[16]; /* the name of the interface */
```

```
    unsigned char addr[4][3]; /* ip address in digits */
    int digit_i, digit_j; /* position */
} IPADDR;
/* global structures */
static IPADDR gIPAddrs[MAX_IFACES];
```

In this example, each user-defined function calls a common function, as shown below, to enter data for an IP address that the LCM displays.

```
static void ipaddr_flush2lcm(LCMDAT *lcm, IPADDR *ip, char *msg)
{
sprintf(lcm->text[0], "LAN:%s", ip->ifname);
if (msg)
    sprintf(lcm->text[1], "%s", msg);
else
{
    int i;
    /* convert IP to a string style shown on LCM */
    for (i=0; i < 4; i++)
        sprintf(lcm->text[1]+4*i, "%d%d%d.",
        ip->addr[i][0],ip->addr[i][1],ip->addr[i][2]);
    lcm->text[1][15] = 0;
}
lcm->cursor_y = 1;
lcm->cursor_x = ip->digit_i*4+ip->digit_j;
}
```

DIO Sample Program

This DIO sample program shows how users can develop a set of higher layer functions using preliminary DIO functions from the peripheral I/O library. These functions allow user applications to focus on event handling when events happen. A callback function is defined by the programmer to associate with an event. The source code files of the sample program are located in the *samples/mxphio/digit_input_change* directory for Linux, or the *samples\mxphio\digit_input_change* folder for Windows.

Four higher layer functions, **digit_io_timer_init**, **digit_io_timer_dispatch**, **digit_io_timer_add_callback**, and **digit_io_timer_dispatch_quit**, are provided. Four callback functions in the sample are added for four different events: **DGTIO_GET_INPUT_STATE_CHANGE**, **DGTIO_GET_INPUT**, **DGTIO_GET_OUTPUT**, and **DGTIO_SET_OUTPUT**, via the **digit_io_timer_add_callback** function.

```
mngr = digit_io_timer_init();
...
if (digit_io_timer_add_callback(mngr, port, DGTIO_GET_INPUT_STATE_CHANGE, interval,
input_chg_cb, &port) < 0) {
...
}
if (digit_io_timer_add_callback(mngr, port, DGTIO_GET_INPUT, interval, input_get_cb, &port) <
0) {
...
}
if (digit_io_timer_add_callback(mngr, port, DGTIO_SET_OUTPUT, interval, output_set_cb, &port)
< 0) {
...

}
if (digit_io_timer_add_callback(mngr, port, DGTIO_GET_OUTPUT, interval, output_get_cb, &port)
```

```
< 0) {
…
}
digit_io_timer_dispatch(mngr);
```

5

Application Library

In Moxa's sample code the higher layer application library contains a connection library developed by Moxa for TCP, UDP, and serial programming, using corresponding functions in the peripheral I/O library. The connection library provides a framework that makes it easier for developers to write socket and serial programs. In this chapter, we introduce user-defined functions, data structures, and API functions of the connection library. In the next chapter, sample programs using the connection library are introduced. To begin with, we define what a connection is.

A *connection* refers to when data packet transmission is established between a source device and a target device. Currently, networking and serial connections is a major segment of data transmission between an embedded computer and other devices.

The following enumeration in C language differentiates the types of supported connections.

```
enum {
    CONNECTION_TYPE_NONE,
    CONNECTION_TYPE_TCPACCEPT,   /* a client connection accepted by a TCP server */
    CONNECTION_TYPE_TCPSERVER,   /* a connection of a TCP server */
    CONNECTION_TYPE_TCPCLIENT,   /* a TCP client making the connection */
    CONNECTION_TYPE_UDPCLIENT,   /* a UDP client making the connection */
    CONNECTION_TYPE_UDPSERVER,   /* a connection of a UDP server */
    CONNECTION_TYPE_UARTPORT,    /* a connection of a serial port */
};
```

The following set of programming functions consolidates each connection to handle four states: open, packet consumption, packet generation, and close. The functions hide the detailed socket implementation and serial port programming, allowing programmers to focus on implementing user-defined functions for the four connection states. The connection library header file of is *connection.h*, which is located in the *inc/mxconn* directory for Linux, or in the *inc**mxconn* folder for Windows.

User-defined Functions

The five user-defined functions open, dispatch, close, timer, and initialization are described in this section.

open user-defined function

This is the prototype of a user-defined function that is called after a connection is created or accepted.

typedef void* (*conn_open_t) (MHANDLE conp, void *param, unsigned int *timer_interval);	
Inputs	
conp	Specifies the connection.
param	Pointer to a data structure that contains the information, such as the listening port and IP address, of the connection. The information content will vary depending on the type of connection.
Outputs	
timer_interval	Specifies the period (in milliseconds) of a timer. This timer will call an associated user-defined function periodically.
Return Value	
Return value that represents a user-defined data area or a parameter that will be used as an argument for other user-defined functions.	

dispatch user-defined function

This is the prototype of a user-defined function that is called after a connection receives a data packet, or if there is still un-processed data.

typedef int (*conn_dispatch_t) (MHANDLE conp, void *private_data, DATAPKT *dpkt);	
Inputs	
conp	Specifies the connection.
private_data	Pointer to the user-defined data.
dpkt	Pointer to a data structure that represents the data packet, including the data and the length of the data. Refer to the detailed description of the data structure in the following section.
Outputs	
dpkt	Specifies the number of bytes in the data packet that have been consumed.
Return Value	
There are different options for this return value. First, if something is found to be wrong and this connection must be disconnected, then return a negative value. Second, if this function consumes a data frame in the packet and there is data left, then return a positive value. A positive return value forces this user-defined function to be called again until the packet is completely consumed. Lastly, return 0 when the un-processed frame is an incomplete data frame.	

close user-defined function

This is the prototype of a user-defined function that is called when a connection is disconnected.

typedef void (*conn_close_t) (MHANDLE conp, void *private_data);	
Inputs	
conp	Specifies the connection.
private_data	Pointer to the user-defined data.
Return Value	
None.	

timer user-defined function

This is the prototype of a user-defined function that is periodically called if the value of a timer interval was given.

typedef void (*conn_timer_t) (void *private_data);	
Inputs	
private_data	Pointer to the user-defined data.
Return Value	
None.	

initialization user-defined function

This is the prototype of a user-defined function that is called by API function **connection_dispatch_loop** at the initialization stage of the user program.

typedef int (*app_init_cb) (int argc, char **argv);	
Inputs	
argc	Specifies the number of arguments when executing the user program.
argv	Pointer to an array of arguments (command line) of the user program.
Return Value	
Return 0 to continue the user program. Otherwise, the user program exits.	

Data Structures

Seven data structures used for socket and serial connections are described in the following sections.

DATAPKT data structure

This data structure defines a data packet that is received by a connection.

```
typedef struct _DATAPKT
{
    char *packet_data;
    int   packet_size;
    int   packet_consumed;
} DATAPKT;
```

Members

<*packet_data*> Specifies the content of the data packet.

<*packet_size*> Specifies the length of the data packet.

<*packet_consumed*> Specifies the number of bytes consumed by a user-defined function.

USERFUN data structure

This data structure specifies the user-defined functions of a connection.

```
typedef struct _USERFUN
{
    conn_open_t open;
    conn_dispatch_t dispatch;
    conn_timer_t timer;
    conn_close_t close;
} USERFUN;
```

Members

<*open*> This function is called after the connection is established.

<*dispatch*> This function is called after the connection receives a data packet.

<*timer*> This function is periodically called if a timer interval is given at the user-defined function <*open*>.

<*close*> This function is called before the connection is disconnected.

UARTPRM data structure

The data structure defines the communication settings of a serial port connection.

```
typedef struct _UARTPRM
{
unsigned int port;
unsigned int baudrate;
unsigned int parity:3;
unsigned int data_bits:4;
unsigned int stop_bits:2;
unsigned int iface_mode:3;
unsigned int flow_control:2;
unsigned int xxx:18;     /* unused or reserved */
} UARTPRM;
```

Members

<*port*> Specifies the port number (starting from 1) of the serial port.

<*baudrate*> Specifies the baudrate at which the serial port operates; for example *..., 1200, 2400, ..., 9600, ...*.

<*parity*> Specifies the parity to be used. Values of 0 to 4 are possible for *no, odd, even, mark*, and *space* parity.

<*data_bits*> Specifies the number of bits (5, 6, 7, 8) in a byte to be transmitted.

<*stop_bits*> Specifies the number of bits (1, 2, 3 for 1.5 bits) to be used.

<*iface_mode*> Specifies the type of serial port interface. Use of 0, 1, 2, or 3 to indicate *RS232, RS485* (2-wire)*, RS422, or RS485* (4-wire), respectively.

<*flow_control*> Specifies the type of flow control during data communication. Use 0, 1, or 2 to represent *none, software (XON/XOFF), hardware* (RTS) flow control, repsectively.

SRVRPRM data structure

This data structure defines the communication parameters of a TCP server.

```
typedef struct _SRVRPRM
{
    unsigned int listen_port:16;
    unsigned int max_clients:16;
    unsigned char ip_range[16];
} SRVRPRM;
```

Members

<*listen_port*> Specifies the listening port of the TCP server.

<*max_clients*> Specifies the maximum number of clients allowed; use 0 for an unlimited number.

<*ip_range*> Specifies the IP range of clients allowed; use 0 for an unlimited number.

TCPCPRM data structure

This data structure defines the communication parameters of a client connection accepted by a TCP server.

```
typedef struct _TCPCPRM
{
    unsigned int listen_port:16;
    unsigned int local_port:16;
```

```
    unsigned int ip;
} TCPCPRM;
```

Members

<*listen_port*> Specifies the listening port of the TCP server.
<*local_port*> Specifies the local port assigned to the client socket.
<*ip*> Specifies the IP address of the server.

CLNTPRM data structure

This data structure defines the communication parameters of a client making a TCP connection to a server.

```
typedef struct _CLNTPRM
{
    char *host;
    unsigned int server_ip;
    unsigned int listen_port:16;
    unsigned int local_port:16;
    unsigned int connection_retrials:8;
    unsigned int connection_timeout:8;
    unsigned int reconnect_interval:8;
    unsigned int xxx:8;
} CLNTPRM;
```

Members

<*host*> Specifies the host name of the TCP server.
<*server_ip*> a converted IP address of <*host*>.
<*listen_port*> Specifies the listening port of the TCP server.
<*local_port*> Specifies the local port assigned to the client socket.
<*connection_retrials*> Specifies the maximum number of retrials before the connection is established.
<*connection_timeout*> Specifies the timeout value (in seconds) of wait time for the establishment of the connection in each trial.
<*reconnect_interval*> Specifies the amount of time (in seconds) that a new trial is initiated after the connection is disconnected.

UDPXPRM data structure

This data structure defines the communication parameters of a UDP connection; could be a server connection or client connection.

```
typedef struct _UDPXPRM
{
    char *host;
    unsigned int ip;
    unsigned int listen_port:16;
    unsigned int local_port:16;
} UDPXPRM;
```

Members

<*host*> Specifies the host name of the remote UDP server that a client is trying to connect to. Specify NULL to establish a local UDP server.
<*ip*> Specifies the converted IP address of the client or the local server.
<*listen_port*> Specifies the listening port of the remote or the local server.
<*local_port*> Specifies the local port assigned to the client socket.

API Functions

The seven functions defined in the connection library are described in the following sections.

connection_destroy function

This function destroys a connection.

void connection_destroy(MHANDLE con);	
Inputs	
con	The connection.
Return Value	
None.	

connection_send_data function

This function sends a data packet to its peer.

void connection_send_data (MHANDLE con, char *buf, int len);	
Inputs	
con	The connection.
buf	Pointer to the data packet.
len	The length of the data packet.
Return Value	
None.	

connection_open function

This function opens a connection.

MHANDLE connection_open (unsigned int type, void *param, USERFUN *funs, void **private_data);	
Inputs	
type	Specifies the type of the connection: CONNECTION_TYPE_TCPSERVER, CONNECTION_TYPE_TCPCLIENT, CONNECTION_TYPE_UDPCLIENT, CONNECTION_TYPE_UDPSERVER, or CONNECTION_TYPE_UARTPORT.
param	Pointer to the data structure of the communication parameters defined for the connection.
funs	Pointer to the data structure of user-defined functions.
private_data	Pointer to the user-defined data.
Return Value	
When successful, the function returns a positive pointer representing the connection. When an error occurs, the function returns as NULL.	

connection_dispatch_loop function

Your user program calls this routine to enter an infinite loop in which operations of read/write for all types of connections are dispatched.

int connection_dispatch_loop(int argc, char **argv, app_init_cb init);	
Inputs	
argc	Specifies the number of arguments when executing the user program.
argv	Pointer to an array of arguments (command line) of the user program.
init	Specifies a user-defined function for initializing the user program. When using this function, you need to start up servers, make connections, etc.
Return Value	
When successful, returns 0. When an error occurs, a non-zero value is returned	

connection_dispatch_quit function

If you have a thread running, call this function to quit the loop of the main routine, **connection_dispatch_loop**.

void connection_dispatch_quit(void);

mxsp_connection_purge function

This function purges the receiving and sending buffers of a serial connection.

void mxsp_connection_purge(MHANDLE *conp);	
Inputs	
conp	Specifies the serial connection.
Return Value	
None.	

mxsp_connection_set_mask function

This function adds a timer that responds to a change of events (line status and error status) in a serial connection.

int mxsp_connection_set_mask(MHANDLE *hndl, conn_event_t cb, unsigned int mask, unsigned int interval);	
Inputs	
hndl	Specifies the serial connection.
cb	Specifies the user-defined function that is called when events change.
mask	Specifies the events to be enabled.
interval	Specifies the timer interval.
Return Value	
When successful, this function returns 0.	

6

Application Library Sample Programs

The connection library and related sample programs are provided with Moxa's sample code. The sample programs for the connection library provide programming examples for TCP client and server, UDP client and server, and serial master and slave. This chapter will introduce major parts of sample programs using TCP, UDP, and serial functions from the connection library.

TCP Functions

This is a simple client/server example that utilizes some of API's advanced functions. The server reverses the contents of each data packet it receives and then sends the result back to the clients.

A. Server Example

The listen port of the server must be specified in a data structure *SRVRPRM* and other members of the structure must be cleaned up (meaning that they must be initialized as zero values). User-defined functions must be specified in a data structure *USERFUN* to be properly called by the user program.

```
/* This is an initialization function where the user program opens connections */
static int
tcp_server_init (int argc, char **argv)
{
MHANDLE conp;
SRVRPRM srvr;
USERFUN funs;
memset(&srvr, 0, sizeof(SRVRPRM));
if (argc > 1)
      srvr.listen_port = atoi(argv[1]);
else
      srvr.listen_port = SERVER_LISTEN_PORT;
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = tcp_server_accept_client;
funs.dispatch = tcp_server_dispatch_client;
funs.close = tcp_server_close_client;
/* make a client connection */
if ((conp=connection_open (CONNECTION_TYPE_TCPSERVER, &srvr, &funs, NULL)) == NULL)
      return -1;
else
      return 0;
}
```

When dispatching data packets, the member *packet_consumed* of the data structure *DATAPKT* must be specified so that the user program can correctly remove the processed data.

```
/*   this user-defined function is called after the user program receives
a data packet. It reverses the contents of the packet and then sends
the result back to the client */
static int
```

```
tcp_server_dispatch_client (MHANDLE conp, void *private_data, DATAPKT *dpkt)
{
char buffer[1024];
dpkt->packet_consumed = dpkt->packet_size;
memcpy(buffer, dpkt->packet_data, dpkt->packet_size);
/* reverse the received data */
reverse_bytes(buffer, dpkt->packet_size);
/* send data back to the client */
connection_send_data(conp, buffer, dpkt->packet_size);
return 0;
}
```

B. Client Example

In addition to specifying the host name and the listen port of the server in the data structure *CLNTPRM*, the initialization function (*tcp_client_init*) must define user-defined functions in the data structure *USERFUN*. After a client connection is made successfully, this function sends the first packet to the server.

```
/* This is an initialization function where the user program opens connections */
static int
tcp_client_init (int argc, char **argv)
{
MHANDLE con;
CLNTPRM param;
USERFUN funs;
if (argc < 3)
{
     printf("usage: <progname> <hostname> <listen port>\n");
     return -1;
}
/* setting the parameters of a server */
memset(&param, 0 , sizeof(CLNTPRM));
param.host = argv[1];
param.listen_port = atoi(argv[2]);
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = tcp_client_open;
funs.dispatch = tcp_client_dispatch;
funs.close = tcp_client_release;
/* make a client connection */
if ((con=connection_open (CONNECTION_TYPE_TCPCLIENT, &param, &funs, NULL)) == NULL)
     return -1;
else
{
     char buf[256];
     /* send 1st packet */
     strcpy(buf, "I am a client 0");
     connection_send_data(con, buf, strlen(buf));
     return 0;
}
}
```

Again, when dispatching data packets, the member *packet_consumed* of the data structure *DATAPKT* must be specified.

```
/*   this user-defined function is called after the user program receives
a data packet. It will keep sending packets to the server */
static int
```

```
tcp_client_dispatch (MHANDLE conp, void *private_data, DATAPKT *dpkt)
{
static int count = 1;
char ch, *buf = (char*) private_data;
dpkt->packet_consumed = dpkt->packet_size; /* consumed all */
ch = dpkt->packet_data[dpkt->packet_size];
dpkt->packet_data[dpkt->packet_size] = 0;
printf("RECV [%d]: %s\n", dpkt->packet_size, dpkt->packet_data);
dpkt->packet_data[dpkt->packet_size] = ch;
#ifdef WIN32
Sleep(200);
#else
sleep(1);
#endif
sprintf(buf, "I am a client %d", count++);
connection_send_data(conp, buf, strlen(buf));
return 0;
}
```

UDP Functions

This is a simple client/server example that utilizes some of API's advanced functions. The server reverses the contents of each data packet it receives and then sends the result back to the clients.

A. Server Example

The listen port of the server must be specified in a data structure *UDPXPRM* and other members of the structure must be cleaned up (meaning that they must be initialized as zero values). User-defined functions must be specified in a data structure *USERFUN* to be properly called by the user program.

```
/* This is an initialization function where the user program opens connections */
static int
udp_server_init (int argc, char **argv)
{
MHANDLE con;
UDPXPRM srvr;
USERFUN funs;
memset(&srvr, 0, sizeof(SRVRPRM));
if (argc > 1)
    srvr.listen_port = atoi(argv[1]);
else
    srvr.listen_port = SERVER_LISTEN_PORT;
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = udp_server_accept_client;
funs.dispatch = udp_server_dispatch_client;
funs.close = udp_server_close_client;
/* make a client connection */
if ((con=connection_open (CONNECTION_TYPE_UDPSERVER, &srvr, &funs, NULL)) == NULL)
    return -1;
else
    return 0;
}
```

When dispatching data packets, the member *packet_consumed* of the data structure *DATAPKT* must be specified.

```
/*  this user-defined function is called after the user program receives
a data packet. It reverses the contents of the packet and then sends
the result back to the client */
static int
udp_server_dispatch_client (MHANDLE conp, void *private_data, DATAPKT *dpkt)
{
char buffer[1024];
dpkt->packet_consumed = dpkt->packet_size;
memcpy(buffer, dpkt->packet_data, dpkt->packet_size);
/* reverse the received data */
reverse_bytes(buffer, dpkt->packet_size);
/* send data back to the client */
connection_send_data(conp, buffer, dpkt->packet_size);
return 0;
}
```

B. Client Example

In addition to specifying the host name and the listen port of the server in the data structure *UDPXPRM*, the initialization function (*udp_client_init*) must define user-defined functions in the data structure *USERFUN*. After a client connection is made successfully, this function sends the first packet to the server.

```
/* This is an initialization function where the user program opens connections */
static int
udp_client_init (int argc, char **argv)
{
MHANDLE con;
UDPXPRM param;
USERFUN funs;
if (argc < 3)
{
     printf("usage: <progname> <hostname> <listen port>\n");
     return -1;
}
/* setting the parameters of a server */
memset(&param, 0 , sizeof(UDPXPRM));
param.host = argv[1];
param.listen_port = atoi(argv[2]);
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = udp_client_open;
funs.close = udp_client_close;
funs.dispatch = udp_client_dispatch;
/* make a client connection */
if ((con=connection_open (CONNECTION_TYPE_UDPCLIENT, &param, &funs, NULL)) == NULL)
     return -1;
else /* send 1st packet */
     connection_send_data(con, "I am a client 0", 15);
return 0;
}
```

Again, when dispatching data packets, the member *packet_consumed* of the data structure *DATAPKT* must be specified.

```
/*  this user-defined function is called after the user program receives
a data packet. It will keep sending packets to the server */
static int
udp_client_dispatch (MHANDLE conp, void *private_data, DATAPKT *dpkt)
```

```
{
static int count = 1;
char *buf = (char*) private_data;
dpkt->packet_consumed = dpkt->packet_size; /* consumed all */
#ifdef WIN32
Sleep(200);
#else
sleep(1);
#endif
sprintf(buf, "I am a client %d", count++);
connection_send_data(conp, buf, strlen(buf));
return 0;
}
```

Serial Functions

This is a simple serial communication example that utilizes some of API's advanced functions. The communication involves a master operating on a serial port and a slave operating on another serial port while both are connected by a loop back cable. The slave reverses the contents of each data packet it receives and then sends the result back to the master.

A. Slave Example

You must consider a few things before calling the API function *connection_open*. To begin with, the communication parameters of the serial port must be specified in a data structure *UARTPRM*. Three user-defined functions are also specified in a data structure *USERFUN.*

```
/* This is an initialization function where the user program opens connections */
static int
serial_slave_init (int argc, char **argv)
{
MHANDLE conp;
UARTPRM uart;
USERFUN funs;
memset(&uart, 0, sizeof(UARTPRM));
if (argc < 2)
{
      printf("usage: <progname> <port>\n");
      return -1;
}
uart.port = atoi(argv[1]);
uart.baudrate = 9600;
uart.parity = MSP_PARITY_NONE;   /* 0~4: none, odd, even, mark, space */
uart.data_bits = 8;       /* 5,6,7,8 */
uart.stop_bits = 1;/* 1,2,3 (1.5 bits) */
uart.iface_mode = MSP_RS232_MODE;  /* 0~3: RS232, RS485_2WIRE, RS422, RS485_4WIRE */
uart.flow_control = MSP_FLOWCTRL_HW; /* 0~2: none, software, hardware   */
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = serial_slave_open;
funs.dispatch = serial_slave_dispatch;
funs.close = serial_slave_close;
/* make a client connection */
if ((conp=connection_open (CONNECTION_TYPE_UARTPORT, &uart, &funs, NULL)) == NULL)
      return -1;
else
```

```
    return 0;
}
```

When dispatching data packets as below, the member *packet_consumed* of the data structure *DATAPKT* must be specified so that the user program can remove the processed data.

```
/*  this user-defined function is called after the user program receives
a data packet. It reverses the contents of the packet and then sends
the result back to the client */
static int
serial_slave_dispatch (MHANDLE conp, void *private_data, DATAPKT *dpkt)
{
char buffer[1024];
dpkt->packet_consumed = dpkt->packet_size;
memcpy(buffer, dpkt->packet_data, dpkt->packet_size);
/* reverse the received data */
reverse_bytes(buffer, dpkt->packet_size);
/* send data back to the master */
connection_send_data(conp, buffer, dpkt->packet_size);
return 0;
}
```

B. Master Example

The initialization function (*serial_master_init*) is almost the same as the one defined for the slave. The only difference is that the master sends the first packet to the slave after the connection is made successfully.

```
/* This is an initialization function where the user program opens connections */
static int
serial_master_init (int argc, char **argv)
{
MHANDLE con;
UARTPRM uart;
USERFUN funs;
memset(&uart, 0, sizeof(UARTPRM));
if (argc < 2)
{
    printf("usage: <progname> <port>\n");
    return -1;
}
uart.port = atoi(argv[1]);
uart.baudrate = 9600;
uart.parity = MSP_PARITY_NONE;   /* 0~4: none, odd, even, mark, space */
uart.data_bits = 8;      /* 5,6,7,8 */
uart.stop_bits = 1;/* 1,2,3 (1.5 bits) */
uart.iface_mode = MSP_RS232_MODE; /* 0~3: RS232, RS485_2WIRE, RS422, RS485_4WIRE */
uart.flow_control = MSP_FLOWCTRL_HW; /* 0~2: none, software, hardware   */
/* callback functions */
memset(&funs, 0 , sizeof(USERFUN));
funs.open = serial_master_open;
funs.dispatch = serial_master_dispatch;
funs.close = serial_master_close;
/* make a client connection */
if ((con=connection_open (CONNECTION_TYPE_UARTPORT, &uart, &funs, NULL)) == NULL)
    return -1;
else
{
    char buf[256];
```

```
    /* send 1st packet */
    strcpy(buf, "I am a master 0");
    connection_send_data(con, buf, strlen(buf));
    return 0;
}
}
```

Again, when dispatching data packets as below, the member *packet_consumed* of the data structure *DATAPKT* must be specified.

```
/*  this user-defined function is called after the user program receives
a data packet. It will keep sending packets to the server */
static int
serial_master_dispatch (MHANDLE conp, void *private_data, DATAPKT *dpkt)
{
    static int count = 1;
    char ch, *buf = (char*) private_data;
    dpkt->packet_consumed = dpkt->packet_size; /* consumed all */
    ch = dpkt->packet_data[dpkt->packet_size];
    dpkt->packet_data[dpkt->packet_size] = 0;
    printf("RECV [%d]: %s\n", dpkt->packet_size, dpkt->packet_data);
    dpkt->packet_data[dpkt->packet_size] = ch;
#ifdef WIN32
    Sleep(1000);
#else
    sleep(1);
#endif
    sprintf(buf, "I am a master %d", count++);
    connection_send_data(conp, buf, strlen(buf));
    return 0;
}
```

7

MODBUS Sample Programs

The MODBUS serial communication protocol, which was published in 1979, has become the de facto communication standard for industry. MODBUS has two variants. MODBUS RTU is a compact, binary encoding of the data and MODBUS ASCII is a hexadecimal encoding of the data, represented with readable ASCII characters.

MODBUS TCP is a variant of the MODBUS family and covers the use of MODBUS messaging in an Internet or intranet environment using the TCP/IP protocols.

The MODBUS protocol defines a simple **Protocol Data Unit (PDU)** independent of the underlying communication layers. The mapping of the MODBUS protocol to serial lines or a network introduces some additional fields to encapsulate PDU to form the **Application Data Unit (ADU)**. For MODBUS TCP, a dedicated **MBAP** (MODBUS Application Protocol) header is used to identify the MODBUS ADU. The MBAP header, but not including the slave ID field, is defined as an *MBTCPHDR* structure in the MODBUS programming functions.

For the MODBUS serial line protocol the PDU follows an error check field. The RTU format follows data with a **cyclic redundancy check (CRC)** checksum, whereas the ASCII format uses a **longitudinal redundancy check (LRC)** checksum.

In Moxa's sample code, the MODBUS library and its sample programs are also provided. The MODBUS library provides programming functions for MODBUS TCP, MODBUS RTU, and MODBUS ASCII. The sample programs provide programming examples for MODBUS TCP client and server, MODBUS RTU master and slave, and MODBUS ASCII master and slave. In the following sections all MODBUS functions are introduced and short codes will be presented for message conversion between MODBUS TCP and MODBUS RTU as well as message conversion between MODBUS RTU and MODBUS ASCII.

MODBUS Functions

The MODBUS library provides two functions for each of MODBUS TCP, MODBUS RTU, and MODBUS ASCII to verify and compose its corresponding messages. In this section these six functions are introduced.

This function parses a MODBUS TCP ADU data packet into a MODBUS TCP structured header and a PDU buffer.

unsigned char* mbtcp_packet_digest(unsigned char *packet, unsigned int *plen, MBTCPHDR *tcp);	
Inputs	
packet	ADU data packet.
plen	The length of an ADU data packet.
Outputs	
tcp	PDU header, excluding slave ID.
plen	The # of bytes that have been consumed from the ADU data packet.
Return Value	
Pointer to the data part of the MODBUS TCP PDU inside the ADU data packet.	

This function composes PDU data and a MODBUS TCP header into a MODBUS TCP ADU data packet.

unsigned int mbtcp_packet_format(MBTCPHDR *tcp, unsigned char *data, unsigned int len, unsigned char *packet);	
Inputs	
tcp	PDU header, excluding slave ID.
data	PDU data, including slave ID.
len	The length of the PDU data.
Outputs	
packet	ADU data packet.
Return Value	
The # of bytes of the ADU data packet.	

This function digests a MODBUS RTU ADU data packet into a MODBUS RTU PDU buffer.

unsigned int mbrtu_packet_digest(unsigned char *packet, unsigned int plen);	
Inputs	
packet	ADU data packet.
plen	The length of ADU data packet.
Return Value	
The # of bytes in a packet excluding CRC, 0 meaning incomplete/wrong CRC packet.	

This function formats PDU data into a MODBUS RTU ADU packet.

unsigned int mbrtu_packet_format(unsigned char *data, unsigned int dlen, unsigned char *packet);	
Inputs	
data	PDU data, including slave ID.
dlen	The length of the PDU data.
Outputs	
packet	ADU packet.
Return Value	
The # of bytes of the ADU packet.	

This function digests a MODBUS ASCII ADU data packet into a MODBUS ASCII PDU buffer.

unsigned int mbasc_packet_digest(unsigned char *frame, unsigned int *plen, unsigned char *data);	
Inputs	
frame	ADU data packet.
plen	The length of ADU data packet.
Outputs	
data	PDU data, including slave ID.
plen	The length of data that is consumed.
Return Value	
The # of bytes in a packet excluding LRC, 0 meaning incomplete/wrong LRC packet.	

This function formats PDU data into a MODBUS ASCII ADU packet.

unsigned int mbasc_packet_format(unsigned char *data, unsigned int dlen, unsigned char *frame);	
Inputs	
data	PDU data, including slave ID.
dlen	The length of PDU data.
Outputs	
frame	ADU frame.
Return Value	
The length of an ADU frame.	

MODBUS TCP to RTU

In addition to transferring messages of the same MODBUS message type between two devices, transferring messages of different MODBUS message types is also required for MODBUS gateways. MODBUS gateways often need to convert between MODBUS TCP messages and MODBUS RTU messages. The following is an example of using the MODBUS library to convert from MODBUS TCP messages to MODBUS RTU messages. Suppose the connection library is used to do the conversion and in the user-defined dispatch function of a TCP connection for MODBUS TCP server, the function **mbtcp_packet_digest** is used to get a MODBUS TCP message from input data as normal MODBUS TCP message handling. Then, the PDU of the MODBUS TCP message is used to compose a MODBUS RTU message using the function **mbrtu_packet_format**. Finally, based on some rules or message content the MODBUS RTU message is sent to the serial port of a determined MODBUS RTU slave using **connection_send_data** function.

```
MHANDLE uart_hndl; /* connection handle of serial port for MODBUS RTU */
unsigned char *packet; /* PDU, including Unit Identifier */
unsigned int plen = dpkt->packet_size;
MBTCPHDR mb;
unsigned char mbrtu_buffer[261]; /* buffer for a MODBUS RTU message */
int len;
packet = mbtcp_packet_digest((unsigned char *)dpkt->packet_data, &plen, &mb);
if (packet == NULL) /* MODBUS TCP ADU packet not complete */
{
    dpkt->packet_consumed = 0;
    return 0;
}
len = mbrtu_packet_format(packet, mb.length, mbrtu_buffer);
if (len > 0)
{
    connection_send_data(uart_hndl, mbrtu_buffer, len);
}
```

MODBUS RTU to ASCII

MODBUS gateways sometimes need to convert between MODBUS RTU messages and MODBUS ASCII messages. The following is an example of using the MODBUS library to do the conversion from MODBUS RTU messages to MODBUS ASCII messages. Suppose the connection library is used to do the conversion and in the user-defined dispatch function of a serial connection for MODBUS RTU slave, the function **mbrtu_packet_digest** is used to verify a MODBUS RTU message from input data as normal MODBUS RTU message handling. Then, the PDU of the MODBUS RTU message is used to compose a MODBUS ASCII message using the function **mbasc_packet_format**. Finally, based on some rules or message content the MODBUS ASCII message is sent to the serial port of a determined MODBUS ASCII slave using the function **connection_send_data**.

```
MHANDLE uart_hndl; /* connection handle of serial port for MODBUS ASCII */

unsigned char mbasc_buffer[513]; /* buffer for a MODBUS ASCII message */

int len;

/* determine the length of an incoming MODBUS RTU request message */
len = mbrtu_get_request_len(dpkt);
…
len = mbrtu_packet_digest((unsigned char *)dpkt->packet_data, len);
if (len <= 0)
{
dpkt->packet_consumed = 0;
```

```
        return 0;
    }
    len = mbasc_packet_format(dpkt->packet_data, len, mbasc_buffer);
    if (len > 0)
    {
        connection_send_data(uart_hndl, mbasc_buffer, len);
    }
```